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Foggy pursuit of ethical response-ability : art and science of collecting water from fog

Anna Emilia Rewakowicz

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Foggy Pursuit of Ethical Response-Ability: Art and Science of Collecting Water from Fog

Thèse de doctorat de l'Institut Polytechnique de Paris
préparée à École Polytechnique

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Thèse présentée et soutenue à Paris, le 12 octobre, 2021 par

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sous le nom artistique de
Ana Rewakowicz

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Dedicated to my mother Anastazja Rewakowicz

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Abstract

Title: *Foggy Pursuit of Ethical Response-Ability* *Art and Science of Collecting Water from Fog*

Water scarcity has become one of the world's most pressing issues, one that particularly affects arid regions, where there is little or no precipitation and groundwater is not available or is polluted. My practice-based research investigates an alternative means of collecting water from fog arising from imaginative solutions brought forward by art and science collaboration. The collaboration challenged the standard method of collecting water from fog with grid mesh nets and proposed an alternative method of harvesting fog water with a net of parallel vertical fibres. This new idea came from an image of a forest of fibres that launched technical research on a new substrate (a net of parallel fibre), controlled production of artificial fog on a large scale and the proposition of novel aerodynamic structural forms.

My art-based research expanded on the scientific question of efficiency through the production of multi-sensory installations that aim at bringing forward a more acute awareness of the intricate co-existence we share and must sustain with water, not as a passive object of investigation, but rather a participant in meaning co-creation. In adopting posthumanist and new materialist philosophical stances of agential realism, my art has concentrated on the creation of a platform of encounter and exchange, inviting the public to enact what feminist theorist Karen Barad calls an “ethical response-ability” (the ability to respond to a call for participation, i.e., ethical behaviour) by engaging with artworks’ space of materiality, physicality and meaning. This interactive, ethically responsive approach has been extended to the writing

process through the use of different forms of narration (possibly atypical for a thesis), to invite readers to become participants in meaning co-creation.

The art and science collaboration described in the current thesis has successfully demonstrated the power of imagination and participation that created new relationships and novel solutions. However, to deal with complex problems such as water scarcity, we need to extend the invitation to participate beyond artists, scientists, and viewer/participants to include the communities for which the research is intended, thereby expanding the circle of inclusion and closing the gap between what we know, what we sense and feel, and what we do.

Version française

La pénurie d'eau est devenue l'un des problèmes les plus urgents au monde, qui touche particulièrement les régions arides, où les précipitations sont faibles ou inexistantes et où les eaux souterraines ne sont pas disponibles ou sont polluées. Mes recherches sont basées sur la pratique, portent sur un moyen alternatif de recueillir l'eau du brouillard à partir de solutions imaginatives proposées par une collaboration entre l'art et la science. Cette collaboration remet en question les méthodes standards de collecte de l'eau du brouillard à l'aide de filets à mailles et proposa une méthode alternative de récolte de l'eau du brouillard à l'aide d'un filet de fibres verticales parallèles. Cette nouvelle idée est née de l'image d'une forêt de fibres qui lança la recherche technique sur un nouveau substrat (un filet de fibres parallèles), la production contrôlée de brouillard artificiel à grande échelle et la proposition de nouvelles formes structurelles aérodynamiques.

Ma recherche artistique s'est étendue à la question scientifique de l'efficacité à travers la production d'installations multi-sensorielles qui visent à mettre en avant une conscience plus aiguë de la coexistence complexe que nous partageons et devons maintenir avec l'eau, non pas comme un objet passif d'investigation, mais plutôt comme un participant dans la co-crédation de sens. En adoptant les prémisses philosophiques posthumanistes et néomatérialistes du « réalisme agentiel », mon art s'est concentré sur la création d'une plateforme de rencontre et d'échange, invitant le public à mettre en œuvre ce que la théoricienne féministe Karen Barad appelle une « capacité de réponse éthique » (la capacité de répondre à un appel à la participation, c'est-à-dire un comportement éthique) en s'engageant avec l'espace de matérialité, de physicalité et de signification des œuvres d'art. Cette approche interactive et éthiquement réceptive a été étendue au processus d'écriture par l'utilisation de différentes formes de narration (peut-être atypiques pour une thèse), afin d'inviter les lecteurs à devenir des participants à la co-crédation de sens.

La collaboration entre l'art et la science présente dans cette thèse a démontré avec succès le pouvoir de l'imagination et de la participation qui créa de nouvelles relations et de nouvelles solutions. Cependant, pour faire face à des problèmes complexes tels que la pénurie d'eau, nous devons étendre l'invitation à participer au-delà des artistes, des scientifiques et des spectateurs/participants pour inclure les communautés auxquelles la recherche est destinée, élargissant ainsi le cercle d'inclusion et comblant le fossé entre ce que nous savons, ce que nous ressentons et ce que nous faisons.

Preface

This thesis is based on art and science research that addresses the issue of diminishing sources of fresh water in the world and looks at alternative methods of collecting water from fog. The *Mist Collector* project, carried out at the Hydrodynamics laboratory (Ladhyx) at École Polytechnique in Paris, is an art and science collaboration between me and physicist Camille Duprat and physicist/artist Jean-Marc Chomaz that demonstrates that advances in both science and art are possible through this type of collaboration. The current thesis describes the problem, the scientific and artistic outcomes and explores how art-science collaborations can contribute to finding different solutions to the environmental crisis of water scarcity through new approaches to problem solving and the practice of ethical responsiveness.

The *Mist Collector* collaboration was initiated during an artist-in-residence program (2014), later evolving into doctoral research at École Doctoral Université Paris-Saclay (2015) under the supervision of physicist/artist Jean-Marc Chomaz (LadHyx) and historian of science Frédéric Brechenmacher (LinX). This newly established doctoral program, aiming to bridge art and science, was initiated and created by Chomaz through an affiliation between two laboratories at École Polytechnique: Laboratoire interdisciplinaire de humanités et sciences sociales (LinX) and Laboratoire d'hydrodynamique (LadHyx) within École doctorale "Sciences de l'Homme et de la Société" de l'Université Paris-Saclay (2015-19) and currently within École doctorale d'Institut Polytechnique de Paris (2019-2021). My study was financially supported by a doctoral fellowship awarded from the Social Sciences and Humanities Research Council (SSHRC) of Canada, as well as Chair arts & sciences, established in

2017 in partnership with École polytechnique, École nationale supérieure des Arts Décoratifs-PSL and the Daniel and Nina Carasso Foundation. Being one of the first two doctoral fellows in this new program has had its pluses and minuses. While absence of a pre-established structure and protocols allowed for greater freedom, it also resulted in the thesis work taking longer, as there were no established benchmarks. Thesis work consisted of two research periods: practice-based research leading to the production of three art installations and one prototype (2015-2018) and theoretical research and writing (2019-2021) that concentrated on methodological investigations on how to write about practice-based research and art and science collaboration.

During the practice-based research, the *Mist Collector* project has led to challenging the standard method used in current fog harvesting techniques, and has triggered a novel metaphor for fog collection - a forest of parallel vertical fibres. Based on this concept the following artworks were created: *Through the Looking Mist...* (2014) - a video projection focusing on the behaviour of water droplets on parallel vertical fibres, *Porous Sail* (2015) – the prototype of a new aerodynamic structural form, *Misty Way* (2016) – an installation zooming in on the process of the collection of water from fog and *Nephelograph (Mist Impressions)* (2018) that concentrated on the controlled production of artificial fog on a large scale. In addition to exhibiting these artworks, the *Mist Collector* project was also presented at various conferences and symposia, as well as featured in two films and a book. For the list of exhibitions, publications, teaching and other activities undertaken during this period, including co-organization of the *Garden the Sky Water* conference (2019), please refer to Appendices A, B and C.

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Introduction

Humanity is facing existential crises of ecological disintegration on an unprecedented scale. The expansion of our life styles of comfort and pleasure that go beyond our needs, exacerbated by an increasing population, have infringed on habitats of other beings on this planet causing the loss of biodiversity and likely implicated in such global incidents as the appearance of the coronavirus, SARS-CoV-2 in 2019. With climate change that can cause further diseases, economic and social inequalities and even wars, in a not so far distant future, we might find ourselves unable to live on this planet.

While science and technology have been able to mitigate some of these problems, for example coming up with vaccines for Covid-19, the techno-scientific approach has also added to the creation of other problems, for example the loss of jobs due to artificial intelligence or water shortages caused by lithium mining. Science and technology alone will not be able to find solutions to the problems we are facing and we need to consider all points of view and develop ways to collaborate and cooperate across disciplines, at different socio-cultural and political levels, as well as with communities in need (both human and non-human). We need to share this planet with *others* in order to survive and thrive, and move away from the idea of short-term profit ahead of long-term protection for all, giving time for regeneration and replenishment.

One of the critical problems we face is water shortage in some areas of the world and one of the potentially sustainable solutions that science has brought us is to collect water from fog. By taking cues from nature, scientists have discovered more efficient ways of extracting water from fog by placing woven nets in the path of the

wind to collect condensed water droplets in the air. While these solutions have transformed several small-scale societies, standard methods for collecting water from fog still grapple with problems of reduced inefficiency (due to water clogging in the pores of the nets), cost, fragility of nets and impracticality of sustaining the technology in rural areas.

While collaborations between artists and scientists cannot solve all of these problems, by bringing radically different perspectives together, art-science collaborations can go a long way toward solutions. Critical aspects of collaboration are finding the words and frameworks in which to describe the problem and its solutions. The *Mist Collector* collaboration is an example of one such successful collaboration and the current thesis describes how some of the scientific and artistic solutions discovered through this collaboration point to possible future directions.

As a practicing artist collaborating with scientists and as one of the first students in the art-science doctoral program at École doctorale d'Institut Polytechnique de Paris, I am writing a practice-based thesis, not a thesis in a physics, art history, or philosophy, which each have their own disciplinary norms. While the creation of works of art and of science have many parallels, treating art production as similar to scientific experimentation or slavishly following the norms of scientific writing in either structure or form was inadequate. After all, art usually attempts to break down norms and forms, rather than to follow them; it attempts to problematize questions by bringing more questions and employing multiple perspectives.

Since my artistic practice has been centred on co-creation in the act of participation, I have applied a similar approach to writing this thesis. Instead of an exegesis or merely a postscript to my artistic production, I use the framework of

agential realism created by American feminist theorist and theoretical physicist Karen Barad (2007) that allows for multiple perspectives to overlap, creating different patterns of interaction. Thus, my thesis weaves in and out of the scientific question of fog water collection efficiency and artistic responses that do not necessarily provide a specific solution, but draw on participatory possibilities for a solution.

In experiencing art, meaning happens at the boundary of interaction between an artwork (a proposition for an interaction) and viewer/participant, who, by bringing their own insights, is a co-creator of a temporary meaning that can change with different viewers/participants. Meaning, like knowledge, is participatory and there is no single meaning but as many meanings as there are participants. Differences, and consequential exclusions that arise in the process of interactions, are embraced in agential realism through the concepts of ethical response-ability (inclusiveness) and diffraction – a wave-behaviour-defining pattern. While *ethical response-ability* involves both; the ability to respond and the responsibility to provide for the possibility of a response, *diffraction* allows for the differentiating of patterns which expose how different manners of relating produces different meaning. The diffraction approach permits us to make distinctions such as discriminating between small bumps on the skin and the surface of the skin itself (detecting separations), while acknowledging that the bumps are part of the skin (detecting their inseparability from the skin). Agential realism offers the possibility of experiencing different views in an effort to enlarge the circle of meaning (inclusion), where the action of changing perspectives does not parallel disciplinary ‘blindness’ of not seeing ‘otherness’ (zooming in) or looking at an object from a distance (zooming out), but rather it allows for changing views by performing different subjects. A multiplicity of perspectives becomes possible not

through the act of looking that creates a distance (with the effect of blurring details and making what is observed into a uniform ‘oneness’¹), but instead through the act of touching that enables ‘closeness’ of sensing differences (details) without separating them from the larger surroundings. My thesis explores a multi-view and relational approach to ‘closeness’ not only conceptually, by incorporating insights from different fields, but also practically, through the exploration of different styles of writing. Thus, writing in the current thesis is not only a means to describe the problem and the process of solution, but also the process of meaning (re)creation that changes through different patterns of engagement and participation in different contexts. Throughout my dissertation, I move in and out² of writing in the styles of science, philosophy, personal reflections and poetry to augment the scope of experience for the reader, as well as the writer. Through this writing process, not unlike in the creation of the artworks, I invite readers to participate in meaning co-creation while reading the thesis.

The thesis has a 2-part structure. Part I is comprised of three chapters and paints the landscape within which my research took place. Chapter 1 situates the scientific question of the efficiency of collecting water from fog that constituted the basis of the art and science research. Chapter 2 introduces my background that influenced the

¹ We can compare this process to pointillism – a technique of painting dot by dot (individual brush strokes) such as employed by French painter George Seurat. When looking from afar, one does not distinguish individual dots seeing only a swath of colour, a phenomenon similar to that found with digital images that are composed of small pixels, which we do not individually recognize when looking at an image.

² Educator and a member of the Synergetics Collective (an educational and scientific non-profit organization in the US that follows the principles of Synergetics initiated by Buckminster Fuller), John Belt explained to me how Buckminster Fuller persisted in using ‘in’ and ‘out’ in reference to movement. According to Belt, Fuller said that we do not go up or down stairs but we go in and out of stairs because movement depends on a point of reference, and for Fuller, his point of reference was the earth. Belt said: “Bucky’s reference is the center core of earth, NOT the floor or ground, which is flat earth language,” email message to author, January 3, 2020.

artistic production of my practice-based research and Chapter 3 introduces the agential realism approach critical to understanding the *Mist Collector* collaboration as practices oriented towards relational and ethical responsiveness. Part II, also comprised of three chapters, embodies the core of my research and centres on the question of meaning creation by addressing different aspects of the *Mist Collector* collaboration. Chapter 4 traces early encounters between art and science in the quest of developing a new way of thinking about the problem. Chapter 5 describes the production of the *Mist Collector* artworks as a response to the scientific question. Chapter 6 examines the pros and cons of this and future art and science collaborations as a means to tackle complex problems like the environmental crisis of water scarcity.

In Chapter 1, I present the global problem of water scarcity that is especially relevant in arid regions of the world with little precipitation or access to groundwater and identify a possible solution to this problem that involves harvesting water from fog. This technology is not new, for millennia some animals, plants and humans have used it, but only within the last few decades, has collecting water from fog been implemented on a large scale. Driven by the question of increasing efficiency of this process, scientific research has focused on various advancements of this technology and the investigations described in this thesis add to this line of work. As this chapter reviews the basic scientific problem, it follows an academic style of writing.

In contrast, Chapter 2 recounts personal stories of how I came to work collaboratively with scientists on the problems that obstruct collection efficiency (clogging, drainage and re-entrainment). Since gathers personal memories and reflections, as well as narration through artworks and events, it is written with a personal voice in the first-person perspective and is accompanied by images.

Chapter 3 introduces the theoretical framework and three relevant aspects of agential realism theory. The first deals with the notion of *relating* and how different relationships constitute different meanings. This relational approach helps to understand heterogeneous entities that arose from the *Mist Collector* collaboration and project, sometimes producing knowledge related to science, sometimes to art and other times to art-science. The second tackles the concept of *ethical response-ability* to demonstrate how the *Mist Collector* artworks engaged in ethical practices of inclusion by creating invitations for participation for water, science and the general public. The third explains the *diffraction approach* that opens the possibility for communicating tacit experiences of creation through bursts of insight that do not necessarily follow the linear logic of explicit knowledge, and becomes a tool for an active and participatory way of thinking, writing and reading about creative processes.

Chapter 4 presents art-science interactions in pursuit of the scientific question of fog water collection efficiency and describes their initial efforts toward understanding disciplinary differences and finding ways of communicating and working together. The meeting between the two cultures of art and science led to a novel metaphor for fog collection, a forest of parallel vertical fibres. This metaphor set the direction for technical research, involving controlled fog production, a novel method of substrate fabrication and new structural collecting forms incorporating wind that demonstrated the utility of our art-science collaboration. Chapter 4 is written in the first-person but not the personal voice, as it recounts a story of an encounter with science and details the development of technical research.

Chapter 5 deals with the artistic production of three installations and the prototype of a porous sail. It is written using the approach of diffraction, in which both

the first-person and personal voices carry the reader through philosophical reflections, scientific interludes, logs, poetic encounters, and recounting of public reactions, while incorporating images. As the *Mist Collector* artworks invite the viewer to become the participant in meaning co-creation, the chapter's non-linear narration attempts to invite the reader to become a co-creator of the experience of reading by using multiple writing styles and through employing multiple formal strategies, such as different columnar structures, using text boxes and including poems to provide an opportunity for the reader to engage in active reading.

Chapter 6 points out the necessity of collaborations, especially when facing environmental challenges. In this chapter I examine the kind of knowledge (meaning) the *Mist Collector* collaboration has produced. I argue that art, through the practice of ethical response-ability and when treated as an equal partner in the relationship, can contribute to problem solving and create a more-inclusive collaboration, as was the case with the *Mist Collector* collaboration. Drawing from experiences gained from two exploratory field trips, the first to Morocco, to the largest fog-collecting site in the world, and the second to the Atacama Desert in Chile, I recommend that community be included in future collaborations.

In sum, the current thesis describes a scientific problem, that of providing water to areas with limited water supplies, and demonstrates that through a collaboration of art and science, new scientific, artistic, as well as art-science solutions can be co-created. To provide the reader with a more intimate understanding of the co-creating process, the thesis employs novel and experimental formal writing structures, as well as writing from a variety of unusual (for a thesis) viewpoints. Using the stance of agential realism, we can understand how different ways of relating produce different

relationships and meanings, and how to solve major global problems, such as water scarcity, we need viewpoint-altering collaborations that bring together artists, scientists, viewer/participants, and entire communities, thereby expanding the circle of inclusion.

PART I

CONSTRUCTING A QUESTION: Collecting Water from Fog

Chapter 1

Science: The Problem and Current Solutions

1. Water crisis

Water accounts for approximately two-thirds of the volume of a human's body¹ (depending on your age) and human body's liquid component, blood - is a river network that delivers nutrients to our brains and all the tissues to keep us alive.² "Water is Life,"³ declared the Bolivian ambassador to the United Nations, Pablo Solón in his speech to the United Nations (UN) General Assembly on July 28, 2010, introducing a resolution to recognize the right of all humans to safe and clean drinking water.⁴ Canadian writer and activist Maude Barlow in her book *Blue Future*, describes the tension felt in the air before the vote on the resolution, as there were many powerful adversaries, especially the United States and Canada. Despite this fact, to everyone's relief and joy, the resolution for the right to safe and clean drinking water and for sanitation was ratified,⁵ after almost two decades of hard work by many organizations and dedicated activists. Finally, water became "a legal entitlement rather than a charity

¹ Anne Marie Helmenstine, "How Much of Your Body Is Water?," last modified February 11, 2020, Thought Co., <https://www.thoughtco.com/how-much-of-your-body-is-water-609406>.

² Veronica Strang, *Water* (London: Reaktion Books Ltd, 2015), 7. Kindle.

³ Maude Barlow, *Blue Future: Protecting Water for People and the Planet Forever* (Toronto: House of Anansi Press, 2013), 12. Apple Books.

⁴ *Ibid.*, 13.

⁵ *Ibid.*

or a commodity.”⁶ Subsequently, the UN declared 2013 to be the Year of Water Cooperation and 2018-2028 as the Water Action Decade.⁷

Curiously, when the Universal Declaration of Human Rights was first proclaimed in 1948,⁸ water was not on the agenda, as it was unimaginable at that time that something so fundamental as water would become unavailable. It is also startling to realize that political rights, such as freedom of speech, religion, voting rights and the right to a fair trial are considered as the ‘first generation’ of human rights, while the rights to clean drinking water and sanitation are regarded as ‘third-generation’ human rights. In other words, political freedom is treated as more important than socio-economic (second generation) or environmental (third generation) considerations for the ‘enjoyment of life.’⁹ In the meantime, human life without clean air to breathe, or food to eat, or without water, would not exist.

A generally held misconception that water is imperishable and everlasting has contributed to the problem of water scarcity we face today. For example, while it is almost unimaginable that US industries have injected 120 trillion litres of liquid toxins deep into the ground over many decades, they have done so, polluting precious groundwater supplies.¹⁰ According to Mario Salazar, an engineer working for the United States Environmental Protection Agency’s underground injection program in 2011, in the short span of 10 and 100 years from now, most underground water in the

⁶ Ibid., 56.

⁷ United Nations Sustainable Development Goals, “International Decade for Action on Water for Sustainable Development, 2018-2028,” accessed May15, 2021, <https://www.un.org/sustainabledevelopment/water-action-decade/>.

⁸ Barlow, *Blue Future*, 41.

⁹ Ibid., 51.

¹⁰ Ibid., 195.

US will be polluted.¹¹ Another example of this fallacy of everlasting water is the practice of monoculture irrigation - intensive crops that exhaust already dwindling groundwater sources, especially in drylands,¹² even as the Executive Secretary of the UN Convention to Combat Desertification Luc Gnacadja, states that “drylands hold the key to world hunger if treated properly.”¹³ He insists that there is “a widespread but misguided belief that drylands are wastelands or marginal lands with low productivity and adaptive capacity (...),”¹⁴ and calls for a return to small-scale community-based farming that restores degraded soil and supports biodiversity, strengthened by water-retentive agriculture.¹⁵ He continues with an example of the importance of “dry forests that are home to the planet’s largest diversity of mammals (...)”¹⁶ and notes that if not handed with care, drylands will become deserts, where not “even a blade of grass”¹⁷ will grow. The danger will be that if there will be no soil left to grow food, the only option would be to move to another planet, if such an option is at all feasible or desirable.

In spite of the fact that the UN has ratified the resolution on the human rights to water and sanitation, the implementation of these rights has been far from satisfactory. As Sandra Postel from the Global Water Policy Project points out: “(...) we have been quick to assume rights to use water but slow to recognize obligations to preserve and protect it.”¹⁸ Privatization of ecological commons and economic globalization with its

¹¹ Ibid., 195.

¹² Ibid., 352.

¹³ Ibid.

¹⁴ Ibid.

¹⁵ Ibid., 353.

¹⁶ Ibid., 352.

¹⁷ Ibid., 353.

¹⁸ Ibid., 267.

emphasis on competitive growth and expansion has created tensions over the control and ownership of water.¹⁹ While multinational companies and international investors buy up massive parcels of land in Africa, Asia and South America for industrial agriculture and producing food for export, depleting local water sources, small farmers are squeezed and unable to produce food for their families.²⁰ This economic model with “its entrenchment of corporate rights in international trade laws, and its displacement of the local caretakers of land and water everywhere, is a sure-fire recipe for water disaster”²¹ says Barlow. In addition, the increasing rise of temperature and unpredictable weather patterns due to climate change, as well as population growth, are all factors contributing to diminishing water sources in an unprecedented way.

A recent article in The New York Times states that according to the World Resources Institute, a quarter of Earth’s population will face a water crises by 2030, especially in cities with population over 3 million, which will account for nearly 470 million people.²² According to research by Mekonnen and Hoekstra at the University of Twente in the Netherlands, four billion people already experience water scarcity at least one month each year, and a half billion people “face severe water scarcity all year round.”²³ The UN-Water agency, in its 2018 report, states that water scarcity will displace between 24 and 700 million people from arid and semi-arid areas by 2030,

¹⁹ Ibid., 308.

²⁰ Ibid., 302.

²¹ Ibid., 312.

²² Somini Sengupta and Weiyi Cai, “Trapping humidity out of fog,” *New York Times*, August 6, 2019, <https://www.nytimes.com/interactive/2019/08/06/climate/world-water-stress.html>.

²³ Mesfin M. Mekonnen and Arjen Y. Hoekstra, “Four billion people facing severe water scarcity,” *Science Advances* 2, no. 2 (2016): 1, <https://advances.sciencemag.org/content/2/2/e1500323>.

and water demand will rise 20 percent by 2050.²⁴ Access to water is one of the most crucial issues with which we need to come to terms.

Thus, it becomes evident that to combat a global water crisis we need all our ingenuity, including technological, social and ethical practices for dealing with this issue. To better understand the problem and some of the current solutions, in the sections that follow, I describe the water cycle (section 2) and the significance of a potential source of water, hydrometeor, or water that is trapped in the air, such as fog (section 3). Then, I explain what fog is and how it forms (section 4) and describe how natural fog collection occurs and how historically, humans have endeavored to extract water from air (section 5). Next, I characterize modern fog collection processes (section 6), followed by an explanation of fog collection technology (section 7). Subsequently, I outline some recent technological innovations for extracting water from air (section 8), including new types of meshes (section 8.1) and developments in collecting structures (section 8.2). Finally, I present my current research focus in the context of recent advancements (section 9) and end with a recap of the chapter (section 10).

2. The Water Cycle

The water (or hydrological) cycle is the engine of life that runs on solar power and is driven by gravity.²⁵ Water covers 75 percent of the Earth's surface distinguishing

²⁴ United Nations, "Scarcity: UN-Water," accessed May 10, 2020, <https://www.unwater.org/water-facts/scarcity/>.

²⁵ David Maidment, ed., *Handbook of Hydrology* (New York: McGraw-Hill Education, 1993), 13, quoted in Veronica Strang, *Water* (London: Reaktion Books, 2015), 26.

Earth from other planets in the Solar System.²⁶ The hydrological cycle circulates water from the clouds to the land and ocean and back to the clouds again, and is “at the heart of both the causes and effects of climate change.”²⁷ The Sun’s energy causes water to go through different stages, from liquid to gas, from gas to solid and back to liquid. The Sun evaporates water from the surface of land, oceans, lakes, rivers and streams, including the polar icecaps, glaciers and snow (in what is known as sublimation, which accounts for 90 percent of water vapor in the atmosphere), and also from plant leaves (known as evapotranspiration, accounting to 10 percent of water vapor).²⁸ The rising moisture depressurizes and condenses into cloud droplets in the lower layers of the atmosphere. These condensed masses of cloud produce precipitation, such as snow, rain, freezing rain or hail. Water that comes back to land can either penetrate the ground, run off into rivers, lakes, streams and oceans, and evaporate again from their surfaces.²⁹ Freshwater, necessary to living beings, comprises only 3.5 percent of the total water available on Earth,³⁰ approximately half of which (1.7%) constitutes rivers, lakes, streams and groundwater, while the other half (1.7%) is stored in polar icecaps, glaciers, permafrost and snow, with the remainder (0.1%) existing as water vapor in the atmosphere.³¹

Climate change affects the water cycle by shifting how quickly water moves

²⁶ Steve Graham, Claire Parkinson and Mous Chahine, “The Water Cycle,” NASA Earth Observatory, last modified October 1, 2010, <https://earthobservatory.nasa.gov/features/Water>.

²⁷ NASA Science, “Water Cycle,” accessed May 31, 2020, <https://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-water-cycle>.

²⁸ Graham, Parkinson and Chahine, “The Water Cycle.”

²⁹ Ibid.

³⁰ Oceans constitute the remaining 96.5 %. Graham, Parkinson and Chahine, “The Water Cycle.”

³¹ Ibid.

through the cycle of evaporation and precipitation (changing states from liquid to vapor to solid).³² Rising temperatures increase the surface water evaporation from oceans, lakes, rivers or streams, as well as from icecaps, glaciers and snow. The increase in evaporation in turn produces more precipitation. However, as precipitation increases in volume, it more often takes the form of rain than snow, generating torrential rain storms that cause greater runoffs, where freshwater returns to the oceans rapidly and becomes diluted in the salty water, instead of being retained by soil and replenishing groundwater reservoirs.³³ The rise of water runoffs³⁴ results in the reduction of water availability and an increase in droughts, especially during seasons with the highest water demand, such as summer and fall, when there is little precipitation and water is most needed for agriculture.³⁵

3. Atmospheric Water (Hydrometeors)

According to the NASA Earth Observatory, the amount of water in the atmosphere is approximately 13,000 cubic kilometres at any given moment, which constitutes an extremely small fraction (0.001%) of Earth's total water supply.³⁶ For example, if the atmospheric water would become rain, it would cover the Earth's surface in only 2.5 centimetres of water. However, water in the atmosphere cycles much faster than water in other source (rivers, streams or oceans). So even though, at any particular moment, there may be only 13,000 cubic kilometres of water in the

³² Ibid.

³³ Ibid.

³⁴ Not to mention physical devastation that storms with torrential rains cause, such as floods or landslides that destroy homes and land.

³⁵ Graham, Parkinson and Chahine, "The Water Cycle."

³⁶ Ibid.

atmosphere, this water passes through the hydrological cycle nearly 40 times per year, amounting to approximately 500,000 cubic kilometres a year;³⁷ a quantity that if rained, would cover the Earth's surface 1 metre deep. This crucial detail means that water vapor could substantially contribute to freshwater availability in the future.

We can access water in the atmosphere when it becomes available in the form of rain, fog or dew. Collecting water from rain can be traced back 6000 years to China and there is archeological evidence of runoff cisterns existing in Israel dating 2000 years ago.³⁸ Dew is also not an unfamiliar source of water.³⁹ Archeological remains in many parts of the world, such as the Atacama Desert and the Mediterranean region (including the Crimean Peninsula or Palestine as a geographical territory), reveal piles of stones used for condensation of moist air into depressions in the ground.⁴⁰ In contrast to dew that condenses on various surfaces (when there is a difference in temperatures between the air and a surface), fog requires more specific meteorological and topological conditions, and thus collection of water from fog has mainly arisen in specific locations (such as the west coast of the Americas or Africa), where cold ocean currents in combination with coastal mountains produce frequent fog events. In these arid and semi-arid areas, with little or no precipitation, and little access to groundwater, fog acts as the only source of water for plants, animals and people.

³⁷ Ibid.

³⁸ Gary Edwin Battenberg, "A Brief History of Rainwater Harvesting," *Water Conditioning & Purification Magazine*, September 9, 2009, <http://wcponline.com/2009/09/14/flowing-issues-brief-history-rainwater-harvesting/>.

³⁹ Detlev Möller, "On the History of the Scientific Exploration of Fog, Dew, Rain and Other Atmospheric Water," *Die Erde* 139 (2008): 11-12.

⁴⁰ Mussie Fessehaye et al., "Fog-water collection for community use," *Renewable and Sustainable Energy Reviews* 29 (2014): 54, doi: 10.1016/j.rser.2013.08.063.

4. Fog Formation

Fog is a cloud close to the ground, already composed of small, condensed water droplets, which are large enough not to evaporate back and small enough to stay in suspension and not to be brought down by gravity in the form of rain. The size of water droplets in fog ranges from 1 to 40 microns (one millionth of a metre) in diameter. When water droplets are 40 microns to 0.5 millimetres in diameter, they are classified as drizzle and when they are 0.5 millimetres up to 5 millimetres in diameter they become rain, where droplets larger than 5 millimetres constitutes hail.⁴¹

Fog formation entails the presence of air saturated with humidity along with the temperature dropping below dew point,⁴² the specific temperature at which water vapor in the air cannot be contained any longer and must condense, as air can only hold a certain amount of humidity at any given temperature.⁴³ There are many types of fog, including radiation fog, valley fog, evaporation fog, freezing fog,⁴⁴ as well as advection fog, upslope fog, but not all of them are suitable for water collection.⁴⁵ In addition to the presence of humidity in the air, the most important element in the collection of water from fog is wind, hence only fogs that involve the movement of air (e.g., advection or upslope) are appropriate. *Advection fog* (also called *sea* or *costal* fog) occurs when a warm and moist air is carried by advection (horizontal wind) over the

⁴¹ Fessehaye, "Fog-water collection for community use," 56.

⁴² Jeremy K. Domen et al., "Fog water as an alternative and sustainable water resource," *Clean Technologies and Environmental Policy* 16 (2014): 237, doi: 10.1007/s10098-013-0645-z.

⁴³ Fessehaye, "Fog-water collection for community use," 56.

⁴⁴ Oishimaya Sen Nag, "What Are The Different Types Of Fog?," World Atlas, last modified May 15 2019, <https://www.worldatlas.com/articles/what-are-the-different-types-of-fog.html>.

⁴⁵ La Sampurno Bruijnzeel, Werner Eugster and Reto Burkard, "Fog as a Hydrologic Input," in *Encyclopedia of Hydrological Sciences*, ed. M. G. Anderson (Hoboken: John Wiley & Sons, 2005), 561-564, doi: 10.1002/0470848944.hsa041.

cold surface of the ocean causing water vapor to condense.⁴⁶ *Upslope fog* (also known as *orographic fog*) forms when warm and moist air increases in altitude through orographic lift (by being forced upwards following mountainous terrain) then through adiabatic cooling (decrease in temperature due to increase in altitude) reaches its dew point, leading to the condensation of small water droplets.⁴⁷ This type of fog appears as stratus clouds touching the mountains (fig. 1).



Figure 1. Photo of advection/upslope fog over a mountain on the west coast of Chile, south of the city of Iquique. © Ana Rewakowicz, 2018.

Another crucial element in fog collection is topography.⁴⁸ Since oceans are significant sources of water vapor, a combination of ocean and coastal mountains create

⁴⁶ Fessehayé, "Fog-water collection for community use," 56.

⁴⁷ *Ibid.*

⁴⁸ *Ibid.*

especially favourable settings for the collection of water from fog.⁴⁹ In locations, where cold currents (such as California in the US, Humboldt in South America, Canary and Benguela in Africa) come into contact with warm air, abundant masses of fog (low stratus clouds) are produced and pushed towards coastal hills by advection winds, then raised up mountain slopes by orographic lifts. In these areas, including parts of California, Peru, Chile, Morocco, South Africa, the Canary Islands, Eritrea and Oman, recurring fog events are advantageous for water harvesting, especially in regions that are far-removed from industry and pollution.

Thus, because fresh water is scarce, research into alternative water sources that do not require a great amount of energy to extract is critical and of great importance.⁵⁰ Atmospheric water (hydrometeors), including rain, dew, and especially fog,⁵¹ are currently underutilized sources of fresh water. In the next sections of this chapter, I describe how fog collects naturally and review the (pre)historic evidence that people have deliberately harvested fog water (section 5), examine current processes for fog collection (section 6), new technologies for collecting water from fog (section 7), and explore potential areas of improvement in these technologies (section 8), before describing my current research focus (section 9) and summarizing (section 10).

5. Natural and (Pre)Historic Fog Collection

Fog collection is a natural phenomenon.⁵² For example, trees are especially good at intercepting fog clouds, causing an accumulation of water droplets on their leaves

⁴⁹ Ibid.

⁵⁰ Domen, "Fog water as an alternative and sustainable water resource," 237.

⁵¹ Ibid.

⁵² Fessehaye, "Fog-water collection for community use," 54.

that act as strainers and produce drip rain.⁵³ Intercepted in this way fog water significantly contributes to hydrological input in certain coastal dry areas, such as the coastal redwood forests (sequoias) in California.⁵⁴ In numerous studies, it has been found that fog water plays a pivotal role in the redwood forest hydrology, especially during the summer months, when there is little precipitation. In the dry season, from May to September, tree roots are not able to get enough water from the ground and rely primarily on water supplied from fog.⁵⁵ Another example of fog-dependent ecosystems are *Lomas* (fog forests) in the northern part of Chile and Peru, where rainfall is almost absent and where some forest groves depend almost completely on advection fog that often occurs in these areas.⁵⁶

For many years, in arid regions with little precipitation, local populations used the trees' interception of fog as water for human and animal consumption.⁵⁷ Fog and fog-supported vegetation are supposed to have played an essential role in the advancement of the agricultural settlements of Preceramic hunter-gatherers (8000 – 4500 BP - Before the Present) in coastal communities of Chile and Peru.⁵⁸ Historical evidence shows that in mountainous communities in Oman, people built cisterns under olive trees to collect dripping fog water for domestic use.⁵⁹ Also, pre-Hispanic native

⁵³ Ibid.

⁵⁴ Ibid.

⁵⁵ Emily Francis, "Can California's Iconic Redwoods Survive Climate Change?," interview by Tara Lohan, *The Revelator*, February 13, 2019, <https://therevelator.org/redwoods-climate-change/>.

⁵⁶ Fessehaye, "Fog-water collection for community use," 54.

⁵⁷ Ibid.

⁵⁸ David Beresford-Jones et al., "Re-evaluating the resource potential of lomas fog oasis environments for Preceramic hunter-gatherers under past ENSO modes on the south coast of Peru," *Quaternary Science Reviews* 129 (2015): 196-215, doi: 10.1016/j.quascirev.2015.10.025.

⁵⁹ Fessehaye, "Fog-water collection for community use," 53.

inhabitants of the Canary Islands Archipelago used junipers, laurels and pine trees as their source of water by placing pots under the trees and collecting water from drip rain.⁶⁰ On El Hierro Island, a legend talks about a ‘fountain tree’ – a laurel tree (*Ocotea foetens*) called *Garoé* used by locals as their source of potable water until 1610, when it was uprooted in a hurricane. In 1945, 300 or so years later, in the memory of *Garoé*, another laurel tree was planted in the same place by conservationist Don Zósimo Hernández Martín and it has been producing dripping rain, not unlike the original tree.⁶¹

Horacio Larrain and colleagues describe the significance of fog in sustaining local communities since the Stone Age in the Alto Patache Loma, south of Iquique in Chile.⁶² Their archeological observations provide evidence that this location has been continuously occupied since approximately 5000 – 4500 BC first by Chinchorro culture then others, and that inhabitants used fog as their water source continuously until the colonial times. Larrain discovered a structure, presumed to be a well, composed of deliberate arrangement of stones with remains of mud. This structure appears to collect water dripping from vertical surfaces of the rocky blocks above. Larrain hypothesizes that lichens covered these rocks, which acted as fog interceptors, producing water droplets that then dripped down the walls. As there is no evidence of other water

⁶⁰ Alain Gioda et al., “Some Low Elevation Fog Forests of Dry Environments: Applications to African Paleoenvironments,” in *Proceedings of the Tropical Montane Cloud Forests International Symposium*, eds. Lawrence S. Hamilton, James O. Juvik and Fred N. Scatena (San Juan, Puerto Rico: East-West Center, 1993), 97.

⁶¹ *Ibid.*, 98.

⁶² Horacio Larrain et al., “Archaeological Observations at a Coastal Fog-site in Alto Patache, South of Iquique, Northern Chile,” PDF file, accessed May 30, 2020, <http://www.cda.uc.cl/wp-content/uploads/2016/07/Archaeological-observations-at-a-coastal-fog-site-in-Alto-Patache.pdf>.

sources in the area, and rain is almost non-existent there, the idea that the stone structure was for water collection seems the most likely explanation. Larrain also speculates that the Chinchorro people used hides with thin hairs (e.g., from guanaco and sea lions) to intercept water droplets from fog, channeling the water into vessels placed below.⁶³ Together these examples demonstrate fog's significance in many parts of the world, as well as people's ability to astutely observe natural phenomena and use them to their own advantage.

6. Modern Fog Collectors

As we saw, gathering water from humidity in the air (e.g., rain, dew or fog) is not a new idea, especially in arid and semi-arid regions of the world, where people have long used innovative ways of coping with limited water sources. However it was not until the beginning of the 20th century that fog was considered to be a natural resource, with deliberate efforts to make its collection more efficient. Modern interest in collecting water from fog originated in South Africa between 1901 and 1904, when botanist Rudolf Marloth, attempting to measure how much fog was being collected by vegetation on Table Mountain, used rain gauges, leaving one in the open and suspending the other under reeds. In this process he discovered that the reed-hidden rain gauge collected 16 times more water than the one in the open.⁶⁴ It was not until 1969 however, that the first deliberate fog collection project took place in South Africa, producing a temporary water supply for air force personnel in the Mpumalanga region

⁶³ Ibid.

⁶⁴ J. Olivier, "Fog-water harvesting along the West Coast of South Africa: A feasibility study," *Water SA* Vol. 28, No. 4 (October 2002): 349.

over the course of a year.⁶⁵ And not until the 1980s did the pioneering development of modern fog harvesting technologies start in Chile.

It was a resourceful physics student - Carlos Espinosa Arancibia at the Catholic University of Chile in Antofagasta, who, during a severe drought in 1956, began experimenting with various prototype structures to collect water from fog in the hills around Antofagasta, one of the driest cities in Chile. It was then that he came up with the idea of Atrapanieblas - fog catchers.⁶⁶ In 1963 he patented his invention and assigned the patent to UNESCO so it could be copied free of charge.⁶⁷ To demonstrate how crucial fog was to a local biota, in 1962, he planted a cypress tree on a hill close to El Tofo, Chile, that not only sustained itself through drip rain by intercepting fog, but also supported small vegetation underneath. This cypress tree became a symbol of inspiration for the future development of harvesting water from fog in Chile.⁶⁸

Expanding on Carlos Espinosa's study, geographer and professor from Pontifical Catholic University of Chile (PUC) Pilar Cereceda began to conduct systematic scientific research on fog collection in the 1980s. In 1985, she set up the first, large-scale collection site, consisting of 50 fog catchers, along the coast, close to a small (about 330 inhabitants) desert community in Chile, called Chungungo.⁶⁹ Originally financed by Chile's National Forestry Corporation in collaboration with Canada's International Development Research Centre, the project was supposed to be a proof-of-

⁶⁵ Fessehayé, "Fog-water collection for community use," 54.

⁶⁶ Making Use – Muzeum Sztuki Nowoczesnej, "Carlos Espinosa Arancibia," accessed May 12, 2020, <https://makinguse.artmuseum.pl/en/carlos-espinosa-arancibia/>.

⁶⁷ Palais de Tokyo, "Carlos Espinosa," accessed May 12, 2020, <https://www.palaisdetokyo.com/en/event/carlos-espinosa>

⁶⁸ Christiaan Gischler, *The missing link in a production claim* (Montevideo: UNESCO, 1991), 6.

⁶⁹ Robert S. Schemenauer and Pilar Cereceda, "Fog collection's role in water planning for developing countries," *Natural Resources Forum* 18, No. 2 (1994): 94.

concept for reforestation technology for a nearby forestry plantation. However, the large quantities of water that were yielded, quickly led Cereceda to realize that it would be possible to use the fog catchers to supply water to the local community of Chungungo.⁷⁰ Prior to that, residents of Chungungo were receiving water through the auspices of the near-by El Tofo iron mine, but since its closure in the 1970s, villagers had to rely on truck delivery from over 40 km away that was irregular, costly and had water of poor quality.⁷¹ With the financial backing of the Canadian embassy, Cereceda was able to build an additional 50 fog catchers, storage tanks and piping, and in 1992, for the first time, fog water ran from taps in the homes of Chungungo.⁷² Cereceda described the significance of this moment: “With this you had water for showering, you had water for animals, you had water for everything. In this sense, Chile is very important. Because this project was very successful, people came from all over to report on it and it opened the idea to the world. They could see that this was a case where the system had worked.”⁷³ The success of the Camanchaca (“fog” in Chilean Spanish) Project provided a template for the development of many other fog-collection projects in Chile and Peru, and later in other parts of the world. In Chile, collected fog water has been used for afforestation (planting and seeding trees in areas that previously have not been forested) with native trees, gardening, agriculture,⁷⁴ as well as

⁷⁰ Nick Lavars, “How Chile’s fogcatchers are bringing water to the driest desert on Earth,” *New Atlas*, August 25, 2015, <https://newatlas.com/how-the-fogcatchers-of-the-atacama-are-bringing-water-to-the-driest-desert-on-earth/39040/>.

⁷¹ Schemenauer and Cereceda, “Fog collection’s role in water planning,” 93.

⁷² *Ibid.*, 94.

⁷³ Lavars, “How Chile’s fogcatchers are bringing water to the driest desert on Earth.”

⁷⁴ Otto Klemm et al., “Fog as a Fresh-Water Resource: Overview and Perspectives,” *Ambio* 41 (2012): 224, doi: 10.1007/s13280-012-0247-8.

for an artisanal brewery in Penã Blanca.⁷⁵ Similar, fog-collection projects in Peru include reforestation, agriculture, chicken farming,⁷⁶ as well as human consumption, especially on the outskirts of Lima.⁷⁷

7. Technology of Fog Collection

The technology of fog collection involves the process of impaction, in which small fog water droplets carried by the wind encounter an obstacle (substrate) such as a net. Upon collision with the substrate, the water droplets cluster together (coalesce). When they reach a critical size, when the water droplet's surface tension (which is holding it to the net) becomes weaker than gravity, the drop falls. The collected water droplets trickle along the fibres of the net to a collecting gutter at the bottom of the structure and flow into a sedimentation tank, and eventually to a domestic supply or irrigation system.⁷⁸

The development of fog harvesting technology has mainly been attributed to collaboration between Pilar Cereceda and atmospheric physicist Robert Schemenauer from Canada's International Research Development Centre. Together, they introduced Standard Fog Collectors (SFC) and Large Fog Collectors (LFC) that became the accepted

⁷⁵ Felipe Abreu and Luiz Felipe Silva, "Trapping humidity out of fog in Chile," *BBC News*, May 17, 2015, <https://www.bbc.com/news/world-latin-america-32515558>.

⁷⁶ Miguel Trancozo Trevino, "The ethereal art of fog-catching," *BBC Future Planet*, February 23, 2020, <https://www.bbc.com/future/article/20200221-how-fog-can-solve-water-shortage-from-climate-change-in-peru>.

⁷⁷ Anne Lummerich and Kai Tiedemann, "Fog farming: linking sustainable land management with ecological renaturation in arid areas by means of reforestation," (paper presented at *International Research on Food Security, Natural Resource Management and Rural Development Conference*, University of Hamburg, Tropentag, October 6-8, 2009), 1.

⁷⁸ Fessehaye, "Fog-water collection for community use," 57.

system of collecting water from fog, distributed by not-for-profit Canadian organization FogQuest, initiated by Schemenauer in 2000.⁷⁹ Both the SFC and LFC use a polyethylene double layer Raschel (a brand name) mesh, which is the most economically produced warp-knitted fabric, and commonly used for packaging vegetables and fruits, such as potatoes, onions or lemons (as seen in fig. 2).

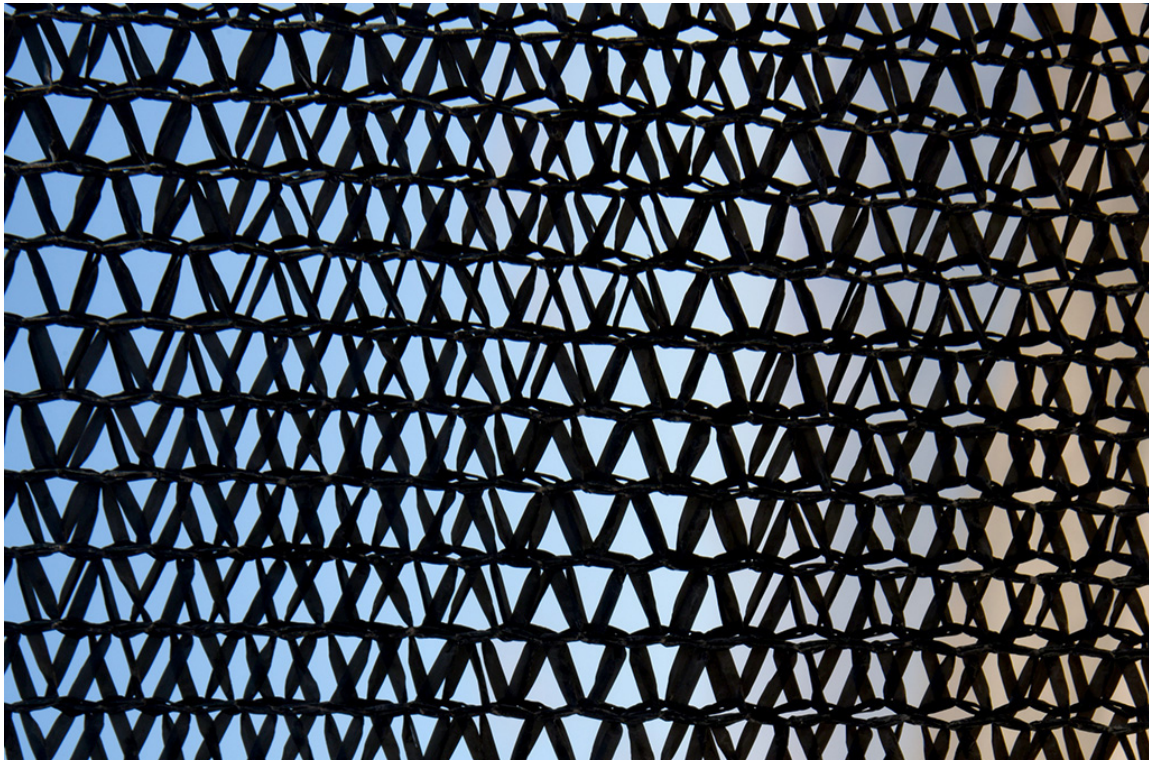


Figure 2. Example of double layer Raschel Mesh. Photo taken by Ana Rewakowicz at the Alto Patache scientific site, south of Iquique in Chile in 2018.

In the case of the SFC, this mesh is stretched on a mounted frame with an area of 1 m² placed 2 metres above the ground, where a water gutter is connected to a tipping bucket gauge and a data logger that measure collected fog water.⁸⁰ The SFC is mainly used for exploratory purposes, to determine the efficiency of fog-water collection in a

⁷⁹ Fog Quest, accessed April 22, 2020, <http://www.fogquest.org/about-fogquest/directors-volunteers/>.

⁸⁰ Fessehaye, "Fog-water collection for community use," 57.

given location. If the SFC yield is sufficient, then an LFC is installed.⁸¹ Below, I am showing an in-situ set of two LFC at the Alto Patache scientific site in Chile (fig.3).



Figure 3. Two LFCs (Large Fog Collectors) with water tanks at the Alto Patache scientific site in Chile, south the city of Iquique. © Ana Rewakowicz, 2018.

The LFCs use a large size mesh-net (ranging from $40 \text{ m}^2 = 4 \text{ m} \times 10 \text{ m}$ ⁸² to $48 \text{ m}^2 = 4 \text{ m} \times 12 \text{ m}$ ⁸³) that is stretched by cables over two vertical posts with a plastic gutter installed about 2 metres off the ground.⁸⁴ On average the LFC is capable of collecting about 6 litres of water per 1 m^2 of mesh per day,⁸⁵ but its yield fluctuates and can be as high as 75 litres per 1 m^2 per day in certain locations, such as in Cape Verde.⁸⁶

⁸¹ Ibid.

⁸² Klemm, "Fog as a Fresh-Water Resource," 222.

⁸³ Schemenauer and Cereceda, "Fog collection's role in water planning," 94.

⁸⁴ Fessehaye, "Fog-water collection for community use," 57.

⁸⁵ Klemm, "Fog as a Fresh-Water Resource," 224.

⁸⁶ Ibid., 225.

Generally higher altitudes and higher wind speeds lead to higher yields.⁸⁷

The success of SFCs and LFCs (that have spread to many parts of the world, including Ecuador, Guatemala, Morocco, Nepal, Yemen, Oman, Namibia, Croatia, South Africa and the Canary Islands)⁸⁸ has mainly been attributed to the simplicity of its design and low maintenance requirements, as well as relatively low cost and financial support of the FogQuest organization.⁸⁹ On one hand, although the LFC system is cost-effective, remote and underdeveloped communities may not be able to cover the initial infrastructure expenses and may have to rely on external investors. On the other hand, rich countries that have plenty of water are not always aware of and/or interested in investing in poor regions, from which they will gain little profit.⁹⁰ Hence, a mediator, who fills the communication gap, creates awareness of the problem, and brings conviction that this problem is solvable and worth solving, is of the essence. In this sense FogQuest has done an excellent job at providing the fog collecting technology to many water-deprived communities. In her enthusiasm and belief in the potential of fog water, Pilar Cereceda dreams of the day, in which the fog catchers could compete with the less environmentally friendly desalination plants (factories that produce potable water by removing salt from sea water), as a source of water,⁹¹ noting that “In Chile, we

⁸⁷ Fessehaye, “Fog-water collection for community use,” 58.

⁸⁸ Ibid.

⁸⁹ Domen, “Fog water as an alternative and sustainable water resource,” 242.

⁹⁰ Gloria Morichi, Lucas Bandeira Calixto and Alessandra Zanelli, “Novel Applications for Fog Water Harvesting,” *Journal of Geoscience and Environment Protection* 6 (2018): 32, doi: 10.4236/gep.2018.63004.

⁹¹ Pilar Cereceda in conversation with Ana Rewakowicz at the Alto Patache site in Chile, November 30, 2018.

aren't the true pioneers of collecting water (...), but we are pioneers in one sense, because we dared to create a project of a grand scale."⁹²

8. Technological Improvements in Fog Collection

For harvesting fog to be a viable source of water, especially in remote locations, it has to be economically feasible and require little maintenance. Passive collectors that rely on the naturally occurring process of impaction and gravity to collect water are thus ideal.⁹³ As we saw, the LFC collectors distributed by FogQuest have been accomplished at relatively large scales with reasonable efficiency and cost effectiveness, and have already had positive effects in different parts of the world. However, there is always room for improvement from multiple angles, including the technological, financial and social.

A fog collector comprises three main components: a substrate (e.g., mesh, described further in 8.1), a structure (i.e., the form upon which the mesh is stretched, described further in 8.2), and a storage facility (i.e., the container into which the water eventually drains). So, for example, in the SFC and LFC, the mesh is a polyethylene 1mm ribbon of triangular weave with pore sizes of 1.0 - 1.3 cm.⁹⁴ The structure is essentially a flat rectangle, held on each side by a vertical pole, with the lower edge of the net placed about 2 metres from the ground. The storage system is composed of a sedimentation tank and water reservoirs.

⁹² Lavars, "How Chile's fogcatchers are bringing water to the driest desert on Earth."

⁹³ Domen, "Fog water as an alternative and sustainable water resource," 242.

⁹⁴ Ibid.

8.1 The Mesh

The most widely used substrate in fog-water collection has been the double layer of Raschel-brand mesh. Proposed by Schemenauer and Cereceda as economical and durable, with the ability to resist wind and UV-radiation, the Raschel mesh has become the standard in the SFC and LFC collectors.⁹⁵ However, water droplets can fill the entire hole in grid-like nets (see fig.4) and create strong surface tension, the problem known as clogging.⁹⁶ Clogging means that water does not drain as gravity cannot overcome surface tension and water droplets do not fall, the problem known as drainage.⁹⁷

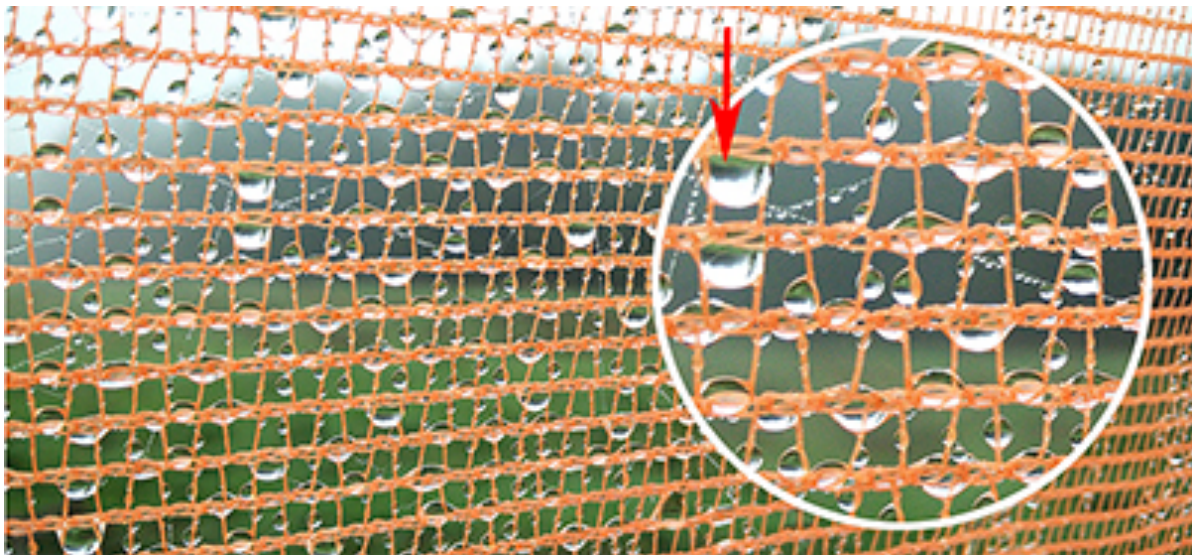


Figure 4. Image of a single layer of Raschel-type of mesh used in the Warka Water Project in Ethiopia. Circle inset shows close up of mesh. Red arrow shows an example of *clogging* in which water droplet fills hole in mesh leading to high surface tension and preventing droplet from falling into collection gutter below. Arturo Vittori, Warka Water Project, accessed from

⁹⁵ Ibid.

⁹⁶ Kyoo-Chul Park et al., "Optimal Design of Permeable Fiber Network Structures for Fog Harvesting," *Langmuir* 29 (2013): 13270, doi: 10.1021/la402409f.

⁹⁷ Ibid., 13272.

<https://lightroom.adobe.com/gallery/3040b751460a4b70bc4c79179dd1c018/albums/889f0b27c0da4833abfd4409b5532f10/assets/282a62d37d0eb81b40fd32da871fa60c>.

Another issue that reduces collection efficiency is when incoming water droplets are blown away by the wind before they are able to reach a critical size and be pulled by gravity along the net to the collecting gutter,⁹⁸ a problem known as *re-entrainment*. To deal with these problems, there have been various attempts to develop new types of meshes that could eliminate clogging, improve drainage and overall increase efficiency of fog water collection. Often, the human-designed meshes have taken inspiration from nature, demonstrating both the importance and limitation of biomimicry for developing novel solutions. Below, I focus on two such examples, MIT-14 and FogHa-Tin meshes, comparing them with the Raschel mesh. Finally I describe a patented system (that uses the FogHa-Tin mesh) called CloudFisher™.

MIT-14 mesh was developed from research conducted at the Massachusetts Institute of Technology (MIT), where mechanical engineering professor Gareth McKinley and chemical engineering professor Robert Cohen produced a fine (hole spacing in the size of 0.051 inch) stainless steel mesh with thin (0.02 inch in diameter) wires,⁹⁹ with a hydrophobic (water repelling) coating (POSS-PEMA) coating,¹⁰⁰ inspired by a beetle from the Namib Desert. The beetle uses a combination of hydrophilic (water loving) bumps on its back to pull moisture from the air with hydrophobic lining to channel the collected drops directly into the beetle's mouth.¹⁰¹ The coating enhances

⁹⁸ Ibid.

⁹⁹ Daniel M. Fernandez et al., "Fog Water Collection Effectiveness: Mesh Intercomparisons," *Aerosol and Air Quality Research* 18 (2018): 273, doi: 10.4209/aaqr.2017.01.0040.

¹⁰⁰ Ibid.

¹⁰¹ Domen, "Fog water as an alternative and sustainable water resource," 236.

the draining capability of their fine mesh, which would otherwise tend to suffer from clogging.

A second novel mesh type, FogHa-Tin Mesh, took inspiration from the South African *Cotula Fallax* plant that collects and channels fog water to its stem using leaves with enhanced surface area created by tiny hairs in a mat-like structure.¹⁰² Created by the Institute of Textile Technology and Process Engineering in Denkendorf, Germany, the FogHa-Tin mesh is a manufactured 3D textile composed of two outer layers of fabric connected by an internal layer of thread, forming a 3-dimensional framework, known as spacer fabric (fig. 5). This material is used for cushioning in car seat padding, for vibration reduction or as breathable panels in apparel.¹⁰³

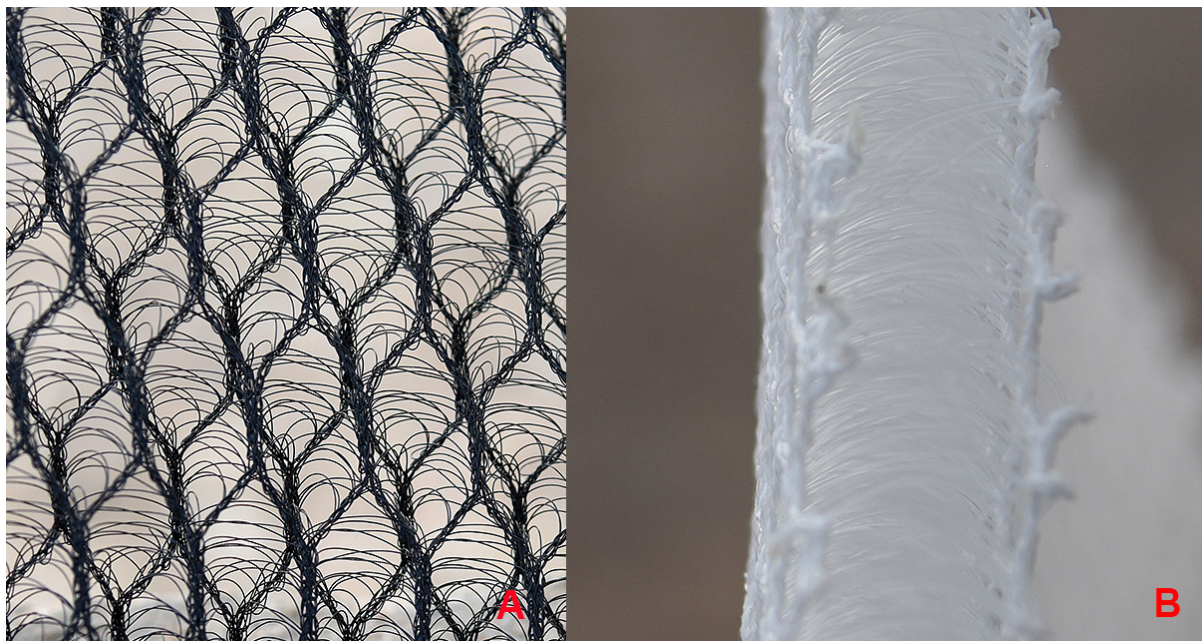


Figure 5. Examples of spacer fabric. A. Frontal view of spacer fabric used in the CloudFisher™ system, showing one outer layer of the fabric (dark) with threads from internal layer (grey) visible within the gaps of the outer layer. B. Cross-sectional view

¹⁰² H.G. Andrews et al., "Three-Dimensional Hierarchical Structures for Fog Harvesting," *Langmuir* 27 (2011): 3799, doi: /10.1021/la2000014.

¹⁰³ David J Spencer, *Knitting Technology* (Abington: Woodhead Publishing Limited, 2001), 429.

showing of in between internal layer of thread between two outer layers. © Ana Rewakowicz, 2018.

In field investigations, Daniel M. Fernandez from the School of Natural Sciences in Monterey Bay, California and colleagues compared the MIT-14 and FogHa-Tin meshes with the Raschel mesh for their water collecting efficiency. Over three summer fog seasons (2014–2016), they collected recordings at 15-minute intervals.¹⁰⁴ According to their findings the meshes performed differently in different conditions, with each mesh showing an advantage in specific situations. Although the study mainly focused on wind speed and direction, it also pointed to additional factors affecting collection efficiency, such as a droplet size, fog density, intensity and chemical composition of the particles leading to droplet condensation,¹⁰⁵ as well as the issue of practicality and cost.

In general, the MIT-14 mesh appeared to outperform other meshes.¹⁰⁶ It had a quicker initial response, meaning that the MIT-14 mesh started to collect water before other meshes did,¹⁰⁷ and over all it collected more, especially in higher winds, perhaps due to its rigidity of its metallic screen.¹⁰⁸ Nonetheless, the better performance of the MIT-14 mesh comes at significant cost. Fernandez and colleagues noted that the stainless steel mesh could cost up to a hundred dollars more per square metre than the Raschel mesh.¹⁰⁹ Also, the increase in weight could substantially contribute to shipping

¹⁰⁴ Fernandez, "Fog Water Collection Effectiveness," 270.

¹⁰⁵ Condensation of water drops happens only in the presence of small particles, also called aerosols, without which water cannot condense.

¹⁰⁶ Fernandez, "Fog Water Collection Effectiveness," 281.

¹⁰⁷ *Ibid.*.

¹⁰⁸ *Ibid.*, 274.

¹⁰⁹ *Ibid.*, 281.

expenses, as well as difficulties in deploying it in large fog collectors.¹¹⁰ Similarly, the FogHa-Tin mesh collected more water and displayed a great resilience to high winds compared to the Raschel mesh, but its cost is about fifteen times higher.¹¹¹ In contrast, the Raschel mesh surpassed MIT-14, as well as FogHa-Tin at a lower wind speed (less than 2m per second¹¹²), suggesting strong wind-speed dependence.¹¹³ And while the MIT-14 mesh has not been commercialized, the FogHa-Tin mesh has been. Thus, the choice between meshes always involved considering the requirements of the specific installation.

In 2013, recognizing the Raschel mesh's inability to withstand high winds, the German Water Foundation began working with industrial designer and engineer Peter Trautwein and a team of researchers to devise a more robust and more efficient fog-harvesting system.¹¹⁴ For three years (2013 – 2016) Trautwein conducted investigations on Mount Boutmezguida in Morocco, working in collaboration with the not-for-profit organization Dar Si Hmad, testing the performance of available meshes.¹¹⁵ Based on his extensive research, Trautwein developed the CloudFisher™ system, which is a registered trademark of WasserStiftung®, a water foundation based in Munich, Germany.¹¹⁶ The novelty of the CloudFisher™ system was in combining work on the mesh with consideration of the structure upon which the mesh rested. The system

¹¹⁰ Ibid., 282.

¹¹¹ Ibid.

¹¹² Ibid., 275.

¹¹³ Ibid., 278.

¹¹⁴ Catherine Jewell, "Pioneering fog-harvesting technology helps relieve water shortage in arid regions," *Wipo Magazine* 3 (June 2018): 16, https://www.wipo.int/wipo_magazine/en/2018/03/article_0003.html.

¹¹⁵ Christian Schunk et al., "Testing Water Yield, Efficiency of Different Meshes and Water Quality with a Novel Fog Collector for High Wind Speeds," *Aerosol and Air Quality Research*, 18 (2018): 240, doi: 10.4209/aaqr.2016.12.0528.

¹¹⁶ "CloudFisher," accessed April 20, 2020, <https://www.aqualonis.com/>

consists of a 3D mesh structure supported by a sturdy plastic grid mounted on the leeward side of the net and held inside a steel frame by a series of rubber expanders attached to the collector frame (shown in fig.6).



Figure 6. Details of the CloudFisher™ system installed on Mount Boutmezguida, Morocco. Left image, a sturdy plastic grid (large equilateral triangles) is visible on leeward side with diamond/hexagonal mesh (thinner smaller fibres) visible behind the plastic grid. One of the rubber expanders can be seen connecting the plastic grid to the steel frame (vertical structure at left edge of photo). Right image, rubber bands support a collecting gutter (black) between the plastic grid and the steel frame. © Ana Rewakowicz, 2017.

All collecting materials (grid, mesh, gutter and rubbers) are UV-resistant and made from food-grade polyethylene.¹¹⁷ According to Trautwein, the rubber expanders connecting

¹¹⁷ Martina Mayerhofer and Thomas Loster, eds., "Fog net technology 2.0," *Into Action 5*, (Munich: Re Foundation, 2015): 16.

the nets (grid plus mesh) to the frame stabilize them even in winds up to 120 km/h,¹¹⁸ while allowing collection of up to 23 litres per 1 m² per day.¹¹⁹ In 2017, fifteen large-scale collectors (made up of 4 panels each) were installed on Mount Boutmezguida in Morocco in collaboration with Dar Si Hmad (fig.7),¹²⁰ followed by an additional fifteen collectors in 2018, making it the largest fog-harvesting site in the world, with 1682 m² of collecting surface capable of producing up to 37,000 litres of water per day.¹²¹ However, the cost of the CloudFisher™ system on Mount Boutmezguida, excluding construction costs (transport, labour) and infrastructure (piping, storage, filtration), was about 20,000 euros,¹²² potentially a high barrier for many communities.



¹¹⁸ Jewell, "Pioneering fog-harvesting technology helps relieve water shortage in arid regions," 19.

¹¹⁹ "CloudFisher," accessed April 20, 2020, <https://www.aqualonis.com/>

¹²⁰ Jewell, "Pioneering fog-harvesting technology helps relieve water shortage in arid regions," 20.

¹²¹ Calculations based on Dar Si Hmad technical report from 2019, received from Jamila Bargach, May 5, 2020.

¹²² Calculations based on the price list provided on the CloudFisher website, accessed April 20, 2020, <https://www.aqualonis.com/>.

Figure 7. View of CloudFisher™ collectors (phase 1) installed on Mount Boutmezguida, Morocco. © Ana Rewakowicz, 2017.

8.2 Structure

Since wind is an essential factor in the fog water collection process, in addition to considering specific mesh types, it is clear that another essential element for enhancing water collection would be the shape and positioning of collecting structures. Regardless of the type of mesh, most currently used large-scale fog collectors are designed to be placed perpendicular to the direction of the prevailing wind and to work in only one plane. Hence, we could say that they do not exploit wind's multi-directionality and are not aerodynamically optimized. Newer fog collectors attempt to address the issue of the wind direction variability, but have not yet been implemented on a large scale. I describe 3 such structural designs: the octahedron-based Macro-Diamond structure, several multi-layered experimental collectors and vase-shaped collector used in Ethiopia.

Carlos Espinoza Arancibia, the pioneer of fog collection in Chile, was also the first to explore the idea of three-dimensional collectors that could take advantage of multi-dimensionality of wind by using a structure with multiple planes that could guide the wind differently, thus increasing the amount of water collected. His design involved octahedral (two square-based pyramids joined at the base) and tetrahedral (a triangle-based pyramid) units (named Macro-Diamonds) made from bronze anti-corrosive bars,¹²³ partially covered with mosquito-like nylon netting able to collect small water

¹²³ Gischler, *The missing link in a production claim*, 80.

droplets.¹²⁴ These modular units could expand in any direction, similar to LEGO, depending on a need (see images available on

<https://makinguse.artmuseum.pl/en/carlos-espinoza-arancibia/>).¹²⁵

The idea was that by leaving certain sections of this 3D skeleton uncovered by netting, the structure would not become a wind barrier and allow the moist air to zigzag through it, sweeping heavier water droplets against the netting.¹²⁶ Macro-Diamonds could not only be arranged in different formations, but were also intended to serve as a temporary dwelling and a portable self-supporting experimental science station.¹²⁷ Being mobile, they were also envisioned as drip rain producing apparatuses that could sustain reforestation and agriculture.¹²⁸ Practically however, Macro-Diamonds were too costly and unstable to be left without any anchorage in the soil, contrary to their initial portable intent.¹²⁹ In addition, it was observed that while the three-dimensional structures were efficient for stagnant cloud masses due to their spatial drainage capacity, in wind two-dimensional collectors yielded more water better.¹³⁰ As a result, the LFC collectors became dominant in Chile, and with time, in other parts of the world.

The second example of three-dimensional fog collectors comprise three experimental fog catchers built by two German conservationists *Anne Lummerich* and *Kai Tiedemann* in Peru.¹³¹ From 2007-2008, they constructed three kinds of fog

¹²⁴ *Ibid.*, 10.

¹²⁵ *Ibid.*, 27.

¹²⁶ *Ibid.*, 87.

¹²⁷ *Ibid.*, 85.

¹²⁸ *Ibid.*, 85.

¹²⁹ *Ibid.*, 87.

¹³⁰ *Ibid.*, 112.

¹³¹ Domen, "Fog water as an alternative and sustainable water resource," 242.

collectors, *Eiffel*, *Harp* and *Diagonal Harp* and compared them with the LFC. The *Eiffel* collector had the same frame dimensions as the LFC (8 m x 4 m = 32 m²) and comprised two double layers of Raschel mesh fastened to two sides of a metal truss with a 30-centimetre gap between two layers. Ten additional strips of mesh were installed diagonally in the gap, forming a three-dimensional structure capable of intercepting wind from all directions.¹³² The *Harp* collector had a similar structure but a smaller frame (4 m x 2 m = 8 m²) and a net composed of 2,256 m of 1.5 mm rubber strings attached vertically on both sides of the metal truss, while the *Diagonal Harp* collector used 1,520 m of 1.5 mm rubber strings stretched diagonally.² According to *Lummerich* and *Tiedemann's* records, the *Eiffel* fog collector was able to harvest an average of 281.2 litres per day, which was substantially higher than the LFC of the same surface, which yielded an average of 28.7 litres per day.¹³³ Water yields from the *Harp* and *Diagonal Harp* collectors were smaller, but still at least twice as large as the LFC even with the smaller surface area.¹³⁴ Despite the fact that the *Harp* collector had the highest surface-water yield ratio, meaning that water collection was the highest when taking into account the surface area, the *Eiffel* collector was preferred due to its design simplicity, reproducibility and robustness.¹³⁵

The final example of a three-dimensional structure used in fog water collection is the Warka Water Project structure being used in a community-based initiative in Ethiopia. The project was named after the Warka Tree (a giant wild fig tree) that in Dorze culture plays a crucial role as a meeting place, providing shade and relief from

¹³² Ibid.

¹³³ Lummerich and Tiedemann, "Fog farming," 3.

¹³⁴ Ibid.

¹³⁵ Ibid.

the sun and heat, as well as supplying fruits.¹³⁶ The structure was developed by Italian industrial designer Arturo Vittori and Swiss architect, designer and artist Andreas Vogler. In collaboration with the Dorze people, they designed 30-foot tall vase-shaped (Warka Water version 1 – fig. 8) and tower-shaped (Warka Water versions 2-5 – fig. 9) prototypes,¹³⁷ using locally available bamboo for the structure and a single layer of Raschel mesh, capable of capturing water from rain, fog and dew, and draining it into a container at the bottom of the structure.¹³⁸ The Warka Towers can yield between 50 and 100 litres per day, becoming an essential water source for the local community,¹³⁹ although Vittori recounts how significant it was that the villagers accepted and took ownership of the project and how creating a link with the fig tree made a difference, allowing villagers to adopt this new structure and express their acceptance by dancing around the Warka Tower, unlike they would dance around the fig tree.¹⁴⁰

¹³⁶ Warka Project, accessed April 30, 2020, <https://www.warkawater.org/>.

¹³⁷ “Warka water towers collect clean drinking water from the ‘lakes in the air’,” Design Boom, accessed April 30, 2020, <https://www.designboom.com/architecture/warka-water-tower-bamboo-sustainable-clean-drinking-water-air-02-15-2019/>.

¹³⁸ Warka Water, accessed April 30, 2020, <http://www.warkawater.org/ethiopia/>.

¹³⁹ Ibid.

¹⁴⁰ Arturo Vittori, “Warka Water: An idea to feed the world,” TEDx Talks, August 25, 2015, video, 18:44, <https://www.youtube.com/watch?v=41mLIEoo6D4>.



Figure 8. Prototype of the vase-shaped Warka Water version 1, showing a bamboo structure supporting a single layer of Raschel mesh (orange), as presented at MAXXI (national museum of contemporary art and architecture) in Rome, Italy in 2014. © Ana Rewakowicz, 2014.



Figure 9. Prototype of a tower-shaped Warka Water version 2. © Arturo Vittori, accessed from <https://lightroom.adobe.com/gallery/3040b751460a4b70bc4c79179dd1c018/albums/889f0b27c0da4833abfd4409b5532f10/assets/f67e6caf28236b5018a66b90d2a233dd>.

Thus, the initial attempts to develop 3D structures (Macro-Diamonds) by Chilean pioneer Carlos Espinoza Arancibia were not easily adopted, as they did not prove to be cost-efficient, giving way to the essentially 2D LFCs distributed by FogQuest. In contrast, while the experimental collectors in Peru and the Water Warka project in Ethiopia serve as effective examples of community-based projects, their shape and performance have not been optimized. Thus, further research into cost-efficient adoptable 3D structures with higher efficiencies is required.

9. Research Problems and Focus

We are facing an increasing water crisis, and one of the untapped sources of potable water is humidity in the air that is in particular pertinent in arid areas, where other water sources, such as rivers, lakes or underground water (aquifers) are either non-existent or not easily accessible. In regions where fog events are frequent, it is possible to collect water from fog. Organisms, such as plants and animals, naturally extract water from the air, and through observation, humans have applied this knowledge to extract water from the air on a small scale. The development of modern fog collectors, however, only began in the 1980s. Since then, fog collectors have been successfully implemented on a larger scale, substantially contributing to improved access to water in rural, remote communities. But technologically and practically, there is much room for advancement. Hence research into better technology and implementation is of great significance.

The current research has focused on two essential aspects involved in the process of fog water collection, the mesh substrate and the structure that supports the mesh. Regarding the efficiency of the mesh our aim was to address the problems of

clogging, drainage and re-entrainment experienced in harvesting water from fog. We started with recognition that Raschel mesh was not optimal. However, in contrast to already existing developments, such as the chemically coated wire (MIT-14) and 3D (FogHa-Tin) meshes, both quite costly to produce, we wanted to work with easily available materials such as regular thread and take into consideration economic aspects of fog collection technology and the fact that it has to serve people in remote areas with little financial means. To do that, we focused on the physical properties of thread and observed how they wet and deform in interaction with water. Our novel insight, in relation to existing meshes was a new paradigm of flexible parallel vertical fibres instead of grids. It is worthwhile mentioning that even though the MIT-14 and FogHa-Tin meshes produce higher yields (especially in higher winds) compared with Raschel mesh, they do not directly address the problems of clogging, drainage and re-entrainment. Thus, our approach fills this gap. In addition, we wanted to avoid chemically enhanced materials like MIT-14, as such materials would require supplementary studies to understand the effects of their chemical composition on the quality of potable water.

The second aspect of our research addressed the aerodynamics of the collecting structures. Our studies proposed new types of structures arising from the concept of flexible parallel vertical fibres and looked at how such constructions might maximize water yield. In our investigations we explored structures based on the ideas of a forest and a sail. The forest idea examined the notion of multiple-layers that would deal with the problem of re-entrainment (when water droplets are blown away by the wind before reaching the critical size needed to be pulled down by gravity), by creating a structure in which the droplets can be re-captured by another layer of threads. In

thinking about sails, our approach derives from the idea of ‘going with the wind’ rather than ‘against the wind.’ It is well known that a sailing boat goes faster when its sail is not positioned perpendicular (90 degrees) to the wind,¹⁴¹ and it is best to sail off-wind, which means sailing with the wind coming at an angle of 40 degrees or less.¹⁴² With this in mind and using the concept of flexible parallel vertical fibres, I created a prototype of a porous sail, which I describe in detail in chapter 4.

Furthermore, it is essential to emphasize that these scientific questions about maximizing the efficiency of water extraction from fog have been explored through an art and science collaboration, which has not only resulted in scientific discoveries and publications (e.g., Rewakowicz, Chomaz and Duprat’s paper in the book proceedings of the 7th International Conference on Fog, Fog Collection and Dew conference in 2016,¹⁴³ as well as Labbé and Duprat’s paper in *Soft Matter* journal in 2019¹⁴⁴) but also in the creation of multiple artworks. In addition, our art and science collaboration can serve as an example of inter/trans/disciplinary collaboration that has aimed at blurring disciplinary boundaries and developing a collaborative problem solving methodology, which has expanded the scientific question of efficiency and opened the door to new questions of ethics and action. Discussion about these directions is presented in chapters 5 and 6.

¹⁴¹ Gischler, *The missing link in a production claim*, 178-179.

¹⁴² Molika Ashford, “How Do Sailboats Sail into the Wind?,” *Live Science*, September 29, 2010, <https://www.livescience.com/32822-sailboats-sailing-windward-not-impossible.html>.

¹⁴³ Ana Rewakowicz, Jean-Marc Chomaz and Camille Duprat, “Mist Collector: Art and Science project,” in *Proceedings of 7th International Conference on Fog, Fog Collection and Dew, Wroclaw, Poland, July 24-29, 2016*, eds. Marek Blas and Mieczyslaw Sobik (Wroclaw: University of Wroclaw, 2016), 129-132.

¹⁴⁴ Romain Labbé and Camille Duprat, “Capturing aerosol droplets with fibers,” *Soft Matter* 15 (2019): 6946-6951, doi: 10.1039/C9SM01205B.

10. Summary

As noted, due to the excessive exploitation of water sources, including privatization, monopolization, mono-agriculture, population growth, as well as climate change, we are facing a rising problem of water shortage in the world, especially in the arid and semi-arid areas where water sources are already scarce. Under these circumstances research into alternative fresh water sources that do not require a great amount of energy is crucial and of great consequence (1). Looking at the water cycle (2), we can see that one possible alternative is the collection of atmospheric water (hydrometeors) from rain, dew and fog (3). While water harvesting from rain and dew are not insignificant, the current research examines fog, focusing on advection and upslope fogs that are especially conducive to harvesting water as they incorporate air movement (4). There is evidence that people took advantage of the naturally occurring phenomenon of drip rain produced by trees as they intercept water in fog clouds, and collected fog water especially in parts of the world where fog is the only available source of water (5). Despite the fact that fog water collection has a long history, modern fog collectors are relatively new, only implemented on a large-scale in Chile in the 1980s (6). Technology of collecting water from fog relies on impaction and involves three main elements: substrate, structure and storage. When the wind brings small water droplets suspended in the air (fog cloud) onto a mesh-net (substrate), usually placed perpendicular to the prevailing wind, water droplets cluster, grow bigger and are brought down into a collecting gutter by gravity (7). The apparatus (substrate, structure) used to collect water has a large effect on the yield, which can be enhanced through mesh or structural improvements. Recent mesh advancements improved efficiency but were expensive, while recent structural improvements remain not

optimized (8). In contrast, through the understanding of the physical properties of fibres, our research proposed a new paradigm of flexible parallel vertical fibres (rather than grids), which may be more efficient and less expensive and not require chemical enhancement. We also propose novel 3D collecting structures that take advantage of our forest of parallel vertical fibres (9). Through collaboration we address critical scientific questions regarding water collection efficiency while creating novel artworks. The collaboration has also brought forward new questions of ethics and action so needed when facing environmental challenges like water scarcity (9). Now that we understand the scope of the problem, next I will briefly describe my artistic trajectory that brought me to these problems (chapter 2) before turning to some of the solutions we discovered.

Chapter 2

Art: Encountering Clouds

Chapter 2 describes the artistic path that led me to work on the problem of water shortage and to conduct research on the collection of water from fog at the Hydrodynamics Laboratory (LadHyx) at École Polytechnique in Paris. One could say that it is the story of an encounter with clouds through touch. In contrast to chapter 1 that deals with a scientific account of the problem and available solutions, presented in the third person narrative voice, this chapter is written in the first person narrative voice as a participant meandering through memories, reflections, as well as narration through artworks and events.

Little Fluffy Clouds by The Orb (1990 single) is playing in the background.

Ever since my first airplane flight and seeing clouds from above, I could imagine myself spending my entire life in the clouds. I did not want to land, I just wanted to stay in the sky. For a period of more than 10 years I obsessively recorded clouds from planes, first with a super 8 camera (I liked the blurriness and grainy black and white feel of the image), then with video cameras and finally with smart phones. I have accumulated hours upon hours of cloud footage, some still unwatched, like the super 8 films waiting for the day that I get a hold of a super 8 projector, which I have not done yet. Still, it was not enough to simply look at the clouds from afar, I needed to zoom in, to get closer, so close that I could touch them.

That happened in 2017, when I was visiting the fog-collecting site on Mount

Boutmezguida in Morocco (fig.10). For the first time in my life, I was able to extend my hand and feel a gentle and intangible presence moving through my fingers, uncatchable and yet all embracing. Before that moment I was not aware that fog is a cloud and that it would be possible to touch clouds from the ground. And there I was, not on a plane looking at them from a distance, but on a mountain, enshrouded in the invisible milkiness inside a cloud. This intimate sensation gave rise to the feeling of quietude and stillness. For a change, it was not me, moving around and running to get things done... I was at rest, blinded by whiteness, able to touch and was being tenderly touched back, ever so slightly, almost ghost like. I was in the clouds, among many small water droplets suspended in the air that were moved by the wind going and coming from somewhere.



Figure 10. Fog clouds on Mount Boutmezguida, Morocco, 2017. © Ana Rewakowicz.

Mobility has been the story of my life. I was born in northern Poland, where the

skies were full of colours, red, pink, yellow and purple and the clouds were on fire, especially in the summers. I migrated to Canada via Italy, and as an artist I have moved and lived in many places, countries, languages and cultures. I was surprised to discover that the colour of the sky in Toronto, Canada was the same as in Rome, Italy, as there is only a 1.5 degree difference in latitude between them. In contrast, I was born 10 degrees further north and the skies there were different, the light and colours were different and sunsets lasted forever.

This trajectory of moving or being moved by circumstance has instilled in me a sense of impermanence and fluidity that have been present in my art practice since its inception. For many years, I *breathed* air into mobile structures that questioned our relationship with the body and the environment in the context of nomadic architecture. In contrast to the stable mass of monumental sculpture and architecture, my costumes and objects were air-filled, mobile and concerned with the places and people that activated them. Visionary ideas of architectural groups from the 1960s, and in particular the British architectural group Archigram, who combined playful design with technological fascination to develop socially responsive forms and create alternative propositions for living, were the inspiration for my art production during this time. Stimulated by their concept of 'clothing for living in' I created a series of dresses entitled *Dressware* that through inflation changed function, enabling survival in different habitats (land, air, water) and played with the phrase 'you never know wear.' For example the *SleepingBagDress* prototype is a kimono-type dress that when inflated transforms into a shelter for sleeping in (figs. 11 - 12). Similarly, upon inflation *Parachute Dress* converts into a parachute and *Lifesaving Dress* morphs into a life preserver able to float on water.



Figure 11. Ana Rewakowicz, *SleepingBagDress Prototype*, 2004, in its pre-inflated dress form.

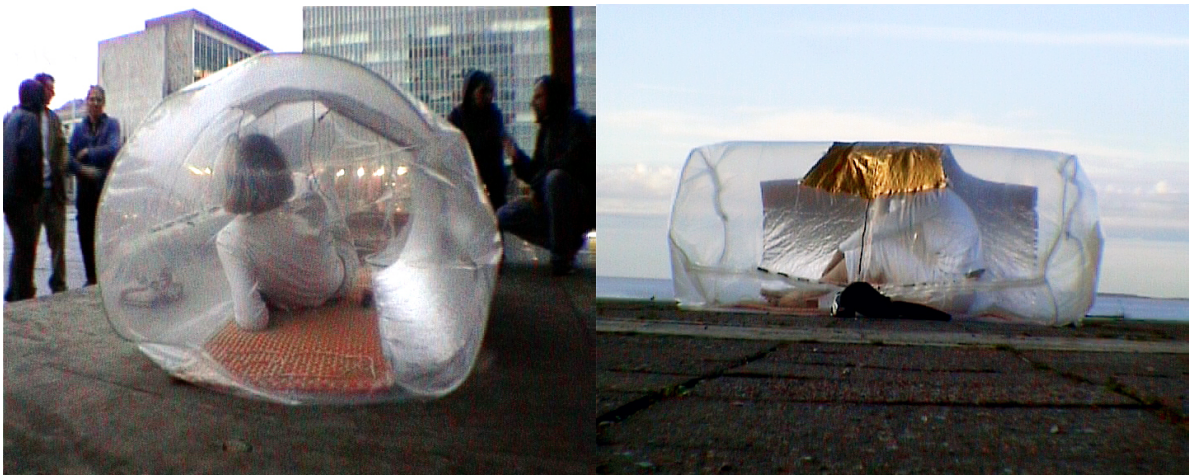


Figure 12. Ana Rewakowicz, *SleepingBagDress Prototype*, Brussels, Belgium (left) and Tallinn, Estonia (right), 2004, in its inflated sleeping shelter form.

In another piece, together with students from the Department of Mechanical Engineering at McGill University in Montreal, I developed a solar bicycle prototype for

urban commuting and dwelling. In Pori, Finland, I installed a greenhouse full of domestic plants on the roof of the Rosenlew Machine Factory to purify air exiting from one of the factory vents (fig. 13), and in my *Life Support System (LSS)* piece I produced a participatory hydroponics installation where visitors/participants were able to ‘donate’ their breath (CO₂) to plants to help them grow (figs. 14 – 15).



Figure 13. Ana Rewakowicz, *Air Cleanser*, 2008, 24h intervention, in which an inflated dome contained plants that filtered the air coming from a vent on the roof of the Rosenlew Machine Factory, Pori, Finland.



Figure 14. Ana Rewakowicz, *Life Support System (LSS)*, 2015, installation, B312 Gallery, Montreal, Quebec, Canada. Suspended inflatable oval spheres, each containing edible plants, were connected to a water supply with nutrients (black box on floor).

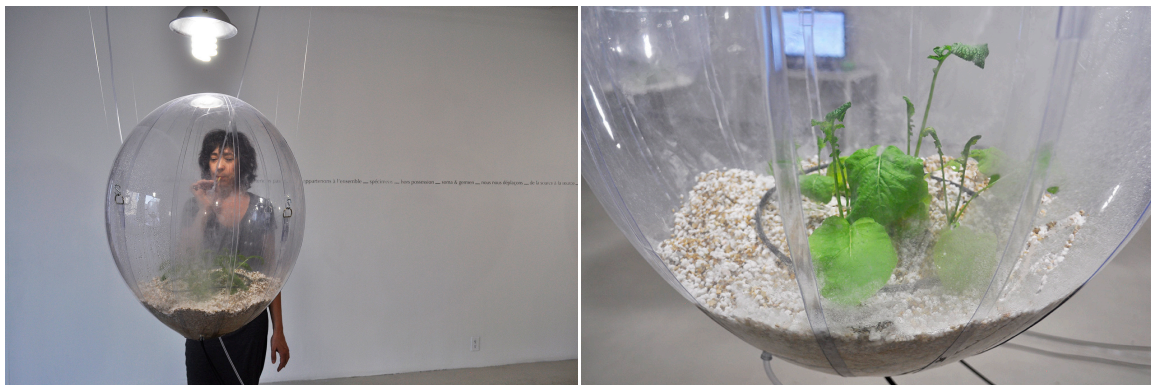


Figure 15. Ana Rewakowicz, *Life Support System (LSS)*, 2015, installation, B312 Gallery, Montreal, Quebec, Canada. Each bubble had a small tube through which participants/viewers were invited to donate their breath to help sustain the plants.

Striving for integrity of processes, materials and ideas, and inspired by American

thinker Buckminster Fuller's concept of *Synergetics*,¹⁴⁵ which is a system of thinking that encompasses a multi-faceted approach towards life and design, I worked through and with different materials. I used rubber latex as a material that resembles skin—the largest organ of our body through which we experience the sense of touch. I was obsessed with touch, as “so much happens in a touch: an infinity of others—other beings, other spaces, other times—are aroused.”¹⁴⁶ In my case it was the texture of goosebumps, the involuntary reaction of the skin capable of both connecting us with the environment and expressing inner sensations of excitement (arousal/attraction) or a state of shock (fear/discomfort/cold). Using rubber latex with a goosebump-like texture, I created a body-size mattress, a series of clothing as a second skin and the *Come Closer* installation in which I covered an entire room (walls and ceiling) in the texture of goosebumps as shown in the detail below (fig. 16).

¹⁴⁵ “Synergetics is a coordinate system that attempts to show how nature operates (its ‘operational mathematics’). It employs geometry and topology to measure all information regarding our experiences, both physical and metaphysical, and it represents an interrelationship between parts and whole.” Ana Rewakowicz, “Blowing the Ruled,” trans. Hélène Wilkinson, in *Objects mathématiques*, eds. Cédric Villani and Jean-Philippe Uzan (Paris: CNRS Éditions, 217), 169.

¹⁴⁶ Karen Barad, “On Touching—The Inhuman That Therefore I am (v 1.1),” in *The Politics of Materiality*, eds. Susanne Witzgall & Kerstin Stakemeier (Berlin: Diaphanes, 2014), 153.



Figure 16. Ana Rewakowicz, *Come Closer*, 1998, installation, Abandoned Social Housing Building, Montreal, Quebec, Canada. Installation detail: the corner of a room covered with a goosebump-like texture illuminated by a nightlight.

The body is our first house and home simultaneously, defining the boundary of the inside and outside and navigating in between them in an ongoing and never-ending relationship. The body sends and receives signals, it responds, reacts, does, makes, creates and changes until it ceases to separate and dissolves into the ‘nothingness’ of an inside-out-ness. But before that, it establishes home “at the heart of the real,”¹⁴⁷ not as a thing or a place but as doing, “a practice or a set of practices,”¹⁴⁸ where “everyone has

¹⁴⁷ Mircea Eliade, *Cosmos and History, The Myth of the Eternal Return*, trans. Willard R. Trask (Princeton: Princeton University Press, 1954), 95, quoted in John Berger, *And our Faces, My Heart, Brief as Photos* (London: Bloomsbury, 2005): 55. Kindle.

¹⁴⁸ John Berger, *And our Faces, My Heart, Brief as Photos* (London: Bloomsbury, 2005), 64. Kindle.

its own."¹⁴⁹ Home is "the untold story of a life being lived,"¹⁵⁰ says art critic and writer John Berger, and home starts with the body.

Growing up in Communist Poland with older parents that were at the age of my cohort's grandparents, who themselves were survivors of World War II, being imprisoned and deported from their own land and culture, my body became a living memory of my parents' stories, engaged in the practice of *survival*. My art took me on explorations of habitat and sustainability, understood as an ethical response-ability to provide the basic needs of shelter, food and water. If what holds home together is memory,¹⁵¹ then the path of (un)doing one's memories is about (un)doing one's body.

I started with a representation of the body caught in the performance of lying on a wet paint-covered canvas and letting the clothes absorb the paint to create imprints of the body, turning in increments from front to back, as depicted in fig. 17.

¹⁴⁹ Ibid.

¹⁵⁰ Ibid.

¹⁵¹ Ibid.



Figure 17. Ana Rewakowicz, *Untitled*, 1992, installation, YMCA (Young Men's Christian Association), Toronto, Canada. Installation in the swimming pool of YMCA with six body imprints capturing the body turning from back (right) to front (left), transferred onto cotton fabric and installed in windows as curtains, billowing in circulating air coming out of vents below.

However, dissatisfied I moved on to dissolving the boundaries between the inside and outside of the body and took an imprint of a space/room from the Montreal apartment, in which I used to live. For a period of three weeks I covered the ceiling, walls and floor in many coats of rubber latex in order to build up the desired thickness of latex. When finished, I peeled off the entire surface of transportable *skin* of the interior of the room containing original mouldings, cracks and other remains like dirt or hair...memories of lived experiences and turned it inside out (what used to be a negative impression – a mould, became a reverse impression – a cast, fig. 18). Later, I constructed outside layers and connected them to the skin of the room so the whole

structure could inflate or deflate as desired. The *Inside Out* room created a two-fold viewing situation allowing the visitor/participant to look at the exterior structure of a *room within a room* (fig. 19), as well as to enter into it to experience touchable memories of the whimsical and unsettling space inside out (fig.20).



Figure 18. Ana Rewakowicz, *Inside Out*, 2001, installation, details of ceiling (left) and doorknob (right), La Chambre Blanche Gallery, Quebec City, Quebec, Canada. I painted a room with layers of rubber latex, peeled the latex off and turned it inside out, i.e., a negative impression (a mould) became a reverse impression (a cast), then constructed an outside support structure to inflate the room, resulting in a latex imprint of the interior (ceiling, walls, floor) of the room including fixtures, cracks, and even dirt and hair.



Figure 19. Ana Rewakowicz, *Inside Out*, 2001, installation, Saidye Bronfman Centre, Montreal, Quebec, Canada. External support structure needed for the room's inflation.



Figure 20. Ana Rewakowicz, *Inside Out*, 2001, installation, La Chambre Blanche Gallery, Quebec City, Quebec, Canada. Viewer/participant enters the inflated room that contains impressions of the original room.

I took my portable body-house, inflatable room-like *skin* on a cross-Canada trip, during which I ‘camped’ in it at different urban (local parks, underground parking areas, private and public backyards, unoccupied buildings, street corners) and rural (parks, campsites, abandoned villages, ‘no man’s land’¹⁵²) locations as shown in a few video stills (fig. 21).



Figure 21. Ana Rewakowicz, *Travelling with My Inflatable Room*, 2005, video. Four stills from the video depict the inflated room on a pier in North Bay, at a campsite in Dinosaur Provincial Park (north of Medicine Hat, Alberta), by a lake in Alberta, and in front of the Kamloops Art Gallery in Kamloops.

¹⁵² The “no man’s land” term originates from feudalism and refers to a disputed territory involved in a legal battle between fiefdoms, which were hereditary property or rights given to a vassal by overlord. Joseph E. Persico, *Eleventh Month, Eleventh Day, Eleventh Hour: Armistice Day, 1918 World War I and Its Violent Climax* (New York: Penguin Random House, 2005), 68.

John Berger says that migration “does not only involve leaving behind, crossing water, living amongst strangers, but, also, undoing the very meaning of the world and—at its most extreme—abandoning oneself to the unreal which is the absurd.”¹⁵³ And what could be more absurd than traveling with the most unpractical tent, one that involves getting up every two hours to re-inflate so it would not collapse and suffocate me. I was wondering if personal memories could be lost in the vastness of a foreign landscape or undone in bodily vulnerabilities but I did not find the answer.

To understand the idea of migration and nomadism, I went to Mongolia and discovered a fundamental difference between a ‘modern day nomad’ and a culturally nomadic people. For nomadic people, ‘a sense of place’ embeds both knowledge and understanding of the local environment through a deep connection with ancestral practices. In contrast, the modern-day nomad feels a state of placelessness or ‘homelessness’ in the global village, with experiences being quite different depending on whether one is a refugee, an immigrant, a seasonal worker or a privileged traveler for whom borders are mere markers of different currencies.

In a world of migration, the idea of home is always in flux. Berger describes home as a place positioned at the intersection of vertical and horizontal axis, where the vertical line connects the sky (the gods) with “dead in the underworld”¹⁵⁴ (the way ancestors lived) and the horizontal one joins “all the possible roads leading across the earth to other places.”¹⁵⁵ In today’s world the vertical line no longer exists,¹⁵⁶ Berger says, “there is no longer any local continuity between him and the dead, the dead now

¹⁵³ Berger, *And Our Faces, My Heart, Brief as Photos*, 56.

¹⁵⁴ *Ibid.*, 55.

¹⁵⁵ *Ibid.*

¹⁵⁶ *Ibid.*, 65.

simply disappear; and the gods have become inaccessible.”¹⁵⁷ If so, when lost between the sky and the dead, there is no place to return to, it is not possible to “return to that historical state in which every village was the center of the world.”¹⁵⁸ However, “Without a home at the center of the real, one [is] not only shelterless, but also lost in non-being, in unreality. Without a home everything [is] fragmentation.”¹⁵⁹

When home becomes fragmented, we turn to memories, both our own and those found in the materials around us, which also contain memories, stories, likes and dislikes. If you are attentive enough you may hear their whispers and feel their pains and pleasures. For example, latex has a distinct odor and is fragile and sensitive to sunlight, making it difficult to bring it into the permanence of the art world. Latex did not want to conform and kept deteriorating, breaking and demanding attention and time to be repaired. I had to let it go. I could no longer hold its vulnerability. I started to work with other polymers, flexible and transparent polyvinyl chloride (PVC), polyurethane (PU), biodegradable polylactic acid (PLA), space blankets (NASA insulating technology) or lightweight fabric (ripstop nylon or polyester), always in the context of inflatable structures. I replaced the material temporality with the temporality of an encounter and harnessed technology (solar panels, batteries, ventilators, sensors) to create various platforms for interaction. Transparent materials helped to play with fluid boundaries of inside and outside, private and public, individual and group. For example in *The Conversation Bubble* at any given moment, five participants breathe the same air while sharing the common space of the inflatable bubble (fig. 22). Though their heads were free to move, the rest of their bodies were squeezed between two

¹⁵⁷ Ibid.

¹⁵⁸ Ibid., 66.

¹⁵⁹ Ibid.

layers of vinyl. No one was able to leave on their own accord and the duration of the performance depended on the five participants' agreement to end it (fig.23).

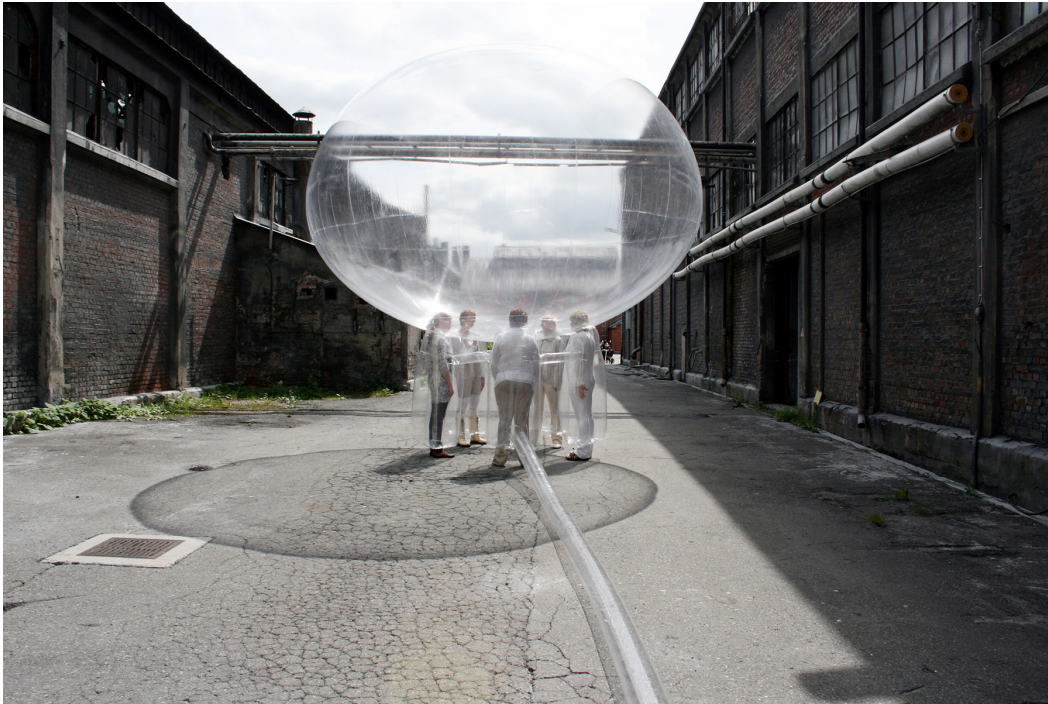


Figure 22. Ana Rewakowicz, *The Conversation Bubble*, 2008 (Odda, Norway), in which 5 participant/viewers' bodies were enclosed in vinyl tubes, while their heads were inside a vinyl bubble, sharing the same air and conversation.



Figure 23. Ana Rewakowicz, *The Conversation Bubble*, performance, Romanian Academy, Rome, Italy, 2012. The image shows view from inside the bubble where participant/viewers' heads are free to move.

Agreement is an enactment producing a specific outcome, such as the end of a performance but of course, this outcome is not fixed and can be changed through a different enactment by different people in a different time and place, resulting in different forms of agreement. There is no continuity in the outcome, there is only participation, which is always a relation of responsiveness, a temporality of responding and creating a response and constituting meaning through responses in the process, and following Barad, each response means the excluding of other responses (and outcomes). We could never include all, not the dead that are gone nor the new ones that are not yet born. This impossibility of including all comes as an intrinsic part of life, bringing forward responsibility not towards oneself but towards the other who is the excluded.

Whatever we do, and however we participate in the world, we are always embedded in a context; no thing exists without context. Being embedded in context means that we cannot escape, at least to some degree, from being sensitive to it, and “[In] our sensibility we are exposed to the world’s being, in such a way that we are bound to answer for it,”¹⁶⁰ says American philosopher Alphonso Lingis. My answer to being exposed and sensitized to the other is to practice an on-going process of enacting new patterns of engagement through artworks that play with the space of matter and

¹⁶⁰ Alphonso Lingis, *The Community of Those Who Have Nothing in Common* (Bloomington: Indiana up, 1994), 226, quoted in Karen Barad, “On Touching—The Inhuman That Therefore I am (v 1.1),” in *The Politics of Materiality*, eds. Susanne Witzgall and Kerstin Stakemeier (Berlin: Diaphanes, 2014), 161.

through creating materiality and meaning (mattering) as an invitation for the viewer/participant to respond.

In 2011, I invited people to pump water, using small hand pumps with one-way valves, into a large cloud-like-shaped object floating in a gallery space suspended by helium¹⁶¹ (fig. 24). Through multiple thin tubes connected to the hand pumps and attached to bottles filled with water underneath the piece, the water raised through capillarity action (against gravity) into a hidden water compartment inside the cloud. Collected water added weight to the object and *The Cloud* descended. When water overflowed the hidden compartment inside and spread via internal tubing to nozzles inserted at the bottom of the structure, *The Cloud* 'rained.' In the process of emptying the accumulated water, *The Cloud* became lighter and ascended (fig. 25).



¹⁶¹ In later presentations of this piece, upon realization that we are running out of natural helium on Earth, I changed its operation to a cantilever mechanism that allowed *The Cloud* to function in the same way but without helium.

Figure 24. Ana Rewakowicz, *The Cloud*, 2011, installation, Expression Centre d'exposition de Saint-Hyacinthe, Quebec, Canada. A large (3 m x 5 m x 2.5 m) ripstop nylon polyester cloud-shaped structure floats above the floor of the gallery connected by thin tubes to 5 hand pumps attached to bottles filled with water.



Figure 25. Ana Rewakowicz, *The Cloud*, 2011, installation, Expression Centre d'exposition de Saint-Hyacinthe, Quebec, Canada. By using the hand pumps to push water into the structure (left), the structure becomes heavy and descends (middle). When the hidden water-holding chamber inside the structure becomes full, the water overflows, creating rain and lightening the structure, which then ascends again (right).

I worked on *The Cloud* project with Montreal-based engineer Pierre Jutras. Originally my idea did not involve water; the vertical movement of the cloud was supposed to be triggered by people breathing into it. However after discussing my idea with Pierre, I learned that air would not be heavy enough to activate the structure despite the fact that I had attempted to make it as light as possible using the lightest material available at that time.¹⁶² We switched our attention to water. Right then, everything came together, the concept, material and technique became one and the piece began to have a life of its own. It is at such a moment when an artwork speaks back and communicates its own messages.

¹⁶² Icarex is a ripstop nylon polyester material used for kites and it was the lightest commercially available material at that time.

In pre-Socratic philosophy, Thales of Miletus (the Father of Science¹⁶³) and his pupil Anaximander, considered water as primary matter from which the world emerged.¹⁶⁴ In contrast, Anaximenes from Miletus (a student of Anaximander) regarded air as the primordial element, from which other substances arose according to their density.¹⁶⁵ Diluted air turns into fire, condensed air first becomes wind, then water and finally soil and rocks. In *The Cloud*, I weaved between these points of view when I ‘condensed’ air into water circulating in and out of the cloud in precipitation and participation.

Since ancient times, the image of the cloud has held profound meaning for the human psyche.¹⁶⁶ It has been a sign of divine presence, for example the Ancient Hebrews adapted the image of the cloud for Yahweh,¹⁶⁷ and a symbol of creation, fertility, power and protection, as in the story of the Egyptian Orphic creation myth that describes the world emerging from a cloud (the Cosmic Egg).¹⁶⁸ From the industrial revolution onwards, the meaning of clouds has expanded to include human control and power, as represented by the factory chimneys’ clouds.¹⁶⁹ More recently, clouds have come to symbolize connectivity, as illustrated by the computational cloud of information, becoming an emblem of both real and virtual pollution at the same time.

¹⁶³ Strang, *Water*, 19.

¹⁶⁴ Möller, “History of the Exploration of Fog, Dew, Rain,” 15.

¹⁶⁵ *Ibid.*

¹⁶⁶ Jacqueline Taylor Basker, "THE CLOUD AS SYMBOL: Destruction or Dialogue," *Cross Currents* 56, no. 1 (2006): 112. Accessed December 1, 2020. <http://www.jstor.org/stable/24461099>.

¹⁶⁷ *Ibid.* 113.

¹⁶⁸ *Ibid.*

¹⁶⁹ Hehe, *Man Made Clouds*, eds. Helen Evans and Heiko Hansen (Orleans: Editions HYX, 2016), 34.

The cloud “will forever elude our human understanding”¹⁷⁰ as it defines limits of our knowledge and the impossibility of seeing clearly. “Symbolically the cloud form is as much a reminder of our loftiest aspirations and dreams as it is of the gathering storm unchecked environmental deterioration has us riding straight into.”¹⁷¹

In my case however, it was not the image of the cloud and its symbolism that was the driving force behind the creation of *The Cloud*. Instead I focused on what the cloud does. As we can recall clouds are essential elements of the hydrological cycle responsible for water circulation from the surface of the earth to the atmosphere and then back again to the surface; the cycle, which is considered the engine of life on Earth. Both the weather and climate depend on it and so do we along with the rest of biota on this planet. But we are also part of this cycle. When working on *The Cloud* project my interest laid in the object’s relation with participants and their mutual co-dependence. Writer Bernard Schütze commented that the project’s “poetically pragmatic rainmaking function [that] offers a direct vision of how atmospheric conditions may be constructively impacted by sensitively thought out design.”¹⁷² He says: “Brought so close to view in our big interior [space] this cloud leaves little room to evade the current condition: in this change of atmosphere we are now all weather makers of one sort or another.”¹⁷³

Working with inflatable structures, I was drawn to Buckminster Fuller’s interest in lightness and the weight of materials as a means to counteract excessive materialism and waste. In the context of contemporary issues such as environmental degradation,

¹⁷⁰ Basker, "THE CLOUD AS SYMBOL: Destruction or Dialogue," 111.

¹⁷¹ Bernard Schütze, “Change of Atmosphere,” in *Ana Rewakowicz. Here is not There/Ici n’est pas là-bas* (Saint-Hyacinthe: EXPRESSION, Centre d’exposition, 2011).

¹⁷² Ibid.

¹⁷³ Ibid.

climate change, social displacement or population growth, we need to think about lightness, and how to live, travel and transport our goods with reduced impact on the environment. The long-term durability of inflatable materials still eludes us, yet their potential for both usefulness and playfulness is paramount. As an artist, I have investigated not only the material potential of inflatables (durability, lightness, portability, thermal and structural properties, fabrication processes, material 'memory,' biodegradability), but also the cultural and aesthetic implications of *lightness*, such as the possibility for humour.

Upon invitation, I gave a presentation of *The Cloud* at the "Water is in the Air" Symposium at the Institute for Advanced Study of Aix-Marseille University (IMeRa) in Marseille in 2012, organized by director of Leonardo/Olats, European sister organization to Leonardo/ISAST,¹⁷⁴ Annick Bureau. At this colloquium I met physicist/artist Jean-Marc Chomaz, who a year later came to Montreal where we discussed the possibility of a future collaboration.

At the time of Jean-Marc Chomaz's visit, I was working on *Ponte Rotto*, an installation for a solo exhibition at the Polish Institute in Rome, Italy (fig 26).

¹⁷⁴ Leonardo/ The International Society for the Arts, Sciences and Technology is a nonprofit organization that serves a global network of distinguished scholars, artists, scientists, researchers and thinkers through programs, which focus on interdisciplinary work, creative output and innovation, <https://www.leonardo.info/about>.

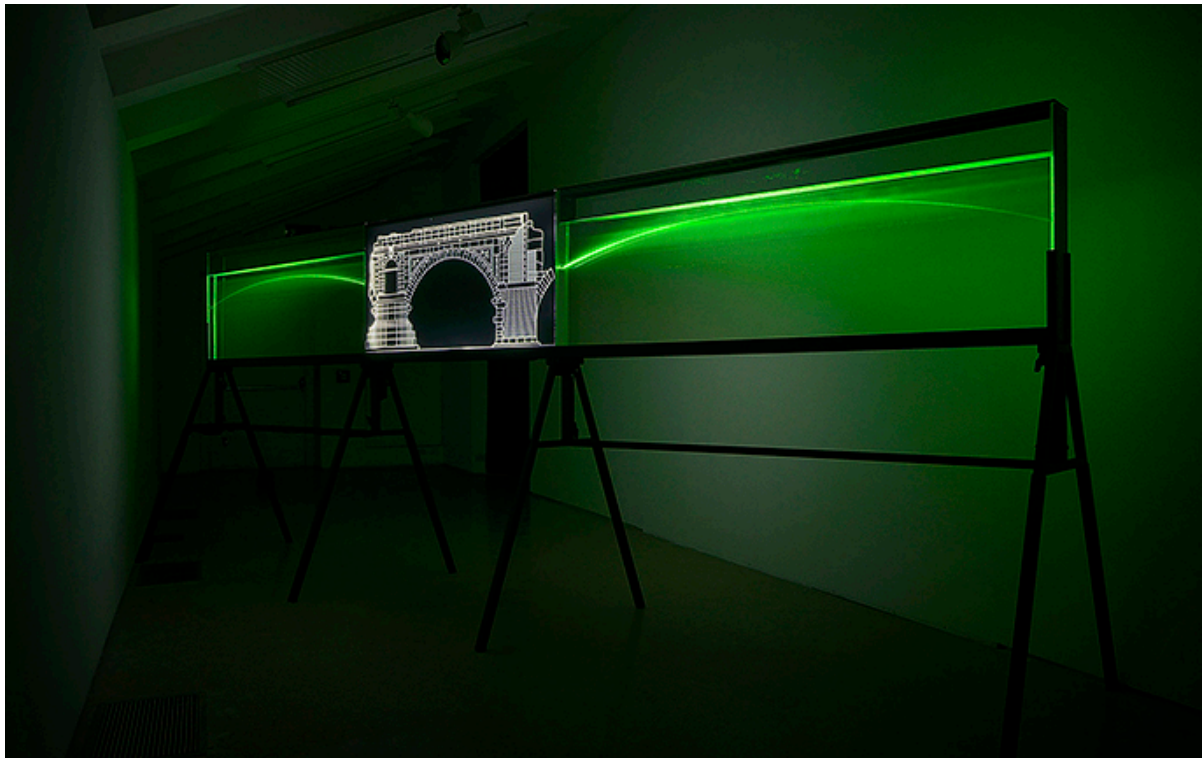


Figure 26. Ana Rewakowicz, *Visualization of the Ponto Rotto Project*, 2014, installation, Polish Institute in Rome, Italy, in which water and light are used to visualize the Broken Bridge (Ponto Rotto) of Ancient Rome and conceptually reconnect the past, present and an unknown future.

Ponte Rotto, which means *Broken Bridge*, is a single remaining arch of an ancient Roman bridge that today, as a ruin, sits in the middle of the Tiber River and is not accessible from either side. It can be viewed from both sides of the embankment and from above, by standing on the nearby Palatino Bridge, but it is impossible to get close. The closest and most impressive view, revealing its ornamented relief, is from Tibertina island where I often sat (when I lived in Rome before my immigration to Canada) and admired its monumental presence – a remnant of a glorious past, now turned into a ruin. Only black cormorants can set foot on it and their sunbathing silhouettes have become part of the *Broken Bridge* tourist postcard. Occasionally, a rat swam and climbed on its base and if your eyes continued to look past the ruin, in the distance you

could catch a glimpse of the Cloaca Maxima, one of the world's earliest sewage systems (still in use today) that was designed to drain local marshes and remove waste from the city, before the construction of embankments in the nineteenth century. The image of *Ponte Rotto* captured my imagination and my impossible longing to reconnect to and stitch together time (the past, present and unknown future).

Many years later, I returned to Rome as an artist-in-residence and was playing with the idea of making two inflatable arches that would temporarily reconnect the single arch with the two banks of the river creating a visualization of the bridge. It was never meant to be a reconstruction of the original bridge, as the Roman bridge had seven arches spanning over the river and marshes. Instead, I always imagined the project to be a drawing in space, a connecting gesture, a link between antiquity and the present, between old and new technologies, between expansion, collapse and rebirth. Its aim was to redefine our relation with the surroundings and to alert us to the necessity of connecting actions (building bridges), on which our future depends.

At the moment that Jean-Marc Chomaz came to Montreal, I was experimenting with making a gradient using sugar-saturated water in a small aquarium. I was interested in using a laser as my drawing medium, taking advantage of the fact that a laser beam will bend in a stratified liquid. When shining a laser through a sugar-saturated solution, I was able to *draw* an arch. It was wonderful to discover that Jean-Marc and I had an immediate connection as one of his research projects dealt with the production of stratified liquids. He helped me to establish a suitable ratio of saturation and suggested a more-controlled method of producing the gradient by using two containers connected at the bottom with a tube and a drip system that allowed for

gradual dilution of the 100 percent saturated solution in one container by the plain water in the second container.

We discussed the possibility of me coming to the Hydrodynamic Laboratory (LadHyx) at École Polytechnique in Paris for a two-month residency the following year to work on a project related to collecting water from fog. Considering that air and water have been flowing in and out my art production since the beginning, the invitation to collaborate with scientists on a project involving water presented itself as an exciting opportunity. It strongly resonated with my art practice that has been addressing basic survival needs such as shelter, food and water, and my desire to build disciplinary bridges. I went to LadHyx as an artist in residence in 2014, and joined the PhD program in art-science in 2015, the results of which are described in the current thesis.

Chapter 3

Approach: Relational Ethics

To tackle global problems such as water shortages, we need new ways of thinking. In chapter 3, I present the theoretical framework for the thesis, the theory of agential realism that offers novel ways of thinking and writing about art practices and collaborations, especially pertinent when addressing the environmental problem of water scarcity. First I introduce agential realism and explain how it provides a new perspective (section 1). Then, I discuss the three main premises of agential realism, namely the notion of relating and the creation of relationships (section 2); the concept of ethical response-ability as a practice of engagement and inclusion (section 3); and the diffractive approach that allows us to entangle with differences to create a more enriching perspective on meaning creation (section 4). Finally, I draw parallels between agential realism and my artistic practice, which has consistently engaged in a relational practice of ethical response-ability (section 5).

1. What is agential realism and how does it provide a new perspective?

The centerpiece of agential realism for my thesis is active participation in meaning and difference creation; a process, in which our actions, not being separable from the world, come with innate responsive responsibility (ethics), and hence all matter. The theory of *Agential realism* attempts to combine the three areas of philosophy, namely ontology (the study of *what is*), epistemology (the study of *how we*

know what is) and ethics (a system of moral values or principles¹⁷⁵), creating a new approach of ethico-onto-epistemology. It was created by American feminist theorist and theoretical physicist Karen Barad,¹⁷⁶ as a way of synthesizing philosophical approaches in science and social sciences. Agential realism is similar to the philosophy of posthumanism in rejecting the human-centred position of agency that sees the human as an autonomous, “exceptional animal that is superior to other creatures;”¹⁷⁷ to the philosophy of new materialism(s) in considering matter as an active agent;¹⁷⁸ and it adopts the ‘material turn’ that pays attention to materiality of ‘things,’ including mental processes.¹⁷⁹ In fact, Barad is one of the thinkers, along with Rosi Braidotti, Elizabeth Grosz, Jane Bennett, Vicki Kirby, and Manuel DeLanda, who coined the new materialism term.¹⁸⁰ However, in addition to posthumanism and new materialism(s), agential realism brings attention to ethics, not as a moral philosophy of rights and wrongs, but as an inherent part of ongoing relating, which constitutes different

¹⁷⁵ Peter Singer, “Ethics,” in *Encyclopedia Britannica*, accessed May 15, 2021, <https://www.britannica.com/topic/ethics-philosophy>.

¹⁷⁶ “Karen Barad is Professor of Feminist Studies, Philosophy, and History of Consciousness at the University of California at Santa Cruz. Barad is also affiliated with the program in Critical Race and Ethnic Studies, and is the former Director of the Graduate Training Program for the Science & Justice Research Center. Barad is on the faculty of the European Graduate School. Barad holds a PhD in theoretical particle physics and quantum field theory. Barad held a tenured appointment in a physics department before moving into more interdisciplinary spaces.” The University of British Columbia, The Social Justice Institute, accessed June 5, 2021, <https://grsj.arts.ubc.ca/person/karen-barad/>.

¹⁷⁷ Diane Marie Keeling and Marguerite Nguyen Lehman, “Posthumanism,” in *Oxford Research Encyclopedias of Communication*, last modified April 26, 2018, <https://doi.org/10.1093/acrefore/9780190228613.013.627>.

¹⁷⁸ Liedeke Plate, “New Materialisms,” in *Oxford Research Encyclopedias of Literature*, last modified March 31, 2020, <https://doi.org/10.1093/acrefore/9780190201098.013.1013>.

¹⁷⁹ John Jamieson Carswell Smart, “Materialism,” in *Encyclopedia Britannica*, accessed May 15, 2021, <https://www.britannica.com/topic/materialism-philosophy>.

¹⁸⁰ Kameron Sanzo, “New Materialism(s),” *Critical Posthumanism, Genealogy of the Posthuman*, last modified April 25, 2018, <https://criticalposthumanism.net/new-materialisms>.

relationships creating various entities and meanings; the process of which we are an inseparable part.

Agential realism is rooted in quantum physics, especially the science-philosophy of physicist Niels Bohr (one of the founders of quantum theory), which brings focus to the inseparable relation between questions we ask and answers we get, and the impossibility of separating knowledge from meaning. Thus, agential realism opposes the binary thinking of Western philosophy that goes back to Ancient Greece, which assumes the possibility of an observation-independent reality (nature¹⁸¹), to which we only have access through various forms of representation (never complete¹⁸²) mediated by objects (material phenomena – ‘things’) or words (semantics - language), which serve as tools providing us glimpses of that reality (the ‘world-out-there’). In opposition, agential realism, rather than focusing on the question of a reality independent-from-us, hones in “real consequences, interventions, creative possibilities, and responsibilities of intra-acting within and as part of the world.”¹⁸³

As reflected in its name, agential realism prioritizes the role of agency, which is not an attribute, “not something that someone or something has,”¹⁸⁴ but rather what someone or something does. Putting priority on verbs rather than nouns brings forward the most essential concept of agential realism, that of ‘intra-actions.’ In contrast to *interactions* that assume the existence of separate entities (such as objects/subjects or signifiers/signified etc.) that precede the interactions between them, *intra-actions*

¹⁸¹ Barad quotes Sandra Harding: “There is more to nature than ‘nature-as the-object-of-human-knowledge’,” in *Meeting the Universe Halfway*, 2nd ed, Karen Barad (Durham & London: Duke University Press, 2007), 378.

¹⁸² For Plato, the world we live in was only a pale imitation of a ‘true’ and ‘ideal’ reality inaccessible to us in any form but through the deduction of innate reason. Siân Ede, *Art & Science*, 2nd ed. (New York: I.B. Tauris, 2008), 18, Kindle.

¹⁸³ Barad, *Meeting the Universe Halfway*, 37.

¹⁸⁴ *Ibid.*, 178.

recognize the impossibility of separation between *what is* (ontology) and *how it came to be known* (epistemology), between questions and answers.

In this dynamic and open-ended process offered by intra-actions, we are neither 'passive' observers (a deterministic view that assumes a world not under our control) nor omnipotent creators (a world of free will with infinite freedom where we can do what we want), but rather attentive participants, responsible for doing/creating/enacting as part of reality, not inside or outside but together/with. In agential realism, matter is both, physical materiality and agency at the same time, and the concept of intra-action "entails a rethinking of fundamental concepts that support such binary thinking, including the notions of matter, discourse, causality, agency, power, identity, embodiment, objectivity, space, and time."¹⁸⁵

The three main elements of agential realism: *relationality*, *ethical response-ability* and *diffraction* offer a radically different way of interacting as part of the world. In contrast to a mediated representation of the world, in which, by being separated from it, we become less active, pushing accountability onto others while removing ourselves from the creative potential we have, agential realism focuses on participatory creation, of which ethical responsibility is an intrinsic component; an approach, which is much needed in dealing with the environmental crises of water shortage that this thesis explores.

2. Relationality: relating and creating relationships

The concept of intra-action defines the nature of relating in agential realism. Since we cannot separate *what is* from *how it came to be known* (answers from

¹⁸⁵ Ibid., 26.

questions), intra-actions offer us a different way of building relationships. By dissolving the boundaries between ontology and epistemology, agential realism brings forward entangled relationality, where different actions give rise to different entities (separations), which then in turn constitute different meanings.

To follow the logic of agential realism, which is guided by quantum physics, we could say: “I don't sit on a chair, but through the action of sitting, both chairness and I-ness come into existence.”¹⁸⁶ Thus, intra-active doing and becoming constitute temporary separations and produce different meanings in the process. In the usual way of thinking, relationships start with separate entities, which then *interact* with each other. For example we have *a chair* and *a person*, and normally we consider the chair as a passive object on which the person sits. However, taking the stance of agential realism, we start with the relationship of *sitting*, in which different actions can give rise to different entities (chairs, people). For example, *a relaxed person* and *a comfortable chair* might arise from a relationship of sitting (comfortably), or *a person with a sore back* and *an uncomfortable chair* might be created from sitting (painfully). There is never just one possibility, but always multiple opportunities (and of course *sitting* is not the only possible relationship we might have with a chair). Critically however, only one possibility can be evident at a time (created through the act of performing an action),¹⁸⁷ i.e., every action is a form of decision and creation, bringing some entities (comfortable chair) into existence while excluding others (uncomfortable chair). Performing an

¹⁸⁶ Kris Onishi (Cognitive Psychologist), personal communication, January 9, 2020.

¹⁸⁷ Barad says: “only part of the world can be made intelligible to itself at a time, because the other part of the world has to be the part that it makes a difference to,” (Barad, *Meeting the Universe Halfway*, 351), which resonates with Buckminster Fuller’s statement about unity that “is plural and at minimum two, in which only one is spontaneously accounted as obvious.” Buckminster Fuller and E.J. Applewhite, *Synergetics* (Sebastopol: Estate of R. Buckminster Fuller, 1997), Conceptuality 507.03.

action is what Barad calls enacting ‘agential cuts,’ which manifest temporary separations that are always ready to be re/un/done.

For a concrete way of trying to visualize this idea we can use the famous XIX century optical illusion, “My Wife and My Mother-in-Law”¹⁸⁸ by British cartoonist William Ely Hill. Depending on how you look at the image (fig. 28), you may see either the portrait of a young lady facing away and looking over her right shoulder or that of an old woman gazing downwards. The meaning of this one image (either a young or old woman) is determined by the way the observer intra-acts with it, and the idea of agential realism is that all meanings (not just so-called optical illusions) are a co-creation arising from intra-actions.



Figure 27. A replica of a famous optical illusion, which portrays both a young lady looking away and over her right shoulder, as well as an old woman gazing downwards. The young lady appears to have a decorative necklace around her neck, which becomes the mouth of the old woman, whose chin becomes the young lady’s cleavage,

¹⁸⁸ Yasemin Saplakoglu, “What You See in This Famous Optical Illusion Could Reveal How Old You Are,” LiveScience, last modified September 21, 2018, <https://www.livescience.com/63645-optical-illusion-young-old-woman.html>.

<https://www.livescience.com/63645-optical-illusion-young-old-woman.html> (Image credit: public domain).

Working through the concept of *intra-actions* (in lieu of interactions that assume existence of already separate elements) draws attention to practices of making differences (the idea that if different actions were taken, different entities would have been brought into being). For example, the act of putting together parallel fibres and seeing how water coalesces from the air onto these fibres might create an artwork (as in *Through the Looking Mist...*) or it might create an experiment, in which we discover that particular arrangements of fibres are more effective at collecting water.¹⁸⁹ Similarly, we can see an artwork as separate from an experiment or we can see it as a complimentary element of the same relationship (parallel fibres collecting water), which in our case constituted the basic unit of our investigations.

For Barad, basic units of reality are material phenomena, which “are ontologically primitive relations—relations without preexisting relata.”¹⁹⁰ In any phenomenon, parts intra-act not as separate entities but as ontologically inseparable components, producing different material reconfigurations such as separation into object(s) and subject(s). Barad explains that “phenomena are constitutive of reality”¹⁹¹ and “reality is composed not of things in-themselves or things-behind-phenomena but of things-in-phenomena,”¹⁹² or said slightly differently, things-in-relationships.

To imagine how different components could intra-act with each other without being separate we could use an analogy from quantum physics about the

¹⁸⁹ Rewakowicz, Chomaz and Duprat, “Mist Collector: Art and Science project,” 129-132. Labbé and Duprat, “Capturing aerosol droplets with fibers,” 6946-6951.

¹⁹⁰ Barad, *Meeting the Universe Halfway*, 333.

¹⁹¹ *Ibid.*, 140.

¹⁹² *Ibid.*

characteristics (wave and particle) of light, which according to Bohr is not a duality but complementarity.¹⁹³ For Bohr, the reason we cannot see wave and particle behaviours simultaneously is because these attributes do not exist independently from the apparatus used to measure these characteristics. Light is not sometimes a particle and sometimes a wave, nor is it both, a particle and wave simultaneously. Rather, light has the possibility of being one or the other depending on its intra-actions with the measuring apparatus, which allows the detection of one aspect while excluding the other.¹⁹⁴ To determine a location, we cannot have an apparatus that moves, and in contrast, to determine momentum, we cannot have a static apparatus. *What is* is always determined in relation to *how we know what is* and Bohr considers characteristics to be defined within the measurement,¹⁹⁵ i.e., to be defined in intra-actions with agencies of observation (apparatuses).

Bohr explains the principle of complementarity using an example of being in a dark room with a cane in your hand. He says that there are different ways of experiencing a room using the cane; in one, if we hold the cane very firmly in our hand, we lose the sense that the cane is separate from our body and the cane becomes

¹⁹³ For Bohr, the principle of complementarity differs from Heisenberg's principle of uncertainty in that, uncertainty presupposes determined properties existing independently of a measurement, while Bohr considers characteristics to be defined by the act of measurement, that is, entities are created through intra-actions with apparatuses. In 1927 physicist Werner Heisenberg introduced the uncertainty principle, which states that we cannot know simultaneously the electron's position and momentum. According to Barad, when Bohr rejected Heisenberg's claim, Heisenberg admitted to a mistake and added a postscript to his paper in which he agreed with Bohr's idea of complementarity, however, "this crucial postscript to Heisenberg's paper has (for the most part) been forgotten and its implications lost." Barad, *Meeting the Universe Halfway*, 116-117.

¹⁹⁴ Karen Barad, "Quantum Entanglements and Hauntological Relations of Inheritance: Dis/continuities, SpaceTime Enfoldings, and Justice-to-Come," *Derrida Today* 3.2 (2010): 253.

¹⁹⁵ *Ibid.*, 261.

a hand extension investigating the room.¹⁹⁶ This approach parallels scientific investigations, where apparatuses are seen as tools - extensions of our senses and used with little acknowledgement of the actions such tools perform (i.e. without acknowledging the agency of the apparatus). In the second instance, if we hold the cane loosely, we experience the cane as a separate entity (through touch).¹⁹⁷ In this case, we become aware that in order to know anything about the room, we first must understand (establish a relationship with) the object in our hand (the cane), then the cane, rather than the room, becomes the object of our investigation. For example, by holding the cane tightly, we may treat a fast camera (camera with a rapid shutter speed) as a tool - an extension of our eyes enabling us to see what we cannot see with our physical eyes (such as water droplets in mist), or, by holding the cane loosely, we may recognize the camera as an entity with which we create different relationships (such as artworks or scientific experiments), resulting in multiple experiences within a given physical configuration.

Thus, the new way of relating that is proposed by agential realism, is a way of perceiving, thinking and acting that makes us aware that different ways of asking questions (intra-acting) produce different relationships, and that by employing complementary meaning-producing practices (different apparatuses, such as art and science) we may create a fuller engagement with our surroundings (a more inclusive relationship with others).

3. Ethical response-ability: practicing engagement and inclusion

¹⁹⁶ Barad, *Meeting the Universe Halfway*, 358.

¹⁹⁷ Ibid.

In agential realism, apparatuses are meaning producing practices that perform ‘agential cuts’ creating temporary separations, differences and meanings, and are not just “prefab laboratory instruments, physical set ups that embody human concepts and take measurements.”¹⁹⁸ Furthermore, humans are not the only agents who can engage in practices of difference and meaning creation. Everything is capable of intra-acting and producing phenomena with different agencies of observation (apparatuses). By dissolving the anthropocentric focus, humans become more integrated with the environment, which would then be seen not as a separate entity in a static state, but as a dynamic relation of intra-acting processes of becoming (including flux between organic/inorganic, human/non-human, being/non-being, and even existent/non-existent).

In performing agential cuts (temporarily defining what is important) we can never include everything; each way of relating and producing meaning excludes another way of relating, thus exclusion is an inherent part of the ongoing process of entangled intra-activities. *Ethicality*, in agential realism, is accountability towards what has been excluded in this ongoing flux of always cutting together-apart, manifesting, materializing and excluding; accountability not only for configurations (meaning) we make, but more importantly, for configurations (meaning) that have been excluded or concealed. Hence, ethics from the stance of agential realism, is not about morality of rights or wrongs, but rather responsiveness towards what is hidden and less obvious, and thus, a responsibility towards greater inclusion. Ethicality is about “hospitality to

¹⁹⁸ Ibid., 146.

the stranger threaded through oneself and through all being and non/being,"¹⁹⁹ says Barad.

The ability to respond ethically is not an obligation, but rather, a necessary outcome of intra-acting. Barad states: "The very nature of matter entails an exposure to the Other. Responsibility is not an obligation that the subject chooses but rather an incarnate relation that precedes the intentionality of consciousness. Responsibility is not a calculation to be performed. It is a relation always already integral to the world's ongoing intraactive becoming and not-becoming. It is an iterative (re)opening up to, an enabling of responsiveness. Not through the realization of some existing possibility, but through the iterative reworking of im/possibility, an on-going rupturing, a cross-cutting of topological reconfiguring of the space of responsi-bility."²⁰⁰ Ethical responsiveness means creating an invitation to the excluded and being accountable for providing a space, in which the excluded is able to respond. For example, when a fast camera (through intra-action) invites water droplets in fog (that are usually invisible to the human eye) to become visible light droplets (as in the *Misty Way* artwork), this kind of intra-action opens the possibility for us to become more aware of the presence of water in the air, in our bodies and the environment. Making the invisible visible enables a change of perspective.

Practices of ethical response-ability are practices of engagement, where our responsibility lies in leaving the door open for *the other* to enter so we can continue to intra-act. If we close the door, we close an opportunity to further relate. Barad says: "Intra-acting responsibly as part of the world means taking account of the entangled phenomena that are intrinsic to the world's vitality and being responsive to the

¹⁹⁹ Barad, "On Touching (v 1.1)," 162.

²⁰⁰ Barad, "Quantum Entanglements," 265.

possibilities that might help us and it flourish. Meeting each moment, being alive to the possibilities of becoming, is an ethical call, an invitation that is written into the very matter of all being and becoming. We need to meet the universe halfway, to take responsibility for the role that we play in the world's differential becoming."²⁰¹

If through intra-acting with others (beings and non-beings, humans and non-humans) we create meaning (knowledge) that defines facts and values, that in turn create societies and cultures, and if ethical response-ability is an integral part of everything we do, then ethical practices offer us an opportunity to change the very facts and values that have driven us to environmental degradation. And since agential separations are not intrinsic to the structure of the world, but only temporary and local divisions within relationships, we have infinite possibilities to endlessly (re)create both society and culture, with different values, which could bring us to a new reality. This infinite potential for reworking offers a rather optimistic alternative to the apocalyptic prediction of the Anthropocene's sixth mass extinction (an accelerated loss of biodiversity, perhaps even including a human kind) caused by human activities.²⁰² The optimism comes from a realization that in (re)doing and engaging (rather than observing from a distance of objectivity), we have relational power (not all the power²⁰³) to change things. We can only fail if we give up on (re)doing, (re)creating and (re)making; if we stop engaging. Inherent in each of us is the potential for making things differently, thus every action (no matter how small) carries responsibility that matters!

²⁰¹ Barad, *Meeting the Universe Halfway*, 396.

²⁰² Frederik Saltre & Corey J.A. Bradshaw, "Are We Really in a 6th Mass Extinction? Here's The Science," *Science Alert*, November 18, 2019, <https://www.sciencealert.com/here-s-how-biodiversity-experts-recognise-that-we-re-midst-a-mass-extinction>.

²⁰³ We do not have unlimited power as we are not alone in the world and the world is constituted through multiple relationships and entities that arise from different relating.

Barad declares, “Making knowledge is not simply about making facts but about making worlds (...).”²⁰⁴ That is, thinking within the framework of ethical response-ability could help us to close the gap between what we know and what we do in order to enact change.

4. Diffraction: entangling with differences from multiple perspectives

In agential realism, being a part of ongoing relationships creating different entities and meanings prevents us from having an external perspective, i.e., a perspective from outside of a relationship. We are always a part of these relationships because it is the only way that we can constitute meaning. Moreover, we are not the only beings in the world and all entities (human/non-human, living/non-living) are capable of intra-acting and performing agential cuts creating temporary separations (enacting agency). Thus, different perspectives are an inseparable part of relating. The diffractive perspective helps us to deal with differences arising from paying attention to details and teaches us how to read changing patterns of engagement (re)constituting meaning. Barad states: “a diffractive methodology is a critical practice for making a difference in the world. It is a commitment to understanding which differences matter, how they matter, and for whom.”²⁰⁵ This approach is particularly crucial when dealing with different disciplinary perspectives, such as art and science, as explored in my thesis work.

To understand how the diffraction approach works, we need to first define what diffraction is. Diffraction refers to the behaviour of waves that under right circumstances bend when encountering obstacles (diffraction) and create a pattern of

²⁰⁴ Barad, *Meeting the Universe Halfway*, 91.

²⁰⁵ *Ibid.*, 90.

alternating dark and light concentric circles (interference – fig. 28).

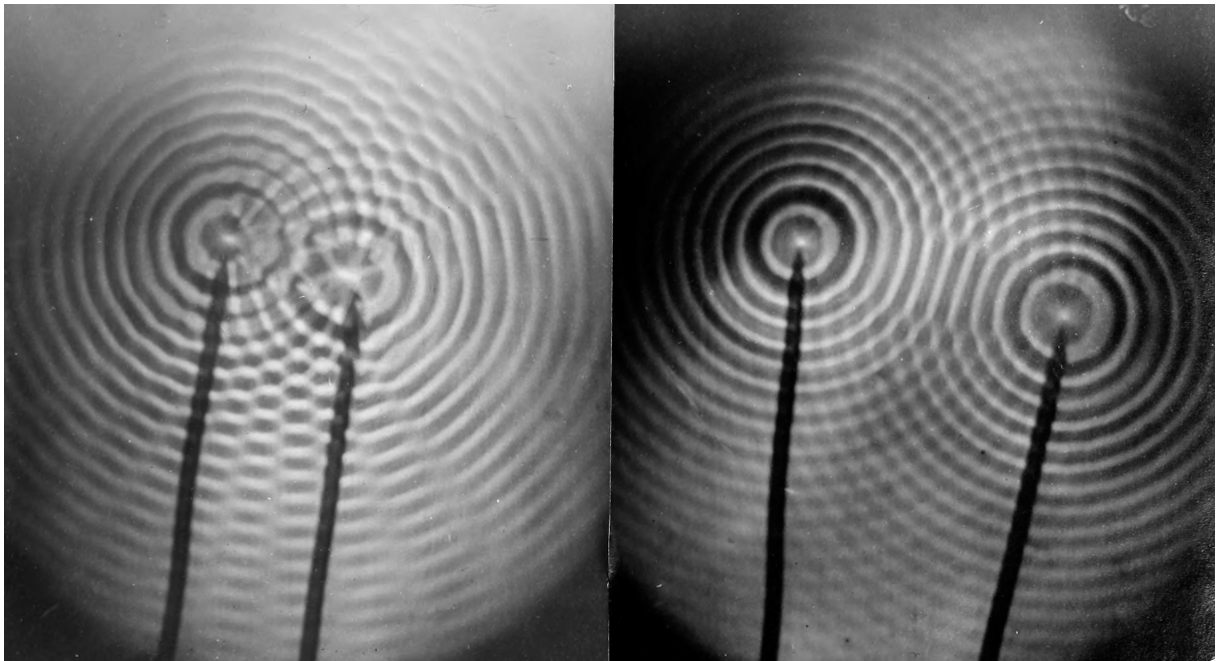


Figure 28. A pattern of diffraction/interference created by two sets of generated waves in a ripple tank. When the crest (high point) of a ripple meets the trough (low point) of another, these two ripples (waves) cancel each other out, creating flat areas of water or dark circles as in the image above. In contrast, when two wave crests come together, they reinforce each other and produce an even higher wave or brightly marked circles in the image above.

<https://www.flickr.com/photos/internetarchivebookimages/14596074950/> (Image credit: Walter Andrew Shewhart, 1914).

It is relevant to mention that Barad does not distinguish between diffraction and interference, which she claims is only a historical distinction.²⁰⁶ For Barad, the essential idea of diffraction is that waves are non-local (they can occupy different places simultaneously) and can overlap, sometimes cancelling each other (dark intersected circles in fig. 29) and other times reinforcing each other (bright intersected circles in fig. 29); something that particles cannot do, as particles appear only in one place at a time. Barad considers this difference in behaviour between waves and particles as having far

²⁰⁶ Ibid., 28-29.

reaching consequences in the ways we engage with the world.

One way of engaging with the world is representational, where that is perceived is separate from what is.²⁰⁷ According to Barad, this perspective is based on the concept of light as rays used in geometric optics, where rays are straight lines (approximations of the path of light) that indicate the direction of light movement from one point to another (e.g., from point A to point B). This view is associated with the behaviour of particles, where we can predict where each particle will end up, as a consequence of each being in a particular location (i.e., point B can be calculated from the position of point A). Hence, this approach stakes advantage of concepts such as *reflection* or mirroring (when light bounces off different reflecting surfaces like mirrors²⁰⁸) or *refraction* (when light bends going through different transparent materials such as magnifying glasses, prisms, lenses, air or water). Barad considers both reflection and refraction as mirroring techniques that produce a representational view of the world that focuses on “the belief that practices of representing have no effect on the objects of investigation and that we have a kind of access to representations that we don’t have to the objects themselves,”²⁰⁹ for example, when scientists claim that “knowledge accurately reflects physical reality.”²¹⁰ Barad says that representationalism (“and related

²⁰⁷ Ibid., 46.

²⁰⁸ Curiously, philosopher Peter Sloterdijk in his book *Bubbles* describes how our relations with our surroundings and with ourselves has changed with the technology of mirrors. He recounts how, with popularization of mirrors as everyday household objects at the end of 19th century, recognition of one’s face became a form of self-knowledge and “a primal form of self-relation,” (197) and how before, self-encounters co-depend on others. (197-200) He says: “The Greek word for the human face, *prosopon*, expresses this fact most clearly: it refers to the sight one presents to the other’s gaze.” Peter Sloterdijk, *Bubbles*, trans. Wieland Hoban (Los Angeles: Semiotext(e), 2011), 192.

²⁰⁹ Barad, *Meeting the Universe Halfway*, 87.

²¹⁰ Ibid., 86.

questions of reflexivity”²¹¹) “aims to acknowledge the tripartite arrangement between objects, representations, and knowers that produces knowledge.”²¹²

In contrast, another way of engaging with the world uses the technique of *diffraction*, which, according to Barad, is based on the behaviour of waves, bringing attention to intra-actions between apparatuses (material-discursive practices²¹³) and meaning. The diffraction approach blurs the boundary between the subject and object allowing for performative *subjectification* of investigations (multiple perspectives), where subjectification refers to an ability of changing perspectives not as separate points of view but rather as the possibility of taking on roles of different subjects in different situations. For example, using Bohr’s example of investigating a dark room with a cane; in one case, when we hold the cane tightly, the cane becomes a part of a subject (that which does the investigation), and in the other, when we hold the cane loosely, the cane becomes a part of the object (that which is investigated – the room). According to Bohr’s principle of complementarity, we cannot do both explore with the room and the cane simultaneously) because we cannot engage in two different practices (use two different apparatuses, in this case tight grip/loose grip) at the same time. The diffraction approach, by permitting us to shift positions (from cane-us as the subject/room as object to us as subject/cane-room as object), offers a more enriching way of intra-acting with the world; one that is not representational (holding the world at

²¹¹ Ibid.

²¹² Ibid.

²¹³ For Barad all apparatuses are material-discursive practices, in which *material* is understood as a physical phenomenon and *discursive* relates to meaning producing conditions, such as language, thoughts, ideas, concepts etc. (*Meeting the Universe Halfway*, 148-152) She says: “discursive practices and material phenomena do not stand in a relationship of externality to each other; rather, the material and the discursive are mutually implicated in the dynamics of intra-activity. The relationship between the material and the discursive is one of mutual entailment.” Barad, *Meeting the Universe Halfway*, 153.

the distance of the cane tool), but rather performative, where, by becoming different subjects, we are able to read insights one through another, not unlike overlapping waves being in different places/situations at once. For Barad, diffraction is: “about experimenting with different patterns of relationality, opening things up, turning them over and over again, to see how the patterns shift. This is not about solving paradoxes or synthesizing different points of view from the outside, as it were, but rather about the material intrainplication of putting ‘oneself’ at risk, troubling ‘oneself,’ one’s ideas, one’s dreams, all the different ways of touching and being in touch, and sensing the differences and entanglements from within.”²¹⁴

In my thesis, I use diffraction as a conceptual and practical approach. For example, I map differences and changing relations between art and science to show how these changing relations can produce different meanings. When art and science interact from a position of difference, they produce, separately, artworks and scientific experiments. However, if they intra-act as different components within the same phenomenon of collaboration, they can create complementary solutions, as was the case with the *Mist Collector* collaboration. Using the diffraction approach I am able to reconcile the view of art and science as opposites (each within its own tools and ways of answering questions), and think about art and science as complementary positions within the same action of investigating the efficiency of fog water collection. In addition, I employ the diffractive approach practically, in writing, where I experiment with different styles of writing to create different patterns of engagement and invite the reader to participate in the meaning co-creation process.

Understanding that we are not outside observers looking at the world from a

²¹⁴ Karen Barad, “Intra-actions,” interviewed by Adam Kleinman, *Mousse* 34 (Summer 2012): 77.

distance (as separate entities sending rays of lights to see how they bounce back), but rather active participants within the phenomena that touch and respond to what touches us, being entangled and connected, helps us to attend to all intra-active articulations (meanings) from different viewpoints and scales.²¹⁵ In identifying that “differences are made and not given,”²¹⁶ the diffractive approach opens the potential for active (re)shaping, a potential that we have as readers, makers and citizens of the world.

5. Choosing Agential Realism: Links to my Artistic Practice

According to the perspective of agential realism, knowing is “a matter of part of the world making itself intelligible to another part”²¹⁷ and comes from direct engagement with the material world that is not static or predetermined, but performative; knowing is “an ongoing performance of the world.”²¹⁸ My artistic practice has always been focused on performative relationality between materials, ideas and processes, and it is from intra-actions with materials (relationship-making-processes) that my art ideas have emerged. Hence, it comes as no surprise that agential realism strongly resonates with my material approach and practice, oriented towards the creation of a platform for participation, in which viewers are invited to become participants in meaning creation.

²¹⁵ “Quantum mechanics is not a theory that applies only to small objects; rather, quantum mechanics is thought to be the correct theory of nature that applies at all scales.” Barad, *Meeting the Universe Halfway*, 85.

²¹⁶ Barad, “Intra-actions,” 77.

²¹⁷ Karen Barad, “Posthumanist performativity: Toward an Understanding of How Matter Comes to Matter,” *Journal of Women in Culture and Society* Vol. 28, No. 3 (2003): 829.

²¹⁸ Barad, *Meeting the Universe Halfway*, 149.

We are all participatory creators and this privilege comes with responsibility. “Learning how to intra-act responsibly as part of the world means understanding that ‘we’ are not the only active beings,”²¹⁹ and that we are responsible not only for what has been revealed (measured/created) but also, and more importantly, for what has been left out. Art helps us to cultivate a sensitivity towards the hidden and less obvious, and imagination and poetics play crucial roles in the process of making the invisible visible and touching the hidden. “The force of imagination puts us in touch with the possibilities for sensing the insensible, the indeterminate,”²²⁰ and poetics augments the sense of touch by bringing us closer to infinite ‘otherness’ of the world, in which differences enrich and sustain the process of intra-activities. From this perspective, the way we deal with differences can be a measure of a healthy relationship, not unlike biodiversity determining sustainability of an ecosystem. It is through imagination (the sensitivity towards visible and invisible differences) that we can sense the water drops’ struggle to stay attached to threads in the wind, their pain when giving into gravity, in which a drop (as a gift) necessary to our survival is born. It is through poetics that we can draw connections between visible water droplets and their invisible counterparts circulating in our bodies, in the air, or in the universe. Imagination helps us to envision water as an active partner (subject) in collaboration with us, and not merely the static object of our investigations. It is through poetics that we can learn how to engage in practices of ethical response-ability leading to ever more inclusion.

For Barad, touch is crucial in practicing ethical response-ability, as it dissolves distance and enables us to connect with parts that are hidden, like the ‘inhuman,’ understood here not as a behaviour in a not human way (a position which only mirrors

²¹⁹ Ibid., 391.

²²⁰ Barad, “On Touching (v 1.1),” 163.

the human-centeredness), but rather as a space of undefined and disorienting possibilities that bare the pain of the insensitive, the ruthless, the indifferent and compassionless that are always part of us. Barad says:

What if it is only in the encounter with the inhuman—the liminality of no/thingness—in all its liveliness, its conditions of im/possibility, that we can truly confront our actions lacking in compassion, that which wrongly gets called "inhumanity", as if compassion is always already human in nature? (...) Perhaps it takes facing the inhuman within us before com-passion—suffering together with, participating with, feeling with, being moved by—can be lived. How would we feel if it is by way of the inhuman that we come to feel, to care, to respond?²²¹

Agential realism, with focus on relationships, takes away the human-centred view and brings attention to the need of more inclusive relating. It offers a dynamic and open-ended framework for developing relationships with others, responsively and responsibly. Diffraction, as a perspective of inclusion and heterogeneity, allows us to tune into differences, by offering the possibility of relating from different subject-positions. The diffraction method in its multiplicity offers an alternative way to think and write about art practices and art and science collaborations, not as descriptions or interpretations, but rather as the active and participatory performance of meaning (re)creation, in which we can make a difference.

In summary, agential realism proposes a radically different approach to relating, one that abandons the dichotomies of known/knower or signifier/signified, and focuses

²²¹ Ibid., 160.

on performative intra-active becoming, of which we are inseparable part. Through different ways of relating (intra-acting) we produce different entities (relationships – phenomena) that constitute different meaning through temporary separations (agential cuts). At the same time, relationships make us aware that we are not alone in the world and that we co-depend and co-exist with multiple others. Thus, we humans are not the only agents. All entities are active actors in infinite possibilities of becoming and difference/meaning creation. Being a part of a world constructed by and of relationships makes us aware that an inevitable part of this process is exclusion, where we privilege some meanings while excluding others. Ethical response-ability sensitizes us to strive for practices of ever-more inclusion, and diffraction offers us an approach for performative engagement.

The world is not a fixed entity that exists outside us or inside us. It is a place that is born out of creative and participatory relating. In the following chapters, I present my participatory (re)creation of extracting water from fog through art, as well as through an art and science collaboration.

PART II

CATALYZING MEANING: *Mist Collector* Collaboration

Chapter 4

Relating Attentively

In chapter 1, I detailed the global water crisis we are facing and presented currently available solutions that drive scientific research on the collection of water from fog. In chapter 2, I painted my artistic trajectory that led me to work on this specific ecological problem. In chapter 3, I outlined a framework in which relationships are paramount in constituting practices of meaning and difference creation that come with the intrinsic ethical response-ability of ever-more inclusion. This framework allows me to connect two critical aspects of my research: the water shortage (problem) and collecting water from fog (possible solution). First, the framework clarifies why it is crucial to engage in ethical practices. Second, the framework provides a means for combining research on the environmental crisis into artistic processes while maintaining the goal of creating positive actions in the world.

The current chapter presents how the initial intra-actions between art and science helped structure the scientific question about a more effective way to collect water from fog. To begin, I start with my 2014 artist-in-residence at the Hydrodynamic Laboratory (LadHyx) and describe my path of intra-acting with science (section 1). Then, I introduce a new paradigm – an image of a forest that launched experiments with flexible parallel vertical fibres (section 2). Next, I detail 3 strands of technical research and experimentation: first, artificial fog production (section 3.1), second, new fabrication methods of parallel fibre nets (substrate) (section 3.2) and I also show some of the preliminary results arising from these technical improvements (section 3.3), and third, I outline explorations with novel fog collecting structural forms (section 3.4).

1. Getting Oriented (2014 Artist-in-Residence)

In 2014 (July – October), I was an artist-in-residence at the Hydrodynamic Laboratory (LadHyx) at the École Polytechnique in Paris, during which time I worked closely with physicist Camille Duprat on fog water collection research. This period was significant in that it provided the foundation for my scientific understanding of physics involved in the process of collecting water from fog. By being exposed to the scientific language and terminology, I learned to see the problems impeding fog water collection from a scientists' point of view, the problems of clogging, drainage and re-entrainment. Our intra-actions were critical, as together we created a new paradigm that has impacted all aspects of our art and science collaboration, and deeply informed the concepts and development of the *Mist Collector* Project.

When we encounter someone or something new what do we do? We interact by engaging in an attempt to understand, to get to know better. Language is one of the most common means by which we do that. However, every group or profession uses words and expressions that are particular to their practice and are difficult to comprehend from the outside. Understanding of this specialized language (jargon) gives access to its members and excludes those who do not understand. We use these specialized languages for many reasons, mostly because it is faster and easier (the path of least resistance) to communicate and often we do it unconsciously. When encountering outsiders, it takes an extra effort to notice and willingness to change it— one must walk the extra mile to meet the other a halfway. Additional difficulty piles up if one comes from a different cultural background. In this case, one must not only overcome cultural, professional but also linguistic gaps.

I could not imagine myself collaborating with scientists without understanding what they were talking about. I needed to learn the language of science, which despite my best efforts escaped me on many occasions. My science education took place in another language and I had to work in translation.²²² But regardless, working together meant for me to understand and I was happy that Camille Duprat was open to explaining things to me. Thus, my first encounters with her were a series of lessons in the language of science.

The first was about the core of what we would be investigating. In response to my LadHyx residency proposal, in which I presented selected examples of both fog and dew collection, she pointed out that dew is not the same as fog, and explained the difference. Dew forms on the basis of temperature differences between air and surfaces it touches, resulting in condensation (water in the air forming droplets on the surface). Whenever surface temperatures drop down to the dew point (a temperature that varies with humidity, at which water droplets form), it forces atmospheric moisture to condense on these surfaces, such as leaves, railings or car roofs. In contrast, fog is quite different because fog already contains condensed water droplets. It is a cloud containing small, condensed water droplets that can then coalesce (grow bigger in size by clustering together) and be pulled by gravity when they are too heavy to stay on surfaces on which they have coalesced. Thus, the process of collecting water from fog

²²² A very funny example of the multi-layer understanding process entails the English word 'mean,' which for me, not studying science or mathematics in English, always meant as a verb to 'intend' or 'indicate,' or as an adjective to be 'nasty' or 'unkind,' or as a preposition 'by means of,' but I was not aware of its meaning as the average, since in the arts I never came across this sense. Hence, during one of the seminars at Ladhyx, I could not understand what was Wave mean? I could not understand why a wave was mean or how could we see that it was mean? In my bewilderment I even asked someone but I think that this person did not understand my question and gave me a confused look, perhaps thinking that I was making a joke or that I was a dimwit.

(where the water droplets already exist) is not the same as collecting it from dew (where the droplets must be formed).

My second lesson involved understanding Duprat's research on wettability and elastocapillarity (how water gets pulled along a surface or substrate). First, I had to familiarize myself with surface tension, the propensity of liquid molecules to create stronger bonds with other molecules of the same type. For example, water molecules prefer to stay together with other water molecules rather than mixing with air molecules. This tendency is in particular apparent on the surface of water, where often above is air. Due to the attraction of the same type, water molecules on a surface facing air produce strong bonds (tension) with each other that form a thin membrane keeping the water separate from the air. Water tension can be observed when a trampoline-like surface supports entities that are denser than water, such as floating leaves or walking water striders bugs.

Next, I moved to grasping wettability, which defines interactions between liquids and solids. The more a liquid (such as water for example) has a tendency to spread on a solid surface (e.g., a leaf), the greater is that surface's wettability. A surface that allows water to spread easily is hydrophilic (water loving/attracting), while a surface that inhibits the spread of water, causing it to stay in one place (and forming a droplet due to surface tension), is hydrophobic (water fearing/repelling). As we saw in Chapter 1, hydrophobic and hydrophilic properties play a significant role in the Namib Desert beetle's ability to gather water from humidity in the air and the enhancement of these characteristics by chemical means had contributed to the development of the MIT-14 mesh.²²³

²²³ Chapter 1, 32-33.

The third concept was capillarity, which also describes interactions between liquids and solids, and describes the capacity of a liquid to ascend against gravity in narrow spaces, such as thin tubes, without the assistance of external forces. Capillarity results from interplay between two types of attractions, one between molecules of different types, e.g., liquid and solid (called adhesion), and the other between molecules of the same type, e.g., in liquid (called cohesion). In narrow spaces such as tubes, with small diameters, when the adhesive force (the attraction between e.g., water and a glass surface causing water to stick to the glass) in combination with the cohesive force (the attraction between e.g., water molecules creating a thin membrane to stay together), are greater than the force of gravity, it induces the liquid to rise on a solid surface (e.g., as water crawls up a glass surface).²²⁴ Just as capillary forces are able to cause the surface of water to curve upward in a narrow glass tube, they can also significantly contribute to deforming the surface of elastic solids, such as gels or flexible fibres, a phenomenon called *elastocapillarity* – the study of which Camille Duprat is a specialist.

Curiously, surface tension, which (by virtue of the tight bonding between liquid molecules) causes fluid surfaces to shrink to the minimum surface area,²²⁵ also bears responsibility for giving shape to inflatable structures, such as spheres of soap bubbles. For example, a soap bubble's shape is determined by its reaching minimum surface

²²⁴ Science JRank, "Capillary Action," accessed March 15, 2021, <https://science.jrank.org/pages/1182/Capillary-Action.html>.

²²⁵ Tobias Holck Colding and William P. Minicozzi "In Search of Stable Geometric Structures," *Notices of The American Mathematical Society* vol. 66, no. 11 (December 2019): 1785.

energy, which is the lowest ratio of surface area to volume,²²⁶ giving it a form of a sphere.

In an interesting way, we could say that our first meeting took place on the surface tension bridge, where like in the capillary action, art and science stuck to each other through adhesion - an attractive force between molecules of different types.

2. New Insights – Image of a Forest and Initial Experiments

After basic terminology was shared, we were able to connect in a more meaningful way, as equals with different perspectives on the same questions. For our collaboration, this meeting arose from materials. While spending time at the laboratory I witnessed Camille Duprat making silicone fibres as part of her experimental research. She squeezed liquid silicone into extremely thin (2 mm diameter) glass tubes, then, when the silicone solidified, breaking the tubes and extracting the thin (1 mm) elastic fibres. These thin elastic fibres would be lined up in a parallel formation, held together by a silicone cross piece, looking like a comb. As an artist, who has been engaged in a material-based, process-oriented practice, I was instantaneously attracted to these silicone fibres. They reminded me of my experimentation with rubber latex. Touching these green elastic silicone fibres, I imagined a forest of vertical lines. I shared this mental image of the forest with Camille and we immediately began to implement this idea into our first experiments together.

We began with the construction of small structures to hold the fibres. The basic structure was 2 rectangles of plexiglass with laser-cut holes (approximately 2mm in diameter), which served as a top and bottom anchor point for the fibres. The plexiglass

²²⁶ Ibid., 1786-1787.

was held in place by 4 rods (at each corner of the rectangles), which allowed the distance between the plexiglass to be adjusted. With a needle we passed thread through the holes in the plexiglass, creating our 'forests' (arrangements of flexible parallel vertical fibres), depending on hole patterns in the plexiglass. For example, one pair of plexiglass plaques had holes along multiple parallel lines, another used a flower pattern and a third had holes placed in an arc curve, as shown in the images below (fig. 29).

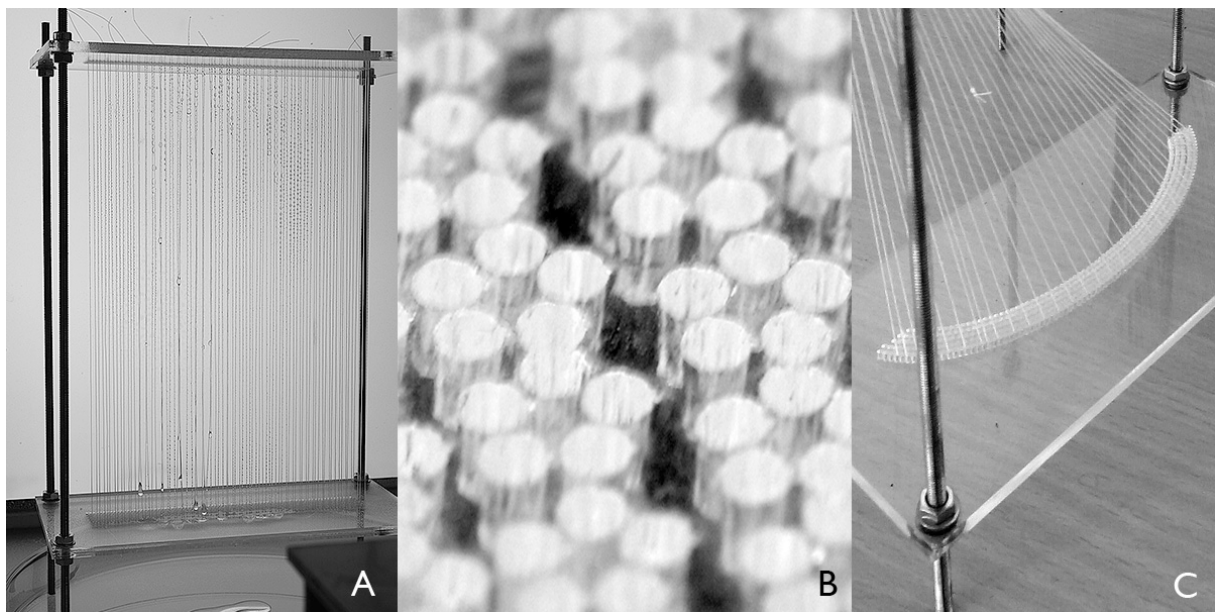


Figure 29. Examples of various fibre arrangements depending on hole patterns in the plexiglass. On the left (A) we see the fibre arrangement following holes along multiple parallel lines. In the middle (B) we see the detail of the flower pattern hole arrangement cut in the plexiglass. On the right (C) we see the hole arrangement in an arc. © Ana Rewakowicz, 2015.

Early patterns involved a multi-layer assemblage of threads, but later patterns became simpler so we could better observe and understand the water droplet behaviour on flexible parallel vertical fibres. The entire rod/plexiglass/fibre structure was placed in a collecting container (petri dish) on a precision scale (to measure

collected water) and backlit by LED lights (to be able to observe and film droplet behaviour - fig. 30). We were then able to spray mist on the fibres (using an atomizer) and observe and measure droplet formation and water collection.

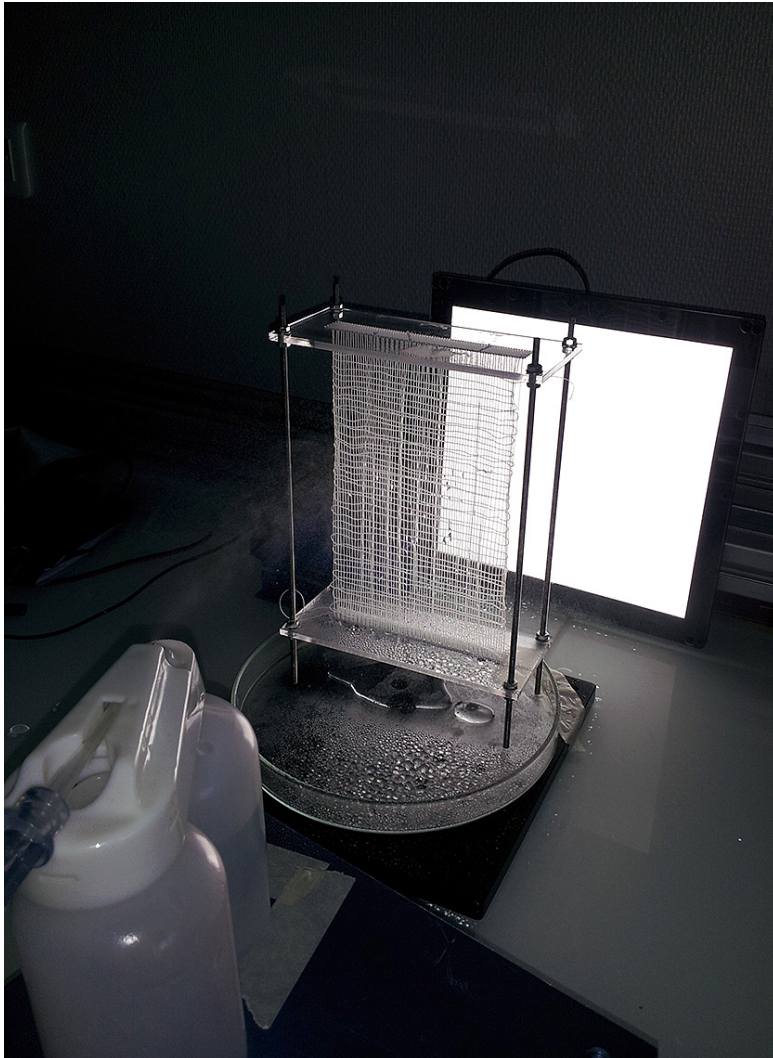


Figure 30. Experimental set-up comprising a water bottle (atomizer) which created mist, a collecting structure composed of a 4-rod frame with 2 rectangles of plexiglass (at top and bottom of structure), with vertical threads passed between the 2 pieces of plexiglass and horizontal threads weaved through. The arrangement of fibres comprise of a single layer mesh-net in the parallel hole arrangement in the plexiglass. The entire structure rests in a petri dish standing on a precision scale and backlit by LED panel. © Ana Rewakowicz, 2014.

With the basic flexible structure in place, Camille Duprat introduced me to the

scientific method so that we could systematically vary the types of fibres used and their arrangement to understand what conditions enhanced water collection. To determine collecting efficiency, we first had to calculate the amount of water we sent to the collecting structure. We did this by subtracting the weight of the water bottle at the end of the experiment from the amount at the beginning of the experiment. Then, we divided the amount of water we collected (the weight of the structure after wetting together with the accumulated amount in the petri dish) by the amount of water we sent to tell us how much water had been lost or retained by the structure. The larger this number was, the greater the collection efficiency.

We tested several structures with different thread formations, layers and geometries and observed an increase in efficiency with an increasing number of layers as shown in fig. 31, produced by Camille Duprat in 2014.

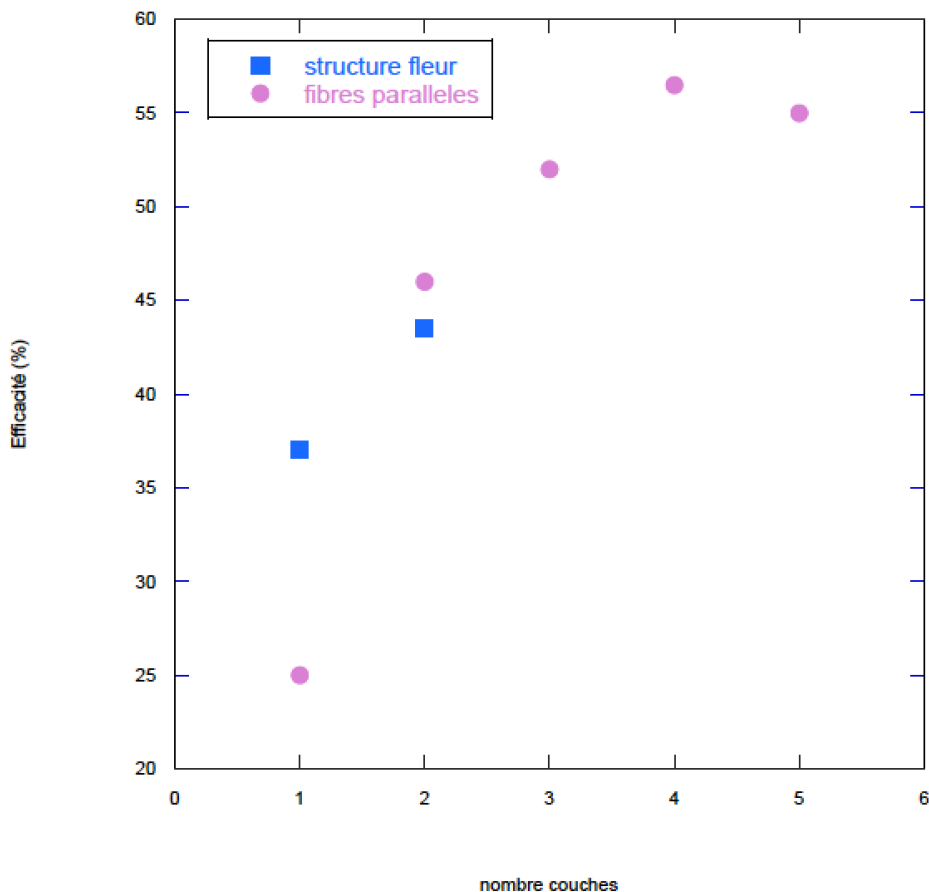


Figure 31. Graph depicting collection efficiency (as defined in percentage by division of the amount of collected water by amount of the water sent - vertical axis) of fibres arranged in a parallel vertical configuration (●) and in 'flower' configuration (■) with differing number of layers (horizontal axis). © Camille Duprat, 2020.

Data collected in our experiments in 2014 gave us good incentive to continue our research. First, it indicated that the idea of collecting water with flexible parallel vertical fibres had the potential to address the issue of efficiency in a novel way. Instead of focusing on a chemical enhancement, like the MIT-14 mesh, or the costly fabrication process of the 3D mesh, we could increase efficiency through careful understanding of the arrangement and physical properties of threads which are easily available; an approach that has not yet been fully explored in research on fog water collection. Second, our initial experiments made us aware of the need for a better-controlled system of fog production. Third, we realized that we needed a new method to fabricate our mesh/fibre substrate, and finally, that different kinds of structural forms would have an impact on water collection efficiency.

3. Technical Research and Experimentation

The 2014 artist-in-residence period played a crucial role in the development of our research. It not only specified the basic research question addressing the problems of clogging, re-entrainment and drainage, but it also mapped out some of the technical hurdles that needed to be addressed to achieve adequate experimental control. Our research thus tackled 3 issues. The first involved the development of a controllable fog mechanism, capable of producing water droplets similar in size to real fog (3.1). The second investigated a new fabrication method for flexible parallel fibres (3.2), including

experiments that build on these technological advancements in fog and substrate production (3.3). Third, I explored novel structural forms (3.4).

3.1 Creating Fog (2014 - 2018)

Fog is a cloud close to the ground that contains small and condensed water droplets from 1 to 40 microns in diameter. To run experiments on fog water collection, our first issue was figuring out how to generate controllable fog. In our 2014 experiments, we initially used a commercially available misting nozzle that we inserted into a garden hose connected to a sink tap. However, the nozzle produced drops larger than the range considered to be fog so we switched to an atomizer. The atomizer works like an old style perfume bottle. One end of a tube rests in liquid and when air passes forcefully across the other end, a vacuum is formed causing the liquid to be drawn up the tube. As the liquid leaves the tube the air breaks the liquid into small droplets, which then become dispersed with the air producing a fine mist. With the atomizer we were able to produce water droplets of 100 microns in diameter, which was better than the nozzle, but still too large for the typical range of fog.²²⁷ Given that we did not have a better method, the atomizer served as our mist generator in our first experiments.

Another issue we needed to address was the question of how to regulate and control the volume and wind speed of fog produced, which our improvisational mist-generating system did not provide. In 2015, science doctoral student Romain Labbé joined LadHyx and his research focused on fog-water collection and in particular on a fog-making apparatus. His first construction became to be known as the *soufflerie en carton* (cardboard wind tunnel) and was composed of a commercially available

²²⁷ 100 microns falls into the drizzle category explained in detail in Chapter 1, 18.

humidifier, previously used by Jean-Marc Chomaz for a video projection with artist Anaïs Tondeur, with a cardboard funnel attached to it. The cardboard wind tunnel had the advantage of producing a more directed fog flow with smaller sized water droplets and I used it during the *Architecting Water Collection* course, co-taught with Jean-Marc Chomaz, as part of the Summer School at the École Polytechnique in the fall of 2015.

However, the functioning of the *soufflerie en carton* was still not quite controllable and hence, Labbé continued to perfect it. First he substituted the humidifier with piezoelectric foggers emitting ultrasonic pulses that broke the water surface into tiny 4-microns droplets (within the range of naturally occurring fog). Later, he constructed a clear plexiglass chamber, in which the foggers rested on the bottom covered with 1.5 cm of water, kept at a consistent depth by a drainage system. The plexiglass chamber had two sets of fans, one positioned above the foggers producing a turbulent mass of accumulated water droplets, and the other located at the back of the chamber pushing forward the turbulent mass through a honeycomb filter, placed at the front of the chamber, that made the exiting fog more uniform. These advancements allowed Labbé to produce controllable fog (fig. 32), which he and we could use in experiments.

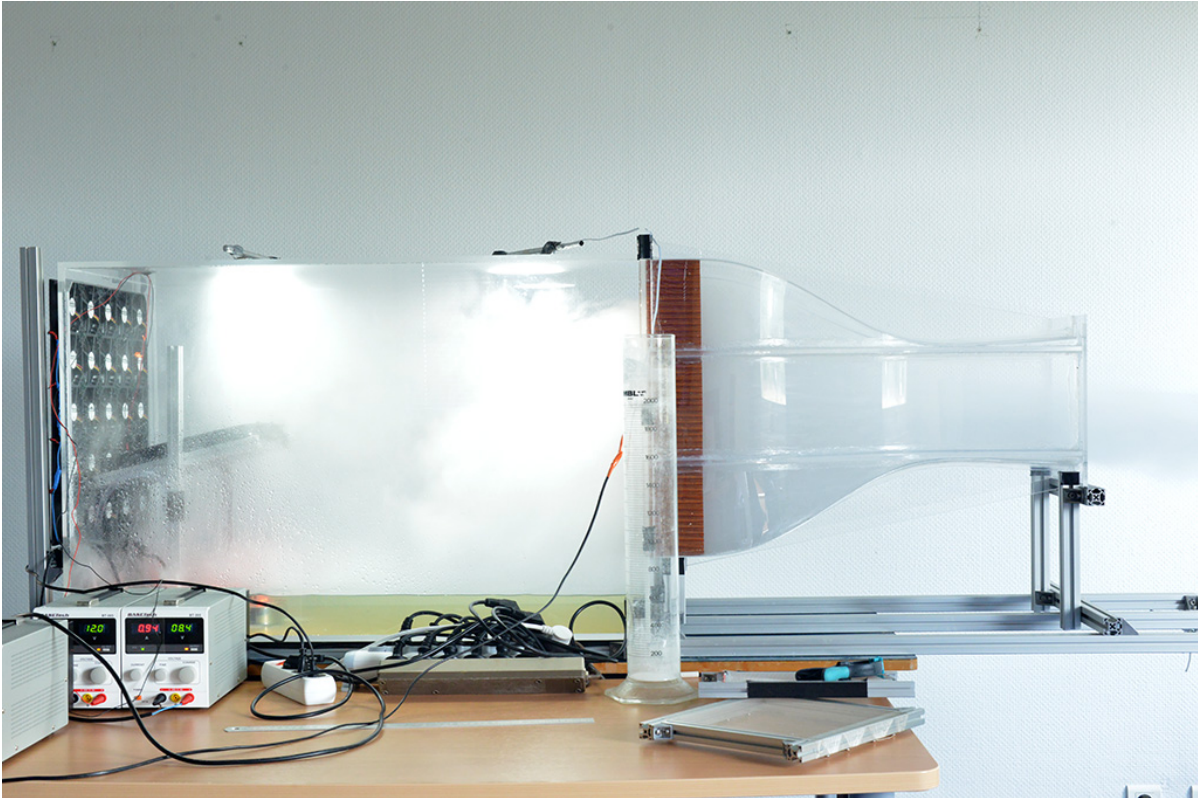


Figure 32. Wind tunnel fabricated by Romain Labbé to produce controllable fog. Ultrasonic foggers (not visible behind power supplies on the left) are covered with 1.5 cm of water. The first set of fans positioned almost horizontally above the foggers (middle-left) controls the amount of accumulated turbulent mass inside the middle chamber. The second vertical set of fans, seen on the left (black), controls the speed of the exiting fog, which is pushed through the honeycomb filter (brown, central) making the fog more uniform as it exits through the funnel (right). Both, fog's volume and speed are controlled by voltage adjustments on two power supplies operating two sets of fans separately. © Ana Rewakowicz, 2015.

Labbé's wind tunnel was approximately 2 metres long and was capable of producing an even output of fog over a 20 x 20 cm surface. To increase this surface, to be able to conduct larger-scale experiments, we would need to lengthen the wind tunnel. For example, to have a consistent fog output over an area of 100 x 100 cm, the wind tunnel would have to be approximately 10 metres long. Due to the impracticality of constructing such a long apparatus, our goal was to find a method that would allow

us to obtain a larger functional surface area without having to excessively lengthen the apparatus. Jean-Marc Chomaz and I attained the goal of a larger fog surface area with a relatively short chamber while maintaining low turbulence and high homogeneity through an unconventional approach, arising from our art-science collaboration. We worked on the design for a modular system that could enable us to control fog over a larger surface area, without the need for a longer chamber. This innovative design led to a novel fog-producing system with a functional surface area of 110 x 150 cm with the equivalent of a 1-metre long apparatus.

However to get to this new model, we needed to go through trial and error experimentation. Our first prototype of this modular system, called the *Mist Collector* (fig. 33), consisted of 10 plexiglass boxes, each containing two ultrasonic foggers with a small fan positioned above them and a panel of nine fans installed at the back of the box, pushing the produced fog mass through a honeycomb filter in front. Each box with a depth of only 38 cm had a 27 cm x 27 cm surface, but by placing 10 of these units together, they created a surface of 54 cm x 135 cm. By implementing this prototype, we discovered that the boxes were too shallow (the distance from the fans in the back to the honeycomb filters in front was too short) to produce the necessary volume of fog to evenly cover the entire surface at the exit.

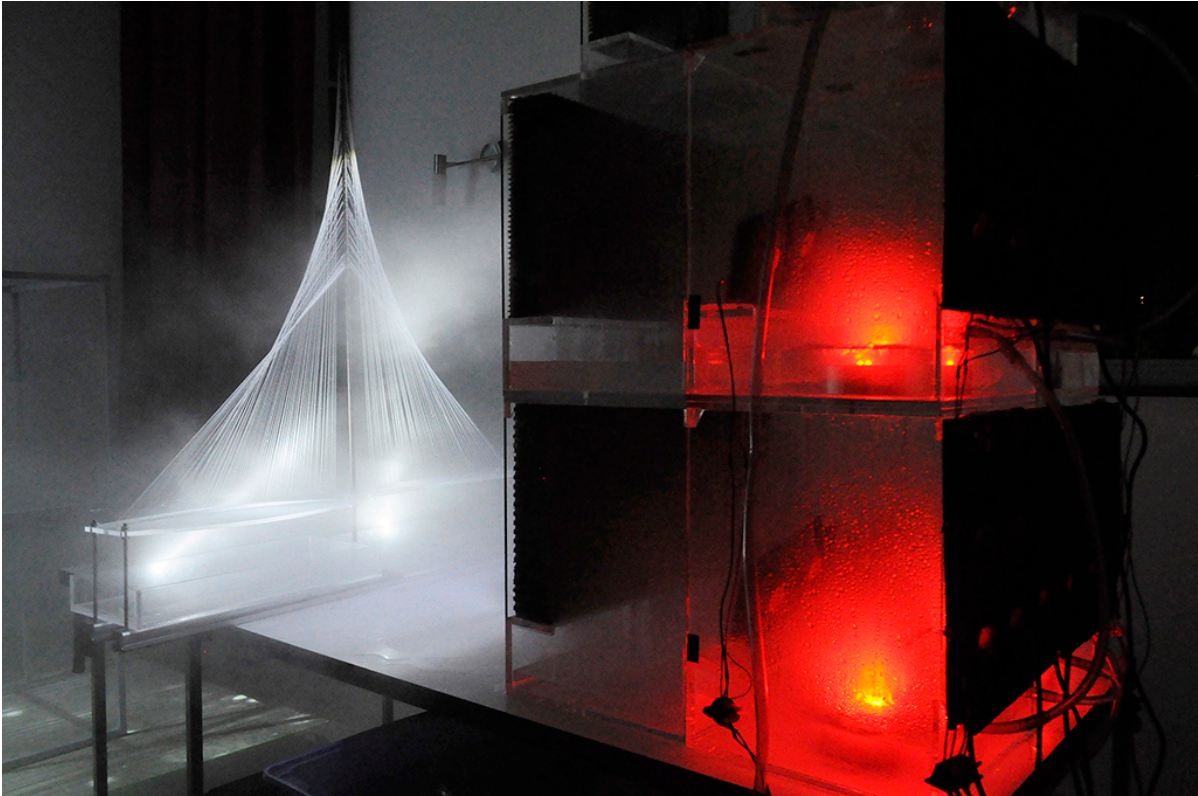


Figure 33. *Porous Sail* (left) and *Mist Collector* (right) prototypes presented at Open Studio event as part of the International Artist-in-Residence at Récollets, Paris, 2015. Here we see 2 of the boxes that made the *Mist Collector*. The fans on the right pushed fog through the honeycomb filters on the centre-left. The red lights are LED lights on foggers that lit up when they are activated. © Ana Rewakowicz, 2015.

Over the next two years (2017- 2018), we developed a second prototype that addressed the problems of the insufficient fog volume, as well as several other issues we encountered: water circulation, condensation and a lack of drainage on the inside of the honeycomb filters, as well as the need for waterproof fans. Our new prototype included 4 columns of 4 fog units, with 4 new water reservoirs at the bottom of each column. To provide the entire structure with airflow, we incorporated the 10 fog boxes from 2015 (without water) in 2 columns of 5, placed to the left and right side of the 4 new columns, as well as 4 new dry boxes (without water compartments) placed on top of the columns, as shown in the image below (fig. 34).

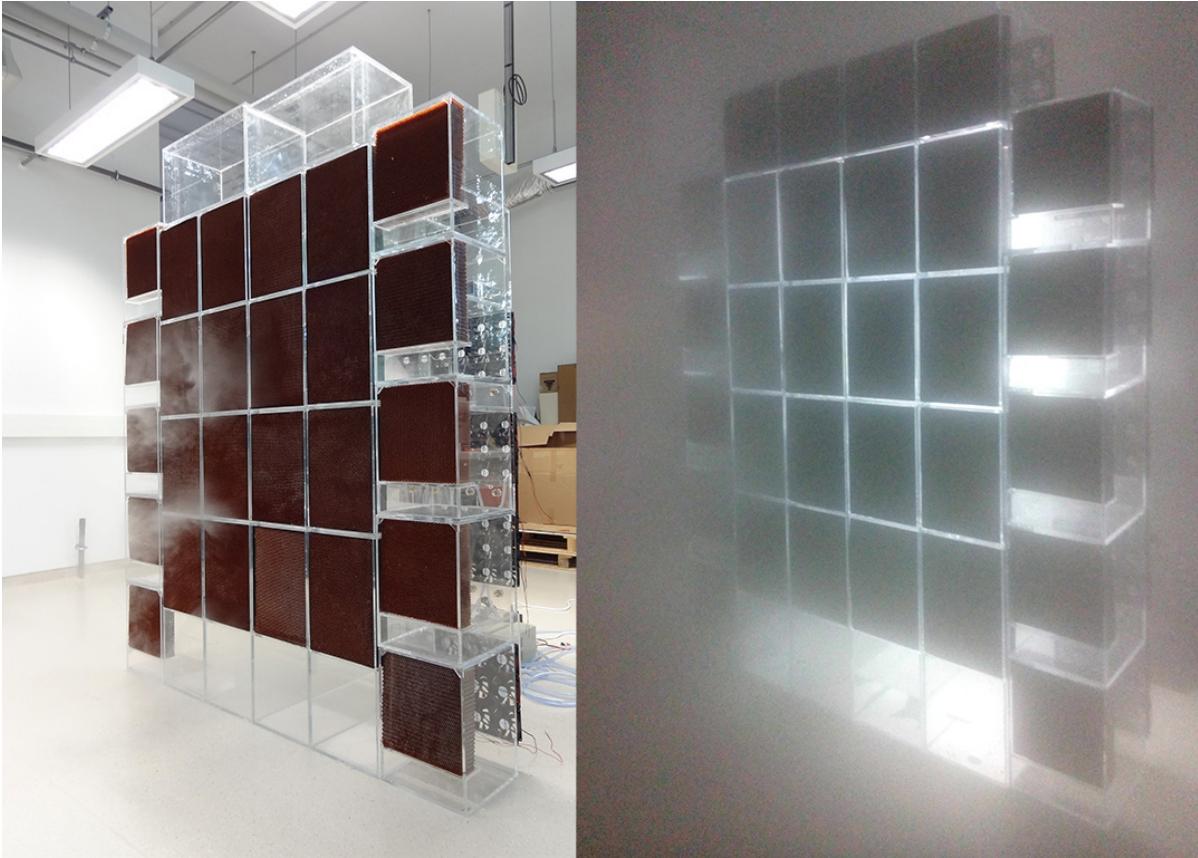


Figure 34. Second prototype of modular fog production system for the *Mist Collector*. Left image. Here we see the 16 new fog boxes (brown) on top of 4 (transparent) water reservoir boxes. To the left and right are columns of 5 dry boxes for guiding the generated fog with airflow. Right image. Here we see the apparatus in produced fog with 4 additional dry boxes on top of the 4 columns. © Daniel Schorno, 2017.

In this new design the units were three times deeper (1 metre) and water circulation was improved through reducing the size of the water compartments inside the fog producing boxes and separating water reservoirs by placing them at the bottom of each column. Using transparent plastic tubing and push-in pneumatic fittings (allowing for a quick, leak-free connection) inserted at the back of each box, we vertically connected pumps from the water reservoir at the bottom with the top fog producing boxes in each column. To maintain the level of 1.5 cm necessary for the proper functioning of the ultrasonic foggers, we drained water (using a second opening

at the back of the boxes) to the units below, filling and draining them at the same time, all the way until the remaining water returned to the reservoir at the bottom (fig. 35). To pump water up to the height of 1.8 metres, we used a powerful aquarium pump (JECOD DCS-4000) with an adjustable controller for regulating flow rate.

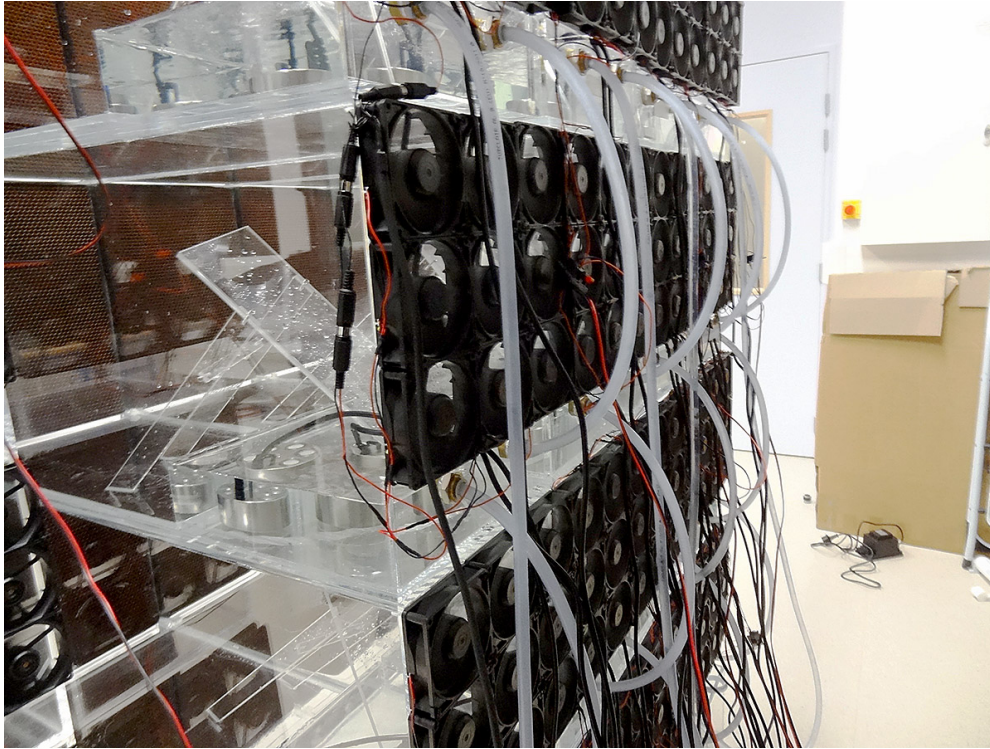


Figure 35. Detail of vertically connected tubing using push-in fittings. Each box has two openings at the back, one for water entry and another for drainage. A long tube connects the pump from the water reservoir to the top box of the column. Using gravity, the shorter tubes allow water to drain to the unit below, filling them and then draining in order to maintain the level of 1.5 cm necessary for the proper functioning of the ultrasonic foggers. © Daniel Schorno, 2017.

To solve the problem of water condensing on the inside of the honeycomb filters (that we observed in our early 2015 prototype), we made narrow openings on the floor of the boxes, just behind the honeycomb filters, permitting water to drain more easily through the units back to the water reservoirs.

Finally, the third crucial element that required our attention was the fans. In the 2015 prototype we noticed considerable splashing during operation that was wetting the fans and could eventually cause a short circuit. Hence we decided to replace the regular fans with 144 waterproof fans. With the help of internship students, we soldered 16 panels composed of 9 fans each in parallel circuits (like Christmas lights) to avoid the situation in which failure of one unit would cause the break down of the whole panel.

Our elaborate, modular system of fog production (cloud machine) that grew out of the scientific question of how to produce fog over a large surface without requiring a very long tunnel to reduce turbulence, became an artwork (*Nephelograph – Mist Impressions*). In contrast to Labbé's wind tunnel, the cloud machine apparatus has not yet been used for the purpose of scientific investigations.

3.2 Producing Nets for Collection (2014 - 2016)

While working on a controllable system for creating fog, we were simultaneously re-imagining the substrates upon which our fog would be captured. The image of a forest composed of vertical lines inspired us to create the first nets made of parallel fibres rather than grids. Our initial method involved passing a needle with a thread through holes made in pieces of plexiglass. This technique was sufficient for making small-scale models but, due to its time consuming nature, it was not efficient for quick adjustments often needed in experiments. This method was also not fitted for larger applications, such as fabric net production or a large-scale art installation. We needed to find a different technique. In the summer of 2015, I thought of working with larger one-metre long threaded rods (having screw-like grooves), positioning them at a

distance of 1 or 2 metres apart and rather than threading the fibre through holes in plexiglass, wrapping the fibre around the rods into their interstices. However, there were multiple issues that needed to be overcome. When I used people to hold the rods apart and threads under tension, the threads stayed in the grooves, but as soon as there was no tension, the threads would become loose and slide out and become tangled. This issue was quickly resolved with the use of instant liquid glue that permanently attached the threads to the metal rods, but it was more complicated to find a way of keeping the two rods apart without relying on extra hands (aka people). To do this, we ended up using heavy metal slabs (laboratory bases) into which we could screw the rods and keep them upright as we walked around them placing the thread in each groove. Using this method, we produced a first screen of 1 x 2 metres, discovering in the process another dilemma. No matter how lightly the thread was applied, tension kept building up, pulling two upper rod tops inwards and distorting the shape of the screen. Instead of the expected rectangle, we were getting a trapezoid. This challenge necessitated holding the upper rod tops in a fixed position to counterbalance the tension built-up. To do that, the rod tops were anchored with wires to the wall behind. The final set up for large-scale net production required two tables placed on the opposite ends of a long hallway with the threaded rods screwed into the metal slabs and secured with clamps to the tables, and the upper tip of the rod fastened with wires to two anchor points on the wall behind, high enough so there was room to walk under, as seen in a series of images in fig. 36.

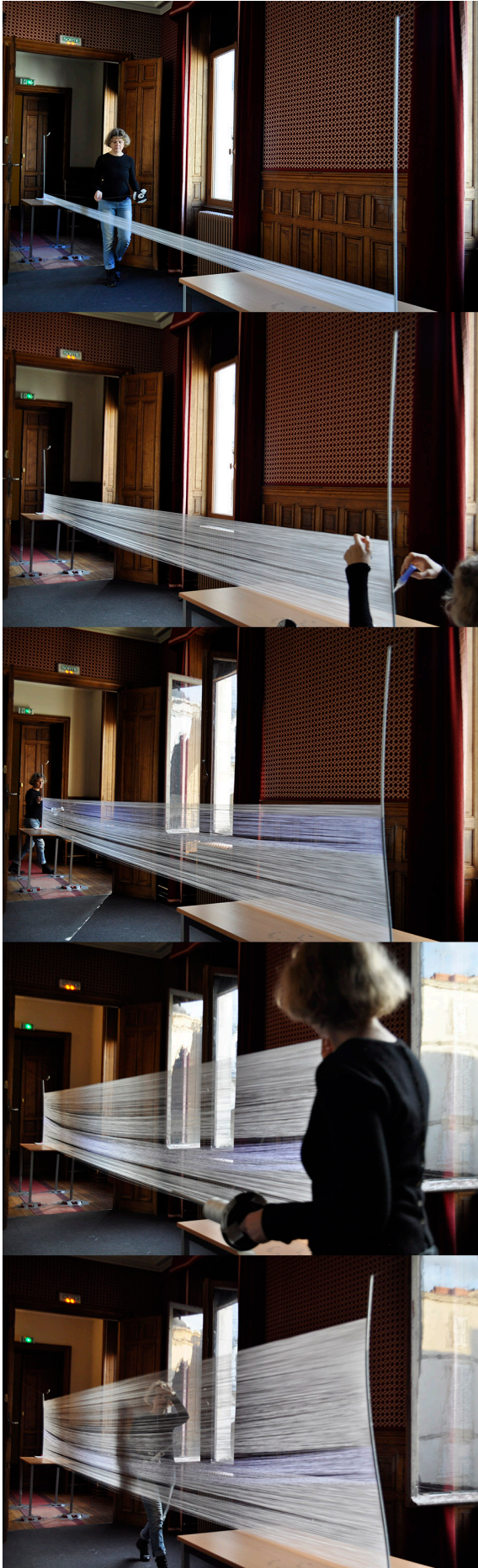


Figure 36. Image sequence of net production between two threaded rods at Centre Intermondes, La Rochelle, France. Each rod is attached to a metal slab, which is clamped to a table. The top of the rod is wired to the wall to counter balance the tension build-up and screen distortion. The net fabricator (me in these images) circumambulates the tables placing the thread into each interstice and gluing them in place (as seen in image 2 from top). © Ana Rewakowicz, 2016.

Using the technique of walking around two metal rods, we produced our first three large nets (1 x 10 metres) with the intent to employ them as projection screens in an art installation, as part of the 2015 Curiositas Festival taking place at CNRS castle in Gif sur Yvette and organized by Diagonale Paris-Saclay - our main sponsor. Despite our best efforts, this installation did not work out as envisioned. A lack of flexibility and understanding on the part of the organizers and miscommunication, amplified by language and cultural differences were all the factors that contributed to its failure. But every failure marks a new beginning and a year later we produced a successful installation based on this method of screen-net production. Working out our alternative method of net fabrication has indicated future challenges in making nets with parallel fibres using industrial processes. Making a fabric with only warp threads (usually held under tension on a loom to pass weft threads through) will require future research and development.

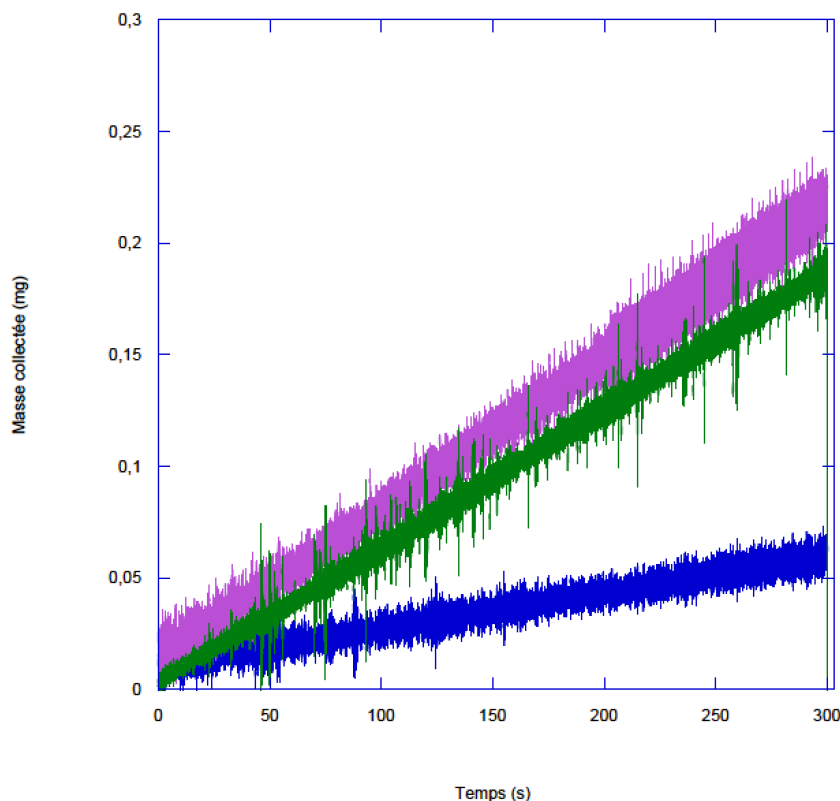
Similar to the modular fog production system that originated in the scientific question of how to enlarge the fog-generating surface area, the substrate fabrication method also derived from the scientific pursuit of how to make a collecting fabric inspired by the forest metaphor. And just as working on fog creating led to scientific insights²²⁸ and artwork, investigations into a substrate also went beyond science, resulting in artworks that expanded the scope of concern beyond the initial scientific questions.

3.3 Weaving Two Strands Together

²²⁸ In 2019 a new intern student at LadHyx, Adèle Moncuquet installed a large fog net prototype on an experimental site of SIRTÀ (Site Instrumental de Recherche par Télédétection Atmosphérique) at École Polytechnique to capture natural fog. I am not aware of any data being collected.

In 2018, Duprat and I combined these two strands of research: fog production and net production. Using Romain Labbé's wind tunnel that produced natural fog-like 4-micron water droplets, we tested the efficiency of a Raschel type mesh, a type of 3D mesh (the Aqualonis mesh²²⁹) and various arrangements of parallel fibre arising from our forest metaphor.

To measure water collection efficiency in a precise way, we weighed our net structures using a strain gauge (a sensor that detects pressure, tension and weight) before subjecting them to fog and over time as fog was being applied. First, we observed that regardless of the mesh we used, the mass of collected water increased linearly with time. We could thus deduce a collection rate (in mg per hour for instance), as shown in the graph produced by Camille Duprat (fig. 37).



²²⁹ The Aqualonis mesh produced by Aqualonis is a company founded by engineer Peter Trautwein, who patented the CloudFisher™ system for fog water collection that uses a 3D fabric spacer referred to in Chapter 1 as FogHa-Tin. The sample we used comes from the CloudFisher™ net employed in Morocco.

Figure 37. Linear increase of the collected water mass in mg (vertical axis) over time (horizontal axis), for white nylon coated thread arranged in 2-layers (purple), for nano-braided fishing filament thread arranged in 4 layers (green), and polyester thread in 1-layer (blue). Thus, white nylon coated thread arranged in 2-layers produced the highest yield of water per second, for a fixed wind speed. © Camille Duprat 2020.

Second, we also detected a rise of efficiency with an increase in wind speed, for all types of substrates. The change in efficiency (defined as the amount of water collected over time) in relation to the wind's velocity, as calculated by Duprat (fig. 38), shows that each substrate's efficacy increased with wind velocity (all lines slope up to the right), but that for some substrates the effect of velocity is greater (the slope of the line is steeper), e.g., 'poly 9 a 1' (black squares) or 'Acqualonis' (quadrant square) efficiency increases more rapidly with wind velocity than does 'poly 9 a 3' (pale grey squares).

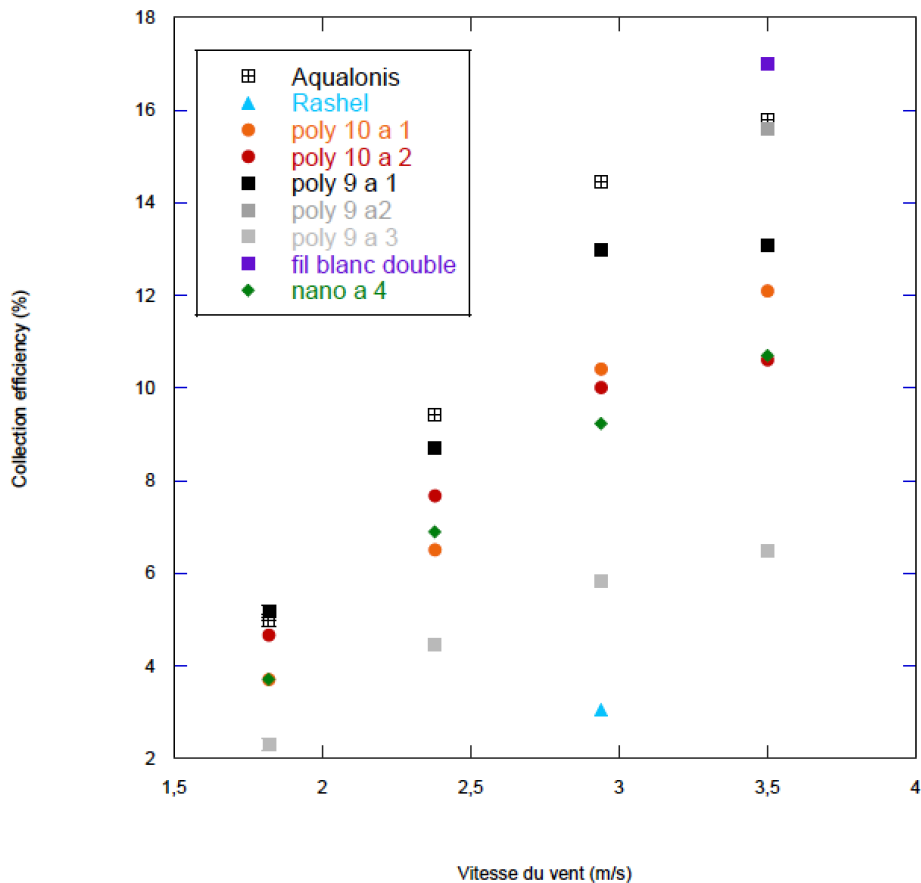


Figure 38. Change in collection efficiency (vertical axis) in relation to different wind velocities for different substrates (from top to bottom in legend): 3D Moroccan mesh (Aqualonis), Raschel net sample taken from a potato bag, polyester thread #10 in 1 and 2 layers, polyester thread #9 in 1, 2 and 3 layers, white nylon coated thread in 2 layers, white nylon coated thread in 2 layers and nano-braided fishing filament in 4 layers. © Camille Duprat 2020.

Third, in terms of substrate, we found that the traditional Raschel mesh actually performed quite poorly, and our parallel fibre arrangements were performing quite well, especially the white nylon coated thread arranged in 2-layer configuration, which outperformed all the other substrates at the 3.5 m/s wind speed (fig. 38). Although the 3D Moroccan mesh from the CloudFisher™ system was very effective, our substrates with parallel fibres were not far behind, indicating that our idea of multiple-layer ‘forest’ arrangements have potential. To better understand collection efficiency, we

decided to consider the relationship between collecting rate (defined as the amount of water collected over time) and mass of used materials. For example, in our experiments, we equated the frame size of our substrates to 18 cm x 5 cm. However, different substrates started with different weights that depended on different weaving patterns and arrangements. Thus, some used more material than others. Therefore, we decided to measure collection efficiency by dividing the collection rate by mass of fibres utilized. If we do this, parallel fibres substrates (even without the most efficient 2-layered option) were much more efficient (fig. 39).

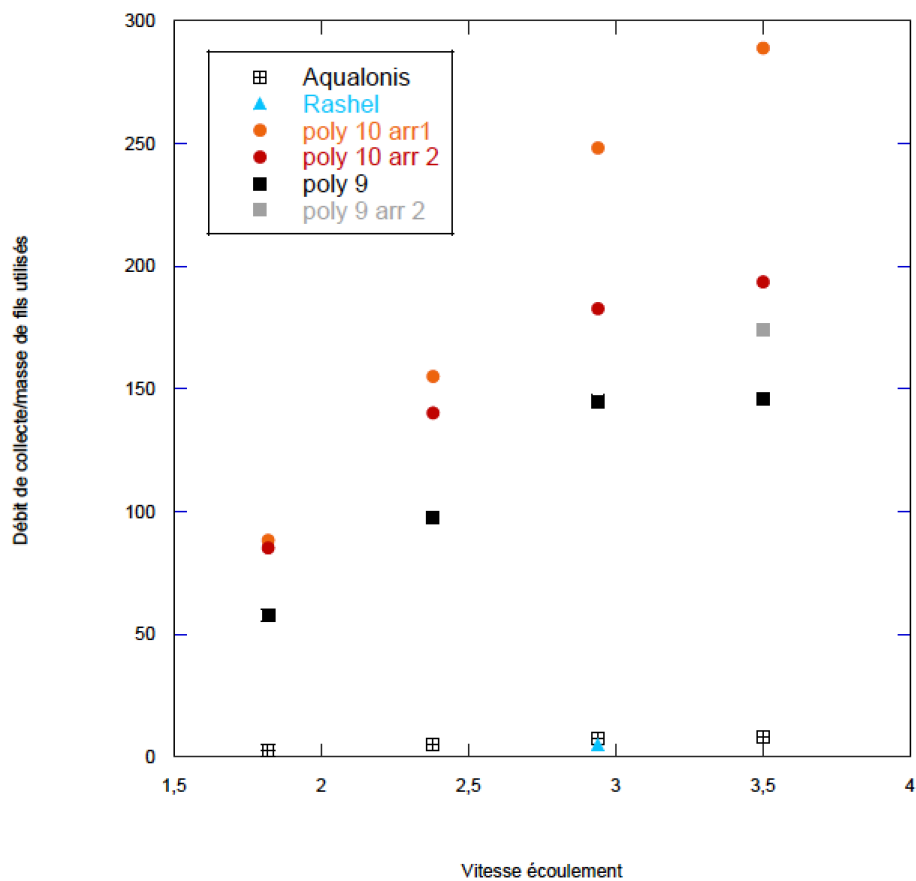


Figure 39. Efficiency, defined as collection rate divided by mass of used threads (vertical axis) in relation to the flow rate (horizontal axis). If we take into consideration mass of used thread, our parallel fibres substrates substantially outperform the 3D Moroccan Aqualonis mesh. © Camille Duprat, 2020.

3.4 Experimenting with New Structures (2014 - 2015)

In addition to our success with re-thinking substrates, we also explored the effect of structure on water collection efficiency, by thinking beyond flat surfaces, which have been the basis for fog collectors to date. Even when the substrate has moved to 2 layers with connecting fibres (as in the CloudFisher™ system), the global structure remains still essentially flat.

In 2014, inspired by the image of the forest, we were working with parallel vertical fibres. However, thinking about organization in nature, which appears to be less predictable, I was envisioning a multi-layer structure that, being made of parallel vertical fibres, could still capture a feeling of randomness, such as when walking through a virgin forest, where trees do not follow a specific spacing pattern, in opposition to a forest made-up of well-organized rows of re-planted trees. Having worked for years with geometry, constructing 3D inflatable objects from 2D sheets of latex or polyurethane, I immediately began thinking of the pentagon, as a base pattern for our forest structures.

Pentagonal or fivefold symmetry is common in nature, found in flowers, fruits (such as cross sections of apples), and animals (e.g., starfish, sea cucumbers). It has also been called a forbidden symmetry in crystallography (the science of molecular arrangements in solids) because until recently, it was not believed that such symmetry occurs naturally in crystals²³⁰ (solids with extremely well-organized molecular

²³⁰ Trevor Nace, "'Forbidden Symmetry' Found in 4.5 – Billion – Year – Old Meteorite," *Forbes*, June 27, 2017, <https://www.forbes.com/sites/trevornace/2016/06/27/forbidden-symmetry-found-in-4-5-billion-year-old-meteorite/>.

structures²³¹). Fivefold symmetry is captivating in that it appears to be asymmetrical although there is symmetry. Five-fold symmetry is also an efficient use of surface area. For example, petals in flowers with 5-fold symmetry get maximum sunlight without shading each other.²³² Moreover, 5-fold symmetry has been considered as a symbol of divine perfection and harmony of the human body, as illustrated in the Vitruvius Man (man with arms outstretched inscribed in a circle) by Leonardo da Vinci.²³³ Inspired by the pentagon, we arrived at clusters of flower patterns (fig. 40).

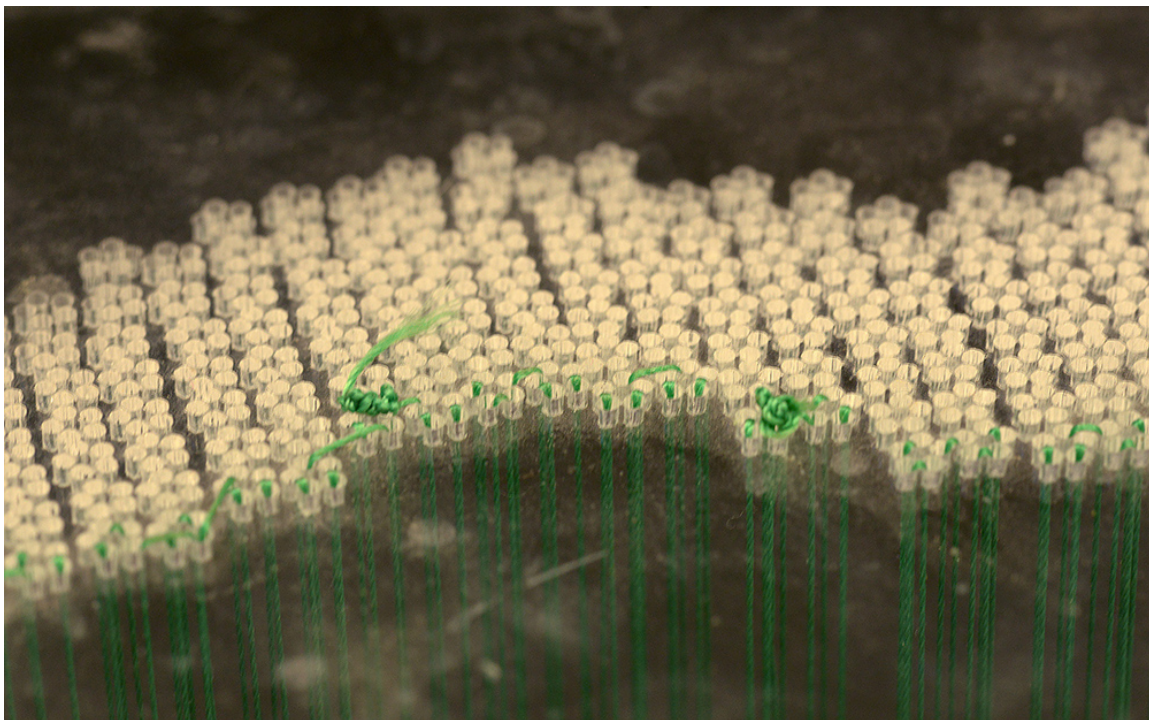


Figure 40. Laser cut holes (white) in plexiglass in repeating flower patterns. Each flower shows 5-fold symmetry and the flowers are distributed in 7 wavy layers. Towards the front of the structure, we can see green threads knotted and passed through the plexiglass extending down towards the another plexiglass rectangle. © Camille Duprat, 2020.

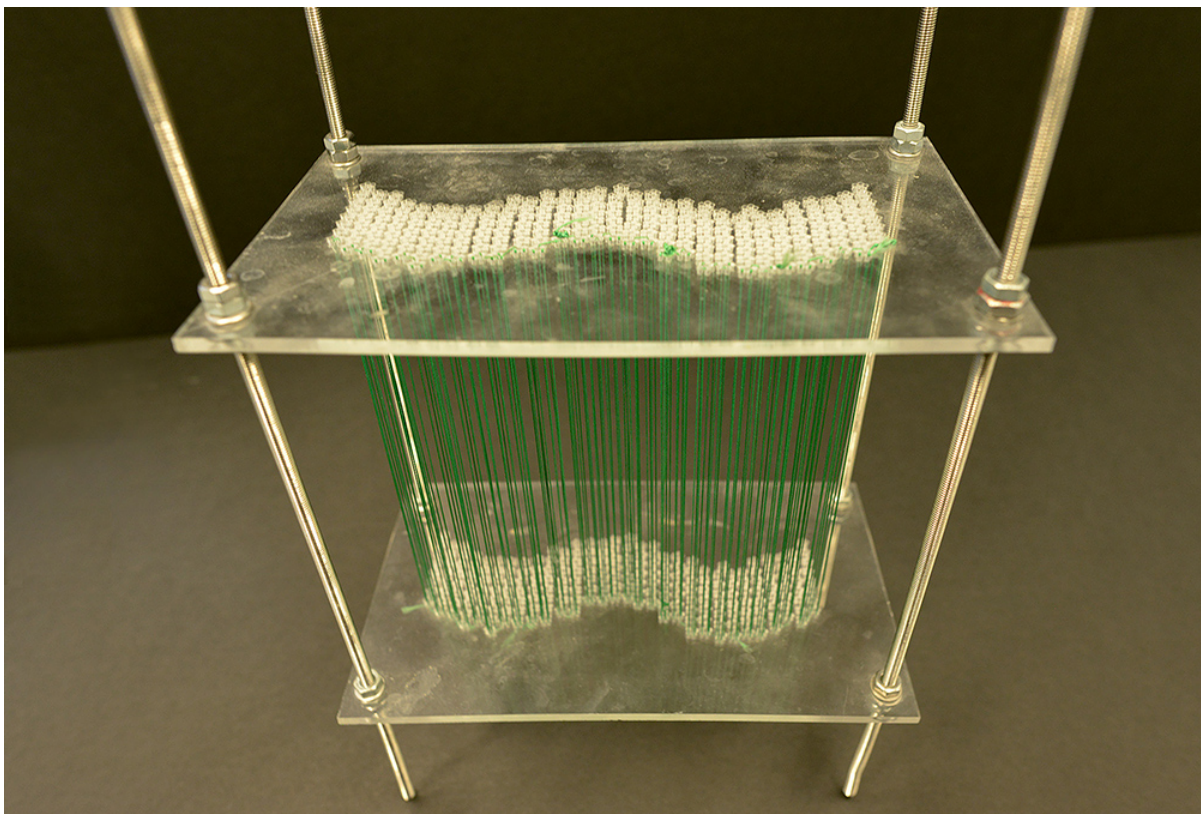
²³¹ "What are crystals," Let's Talk Science, accessed March 24, 2021, <https://letstalkscience.ca/educational-resources/stem-in-context/what-a-crystal>.

²³² István Hargittai, *Fivefold Symmetry* (Singapore: World Scientific Publishing, 1992), 532.

²³³ *Ibid.*, 20.

Taking turns in a laborious process of passing thread through laser cut holes in between two plexiglass rectangles, Camille and I made our first green²³⁴ forest. We called it the flower (fleur) structure (fig. 41).

The flower structure possibly holds a solution to the question of higher yields and the problem of re-entrainment (when wind blows the incoming water droplets away before they are able to grow large enough to be pulled by gravity to a collecting gutter). Data (however limited) from our preliminary experiments in 2014 suggests that collection efficiency increases in a straight line, which scientifically speaking indicates a stronger relationship between variables (fig. 31), implying that the flower structure might be less susceptible to re-entrainment with an increased number of layers, where the blown-away drops can be caught by fibres in layers behind. However, the full potential of this structure still needs to be explored.



²³⁴ The green colour refers to our first thread we found in the laboratory drawer.

Figure 41. Flower (fleur) structure. Here we see 2-layer strings weaved through holes arranged in 5-petal flowers. Even with 2 layers the structure gives a feeling of randomness, accentuated by the wavy configuration, as opposed to parallel multi-layer arrangement shown in fig. 29A. © Camille Duprat, 2020.

Our next idea was inspired by thinking about the wind. As we learned, wind plays a crucial role in the collecting process, as it carries small water droplets towards a substrate (rocks, thorns and leaves), on which they coalesce upon impact. Although it is due to the wind hitting the substrate that we are able to collect water from fog, it has been fascinating to learn that the wind ‘sees’²³⁵ what is in front of it and ‘tries’ to avoid any obstacles. Thus, from the perspective of aerodynamics, the mechanism of fog water collection presents an interesting dilemma. On one hand, harvesting of fog water happens upon impact, when water-laden air hits a substrate (such as a collecting net), and it is desirable to put the substrate perpendicular to the direction of the wind. On the other hand, it is not advantageous to have a substrate in the wind’s path, as the wind will ‘see’ it as a hurdle and try to avoid it. One of the solutions to this conundrum is to ‘trick’ the wind into perceiving that there is ‘nothing’ in its path, and never facing it directly. Sailors know this well. It is more efficient (and creates less strain on the sail) to have a sail at 30 degrees instead of 90 degrees to the wind.²³⁶ Hence inspired, we created a structure that would allow *sailing with* the wind rather than against it! Our porous sail combines the aerodynamics of sailing with the idea of a fabric made from warp threads only (parallel fibres).

The efficiency of the porous sail has yet to be tested, but the flower structure has

²³⁵ Throughout this section the wind is being anthropomorphized.

²³⁶ Allan Haeger, “Shaping Your Mainsail, Part 1: Angle of Attack,” SailZing, accessed April 5, 2021, <https://sailzing.com/shaping-your-mainsail-part-1-angle-of-attack/>.

shown itself to be efficient during small-scale testing. Again, although the science still has to be explored further, the art-science collaboration has led to a new artwork (*Porous Sail*, described more fully in Chapter 5) and to new conceptualizations for structures, first, by moving away from essentially planar structures, and second, by putting the structure into context, into a relationship with other active agents in the situation, such as water and wind.

In summary, the *Mist Collector* project brought art and science together to address the question of the efficiency of collecting water from fog. Our initial intra-actions between art and science encompassed a process of adaptation and learning to understand disciplinary differences, how to communicate and work together (section 1). This meeting of art and science cultures led to a novel metaphor for fog collection, a forest of parallel fibres, which set the direction for our technical research (section 2). By working with parallel fibres, we realized that some technical innovations were necessary. First, we needed better control over fog production (section 3.1). Second, we needed alternative fabrication methods for the substrates of parallel vertical fibres (section 3.2). Using our well controlled fog and exploring different substrates under different conditions, we discovered that relative to the mass of fibres used, our parallel vertical fibre substrates were more efficient at water collection than either of the two commercially available substrates (Rashel mesh, and mesh from the CloudFisher™ system), demonstrating the utility of our art-science collaboration (section 3.3). Third, by thinking outside the plane and bringing in relationships between water, wind and substrate, we came up with two novel collecting structural forms, demonstrating the value of re-thinking relationships (section 3.4).

Chapter 5

Responding Inclusively

In the previous chapter we saw how intra-actions between art and science changed the direction of scientific research on the efficiency of fog water collection by conceiving a new metaphor of a forest of fibres. The current chapter presents the artistic response to the same questions, a response that includes the creation of four artworks: *Through the Looking Mist...* (section 1), the *Porous Sail* prototype (section 2), *Misty Way* (section 3) and *Nephelograph (Mist Impressions)* (section 4).

According to Barad's theory of agential realism (described in chapter 3), an external perspective is not available, as it is not possible to describe 'things' independently of the process of description; *what is* (ontology) is always in relation with *how it came to be known* (epistemology). Instead, we have different ways of relating that can overlap like waves and produce different patterns of meaning of which we are an inseparable part. To apply Barad's way of thinking, in the passages below, my intent is not to represent the artworks as 'objects' with definitive meaning but rather as potentials, always ready for different engagement. In agential realism, objects and meaning arise through relationships, which are constantly in flux, and through changing relationships we have the opportunity to create a new vision and different meaning.

To help the reader experience the artworks through a changing set of relationships, I use a diffractive method of narration. In this method, different voices carry the reader through vignettes from different perspectives, in different styles of writing and with different formal (visual) characteristics (including changing the number

of columns, using poems, applying different fonts and arranging text on the page in non-traditional ways). Thus, I interweave descriptive and technical explanations with philosophical reflections, scientific interludes, lab logs, poetic encounters, recountings of public reactions, as well as images; all with the goal of engaging the reader to become part of changing relationships with the artworks, and hence part of the creation of meaning. Our journey is one that stitches together a new landscape and offers a relational experience of creation.

1. Artwork I: *Through the Looking Mist....* (2014 and 2016)

Seeing A Void

Through the looking mist... is a large slow motion video projection of water droplet coalescence on parallel fibres.²³⁷ The video was edited from video clips recorded as part of our initial experiments, in which we attempted to evaluate how water behaved on flexible parallel vertical fibres, to help understand how to effectively collect water from fog. Projected large, spectators/participants are able to see drops slowly appearing, growing and then falling. This spatio-temporal change of scale invites the spectators/participants to examine their points of view and to feel the phenomenon at the scale of a constitutive fog droplet.²³⁸ Similar to the heroine of *Alice in Wonderland*, whose body proportions vary depending on different spaces she passes through, the piece draws attention to the world, where importance does not depend on

²³⁷ Video documentation excerpt (2:35) available on Vimeo: <https://vimeo.com/258962626>.

²³⁸ Rewakowicz, Chomaz and Duprat, "Mist collector: Art and Science project", 130.

size, but on the balance of forces.²³⁹ In the video, a growing tension, the anthropocentric feeling of resignation facing the ineluctable pull of gravity, gives rise to different formations and various rhythms²⁴⁰ (figures 42, 43 and 44). In all presentations, the video captivated people and held their attention for many minutes.

Figure 42. *Through the Looking Mist...*, 5-metre by 1.25-metre video projection of water droplets sliding down parallel vertical fibres on a wall at the Zayed University Gallery in Abu Dhabi, United Arab Emirates. Group exhibition, as part of International Symposium of Electronic Art (ISEA 2014). © Ana Rewakowicz, 2014.



²³⁹ Ibid.

²⁴⁰ Ibid.



Figure 43. *Through the Looking Mist...*, 10-metre by 2.5-metre nocturnal video projection on the side of the Centre Intermondes building in La Rochelle, France. Part of the solo exhibition entitled *In Conversation: Art and Science*. © Ana Rewakowicz, 2016.

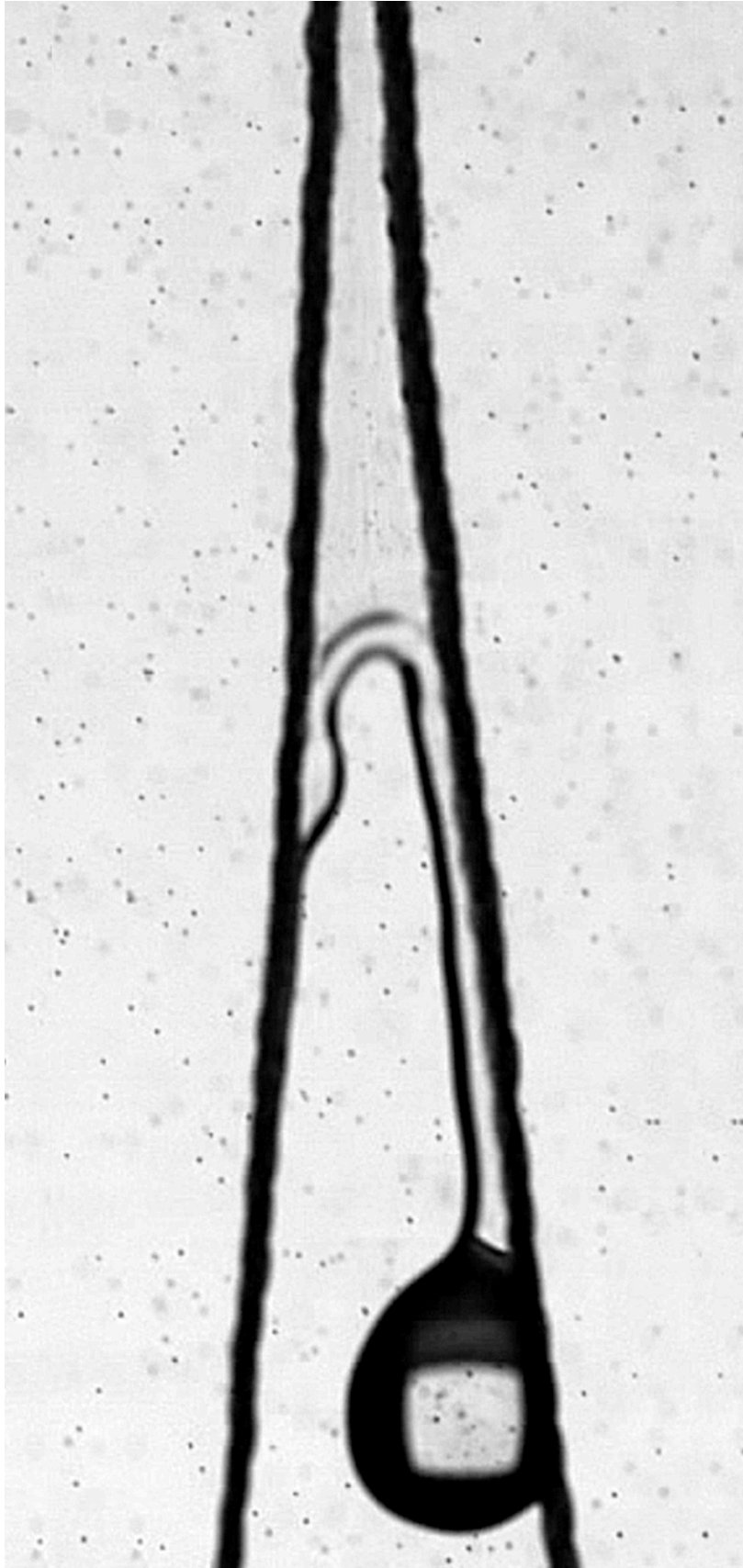


Figure 44. Video still of a water droplet breaking from a film between triangular fibres, recorded with a fast (high-shutter speed) camera. © Ana Rewakowicz & Camille Duprat, 2014.

Lab Log 1.

September 29, 2014, at 9:30, Prefab, LadHyx, École Polytechnique, Palaiseau, France.

A fast camera connected to a computer operated by software captures consecutive images (snapshots in time) of water collection from mist we have generated. The high-speed camera is capable of taking up to 10,000 images per second, which is more than I can distinguish with my eyes or my conscious brain. For example, when I look at fog I cannot perceive individual water droplets but with a fast camera I can see differently sized particles (drops) moving around. Regardless, no matter how many images the camera records, the playback depends on the frame rate, which is how many images (frames) can be replayed each second in sequence (in fps or frames per second) that determines the speed of a film. Movies in North America are played at 30 fps (known as NTSC) and in Europe at 24 fps (known as PAL), which is supposedly the minimal number of images per second, at which the human eye does not perceive image flickering.²⁴¹ In our experiments, for example, if we record at 1500 fps and play it back at either 24 fps or 30 fps, suddenly, one second becomes 50 seconds. This realization confuses my senses; I did not think that time would be stretchable and that we can slow it down or speed it up. Does it mean that what I can or cannot see depends on time? Does that mean that if every cell in my body could stop, I could see 'everything'? Would there be no more space, as there would be no time?

²⁴¹ Hypothetically, it is possible to send subliminal images that are not perceived with the conscious brain and supposedly, during the 1950s, cinemas used the so-called 25th frame effect to put images of coke or popcorn at every 25th position before breaks to subconsciously influence customers to buy food and drink during intermission. Apparently, based on this rumor, Congress in the US "passed a law against such subliminal manipulations." Lewis Miller, "How many frames can human eye see?," Physics StackExchange, last modified July 1, 2016, <https://physics.stackexchange.com/q/227643>.

Lab Log 2.

September 30, 2014, at 14:30, Building 67, LadHyx, École Polytechnique, Palaiseau, France.

Buckminster Fuller said that our bodily senses are tuning apparatuses “within the physical, sensorial range of tunability of the electromagnetic sensing equipment with which we personally have been organically endowed.”²⁴² Furthermore, Fuller indicates that things that we are not aware of are simply things that we have not tuned into yet, or perhaps touched. Could the camera as an extension of my eye bring me closer to see/touch a single water droplet in fog?

Lab Log 3.

September 30, 2014, at 17:30, Building 67, LadHyx, École Polytechnique, Palaiseau, France.

Watching water drops coalescing on parallel vertical fibres, I could not but think of time in water’s generative cycle of giving and receiving, living and dying, and the temporal nature of life. In their cycle of emergence and disappearance, I saw an ode to life, in which time is not linear but cyclical. And if everything is cyclical, there is nothing to progress towards other than the end of the cycle, which is nothing more than a new beginning.

²⁴² Fuller and Applewhite, *Synergetics*, Synergy 100.62.

Diffraction 1: on time

Westerners usually perceive time as a linear progression of events that has directionality, flowing from the past, through the present into the future. We are born, we get older while knowing that we were younger before, and we die. We live through daily changes of day and night and have memories and traces of the past but have no memories of the future. Yet, in the fundamental laws of physics, there is no difference between past and future, and the present is blurry, what seems like ‘now’ depends on the distance that light has traveled between us and whatever we perceive; seeing is already always located in the past.²⁴³ “There is very little time in

²⁴³ Carlo Rovelli, “The Physics and Philosophy of Time,” The Royal Institution of Great Britain, June 13, 2018, Video, 54:53, <https://www.youtube.com/watch?v=-6rWqjhDv7M>.

nature,”²⁴⁴ declares theoretical physicist Carlo Rovelli in his lecture at the Royal Institution in London in June 2018. Yet, this is not how we experience time in our lives. So from whence does the flow of time that starts somewhere in the past and goes to an undefined future come?

Only one branch of physics, thermodynamics (the study of heat, work and temperature) distinguishes between past and future.²⁴⁵ “The link between time and heat is therefore fundamental,”²⁴⁶ asserts Rovelli. For example, he says “thinking produces heat in our heads...”²⁴⁷ Our experience of time’s directionality (called the

²⁴⁴ Rovelli, “The Physics and Philosophy of Time.”

²⁴⁵ Jim Lucas, “What Is Thermodynamics?,” *Live Science*, May 7, 2015, <https://www.livescience.com/50776-thermodynamics.html>.

²⁴⁶ Carlo Rovelli, *The Order of Time* (New York: Riverhead Books, 2018), 24 -25.

²⁴⁷ Rovelli, *The Order of Time*, 25.

arrow of time) is a consequence of the second law of thermodynamics, which states that heat cannot pass from a cold body to a hot one.²⁴⁸ This “irreversible progress of heat in only one direction”²⁴⁹ is called entropy, a quality we intuitively understand when we know that the hot cup of tea sitting on a kitchen table will get cooler and that the probability of it getting hotter is small.²⁵⁰ As heat moves from the hot body to the cooler one, we say that entropy increases. Thus, entropy is a measurable quantity that can remain the same or increase, but never decrease in a closed system.²⁵¹

A common understanding of entropy links it with a measure of

²⁴⁸ Ibid., 24.

²⁴⁹ Ibid., 25.

²⁵⁰ Richard Feynman, “The Character of Physical Law (1964) – Complete,” Cornell University, February 1, 2019, video, 5:59, <https://www.youtube.com/watch?v=kEx-gRfuhhk>.

²⁵¹ Rovelli, *The Order of Time*, 26 - 27.

‘disorder.’ Since heat is kinetic (moving) energy, there is an a priori assumption of the primal state of order, from which a more and more complicated, thus ‘disordered’ (less possible to predict) condition has evolved. Rovelli gives an example of a deck of cards, in which the first twenty-six cards are red and the following twenty-six cards are black, put together in some order. If we shuffle the deck, the previous order (low entropy) will be lost and cards become mixed, thus creating a configuration of higher entropy.²⁵² And it would be almost impossible to put the cards back to the original order in which they were before shuffling. Even if we were to put all the red cards in front and the black behind, it does not mean that they would be in the original arrangement.

²⁵² Ibid., 31.

However, Rovelli points out that is it us who assigns the first shuffle of the cards as ordered. To him, it is us who interacts with a system in such a way that we situate the *order* in the past, assuming that things were more organized *before* than they are *now*. Thus, it is us who decided that the first twenty-six red cards followed by the twenty-six black cards is the primary state of order. In fact, Rovelli suggests, following American neuroscientist and psychologist Dean Buonomano, that the flow of time is an inherited function of our brain,²⁵³ necessary to our survival. Perhaps we could say that organization of time depends on our memories that play a key role in the survival process. We learn by memorizing and memorize by repeating so we can do things without thinking. Perhaps being alive in a given surrounding depends on our

²⁵³ Rovelli, "The Physics and Philosophy of Time."

environmental memories of 'fight or flight,' repeated so many times that they can be performed without thinking (because thinking takes time and heat).

Hence, if humans cannot exist outside of time, time becomes their main source of suffering because it reminds them of their temporal existence and inability to hold onto things, including memories. If time is an innate part of our existence then perhaps it is not a single everlasting entity flowing outside of us, but rather, like our lives, "is born, lives and dies."²⁵⁴ And if we can relive time again and again, we have no need to hold onto it in fear of losing it. It will be (re)born again.

²⁵⁴ Barad, "On Touching (v 1.1)," 155.

Lab Log 4.

October 8, 2014, at 10:30, Building 65, LadHyx, École Polytechnique, Palaiseau, France.

Cut. Editing requires memorizing and internalizing every video clip so it becomes mentally available at a glimpse. One clip calls the other and the next calls yet another. They follow like thoughts until the brain overheats from different arrangements. Creation is an anti-entropic activity that decreases entropy by bringing 'order' to the chaos of a multitude of unorganized clips. This order is the one envisioned by the maker and once created offers additional possibilities for the viewer/participant to re-order through intra-action.²⁵⁵ The viewer/participant's intra-actions will generate distinct sequences (memories) and create meaning that is less predictable (has higher entropy) in the process.

Cut. There is a gap in the sequence; we are missing a clip. In one moment we see water drops coalescing on parallel fibres and then we see them falling but these are two different views (frames). In one, the camera's frame is set on the upper section of the collecting structure, in the other it is positioned on the lower proportion but we do not know how a water droplet got from one part to another.

Cut. When the camera moves spatially while filming continuously, it is called a pan, which means that the camera shows a path between one fixed position and another. You can pan from left to right, right to left, up down and down up if the camera is mounted on a tripod, or in any imaginative way if you hold the camera freehand. However, if you move the camera too much, you might end up with *The Blair Witch*

²⁵⁵ Following Barad, I do not distinguish between mental and physical and consider mental processes as physical.

Project effect, which is a 1999 American horror film that uses shaky camera movement to accentuate a nauseating feeling (of fear and anxiety).

While panning deals with movement, an added transition in editing acts like glue between clips. For example, it can involve fading out the end of one clip and fading in the beginning of the next or overlapping the distinctive ends and beginnings of clips by blending them together. There are different ways of combining clips, but often using too many transitions creates a feeling of commercial ads (especially TV ads from the 1980's) and I do not like it. I prefer cuts, which is putting the end of one clip with the beginning of another with no transition in between. Cuts are like eye blinks; every time you blink a new scene pops up. They are like quantum leaps, where electrons jump between orbits with specific energy levels, they do not stay in between. To get a good cut is like looking for a specific energy level and to find it you can 'roll' the end and beginning of two clips in such a way that when you extend the end of one clip, you cut the beginning of the other and the opposite way around. It is a bit like turning the knob on a radio a little bit to the left, a little bit to the right, until you get clear transmission (the right energy level). This is when you know that your cut is good. It vibrates.

Cut. But if there is a gap, if one clip does not follow the other, a transition will not fill it. It would be like combining two different sentences into one, a comma or a colon would not fill the gap in meaning. You would not be able to make sense of its meaning. We definitely need a new clip. I approach Camille and we decide to film and pan from the upper to the lower part of the structure, where we can see the dripping drops. It is not easy! The fast camera sitting steadily on the tripod is not intended to follow movement.

Cut. Quantum mechanics asserts that position and momentum cannot be simultaneously determined. Heisenberg calls this impossibility *the uncertainty principle*, while Bohr calls it *the principle of complementarity*. Bohr says that we cannot determine both the position and momentum, because these characteristics require different measuring apparatuses with fixed and movable parts respectively.²⁵⁶ How can we make a fixed camera move?

Cut. Do you remember using an old style of microscope? The most difficult part is positioning what you want to see in view. The slightest touch of the glass slide, on which sits the object you want to observe makes it disappear. Working with a fast camera firmly attached to the tripod with high magnification, is similar. It behaves like a microscope and it is not designed for movement. And here we are, trying to make it to conform to our desires, as if against its will. We fail and fail again, taking turns out of frustration. Who can use the bigger power of persuasion? Who can control their hand better? Who will have a better luck to convincing the camera to do what we want?

Final Cut. The fast camera gave in – we got a pan shot.

Seeing A Void

From nothingness

*a drizzle, or a quiet snow, or a misty rain, or pelting rain, or a stinging sleet, or at times a hail
materializes and unfolds.*

²⁵⁶ Barad, *Meeting the Universe Halfway*, 112.

*It is mesmerizing to see small water droplets becoming visible points in space,
emerging on thin lines of flexible threads.*

*They coalesce, slowly grow bigger
and struggle to stay attached in the airflow.*

When their mass overcomes surface tension they give into gravity and fall.

*At other times, the water's surface tension brings two adjacent fibres together creating
capillary bridges that then,
turn into long liquid columns.*

*Different geometries produce different behaviours;
triangulated threads produce a thin film that deforms fibres by bringing them closer together,
the film elongates, stretches to the maximum capacity and breaks, yielding a water drop.*

A dance, a cycle between a rise and fall.

Could this be a more efficient way of collecting water from fog?

We measure, we weigh, we observe, we repeat and we wait.

2. Artwork II: *Porous Sail* Prototype (2015)

Sailing with the Wind

The *Porous Sail* prototype is a new proposition for an aerodynamic structural form. Wind is an essential factor in harvesting water from fog, as it causes tiny water droplets in fog to coalesce into bigger water droplets upon impact with a substrate. However, putting an obstacle in the wind's path is not the most efficient way of causing coalescence, so we thought of the idea of 'going with the wind,' like a sail. To do this, we imaginatively

speaking stretched the surface of conventional fabrics to the point where all that is left were warp yarns (threads stretched lengthwise on a loom) and applied the mathematical concept of ruled surfaces to allow the creation of different 3-dimensional shapes from the movement of a straight line (a thread). For example, a cone is a ruled surface structure made by the movement of a straight-line segment fixed in space on one end while its other end traces a circle (fig.45).

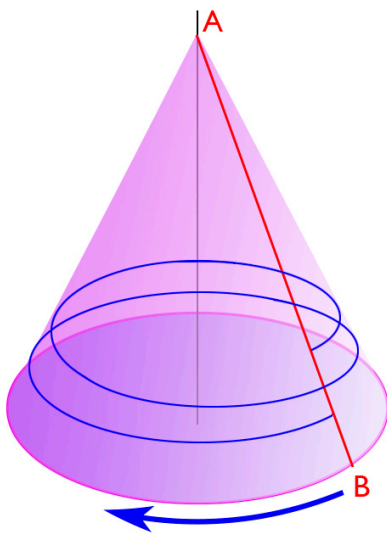


Figure 45. A cone can be described as the surface (lilac) created by a line (red) with one end (A) fixed and the other end (B) tracing a circle (purple) on a plane, following the direction of the blue arrow. Instead of the red line tracing the purple circle, one could imagine thousands of threads starting from A and attaching to different points along the purple circle. The resulting cone shape is a ruled surface. © Ana Rewakowicz, 2021.

Working with ruled surfaces required applications of a logic of twisting, which was demanding while stimulating at the same time. I first proceeded with simple tests to understand the process and produced small structures, passing a thread from top to bottom in such a way that it would create a twist while not being twisted, as depicted in images below (fig.46).

Later, together with students participating in the *Architecting Water Collection* summer course at École Polytechnique in 2015, we fabricated a hyperboloid, a shape that appears a bit like a twisted cylinder, as displayed in the image below (fig.47).

Figure 46. Small-scale ruled surface trials, which show how straight threads being passed from different points on a structure can produce shapes that appear to be twisted but are not, while creating 3D forms. © Ana Rewakowicz, 2015.

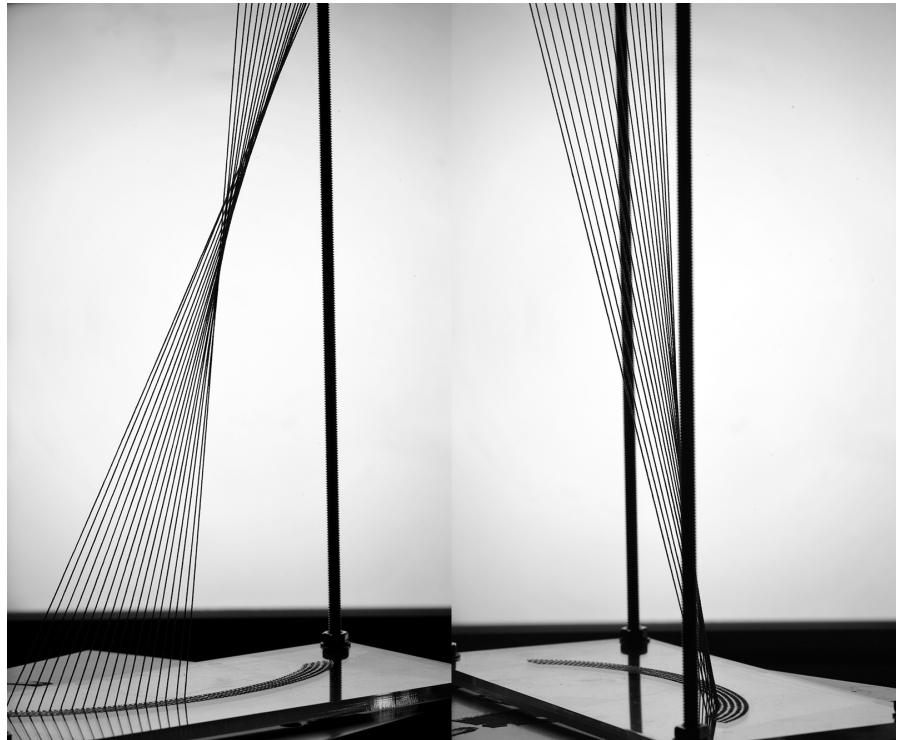


Figure 47. Hyperboloid presented in an experimental set-up, is another example of a ruled surface structure tested in collecting water from fog. Made with threads of different colours by students as part of the *Architecting Water Collection* summer course (École Polytechnique, 2015). © Ana Rewakowicz, 2015.

The experience I acquired from trials and working with students, allowed me to create the *Porous Sail* prototype, which is a structure resembling a double sail (two sails on opposite sides of a mast) with threads twisting around a central 'mast' and following patterns of reversed curves in plexiglass plaques on opposite sides of the mast (fig.48).



Figure 48. *Porous Sail* prototype in mist – an experimental aerodynamic structure in the shape of a double sail for collecting water from fog. The porous sail prototype is a complex ruled surface resulting in a 3D structural form composed of parallel fibres. Open Studio event, International Artist-in-Residence at Récollets, Paris. © Ana Rewakowicz, 2015.

3. Artwork III: *Misty Way* (2015-2016)

Water Encounter

Through the Looking Mist... centred on the observation of water droplet behaviour on flexible parallel vertical fibres and explored the idea of seeing invisible to the human eye water droplets through the relationship with a fast camera. *Porous Sail Prototype* explored the creation of an aerodynamic structural form that can be made with parallel fibres using the concept of ruled surfaces through a relationship with the wind. The current artwork - *Misty Way* focuses on the (re)creation of the environment in which fog water collection happens (an audio-visual installation) through the relationship with water, while incorporating the new net fabrication method with threaded rods described in chapter 4.

In 2015 we decided to zoom in further and use a high-speed camera with magnification to capture single water drops in mist. Filmed against an LED light panel, the captured water droplets became dark circles, which when inverted in editing software, transformed into white sparks moving across a black background and oscillating to their own rhythms – see image below (fig. 49).



Figure 49. Magnification of water droplets in a mist captured with a high-speed camera with colour inversion such that water droplets appear as white spots against a black background. Video still © Ana Rewakowicz, Camille Duprat, Jean-Marc Chomaz, 2015.

We projected this video footage along the fibres of a 1 x 2 metre screen suspended from metal frames, as shown in the image below (fig. 50), and while doing so discovered a 'double projection' visual effect in which a part of the light-droplet footage was visible on the parallel-fibre screen and the rest, bypassed the screen and spread onto the floor.

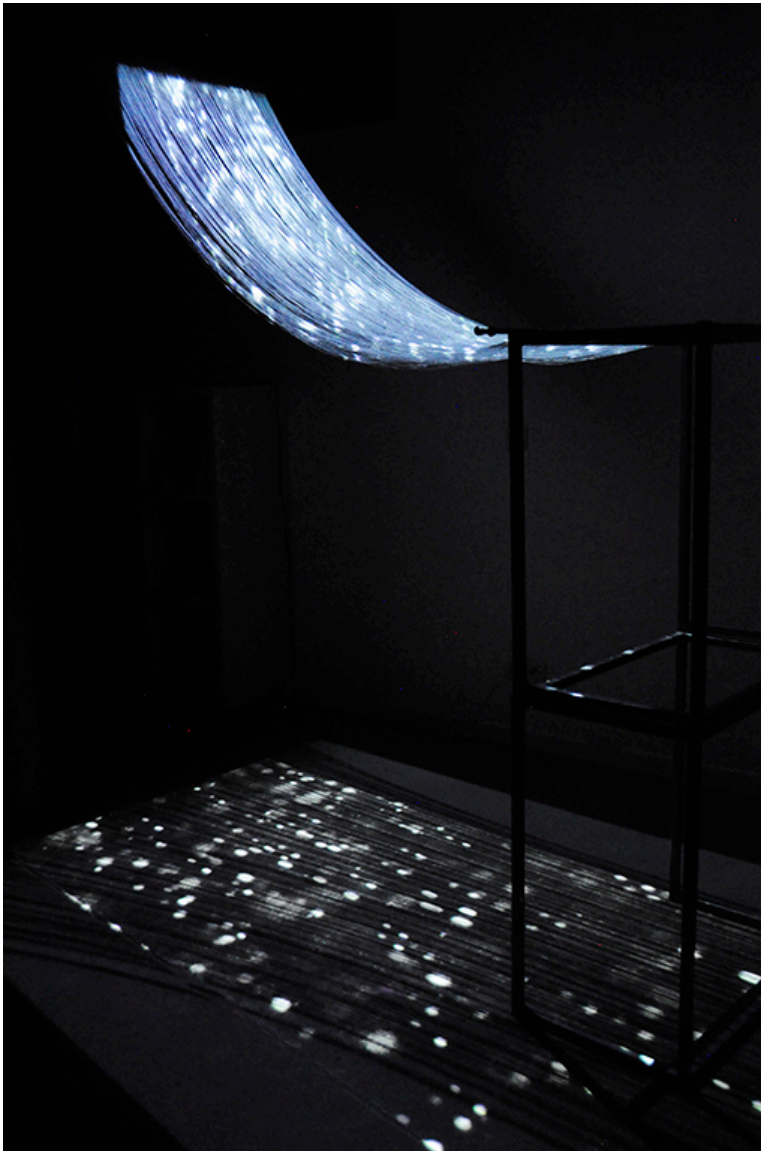


Figure 50. *Misty Way* prototype presented at the Open Studio event at the International Artist-in-Residence at Récollets in Paris, displaying an effect of a double projection on the screen and the floor. © Ana Rewakowicz, 2015.

With the projector behind the observer/participants who was looking along the length of the parallel fibres, a tunneling impression was created, where waterlight droplets from the screen, mirroring waterlight droplets on the floor, appeared to be moving away and disappearing into the darkness (fig. 51).

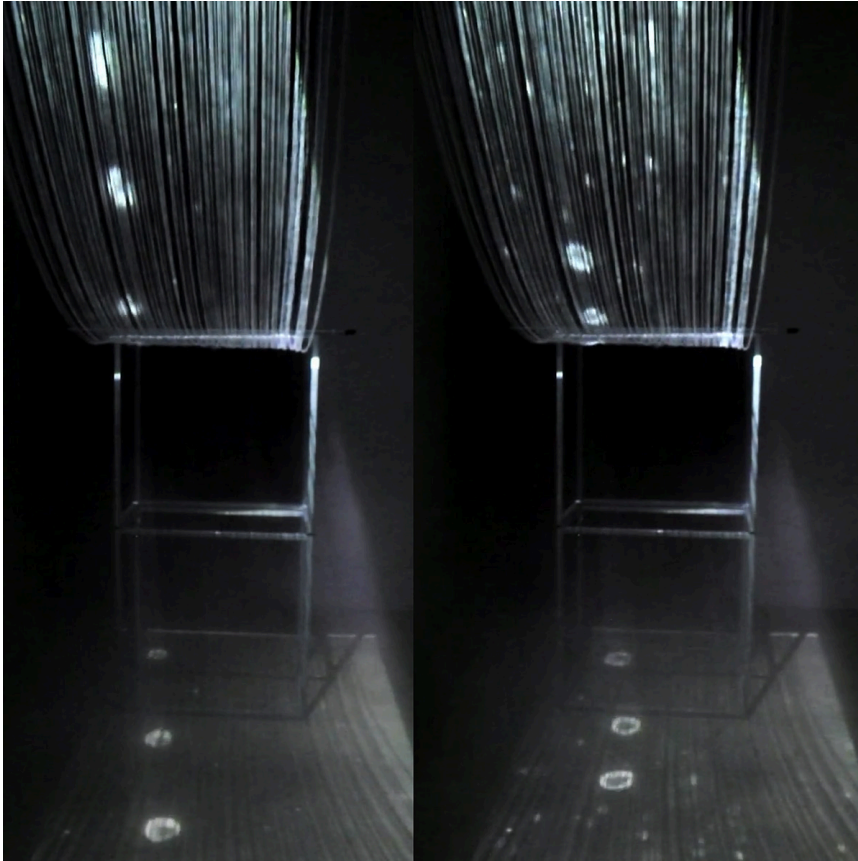


Figure 51. In these video stills taken from under the projector looking towards the metal frame along the lengths of the parallel fibres, we can see the tunneling effect where mirrored water waterlight droplets appear to be moving away and disappearing into the dark distance. Video stills, <https://vimeo.com/manage/videos/150961832>. © Ana Rewakowicz, 2015.

This intriguing tunneling effect was quite mesmerizing and inspired the creation of an independent installation entitled *Misty Way* that took place at Centre Intermondes in La

Rochelle, France in 2016. For this artwork, in collaboration with volunteer students from the University of La Rochelle, I produced nine parallel-fibre panels, each of 1 x 10 metres, that were combined into three large-scale screens of 3 x 10 metres each and installed in three areas of the gallery room, separated by two columns. Hanging along on a curve (not unlike a hammock, as shown in fig. 52), these panels created a large tripartite video projection area.

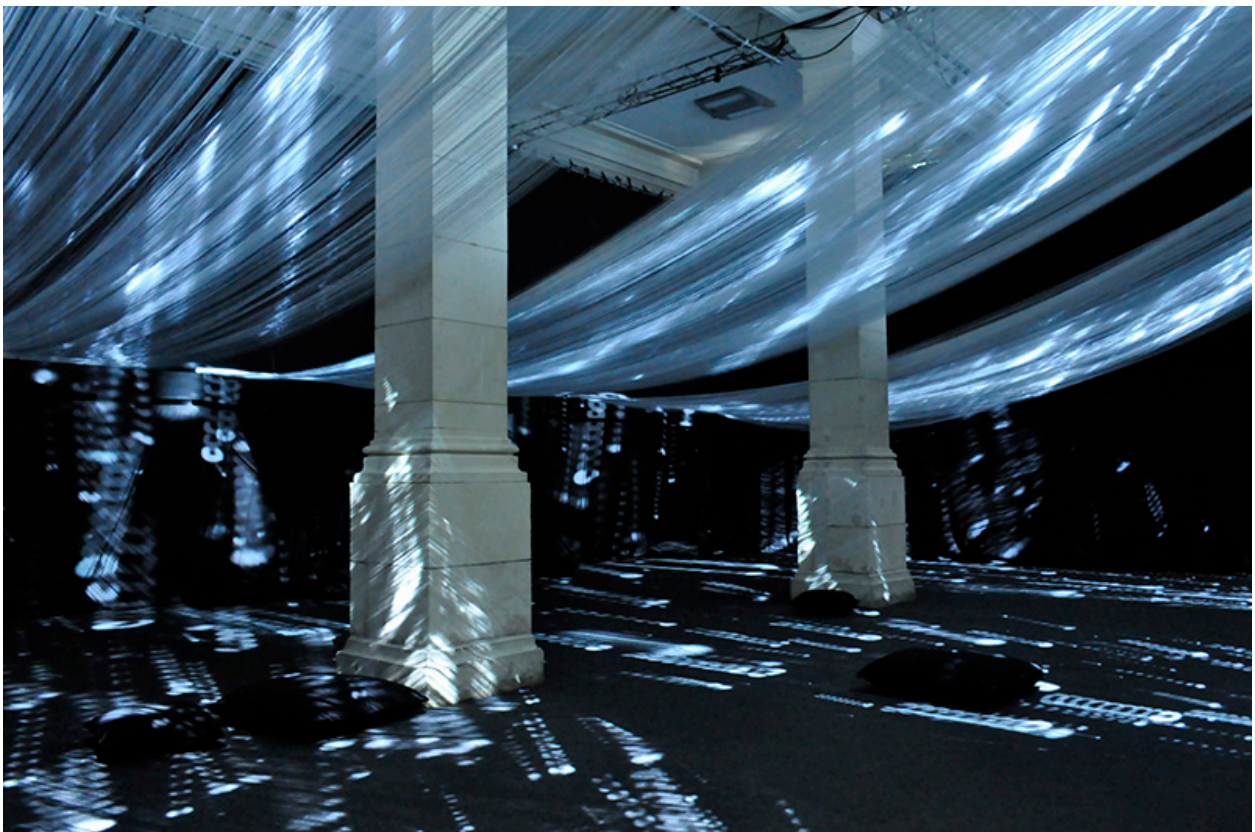
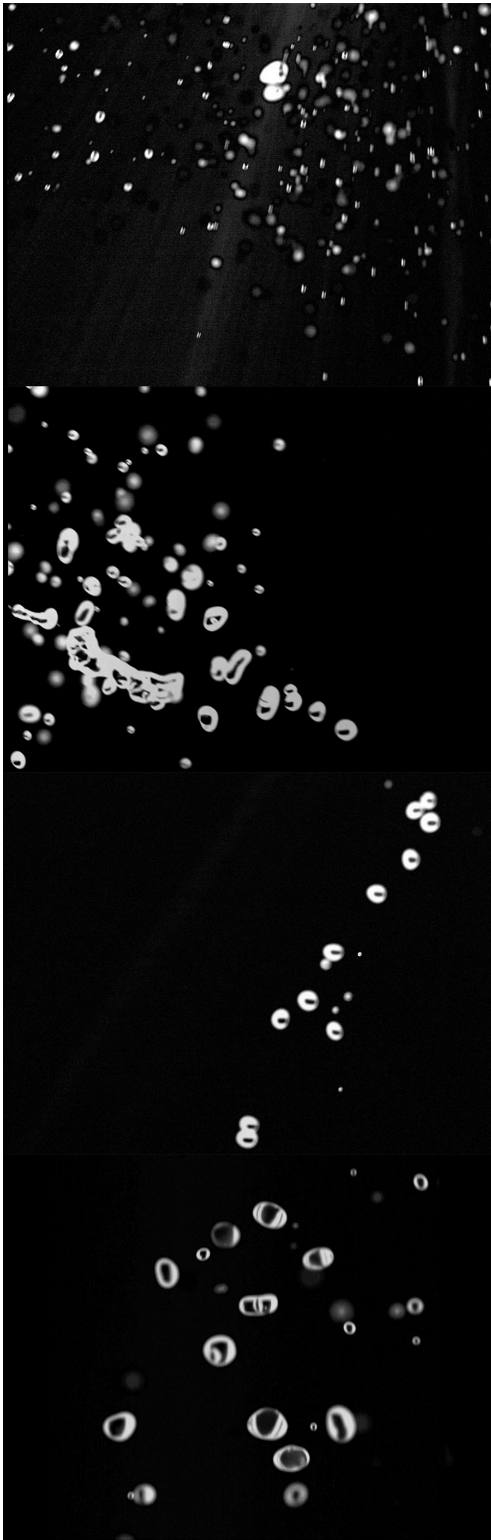


Figure 52. *Misty Way*, three screens, 3 x 10 metres each, were hung along a curve between two columns. Centre Intermondes, La Rochelle, France. © Ana Rewakowicz, 2016.

For the video footage, we re-filmed water droplets with an even higher magnification than in the first trials, deliberately experimenting with various sizes of the droplets (100 microns to 0.5 mm) and their movement trajectories (left to right, diagonally



or up and down) as illustrated in the composed series of video stills below (fig. 53). These different shots, edited together into a movie, were projected split across three screens (controlled by Isadora software²⁵⁷) to evoke a feeling of water droplets traversing in space.

Figure 53. *Misty Way*, sequence of 4 video stills combined together into a filmstrip, portraying waterlight droplets' movement in space. © Ana Rewakowicz, Camille Duprat, Jean-Marc Chomaz, 2016.

²⁵⁷ Electronic music composer Daniel Schorno came to Ladhyx in the summer of 2016 to record sounds accompanying our laboratory experiments. He also proposed and set up a Matrox splitter, which allowed us to split video into three parts and the Isadora software, which allowed us to control how the three parts were projected onto screens.

Misty Way (re)constructs the environment of capturing mist water with a textile net of parallel fibres. In this installation, the fog metamorphosed into light drops is collected by the screens (fig. 54) covering the entire ceiling of the room and vibrating in a wind created by invisible fans (fig. 55).



Figure 54. *Misty Way* installation, a detail of *waterlight* droplets being ‘collected’ by the screen made from flexible parallel fibres. Centre Intermondes, La Rochelle, France. © Ana Rewakowicz, 2016.

The light drops splash on the spectator/participant and the floor creating an immersive space, where viewers/participants are submerged in a ‘virtual’ mist of spattered drops of light, shadows and sound (a musical composition reconstructing noises recorded during the experiments, written specifically for the piece by Daniel Schorno, an electronic music composer).²⁵⁸ For some of the audio recording setups see fig. 56.

²⁵⁸ Video documentation excerpt (2:30) available on Vimeo: <https://vimeo.com/manage/videos/211308766>.



Figure 55. *Misty Way* installation, medium-distance view of the immersive environment where light-drops splash on the screen, walls and floor. Centre Intermondes, La Rochelle, France. © Ana Rewakowicz, 2016.

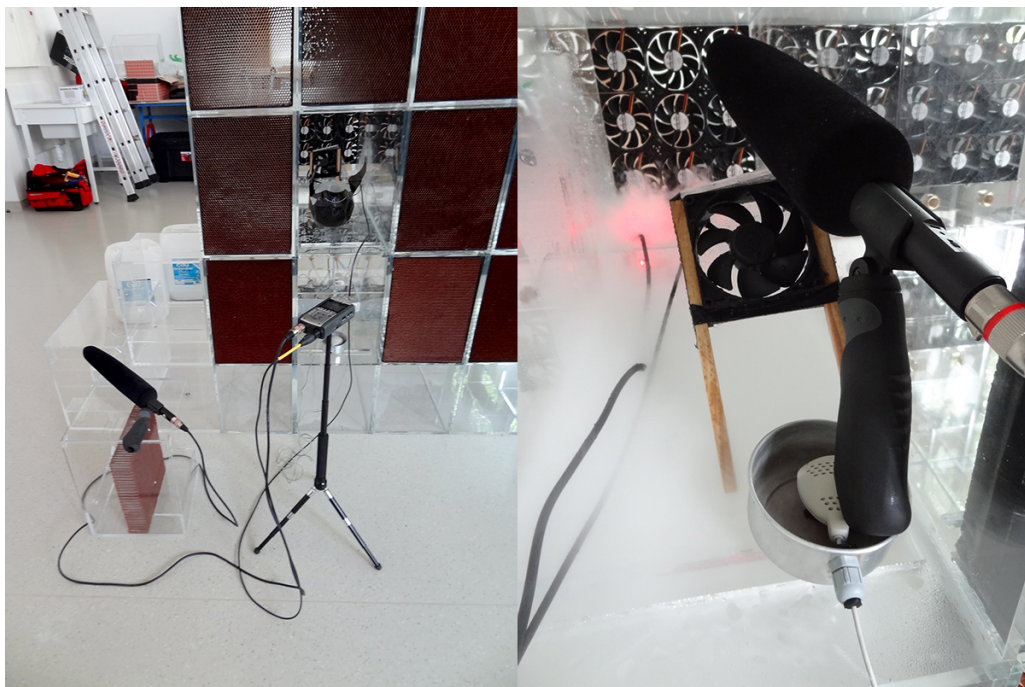


Figure 56. Images of sound recording setups used by Daniel Schorno to capture audio during the laboratory experiments. © Daniel Schorno, 2016.

Diffraction 2: on light

Cameras are optical apparatuses that rely on light to receive and record information. Light is crucial in the process of filming. Too little or too much light produces the same effect - a lack of information. If there is not enough light, the image is dark and unrecognizable and if there is too much light, the picture is washed out (white) and also unidentifiable.

“Light carries information about our surroundings, from distant stars and galaxies to the cells in our bodies to individual atoms and molecules,”²⁵⁹ and “without light, there is no space, and (...) no forum in which events can take place,”²⁶⁰ states Ian Walmsley, physicist researcher and Provost of Imperial College London.

Optics is the study of light and in

²⁵⁹ Ian Walmsley, *Light: A Very Short Introduction* (Oxford: Oxford University Press, 2015), xv. Kindle.

²⁶⁰ *Ibid.*, 65.

modern physics there are two main branches of optics, geometrical and physical.²⁶¹ Geometrical optics treats light as a ray - a straight line (an approximation path of the light) that “is simply an indicator of the direction of propagation of the light, devoid of any ontological commitment about the nature of light,”²⁶² says Barad. Light as a ray becomes a tool that allows us to predict the location of point B in relation to point A, but it does not tell us much about what light is, only how it functions if we use it in a specific way. According to Barad, geometrical optics creates a representational mode of knowledge (meaning - mattering) that produces distance (from points A to B) and uses mirroring techniques of

²⁶¹ Brian J. Thompson and Rudolf Kingslake, “Optics,” in *Encyclopedia Britannica*, accessed September 30, 2020, <https://www.britannica.com/science/optics>

²⁶² Barad, *Meeting the Universe Halfway*, 84.

reflection ignoring the influence of the tools on the objects of investigations.

In contrast, physical optics considers light as a wave and does not deal with discrete points on a path, but rather light behaviour (the nature of light) that under the right circumstances is capable of cancelling or reinforcing itself (pattern of diffraction). And diffraction, for Barad, help us to tune into differences by permitting us to read different patterns of engagement to see how different configurations (different perspectives) affect meaning.

For Barad, knowing “is not a matter of reflecting from a distance; rather it is an active and specific practice of engagement.”²⁶³ She rejects modes of thoughts which distance the observer from the observed. Metaphors of lenses and mediation, where the

²⁶³ Ibid., 453.

lenses of consciousness, language, culture, technology or nature mediate “between the object world and the mind of the knowing subject, a geometry of absolute exteriority between ontologically and epistemologically distinct kinds,”²⁶⁴ are problematic for Barad. Instead, she proposes a “living optics”²⁶⁵ in which seeing/perception and action/living are inseparable and perception is not an act that links a subject to an object but a direct consequence of being in the world. For an example of unmediated perception, Barad points to the brittlestar, a close relative of the starfish that does not appear to have eyes or a brain and yet is capable of escaping predators in dark water of at the bottom of the ocean.²⁶⁶ The brittlestar’s entire body (skeleton) is

²⁶⁴ Ibid., 374.

²⁶⁵ Ibid., 376.

²⁶⁶ Ibid., 369.

covered in calcite crystal microlenses directly connected to its nervous system that allows it to sense tiny changes in light from all directions.²⁶⁷ Similar to digital cameras with pixel-by-pixel definition, except that the brittlestar's lenses are tens of microns (one millionth of a metre) smaller in diameter.²⁶⁸ Researchers have called it "very clever engineering,"²⁶⁹ but for Barad, the brittlestar:

(...) is not a creature that thinks much of epistemological lenses or the geometrical optics of reflection: the brittlestar does not have a lens serving as the line of separation, the mediator between the mind of the knowing subject and the materiality of the outside world. Brittlestars don't have eyes; they are eyes. It is not merely the case that the brittlestar's visual system is embodied; its very being is a visualizing apparatus. The brittlestar is a living, breathing, metamorphosing optical system. For a brittlestar, being and knowing, materiality and intelligibility, substance and form, entail one another. Its

²⁶⁷ Ibid., 370.

²⁶⁸ Ibid., 372.

²⁶⁹ Ibid., 373.

morphology-its intertwined skeletal and diffuse nervous systems, its very structure and form-entails the visualizing system that it is. This is an animal without a brain. There is no *res cogitans* agonizing about the postulated gap (of its own making) between itself and *res extensa*. There is no optics of mediation, no noumena-phenomena distinction, no question of representation.²⁷⁰

Can being immersed in the water/light droplets lead us to direct perception of fog, unmediated by our eyes or tactile senses? Or are we forever doomed to be passive observers and uninvolved spectators watching the world from a distance with a detached objectivity? Can we 'see' without distance and embody water, not as 'a thing' but as a living, sensitive and responding part of us? How can we create, not as 'controlling masters' over inanimate entities, but as intra-acting participants engaged in the creation of new relationships and thus new meanings?

²⁷⁰ Ibid., 375.

One hundred and twenty kilometers of threads walked and stretched one by one

Not everyone is fit to perform repetitive tasks. It requires both patience and concentration that personally I find soothing and meditative, similar to walking or jogging, when your mind wanders off in an enjoyable and carefree way. A small group of students that keep coming back must share the same feeling. It is an amusing way to spend time together. We play music and talk while taking turns walking between two rods that are 10 metres apart and placing the thread into the 666 grooves spaced (at 1.5 mm intervals) on each rod. Thus each screen of 1 x 10 metres uses approximately 13 kilometers of thread ($666 \times 2 \times 10 = 13320$ m), as the thread is wrapped on both sides. Thirteen kilometers multiplied by 9 panels give us ***one hundred and twenty kilometers*** of walked thread.

We work in groups of three; one stands at each end of vertically positioned threaded rods and a third walks from rod to rod passing around them (fig. 37). Each time the walker passes a rod, the person on that end grasps the thread and places it into the groove while adjusting the thread's tension. After approximately 132 metres (or 66 tours around the rods), we applied glue to hold the threads in place. Keeping a brisk walking tempo (about 5.5 km/h), we are able to produce one panel in approximately 4 hours, plus additional time for take down and new setup. On average, with breaks, we produced one panel per day.

Surprise

My idea is to give visitors/participants the possibility of experiencing the piece in a non-traditional way, by lying on the floor and looking up at the screens, as one would look up

at the stars. To do this, I purchase pillows and spread them around the gallery space in such a way that upon entering, visitors/participants would face the direction of the descent of the droplets so the *waterlight* droplets start from above and behind the visitor/participant, passing over them, and finally move away and into the distance in front, similar to the tunneling effect I observed in the prototype presented at the Récollets. To my surprise, when, I came into the gallery room at the end of the opening evening, after everyone was gone, the first thing I notice is that all pillows are moved to the opposite side of the room. Intrigued, I lie down where the pillows are and discover a new world! Instead of moving away, the *waterlight* droplet universe is rushing towards me!

Water Encounter

Imagine entering a dark room.

In the pitch black your eyes hurt.

It feels like they grow bigger, become rounder

and stretch to the maximum.

And it takes a stretch of imagination to see in the dark.

Imagine...

... being submerged in water

shimmering light passes above and through you,

touching your skin and eyes.

Sound, in and out of sync,

*calms and at other times pierces your ears,
“a cacophony of whispered screams, gasps and cries.”²⁷¹
In the dark,
water passes through every cell in your body
carrying oxygen and nutrients through the tiniest blood vessels against gravity.
Water
transports electrical charges filling your brain with thoughts
that create a stream of consciousness...²⁷²
a dazzling light...
a rain of light drops...
Gazing at distant stars, asteroids or perhaps a solar nebula,
is that the beginning of life?
dis/oriented...
immersed in the darkness of abundant im/possibilities...
I listen, you extend your hand
I touch, you touch.*

²⁷¹ Barad, “On Touching (v 1.1),” 161.

²⁷² Strang, *Water*, 16.

Diffraction 3: on touching

Philosopher Jacques Derrida says that the entirety of Western thought is shaped by the concept of light.²⁷³ From the biblical story of creation, through the scientific ‘seeing,’ to philosophical ‘knowing,’ light has become a symbol and a metaphor for enlightenment that illuminates the darkness of ignorance, “where all that falls (...) in[to] indeterminate darkness, (is) waiting to be brought to the light.”²⁷⁴ Perhaps this is why we call things that we do not know (thus cannot see) ‘dark,’ like dark matter or dark energy.

But how could we know anything about light without darkness or about darkness without light? We need complementary characteristics to reveal the other, where only one can be

²⁷³ Melissa Miles, *Solid States / Liquid Objects* (Melbourne: Monash University Shifted Gallery, August 19 – September 5, 2009).

²⁷⁴ Ibid.

revealed at a time. In *Misty Way*, darkness is just as important as the light of the video projection. It is in the darkness that our physical eyes becomes less important and we can start communicating with the hidden and experience the tangible intimacy of touching waterlight droplets and being touched back.

For Barad, touch is the most essential way of communication. In fact, she considers touch as “the primary concern of physics,”²⁷⁵ in that “its entire history can be understood as a struggle to articulate what touch entails.”²⁷⁶ For example, she asks the question: “how do particles sense one another?”²⁷⁷ And points out that a lack of specific answers: through direct contact, through another medium such as a void (which is never empty),

²⁷⁵ Barad, “On Touching (v 1.1),” 155.

²⁷⁶ Ibid.

²⁷⁷ Ibid.

through Einstein's 'spooky action at a distance' or through an exchange of energy, opening up possibilities for different understanding.

In the darkness of a quantum vacuum there is no mass or light.²⁷⁸ And yet, this dark 'nothing' is "a seething mass of activity"²⁷⁹ filled with fluctuations from which virtual pairs of particles and antiparticles (e.g., electrons and positrons) appear and disappear.²⁸⁰ They borrow energy from the vacuum and return it when they annihilate each other.²⁸¹

²⁷⁸ Ethan Siegel, "Yes, Virtual Particles Can Have Real, Observable Effects," *Forbes*, July 12, 2019, <https://www.forbes.com/sites/startswithabang/2019/07/12/yes-virtual-particles-can-have-real-observable-effects/#793cd29357bc>.

²⁷⁹ Walmsley, *Light*, 83.

²⁸⁰ Malcolm W. Browne, "New Direction in Physics: Back in Time," *New York Times*, August 21, 1990, <https://www.nytimes.com/1990/08/21/science/new-direction-in-physics-back-in-time.html?pagewanted=all>.

²⁸¹ Lenka Otap, "We Might Be Nothing but a Temporary Fluctuation,"

Oddly, "mass is not a *property* of material substance. It's not something that matter *has*,"²⁸² rather, "it is a *behaviour* of quantum fields. It is what quantum fields *do*,"²⁸³ says science writer Jim Baggott in his Royal Institute lecture, *The Concept of Mass*. For example, the mass of a proton that comprises two up quarks and one down quark does not come from the mass of these three quarks added together, as the sum of quarks would only constitute up to 1% of the proton's mass. The rest of the proton's mass (99%) comes from bonds (gluon interactions) between the quarks.²⁸⁴

So matter comes from 'nothing'

Medium, last modified September 27, 2019, <https://medium.com/predict/we-might-be-nothing-but-a-temporary-fluctuation-e2539bd38823>.

²⁸² Jim Baggott, "The Concept of Mass," The Royal Institution of Great Britain, September 27, 2017, video, 49:35, <https://www.youtube.com/watch?v=HfHjzomqbZc>.

²⁸³ Ibid.

²⁸⁴ Ibid.

and disappears into ‘nothing,’ yet ‘nothing’ is not ‘nothing’ and is full of intra-activity from which all the energy we know comes and to which it returns, just as life in aboriginal stories comes from and returns to water.

Anthropologist Veronica Strang describes how in many cultures water is considered a sentient and sacred being. She recounts an Aboriginal story of how “human spirit beings ‘jump up’ from their ancestral waters to materialize or ‘become visible’ in human form. At the end of each individual human life cycle, they return to their watery home to be reunited with their ancestors, ‘becoming invisible’ and so dissolving back into collective formless potential.”²⁸⁵

Light sets a limit on how close we can get to ‘thing.’ Planck’s constant quantizes light and beyond Planck’s

²⁸⁵ Strang, *Water*, 38.

length (the smallest possible length) we cannot make a meaningful statement about length.²⁸⁶ Quantization (dividing something continuous into units) leaves gaps (between the units) and inherently conceals things (what is between the units). But what if, through touch, we could feel “the infinite alterity of the virtual,”²⁸⁷ the virtual waterlight droplets coming to life for a short time before disappearing again into the darkness? What if in the dark we could sense the hidden *other* (like water inside the body) and touch the invisible? Maybe only then, in the darkness, *the other* could present itself, vulnerable and naked and only then, in the dark, we could entwine ourselves with what’s heartless,

²⁸⁶ “The Universe by Numbers,” *The Physics of the Universe*, accessed May 15, 2021, <https://www.physicsoftheuniverse.com/numbers.html>.

²⁸⁷ Barad, *Meeting the Universe Halfway*, 30.

callous, uncaring, unkind or cruel
within us, to enact ethical response-
ability and engage in the practice of

response and embrace the possibility of
water guiding us towards building more
inclusive relationships.

Response

During my time in La Rochelle, I shared the residency at Centre Intermondes with Maori artist George Nuku, who was preparing an exhibition at the Museum of Natural History. I invited him to see *Misty Way*. When he came out from the installation space, he was silent, looked me in the eyes and bowed his head in a gesture of appreciation. It was the highest compliment I could imagine, as I felt that the piece was able to touch someone from a different culture and a different language, and move them to participation.

Magic happens when we accept an invitation and open ourselves to be affected by what is brought to us. Perhaps only in the suspension of disbelief, in letting go of a desire to control seeing (knowing) sharply and clearly, we could be touched and touch back. Perhaps, in surrender to the blurriness of darkness, we could transform into a living optics, and maybe this is the difference between a trickster and a shaman. The former distracts your attention without the necessity for your suspension of disbelief. The latter offers you the possibility to become a participant in a phenomenon, without mediation, without distance of externality. Once you step in, there is no knowing, only participation in responding.

4. Artwork IV: *Nephelograph (Mist Impressions)* (2016 - 2018) *Touching Clouds*

Nephelograph (Mist Impressions) [in French - *Néphélographe (Impressions de brouillard)*] is a cloud machine designed to 'scribe' clouds of different forms. It deals with the production of large quantities of artificial fog and consists of multiple, stackable units made from clear plexiglass with submerged ultrasonic misters that produce a current of fog bouncing against an obstacle (a leaning transparent plaque) to create a turbulent mass (fig. 57).

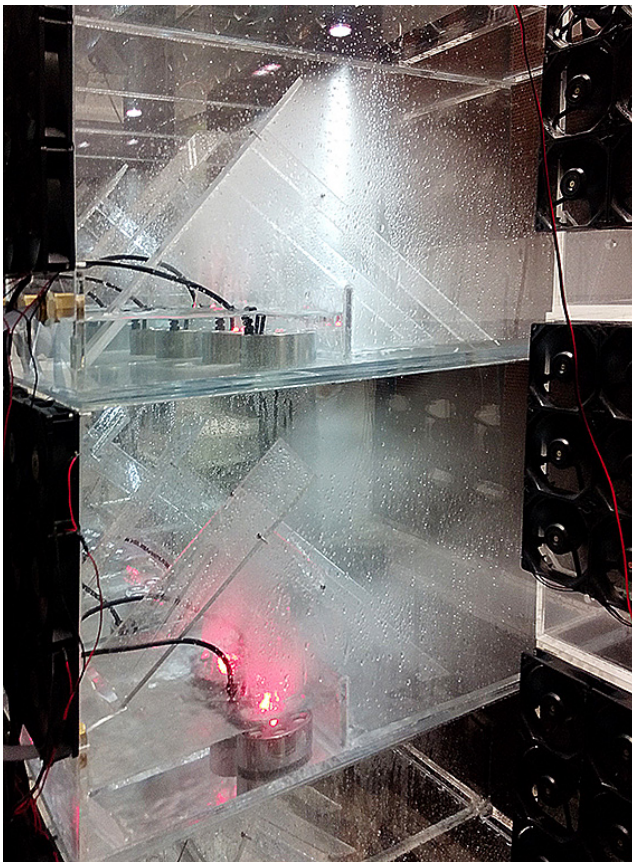


Figure 57. *Nephelograph (Mist Impressions)*. The image shows two of the stackable units made from clear plexiglass with 4 ultrasonic foggers (metallic cylindrical objects with red lights) and 4 transparent plaques (at angles over the submerged foggers) inside. The plaques act as obstacles for creation of turbulent fog mass. © Daniel Schorno, 2017.

This cloud mass is then pushed by fans at the back of the unit (fig. 58) through honeycomb filters to create a unified, homogeneous, well-controlled fog flow at the exit (fig. 59).

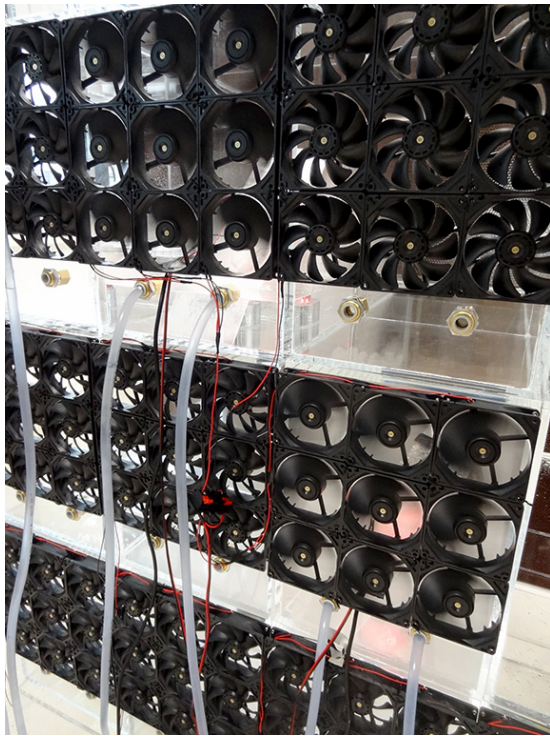


Figure 58. *Nephelograph (Mist Impressions)*, showing fans situated at the back of stackable units. © Daniel Schorno, 2017.

Figure 59. Unified fog mass exiting through honeycomb filters at the front of the stackable units. © Ana Rewakowicz, 2017.



Nephelograph's name comes from the Greek word for clouds – *néphos*²⁸⁸ and refers to *Nephelai* – cloud nymphs from Greek mythology, who are traditionally portrayed as young women, nourishing the earth with rain by pouring water from cloudy pitchers they dipped in *Okeanus* - a sky river circulating Earth.²⁸⁹

²⁸⁸ Merriam-Webster, s.v. “nepho-,” accessed June 15, 2020, <https://www.merriam-webster.com/dictionary/nepho->.

²⁸⁹ “Nephelai,” Theoi Greek Mythology, accessed June 15, 2020, <https://www.theoi.com/Nymphe/Nephelai.html>.

Diffraction 4: on rivers in the sky

We can consider clouds as rivers in the sky circulating Earth, from which we can harvest water, not unlike earthly rivers. According to Anthropologist Veronica Strang, ancient Greeks envisioned the world as surrounded by Okeanus and believed that what is above mirrors what is below, imagining rivers in the sky, reflecting those on Earth.²⁹⁰ Similarly, starry clouds in the night sky, such as the Milky Way, were also viewed as heavenly rivers. Strang describes how the cosmology of sky rivers has been shared by many ancient societies, including different indigenous cultures. From the Silvery Way (in Chinese culture), the River of the Abyss (in Mesopotamia), the Bed of the Ganges (in Indian culture)²⁹¹ or the Rainbow Serpent (in Australian Aboriginals),

²⁹⁰ Strang, *Water*, 20.

²⁹¹ *Ibid.*

these heavenly rivers created humans, animals and plants in a distant time, such as the Australian Aboriginals' Dreamtime.²⁹²

Societies that regarded nature as an active agent, with "numerous and variously gendered spiritual beings and forces,"²⁹³ being able to respond "to human actions by providing resources, offering protection, or dispensing punishment when laws were violated,"²⁹⁴ provided a sense of balance. Water, in these cultures, was seen as an embodiment of female principles of life-giving, fluidity and generative powers. Many rivers had female names, like Sinann (the River Shannon) and Sequana (the River Seine), and were personified by female

²⁹² Veronica Strang, "Lording It Over the Goddess. Water, Gender, and Human-Environmental Relations," *Journal of Feminist Studies in Religion* 30, No. 1 (2014): 88.

²⁹³ *Ibid.*, 85.

²⁹⁴ *Ibid.*

deities, often portrayed as venerated water-related goddesses and serpent beings.²⁹⁵

With the rise of agriculture (sometimes referred to as the Neolithic revolution), there was an increasing need to manage and control water through various practices of irrigation. The increase in need for labour, driven by agricultural expansion, also affected the social structure, where smaller family units with more male-dominated lines of inheritance, replaced common land governance found in tribal community-based living situations.²⁹⁶ “From being owned collectively”²⁹⁷ and “understood as the substance of social and spiritual regeneration,”²⁹⁸ water became “the focus of primarily male property rights and control,”²⁹⁹ as well

as “an economic ‘asset’,”³⁰⁰ states Strang. “With the establishment of increasingly patriarchal systems, both women and ‘nature’ were increasingly treated as subservient to male ‘culture’,”³⁰¹ Strang continues. Slowly but surely, women were confined to domestic roles such as being water carriers, while men became responsible for water management that required both political coordination and technological expansion;³⁰² activities that rely on various forms of power and control.

Technological advancements in irrigation, as well as canal and dam building, gave rise to centralized models of administration, which in turn, effectuated monotheistic religions, as a form of control, asserts

²⁹⁵ Ibid., 89.

²⁹⁶ Ibid., 90.

²⁹⁷ Ibid., 84.

²⁹⁸ Ibid.

²⁹⁹ Ibid.

³⁰⁰ Ibid.

³⁰¹ Ibid., 90.

³⁰² Ibid., 93.

archaeologist and historian James Breasted.³⁰³

According to Strang, the shift from matriarchal to patriarchal societies devalued beings such as water serpents or dragons and treated them as leviathans to be feared, controlled or killed.³⁰⁴ Rivers took on male names and became not only humanized (losing their animal characteristics), but also became masculinized, transforming into male gods that managed (giving or withholding) resources.³⁰⁵ From Zeus through Saint George, Saint Michael to Saint Patrick, the slaying of serpents or female related beings, such as Scylla and Charybdis (who drowned sailors), Medusa (who turned her opponents to stone) or the multi-headed Hydra monster was performed by powerful

and righteous male gods.³⁰⁶ And with the abandonment of a spiritual agency that water once possessed and “the growing instrumentality of human relations with it,”³⁰⁷ also brought forward the development of science as “a new form of patriarchy,”³⁰⁸ declares Strang. She further contends that male scholars, starting with Greek philosophers, have created a mechanistic view of Nature, “bifurcating the world into active subject and passive object.”³⁰⁹ She quotes historian Gary Deason, who says that: “the mechanical view rested on a single, fundamental assumption: *matter is passive*. It possesses no active, internal forces.”³¹⁰ This separation between “humans (as the sole possessors of reason) and nonhuman

³⁰³ Ibid., 86

³⁰⁴ Strang, *Water*, 82-86.

³⁰⁵ Strang, “Lording It Over the Goddess,” 94.

³⁰⁶ Ibid., 94-95.

³⁰⁷ Ibid., 99.

³⁰⁸ Ibid.

³⁰⁹ Ibid.

³¹⁰ Ibid.

Nature,”³¹¹ has created a situation, in which nature became “another mode of divine operation”³¹² and “ecology was recast as technology.”³¹³ Strang continues by citing American ecofeminist Rosemary Ruether, who points out that “In Western society, the application of science to technical control over nature marched hand in hand with colonialism.”³¹⁴ These narratives have changed our relationship with water and moved us away from the idea of water as a being with its own agency, or water as a common good, and brought us instead to “individuated forms of resource ownership.”³¹⁵

I like to think of the *Nephelograph* machine as an animated dragon that spews clouds and induces a

different understanding of our relationships with water. I like to think of water droplets inside the clouds as various countermovements of feminism, civil rights and environmentalism(s), able to coalesce a “critique of patriarchal, market-driven rule and techno-managerial instrumentality,”³¹⁶ and to unveil “an array of active demands for social and environmental justice.”³¹⁷

³¹¹ Ibid.

³¹² Ibid., 100.

³¹³ Ibid., 99.

³¹⁴ Ibid., 101.

³¹⁵ Ibid.

³¹⁶ Ibid., 107.

³¹⁷ Ibid.

The initial idea behind the *Nephelograph* was to make a modular system for the production of controllable fog on a large scale. We started with a small prototype comprised of 10 units (fig. 33) and then expanded it to 30 units, making a range of adjustments that incorporated the units' elongation, modification of water circulation, drainage, condensation and replacement of non-waterproof fans. Our preliminary objective was to bring the machine to life by producing of various fog/cloud formations. To do that we first needed to control the ultrasonic foggers by turning them on and off. For this purpose we employed the Stairville lighting stage control system that allowed us to set up a communication interface between the foggers and a computer using Stairville DMX Joker software for programming.³¹⁸ However, our first attempts made us aware that alone, the fogger control system we designed would not enable us to create a variety clouds formations. Our repertoire of clouds was limited to small cumulus type of clouds resembling a heap or a mound, as shown in the image below (fig. 60).

For our first presentation of *Nephelograph (Mist Impressions)* that took place at Cité internationale de arts in Paris, in February 2018, as part of the *Nous ne sommes pas le nombre que nous croyons être* exhibition,³¹⁹ we decided to bring our machine to life through participatory collaboration with 5th grade students from Paul Langevin elementary school, using the machine as a message scribe. Employing a 16-unit grid, numbered from top right (1) moving down (to 4), then moving to the next column to the left until reaching

³¹⁸ The construction of this interface was produced in collaboration with Daniel Schorno during his residency at Ladhyx in 2017.

³¹⁹ *Nous ne sommes pas le nombre que nous croyons être* venue, showcasing art and science projects, was organized by Béton Salon and sponsored by the newly formed Chaire arts & sciences - a partnership of École Polytechnique, École nationale supérieure des Arts Décoratifs-PSL and the Daniel and Nina Carasso Foundation.

the bottom left (16), when facing the back of the machine (fig. 61), we programmed different letters of the Latin alphabet.



Figure 60. First trials of the cloud machine in 2017, during which we were mainly able to produce the small cumulus type of clouds resembling a heap or a mound. © Daniel Schorno.

For example, to create the letter *C* when looking at the front of the units, we permitted fog to exit only from boxes 1, 5, 9, 13, 14, 15, 16, 12, 8 and 4 for 3 seconds, followed by 5 seconds of no fog release (fig. 62). Like a smoke ring, the letter *C* would be relatively dense and well formed near its exit from the machine and as the fog-*C* was pushed away from the units by the blowing fans, it would disperse and become less clear until its form was only a memory. This technique allowed us to code the full alphabet (for

a full version of the alphabet please refer to Appendix D).

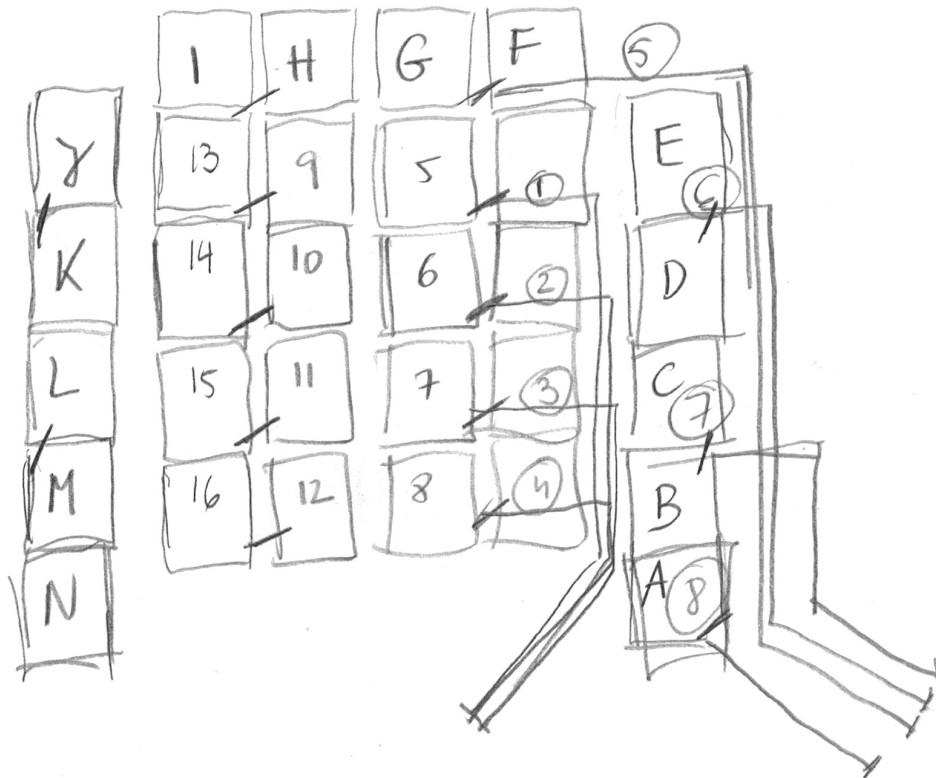


Figure 61. *Nephelograph (Mist Impressions)*, a diagram showing the numbering of the units when facing the back of the machine. The central portion consisted of 16 units (numbered 1-16), which were used to form clouds in the shape letters. These 16 units were surrounded by 14 additional units, used for airflow and sound projection (two outside columns), in an arch formation, labeled A-N starting from lower right and moving counter clockwise. © Ana Rewakowicz, 2018.



Figure 62. Letter C example produced by the *Nephelograph* machine, presented at *Nous ne sommes pas le nombre que nous croyons être*, Cité internationale des arts à Paris. © Ana Rewakowicz, 2018.

To introduce children to the project, Camille Duprat and I gave in-class presentations on the science and art of collecting water from fog and arranged a visit to the École Polytechnique for the kids to experience the cloud machine in action. Afterwards, we asked children to write haikus—short poems with messages to the clouds, an example is depicted in the image below (fig. 63).

NUAGE, EN COMBIEN
de JOURS as-TU FAIS
LE TOUR DE LA TERRE

Figure 63. Example of a short poem written by a 5th grader, which says: “Cloud, how many days does it take you to go around Earth,”³²⁰ 2017.

We took haikus written by the 5th graders and programmed the machine to puff them out letter by letter. These poems carried away and deformed by the wind, created messages that even though not totally legible, echoed a child’s dream of a better future.

To further enliven the machine, we collaborated with composer of electronic music, Daniel Schorno, who sonified these poems by mapping the machine’s 16-unit grid with pre-coded sounds generated in Max/MSP software. The on/off states of each fogger in each of the 16 units activated sound bites through electric signals. Between poems, we programmed short interludes comprised of variously, spatially-shaped patterns (e.g., spirals, up and down, diagonals or left to right), producing auditorily unpredictable sound compositions. To see a selection of children’s haikus together with the programming sequences please refer to Appendix E. For the purpose of incorporating sound into the

³²⁰ Free translation by the author.

machine, Schorno integrated the audio system into the existing design. He used two outside columns with 5 dry (without water) units³²¹ (fig. 34) on each side of the 16-fog producing units and inserted a Xmini capsule speaker inside each (fig. 64). Additionally, behind the 4 units on top of the machine, he placed 4 vibrational Mighty Dwarf speakers (fig. 65) that could produce low-frequency sounds based on any vibration coming from the machine. This two-tiered audio system, which incorporated high frequencies (treble – Xmini speakers) and low frequencies (bass - Mighty Dwarf speakers) proved to be quite powerful and satisfactory for sound projection and blended perfectly into the machine’s design.



Figure 64. Xmini capsule speaker inside the dry unit of the cloud machine. © Daniel Schorno, 2017.

³²¹ Dry units are boxes without water compartments with only fans at the back used for guiding the produced fog with an airstream.



Figure 65. Vibrational Mighty Dwarf speaker positioned on top of the machine, behind the 4 units used for airflow. © Daniel Schorno, 2017.

In the *Nous ne sommes pas le nombre que nous croyons être* exhibition, the machine was placed just outside the main entrance, under the building's overhang to shield it from rain or snow. A piece of black fabric, intended to create wind protection, separated the artwork from the building's entry and from the passage leading to other activities taking place in the courtyard outside (fig. 66).

Unfortunately, the fabric did not safeguard the fog from the wind, and instead, visually isolated the piece from the visiting crowds. As a consequence, the public arriving at the venue followed the designated route without noticing the cloud machine behind the fabric wall. Many visitors with whom I spoke afterwards were surprised to find out that there had been an additional artwork near the entry.

In addition, the piece received too much light during the day, making it quite difficult to see the cloud letters exiting from the machine. Furthermore, in the presence of

wind, any fog configuration produced by the machine was immediately dispersed and not interpretable. Thus, the only time it was possible to experience the machine's performance was during windless evenings and nights, when the piece was lit by artificial light and wind did not rapidly disperse the clouds. The dichotomy between interacting with the living machine and seeing the 'nothing' of blank units was captured by the following story of a student from a class at l'École nationale supérieure d'architecture de Versailles taught by Annick Bureau, director of Leonardo/Olats.



Figure 66. *Nephelograph (Mist Impressions)* placed under the building's overhang and separated from the main passage by a wall of black fabric. *Nous ne sommes pas le nombre que nous croyons être* exhibition, Cité Internationale des arts à Paris. © Ana Rewakowicz, 2018.

During a class discussion following the exhibition, one of her students described his

experience with the cloud machine projecting letters of words accompanied by electronic sounds. He said that he stood there for a long time, mesmerized by the fog, sound and light (produced by the foggers' LEDs) and enjoying the machine's performance. At first, Bureaud and other students thought that he was making up a story. Then, it became evident that he was the only person in the group who had gone to the exhibition on a windless night.

The presentation of *Nephelograph (Mist Impressions)* at the Cité internationale des arts provided two pivotal lessons in what to expect and what not to do in future. First, the piece should not be presented outdoors due to the fog clouds' dissipation in the wind and second, the piece should be experienced in the dark with specifically positioned lighting. Luckily, we were accepted to present the artwork during a Nuit Blanche event that took place from October 7 - 8, 2018 in Paris, where it was installed inside a large sports hall, the Neuve St-Pierre in Le Marais, giving us full control of the surroundings.

For the Nuit Blanche exhibition, our goal was to expand the machine's fog/cloud formation capacity and to do that we needed to be able to program and control the fans in addition to the foggers. This task became more difficult than anticipated, as we had, when producing the fan panels, removed the ground connections (yellow cables) from the fans (as we had needed only the positive (red) and negative (black) cables to run the fans). Little did we know that the yellow cables could have been used to connect to a microcontroller (an Arduino board) that would allow us to program the fans. With this option unavailable, we had to find another solution. Luckily, in 2018, technician Didier Bouchon started to divide his time between École nationale supérieure des Arts Décoratifs (ENSAD) and

LadHyx, and he was able to find a suitable DMX decoder that fulfilled the communication gap between the computer and fans. This advancement significantly augmented our programming capability and gave the cloud machine new life, letting us create more sophisticated cloud variations. They included elongated stratus (low-hanging horizontal clouds),³²² spherical cumulus (clouds resembling heaps or mountains),³²³ vertical cumulonimbus clouds (towering vertical clouds),³²⁴ as well as other configurations of our own invention like falling and tunnel clouds and clouds in the shape of swirling columns and bubbles.

Using our cloud formations as vocabulary we put together an audio-visual composition based on the structure of a symphony of four parts (movements): a sonata (or allegro), a slow movement (or adagio), a scherzo (or minuet - dance) and finally a rondo with a coda (finale). The opening sonata introduced the main elements of our visual vocabulary: 'little cloud,' 'fog tunnel,' 'tornado,' 'big cloud' and 'fall' (falling cloud).³²⁵ The second movement (adagio – a slow movement) created a gentle combination of 'puffs,' 'fall aways,' 'dots' and 'bubbles' (fig. 67). The third movement (scherzo – a vigorous movement) was made up of a faster motion using such variations as 'swirls,' 'exploding columns' or 'fog tunnel windows' and the final part (rondo – a final movement of recurring themes) presented alternating themes of 'falls,' 'denser mixes' and 'dots,' with a coda of 'spirals' at the end.

³²² "Cloud Classification," National Weather Service, accessed September 15, 2020, https://www.weather.gov/lmk/cloud_classification.

³²³ Ibid.

³²⁴ Ibid.

³²⁵ Nicknames used for different cloud formations.

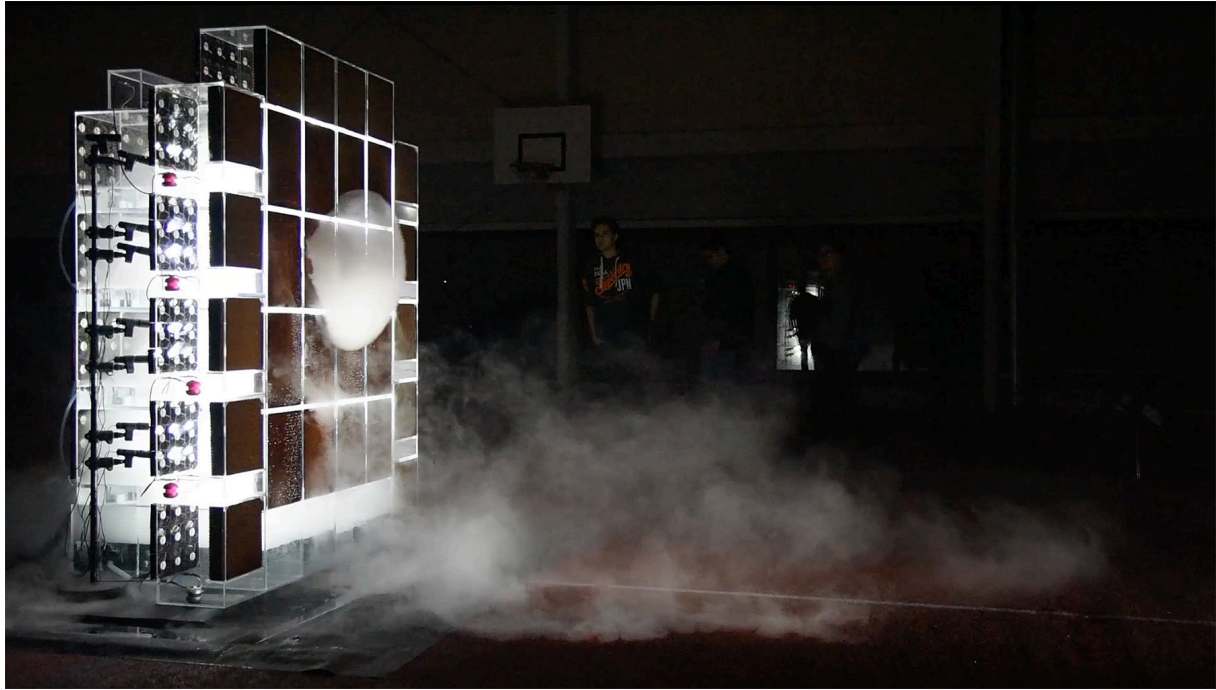


Figure 67. Example of a ‘bubble’ cloud formation. *Nephelograph (Mist Impressions)*, Nuit Blanche 2018, Paris, France. © Ana Rewakowicz.

The audio component of the piece focused on creating an auditory dialogue with the generated clouds and integrating sounds with the machine’s performance as much as possible. Considering that clouds are turbulences of humid air in the atmosphere, Schorno explored the concept of irregular change of airflow in turbulences and a cascading (a series of steps) distribution in data processing algorithms to conceive ‘sound clouds’ that could intra-act with fog clouds.³²⁶

Another important component to take into consideration was lighting and light placement. In our experiments at the lab, we found out that light positioning significantly affected visibility of clouds coming from the fog machine. Almost like magic, under certain light conditions, clouds appeared or disappeared. After multiple tests, we settled on a two-

³²⁶ Daniel Schorno, “Nephelograph – Research & Technical Development Sound Installation, Phase 1/ Paris 2017” (unpublished LadHyx residency report, 2017), 4.

source light system. One involved two stands of four pairs of LED lights, totaling eight lights per stand. A stand was positioned on each side of the cloud machine, with one pair of lights illuminating every level of the 4-fog-producing-unit columns (fig. 68). The second source comprised of another eight LED lights (more powerful than those in source 1) that were placed about 10 m from the front of the machine, facing it as shown in the image below (fig. 68). This two-source light system was crucial for augmenting the visibility of the machine (fig. 69) and clouds as they left the machine and were launched into the exhibition space.

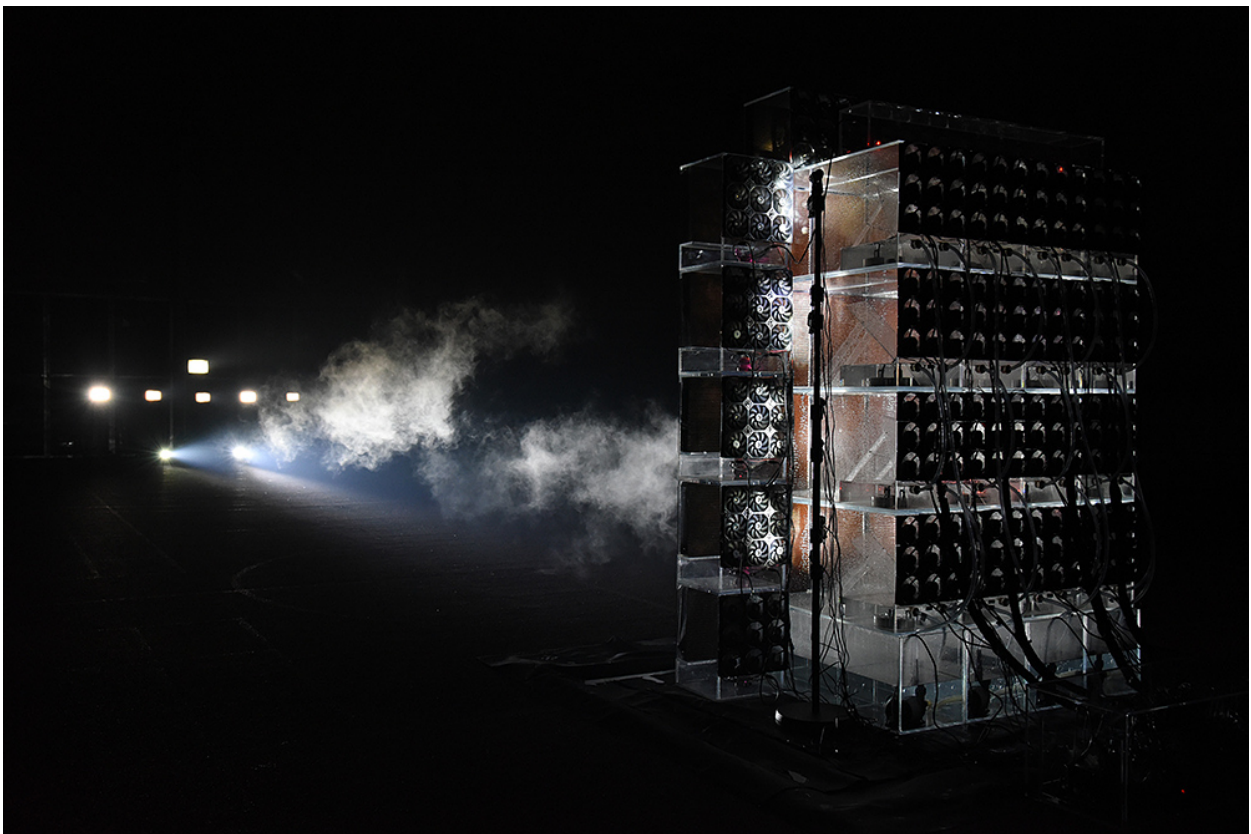


Figure 68. *Nephelograph (Mist Impressions)* at Nuit Blanche 2018, Paris, France. In a dark exhibition space, a two-source light system makes the clouds visible (centre). One of two stands with 4 pairs of lights each (visible on the right) illuminates every level of the 4 fog-producing-unit columns, allowing the visibility of clouds exiting from the machine (not

visible). A second set of lights (visible on the left) illuminates clouds as they are projected into the space (centre). © Ana Rewakowicz.

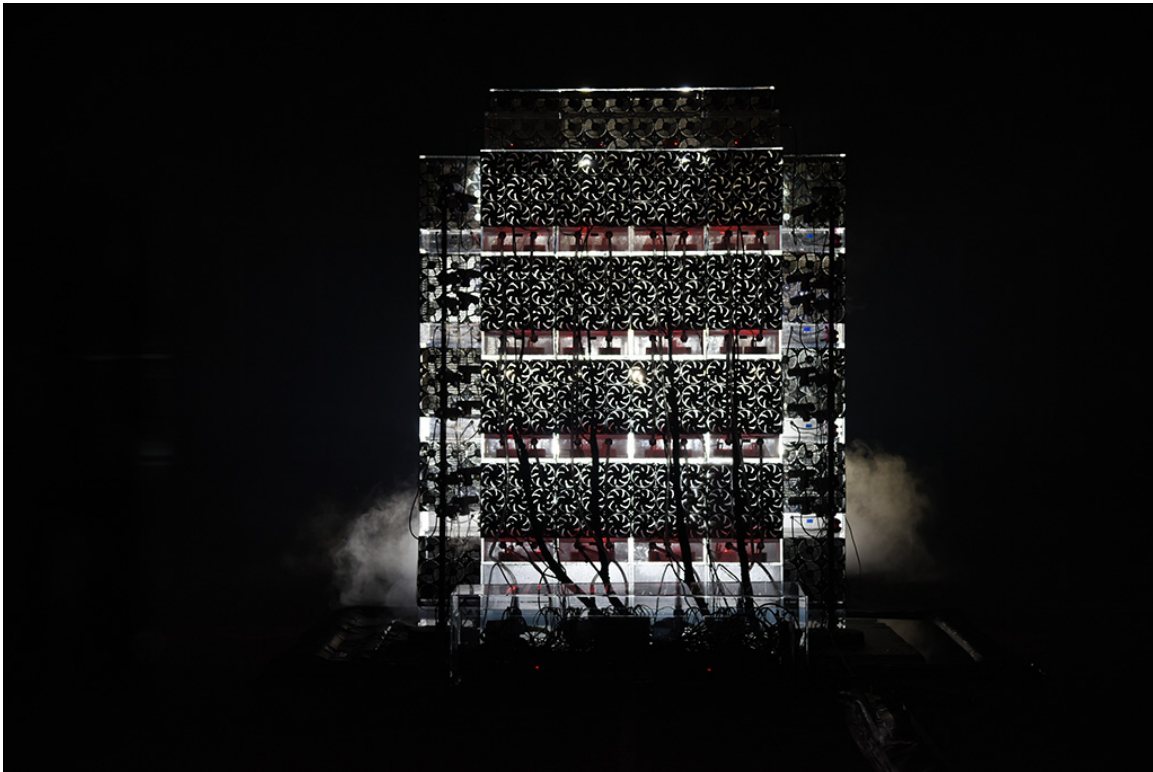


Figure 69. *Nephelograph (Mist Impressions)* visible from behind and illuminated by the front lights (not visible). © Ana Rewakowicz, 2018.

Nephelograph (Mist Impressions) [*Néphélographe (Impressions de brouillard)*], as presented at Nuit Blanche created a multi-sensory environment, where visitors/participants were invited to engage in a dialogue with clouds by touching and interacting with them (figures 70 and 71) and even spontaneously dancing to the sounds generated by the machine (figures 72 and 73).³²⁷

³²⁷ Video documentation excerpt (1:53) available on vimeo: <https://vimeo.com/manage/videos/463534837>.

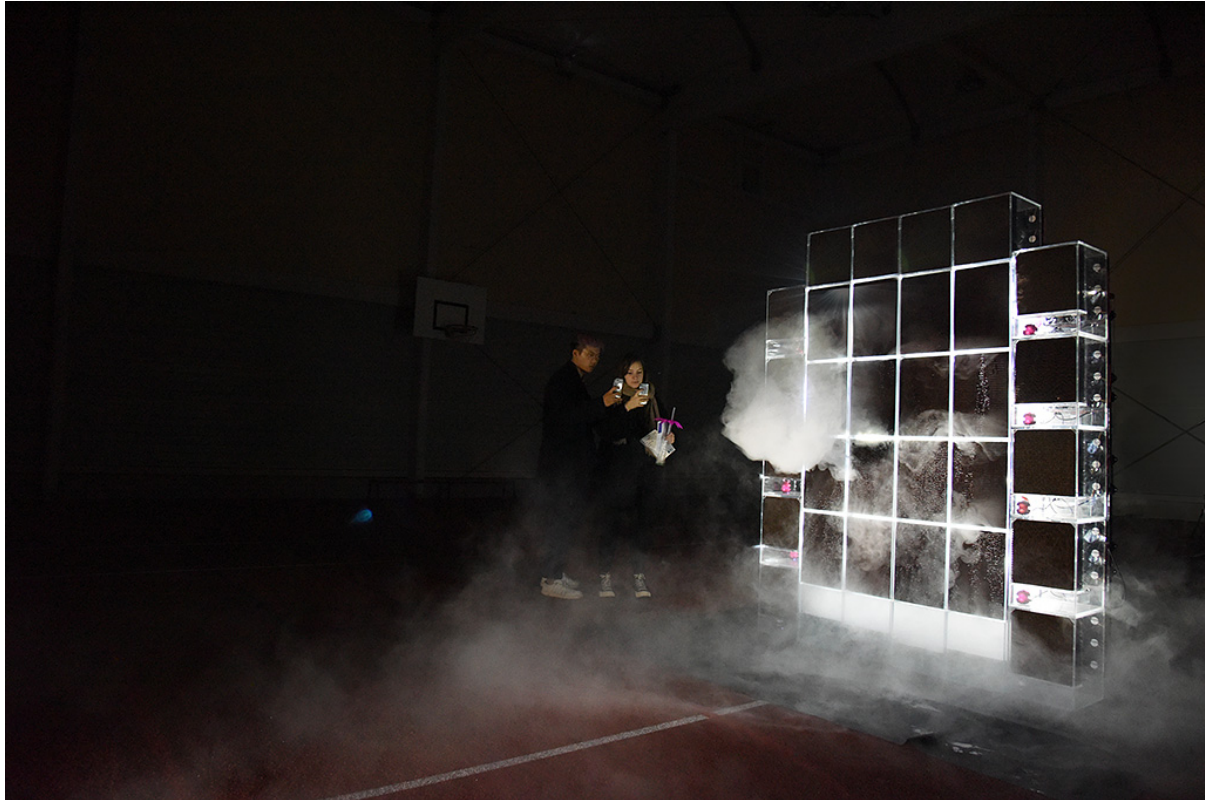


Figure 70. *Nephelograph (Mist Impressions)*, Nuit Blanche 2018, Paris, France. © Ana Rewakowicz.

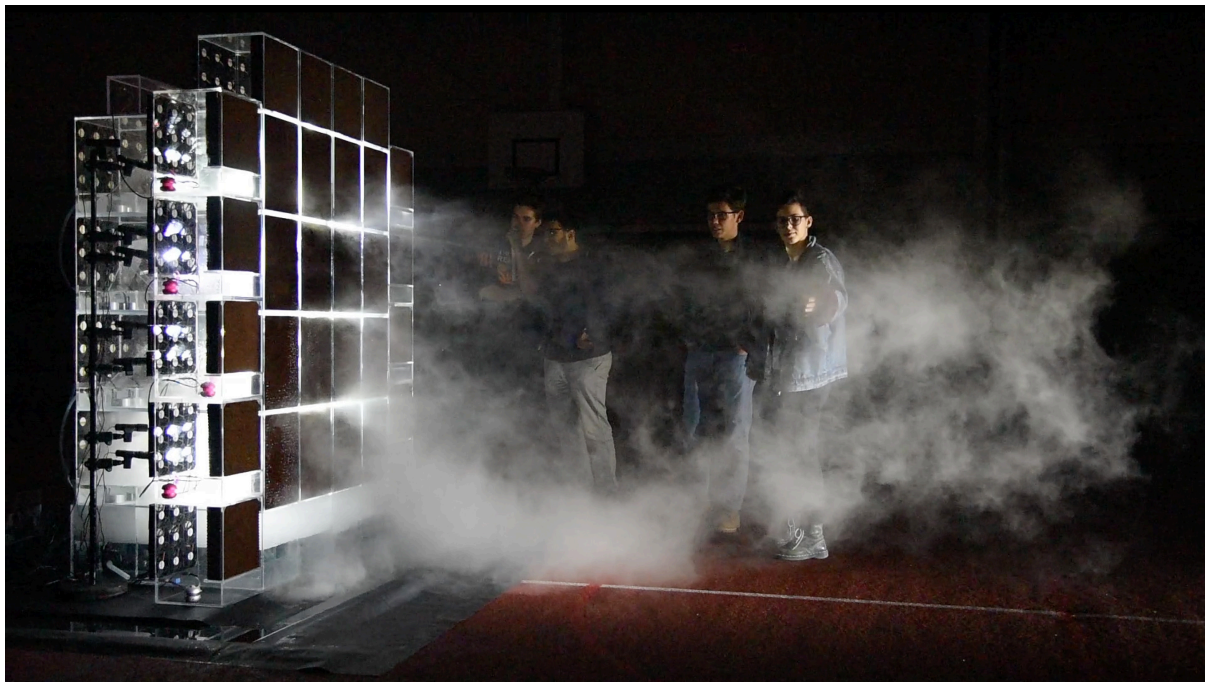


Figure 71. *Nephelograph (Mist Impressions)*, Nuit Blanche 2018, Paris, France. © Ana Rewakowicz.

Cloud Encounters

*Ultrasonic misters break the surface of water
into small droplets that then bounce against transparent plaques
to come together and create turbulent fog masses – small clouds.*

*Ventilators at the back push these small clouds through honeycomb filters
and small clouds combine into bigger clouds.*

*The apparatus is alive;
water percolates as it rushes through tubing and hums pumping tunes.*

*An animal – a dragon or a serpent perhaps,
breathing clouds –
falling clouds, bubble clouds, swirling clouds, spiraling clouds, tornado clouds, little clouds, big
clouds, puffy clouds, exploding clouds, tunneling clouds...*

*clouds...breaths...
being close enough to touch, to sense, to feel, to intra-act with...
breath-sounds –
a polyphony played by an orchestra of different electric signals.*

*You are invited...
to come forward,
to touch,
to respond,
to feel,
to entangle with...*

*yourself...
clouds...
suspended halfway
between earth and sky.*

Dance

A couple moves closer to the machine.

He distances himself; she stays.

She sits on the ground and remains still for a long time.

Then slowly, ever so slightly starts removing her shoes.

Her gestures are slow, fluid, gentle and yet decisive.

She appears and disappears, in and out of clouds, waving her body to cascading sounds.

She astounds me.

I want to touch her... but in the dark I cannot find the right settings on my camera...

a silhouette against bright lights at the end of the space.

Watch!

In silence she dances to the sounds of clouds.

Time passes- 40 minutes!

She casually gets up, sits on a bench and leaves.

I do not know who she was.

I never asked her for her name.



Figure 72. Improvised performance of an unknown dancer during Nuit Blanche 2018, Paris. Video still - © Ana Rewakowicz.



Figure 73. Improvised performance of an unknown dancer during Nuit Blanche 2018, Paris. Video still - © Ana Rewakowicz.

In summary, the four artworks: *Through the Looking Mist...*, the *Porous Sail* prototype, *Misty Way* and *Nephelograph (Mist Impressions)* that comprise the *Mist Collector* project bring forward a phenomenological engagement with water, as *the other* that is never totally separate from our bodies and surroundings through the creation of immersive environments. They invite visitors/participants to re-open themselves to the ethical response-ability of responding inclusively. It is through imagination and poetics that we are able to sense what is hidden, feel the heartless, insensible, and indefinite within every being be/coming, and in so doing enact change and create justice by living responsibly, together/apart with all human, non-human (living and non-living) and inhuman, on Earth, in the cosmos, and with water. The *Mist Collector* project, by inviting all visitors/participants to experience water at the scale of a single droplet, and imaginatively speaking, aboard Spaceship Earth, traveling through fog, calls us towards the necessity of creating a collective narrative of an ever deteriorating Future/Present/Past ecological harmony that we may still shape and imagine together.

Chapter 6

Collaborating Responsibly

In chapter 1, we saw that there was a critical problem with the availability of fresh water, especially in arid areas, and we saw some nature-made and human-made designs that point towards a sustainable solution. Chapter 2 presented my artistic concerns about sustainability and how they motivated me to work collaboratively on this problem. Chapter 3 outlined my theoretical framework of agential realism (Barad, 2007) that provides the dynamic platform of a different kind relationality; one that allows for imaginative participation in ethical response-ability. This approach opens an opportunity for new ways of thinking and collaborating that enables us to close the gap between what we know and what we do, so we can ethically engage with an environmental crisis of water shortage. In chapter 4, I presented art's participation in the scientific question of efficiency in the collection of water from fog and described effects of this intra-action (interaction that combines an ontological question of *what* with the epistemological question of *how*) on our art and science research. Chapter 5 recounted the story of an intimate encounter with water in the creation of four artworks, using a diffractive method of reading insights that permit for a multiplicity of viewpoints to capture the process of creation.

In the current chapter, I step back from the particulars of my art-science research to examine the phenomenon of art and science collaboration - more generally, and to explore what kind of knowledge (meaning) this intra-action has produced in our specific case. I start with the justification for collaboration (section 1) and proceed to characterize changing relationships between art and science; from a common view as

opposites to their different relations in the Enlightenment and Renaissance (section 2). Next, I present a new perspective offered by agential realism that entails reintegration of ethics into knowledge production, creating a link with the Greek concept of *phronesis* (section 3). After, I describe the *Mist Collector* collaboration as an example of a collaboration that engaged in ethical response-ability through the practice of creative participation (section 4). I then describe limitations we experienced and propose recommendations for future art-science collaborations (section 5).

1. The Justification for Collaboration

We live at a crucial moment when we need to fundamentally re-think our relationship with the world of which we are a part. Old worldviews and value systems that focused on expansion and exploitation (as if there were no limit³²⁸) in the form of profit-driven capitalism and consumer culture are no longer viable. To survive on this planet we must work and act differently. This change or “cultural turn,”³²⁹ as artist and scientist Diego Galafassi calls it, requires a radical re-evaluation of our beliefs and practices, and asks for collaborative efforts in developing new kinds of relationships and practices of ethical response-ability. This “cultural turn” requires us to move beyond dichotomies of nature/culture or fact/value and consider nature not as something that is outside of us, but rather as an inherent part of what we do. Cultures are based on value systems that reflect our priorities and the way we look at the world

³²⁸ According to a BBC news article on June 16, 2015, most of the world’s population, particularly in developed countries, sustains a lifestyle that requires resources of a minimum of 3 Earth-equivalents. Charlotte McDonald, “How many Earths do we need?,” *BBC News*, June 16, 2015, <https://www.bbc.com/news/magazine-33133712>.

³²⁹ Diego Galafassi et al., “‘Raising the temperature’: the arts on a warming planet,” *Current Opinion in Environmental Sustainability* 31 (2018): 72.

and which becomes important by virtue of our daily practices.

Complex issues such as climate change, water scarcity or pandemic responses necessitate “more-than-rational ways of thinking and acting”³³⁰ that go beyond scientific facts. As scholar of interdisciplinary studies Julie Thompson Klein expresses, “scientific knowledge alone, (...) cannot inform the process of solving complex problems with strong elements of uncertainty and contextuality.”³³¹ We can see this today with climate change where knowledge of scientific facts alone has not yet produced a significant difference in the political and cultural sphere. To tackle these multi-faceted problems we cannot act alone. We need to co-operate and collaborate in different ways and on different levels to create emotional engagement that might bring us closer to narrowing “the gap between what we know and what we do.”³³² It is a slow process but every effort in the direction of ever-more inclusion, no matter how big or small, matters.

Interactions between different disciplines have always been of value for bringing new perspectives and enriching a dialogue. Over the course of the twentieth century, we have seen many disciplinary mergers and the appearance of new disciplines in the sciences, social sciences, humanities and the arts, including bioinformatics, nanotechnology, artificial intelligence, digital humanities or computational arts. Many of these unions have accommodated the redefining of disciplines in relation to technology but the interaction between art and science opens a different kind of opportunity, the potential for ethical responsiveness, so crucial in addressing

³³⁰ Ibid., 73.

³³¹ Julie Thompson Klein, “Prospects for transdisciplinarity,” *Futures* 36 (2004) : 521.

³³² Galafassi, “‘Raising the temperature’: the arts on a warming planet,” 73.

environmental crisis. Owing to art's ability of "deepen[ing] questions rather than providing answers and solutions,"³³³ art can attune science to imagination and poetics, and help us to sensitize to the response-ability of the 'hidden' excluded that is so crucial in building a different future. That is, art can help science notice what has formerly been ignored, leading to new possibilities.

Art, as Galafassi declares, "can provide a means to envision, express and shape the kind of society we collectively want to create."³³⁴ And to achieve this, we need to step away from the disciplinary "culture of autonomy"³³⁵ and steer towards the "culture of accountability"³³⁶ and collaboration.

2. Relationships between Art and Science: the Possibility of Change

Art and science working together is one example of a collaboration, but like all collaborations, it relies on various practices of relating (interactions and intra-actions), producing different meaning (mattering) in the process. Art and science relations have varied throughout different historical periods but the common view today is that art and science are opposites. Art is perceived as a practice of beauty creation (aesthetics) disassociated from science, politics or philosophy and science is seen as a holder of explicit context-free knowledge (separated from society and culture) leading towards

³³³ Ibid., 77.

³³⁴ Ibid.

³³⁵ Helga Nowotny, Peter Scott and Michael Gibbons, "Re-Thinking Science: Mode 2 in Societal Context," in *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters: A comparative Systems Approach Across the United States, Europe, and Asia*, eds. Elias G. Carayannis and David F.J. Campbell (Westport: Praeger Publishers, 2006), 42.

³³⁶ Ibid.

progress through technological development.³³⁷ Scientists are still seen as “white-coated figures in labs and artists as Salvador Dali-like characters wielding paintbrushes,”³³⁸ states British writer Arthur I. Miller. This view has been encapsulated by the idea of *two cultures* described by British scientist and novelist C.P. Snow, who in his 1959 Rede Lecture under the same title, declared that sciences and humanities/arts are two separate cultures not able to communicate with each other.³³⁹ Ever since, *two cultures* has become a standard phrase used in discussions about art and science.³⁴⁰ Despite the fact that Snow’s dichotomy did not mention visual or performing arts,³⁴¹ *two cultures* pointed to a different status of humanities/arts and sciences in society and especially their differential influence within the political sphere, which, according to Snow, was, at that time, dominated by literary elites who had little knowledge of science and technology.³⁴²

However, the idea that science is rational and objective and art is subjective and concerned with aesthetics arose during the Enlightenment. It was during that time when

³³⁷ Canadian writer Ronald Wright points out that our understanding of progress subscribes to the Victorian ideal of progress that assumes that changes experienced in the history of mankind are irreversible and move in one direction only, towards improvement. He also identifies the difference between progress and progress trap that follows the old maxim that the difference between a medicine and a poison is in the dose. Ronald Wright, *A Short History of Progress*, 2nd ed. (Toronto: House of Anansi Press, 2019), 32. Kindle.

³³⁸ Arthur I. Miller, *Colliding Worlds: How Cutting-Edge Science Is Redefining Contemporary Art* (New York: W.W.Norton & Company, 2014), 341. Kindle.

³³⁹ *Ibid.*, 36

³⁴⁰ *Ibid.*, 341.

³⁴¹ Snow, in his lecture followed by the essay, attacked literary intellectuals, who, at that time in Britain, represented the elite in government, making decisions about industry, while being completely scientifically unprepared to do so, in his opinion. In response, Cambridge literary critic F. R. Leavis accused Snow of being a technocrat. Georgina Born and Andrew Barry, “ART-SCIENCE: From public understanding to public experiment,” *Journal of Cultural Economy* vol. 3, no. 1 (2010): 106, doi: 10.1080/17530351003617610.

³⁴² Ede, *Art and Science*, 5.

modern science and the profession of scientist emerged, changing the role of art and science in society. The word 'scientist' was coined by the English philosopher and historian of science William Whewell in 1834.³⁴³ During that time science separated from natural philosophy of metaphysics (a philosophy of “the first causes of things and the nature of being”³⁴⁴) and became study of nature centred on rationality and objectivity, while art came to be regarded as a depiction of nature and creation of beauty.³⁴⁵ With the dissociation of science from natural philosophy (subjective experience)³⁴⁶ and with industrial development (science engineering), linked to economic power, “artists were no longer needed to represent reality”³⁴⁷ and science started to play “a central role in society and researchers finally became paid professionals,”³⁴⁸ states Strosberg. Art, on the other hand, became an instrument of beauty,³⁴⁹ whose sole value was “purposeiveness without a purpose,”³⁵⁰ produced for “the inherent pleasure to be derived from it,”³⁵¹ in the servitude of pleasure at the hands

³⁴³ “(...) some ingenious gentleman proposed that, by analogy with artist, they might form scientist, and added that there could be no scruple in making free with this termination when we have such words as sciolist, economist, and atheist—but this was not generally palatable.” *Oxford English Dictionary*, s.v. “scientist,” accessed May 10, 2021, <https://www.oed.com/view/Entry/172698?redirectedFrom=scientist#eid>.

³⁴⁴ Dean W. Zimmerman, “Metaphysics,” in *Encyclopedia Britannica*, accessed May 10, 2021, <https://www.britannica.com/topic/metaphysics>.

³⁴⁵ Miller, *Colliding Worlds*, 341.

³⁴⁶ According to writer Lorraine Daston, the separation of knowledge and the knower from ethical virtues happened in reaction to religious dogmas, where an alchemist “failure to transmute base metals into gold could no longer be blamed on an impure soul.” Lorraine Daston and Peter Gallison, *Objectivity* (New York: Zone Books, 2007), 39.

³⁴⁷ Eliane Strosberg, *Art and Science* (Paris: UNESCO, 1999), 23.

³⁴⁸ *Ibid.*

³⁴⁹ Ede, *Art and Science*, 29.

³⁵⁰ *Ibid.*

³⁵¹ *Ibid.*

of those who defined what is pleasurable or not.³⁵²

Nevertheless, before the appearance of modern science in the eighteenth century,³⁵³ in the Renaissance the relation between art and science was different. Artists as artisans and scientists as natural philosophers engaged in similar experimental practices and “used similar measuring instruments (...) in order to respond to analogous preoccupations”³⁵⁴ of exploring the world: science investigating origins (metaphysics) and art linking the physical to the spiritual through technical craftsmanship. In contrast to the Enlightenment, at that period it was artists who “dared to challenge popes,”³⁵⁵ (i.e., political power) while “most of their scientific contemporaries had to pursue research, secretly, and were viewed as enlightened amateurs,”³⁵⁶ according to Strosberg.

Today, we could say that the art and science roles in society have swapped. While, artists in the Renaissance often performed the role of engineers (e.g. Leonardo da Vinci³⁵⁷ or Michelangelo³⁵⁸), today’s technological advancements rest in the hands of scientists and engineers and not artists, who seem to take a philosophical turn, especially nowadays’ in contemporary art practices with focus on ecology. Thus, artists

³⁵² Ede describes beauty as “something that was only ever in the eye of the beholder, has often been exclusively in the hands of a particular holder or a few holders,” which in the Enlightenment constituted rich and privileged men, who traveled and brought different cultural artifacts from afar and treated female bodies in a similar way, as objects of admiration and desire. Ede, *Art and Science*, 33- 36.

³⁵³ Ede, *Art and Science*, 55.

³⁵⁴ Strosberg, *Art and Science*, 28.

³⁵⁵ Ibid.

³⁵⁶ Ibid.

³⁵⁷ Leonardo da Vinci was equal parts artist, scientist and engineer with superb skills for observing and depicting the natural world through painting, drawing and writing, as well as his scientific inventions and imaginary beings.

³⁵⁸ Michelangelo in addition to being a sculptor, architect and poet, he was also a practical engineer, who designed the Florence fortification. Strosberg, *Art and Science*, 148.

often seek to collaborate with scientists so they can have access to advanced technologies, and scientists, like the idea of collaborating with artists so they can reach the general public through augmenting their preoccupation with beauty (aesthetics), which, in their minds, they share with art.³⁵⁹

Unfortunately, building art and science relations on the basis of science bringing technology to art and art bringing aesthetics to science is limiting, as it continues to reflect the Enlightenment's division of specializations that are reinforced by the educational system. Except for recent attempts by STEM (science, technology, engineering and mathematics) programs to incorporate arts, becoming STEAM (science, technology, engineering, arts and mathematics), we can definitely say that the progress of integrating art and science within the education system has been slow and not sufficient. Within a European context, I spent a considerable amount of time in France and was quite surprised to learn that students upon entering lycée (high school) at the age of 15, are supposed to choose their specialization in either sciences or humanities (arts) before passing their baccalauréat exam (high school diploma). Talking to parents, I was made aware of a prejudice that they felt exists against the humanities within the school system in France. According to many, there is an unspoken bias that one chooses humanities only because one is not 'good enough' to go into science. I noted a similar attitude when teaching in the Studio Arts Department, Faculty of Fine Arts at Concordia University in Montreal, Canada, where some students' approach towards art

³⁵⁹ The scientific universal ideas of symmetry, order or inner logic is disputed by art historian Ernst Gombrich, for whom artistic beauty lies in the tension between symmetry and asymmetry. He says: "too much symmetry ensures that once we have grasped the principle of order... it holds no more surprise." Philip Ball, "Beauty ≠ truth," ed. Ed Lake, *Aeon*, May 19, 2014, <https://aeon.co/essays/beauty-is-truth-there-s-a-false-equation>.

was quite trivial, giving an impression that they were in visual arts just because 'it was an easy way' of getting a degree.

3. Agential Realism: a New Approach toward ethical response-ability

Agential realism presents a new approach for thinking about relationships generally and the relationship between art and science in particular. Instead of looking at art and science as binaries, agential realism allows us to move beyond a static idea of an art/science dichotomy by reintegrating ethics into the act of creation. According to agential realism, all relationships are acts of creation, and every act of creation brings some entities into existence while necessarily excluding other entities. In Barad's words: ethicality is an inseparable part of relational intra-activities that in the process of performing 'agential cuts' (measurements) and defining temporary knowable importance (meaning) to some entities, ends up excluding others. It is never possible to include all potential processes and meanings, thus exclusion is an integral part of relationality. Hence, ethicality entails responsibility in meaning creation and accountability for whom and how a given meaning is of significance, while being mindful of what has been excluded.

By constantly creating new relationships (and thus new entities), we are inherently, participating in the practices of ethical response-ability (of trying to reduce exclusion and to fluidly include novel relationships and entities). This type of ever-changing response-ability is critical when dealing with complex global environmental challenges such as climate change, air pollution, or water scarcity. By behaving with response-ability and aiming for inclusivity, we can determine what kind of future we want. Through the use of imagination and poetics, art calls upon ethical response-

ability to bring to our awareness what is not otherwise obvious, and in doing so, perhaps helping us to envision different facts and values for the creation of a different reality.

By bringing the ethical dimension into relationships of meaning creation, agential realism creates a link with the ancient Greek perception of the world that rested on a triad of knowledge production, as presented by Aristotle in *The Nichomachean Ethics: Techné, Episteme and Phronesis*.³⁶⁰ *Episteme*, which means “to know”³⁶¹ in Greek, gave birth to the scientific epistemology regarded as universal and context-independent (explicit knowledge).³⁶² In contrast, *techné*, from which crafts, art and technology take their roots,³⁶³ represented practical knowledge oriented towards production (tacit/implicit knowledge).³⁶⁴ Finally, *phronesis* constituted practical wisdom or a practice oriented towards virtuous actions, allied with ethics.³⁶⁵ For ancient Greeks ethics, understood as virtues,³⁶⁶ was inseparable from knowledge production. Originally, *techné* as a technique (craft/skill) “did not simply designate methods of fabrication [but] it carried symbolic and spiritual connotations,”³⁶⁷ asserts Strosberg. Similarly, “*sophia* meant ‘technical ability’ before it became associated with the notion

³⁶⁰ Amalia Pedemonte, “Aristotle’s Three Types of Knowledge in *The Nichomachean Ethics: Techné, Episteme and Phronesis*,” Aquileana, last modified February 1, 2014, <https://aquileana.wordpress.com/2014/02/01/aristotles-three-types-of-knowledge-in-the-nichomachean-ethics-techne-episteme-and-phronesis/>.

³⁶¹ Ibid.

³⁶² Ibid.

³⁶³ David Blockley, “Practical wisdom and why we need to value it,” *OUPblog*, July 11, 2014, <https://blog.oup.com/2014/07/practical-wisdom-vs-i/>.

³⁶⁴ Christopher C.W. Taylor, “Aristotle on Practical Reason,” *Oxford Handbooks Online* (August 2016): doi: 10.1093/oxfordhb/9780199935314.013.52.

³⁶⁵ Pedemonte, “Aristotle’s Three Types of Knowledge.”

³⁶⁶ Ibid.

³⁶⁷ Strosberg, *Art and Science*, 27.

of wisdom."³⁶⁸ And *phronesis* also meant practical wisdom³⁶⁹ that, not unlike ethical response-ability in agential realism, was oriented towards actions, where *phrone* meant "mental" and the suffix *-sis* denoted action or process,³⁷⁰ as does English *-ing*.³⁷¹ Thus, in ancient Greece it would not be possible to separate knowing/meaning (*episteme*) from a way of (*techné* as technique) acting ethically (*phronesis*).³⁷² Similarly, in agential realism, *what* (ontology) is inseparable from *how* (epistemology), which in turn is inherently connected to ethical response-ability,³⁷³ that is practices of increasing inclusion.

4. *Mist Collector* Collaboration

The perspective of agential realism can help us understand the *Mist Collector* collaboration and its outcomes. The artist and the scientist worked with the same materials on the same experiments, yet the outcomes were different because they asked different questions. The art was striving for a more encompassing way of relating, trying not to consider the entities such as fibres or water as passive objects of investigations

³⁶⁸ Strosberg, *Art and Science*, 34.

³⁶⁹ Another interpretation of *phronesis* is mindfulness, a definition proposed by American art critic, poet and scholar Thomas McEvelley. Thomas McEvelley, *The Shape of Ancient Thought: Comparative studies in Greek and Indian Philosophies* (New York: Allworth Press, 2002), 609.

³⁷⁰ Ibid.

³⁷¹ *Online Etymology Dictionary*, s.v. "-sis," accessed May 5, 2021, <https://www.etymonline.com/word/-sis>.

³⁷² With the caveat that not all adults were considered citizens in Athenian Democracy. Only adult males, who constituted "no more than 30 percent of the total adult population," were allowed to participate in society. Women, slaves and foreigners were excluded from political life; hence the ability of determining what was important. John Thorley, *Athenian Democracy*, 2nd ed. (Abingdon: Routledge, 2004), 74-75.

³⁷³ Where ethical is not about morality or right and wrong, as 'good or bad' virtues were in ancient Greece.

but as relational potentials for new material configurations, which in turn brought forward different things/concepts/ideas and allowed for a different type of responsiveness. Art actively participated in the exploration of the same problem of how to increase the fog water collection and invited science to partake in the creation of an encounter with water. Hence, the focus of the *Mist Collector* collaboration has been to practice ethical response, attempting to be more inclusive of ideas, relationships, and entities that might otherwise go unnoticed.

One critical way in which the *Mist Collector* collaboration tried to change relationships (and thus entities) was through inviting water itself to become a participant in the creation of solutions for extracting water from air. Through imagining of what it might feel like to be a water droplet and employing poetics (to create sensitivity to what is 'hidden' and 'invisible'), the *Mist Collector* collaboration produced artworks that extended to the public, an invitation to participation with encountering water.

The success of the collaboration during the *Mist Collector* project was variable. During the collaboration there were two distinct periods: the artist-in-residence period (2014) and the doctoral practical research period (2015 – 2018). During the 2014 artist-in-residence period, art, in an effort to relate to science, engaged in learning the language of science and scientific method. Working in close contact with science and doing things together (conducting experiments, looking at art or discussing experimental results and their relation to the problem of water scarcity), we could say that our art and science collaboration followed the logic of ontology,³⁷⁴ which, not unlike transdisciplinarity, aims at blurring disciplinary boundaries. In this period art and

³⁷⁴ Born and Barry, "ART-Science," 103-119.

science were not oriented towards either artistic or scientific production, but rather were striving for relational change between art, science and their objects of investigation (water), merging together in an attempt to establish a different way of working and developing a new methodology of problem solving. During this period the collaboration was relatively successful because there was fluidity in the relationships (and thus entities) being created, and from these changing relationships new ideas and perspectives (e.g., the image of the forest of fibres) could arise.

The doctoral practical research period (2015-2018) focused on art production and dissemination on one side and the conducting of experiments and tools (e.g., Labbé's experimental measurements of drop collection efficiency with nylon fibres³⁷⁵) on the other. We could say that while in the first period art paid attention to science, the opposite was true during the second period, when science attended to art. Consistent with agential realism, during neither period, did art treat science, water or the public as non-participants, but attempted to invite science and the public to participate in the practice of ethical response-ability through the creation of an encounter with water, hence enlarging the circle of inclusion. During this period, the collaboration was somewhat less successful because there was less attentiveness to the relationships (and entities) being created, in part because there was less direct interaction between members of the art and science teams.

Overall, however, the *Mist Collector* collaboration was successful as new perspectives, solutions, and response-abilities were enabled. Specifically, the success of the collaboration lay in creating novel relationships between art and science. By

³⁷⁵ Labbé & Duprat, "Capturing aerosol droplets with fibers," 6946-6951.

subverting the expected relationships of art-as-a-visualization-tool-for-science or art-as-means-of-communicating-science-to-the general-public,³⁷⁶ the collaboration created a new relationship, in which art and science co-created experiments and in the process, activated new entities and perspectives that, without the collaboration and novel relationships, would have remained invisible and excluded.

5. Limitations and Recommendations

The *Mist Collector* collaboration, as all relationships, was not perfect. Below, I describe three areas in which limitations were experienced, and for each, I provide a recommendation that could mitigate the limitation.

5.1 Limitations and Recommendations 1: Art and Science Should be Equal Partners

During the doctoral practical research period of the *Mist Collector* collaboration, art and science became less equal in their partnership than they had been during the Artist-in-Residence period. During the doctoral period, art and science interactions became less frequent, allowing each to fall back into its own practice. Whether it was caused by the fact that the art and science program was new and not yet well established, to organizational hierarchy or interpersonal differences, interactions between artists and scientists were not very well integrated during that time, resulting in the separation of artistic and scientific investigations into a binary mode of relating, in which disciplines influence each other but do not converge.

³⁷⁶ Born and Barry, "ART-Science," 103-119.

A solution is to maintain an equality between the partners. When art and science work on equal footing and in a mutually respectful way, their relating can be quite fruitful, as was the case with the *Mist Collector* collaboration during the artist-in-residence period, when the collaboration set a new direction in research on the collection of water from fog through the image of a forest and related technical research.

The difficulties arising during the *Mist Collector* collaboration from the imbalance of power are not specific to our collaboration. Two surveys³⁷⁷ found that a majority of artists perceived their work as being undervalued,³⁷⁸ and some reported not being acknowledged for their research inputs.³⁷⁹ However, all parties, artists and scientists agreed that trust and the mutual respect was paramount in building sound collaborations.³⁸⁰ Factors such as a lack of acknowledgement or “hidden agendas or difficult power relations”³⁸¹ created frustration or distrust among collaborators that consequently led to failure of collaboration.³⁸² Most of the interviewees asserted that communication and time spent working together were essential factors in building acceptance and openness, including personal connections. They emphasized the

³⁷⁷ (1) An anonymous survey of five scientists and six artists from Germany and Finland (University of Gothenburg in Sweden and Aalto University in Finland, 2019). (2) Seventeen artists from the Dunedin School of Art and fifteen scientists from Otago Polytechnic in Dunedin, participated in the *Art and Neuroscience* project and exhibition in 2013 (University of Otago Zoology Department in New Zealand, 2014).

³⁷⁸ Camilla Groth et al., “When Art meets Science: Conditions for Experiential Knowledge Exchange in Interdisciplinary Research on New Materials,” in *Proceedings of International Conference 2019 of the Design Research Society Special Interest Group on Experiential Knowledge*, eds. Nithikul Nimkulrat et al. (Tallinn: Estonian Academy of Arts, 2019), 245.

³⁷⁹ *Ibid.*, 243.

³⁸⁰ *Ibid.*, 247.

³⁸¹ *Ibid.*, 246.

³⁸² *Ibid.*

importance of the transgression into “the uncomfortable,”³⁸³ a zone of the other’s field, and the willingness to be educated by the other’s language,³⁸⁴ a process that has to be nurtured and built consciously over a long period of time. Finnish researchers found that “language can vary greatly between the two fields.”³⁸⁵ They said that science tends to use language where there is “no confusion between what is stated and the nature of facts,”³⁸⁶ while art employs metaphors and poetic language “to make a stronger, immediate connection between experience and conceptualization.”³⁸⁷ Despite these differences and discrepancies, the authors of both surveys saw art and science collaborations as the potential starting point for a leap forward, concluding: “We found that truly interdisciplinary breakthroughs could emerge precisely in the space that nobody could have considered without having to stretch beyond the comfort zone of their familiar discipline.”³⁸⁸

5.2 Limitations and Recommendations 2: Community Involvement is Critical

The second limitation relates to community involvement. To engage in inclusive ethical practices to be able to address complex and long-term environmental issues such as water scarcity, in addition to the relationship between science and art, communities who will contribute to and benefit from the research must also be invited to participate. Just as art is not the passive recipient of science's knowledge, and water

³⁸³ Ibid., 247.

³⁸⁴ Ibid., 246.

³⁸⁵ Ibid., 240.

³⁸⁶ Ibid.

³⁸⁷ Ibid.

³⁸⁸ Ibid., 247.

is not a passive entity in the process of extracting water from fog, the community beneficiaries of the water-from-fog technology are not passive recipients of solutions. I present 3 case studies, one in which the community was not actively involved, with devastating consequences (5.2.1) and two forms of a solution: collaborations in which community involvement resulted in sustainable water solutions (5.2.2, 5.2.3).

5.2.1 Example 1:

Failure to consult community results in water problems (Coyo, Chile)

I became aware of this crucial role of community involvement, during my field trip to the Atacama Desert, Chile in 2018. The Atacama Desert is the driest place on Earth with an annual rainfall of less than 10mm,³⁸⁹ where in some places, like the city of Iquique, annual rainfall is even less than 2mm³⁹⁰ (in comparison, for reference, Paris receives 650 mm per year³⁹¹). As an artist-in-residence, for a period of three weeks, I lived in Coyo - a small community just outside of San Pedro de Atacama, a town that has become a tourist oasis in the middle of the arid high plateau of the Andes Mountains with hotels and spas offering the chill-out experience of soaking in pools in the midst of the desert.

During my residency, my goal was to learn how indigenous people have dealt with the question of water in the driest place on Earth. To my surprise, I found that for

³⁸⁹ Matthew V. Thompson et al., "Multi-annual climate in Parque Nacional Pan de Azúcar, Atacama Desert, Chile," *Revista Chilena de Historia Natural* 76 (2003): 236, doi: 10.4067/S0716-078X2003000200009.

³⁹⁰ Philip W. Rundel et al., "Tillandsia landbeckii in the coastal Atacama Desert of northern Chile," *Revista Chilena de Historia Natural* 70 (1997): 348, https://www.researchgate.net/publication/285800037_Tillandsia_landbeckii_in_the_coastal_Atacama_Desert_of_northern_Chile.

³⁹¹ "Climate – Paris (France)," Travel World Climate Guide, accessed April 30, 2021, <https://www.climatestotravel.com/climate/france/paris>.

the Likanantai people, water was not a concern, especially not in the past. In their cosmology, water is inseparable from mother earth, and hence by venerating Earth they are necessarily celebrating water. The Atacama Desert lies at approximately 2000 metres above sea level and is surrounded by the Andes mountains. Access to water comes from rivers that flow from the mountains with the water then distributed through a system of canals. Today's water problem lies in the extensive lithium and copper mining, as well as tourism activities that while generating employment in the region, also deplete local water supplies. This opposition between economic development and water supply produces tension between the various parties involved. Lack of governmental support and interest in the indigenous communities creates a situation, in which locals must rely on mining and tourism for income. Generally, locals were not opposed to mining and tourism, but they wanted to be in control of these operations. They believe that as people who have always relied on their environment for survival, they would be better able to guard it according to principles of renewal, which are encoded in their traditional knowledge and culture.

It was quite interesting to interview hydro-geologist Mariana Cervetto, who works with local communities and acts as a liaison between them and the government. As a person who is well versed in water politics in the region, she told me about the problem of lack of independent scientific evaluation regarding local water resources. In fact, she said that there have been no studies, which adequately assess the amount of underground water in the region.³⁹² In contrast, scientists employed by the mining industry declare that mining operations have minimal effect on local water ecology. Their official reports proclaim that there is no problem with pumping brine containing

³⁹² Mariana Cervetto, Interview in Coyo, Chile, December 2, 2018.

lithium and letting it evaporate in huge pools in the heat of the desert's sun in order to raise lithium concentration from 1 to 6%,³⁹³ as shown in the image below (fig. 74³⁹⁴). It is mind-boggling that for the mining industry, the usage of approximately 500,000 gallons of water per metric ton of lithium³⁹⁵ in the driest place on Earth does not present the problem.



³⁹³ Lorena Guzman, "Lithium sparks disputes in Chile's Atacama Desert," *Diálogo Chino*, October 16, 2020, <https://dialogochino.net/en/extractive-industries/37907-chiles-lithium-disputes/>.

³⁹⁴ The reason why I am using the image from the Chemetail Foote Lithium Operation in Clayton Valley in Nevada, USA instead of the Atacama Desert is because the mining industry controls access to the mining terrain and it was not possible to get close enough to take a photo.

³⁹⁵ "The Environmental Impact of Lithium Batteries," Institute for Energy Research, last modified November 12, 2020, <https://www.instituteforenergyresearch.org/renewable/the-environmental-impact-of-lithium-batteries/>.

Figure 74. Brine evaporation ponds of the Chemetall Foote Lithium Operation in Clayton Valley, a dry lake bed in Esmeralda County, Nevada, USA. Image by Doc Searls from Creative Commons, <https://search.creativecommons.org/photos/e1be43f2-6c83-4bab-b267-ccb41e752cc2>.

Thus, one of the issues encountered by the *Mist Collector* collaboration was that it did not (yet) involve any communities living with water scarcity. Based on this example from Coyo Chile, we can see that continued failure to link with relevant communities would likely predict failure for any propositions arising from the art/science collaboration. Of course, the *Mist Collector* collaboration is in its early days, so if it were to continue, there would be the opportunity to make the collaboration more inclusive, through engaging communities that would benefit from the co-created solutions.

5.2.2 Example 2:

Community collaboration leads to sustainable collection of water from fog (Bellavista, Peru)

The danger of lack of community involvement in Coyo can be contrasted with the experience in Bellavista, Peru. Bellavista is a typical young settlement on the outskirts of Lima, where people come in hopes of finding jobs in the capital. However, jobs are scarce and local villagers, especially single mothers, struggle to make ends meet.³⁹⁶ In addition, settlements like Bellavista, being illegal, are not connected to the public water supply and residents rely on water delivery by truck, which is more costly

³⁹⁶ Anne Lummerich, "The 'Green Desert' Project," accessed November 15, 2019, <http://www.alimon.org/home-english/green-desert-project/>.

than the public system.³⁹⁷ With an annual rainfall of about 10mm,³⁹⁸ it is out of the question to use this precious resource for agriculture to augment their livelihood.

The *Green Desert* project focused on these issues of water scarcity and cost, as well as the illegality of the settlements and the lack of sustainable income. First, to make the settlements legal, it was necessary to obtain legal land titles. To receive the land titles, the Peruvian government required that the area above (up-mountain from) the settlements be reforested as protection against landslides.³⁹⁹ In 2006, with a huge commitment from the residents of Bellavista, particularly women, two scientists from Germany built and installed experimental fog collectors, including funnel collectors, to gather water from fog for the planting and sustenance of 800 trees that were chosen to fit with the Lomas⁴⁰⁰ ecosystem; they consisted of *Casuarina* (She-oaks), *Schinus molle* (Peruvian Pepper), *Acacia macracantha* (Porknut), *Parkinsonia aculeate* (Jerusalem Thorn).⁴⁰¹ These trees, reaching an average height of approximately 1.5m after a year, were able to collect their own water through a drip system⁴⁰² and to continue the process of reforestation that enabled the community to get the land title and helped increase water availability through the natural water cycle.

In 2007, the community, in collaboration with scientists, constructed an additional Standard Fog Collector (SFC) and three new types of fog collectors (*Eiffel, Harp and Diagonal Harp*),⁴⁰³ as well as two water reservoirs to store the newly

³⁹⁷ Ibid.

³⁹⁸ Ibid.

³⁹⁹ Lummerich and Tiedemann, "Fog farming," 4.

⁴⁰⁰ Lomas means hills in Spanish and refers to 'green hills' that have vegetation supported by water from fog. In Lummerich and Tiedemann, "Fog farming," 1.

⁴⁰¹ Ibid., 3 and 4.

⁴⁰² Ibid., 4.

⁴⁰³ Ibid., 2.

collected water. In an effort not to miss any foggy days, the work was done quickly and all villagers, even pregnant women, worked on weekends and around the clock to speed up construction.⁴⁰⁴ Up to 150 people formed human chains to transport more than 10,000 kilograms of sand and pebbles, plus 2,000 bricks, to the project site.⁴⁰⁵ That year, the water that was collected was used to irrigate 700 newly planted Tara trees.⁴⁰⁶ By 2009, these trees began producing their first fruits,⁴⁰⁷ which the villagers were able to sell to generate additional income. Water collected during the project's third year was used to start family horticulture on terraces built just above the village. Creating a source of income close to the village was of particular importance to single mothers, who were able to keep an eye on their children while working. In spite of the project being initiated by outsiders, its success rested with community involvement at every step, including initial project coordination by women from the community, through the construction of the fog collectors, the building of water reservoirs, the tree planting, all the way to continued maintenance of the collectors. In September 2007 (in the second year of operation), the project was officially handed over to the community to be maintained and managed,⁴⁰⁸ and by 2009, *Green Desert's* successful model had spread to two neighbouring villages.⁴⁰⁹

The *Mist Collector* collaboration has much to learn from the *Green Desert* project. By broadening its collaboration and creating new actions (e.g., planting trees

⁴⁰⁴ I became aware of the difficulty of bringing materials, tools and machinery to a site where there is no road or transport infrastructure on my visit to the fog-harvesting site on Mount Boutmezguida, Morocco, while driving up a steep winding path in a Jeep.

⁴⁰⁵ Lummerich, "The 'Green Desert' Project."

⁴⁰⁶ Lummerich and Tiedemann, "Fog farming," 3.

⁴⁰⁷ *Ibid.*, 4.

⁴⁰⁸ Lummerich, "The 'Green Desert' Project."

⁴⁰⁹ *Ibid.*

with collected water), the Green Desert project also created possibilities and solutions that would have otherwise remained invisible (and impossible), such as family-based agriculture and increased economic stability.

5.2.3 Example 3:
Community consulting and training leads to enhanced autonomy
(Dar Si Hmad, Morocco)

A second positive example of the importance of community participation, is work conducted by the not-for-profit organization Dar Si Hmad (DSH) in Morocco.⁴¹⁰ Since 2006 DSH has been developing a project of collecting water from fog on Mount Boutmezguida with the aim to provide water to local communities of Amazigh Berbers, as well as to revitalize their culture and preserve the region from further environmental degradation.

Mount Boutmezguida is located in the Aït Baamrane region of southwest Morocco, between the Sahara Desert, the Anti-Atlas Mountains and the Atlantic Ocean. The area receives less than 112 mm of rain yearly and experiences endemic droughts.⁴¹¹ With a small amount of rain, sparsely located wells are low on water and are shared with animals. As a result of agricultural runoff and human/animal waste, the

⁴¹⁰ The invitation to visit Dar Si Hmad came from co-founder of DSH, Dr. Jamila Bargach, whom I met at the 7th International Conference on Fog, Fog Collection and Dew that took place at the University of Wroclaw in Poland in 2016, where I gave a presentation titled “Mist Collector: Art and Science project.”

⁴¹¹ Rebecca L. Farnum, “Drops of diplomacy: Questioning the scale of hydro-diplomacy through fog-harvesting,” *Journal of Hydrology* 562 (2018): 450, doi: 10.1016/j.jhydrol.2018.05.012.

water is high in sulfates and nitrates.⁴¹² Climate change is bringing longer dry seasons and destructive, torrential rains resulting in landslides. In combination with poor management, water stress has caused the deterioration of already vulnerable and marginalized communities,⁴¹³ according to Jamila Bargach, co-founder of DSH.

The local population of Amazigh Berbers consists mostly of pastoral agriculturalists. Their income averages approximately \$5 US per day,⁴¹⁴ with their livelihood based on their animals, such as goats and sheep, beekeeping and small-scale farming of prickly pears and Argan trees (for oil).⁴¹⁵ The constant lack of water creates a situation where residents reduce their consumption of water to 10 litres per day per person⁴¹⁶ (in comparison to 455 - 530 litres/day per person in The United States⁴¹⁷) to preserve water for their livestock and agriculture. Decline in water sources diminishes their living, which then leads to migration from villages to cities, weakening their traditional family ties and reducing the local working age population.⁴¹⁸ In addition, women, who traditionally are considered to be water guardians, are responsible for providing water to households. With wells far away and shared by several families, the basic chore of gathering water has turned into a heavy and time-consuming workload performed by women and girls, who may spend up to four hours per day walking to and from wells fetching water.⁴¹⁹ These circumstances “represent a lost opportunity for

⁴¹² Leslie Dodson and Jamila Bargach, “Harvesting fresh water from fog in Rural Morocco: Research and impact Dar Si Hmad’s Fogwater Project in Aït Baamrane,” *Procedia Engineering* 107 (2015): 188.

⁴¹³ Ibid.

⁴¹⁴ Ibid.

⁴¹⁵ Ibid.

⁴¹⁶ Ibid.

⁴¹⁷ Morichi, “Novel Applications for Fog Water Harvesting,” 29.

⁴¹⁸ Dodson & Bargach, “Harvesting fresh water from fog in Rural Morocco,” 188.

⁴¹⁹ Ibid.

women and girls,” declares Jamila Bargach.⁴²⁰

From the beginning, DSH understood that for change to occur, it had to happen on numerous levels and with the involvement of all community residents, particularly women. It took long-term dedication to research, fundraising and collaboration with multiple institutions⁴²¹ for DSH and the community to finally be able to build an infrastructure to provide water to local communities. In 2013, DSH delivered the first fog water collecting systems that began producing up to 6,300 liters of fresh water daily and supply this water to five villages.⁴²² Today, DSH is the largest operating fog-water site in the world and produces on average 10,000 liters per day, supplying water to 16 villages, 2 schools and 5 mosques with mosque schools.⁴²³

Increasing the availability of water has freed women from much of their daily water chores, allowing them to dedicate time to other activities, such as literacy workshops organized by DSH, where they not only learn to read and write but also how to manage the new fog water collection system. With help of a mobile phone program (Mobiles for Development; M4D) developed by Dr. Leslie Dodson,⁴²⁴ women

⁴²⁰ Ibid.

⁴²¹ Thanks to Bargach’s ingenuity, multiple partners/sponsors were brought together, including University de la Laguna in Tenerife, Canary Islands (Spain), National Center for Research on Water and Energy at University of Cadi Ayyad in Marrakech (Morocco), Munich Technical University, and Wasserstiftung (Water Foundation) in Munich (Germany), ATLAS Institute and Mortenson Center at Colorado University in Colorado (USA), as well as Worcester Polytechnic Institute (WPI), Massachusetts (USA). Dodson & Bargach, “Harvesting fresh water from fog in Rural Morocco,” 190.

⁴²² Dodson & Bargach, “Harvesting fresh water from fog in Rural Morocco,” 189.

⁴²³ Dar Si Hmad, “Fiche technique détaillée du projet de brouillard,” shared by Jamila Bargach (Director of DSH) via Google Docs, May 5, 2020.

⁴²⁴ Leslie Dodson developed a configuration network of specific letters and corresponding numbers representing specific states and needs of the fog collecting system. What’s more, she taught them how to use basic tools, such as hammers, screwdrivers or wrenches.

are able to communicate with each other via SMS and can report problems and request maintenance for the water collectors.⁴²⁵ The program helped women to navigate a complex societal structure (e.g., to honour family relationships, women are not supposed to approach men directly) and remain water guardians. Moreover, women can use these 'fog' phones as tracking devices for fog patterns and as instruments for monitoring the distribution system.⁴²⁶ The literacy workshops with mobile phones have paved the way for further community development, including the establishment of a children's water, environment school and an e-learning program for rural youth.⁴²⁷

As with the *Green Desert* project, *The Mist Collector* collaboration has much to learn from the experience of DSH in Morocco. Again, collaboration has led to novel and sustainable outcomes responding to water shortages, which have then helped to turn the marginalized population of Amazigh Berbers into the carriers of change and hope for the future.⁴²⁸ Through creating novel relationships, not only can we find solutions to environmental problems, but we can foster environmental justice and community resilience, just two of the ideals aspired to by organizers such as Jamila Bargach.

5.2.4 Recap of Recommendation 2: Why Community Involvement is Critical

⁴²⁵ Leslie Dodson, "Women in Morocco – More rights through fog water," interviewed by Mayerhofer and Loster, *Into Action* 5, 20.

⁴²⁶ Ibid.

⁴²⁷ Manzoor Qadir et al., "Fog Water Collection: Challenges beyond Technology," *Water* 10, no.4: 372 (2018): 6, doi: 10.3390/w10040372.

⁴²⁸ Dodson & Bargach, "Harvesting fresh water from fog in Rural Morocco," 193.

The second limitation for the *Mist Collector* collaboration arose from its lack of collaboration with community that would most profit from its ideal outcomes. Based on the 3 cases I reviewed, it is clear that close and early links with the community, in which an intervention is embedded, are critical for long-term sustainability of any complex project.

In our case, part of the solution is more time. The *Mist Collector* project has not yet had time to consolidate its findings and to be ready to begin working on site. Although we have not yet engaged in community collaboration, I argue that *Mist Collector* is on the right path. The two successful projects (in Peru and Morocco) serve as examples of *action research*,⁴²⁹ which pointed out the impossibility for research in social sciences to be neutral. To avoid exploiting communities for academic purposes, Colombian sociologist Fals Borda, the inventor of ‘action research,’ called for ‘actionable’ knowledge, i.e., the development of knowledge that would serve the communities in which the research was conducted.⁴³⁰ He called for researchers to strive to “use their knowledge to help bring about change.”⁴³¹ Knowledge actionability should incorporate a variety of perspectives (as in interdisciplinarity), while maintaining social relevance (as in transdisciplinarity), but more importantly “responds to the needs and desires of the stakeholders.”⁴³² There are two critical attributes of creating

⁴²⁹ Developed by Colombian sociologist Fals Borda in the 1970’s. Machiel Keestra, “Interdisciplinary Imagination and Actionability: Reflections on the Future of Interdisciplinarity, Inspired by Julie Thompson Klein,” *Issues in Interdisciplinary Studies* vol. 37, no. 2 (2019): 117.

⁴³⁰ Ibid.

⁴³¹ Peter M. Smith, “A transdisciplinary approach to research on work and health: What is it, what could it contribute, and what are the challenges?,” *Critical Public Health* vol.17, no. 2 (2007), 162, quoted in Keestra, “Interdisciplinary Imagination and Actionability,” 117.

⁴³² Ibid.

actionable knowledge: action and imagination.⁴³³ Imagination provides “participants with experiences that are sufficiently rich and vivid to enable them to sense and understand them, share them, and deliberate about them,”⁴³⁴ and is a key factor in creating change because it connects what *is* with what *could be*. To enable change we first must imagine its possibility. Thus, while the *Mist Collector* collaboration has not yet resulted in community involvement, but it has already engaged imagination that has shaped both scientific and artistic research, rendering the invisible visible through creating novel relationships. It should be only a matter of time and continued relationship-building that will enable community engagement and sustainable solutions to the problem of water scarcity.

5.3 Limitation and Recommendation 3: Funding must have a multi-generational perspective

While one of the goals of community engagement in any ethically response-able art/science collaboration is sustainability of solutions, community collaboration can only go so far. Without long-term thinking when planning funding, no solution can be sustainable. Typically, funding for art and science collaborations focuses on the creation of various platforms for art and science interactions, including sponsoring programs for artist-in-residence in scientific laboratories, for education (e.g., new programs, workshops) in institutions of higher learning and for dissemination programs (e.g., exhibitions, festivals, symposia, conferences). The aim of these activities is to provide space for artists and scientists to work together, enabling different methods of

⁴³³ Ibid., 119.

⁴³⁴ Ibid., 120.

knowledge transfer from one context to another (developing inter- or trans- disciplinary knowledge productions), while promoting innovation and public engagement.

Generally speaking, technology is the glue for art and science collaborations, as is the case with such organizations as Leonardo/The International Society for the Arts, Sciences and Technology (Leonardo/ISAST), Quo Artis – a member of the Council of the Spanish Foundations for Science (Ministry of Science and Technology) or a recent initiative of the European Commission S+T+Arts (science, technology and arts). Technology is often linked with innovation, which is often associated with creativity. For example, the objective of ICT ART CONNECT study by the European Commission is to merge Science, Technology, and the Arts [in an attempt] “to remove the boundaries between art and engineering to stimulate creativity and innovation.”⁴³⁵ One problem with framing art and science collaborations in this way is that this framework seems to follow the Enlightenment’s division of science and engineering, on one hand, as guardians of technological development, and art on the other hand, as an agent of creativity. Unfortunately, this unidimensional linking of art and science through technology is unlikely to bring us as many novel solutions as we would wish. First, technology alone will not save us from the environmental degradation into which we are driving. Second, creativity is not an attribute of the arts only, but rather of all human activities,⁴³⁶ including the invention of the smart bomb.⁴³⁷ We are all endowed with the ability to be creative and the only question is whether and in what way we relate

⁴³⁵ “ICT & Arts,” STARTUP EUROPE, accessed June 17, 2021, <https://startupregions.eu/ict-and-arts/>.

⁴³⁶ Michael Ben Eli, “Architecting the Future,” The Buckminster Fuller Institute, June 3, 2010, video, 31:12, <http://vimeo.com/12808820>.

⁴³⁷ Ibid.

creatively. Thus, what we do and how we build relationships between art and science matters!

To practice ethical response-ability towards sustainable solutions, it is crucial to re-think ways of funding so that it includes not only artists and scientists, but also the communities, for whom the research is intended.⁴³⁸ And to increase the inclusivity of our relationships as agential realism would encourage us to do, we can envision communities to not only mean people, but to also include environments encompassing non-human beings such as plants and/or animals, as well as beings/non-beings such as mountains, rocks or water. With appropriate funding, art and science collaborations could expand their functions beyond public engagement, to incorporate community members, not as passive recipients of solutions, but as active partners in the relationship. It would be of utmost importance for funding bodies, which shape collaborations, to re-envision how to close the gap between academia and the real world problems stemming from social inequality (economic, racial, environmental), especially tangible during the Covid-19 pandemic. Sustainable development must go hand in hand with social justice.

In the context of social justice and sustainable development, reflection on the duration of funding is crucial. Given that grants typically range from 1 to 5 years, it can be hard to think about long-term planning for sustainable projects. Unfortunately, considering the scope of the environmental challenges we are facing, it is unlikely that we can tackle these problems with quick solutions or remedies. Instead, we require

⁴³⁸ Various community-based programs, such as for example EcoAction Community Funding Program by the Government of Canada do not include arts. "EcoAction Community Funding Program," Government of Canada, accessed May 20, 2021, <https://www.canada.ca/en/environment-climate-change/services/environmental-funding/ecoaction-community-program.html>.

durable (as suggested by the French word for sustainability: 'durabilité') and long-term planning and support, i.e. cathedral thinking,⁴³⁹ referring to the multi-generational commitment manifested in the Middle Ages when building gothic cathedrals, which sometimes took over 200 years to complete.⁴⁴⁰ This very long-term view is not unique to the European context and many indigenous cultures have and still live by such long-term philosophies. For example, in North America, the Great Law Of Haudenosaunee, the constituting document of the Iroquois Confederation, is based on the seventh generation principle, which states that we "must consider the impact of our decisions on the next seven generations."⁴⁴¹ This responsibility comes not only from thinking about the future, but also from the past through examining the circumstances that brought us to the present.⁴⁴²

Thus, to address environmental crisis we need a long-term strategy. We need to ask how we apply cathedral thinking or the seventh generation principle to funding? How can we engage in practices of ethical response-ability that are not driven by immediate profit outcomes or market driven solutions? Perhaps to invent, we first must listen to those in need and make sure that their voices are heard, ensuring that they are equal participants, not passive recipients, in the relational exercise of finding solutions.

⁴³⁹ Rick Antonson, "Cathedral Thinking," Broto, May 19, 2020, video, 57:46, <https://www.youtube.com/watch?v=CKuul2sH53s>.

⁴⁴⁰ "20 Buildings and Structures That Took the Longest Time to Build," Great Performers, accessed May 20, 2021, <https://greatperformersacademy.com/interesting/20-buildings-and-structures-that-took-the-longest-time-to-build>.

⁴⁴¹ "Great Law of the Oroquois Confederacy," Fast Company, last modified April 15, 2004, <https://www.fastcompany.com/665006/great-law-iroquois-confederacy>.

⁴⁴² Nick King, "Aspiring vision: Cathedral thinking in the modern world," Institute of Environmental Management & Assessment (IEMA), last modified October 2, 2020, <https://transform.iema.net/article/aspiring-vision-cathedral-thinking-modern-world>.

Perhaps, to create a meaningful future for all humans, non-humans, beings and non-beings, we must first ask meaningful questions and “think and act big,”⁴⁴³ as Buckminster Fuller envisioned years ago. Perhaps only a long-term orientation can bring us closer to imagining multi-generational art/science/community collaborations that include ever greater possibilities for intra-actions, engaging in sustainability and supported by cathedral thinking and seventh generation funding and philosophies.

Summary

To face complex problems such as water scarcity, we need to collaborate on multiple levels and in multiple ways. By putting art and science into a relationship that creates new entities and ideas, we can envision different values and become sensitized to the necessity of ethical response-ability; thus the justification for collaboration (section 1).

The relationships between art and science have varied throughout Western history but today, they are seen as opposites. This view, that science is rational and objective and art is subjective and concerned with the creation of beauty (aesthetics) developed during the Enlightenment, has impeded a more enriching way of art and science intra-actions (section 2). Agential realism provides a new opportunity for art and science relations by reintegrating ethics into the act of creation. Art and science joined in the practice of ethical response-ability become less binary and more integrated; an approach that brings back the ancient Greek notion of *phronesis* (section 3). The *Mist Collector* collaboration serves as an example of trying to apply this approach. In practicing ethical response-ability, the collaboration created invitations for

⁴⁴³ “Remembering Richard Buckminster Fuller’s principles of empathy and ‘doing with less’,” *STIRworld*, July 11, 2020, <https://www.stirworld.com/inspire-people-remembering-richard-buckminster-fuller-s-principles-of-empathy-and-doing-with-less>.

participation: inviting water, science, and the public to be partners in the relationship. Through these new relationships, novel solutions were found, demonstrating the possibility of success through this type of art/science collaboration (section 4). Yet, there were some limitations to the *Mist Collector* collaboration, including disciplinary isolation when interactions between art and science were reduced, the failure to collaborate with communities and lack of big-picture funding opportunities that encompass 'cathedral thinking' or the seventh generation principle of the Iroquois Confederation (section 5). However, for change to occur we must first imagine and the *Mist Collector* collaboration's success lies in engaging imagination and creating invitations to actively participate in finding new sustainable solutions in the face of the environmental problem of water scarcity.

Conclusion

Water is the essence of all aspects of our lives, from quenching our thirst, growing food or flushing toilets, to wearing clothes,⁴⁴⁴ using smart phones⁴⁴⁵ or driving cars. We consume water at every step of the way for survival, comfort, leisure or profit and yet, freshwater sources are not infinite and in fact they are diminishing at an unprecedented rate due to over extraction, over consumption and pollution. With the climate crisis causing a change in weather patterns, with increasing temperatures, more frequent droughts and floods, groundwater does not have time to be replenished. Freshwater is becoming scarce and increasingly unavailable, especially in arid regions.

To draw attention to the water and sanitation problem, the United Nations first declared the Water for Life Decade (2005-2015) and then, in recognizing the gravity of the global water situation, launched the Water Action Decade (2018-2028) to

⁴⁴⁴ The production of one cotton t-shirt requires 2 700 litres of water, which is approximately 900 – 1000 days of drinking water (depending on your weight and consumption), equaling to approximately 2.5 years of the drinking freshwater supply. “The Impact of a Cotton T-Shirt,” World Wide Fund for Nature (WWF), last modified January 16, 2013, <https://www.worldwildlife.org/stories/the-impact-of-a-cotton-t-shirt>. “Water: How much should you drink every day?,” Mayo Clinic, last modified October 14, 2020, <https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/water/art-20044256>.

⁴⁴⁵ Canadian professor of political science at the University of Toronto and director of the Citizen Lab at the Munk School of Global Affairs and Public Policy, Ron Deibert, in his fifth Massey Lecture points to the enormous carbon footprint of our electronic devices and communication. He says that “sending 65 emails is roughly equivalent to driving one kilometer in a car.” In addition, data centres require hundreds of thousands of gallons of freshwater a day to operate, and factories producing components for our smart phones use millions of gallons of freshwater. Ronald J/ Deibert, “Burning Data,” November 15, 2020, produced by CBC Radio Ideas, *CBC Massey Lectures*, podcast, 53:38, <https://www.cbc.ca/radio/ideas/want-to-help-save-the-planet-hang-onto-your-old-smartphone-1.5799102>.

“mobilize action that will help transform how we manage water.”⁴⁴⁶ According to the United Nations World Water Development Report in 2020 as much as 52% of the global population will face water scarcity by 2050.⁴⁴⁷

One of the untapped freshwater sources and a possible solution to the problem of water shortage in arid regions is harvesting water from fog, especially in areas where fog is abundant, such as in coastal areas with cold ocean surface currents, including the west coasts of the Americas and Africa. Fog trapping technology is not new, as some animals, plants and people have used it in various capacities for millennia, but in recent decades, scientific research has made technological advancements in an effort to increase efficiency of this process. While the work of the current thesis adds to our scientific and technological understanding of collecting water from fog, through addressing problems of clogging, drainage and re-entrainment that impede efficiency of current systems, my research did not follow the perspective of a single discipline but instead brought art into collaboration with science.

As an artist whose practice of many years has focused on sustainability and intra-actions between people and their environments, I was driven by a desire to touch clouds and be part of problem solving in addressing water shortage, as well as engaging in novel ways of thinking and collaborating, such as offered by the concepts of relational ethical response-ability and diffraction arising from the theory of agential realism.

⁴⁴⁶ United Nations, “Water Action Decade, 2018-2028: Averting a global water crisis.”

⁴⁴⁷United Nations Water, *The United Nations World Water Development Report 2020: Water and Climate Change* (Paris: UNESCO, 2020), 26.

The *Mist Collector* project and collaboration challenged the standard method of collecting water from fog with a mesh net and proposed an alternative way of harvesting fog water with a net of parallel vertical fibres. Our art and science collaboration devised a new metaphor for fog collection (a forest of fibres), which set the direction of technical research that included controlled production of artificial fog on a large scale, fabrication of a substrate (net) upon which to collect fog water and the proposition of novel structural forms.

At the same time, the *Mist Collector* project and collaboration augmented the scope of the scientific question of efficiency through the production of three artworks (a video projection and two installations) and the *Porous Sail* prototype, which explored other possible questions, such as how to develop different relationships with water, fog or wind in which they are not passive objects of investigations but active participants. Thus, art concentrated on the creation of a platform for intimate encounters and an invitation for participation.

Art enmeshed in the practice of ethical response-ability, employed imagination to expand the circle of inclusion and invited water to become a participant in the collaboration. This invitation for participation was also extended to the general public through immersive art installations in which the viewer/participant was also invited to experience an encounter with water, wind and clouds. Through sensory stimuli (visible, audible and tactile) and poetics, these artworks attempt to create a different awareness of water, one of visceral closeness, while moving science and the general public to action, not in the didactic way of a factual presentation, but through experiential participation.

To deal with such complex problems as water scarcity, we need to collaborate and strive for ethical practices of an ever-more inclusive way to extend the invitation for participation to as many participants as possible, especially to communities for which the research is intended. Perhaps, the approach of working in situated partnerships, with humans but also with non-humans (living and non-living, including animals, plants, soil, water or rocks), might help us avoid the pitfalls of considering technology to be the panacea bestowed on those that cannot help themselves. Considering a problem in a situated context, reveals, perhaps not surprisingly, that indigenous communities in the Atacama Desert, have managed to live with limited water sources for millennia until recent lithium mining activities created the problem of water shortage. Perhaps only by recognizing that humans are not the sole agents in the world and that other entities are active determinants (as many indigenous peoples have long insisted), we can stop treating water as a passive resource that we can use and abuse and thereby start to build different relationships with water.

Could the atmosphere, a diluted ocean of aerial moisture, be a solution for providing freshwater to the underserved? Or will 'the sky's the limit' become another commodity for profit?⁴⁴⁸ Could art and science collaborations provide ethical responsibility in the creation of an Ecosophic⁴⁴⁹ World and open a tap of imagination for the benefit of all beings and non-beings? Can collaboration be the means by which we enact change and begin to do things differently?

⁴⁴⁸ Ana Rewakowicz, *Garden the Sky Water*, accessed June 18, 2021, <https://yakari.polytechnique.fr/gsw>.

⁴⁴⁹ Ecosophy - "A philosophy of ecological harmony or equilibrium that was proposed by Arne Næss, who stressed the need to consider ethics and values as well as the physical symptoms of environmental change." *Oxford Reference*, s.v. "ecosophy," accessed May 10, 2021, <https://www.oxfordreference.com/view/10.1093/oi/authority.20110803095741551>.

Perhaps, we can begin with the realization that we are not uninvolved observers looking from a distance at an inert world that awaits our intervention. Furthermore, we can become aware that we are enmeshed in a world of multiple relationships, a world in which we are only one part. And through this recognition, we can already create change, as we come to understand that everything we think, say or do, no matter how small, matters! One bump in a field of goosebumps matters, not because of its utility as an individual, but because it is part of other bumps on the surface of the body's largest organ, the skin, that creates a response to the environment. Our importance does not lie in that we are individuals, but in the fact that we are in ongoing relationships with other humans and non-humans (living and non-living), with whom we co-create responses and environments. Change happens through small differences we make, which then, can become bigger differences creating cultural shifts, different socio-political realities and natures.

Collecting water from fog can be thought of in a similar way, as a small bump that matters. This technology is not a universal solution to the global water crisis; it is a local solution that, like a penny added to another penny producing a larger amount, can mitigate water shortage on a local scale. However, over time small solutions can create big changes. Imagine small communities managing to sustain themselves through local resources,⁴⁵⁰ as they had done before we became a society and culture of

⁴⁵⁰ According to an article in The Guardian, Elon Musk, Jeff Bezos and Bill Gates have an estimated wealth of \$466 billion (USD), while at the same time having "the biggest personal carbon footprint on the planet." The authors say that they represent "a Davos-centric worldview that sees free markets and technological advancements as the answer to an existential emergency already upending the lives of millions of people." Imagine if their wealth could be distributed among small communities in need of basic resources to be able to help themselves, instead of being invested in big technological schemes, such as establishing colonies in space or on Mars.

colonizers and settlers, a society expanding beyond the means of its immediate environment.

In making a change, time is of essence (as both, an immediacy of the need for change and as a crucial factor in the process of change itself), since there are likely to be no quick, global or immediate solutions to our biggest problems. Perhaps to make a difference we need to think fast (no time to waste!) but in geological time, beyond us, beyond the immediate, and even beyond the here and now, the present that is already in the past.⁴⁵¹ Perhaps to make a difference we need to connect the present, past and future to build multi-generational and long-lasting relationships including as many entities (existent and non-existent) as possible, and maintain them so they can thrive, stay open, die and be reborn “without dismissal (without ‘enough already!’),”⁴⁵² in the tireless pursuit of ethical response-ability.

Imagination is crucial in this process, as we must proceed with the imagining of what kind of relationships we want to have with water, not as a passive (re)source but as an active partner (who can roar with anger and hurt as a response to our actions), with which, in collaboration, we can make a difference. Perhaps it is in dreaming of different relationships with water, rocks or fog that we can become responsive and

Oliver Milman and Dominic Rushe, “The latest must-have among US billionaires? A Plan to end the climate crisis,” *The Guardian*, March 25, 2021, <https://www.theguardian.com/us-news/2021/mar/25/elon-musk-climate-plan-reward-jeff-bezos-gates-investments>.

⁴⁵¹ In an interview with filmmaker Patricio Guzman, astronomer Gaspar Galaz explains: “The camera that I am looking at now, a few meters away, is already a few million or more of a second in the past, with respect to the time I have on my watch.” He declares “the present does not exist” and continues to explore the idea that “the only present that exists, and if it is so, is what I have in my mind and in my conscience.” *Nostalgia for the Light*, directed by Patricio Guzman (Icarus Films, 2010), <https://vimeo.com/ondemand/nostalgiaforhelight>.

⁴⁵² Barad, “Quantum Entanglements,” 265.

responsible to what living and nonliving⁴⁵³ together means. Perhaps then, in dreaming, we can bring justice to *Two Women Sitting Down*, a rock formation in Australia that for the OM Manganese Ltd. mining company, were just rocks (full of manganese), whereas for the Aboriginal people of Kunapa, they were two ancestors, a bandicoot and a rat bleeding in a fight over bush food⁴⁵⁴ - a perfect metaphor of our current world. In the lawsuit that followed the destruction of these rocks, OM Manganese Ltd. was charged with desecration of the sacred Aboriginal site. But who decided that these beings were 'dead' (nonliving) and thus, their demolition not worth calling manslaughter, attempted murder or murder?⁴⁵⁵

Imagination is fundamental because it can help us to develop different kinds of relationships with our surroundings. It allows us to connect the existent and non-existent in time and space and hear a far-away butterfly flapping for our attention. Art can help us to learn how to dream, to create different relationships, to build collaborations based on mutual respect and co-dependence, and to participate in practices of ethical response-ability, so that we can bring justice to (non)life together.

⁴⁵³ Anthropologist Elizabeth A. Povellini points to a mode of governance of liberal Capitalism, which she calls geontopower that promotes the dichotomous relationship between life (bio) and nonlife (geos) to control the discourse and differences between indigenous people and settlers in Australia. Elizabeth A. Povinelli, "Geontologies: The Concept and Its Territories," *e-flux Journal* 81 (April 2017): <https://www.e-flux.com/journal/81/123372/geontologies-the-concept-and-its-territories/>.

⁴⁵⁴ "Mining firm desecrated Australia Aboriginal site," *BBC News*, August 2, 2013, <https://www.bbc.com/news/world-asia-23527303>.

⁴⁵⁵ Jean-Thomas Tremblay, "Jean-Thomas Tremblay reviews Geontologies," *Critical Inquiry* (May 2018): https://criticalinquiry.uchicago.edu/jean_thomas_tremblay_reviews_geontologies/.

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APPENDIX A
Research Publications
(2014-2020)

Research Publications (2014-2020)

EXHIBITIONS

- 2020 **ISEA 2020**, International Symposium on Electronic Art, Montreal, QC, Canada [Online exhibition]
- 2019 **Voltaje Festival**, San Juan de Dios Hospital, Bogota, Colombia [curator: Carmen Gil Vrolijk]
- 2018 **Nephelograph (Mist Impressions) and Through the Looking Mist**, Nuit Blanche, Paris, France
- 2016 **In Conversation: Art and Science**, Centre Intermondes, La Rochelle, France [Solo]
- 2014 **ISEA 2014**, International Symposium on Electronic Art, Dubai, United Arab Emirates

RESIDENCIES

- 2019 **Global Lab – Foisie Innovation Studio**, Worcester Polytechnic Institute, MA, USA
- 2018 **La Wayaka Residency**, Coyo community, Atacama Desert, Chile
- 2017 **Cité Internationale des arts**, Paris, France
- 2015 **International residency at Récollets**, Paris, France
- 2014 **LadHyx Laboratory**, École Polytechnique, Paris, France

CONFERENCES / PRESENTATIONS

- 2020 **Ethical Response-ability in Karen Barad's Mattering: Art and Science Intra-action of Collecting Water from Fog**
International Symposium on Electronic Art (ISEA2020),
October 13-18, Montreal, Canada [online: <https://vimeo.com/560472800>]
- 2019 **Garden the Sky Water**, Conference host
La chaire arts & sciences, Paris, France
- Nuit des idées – Facing our time**
Blowing Hot and Cold: Climate change and New Alliances
Centre Culturel Canadien, Paris, France

Instilling Art Visions in the Science of Collecting Water from Fog
*Design Science Symposium, Rhode Island School of Design,
Providence, USA*

Imagining Futures Together: Mist Collector
Art in the Anthropocene Conference, Trinity College Dublin, Ireland

2018 ***Watering Future Gardens: Reflections on Human Ingenuity***
Balance-Unbalance Conference (BunB 2018), Rotterdam, The Netherlands

Living in a Cloud
FMeeting Conference, Cultivamos Culturas, Portugal

2017 ***Prendre l'eau de l'air au fillet***
LASER Paris, Leonardo/Olats & La Diagonale Paris-Saclay, Paris, France

Mist Collector
*Signature Ceremony of the Chair Arts and Sciences, Institut Pasteur,
Paris, France*

2016 ***The Concept of Design-Science in Art/Science Collaboration***
*Laboratoire Interdisciplinaire de Physique (LIPHY), University of
Grenoble, France*

Mist Collector: Art and Science Project
*7th International Conference of Fog, Fog Collection and Dew (FFCD)
24 – 29 July, Wroclaw, Poland*

2015 ***Anti-entropic Role of Art***, University of Silesia, Katowice, Poland

PUBLICATIONS

Peer-reviewed Texts

Encounters: Art, Science, Clouds and Water. Rewakowicz, A. In ***Transmedia Change: The design, implementation, and testing of socially conscious transmedia stories.*** Edited by Moloney, Kevin, Jenifer Palilonis, and Sarah Jansen. Abingdon: Routledge, 2022 (upcoming).

Ethical Response-ability in Karen Barad's Mattering. Art and Science Intra-action of Collecting Water from Fog. Rewakowicz, A. In *Proceedings of the 26th International Symposium on Electronic Art (ISEA2020), October 13-18, 2020, Montreal, QC, Canada*, edited by Christine Ross and Chris Salter, 341-348. Montreal: Printemps numérique, 2020. <http://www.isea-archives.org/proceedings-catalogue-2/>.

Mist Collector: Art and Science Project. Rewakowicz, A., C. Duprat and J.M. Chomaz. In *Proceedings of the 7th International Conference on Fog, Fog Collection and Dew, July 24 – 29, 2016 Wroclaw, Poland*, edited by Marek Blas and Mieczyslaw Sobek, 129-132. Wroclaw: University of Wroclaw, 2016.

Invited Texts

L’art et la science à l’oeuvre dans la collecte de l’eau du brouillard” une démarche éthique. Rewakowicz, A. In *Art versus Société : soumission ou divergence ?* Edited by Fischer Hervé. Catania: Osservatorio Processi Comunicativi, *M@gm@ vol. 18 n. 3* (2020): 99-108.

Le rôle anti-entropique de l’art. Rewakowicz, A. *Plastir* 54 (2019): <https://www.plasticites-sciences-arts.org/PLASTIR/Rewakowicz%20P54.pdf>.

Blowing The Ruled. Rewakowicz, A. In *Objects mathématiques*, edited by Cédric Villani and Jean-Philippe Uzan, 168-173. Paris: CNRS Editions, 2017.

FILMS

Lazarotto, Quentin [director]. *Man Ray et les équations shakespeariennes*. Paris: Institut Henri Poincaré, 2019.

Sylvain Gourand [director]. *Mist collector*. Paris: Daniel and Nina Carasso Foundation, 2016. <https://vimeo.com/569143860>

REVIEWS

Pejic, Dare. *Is the sky the future of water?* **Makery**, June 21, 2019. <http://www.makery.info/en/2019/06/21/le-ciel-est-il-lavenir-de-leau/>.

Christova, Iglia. *Quand les imaginaires artistiques se jettent à l’eau.* **Arts Hebdo** (2017). <http://artshebdomedias.com/article/imaginaires-artistiques-se-jettent-a-leau/>.

Gracian, Louis. *Suivre La Goutte d’Eau.* **Parcours des Arts n°48** (2016): 85.

Lanoëlle, Agnès. *Le brouillard, tout un art.* **La Rochelle Sud Ouest**, October 13, 2016.

Moeder, Claire. *La solitude des plantes.* **Claire Moeder’s Blog**, January 19, 2016, <http://clairemoeder.blogspot.fr/>.

GRANTS

- 2016 - 2020 **Doctoral Fellowship**
Social Sciences and Humanities Research Council (SSHRC), Canada.
- 2019 **Travel Grant**, Canada Council for the Arts
- 2018 **Residency Grant**, Conseil des arts et des lettres du Québec
- 2017 **Residency Grant**, Canada Council for the Arts
- 2016 **Research and Creation Grant**, Conseil des arts et des lettres du Québec
- 2015 **Residency Grant**, Conseil des arts et des lettres du Québec
- 2015 **Research and Creation Grant**, Canada Council of the Arts
- 2014 **Research and Creation Grant**, Diadonale Paris-Saclay, France

ORGANIZATION AND TEACHING RELATED TO PhD RESEARCH

- 2018 - 2019 ***Garden the Sky Water***, *Conference co-organizer*
École Polytechnique, La chaire art & sciences, Paris, France
- 2016 ***Production workshop in preparation for exhibition***
Centre Intermonde in collaboration with Université de la Rochelle,
La Rochelle, France
- 2015 ***Summer School: Architecting Water Collection***, *Co-Instructor*
École Polytechnique, LadHyx Paris, France

APPENDIX B

Architecting Water Collection

Summer School – l'École Polytechnique, Paris

(September 7 – 16, 2015)

Architecting Water Collection Project – Summer School, L'École Polytechnique

Ana Rewakowicz

We live in a diluted ocean of aerial moisture. In fact, we can say that there are real “sky rivers” full of fresh water in the atmosphere, from which we can draw our water supply. Water is literally in the air!

Access to clean drinking water has become the world's biggest issue. On average a human has to consume about a gallon of water every day in order to remain alive. In many parts of the world access to water is very scarce, especially in arid regions where groundwater or rain is not available. Because of climate change, fresh water sources are diminishing. The “**Architecting Water Collection**” project addresses this problem by looking into an alternative method of obtaining fresh water by means of collection of fog droplets. The conventional fog-harvesting method developed by the FogQuest company in Chile, involves the use of fishing meshes. Although this procedure has produced good results, it requires more research and innovative solutions in order to increase the efficiency of this process.

The research undertaken during the project will explore the architectural possibilities of water collection on a forest of fibers. This is a rich and complex problem as it combines geometry, aerodynamics, capillarity and elasticity. We will look into varying 3D structures that can improve water collection efficiency, including experimentation with ruled surfaces and the study of architectural strategies developed by a small plant, *Cotula fallax*, that captures and drives fog drops towards its roots, with the help of its hydrophobic leaves arranged in a unique hierarchical three-dimensional design.

During the project we will build 2-frame and 1-frame models using flexible tubing. On the 2-frame models we will attach fibers based on ruled surface principles to create various shaped structures. On the 1-frame model we will use gravity to test the behaviour of flexible fibers, referencing architectural strategies practiced by Antonio Gaudí. On these structures we will project mist and observe the formation of water droplets. In both models fishing weights will be used to adjust the tension of fibers to see its effect on the water collection process. To document, as well as to expand our understanding of the underlying mechanisms we will use a high-speed camera.

In this project we will brainstorm together how to improve efficiency of water collection through various hands-on experimentations. You will gain knowledge of ruled surfaces, experiment with their applications within an architectural context and develop an appreciation of art and science collaboration.

APPENDIX C


Garden the Sky Water

Conference Pamphlet

(2019)

12.06.19
Workshop
SIRTA, École polytechnique, Palaiseau

13-14.06.19
Conferences and round tables
Cité internationale des arts, Paris

14.06.19
Screening & debate about the
imaginary of  Dune
Studio des Ursulines, Paris

15.06.19
Conferences, kid lab, art installations
Maison des métaux, Paris

International Interdisciplinary
Symposium June 12-15, 2019,
Paris, France

<https://yakari.polytechnique.fr/gsw>

Garden

the Sky

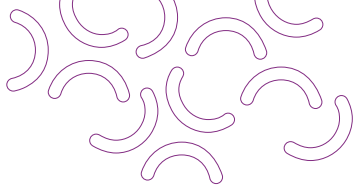
Water

Exploration of alternative water
sources defining different relationships
with our environment

La  chaire
arts &  sciences

École polytechnique
Fondation Daniel
et Nina Carasso

École nationale
supérieure des
Arts Décoratifs
-PSL



Abstract

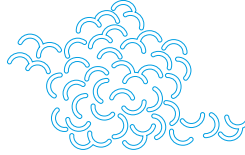
Water is the essence of life on our planet. With climate change and industrial agriculture, **water resources** are diminishing at unprecedented speed. Could the atmosphere, a diluted ocean of aerial moisture, be the solution to provide fresh water? Could we interrogate the cosmos in our links to the mist? But will “the sky’s the limit” become another commodity for profit? Or will we open a tap of imagination for the benefit of all?

In this interdisciplinary conference, we propose to face climate change by **cultivating together new approaches in the exploration of alternative sources of water**. We are calling for post-anthropocentric narratives, entanglements between nature, culture and technology, insisting on our **interdependence** with our environment and playing string figures with companion species, as phrased by Donna Haraway. Our explorations will lead us to wander through **Gilles Clément’s gardens**, which propose a new form of environmental exchange accessible to all, and in which the gardener rejoices in the art of observation “with as little means as possible” (The Garden in Motion).

Throughout this journey we will reflect upon **the socio-political, scientific and philosophic implications of water in the atmosphere and space**. In the tension between infinite desires and finite resources, shall we become gardeners who creatively express their protection, responsibility and love into the world? Or should the figure of the gardener be replaced by the gardener gardened as in the human comedy *L’Arroseur arrosé* by Louis Lumière (1895)?

You are cordially invited to experience voices of various ‘gardeners’: artists, scientists, philosophers, anthropologists and architects, as well as to open and share your own gardens!





Committee

Conference Main Advisors:

- Ana Rewakowicz, Artist and Researcher, École polytechnique
- Jean-Marc Chomaz, Artist and Physicist, École polytechnique / Director CNRS, Co-Head of Chaire arts & sciences

Conference Advisory Board

- Carole Écoffet, Researcher, EnsadLab and Institut de Science des Matériaux de Mulhouse / CNRS / EnsadLab
- Manuelle Freire, Researcher, art & science Post-Doc, Chaire arts & sciences

Executive organizers

- Julie Sauret, Communication-Project Manager, Chaire arts & sciences
- Christine Lavour, Communication Coordinator, Chaire Développement durable

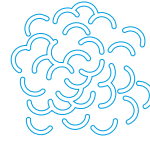
Website

- Do Chi Toai Vu, Systems Engineer, École polytechnique

Short Program

Wednesday June 12, 2019
SIRTA, Ecole Polytechnique, Palaiseau

10am - 6pm
Workshop on atmospheric data



Thursday June 13, 2019
Cité International des arts, Paris 4

10am - 12:30pm
Session 1: Rivers in the Sky
Keynote Speaker: Veronica Strang - "Serpentine Skies: celestial journeys with hydrotheological water beings"

Round Table 1: R. Bidault-Waddington, C.Damesin, M. Delbecq,
(Moderator - A. Rewakowicz)

2pm - 5pm
Session 2: Atmospheric Scenographies
Keynote Speaker: Jamila Bargach - "An Ode Celebrating Fog"

Round Table 2: ML.Nadal, D.Peysson, A. Vasak,
(Moderator - C. Ecoffet)

9am - 5pm
Video Installations

4.30pm - 7pm
Cocktail at Cafe des arts

Friday June 14, 2019
Cité International des Arts, Paris 4
Studio des Ursulines, Paris 5

10am - 12:30pm
Session 3: Environmental Narratives
Keynote Speaker: Karolina Sobecka - "Closure assumptions"

Round Table 3: M.Berthou, MJ. Bourgeois, P. Hegaret & V. Boquet,
S. Soussan, (Moderator - V. Vesna)

2pm - 5pm
Session 4: Every Drop Counts
Keynote Speaker: Daniel Beysens - "Dew and Dew Harvesting"

Round Table 4 : Y. El Turk, A. Rigobello & V. Roussel, (Moderator - L. Dodson)
Artistic performance by : Geneviève Favre-Petroff - "Expecting to Fly"

6.30pm - 9pm

Screening of Frank Pavich's documentary "Jodorowsky's Dune" (2013)

debate by: D.Bouchon, N. Fructus, S. Lainé (Moderator - C. Ecoffet)

Saturday June 15, 2019

Maison de Metallos, Paris 11

2:30 pm - 5pm

Session 5: Gardening Future

Keynote Speaker: Nicolas Reeves - "We are in the water"

Keynote Speaker: Anne-Marie Lagrange - "Exoplanets and distant worlds"

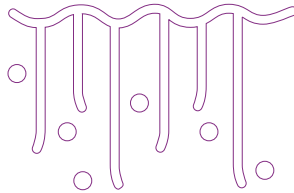
Keynote Speaker: Gilles Clément - "Atmospherics : genealogy and descendency of a cloud harp"

2pm - 5pm

KidLab

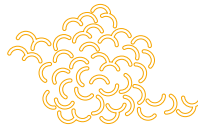
5.45pm - 6.30pm

Art-Science Installation, Music, and Performance



Garden the Sky Water International Symposium

<p>Location Ecole polytechnique Palaiseau, SIRTA</p>	<p>Cité Internationale des arts, Paris 4 auditorium Studio des Ursulines, Paris 5</p>	<p>Maison des métallos, Paris 11</p>
<p>Activities Workshop</p>	<p>Conferences, round tables, video installations (mainly in English) Screening and debate about "Dune"</p>	<p>Conférences (en français) Arts-sciences installations</p>
<p>Days & Schedule June 12 10am - 6pm</p>	<p>June 13 10am - 11am: Conference</p> <p>Video Installations</p> <p>A. Meyer-Brandis, S. Myllyla, J. Otariu</p>	<p>June 14 10am - 11am: Conference</p>
<p>Workshop on Atmospheric Data</p>	<p>Session 2 Rivers in the Sky Veronica Strang, "Serpentine Skies: celestial journeys with hydrotheological water beings" 11:15am - 12:30am: Round table R. Bidault-Waddington, C. Darnein M. Delbecq moderator: A. Rewakowicz</p> <p>12:30am - 2pm: Lunch break 2pm - 3pm: Conference</p> <p>Session 3 Environmental Narratives Karolina Sobocka, "Closure assumptions" 11:15am - 12:30am: Round table M. Bartheu, M.L. Bourgeois, B. Antoine-Loeff P. Hegarret, S. Soussan, moderator: V. Vesna</p> <p>Session 4 Atmospheric Scenographies Jamilia Bargach, "An Ode Celebrating Fog" 3:15pm-5pm: Round table M.L. Nadal, D. Pagnon, A. Vasaki, moderator: C. Ecoffet 4:30pm - 7pm Cocktail at Café des arts</p>	<p>June 15 2pm - 5:30pm: Conferences</p> <p>Session 5 Gardening Future jardins cosmiques 2pm - 3pm Gilles Clément, "Nous sommes dans l'eau" 3:15pm - 4:15pm Anne-Marie Lagrange, "Explorantes" 4:30pm - 5:30pm Nicolas Reeves, "Atmosphères: généalogie et descendance d'une harpe à nuages" 5:45pm - 6:30pm</p> <p>2pm - 5pm: Satellite Activities</p> <p>Kid Labs Organized by E. Ammar-Khodja</p> <p>"Sky" Laboratory (M.M. Ormizak, F. Radtke, L. Karst, G. Louis)</p> <p>Cello solo performance: S. Ballou "Nues": video and music performance: C. Boutilier, G. Parryron, L. Levert</p>
	<p>Screening and debate about "Dune" D. Bouillon, N. Fructus, S. Lahé, moderator: C. Ecoffet</p> <p>6:30pm - 9pm</p>	



Detailed Program

Wednesday June 12th, 2019

10am - 6pm, SIRTA, observatory of École polytechnique, Palaiseau

 Visit of SIRTA “Instrumental Site of Research by Atmospheric Remote Sensing”

 Workshop on the use of atmospheric data.


Sky observation is a major human concern, as we all live immersed in this fluid and atmospheric phenomena that impacts and constrains life. In meteorology, water-related events, including cloudiness, rain, snow have been traditionally monitored by trained human eyes and progressively replaced by automatic instruments that interact with these events in a passive (rain gauges, cameras, radiometers) or active (lidars, radars, light emitters, hot plates) manner, giving us a measure of the atmosphere constrains and state.

The workshop at SIRTA proposes to **discover atmospheric water “observation”** through four keynote speeches and linked questions:

 Is measuring objective?

 A tour in atmospheric water monitoring

 Reviewing the water cycle by experiments

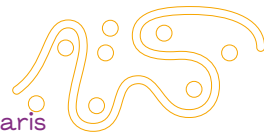
 Water observation through “other’s eyes”? Work through studies from instruments and instrumental synergy.

The journey will take place in open air, on the SIRTA instrumental platform, surrounded by all its instruments, on École polytechnique’s campus, in front of its lake. After every question-session, an open-discussion time will allow the participants and the guides to exchange on the experience.



Thursday June 13th, 2019

9:30am - 12:30am / 2pm - 5pm, Cité internationale des arts, Paris



☁ Conference ☁

Lectures will be mainly in English, with abstracts provided in French.

>> Auditorium (-1)

9:30am Welcoming

9:45am Introduction by [Ana Rewakowicz](#), artist and researcher at École polytechnique / Chair Arts & Sciences

10am ☁ Conference



Session 1: Rivers in the Sky

Keynote Speaker: [Veronica Strang](#)

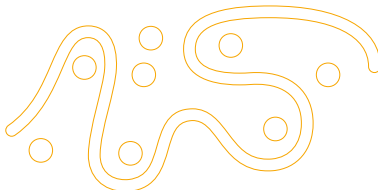
Cultural anthropologist, Director of Durham University's Interdisciplinary Institute of Advanced Study



“Serpentine Skies celestial journeys with hydrotheological water beings”

Living in ways that demanded close and collaborative environmental relationships, early human societies worshipped non-human deities that manifested the world's elemental powers. Recognizing water's essentiality to all living kinds, they observed its cyclical movements between earth and sky, and the journeys of celestial bodies. Ancient origin stories describe vast water serpent beings 'rearing up' from primal seas and creating the world from their own bodies, or 'spitting out' totemic beings to form the landscape and everything in it. Representing water, bringing water, indeed, composed of water, such serpentine beings manifested hydrological and spiritual cycles, carrying both water and life between fluid underworlds and heavens, and the material, earthly world.

Water serpent beings took many cultural forms. As Rainbows, they arched over and under the Earth's surface. They meandered across the sky as glittering 'sky rivers', or whirled around and encircled the earth. They revealed themselves in the patterns of the stars. Many swallowed and regurgitated solar and lunar deities, facilitating daily and seasonal cycles between light and dark. Connecting earthly and celestial worlds, water serpent beings enabled early societies to envisage hydrotheological flows of water, spirit and matter over time and space, and to conceptualize movements between being and non-being. In doing so, they located humankind conceptually within the flows of the world and its celestial spheres. Today, as we struggle to mend our rift with 'nature', and to regain more reciprocal human-environmental relationships, water serpent beings can help us to re-imagine the worlds through which our lives flow.



Round Table

Moderator: **Ana Rewakowicz**, artist and researcher at École polytechnique

1. **Raphaële Bidault-Waddington**, artist, author, funder of the LIID Future Lab : **Occupy the Sky**

“Occupy the Sky” is an experience of thinking about the future, based on a fictional design method and allowing us to feel, through different scenarios and theoretical reasoning, what a real exploitation of sky water could be in the future. Each scenario features a fictional organization deploying its operations in various ways and with more or less ambiguous intentions. The construction of multiple perspectives will make us oscillate between utopia and dystopia, reminding us how much the sky remains the cradle of humanity’s hopes and fears and embraces our lives.

2. **Claire Damesin**, Plant ecophysiologicalist: **“Trees and water...”** How ecophysiological knowledge can help us water our inner and outer gardens?

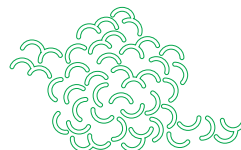
Can a scientific understanding of the water functioning of the tree be a way to access a deeper understanding of our relationship with gardens? The main driver of sap rising in trees is the evaporative demand of air. What about our lives? We will show how to capture an understanding of our own functioning at subtle levels through tree ecophysiology. By perceiving our functional resonance with them, we will then realize that the quality of watering in our outdoor gardens is intimately linked to the way we water our indoor garden and vice versa.

3. **Marcelline Delbecq**, artist, researcher Sacre ENS-PSL: **“A circle of clouds, soaring”** (Un cercle de nuages, planant)

Taking as a starting point the photographic and filmic corpus accumulated since 1926 by the Japanese meteorologist and physicist ABE Masanao from his observatory at the foot of Mount Fuji, Marcelline Delbecq will develop aloud and in images a thread of thought crossing photographic documents and Buddhist thought, worried cosmogony and poetic questioning. Inspired by documents gleaned both from the history of images and from random scholarly texts - A Circle of Clouds, Soaring is a title borrowed from an undated note in Kafka’s *Derniers Cahiers* - she will draw a singular story of the clouds overlooking the movements of the world. Between presence and disappearance.

12:30am - 2pm: Lunch break

2pm: Conference



Session 2: Atmospheric Scenographies

Keynote Speaker: **Jamila Bargach**
Director of the NGO Dar Si Hmad



“An Ode Celebrating Fog”

The conception of the natural world through local Moroccan cultural determinants constructs fog as a largely negative entity. Cognitively, fog is a problem: at the level of living conditions and material culture, fog causes rust to agricultural material and to one’s source of livelihood; and culturally, it is believed to generate a depressive environment. As for the physical aspect of fog, fog is humid, and it is a humidity believed to cross the boundaries of the flesh to seat itself in the marrow of the bones, one that hurts and dis-enables one’s body. A dampness close to ailment, a state of impossible-liquidity and yet impossible-dryness, but an in-between-ness that blurs clear boundaries and contained, clear-cut states. Fog is considered more so as a nuisance, a harbinger of lack of rain and a heaviness too hard to bear, it is not held in high esteem. Because of its elusive nature, it has come to stand figuratively for another negative image of mental blur, things of equivocal nature, and of uncertainty. But there is more to fog than this sum of negative representations. This presentation will take you through a journey of fog, an Ode celebrating it in intimate and different ways.

Round Table

Moderator : **Carole Écoffet**, physicist, researcher at EnsadLab and Institut de Science des Matériaux de Mulhouse / CNRS

1. **Marie-Luce Nadal**, artist, PhD SacrE: “A Stream whose source I do not know” / *Un courant dont je ne connais pas la source*
“ We are made of the material of which the winds are woven ...” Alain Damasio - La horde des contrevents

Creation is a weaving: a thread that is mixed with itself by taking care between each knot to leave space for the void. From a text and a context, “Un courant dont je ne connais pas la source” (A Stream whose source I do not know) is an in situ production that originates in the water, in the air and in the history of a 17th century washhouse buried in the Lot Valley in south of France.

2. **Dominique Peysson**, artist and physicist: “Droplets as information units”

The drop is a particularly interesting entity, because it allows to discretize a fluid, to pass from continuous to individual and vice versa. A set of drops can be considered as a digital system, but analog and not digital. But we can also consider them each as closed entities, carriers of information. And if we protect the surface from the drops by covering them with an oil-water skin, then life can happen...as it was at our origins. I will present the artistic productions I have produced based on these notions. Works where analog replaces digital, where inert matter tends towards living matter.




3. Anouchka Vasak, author, scholar, historian: “Luke Howard’s little atmospheric scenes”

Luke Howard is “the man who invented clouds”: he was the one who, in his lecture *On the Modifications of Clouds* (1803), gave them names, the ones we still use today (cirrus, cumulus, stratus). He accompanies his text with engravings based on drawings of which he is the author, representing the “modifications” of clouds. Most of the following editions are illustrated, some of them pretty “atmospheric scenes” or English landscapes with small human subjects. We will see the posterity of this practice in Constable’s skying or in Eugène Boudin’s beach scenes, and what it reveals about our modern relationship to the world.

10am – 5pm

Studio 4 (Cité internationale des arts, -1)

Video Installations


 “Teacup Tools”, 2014, a project by Agnès Meyer-Brandis; sculptor and new media artist. Duration: 3’42

The Teacup Tools are an array of cybernetic teacups, adapting themselves to the realm of climate related sciences. The work appears as a multifunctional tool for the investigation of tiny micro clouds above tea, for communication and for tea drinking. The tea and its clouds are made from anything falling from the sky: aerosols, litter, rain and mass data computation. It is literally boiled by the calculations of the massive amount of collected data.

The sculptures have a nomadic quality. Like parasites they can be found next to aerosol* measurement stations, in parks, on streets, on rooftops or in the neighbourhood of research laboratories. The Teacup Tools call attention to the investigation of the invisible and borderless air and its aerosols* - tiny particles of organic and inorganic matter, with a major impact on cloud formation, crucial to weather and climate.

 “Yo-cha”, a 2-channel video installation, silent, by Salla Myllyla

The video work Yo-cha was filmed in the Finnish countryside during 2016-2017. The videos follows changing seasons in an abandoned sculpture park in the backyard of an art center. It was filmed with a panoramic trail camera placed in an old sports commentator’s hut. In the unheated building the weather conditions are also visible on the surface of the window between the camera and the landscape: ice or dew can be formed on it which the sun can melt or dry during the day. The work shows water in its different forms: ice, snow, fog, mist, dew, rain.

 “Before Jellyfish Nebula”, 2018, a short film by Julian Olariu, visual artist, painter and sculptor. Duration: 4’35

In India, a peasant creates in his mind the Nebula Jellyfish. Fragments of his experience and memories interfere in a dreamlike narrative where imagination gets ahead of reality.

4:30pm Cocktail at Café des arts, Cité internationale des arts

Friday June 14th, 2019

9:30am - 12:30am / 2pm - 5pm, Cité internationale des arts, Paris

>> Auditorium (-1)

9:30am: Welcoming

10am:  Conference

Session 3: Environmental Narratives

Keynote Speaker: **Karolina Sobecka**

Artist, designer and researcher



“Closure assumptions”

Control of the weather is the ultimate techno-optimist dream. The grand post-war visions of controlling “everything atmospheric, everywhere, always” follow the long history of dubious if not fraudulent practices of rain-makers, and have paved the way for today’s geoengineering proposals and their binary narrativization as either audacious technocratic Trojan horses or planet-saving Promethean dreams. This, while those “global gardening” technologies gradually shift from science-fiction to science-fact. Can we encounter and examine this context with a narrative of our own?

Prefigurative, non-representational forms of artistic practice aim to position themselves within the domains of research, enacting and questioning the logic of technoscientific practices and governance structures that intervene in the Earth’s system. Art is one site where these processes can be staged and rendered as public: objects of both public concern and governance, as a site where meaning is constructed from engagements between materials, humans, and environments.

Round Table

Moderator: **Victoria Vesna**, media artist and Professor at UCLA Department of Design

1. **Maxime Berthou**, student-researcher at EnsadLab: “**Fiction P.**”

Fiction P. relates a performance (June 2011) during which Maxime Berthou artificially triggered rain at the US/Canada border. The three years of development of the project made the artist discovered that clouds - with icebergs - are the last drinking water resources without any legal status. Maxime Berthou will develop these questions and outline the specific context in which this unprecedented performance took place.

2. **Marie-Julie Bourgeois**, artist & **Barthélémy Antoine-Loeff**, media artist and performer: “**Our Meteors**”/ “**Nos météores**”, **fictions atmosphériques**

Our Meteors is an Art-Science exhibitions cycle on the theme of Exo-climates proposed by Marie-Julie Bourgeois and Barthélémy Antoine Loeff in artistic residency with SIANA in Evry in 2019-2020. This research project brings together multidisciplinary objectives around fiction through a set of installations designed by the artists included in Exo-planet Earth. Our environment conditions our perception and influences our “solar” civilization in its relation to man-nature harmony. How can the perception of exo-climates change the

perception and understanding of our environment and how fiction contributes to it?

3. **Pauline Hegaret**, visual and sound artist & **Victor Boquet**, interactive designer: “**There is smog**” / “**Yadusmog**”

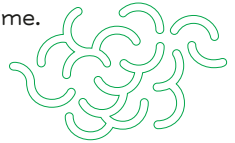
The YADUSMOG-IA project is a pastiche of weather applications for navigators. This artistic & scientific project has been tested on a city scale since March 2019. We rely on the existence of a citizen network. We have installed a network of air sensors to measure air pollution and humidity in these first-time activists in order to carry out a large-scale participatory science study, district by district. The training of artificial intelligence makes it possible to modify the representation of the landscape according to the rate of fine particles captured nearby, based on pictorial representations of “smog” learned by AIs. We will record these data and analyze the correlation between humidity and the rate of floating particles in the air. Artificial intelligence carries out a poetic and political data-visualization.

4. **Sylvain Soussan**, artist: “**Cloud Museum**” / “**Musée des nuages**”

The Clouds Museum follows the art trail to explore the climate issue (exhibitions, events, participatory workshops). In this museum without walls, whose entrance is everywhere and whose exit is nowhere, the materiality of our artistic heritage plays with the fluidity of atmospheric phenomena. Mobile like a cloud, sometimes furtive or nebulous, this artist’s project draws its substance from the metamorphoses of the sky and its elementary components: air, water, energy... the human factor. At a time of global warming when a few degrees can lift an ocean, we will climb a few steps to appreciate the nuances of our time.

12:30am-2pm: Lunch break

2pm: Conference



Session 4: **Every Drop Counts**

Keynote Speaker: **Daniel Beysens**

President of the NGO OPUR and Honorary Director of Research at the Ecole Supérieure de Physique et Chimie Industrielle de Paris (ESPCI-PMMH)



“**Dew and Dew Harvesting**”

The contribution of dew to atmospheric water has long been ignored or neglected. However, in some arid regions and/or during some dry seasons, dew can be an essential source of water for plants, insects, animals. Dew water can be also beneficial to humans by providing a supplementary fresh and clean source of water. Dew is the result of the condensation on a dedicated surface (plant leaves, roofs, collectors) of the atmosphere water vapor (humidity), which is a very large reservoir of water. Condensation is ensured by passive cooling at night due to a natural, inexhaustible, free and carbon free process: radiative heat losses with the sky. To harvest dew, many challenges concerning cooling and drop collection have to be faced. Dew collectors where the above aspects have been optimized have been erected in the world, with size ranging from individual, small collectors, to dew plants. The chemical and biological quality of dew water is in general such that it can be used for human consumption.

Apart from being used as an alternate source of water, dew is the source of inspiration of artists, poets, writers, painters. Dew also exhibits fascinating aspects for the scientist. An association, OPUR was founded in order to explore the different aspects of dew on scientific and artistic grounds and to unite both individuals and organizations interested in achieving these goals. OPUR is not a purely scientific organization but it does represent a wide cross-section of interests from the layman to the scientist.

Round Table

Moderator: [Leslie Dodson](#), reporter and researcher

1. [Yara El Turk](#), Interior Designer/ Communication Arts MA Student : “How water shapes Lebanese identity/environment ?”

Nature has the power to embrace or abandon a country depending on how it is treated by people themselves. Combining both design and communication, Yara El Turk will emphasize the importance of nature in defining a community and establishing its structure, highlighting how the water element is linked to identity and its part in the growth of individuality. To what extent does water play a major role as a healing factor in a country?

2. [Adrien Rigobello](#) and [Tim Leeson](#): [A Drop from the Ocean: Tactical Urbanism & Agency](#)

As the understanding of water is deteriorating in our communities, how can we consider addressing the problems related to the scarcity of drinking water and the increase in extreme climatic phenomena when citizens no longer have a relationship with drinking water? thr34d5 (NGO) is implementing a tactical urban planning intervention to strengthen its surrounding communities, encouraging the emergence of rituals around water in a site-specific manner. This intervention is intended to produce drinking water, and is designed in a way that can be amended and replicated: it belongs to the citizens. They are made responsible for maintaining this vital source, captains of this ship carrying their local communities.

Art performance: “[Expecting to Fly](#)” - [Geneviève Favre-Petroff](#)

“I walk around in a suit with clouded appearance made of expansive foam. My costume is crossed on either side by blue lights that emanate from the heart of the material. This electrical charge refers as much to storms, to the gaseous reactions of the cosmos, as to our own brain activity. With no velvet, I throw words into the air, I open my arms to the sky, I arch to the stars, and continue my journey....” This performance calls on the power of the elements, evokes power of the mind, cites the birth of Aphrodite and the Buffalo Springfield song (1967).

Friday June 14: [Evening about the imaginary of “Dune”](#)

How can we imagine a world without water?

In 1965, Franck Herbert published his novel Dune, which had become a classic in science fiction. In addition to its political plot and alliance games that will inspire many works such as Star Wars, its ecological dimension - Dune is an arid and hostile planet whose inhabitants cannot afford to waste a single drop of water - makes it a particularly topical work concerning the impact of the environment and water resources on lifestyles. This evening dedicated to Dune’s imagination invites you to extend this reflection, by meeting those who think of other worlds.

6:30pm – 8pm: Screening of the documentary “Jodorowsky’s Dune” (Franck Pavich, 2013)

In 1975, the already “cult” director Alejandro Jodorowsky embarked on a very ambitious adaptation of Dune for the cinema, ten years before David Lynch’s film. Inhabited by his visionary project, he gathered around him a team of artistic “warriors”, including Jean Giraud (Moebius), Dan O’Bannon, Hans-Ruedi Giger and Chris Foss. The film will not see the light of day due to lack of funding, but the documentary shows how the imagination of this crazy project, whose extremely detailed storyboard has been widely circulated in Hollywood studios, has infused a number of upcoming science-fiction film adventures (“Star Wars”, “Alien”, “Blade Runner”, “Total Recall”, “Matrix”) and developed certain thoughts and aesthetics on lifestyles without water or in harsh environments.

8pm – 9pm: Round table «Images and imaginary of Dune»

With Didier Bouchon, a research-creation engineer who participated in the design of the first video game “Dune”, Nicolas Fructus, comic book author and illustrator and Sylvie Lainé, science fiction author. The exchanges will be moderated by Carole Écoffet, researcher at the CNRS at the Mulhouse Institute of Materials Science and lecturer at EnsadLab on collaborations between artists and scientists.

Free event, registration encouraged: evenement.recherche@ensad.fr

Saturday June 15th

2pm – 6:30pm, Maison des métałlos, Paris

Théâtre : Session 5 : Gardening future / Jardins cosmiques (conférences en français)

2 pm: Introduction by Jean-Marc Chomaz, Artist and Physicist at École Polytechnique / Director CNRS, Co-Head of Chaire arts & sciences

2pm – 3pm:

Keynote Speaker: Gilles Clément



“We are in the water”

Water inhabits us, it surrounds us. We believe we breathe the air, we breathe the water. Is it really drinkable and breathable? The water biologically disqualified by our discharges modifies the biosphere, our house, by making it less habitable. One of the priorities of the Planetary Garden is to restore the energy we take from it to the environment without changing its qualities: an interesting challenge that has not yet been met. Should we blame the cyanobacteria that store excess nitrates in water bodies? Is the water from the sky immediately drinkable? What about a possible cloud war today? Is there a way to save water in daily domestic, gardening and agricultural use?



3:15pm - 4:15pm:

Keynote Speaker: [Anne-Marie Lagrange](#) :



“Exoplanets and distant worlds”

Our perception of the place of the Earth in the Universe and of the place of man has changed considerably over the centuries. For only two decades, we have known that planets exist around stars other than the Sun. These extrasolar planets, which we are just beginning to explore, already reveal an unexpected diversity compared to the planets of the solar system. Do planets more or less similar to the Earth, possibly harbouring a life form, exist? What are the necessary conditions for the emergence of life? If, in the current state of knowledge, the presence of liquid water on the surface of the planet seems indispensable, other conditions must undoubtedly be verified... Finally, how can we detect, from Earth, signatures of life in these distant worlds?

4:30pm - 5:30pm

Keynote Speaker: [Nicolas Reeves](#):



“Atmospherics : genealogy and descendency of a cloud harp”

“The Ithaca Dream” is a meteorological and electronic installation that continuously probes the atmosphere and extracts all its characteristics: temperature, humidity, barometric pressure, wind speed and direction, sky brightness, rainfall, cloud height and density, electrostatic field level, lightning. All these variables are mixed and transformed to generate a meditative song that never stops. “The Ithaca Dream” is also a meridian probe: the angle between its elements indicates the position of the meridian of Ithaca, also called the meridian of the lost, this great circle arc that connects the island of Ithaca in Greece to the city of Ithaca in New York State. More than 7000 kilometres long, the meridian is the path that those who seek to find their place of origin constantly walk along. If they deviate from it, no compass will bring them back: their only hope is to dive into themselves, to abstract themselves from the tumult of the world, to soak up the voices of the atmosphere and try to detect, in their incessant murmur, the one that will show them the direction to follow. The conference will present the instrument and its genealogy, which is lost in the mists of time. It will be an opportunity to discuss the conditions that allow the emergence of contemporary creative processes that bring science, art and technology together in equal measure, in an inseparable whole, and to discuss the conditions required to ensure the fertility of their encounter.

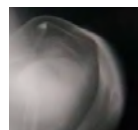
5:45pm - 6:30pm Performances

 “Reflets, Inconnaissance” (18’) by [Séverine Ballon](#): Cello solo performance

 “Nues” (11')

By [Célia Boutilier](#), visual artist, [Labofactory](#), art-science collective and [Gabriel Pareyron](#), composer: a video installation where mist movements interact with a cello solo performed by [Louise Levert](#)

Reflecting on the relationship between art and science images, Nues is a video installation where mist movements interact with a cello solo. The water vapour is set in motion in a twelve-minute sequence shot, according to a previously

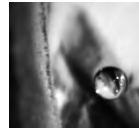


established choreography. The mist is revealed in a grazing light, comes to life gently, begins its dance. The landscape is intended to be misty, carnal; it is formed and torn to the rhythm of off-field movements. Sculpting the impalpable nature of water vapour is working as a place of an ephemeral, intangible and unstable interface. Projected on a very fine projection canvas that oscillates according to the movements of the spectators, the image of the mist is separated from the screen.

2pm - 5pm Satellite activities

Experimental kidlab for children:

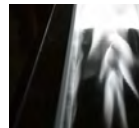
art-science experimentations around a drop of water, conducted by the artist-researcher [Brice Ammar-Khodja](#), assisted by the art student [Gwenaëlle Lallemand](#).



Exploring different states of water and the powerful imagination that emanates from this resource: this will be the objective of this experimental workshop. Artistic laboratory, poetics of science? From an event as imperceptible and insignificant as a drop of water in the middle of a fall, what is happening? By drawing inspiration from simple scientific protocols, we will try to bring the rational object towards the dreamlike imagination. Using various hydrophobic materials, participants will be invited to develop a water drop circuit as a team. Together and each in their own way, they will have to arrange a part of the circuit in order to allow the circulation of the drop. Diversions, bounces and accidents will allow us to describe the behaviour of water in the face of matter.

"Sky" by Labofactory (Jean-Marc Chomaz, Filippo Fabbri, Laurent Karst and Greg Louis): an interactive

art-science installation to explore the behaviour of mist In a 2.5 metre channel, a layer of mist is animated by mobile and ephemeral, ghostly and mucilaginous forms. This substance, which materiality is uncertain, changes texture and moves in response to motions around the basin, to the distant caress of a hand. The space that this behavior deploys in the imagination is musical rather than choreographic: the mist behaves like a sound material made up of textures and rhythms. In SKY, human interaction affects fog just as, in the real world, it affects climate change.



Credits :

Jean Marc Chomaz, artist/physicist (X and Labofactory)

Laurent Karst, architect/designer (X, ENSA Dijon and Labofactory)

Filippo Fabbri, researcher/composer (University of Paris-Saclay and Labofactory)

Greg Louis, composer (ESSS and Labofactory)

Assisted by:

Coralie Betbeder

Antoine Garcia (Ladhyx)

Eunyoung Lee (ENSA Dijon student)





BIOGRAPHIES

Keynote Speakers

Jamila BARGACH, is a cultural anthropologist and Director of the NGO Dar Si Hmad, Morocco. She obtained a Ph.D in cultural anthropology from Rice University, Houston TX USA in 1998. Professor at the National School of Architecture, ENA Rabat from 2000 to 2009 at which date she was given the task of managing a Southern-based Foundation in Morocco. Since this date, Jamila Bardach contributed to the building of the largest fog collection project in the world, and has founded an Ethnographic Field School that hosts and fosters environmental educational programs. She has also run tens of development and education-based initiatives in Morocco's Southwest. She is the winner of the 2018 Moroccan edition of the Tamayuz Prize for projects benefiting rural women, the 2018 French Suez Foundation Prize, and the UNFC prize in 2016 during the COP22-Marrakech.

Daniel BEYSENS, PhD in Physics and in Engineering, is a world specialist of water collection from air. He is the co-founder and President of OPUR International Organization for Dew Utilization. He is also honorary Director of Research at Ecole Supérieure de Physique et Chimie Paris where he carries out with his team experimental and theoretical study on dew condensation and phase transition. He started the field at the Alternative Energies and Atomic Energy Commission (CEA) when he was Head of Institute. He is associate editor of the Physical Science International Journal and has authored or co-authored 12 books and more than 450 publications in international scientific Journals. He was awarded many prizes in Physics and Environmental Sciences and is Knight of the Order of Academic Palms.

Gilles CLÉMENT is a French agronomist, gardener, landscape gardener, botanist and entomologist. In 1977, Gilles Clément ceased his activity of designing gardens for private clients to devote himself to "the public space" and founded the Acanthe Workshop in 1985. He moved independently as an artist in 2000 and organized his services in co-contracting with landscape workshops, especially Coloco in Paris. The concept of Jardin en Mouvement, born from an experiment in its own garden in the Creuse region, finds its application in public space for the first time in the Parc André Citroën in 1986. The book bearing the same name appears in 1991. More than 20 works will follow, some of them addressing other important concepts, such as The Planetary Garden (exhibition at La Villette in 1999/2000) and Le Tiers-Paysage (2003), translated into several languages. As a teacher at the National School of Versailles from 1980 to 2012, Gilles Clément also gave classes at the Collège de France in 2011/12 as part of the Chair of Artistic Creation and continues as a temporary teacher in the form of workshops in Italy, Spain and France. Several awards have been dedicated to his work, including the "Grand Prix du paysage" in 1998. The André Citroën Park (in co-design), the Domaine du Rayol in the



Var, the Jardins de l'Arche in Nanterre, the Valloires Garden in the Somme, the Matisse Park in Lille, the garden of the Quai Branly museum in Paris, the roof of the submarine base of Saint-Nazaire (Jardin du Tiers-landscape) are among the best-known projects of the public. The traveling exhibition "Toujours la vie invente", created in 2013 in Saint-Benoît-du-Sault, installed at the Cultural Center of Noirlac meeting (2014) then at the Paris Val de Seine School of Architecture (2015), at the Melle's Biennale of Contemporary Art (2015), the Meyrin Art Center in Geneva (2016) and the Trévarez Park in Brittany (2017) will be presented in Lausanne in 2019.

Anne-Marie LAGRANGE, is a French astrophysicist, member of the Academy des Sciences (Science Academy) since 2013 and director of CNRS research at the Institute of Planetology and Astrophysics of Grenoble. Anne-Marie Lagrange is an authority in the field of extra-solar planetary systems, their formation and evolution. After studying at Polytechnique, she did a thesis during which she participated in the discovery of the first star surrounded by a disk of matter, prefiguring the formation of a planet. Specialist in spectroscopy, she collaborated in 2004 to realize the exceptional photo of an extra-solar planet and discovered in 2008 the exoplanet Beta Pictoris b with the Very Large Telescope (VLT) of the European Southern Observatory (ESO).

Nicolas REEVES is graduated from the Massachusetts Institute of Technology, trained in architecture and physics and currently a creator-researcher at the School of Design at the University of Quebec in Montreal. His work is characterized by the highly poetic use of science and technology. Founding member, then research-creation director of the Hexagram Institute from 2001 to 2009, vice-president of the Society for Arts and Technology for ten years, he is Head of the NXI Gestatio Design Laboratory that explores the impact of digital in all areas related to the design. Several of his works have had an important media impact, such as the Cloud Harp, Aérostabiles, which studies the artistic potential of flying cubic automata capable of developing autonomous behaviors, or Point d'Origine, which explores the transposition of major architectural places into sound waves. Winner of several awards and scholarships, he presented his work and gave lectures worldwide.

Karolina SOBECKA examines social arrangements that exploit, resist or accommodate technological change. Her work has been shown internationally, including at the Victoria & Albert Museum, The National Art Museum of China, MoMa Film, ZKM and Marfa Dialogues, and has received numerous awards, including from Creative Capital, NYFA and Princess Grace Foundation. Sobecka has taught at SAIC, RISD, and NYU, and is currently a doctoral researcher at the Institute for Aesthetic Practice and Theory, HGK in Basel.



Veronica STRANG is a cultural anthropologist, Director of Durham University's interdisciplinary Institute of Advanced Study, United Kingdom. Her research focuses on human-environmental relations, especially societies' engagements with water. She has held academic positions at the University of Oxford, the University of Wales, Goldsmiths University and the University of Auckland. From 2013-17 she chaired the Association of Social Anthropologists of the UK and the Commonwealth. In 2000 she received a Royal Anthropological Institute Urgent Anthropology Fellowship, and in 2007 an international water prize from UNESCO. Key publications include *Uncommon Ground: cultural landscapes and environmental values* (Berg 1997); *The Meaning of Water* (Berg 2004); *Gardening the World: agency, identity and the ownership of water* (Berghahn 2009); *Ownership and Appropriation* (Berg 2010) and *Water: nature and culture* (Reaktion 2015). She is currently writing a major comparative text examining historical and contemporary beliefs about water serpent beings.

Presenters Biographies

Brice AMMAR-KHODJA, born in Colombes in 1992, he is a graduate of the Haute École des Arts du Rhin (with a major in Design) and is currently a research student at Ensadlab, the research laboratory of the École nationale supérieure des Arts Décoratifs-PSL, within the Reflective Interaction group. His research tends to question the symbolic and spatial relationship between materials with behaviour and projected subject as well as the relationship between environment and users through chance, improvisation. His work is situated between artistic practice, design and scientific research, guided by the notion of “serendipity”, a mixture of art, imagination, science and investigation. Co-founder of the 2920g collective and the typographic journal “Pied de Mouche”, he has also been working for two years with researchers from the IS2M (Institut de Science des Matériaux de Mulhouse) in a group specialising in the interaction between surfaces and water. Water since then has been irrigating his imagination.

Barthélémy ANTOINE-LOEFF is a visual artist whose creations of optical and digital artworks, sometimes interactive, often immersive, express dreamlike worlds crossed by a contemplative and ecological relationship of nature and elements. The artist creates spaces for sharing his feelings about the “forces” of the world: dreams, energies, materials, technologies. Refusing to place himself in the field of the Kantian sublime, he positions himself at the place of wonder and infantile craze, as if to claim the part of the dream that we develop as a child and which remains forever our “desiring motor” throughout our life.

Séverine BALLON is a cellist and composer who works on the classical and contemporary repertoire. She has collaborated with various composers (Rebecca Saunders, Chaya Czernowin, Mauro Lanza, Francesca Verunelli, Liza Lim, Marianthi Papalexandri-Alexandri...). She studied cello at the Hochschule Berlin and Lübeck with Joseph Schwab and Troels Svane and contemporary cello with Siegfried Palm, Pierre Strauch, Rohan de Saram, and with the Ensemble Modern Akademie. She was a visiting fellow at Harvard University and a visiting artist at CCRMA/Stanford



University. She composed and performed the original music for the feature film “The Ornithologist” by Joao Pedro Rodrigues (2016). Her CD Solo was awarded by Deutsche Schallplattenkritik Bestenliste, 5 tuning forks, favorite Charles Cros academy. Her CD “Inconnnaissance” (All That Dust) presents a cycle of 8 solo pieces composed between 2016 and 2018 for her solo instrument.

Maxime BERTHOU, French born in 1981, graduated from the art school of Aix-en-Provence, post-diploma at Fresnoy in Tourcoing, currently student-researcher at EnsadLAB. Since 2004 his work consists of developing and producing artistic performances based on elements of know-how. He invariably uses the tools of cinema to report on his projects. His work follows a two-step working protocol: a collaborative step of preparation sometimes very long (several years) followed by a single film activation sometimes very short (a few seconds). Disproportion being at the heart of his artistic speech, Maxime focuses on the deepening of a cinematographic language and its theoretical extension in the framework of formally imposing projects reminiscent of his obsession with cinema. In 10 years his work has been presented in numerous solo or group exhibitions: Palais de Tokyo, Sydney Opera House, MOMA-PS1, Pompidou Center, etc.

Raphaële BIDAULT-WADDINGTON is an artist, author and the founder of LIID Future Lab, a platform for prospective research on the changes of the contemporary world. Its formats include diagrams, photo montages, texts, conferences, drama scripts, workshops and creative strategies. Since 2000, LIID Future Lab has collaborated with numerous organizations in France and abroad, such as the CNRS (National Delegation), Peclers Future Trends, GDI Future Think-tank (Zurich), Aalto University (Helsinki), the Institute For The Future (Palo Alto, USA).

Didier BOUCHON is a research-creation engineer and a pioneer in video games and 3D systems. After studying biology and a diploma in applied arts at the Boulle school, he turned to computer programming, electronics and graphics and participated in the design of the first video games. In particular, in collaboration with Philippe Ulrich, he is responsible for «L'arche du capitaine Blood» (1988, Ère Informatique). In 1992, he participated in the video game «Dune» inspired by David Lynch's film. Since 2002, he has been collaborating with many artists. Since 2018, he has been involved in research & creation engineering as part of the Reflective Interaction research program of EnsadLab, a laboratory of the École nationale supérieure des Arts Décoratifs (EnsAD - PSL) and the Arts & Sciences Chair.

Marie-Julie BOURGEOIS is a French digital artist. After studying visual communications, she worked in Production company as an AD and a graphic designer. She has been exhibiting her multimedia installations since 2008 in France and abroad. In 2008, she received a Masters in New Media at the ENSCI with honors, developing her own research using digital technologies. In 2009, she followed to the EnsadLab research program and participated in the Topophonie research project at ENSCI. PhD in aesthetics, arts sciences and technologies since 2018 from Paris 8 University, she is currently teaching since 2013.

Célia BOUTILIER holds of a DNAP Art with honours from ENSAD – Dijon and currently continues her studies with a DNSEP at the Beaux-Arts de Paris. Combining videos, installations and photographs, she is interested in the singular deployment of time and space scales. Since time does not exist outside of things, it is in its thickness that she wishes to grasp the possibilities of the image. Since 2014, she has been collaborating with the Hydrodynamics Laboratory of the École Polytechnique (LadHyX) through the Chair Arts & Sciences program, as she finds there an inclusive,



speculative and poetic practice of science.

Jean-Marc CHOMAZ is a physicist artist, director of research at the CNRS, professor at the École polytechnique, director of the LaSIPS Laboratory of Excellence at the University of Paris Saclay and co-responsible, with Samuel Bianchini, for the Chair “Arts & Sciences” of École Polytechnique, École nationale supérieure des Arts Décoratifs – PSL and the Daniel and Nina Carasso Foundation. He co-founded the Hydrodynamics Laboratory (LadHyX) at École polytechnique and co-directed it from 1990 to 2013. Appointed a Fellow of the American Physical Society in 2001, he received the 2005 CNRS Silver Medal and the 2012 Grand Prix Ampère from the French Academy of Sciences. His research interests include soap film dynamics, biomechanics, instability theory, vortex bursting, geophysical fluids, oceanography, climate and art & science.

As an artist, he has created the installations «Un chemin qui chemine» and «Time Trace», as well as «Fleur de Lys» and «Catastrophe domestique n°3» with the artist duo HeHe, «Planète Laboratoire» for the Carbon 12 exhibition in 2012 and the Lost in Fathoms exhibition in 2014 with Anaïs Tondeur, «Misty Way» in 2015 with Ana Rewakowicz and Camille Duprat, as well as the installation-performance «Transmutation de Base» in Mexico in 2015 with choreographer Aniara Rodado and collaborates with her on various installations. He is also the co-founder of the Labofactory collective.

Claire DAMESIN has been studying forest trees for 20 years. As a plant ecophysiologicalist, she is particularly interested in tree carbon functioning (growth, respiration...), and tree responses to inter-annual climate variations through ring isotope characteristics. Her approach is mainly based on experimental studies in the field. Since a few years, she has been carrying out art-science projects about intimacy with trees in collaboration with artists. Currently, by an interdisciplinary approach and coupling human understanding and Ecology, she examines how scientific knowledge and sensitivity can cooperate towards a “fair” human-nature relationship.

Marceldine DELBECQ is a visual artist, writer and scholar based in Paris. After studying photography in the US then fine arts and theory in France, she progressively focused on the cinematic and photographic potential of writing. She is currently enrolled in a practice-based PhD on the movement in/of still images at Ecole Normale Supérieure. She also teaches creative writing at l’Atelier des Ecritures Contemporaines (La Cambre, Belgium). Recent publications include: *Silence trompeur*, Manuella éditions (2015) ; *Camera*, Manucius (2015) ; *Oublier, voir*, Fondation Cartier and Manuella éditions (2015) ; *Beyond Sound*, interview with Pascale Cassagnau (Daviet-Thery éditeur, 2018). Upcoming in 2019: *Camera*, Ugly Duckling Presse, New York.

Leslie DODSON (PhD) is co-director of Worcester Polytechnic Institute’s Global Lab, where she focuses on creative scholarship, humanitarian engineering and the integration of engineering, science and the arts. She has published on ICTs, climate adaptation, participatory community development, human-centered design, and gender and natural resources. Leslie received her PhD from the University of Colorado-Boulder College of Engineering and Applied Science for her dissertation work on “A Foggy Desert: Equitable Information Flow for a Fogwater System in Southwest Morocco.” Leslie is also an award-winning environmental and financial journalist, who has reported for CNN, CNBC, MSNBC, NHK-Japan and Reuters in Tokyo, London and throughout Latin America.



Carole ÉCOFFET is a research fellow at the CNRS at the Mulhouse Institute of Materials Science. Her laboratory work concerns light/matter interactions and the use of new materials in art. At the same time, she is interested in the relationship between scientific knowledge and imagination. She works at EnsadLab, a laboratory of the École Nationale Supérieure des Arts Décoratifs (EnsAD - PSL Research University Paris) and analyses the practices of artists working in collaboration with laboratories in the exact sciences.

Yara EL TURK is a creative interior designer with a four-year track record for delivering exceptional visual designs and a strong creative flair that is born from her passion for design. She is currently pursuing her MA in Communication Arts at the American University of Science & Technology (AUST) in Lebanon. She has participated in many annual exhibitions organized by AUST, from showcasing abstract paintings to displaying detailed interiors concerning the design of a center for alternative medicines. She took part in many workshops such as “Urban Inclusive Design” at ALBA university where she was the leader of her winning team. She was also published in “Mid-week”, the journal of her university, for having outstanding results. She was also formed in the design thinking field at Paris College of Art in France where she was introduced to Social Entrepreneurship, Design Thinking strategies & Personal Leadership skills. This has further increased her curiosity and passion for research.

Filippo FABBRI has a multiple identity, both composer/orchestrator and engineer/researcher. After completing his studies in writing and orchestration at the Conservatory H. Berlioz in Paris, he currently follows a specialization cycle in writing at CRR93 in Aubervilliers. Trained as an engineer, he also holds a PhD in Physics from the Laboratory of Condensed Matter Physics of École polytechnique and a PhD in Systems Engineering from the University La Sapienza in Rome. Currently Associate Professor at the University of Paris-Sud / Paris-Saclay, he conducts his research in the fields of nanosciences and, more recently, in the field of sound-art and audiovisual. His research interests include interaction, adaptive perception, spatialization, augmented reality and art science, and the development of interactive sound spatialization systems. His musical creations are dedicated to theatre, image, dance and contemporary art. An active member of the Labofactory collective, he has co-created new immersive musical instruments, such as “Water-Drums” and “Sky”. As a pianist, saxophonist and sound artist, he has performed in various ensembles and events.

Geneviève FAVRE-PETROFF is a Swiss artist trained at the Haute Ecole d’Art et de Design in Geneva. Her practice is transdisciplinary, she uses performance, installation, costume, voice, music, video and light to meet her audience and invite them to follow her in her visual and poetic proposals. She expresses herself in the world around her by creating dreamlike works with extravagant offbeat characters, imbued with an irony that challenges the viewer. A pioneer of wearable technology in art, she designs visually rich costumes that come to life once worn and animated.

Nicolas FRUCTUS is a comic book author and illustrator. Through his work, he travels through imaginary worlds, fantasy or science fiction. In the mid-1990s, he collaborated with Moebius or Druillet on video game projects. Since 2000, Nicolas Fructus has been regularly involved in the production of fantastic illustrations (Éditions du Béliâl’), games (game boards, card illustration series), or comic strips (Thorinth or Showman Killer with Alejandro Jodorowsky).



Since 2010, he has devoted himself more specifically to illustrated books, often in collaboration with writers (Kadath, Un an dans les airs, Jadis, Gotland).

Pauline HEGARET or Pauline. H., born in 1987 in France, is a visual artist who also holds a degree in architecture. This space training has helped her to realize installation projects. Passionate about science and nature, she trained in human and political sciences, completing her degree as a politician and anthropologist between France & Brazil, which led her to initiate reflective work on the anthropocene and coastal erosion. Most recently, her work has focused on the observation of biodiversity and meteorology, through the use of sensors and the creation of interfaces. Her works question our relationship to landscape and science.

Laurent KARST is an architect designer, graduated from the École d'Architecture de Strasbourg and from the Domus Academy in Milano in industrial design. Winner of the Villa Médicis prize in 1995 for a research on the use of industrial waste, he then worked in various international architectural agencies, notably within the Jean Nouvel agency. In 2006, he created Atelier 16 - architectures and developed small-scale architectural and design projects, with a particular focus on raw materials and their implementation with a strong plastic and artistic footprint. A teacher at Ecole Nationale Supérieure d'Art de Dijon in design and architecture, he created, in 2014, an Art and Science department with the artist Philippe Mailhes, bringing together art students and researchers from the Faculty of Sciences of Dijon. As a project manager within the Chaire Arts & Sciences since 2017, he supervises students of École polytechnique to initiate them to practice based research projects.

LABOFACTORY is an experimental artistic collective created in 2005 by Jean-Marc Chomaz, physicist artist, Laurent Karst, architect designer and François-Eudes Chanfrault, composer. Referring to Andy Warhol's «Factory», LABOFACTORY tends to create a common territory between arts and sciences, a research space conducive to a shared imagination in order to re-found the vision and ethics of science and art through sensitive and poetic narratives. LABOFACTORY's installations integrate scientific research in fluid mechanics with spatial and sound questions, often in relation to climate issues. Bringing together various researchers, composers and artists, LABOFACTORY has developed more than 20 installations (Infraespace, Fluxus, Wave, Exoplanet, 2080, Unresolved Sun, Water Drums, Sky...) presented in Paris, Boston, Moscow, Berlin, Amsterdam and Bogota. LABOFACTORY has obtained the World Label of Physics in 2005 with «Infraespace», an installation created from metamachines producing sound-controlled steam rings.

Sylvie LAINÉ is mainly recognized as a science fiction author. In her stories, she explores the limits of perception and senses, the modes of communication, the encounter with others. Professor in Information and Communication Sciences at the University Jean Moulin de Lyon, she trains future documentalists in new modes of publication and communication in the digital age. Bibliography: Published by ActuSF: Le Miroir aux Éperluettes (2007); Espaces insécables (2008); Marouflages (2009); L'Opéra de Shaya (2014), Fidèle à ton pas balancé (2016). Editions Organic; collection Petites Bulles d'Univers: L'Animal (2014) in collaboration with Francis-Olivier Brunet; Les îles noires (2019) in collaboration with Philippe Aureille.

Louise LEVERT is a complete cellist who has a rich background of musical and scenic encounters. After classical studies at the conservatory, she played in jazz, rock and song groups. She practices improvisation and experimental music. Her attraction for the stage leads her to perform in theatre, circus, or during performances, as a musician but also as an actress. Her great interest in contemporary creation has led her to collaborate with ensembles such as the Ensemble Links, the Deutsche



Opera and the Staatsoper in Berlin, etc. She is the cellist of the Soundinitiative Ensemble.

Greg LOUIS is a singer-songwriter and musical performer. Trained as an engineer at École polytechnique and Ecole normale supérieure des télécommunications, he finally decided to dedicate himself to music, writing film music and collaborating since fifteen years with renowned artists in the French electronic music scene, including Daft Punk, Crydamoure, Modjo or The Supermen Lovers. He composed the sound part of “Soundstram”, “Soleil irresolu” and “Sky” for the LABOFACTORY collective.

Agnès MEYER-BRANDIS studied mineralogy and then sculpture and new media at the Art Academy in Maastricht, Düsseldorf Art Academy and Cologne Media Art Academy. Her work, exhibited worldwide and awarded, is exploring the zone between fact and fiction - artistic research on the quest for a degree of reality within constructions. Meyer-Brandis exhibited at Centre Pompidou Paris, FR/ Museum for Contemporary Art Berlin, ZKM, Karlsruhe, DE / HeK, House of Electronic Arts Basel, CH / National Gallery of Denmark SMK, Copenhagen, DK / National Taiwan Museum of Fine Arts, TWN / FACT, Liverpool, UK / Apexart, New York, US and Ars Electronica, Linz, AT amongst others.

Salla MYLLALÄ is a visual artist based in Helsinki, Finland. She graduated with an MFA from Academy of Fine Arts, University of the Arts Helsinki in 2014 and is currently a doctoral student in the same university. Her work moves between drawing, painting and moving images, and is always site specific. She observes changes in daily environment using time-lapse photography, recently with a panoramic trail camera. Her works have been presented in exhibitions at e.g. Gallery Huuto in Helsinki (2015), Frankfurter Kunstverein (2014), Charlottenborg Kunsthall (2017) and in festivals e.g. Tampere Film Festival (2016) and Japan Media Arts Festival (2016).

Marie-Luce NADAL (Phd) is an architect, artist and associate researcher at the SACRe - PSL laboratory, her work focuses on the human obsession with controlling the atmosphere. The dynamics, the flows and their interactions, the movements at work in the universe are at the heart of his questions. How to capture the aerial, possess the elusive? Between industrial production and utopian dream, the artist's creations challenge the realization of human's Promethean dream: mastering the elements and making them her own.

Julian OLARIU is a contemporary artist who lives in Paris. Painter and sculptor, he uses video art which allows him to develop new artistic expressions combining different media and cinematographic processes for works which approach the fantastic and question memory. His experimental shorts reflect his favourite themes: time, memory, dreams, space, cosmos and nebulae such as the series “Jelly Fish”.

Dominique PEYSSON is a visual artist, who lives and works in Paris. She has two doctorates, in art and physics, and a ESPCI engineering degree. Doctor in contemporary art and new media (Paris 1 Sorbonne), she first joined the EnsadLab research team and then the University of Paris-Est Marne-La-Vallée as an ATER researcher and teacher. Promoting the fertile encounter between contemporary arts and sciences, she has been conducting her research for several years in collaboration with numerous laboratories in exact sciences. Closely combining practice and theory, she regularly exhibits her works in France and abroad and is the



author of numerous publications.

Ana REWAKOWICZ is an interdisciplinary Polish-born artist, living and working in Montreal and Paris. She is currently pursuing her PhD in art and science at École Polytechnique. Known for stimulating, interactive, inflatable works that question our relationship with the environment, she is concerned with issues of sustainability and technology as opportunities for social transformation. Presently her art engages in growing environmental complexities with a focus on water. She has works in permanent collections of MACRO (Rome, Italy), MAC (Montreal), MNBAQ (Québec City), Musée de Joliette, and has exhibited in Canada, Europe and the USA.

Adrien RIGOBELLO is the founder of the NGO thr34d5, and Academic Coordinator of the Advanced Master Design by Data in École des Ponts ParisTech. The foundation of thr34d5 is a proposition of a Strategic Design practice that aims at providing relevant and scalable commons assessing social resilience. By mobilizing the local and global scales an agent is subject to be involved in, the goal is to lead him to become a caring citizen, agents of sustainable change for his community. thr34d5 is non-media specific, composed of ten members living in six countries, with a widely interdisciplinary practice.

Sylvain SOUSSAN created the Clouds Museum in 1991 by painting on the motif the steam plume emanating from the Belleville-sur-Loire nuclear power plant. Since then, he has accompanied us on a visit to an elusive collection, designing devices that invite us to contemplate the sky: motifs on glass roofs at the MAC/VAL (2007); invitations to let go, with deckchairs at the Chamarande Departmental Park (2005), to raise our eyes to water towers (Melle 2007, Poitiers 2016) or by accompanying us on outdoor walks (Biennale internationale d'art contemporain de Melle 2015).

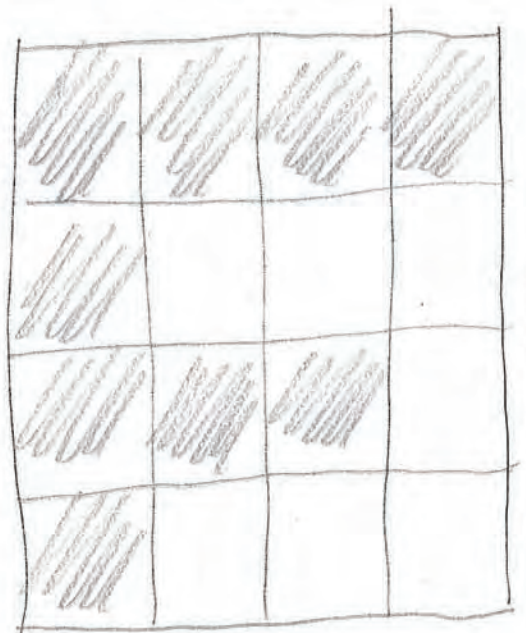
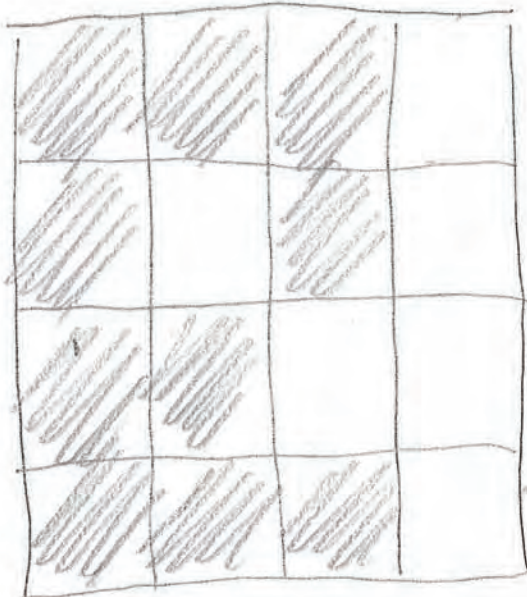
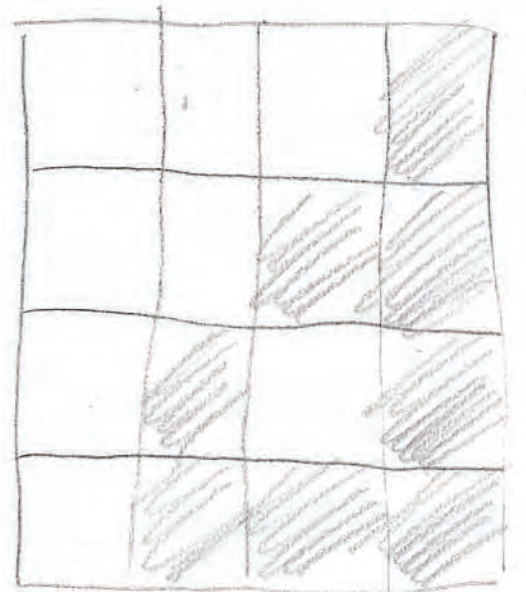
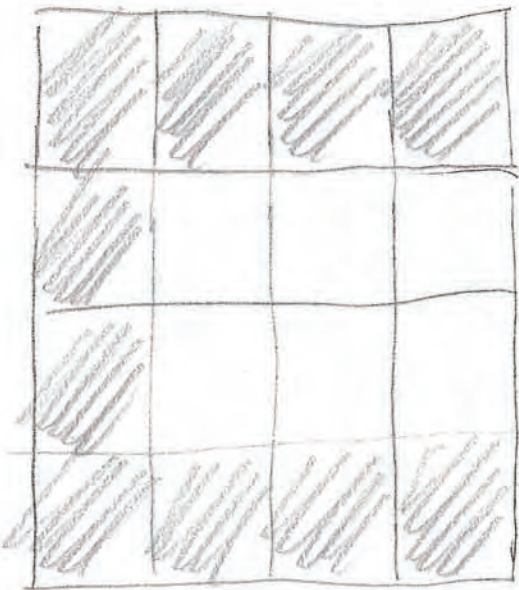
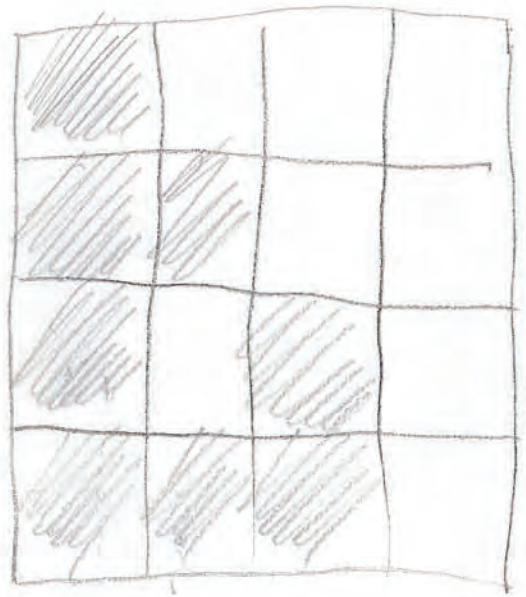
Anoushka VASAK, author and historian, translated and edited Luke Howard's essay, "On the Modifications of Clouds" (followed by Goethe, "La forme des nuages selon Howard", Paris, Hermann, 2012) and published numerous articles on the history of clouds in science and art (for example, with Pierre Glaudes, *Les nuages, du tournant des Lumières au crépuscule du romantisme*, Hermann, 2017). She develops a specific work about meteorology (i.e. through the network and seminar «Perception of Climate», Paris) at the frontier of history, geography, literature and arts.

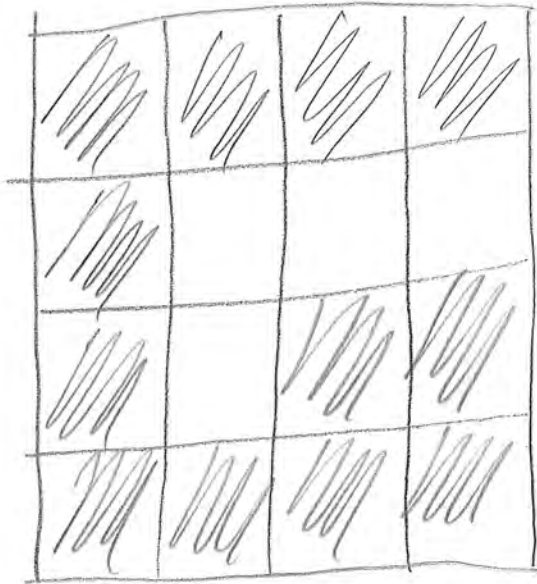
Victoria VESNA is an artist and professor at the UCLA Department of Design Media Arts and Director of the Art|Sci Center at the School of the Arts and California NanoSystems Institute (CNSI). Although she was trained early on as a painter (Faculty of Fine arts, University of Belgrade, 1984), her curious mind took her on an exploratory path that resulted in work can be defined as experimental creative research residing between disciplines and technologies. With her collaborative art projects she investigates how communication technologies affect collective behavior and perceptions of identity shift in relation to scientific innovation (PhD, University of Wales, 2000). Her work involves long-term collaborations with composers, nano-scientists, neuroscientists, evolutionary biologists and she brings this experience to her students.

APPENDIX D

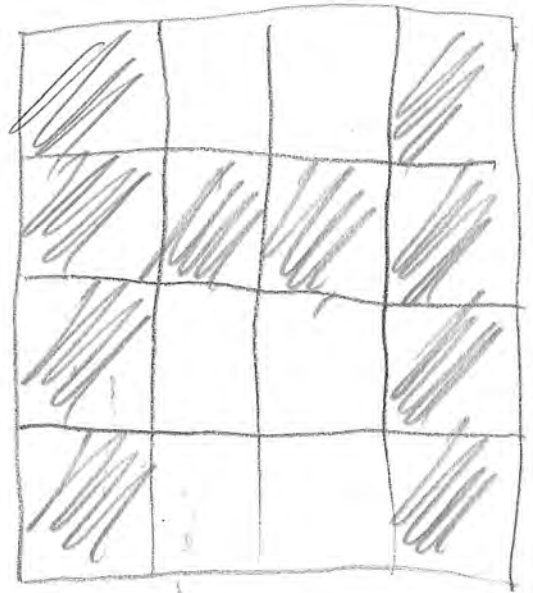
Alphabet for the *Nephelograph* cloud machine

(2017)

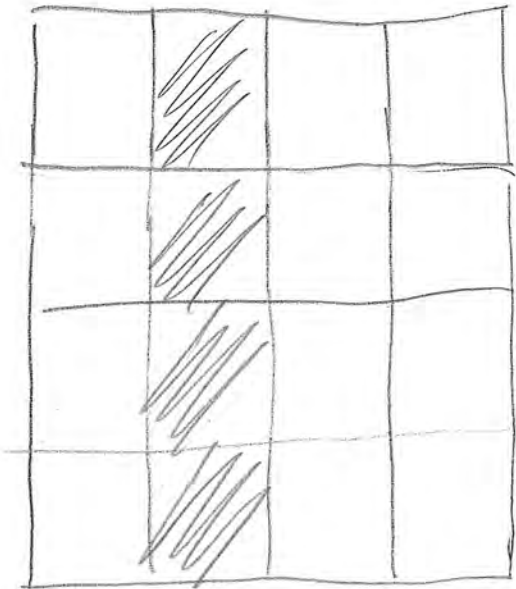




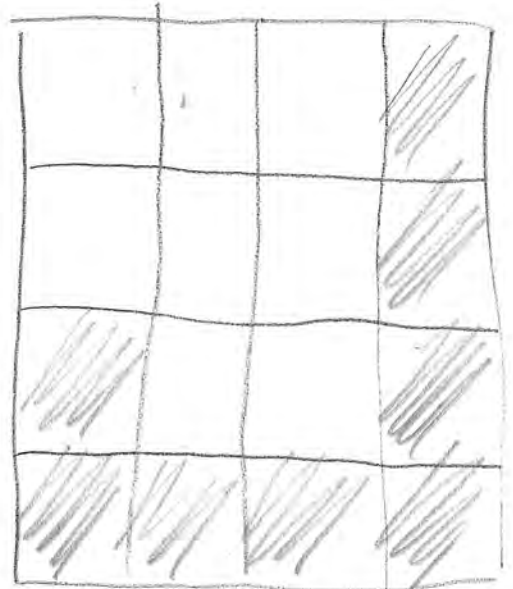
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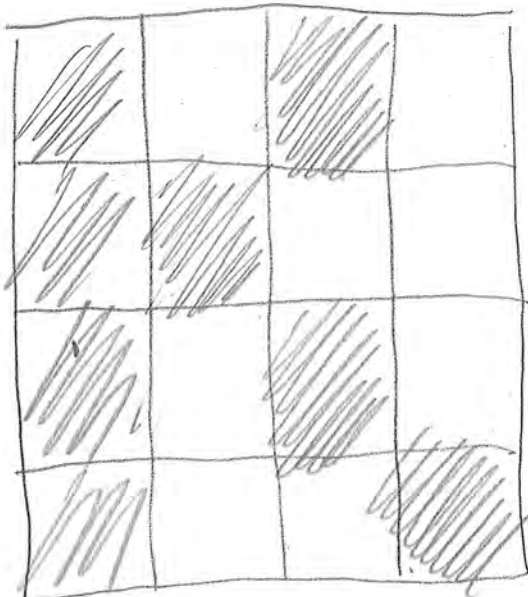
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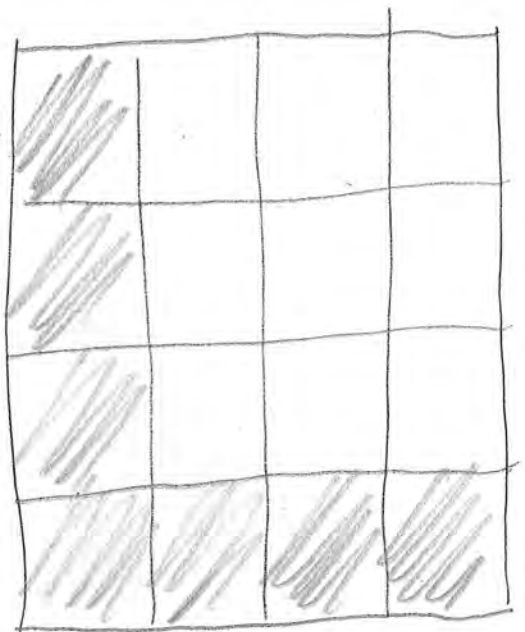
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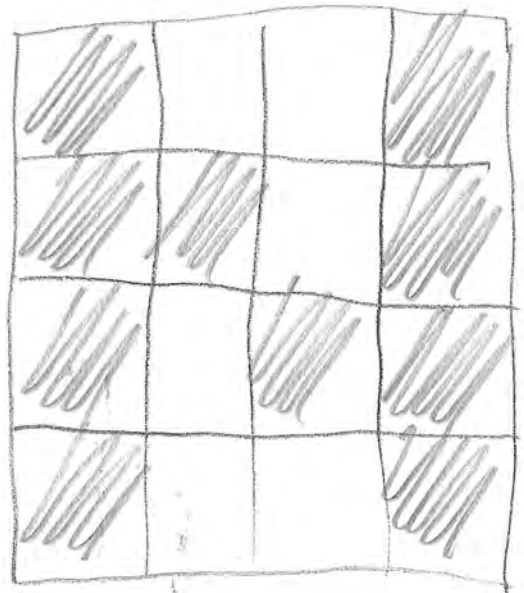
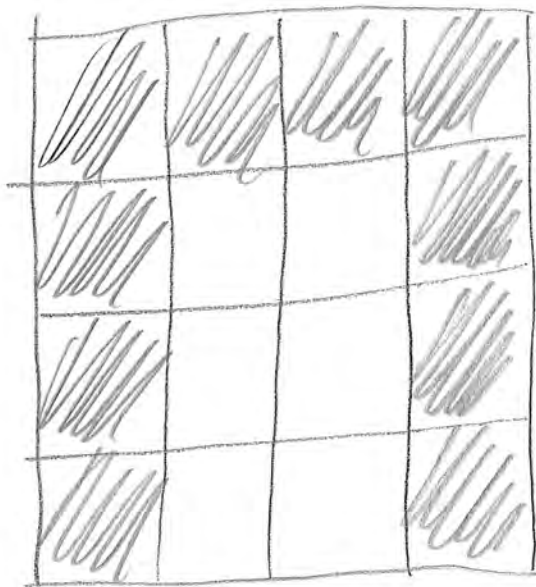
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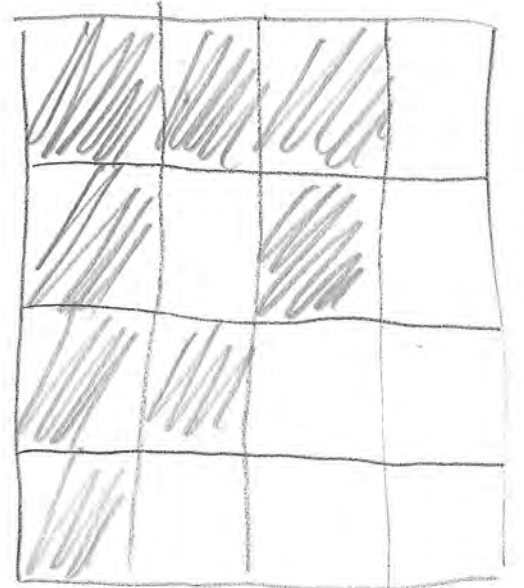
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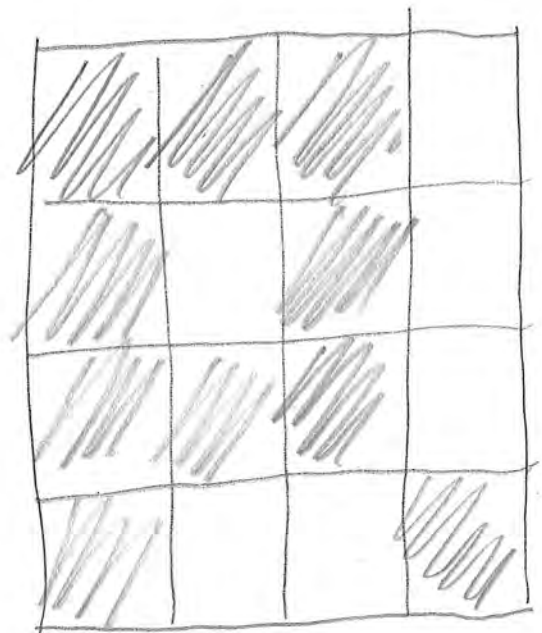
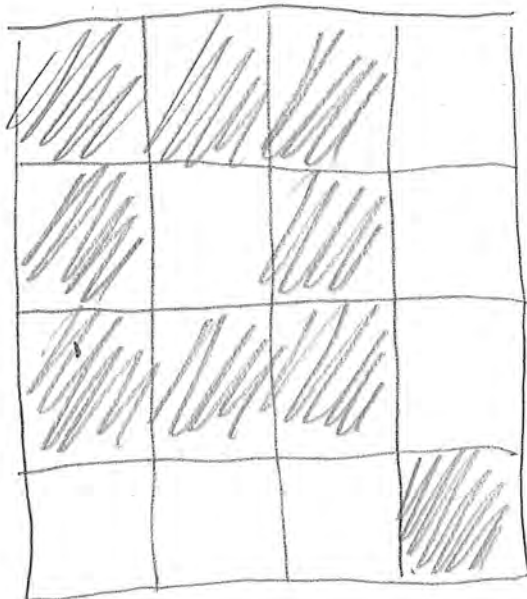
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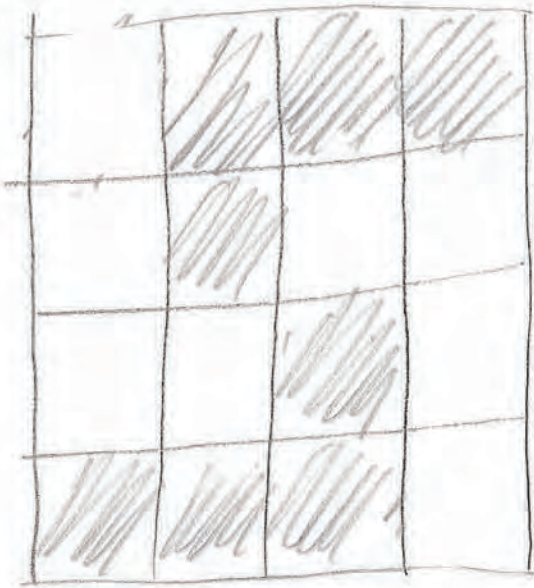
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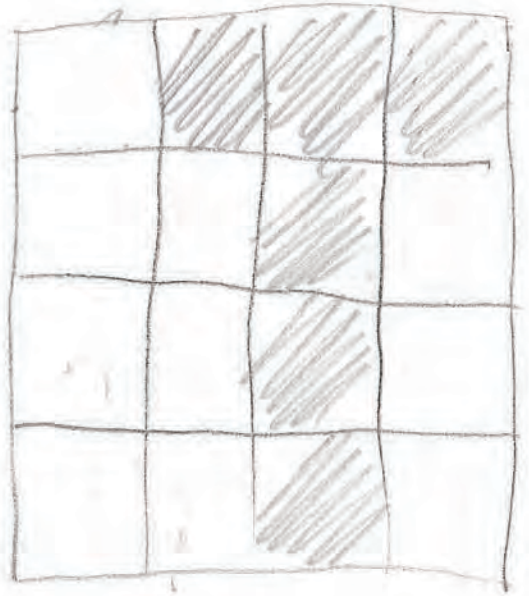
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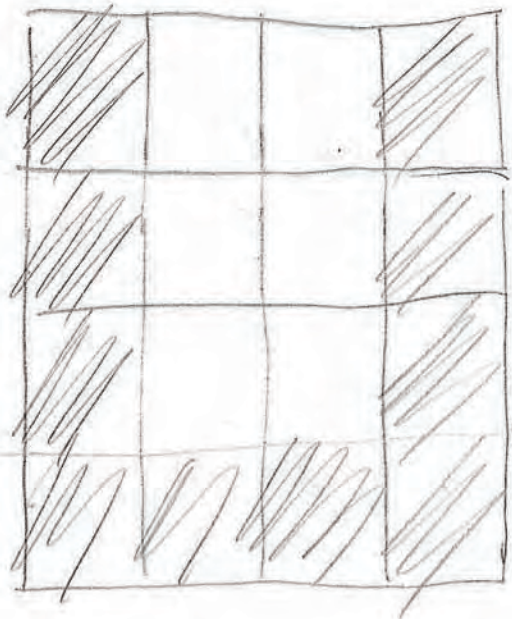
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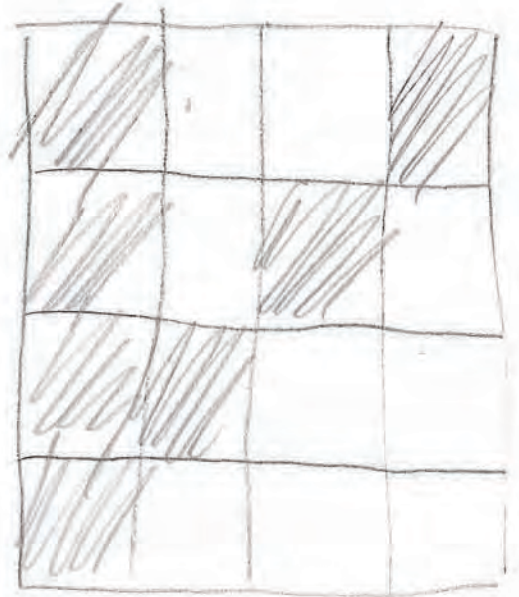
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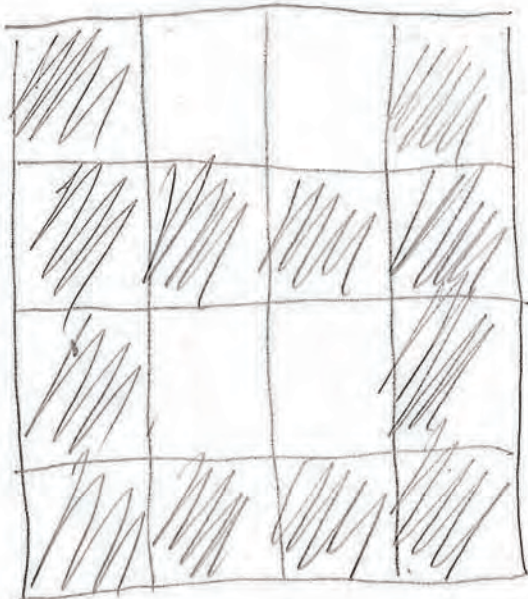
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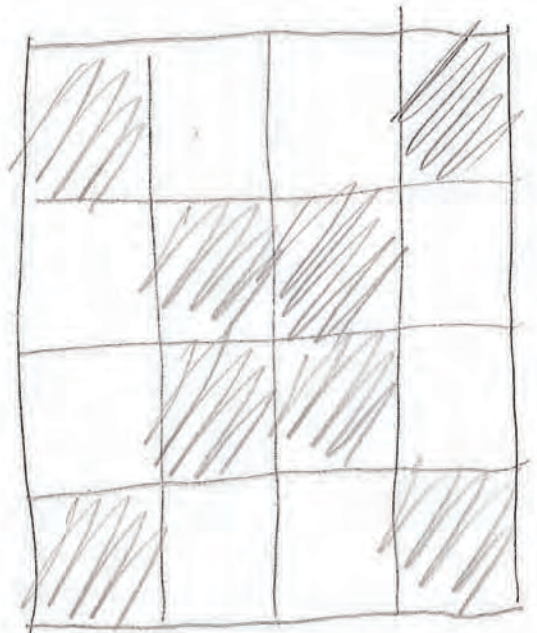
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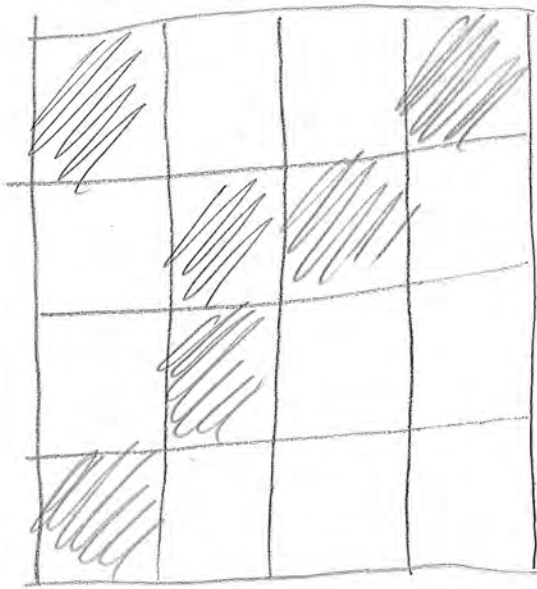
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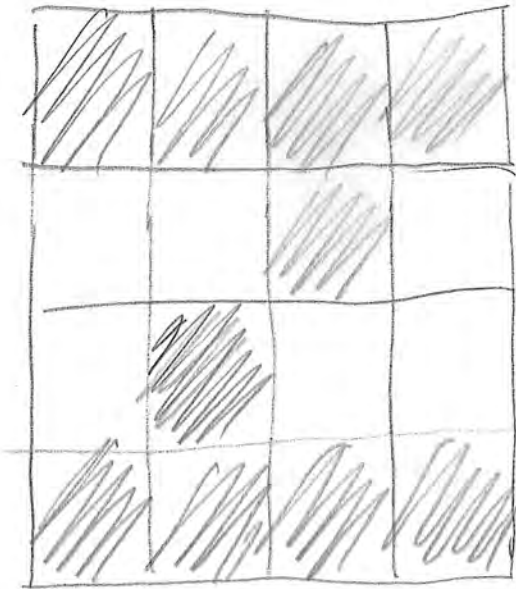
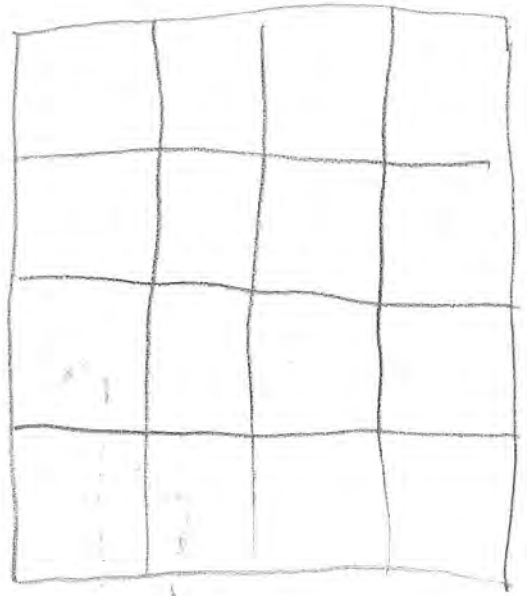
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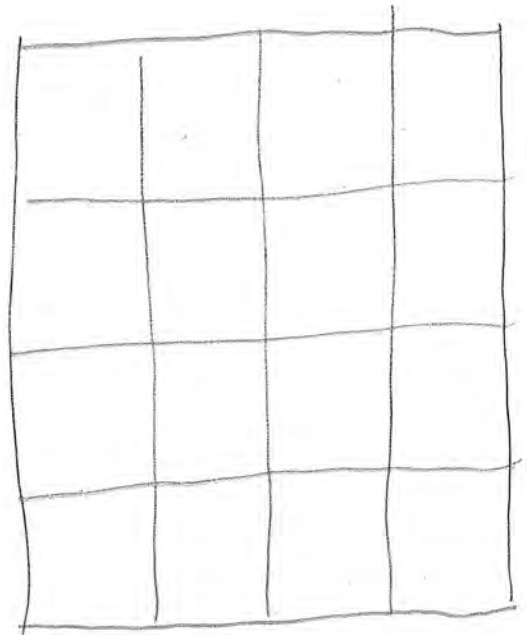
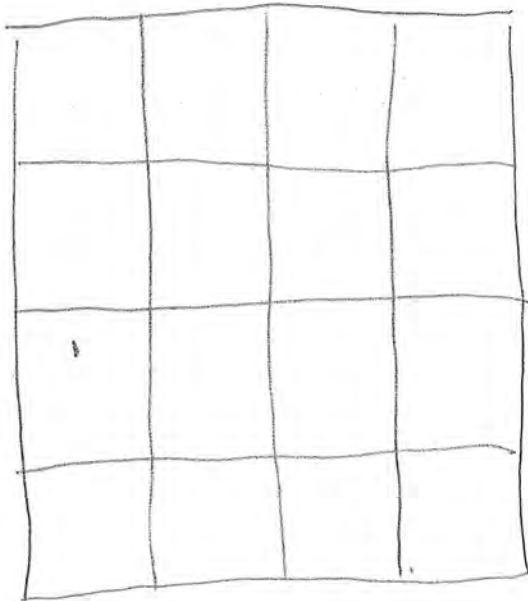
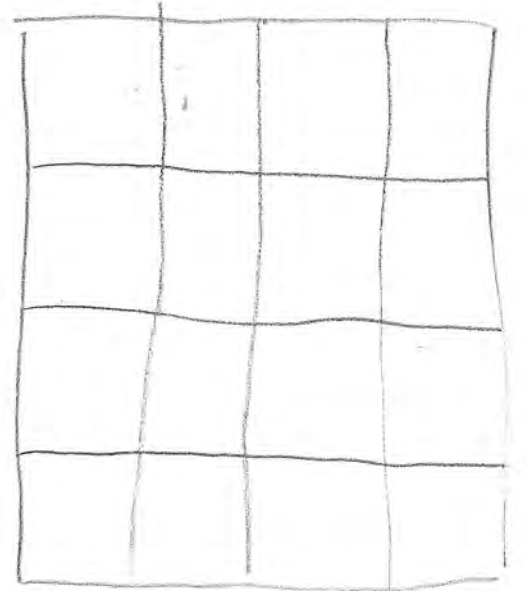
X



Y



Z



A B C D E F G H

I J K L M N O P

Q R S T U V W

X Y Z

APPENDIX E

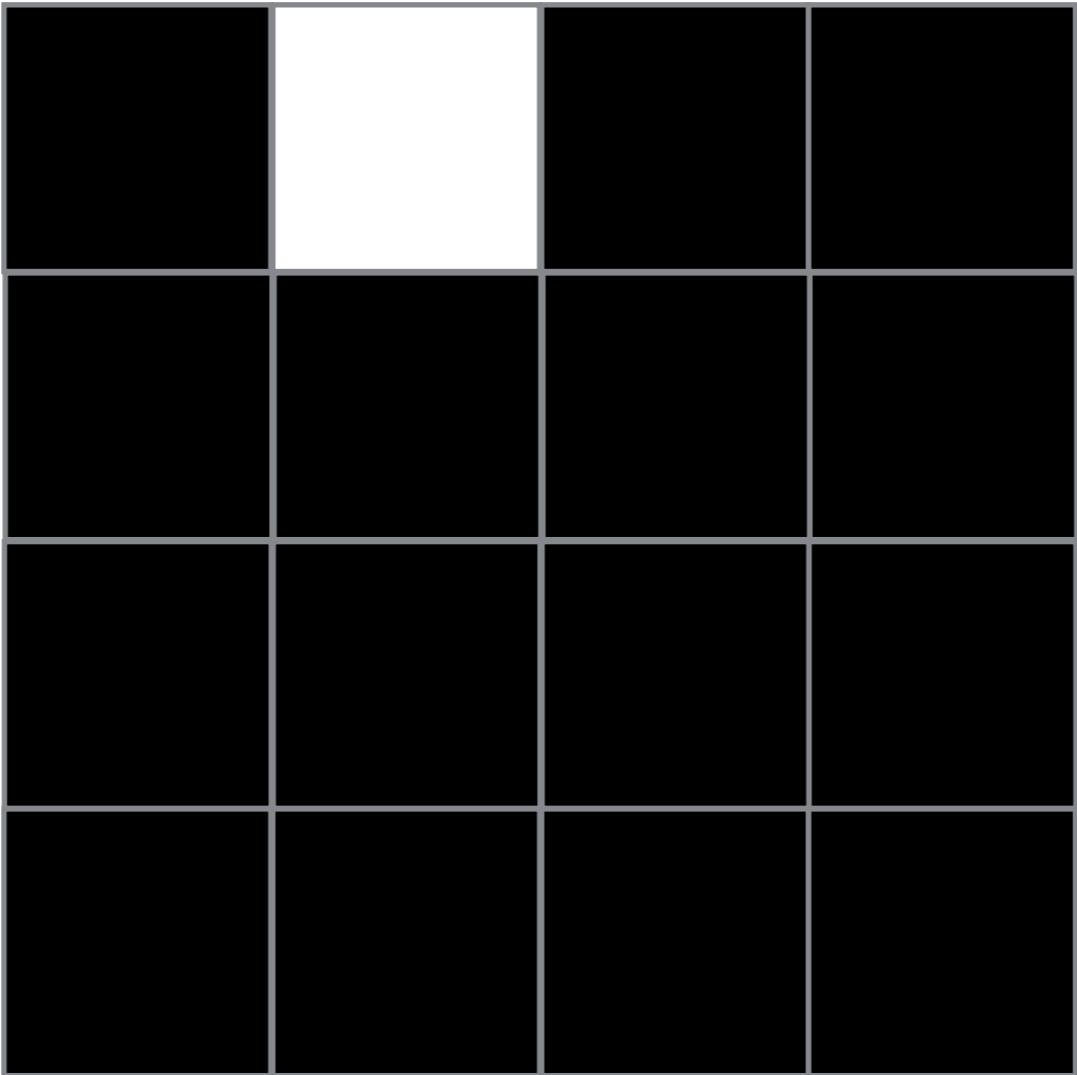
**Selection of children's haikus
(from Paul Langevin primary school in Palaiseau)
together with interlude programming sequences**

(2017)

O TOI NUAGE

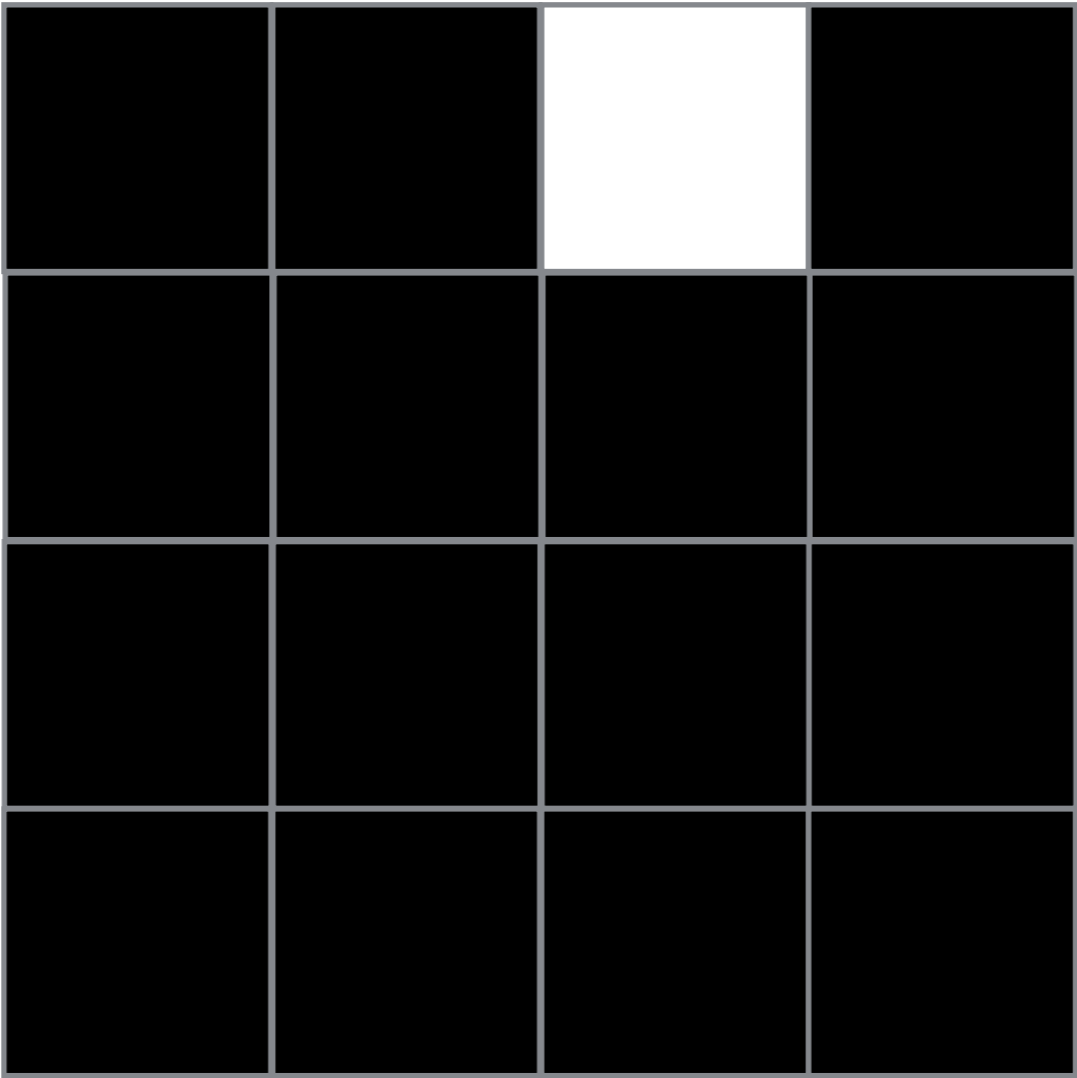
NOI JE TE PROTEGERAZI

NON BEAU NUAGE



ALL





NUAGE EN COMBIEN DE JOURS
AS-TU FAIS LE TOUR DE LA TERRE
?

■	■	■	□
■	■	■	■
■	■	■	■
■	■	■	■

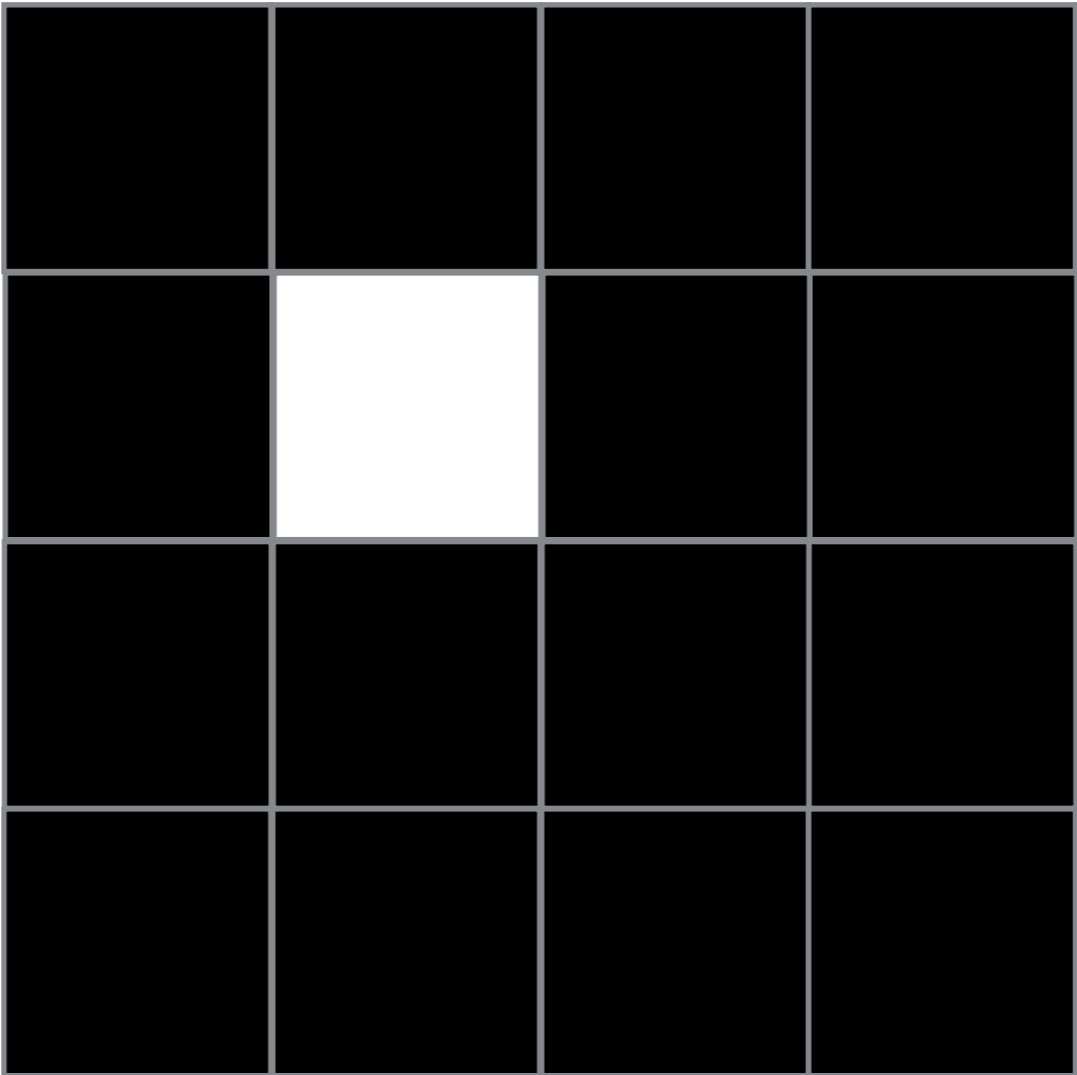
SPIRAL



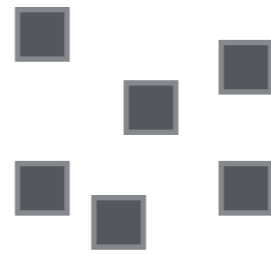
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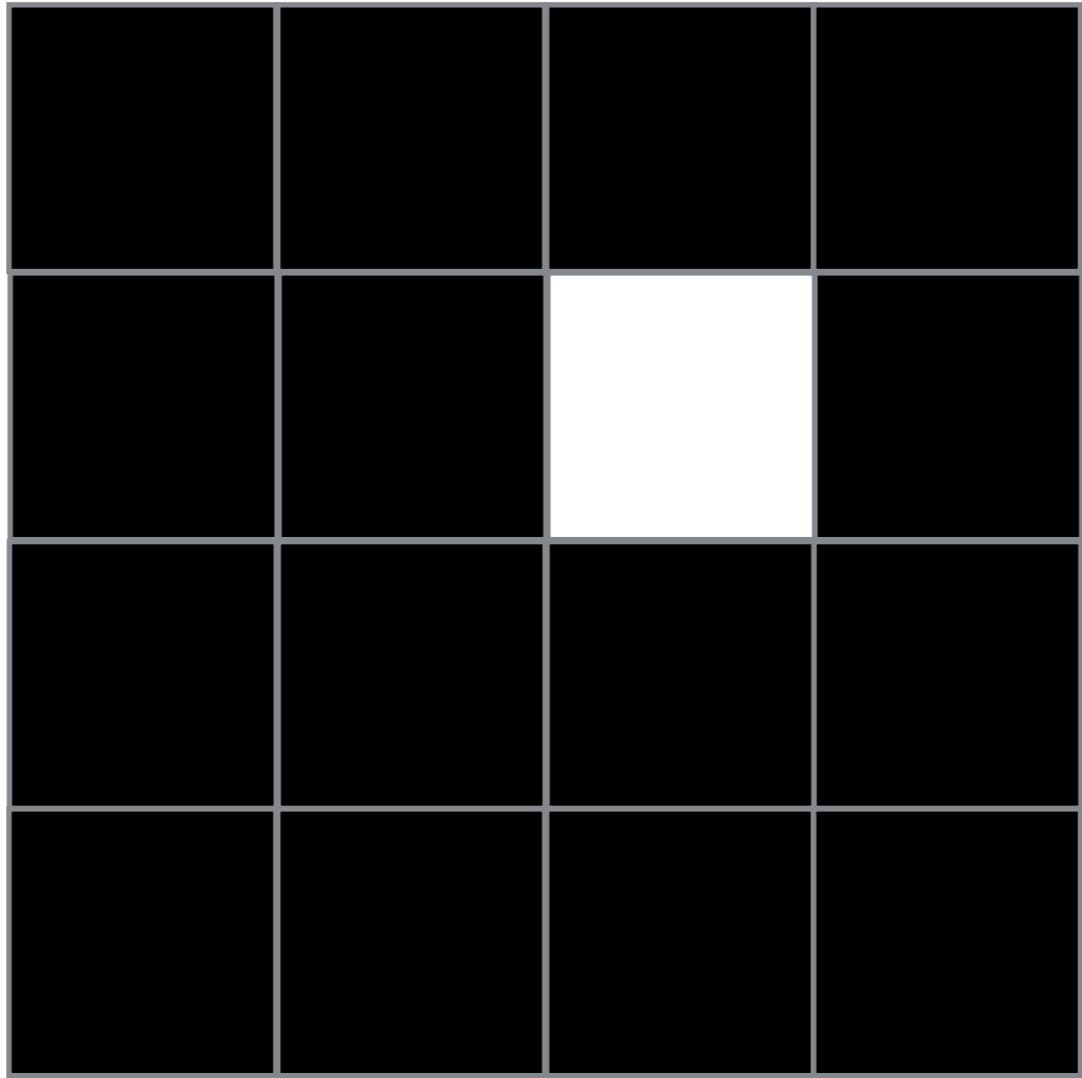
☐ NUAGE BLANC

NOTRE GENTILLE PLANETE BLEVE
à besoin de toi



MIX





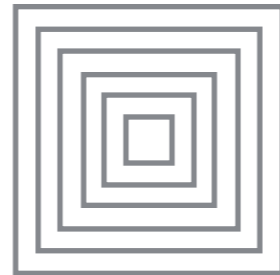
NON PETIT NUAGE

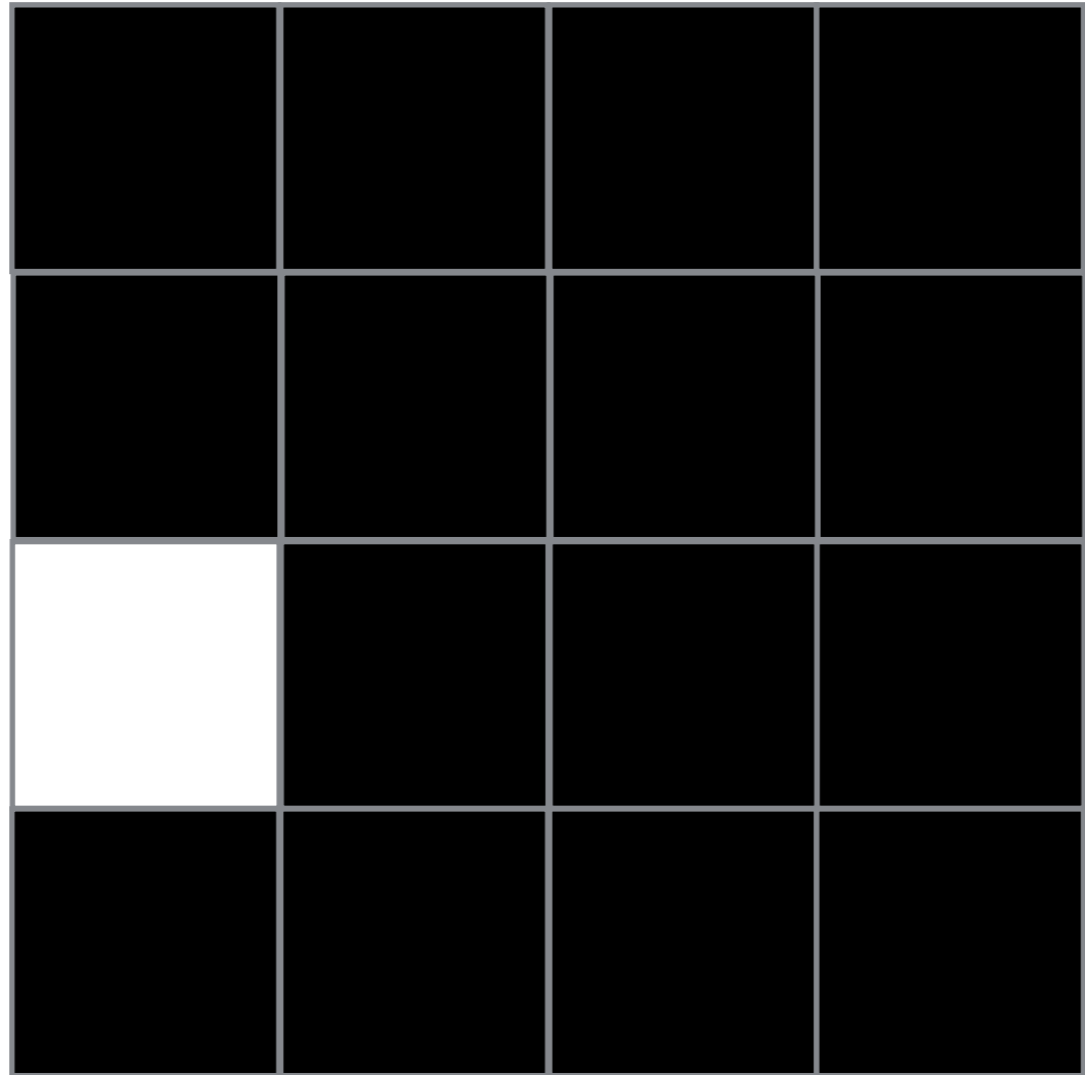
EN FORME DE COQUILLAGE

VAS-TU VOIR LA PER ?

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■	■	■	■

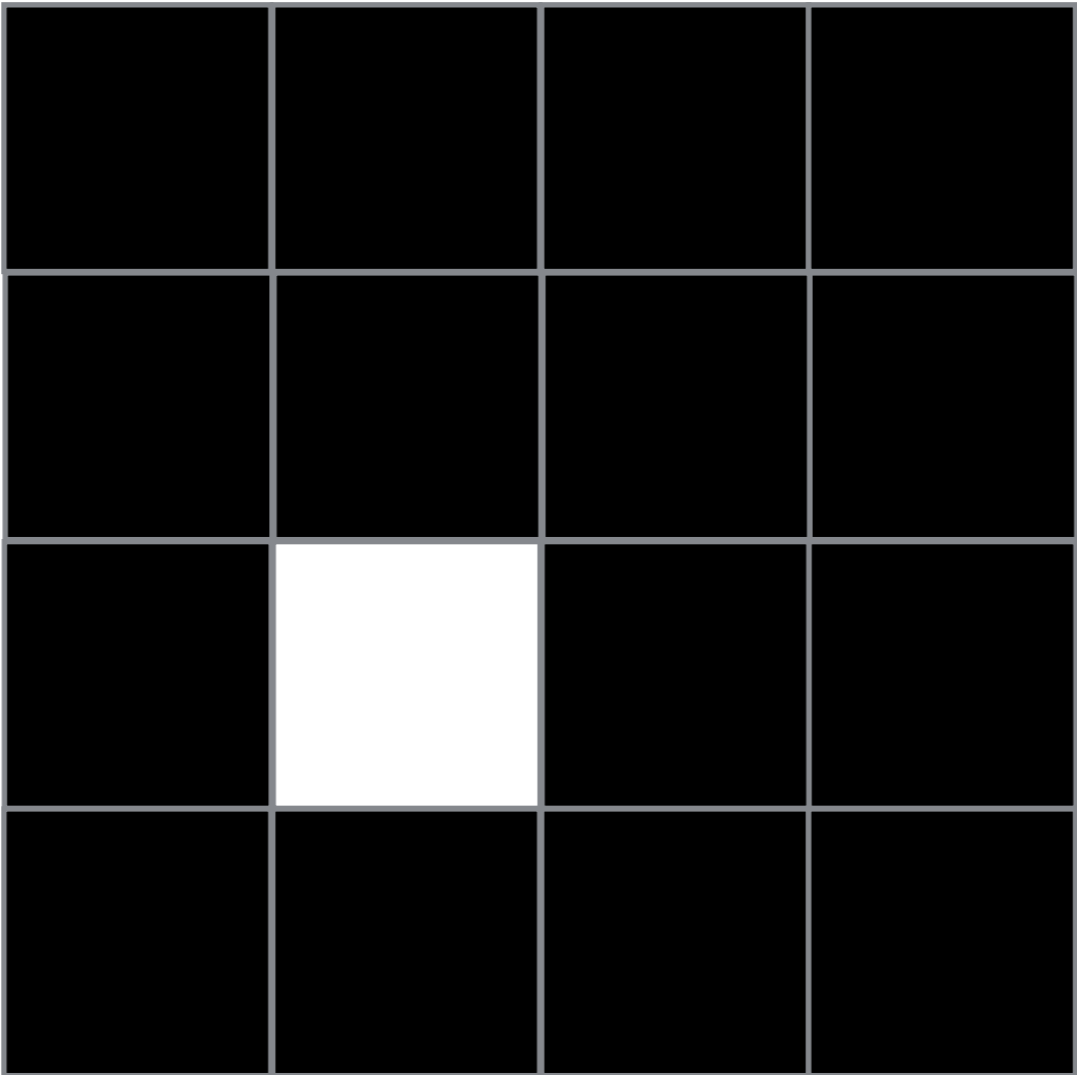
TUNNEL





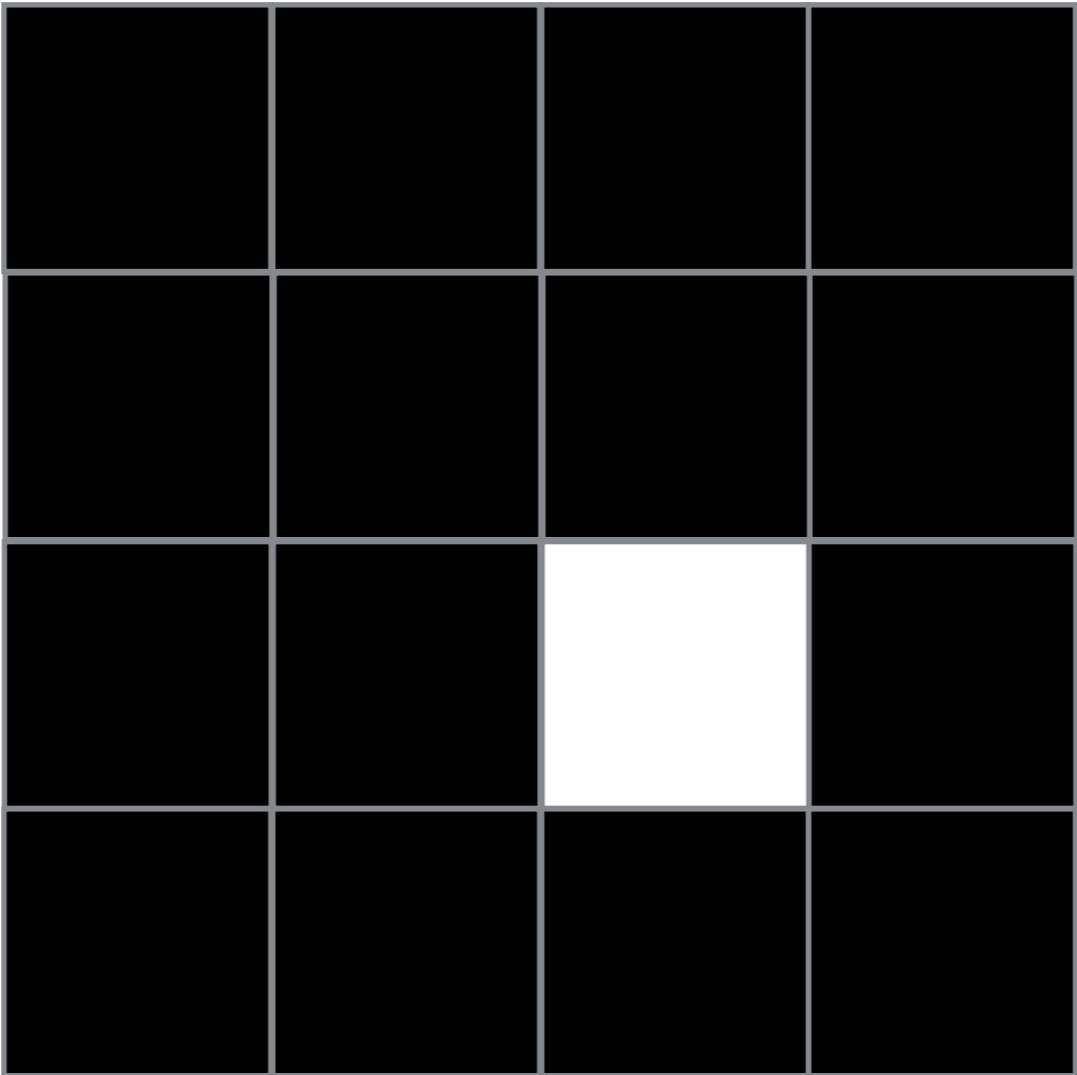
POUVRE NUAGE

MAIS POURQUOI PLEURES-TU AUTANT ?
C'EST LA POLLUTION



UP-DOWN





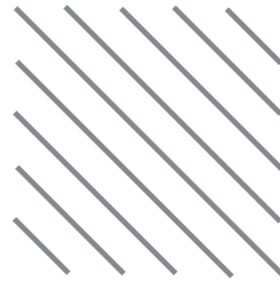
NON BEAU NUAGE

TOI QUI RECouvre LES CIEUX

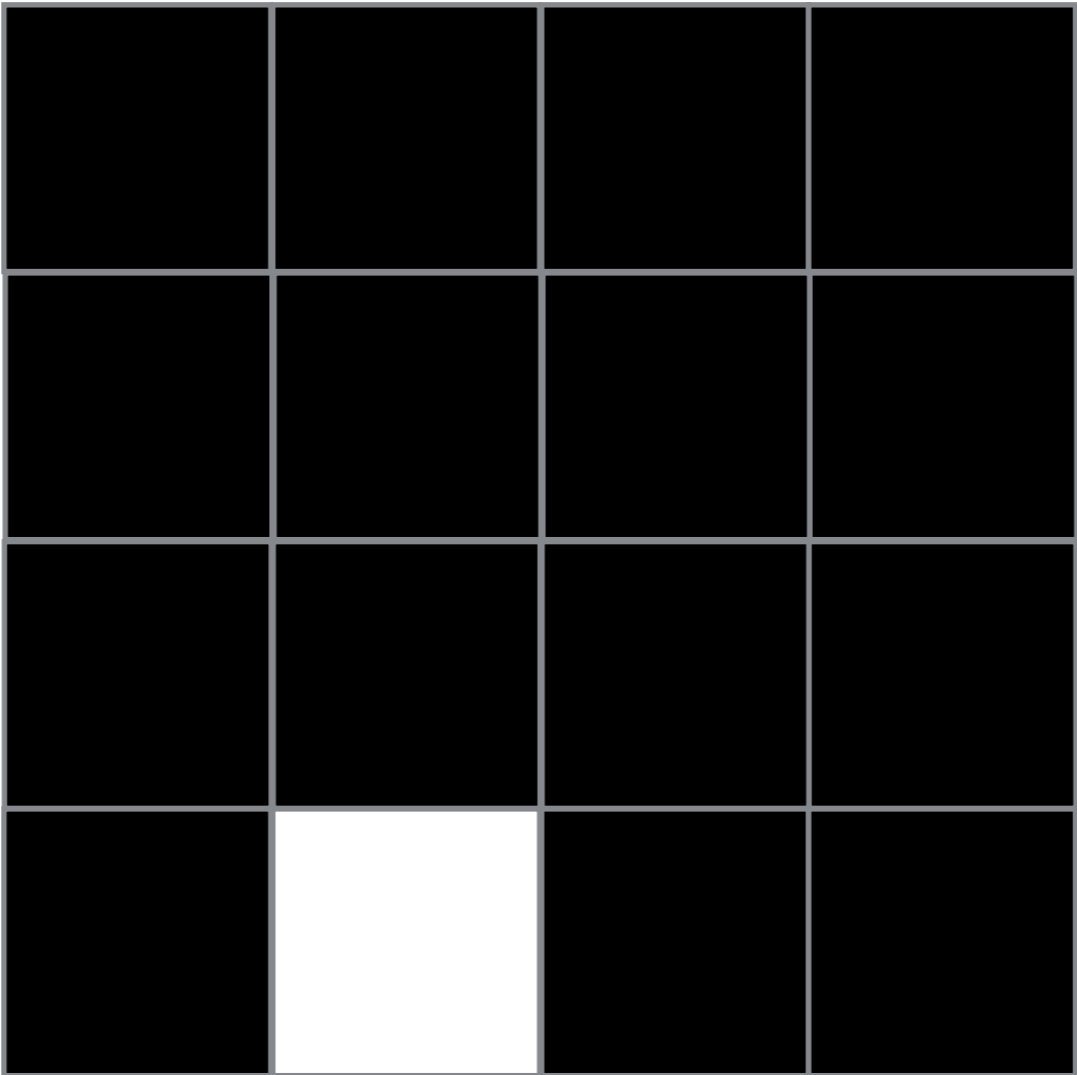
REALISE MES VOEUX

■	■	■	■
■	■	■	■
■	■	■	□
■	■	■	■

DIAGONAL



TU BRILLES CHAQUE SOIR
NON NUAGE ETINCILLANT
COMME UNE ETOILE



LEFT-RIGHT



■	■	■	■
■	■	■	■
■	■	■	■
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Titre : La poursuite brumeuse d'une capacité de réponse éthique: l'art et la science de la collecte de l'eau du brouillard

Mots clés : collaboration art et science, pénurie d'eau, collecte de l'eau du brouillard, éthique relationnelle, communauté

Résumé : La pénurie d'eau est devenue l'un des problèmes les plus urgents au monde, qui touche particulièrement les régions arides où les précipitations sont faibles ou inexistantes et où les eaux souterraines ne sont pas disponibles. Mes recherches, basées sur la pratique artistique, portent sur un moyen alternatif de recueillir l'eau du brouillard et proposent de nouvelles solutions issues de l'imagination et de la participation mises en avant par une collaboration entre l'art et la science.

Cette collaboration remet en question les méthodes standards de collecte de l'eau du brouillard à l'aide de filets à mailles et propose une méthode alternative de récolte de l'eau du brouillard à l'aide d'un filet de fibres verticales parallèles.

Cependant, pour faire face à des problèmes complexes tels que la pénurie d'eau, nous devons étendre l'invitation à participer au-delà des artistes, des scientifiques et des spectateurs/participants pour inclure les communautés auxquelles la recherche est destinée, élargissant ainsi le cercle d'inclusion et comblant le fossé entre ce que nous savons, ce que nous ressentons et ce que nous faisons.

Title: Foggy Pursuit of Ethical Response-Ability: Art and Science of Collecting Water from Fog

Keywords : art and science collaboration, water scarcity, collecting water from fog, relational ethics, community

Abstract : Water scarcity has become one of the world's most pressing issues, one that particularly affects arid regions, where there is little or no precipitation and groundwater is not available.

My art practice-based research investigates an alternative means of collecting water from fog and proposes novel solutions arising from imagination and participation brought forward by art and science collaboration.

The collaboration challenged the standard method of collecting water from fog with grid mesh nets and proposed an alternative method of harvesting fog water with a net of parallel vertical fibres.

However, to deal with complex problems such as water scarcity, we need to extend the invitation to participate beyond artists, scientists, and viewer/participants to include the communities for which the research is intended, thereby expanding the circle of inclusion and closing the gap between what we know, what we sense and feel, and what we do.