Leah Beeferman at the Barbados Cloud Observatory, Deebles Point, Barbados, May 3, 2024. Photo by Friedhelm Jansen.

LEAH BEEFERMAN

CLOUD-SCALE UNCERTAINTIES

I AM INTERESTED in the concept of uncertainty—both subjectively experienced and scientifically measured—and, in particular, how it relates to climate change and the study of changing weather. In June 2022 I encountered the phrase "Cloud-Scale Uncertainties" on the website of *Waves to Weather*,[1] a German Transregional Collaborative Research Centre. The idea of a "cloud-scale" uncertainty captured my imagination: an uncertainty decidedly larger than human-scale, but more accessible than planetary-scale—and one defined by clouds, omnipresent, familiar, and mysterious as they are. In a scientific context, the "scale" of this uncertainty suggests a need for more information—more measurement—to situate these clouds within larger systems of weather and atmosphere, themselves climate-scale uncertainties. But it also offers an opportunity to reconsider our relationship to the things we think we understand, and to remember that even something as ubiquitous (though variably so) as clouds—casting shadows on the landscapes over which they pass—hold as many unknowns as knowns.

Cloud-Scale Uncertainties was the name of a research group, led by Christian Keil at Ludwig-Maximilians-Universität in Munich, which existed from 2019–2023. This name refers to something significant I hadn't known: clouds are a main source of uncertainty when it comes to climate change. Clouds make shadows, both providing shade and trapping heat—cooling the earth while reflecting earth's radiation back to the surface. This balance, dependent on the height and reflectivity of the cloud and the time of day, is affected by warming temperatures and subsequent increases in water vapour (itself a greenhouse gas) in the atmosphere. It is currently unknown how clouds will be affected by rising temperatures: they could become thinner, their patterns of organization could change, or they could burn away completely. Scientists are especially concerned about shallow cumulus clouds, most common in the tropical trade wind regions, due to their prevalence and their potential to impact the "global radiative balance."[2] As Keil's group writes, "clouds are a major contributor to uncertainty in weather prediction … these different sources of uncertainty must be investigated in detail in order to represent their effects accurately in weather prediction systems."[3]

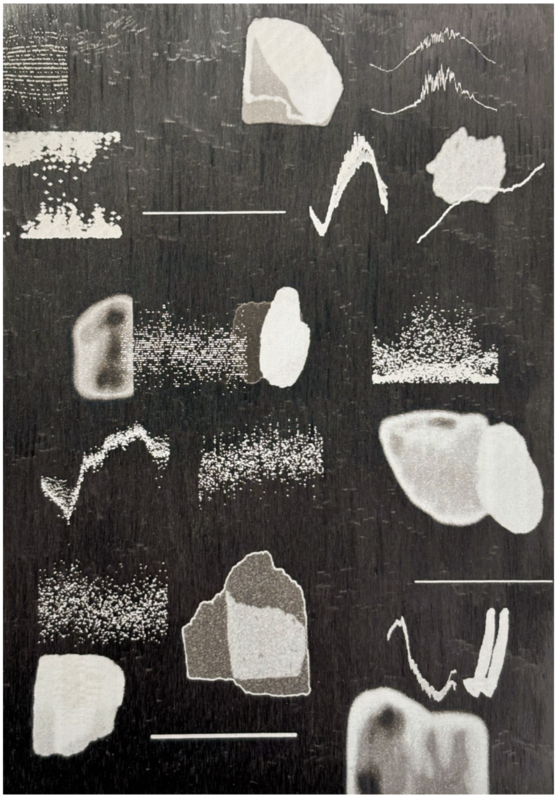
Clouds are visible indicators of weather and atmospheric activity; different accumulations of temperature, pressure, and water vapour combine to form the four main types of clouds (stratus, cumulus, cirrus, nimbus) and their sub-types (e.g., cumulonimbus, stratocumulus, cirrocumulus). Each type or sub-type of cloud results from specific weather conditions; for example, stratus clouds "tend to occur along and to the north of warm fronts," and cumulus clouds form at lower altitudes where "moisture in rising air condenses."[4] As early as 1895, clouds could be artificially modelled in a lab.[5] But to capture real clouds for study, scientists relied on image-making: photography (still and time-lapse) and drawings outlining and overlaying the different stages of a cloud as it moved through the sky. I've been thinking about this image-based history for the better part of a decade, thanks to two books by Helmut Völter: *Wolkenstudien. Cloud Studies. Études des nuages*[6]—which reproduces cloud photography taken between 1890 and 1962—and *The Movement of Clouds around Mount Fuji Photographed and Filmed by Masanao Abe*[7]—which presents Japanese aristocrat/scientist/photographer Abe's

Leah Beeferman, *Weather of the Weather 3* (2023). Dye sublimation print on aluminum. 22.5 in x 40 in.
Photo by Karen Phillipi.

rigorous drawings, photographs, and films from 1926 to 1946. Both books contributed to my ongoing understanding of the triangulation between science, observation, and photography—and my determination that, even if a photograph or image was made "in service" of science, it could also be a compelling or beautiful image serving other ends.

What does it mean to measure clouds? What does it mean to measure the weather? And what does it mean to capture the weather, to attempt to contain this multi-dimensional and world-defining set of conditions within a collection of numbers? I am fascinated by our attempts to understand and represent the weather, broadly defined; to transform these transient phenomena into images or numbers; to make visible the invisible through specialized imaging technologies or by recording the visible effects of an invisible atmosphere on a landscape, which shifts with the weather. After all, as Tim Ingold asks, "if the weather is not part of the landscape, is the landscape, then, part of the weather?"[8]

Landscapes, and weather, defy representation. As an artist, I am interested in how these earthly phenomena are represented as images—both photographic and scientific—and the limitations of that representation. These different kinds of images—representational and "operational" (to use filmmaker and author Harun Farocki's term[9])—are snapshots of moments in time that are focused, or constrained, by a set of tools and parameters. It's impossible to capture weather in its entirety, but it is possible to take snapshot measurements of one moment or a sequence of moments and turn those into images. In a similar way, photography and video capture images of phenomena at a single moment or series of moments within a frame and omit the rest. Weather maps and satellite images present graphic or aerial views depicting different sets of parameters such as wind, dust, pressure, or stability. And many other imaging tools—ranging from LIDAR sensing and particle backscattering to graphs charting CO_2 levels over the course of a day in a particular location—produce an array of dynamic, unfamiliar, and compelling images. Each of these images, these many forms of representation, present certain specific aspects of a landscape or its weather with reliable clarity and/or accuracy. But they are only selections from, windows into, facets of a larger whole.



Leah Beeferman, *Certainties (Hyytiälä July 7-21 2023)* (2023-24). Graphite and laser-etch on aluminum. 3.5 in x 5 in. Four of a series of fifteen.

I am drawn to graphs and scientific imagery because they allow me to engage with otherwise invisible complex systems, removed from time and space and concretized in an image. I want to know, at least in a rudimentary sense, what they represent. But I am also drawn to these images as *images*—as information or abstraction, depending on who reads them and how much knowledge or context they have. As an artist, I explore this space in between information and abstraction—where informational representations of landscapes and atmospheres start to unravel, holding degrees of specificity but without seeking to directly communicate it, stopping short of that in favour of arriving at a feeling, a moment of irresolution, uncertainty, ambiguity. I explore these ideas through image-based work—multi-layered photographic digital prints, 3D scenes, laser-etched aluminum panels, and videos—which seeks to reintroduce elements of ambiguity and uncertainty into photographic and scientific images of landscapes, acknowledging their complexity and elusiveness.

In pursuit of scientific measurements, weather, clouds, images, and uncertainty, I visited two field research stations. In June 2023, I spent three weeks at the Hyytiälä Forest Research Station in southern Finland as part of the Climate Whirl artist residency program. In April/May 2024 I spent one week at the Barbados Cloud Observatory (BCO).[10] In conjunction with this work, I also visited and documented several locations in the New Mexico desert to put this "empty and deathlike territory"[11] in dialogue with the "permanent blossoming"[12] of the forest (resulting in *Deserts and Forests*, my series of photographic inkjet prints in which I intentionally abstract these specific landscapes). Collectively, the work from these three trips—along with *Weather of the Weather* (a group of dye sublimation prints depicting 3D scenes composed from digitally sculpted abstract shapes and weather maps/satellite images downloaded from NOAA and EUMETSAT) and *Three Weathers* (a collaborative weather poster project with Brooklyn-based design studio New Information)—made up my solo exhibition, *Cloud-Scale Uncertainties*, which opened in late August 2024 at the Peeler Art Galleries in Indiana. The images that accompany this text are drawn from these bodies of work.

The Hyytiälä Forest Station, operated by the University of Helsinki, is located within a typical Finnish-managed forest[13] near Juupajoki, Finland. It sits on the edge of Kuivajärvi, an elongated small lake surrounded by pine, spruce, and birch trees. Two of Hyytiälä's main functions are to support the training of forestry students and to facilitate multifaceted research into different forest management practices. (Much of the Hyytiälä forest is subdivided into numbered plots, each under observation for different management strategies: single or multi-species growth, degrees of thinning and regrowing, burning, etc.) I went to Hyytiälä primarily because it is home to the SMEAR II field station which studies the ecosystem and the atmosphere.

SMEAR—Station for Measuring Ecosystem-Atmosphere Relations—is one of the most robust

Several Plexiglas boxes, which are part of SMEAR II. Hyytiälä, Finland, June 9, 2023. Photo by Leah Beeferman.

stations in the world for such study. There are five SMEAR stations in Finland. SMEAR largely monitors greenhouse gases (NO_X, CO_2, SO_2) to study whether (and where) they are stored/absorbed by the ecosystem or released back into the atmosphere. SMEAR also tracks aerosols: particles in the air that affect climate, weather, cloud formation, and ecosystem health. SMEAR's equipment measures the parts-per-billion of different aerosols in the atmosphere, how they fluctuate, and how these fluctuations correspond to changes in weather. Its scientists publish[14] much of what they track daily—wind direction, temperature, CO_2, CO_2 flux, evapotranspiration, O_3, SO_2, NO, NO_X, global shortwave radiation, temperature, air pressure, and relative humidity. These graphs are easily accessible online. I used them alongside digitally-drawn gestural marks for *Certainties* (*Hyytiälä June 7–21 2023*), my series of fifteen laser etchings on aluminum: one piece per day of data for the length of my stay at the station.

At Hyytiälä, SMEAR has two sections: the Scots pines in the forest and the Siikaneva wetlands a few kilometres away. On my first day at Hyytiälä, I was oriented to SMEAR by Timo Vesala, Professor at the Institute for Atmospheric and Earth System Research at the University of Helsinki. Learning about SMEAR—how it works and what it seeks—made me aware that scientists are trying to study how very common, minute forest conditions are affected by climate change and how the resulting conditions may evolve. They study, for example, what sinks carbon and where it is emitted (peatlands are huge carbon sinks, for example, but they also emit methane), and under what conditions that might change (forests are carbon sinks but not at night—in the absence of light for photosynthesis).

SMEAR's equipment is carefully positioned among the trees and on the forest floor. A thirty-five-metre tower stands in the centre of the site, measuring weather conditions and air movements above, within,

The Barbados Cloud Observatory, Deebles Point, Barbados, April 30, 2024. Photo by Leah Beeferman.

and below the tree canopy. There are several smaller towers, climbable so scientists can monitor the equipment mounted on them—equipment that studies how pine needles and light interact, how they exchange greenhouse gases with the atmosphere, and how water passes through trees in cycles of evaporation and transpiration. On the ground, interspersed among plants, trees, and wooden walkways, is a collection of plexiglass boxes which are rhythmically and automatically raised and lowered over small patches of forest floor every fifteen or twenty minutes. These instruments trap air for study, monitoring the greenhouse gas exchange between the soil and plants and the surrounding atmosphere. All of this equipment is connected by long tubes stretching from one end of the forest to the other, feeding the sampled gases into two wooden huts where they are collected and analyzed by a host of instruments and computers.

All around SMEAR is a constant hum: the collective sound of cooling fans, suction tubes, analysis computers. This equipment is not intended to be discrete, and its buzzing changes the tone of the forest. These unfamiliar and unconventional instruments among the trees feel idealistic and playful at times. Or is that how I want to see it—with hope and *not* unease—this effort to measure small-scale exchange in order to understand the crucially significant larger-scale behaviour of greenhouse gases? The undercurrent sonic buzz of electricity is foreboding and forces me to acknowledge that the exchanges studied here have consequences far beyond this one small patch of forest. The longer I watch and listen, the harder it becomes to idealize the instruments and the measurements they seek: this invisible information, which lurks below the surface and bears on our future. What happens to the forest, or to the planet more broadly, if this tenuous balance of elements shifts too far? The electric hum seems to evoke such questions. Still, I leave Hyytiälä feeling inspired by this multifaceted search for invisible information.

Leah Beeferman, *Shallow Clouds Form (Barbados)* (2023). Dye sublimation print on sheer fabric, 74 x 132 in.
Photo by Stuart Snoddy.

I, myself, am also looking for something invisible, an investigation that carries its own optimism.

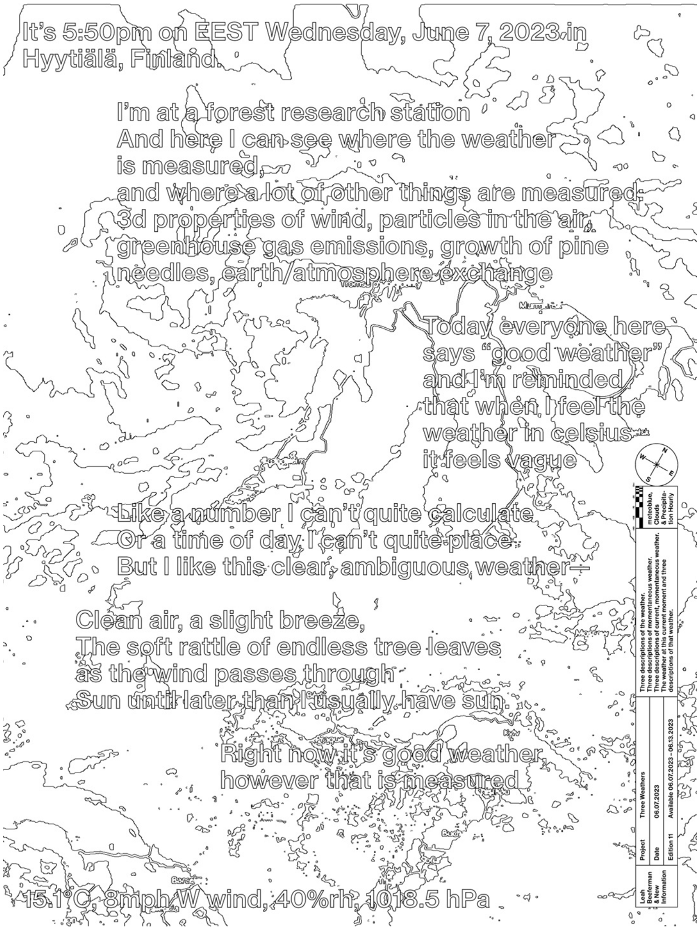
For many years, it has been useful to think of myself and my recording tools as a collective measuring device. After all, as quantum physicist and feminist scholar Karen Barad has written about observation and measurement, any observed phenomenon is inseparable from its observer.[15] I sample, with a regular irregularity, the landscapes I visit, tracking their changes and watching them shift with the weather. I respond to the features and aspects that interest me, framing images or videos based on what I want to see again or see anew. Watching the SMEAR equipment and downloading its daily collected data make me aware of a distinction: SMEAR's measuring is meant to be as consistent as possible, and mine is not at all. Rather, I collect an intuitive and intentionally sporadic set of views on a place. I am not trying to track CO_2 and NO_x flux or assign numerical values to temperature, humidity, or wind. Instead, I want to see the ways in which a landscape is altered, revealed, and obscured by changes in light, wind, weather, water—and the ways by which these evolving weather-landscapes can become images. I want to work with the scientific data-images representing aspects of these landscapes and weathers and explore them through my own artistic lens. I hope to honour the truth that landscapes are complex beyond what I am (or humans, more generally, are) able to see directly or understand.

In late 2023, while researching clouds, I learned about the Barbados Cloud Observatory (BCO), in operation since 2010. The BCO, located on the cliffs of Deebles Point on the eastern, windward edge of Barbados, is operated—primarily remotely[16]—by Professor Bjorn Stevens,[17] engineer Friedhelm Jansen (both of the Max Planck Institute for Meteorology), and technical officer Marvin Forde (of the Caribbean Institute for Meteorology and Hydrology). It is located precisely there to facilitate the study of the ever-present shallow cumulus clouds that arrive on the Barbados coast via the trade winds, blowing westward across the open stretch of the Atlantic from Africa.[18] These clouds have crucial bearing on potential surface temperature rise, but their influence is not well understood. In particular, "the surface evaporation engendered by clouds in the trades is important to the structure of tropical convergence zones"[19] (a band of clouds, rain, and thunderstorms circling the globe near the equator, which shifts with the seasons). Changes in this region have the potential to impact the earth's climate on a much broader scale.

The BCO is well situated to track these clouds: Barbados is relatively flat and remotely located. To the east, the direction from which the trade winds blow, the nearest land is Cape Verde (3700km), and the nearest point on a continental landmass is Dakar, Senegal (4500km). Thus, the seemingly endless clouds "arriving" with the trade winds are generally unaffected by land or direct human activity. Due to its location near the equator, Barbados experiences a range of circulation systems over the course of the year: seasonal shifts in cloudiness, a wet season and a dry season, and different aerosols dependent on shifts in wind. Bjorn Stevens told me that ideally the BCO would be located on a platform somewhere in the open ocean, but the need for power, internet, and infrastructure makes Deebles Point the best possible location for it.

The BCO sits within a rusty perimeter fence exposed to hot tropical sun and the cooling but unrelenting trade winds, which blow continuously from the east and bring clouds, salt, waves, ocean spray, and rain. This constant barrage of air and moisture means that the containers get corroded and rusty and are eventually decommissioned, and the instruments need fairly regular maintenance. Standing on Deebles Point taking pictures and video of clouds in late April/early May of 2024, I am reminded that studying weather and trying to "weather" the weather are inextricable.

The BCO's suite of instruments includes a cielometer, a sun tracker, a wind LIDAR, a micro-rain-radar, a disdrometer, radiation sensors, weather sensors, a cloud radar, and an impressive Raman LIDAR. All of this equipment is situated on or in a set of thoroughly organized shipping containers brought from Germany. One holds a radar dish pointing straight up, for which a circular hole is cut out of the container's top precisely to size. Immediately next to the radar is the Raman LIDAR, the BCO's most expensive and awe-inspiring instrument: a laser



Leah Beeferman and New Information, *Three Weathers Edition 15*, July 5, 2023 (2023). Laser print on paper, 36 x 48 in. Digital image shown for clarity and detail.

beam tuned to certain frequencies and shot up to the sky—its green colour visible only after dusk—which then hits particles in the air and bounces back down, the returning light collected by a group of varyingly sized telescopes that surround it. After dark, you can see the beam, a few inches in diameter, fluctuating between transparent and opaque greens as the atmosphere, always changing, passes through it with the wind. The images the Raman LIDAR produces are stunning: saturated representations of the sky with delineated sections of clouds that almost make me think that it can see how I see—to this end, I included several Raman LIDAR images alongside my own cloud photographs in my large-scale fabric piece *Shallow Clouds Form* (*Barbados*). The other instruments are less dramatically fantastic, standing firmly in their respective locations, patiently collecting measurements and data on a set schedule. This is perhaps the most important part, Bjorn Stevens told me: patience.

Similar to SMEAR, there is a constant hum coming from the BCO, evidence that the power is on and the cooling equipment is functioning; as Friedhelm Jansen told me, something has gone wrong if that sound isn't there.[20] But while SMEAR's pervasive hum sometimes feels foreboding, the BCO's is often masked by the sounds of the wind and the waves crashing on the cliffs below. During my time at these two stations, I am aware that this equipment must intrude on these landscapes in order to study them. At moments, this seems less than ideal, but I quickly remember that we are all intruding observers in our own ways: our cameras, instruments, and bodies stand amidst and within the circulating environments we seek to understand. Though our acts of measuring may sometimes make us seem *outside* the weather, we are only able, at times, to escape it (or, better put, to go indoors) because these instruments can weather that weather better than we can. Still, weather is, perhaps equally, an experiential and scientific phenomenon—yet another aspect that draws me to it. What can be systematically sampled and studied by making mechanical measurements can also often be seen or felt, its effects largely perceivable by those who inhabit a place as it changes. While we may not be able to discern numerical values or activity at certain scales, we do experience the resulting conditions. Perhaps this makes the study of weather somewhat unique in the sciences: those who study it also have an implicit bodily awareness of what is being studied—and so does everyone else. Does such experience of weather factor into understanding it?

Prior to learning about the BCO and making weather-related projects, I had thought about clouds but never included them in my work—or even regularly stood in one place to watch or record them as they passed. But my recent projects, including *Three Weathers*[21]—where we combined three descriptions of weather at one moment (a satellite map, the numerical values, and a poetic description of) into 36 x 48 in. posters—have led me to reconsider clouds. They may be visible indicators of weather and atmosphere, but as they shift and evolve, they are a constant reminder of the continual and unavoidable changes that *we* weather. Finding myself within the gates and atop the containers of the BCO with my cameras and sound recorders, I felt how special it was to experience and become aware of these evolving atmospheric systems—and to, once again, have the opportunity to make my own observations within these disparate scientific contexts.

Watching clouds from Deebles Point means staring east to the horizon, which forms a strangely sharp-looking edge compared to the diffused, heaping cumulus clouds entering the frame of view. The horizon, of course, only appears this edged because we are so far away, unable to see the nuances and fluctuations of the true boundary layer between ocean and atmosphere. I imagine a haze of hovering molecules changing states, evaporating and reabsorbing, fogging the edge. Clouds, too, have soft edges, which gradually fade from moisture to air. Stevens talked about how science has a tendency to turn things into "objects" for study and to give those objects rules. He suggested that clouds, as kinds of anti-objects, refute this; following suit, humans define clouds in terms of boundarylessness and dispersion.

Leah Beeferman, *Deserts and Forests (Bisti/De-Na-Zin)* (2023–24). Digital inkjet print, framed, 36 x 48 in. Photo by Karen Phillipi.

At the BCO, I watched cumulus clouds appear above the horizon. Out there, they seemed so countable and discrete. But when these clouds passed overhead, I became distinctly aware of a shift in scale. What had looked so contained and defined from afar were now, above me, huge and all-encompassing. Each cloud appeared so much less dense and so much more diffuse as it cast a much-appreciated momentary shadow around me—and then it was gone, blown away. I looked back at the horizon, where a new group of cumuli had clustered, and began to watch, waiting for them to arrive. Encountering this seasonal cycle on the coast of Barbados made me realize that clouds—which we often think of as being separate from a locale, bearing no recognizable or identifiable markers of a place—are local in their behaviour. And that given the particular weather patterns of a place, even these blurry anti-objects *are* a part of that place. After all, where does a landscape end, horizontally or vertically?

Clouds are an extension of the landscape, carrying or created by the weather that temporarily defines it. They bring with them uncertainty, casting shadows as they pass: shadows which are, perhaps, a metaphor for what is (or can be) known and what is not (or cannot be). Lately, I have been seeking shadows. I find them in an often cloudless desert: landscape objects block the strong sun, making flattened shadow-versions of themselves angled along the ground. I see them in the forest: watching where the light hits and reflects and where it does not, blocked by impeding surfaces to create regions of bright and dark forest. I seek out the shadows created by clouds: on the edge of an island where there isn't much else making shade, I see shadows that connect the sky to the ground—large-scale shadows, which, in moments, pass by. And I build my own: the unknown knowns of scientific data-images and gestural marks, of weather maps and invented shapes in 3D space, of landscapes that are real but constructed, of weather moments, described, held out of time, and gone.

What does it mean to measure? What can be captured, photographically or scientifically, in light or in data? What images are the results of these captures, how do we look at them, and what can we learn from them? Do we make images as an attempt to understand? Do we capture images to obtain evidence, to remember, or to return to something and see it anew? When do images help find certainty within uncertainty, and when do they prolong or maintain it? For me, images keep questions open as much as they answer them. Even an image made *as* an answer can hold innumerable other answers and questions—not as a tool to dispute facts but to magnify potential, to open up space for thought.

"To most of us, uncertainty means not knowing. To scientists, however, uncertainty means how much something is known."[22] I encountered this articulation while doing an internet search to better understand the relationship between science and uncertainty. My expectations reversed, and I was almost caught off guard. I became acutely aware of scientists' efforts to chisel away at unknowns in hopes of revealing knowns—and of the baseline that knowns are not to be expected but must be sought. Still, I wonder what makes something known. And in our quest to know, how can we sustain this baseline state of uncertainty: to move towards it and not only away from it, to seek out and engage the elusive, the unfamiliar, the ungraspable, the unrepresentable?

Scientists must—of course—do science, make measurements, expand understanding. We need higher-resolution models for weather prediction to address the cloud- (or climate-) scale uncertainty. At the same time, I feel that a cloud-scale uncertainty is most compelling—not in terms of a failure to understand and act to prevent climate disaster, but because of the vast and limitless potential of the unknown that the word implies. To this end, I am committed to exploring the different roles that images and uncertainty play in science and art: when to try and reduce uncertainty, and when to sustain or heighten it. These tensions are at the heart of my work and research. Perhaps it is here—in the form of images or artworks that do not seek to explain or make certain—where a comfort with and curiosity about cloud- (or climate-) scale uncertainties can reside. And perhaps it is here that these uncertainties will remain, as what is known expands and enlarges—from shadows and light, questions and answers, information and abstraction.

NOTES

1 "Projects during Phase 2 (2019–2023)," Projects during Phase 2 (2019–2023)—Waves to Weather Transregional Collaborative Research Center 165–LMU Munich, https://www.wavestoweather.de/research_areas/phase2/index.html.

2 Fred Pearce, Jim Robbins, and Jocelyn C. Zuckerman, "Why Clouds Are the Key to New Troubling Projections on Warming," *Yale Environment360*, https://e360.yale.edu/features/why-clouds-are-the-key-to-new-troubling-projections-on-warming; "The Role That Clouds Play in Climate Change," CORDIS, December 30, 2022, https://cordis.europa.eu/article/id/442741-the-role-that-clouds-play-in-climate-change; Sarah Wild, "Cloud Shapes and Formations Impact Global Warming – but We Still Don't Understand Them," *Horizon Magazine*, November 9, 2020, https://projects.research-and-innovation.ec.europa.eu/en/horizon-magazine/cloud-shapes-and-formations-impact-global-warming-we-still-dont-understand-them; Richard Gray, "Q&A: Why Clouds Are Still 'one of the Biggest Uncertainties' in Climate Change," *Horizon Magazine*, November 4, 2020, https://projects.research-and-innovation.ec.europa.eu/en/horizon-magazine/qa-why-clouds-are-still-one-biggest-uncertainties-climate-change.

3 "Projects during Phase 2."

4 "The Four Core Types of Clouds," National Oceanic and Atmospheric Administration, https://www.noaa.gov/jetstream/clouds/four-core-types-of-clouds.

5 James Livesey, "Cloud Studies," Whipple Museum, October 23, 2018, https://www.whipplemuseum.cam.ac.uk/explore-whipple-collections/meteorology/cloud-studies.

6 Helmut Völter, *Wolkenstudien. Cloud Studies. Études des nuages*, eds. Jörn Dege and Mathias Zeiske (Leipzig: Spector Books, 2011).

7 Helmut Völter, *The movement of clouds around Mount Fuji: Photographed and filmed by Masanao Abe* (Leipzig: Spector Books, 2016).

8 Tim Ingold, "The Eye of the Storm: Visual Perception and the Weather," *Visual Studies* 20.2 (October 2005): 97–104.

9 Jussi Parikka, *Operational images: From the Visual to the Invisual* (Minneapolis, MN: University of Minnesota Press, 2023), 12: "Operational images are, in Farocki's words, 'pictures that are part of an operation,' implying the primacy of action and function instead of a picture to be seen and interpreted for meanings."

10 I also made short stops at the Caribbean Institute for Meteorology and Hydrology (CIMH) and the Barbados Atmospheric Chemistry Observatory (BACO) and explored nature on the eastern side of the island.

11 Ida Soulard, Abinadi Meza, and Bassam El Baroni, *Manual for a future desert* (Milan, Nantes, Italy: Mousse Publishing (2021), 11. In the introduction to *Manual for a Future Desert,* the authors discuss geographer Diana K. Davis's notion of the "arborcentric," defined in opposition to "desertification." They state: "In between these two polarities, the lush scenario of endless forests … and the horror brought on by desertification, lies a conception of nature as a luxurious place of growth…. If the Forest is seen as a space of permanent blossoming … the desert is mostly understood as an empty and deathlike territory … [but] deserts are of course rich ecosystems with high biodiversity, even if mostly unseen."

12 Ibid, 11.

13 97% of the forest in Southern Finland is managed, meaning it is continuously cut and regrown, and is not "old growth" forest.

14 These graphs can be found at https://smear.avaa.csc.fi. However, I had found—and used for my series of laser-etchings—a different set of graphs, which I much preferred, through a previous version of the Hyytiälä website in 2023, https://www.atm.helsinki.fi/pics/atmosphere.html.

15 Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Duke University Press, 2007), 308–309: "Phenomena do not merely mark the epistemological inseparability of observer and observed; rather, phenomena are the ontological inseparability of agentially intra-acting "components.' That is, in the case in question, phenomena are the ontological entanglement of objects and agencies of observation."

16 Barbados Cloud Observatory, https://barbados.mpimet.mpg.de.

17 Bjorn Stevens, et al., "Sugar, Gravel, Fish and Flowers: Mesoscale Cloud Patterns in the Trade Winds," *Quarterly Journal of the Royal Meteorological Society* 146.726 (November 19, 2019): 141–52. https://doi.org/10.1002/qj.3662.

18 Bjorn Stevens et al., "The Barbados Cloud Observatory: Anchoring Investigations of Clouds and Circulation on the Edge of the ITCZ," *Bulletin of the American Meteorological Society* 97.5 (May 1, 2016): 787–801. https://doi.org/10.1175/bams-d-14-00247.1.

19 Ibid, 787–801.

20 I e-mailed Friedhelm Jansen after Hurricane Beryl passed through the region in July 2024. While Barbados was spared a direct hit, the BCO was without power for some days. As of this writing, it is running again.

21 Leah Beeferman and New Information. *Three Weathers*, http://threeweathers.xyz.

22 "Certainty vs. Uncertainty: Understanding Scientific Terms about Climate Change," Union of Concerned Scientists, https://www.ucsusa.org/resources/understanding-scientific-terms-about-climate-change.