Keywords model, environment, atmosphere, wind tunnel, filling box

Abstract This paper explores the intermedial dialogues between my environmental model prototypes— of wind tunnels, water tables, and filling boxes —and photographs of them. I speculate about how photographs of my models make comprehensible some of the seemingly incomprehensible scales and material complexities associated with atmospheric constructions underpinning the climate crisis. I illustrate how environmental models can be read at several scales: the one-to-one scale of the instrument as a tectonic artefact; the scale set by the architectural model on the testing bed; and the ambiguous scale of the controlled space of air and water flow. Each scale offers new vantage points for thinking about architecture's many atmospheric dialogues between inhabitants, buildings, instruments, architectural models, and the wider world we are immersed within. Photography aids in the readings across scales, enabling design insights not possible outside of the mediating lens of the camera. Fundamentally, I suggest that the intermedial dialogues between source model and abstracted photograph merge two conceptions of 'the atmosphere' by first following and then disrupting the protocols of scientific flow visualization.

Résumé Cet article explore les dialogues intermédiaux entre mes prototypes de modèles environnementaux (souffleries, tables d'eau et boîtes de remplissage) et les photographies de ces modèles. Je spécule sur la façon dont les photographies de mes modèles rendent compréhensibles certaines des échelles apparemment incompréhensibles et des complexités matérielles associées aux constructions atmosphériques qui sous-tendent la crise climatique. J'illustre comment les modèles environnementaux peuvent être lus à plusieurs échelles : l'échelle univoque de l'instrument en tant qu'artefact tectonique, l'échelle fixée par le modèle architectural sur le banc d'essai et l'échelle ambiguë de l'espace contrôlé de l'écoulement de l'air et de l'eau. Chaque échelle offre de nouveaux points de vue pour réfléchir aux nombreux dialogues atmosphériques de l'architecture entre les habitants, les bâtiments, les instruments, les modèles architecturaux et le monde plus large dans lequel nous sommes immergés. La photographie facilite la lecture à travers les échelles, permettant des perspectives de conception qui ne sont pas possibles en dehors de l'objectif médiateur de l'appareil photo. Fondamentalement, je suggère que les dialogues intermédiaux entre le modèle source et la photographie abstraite fusionnent deux conceptions de « l'atmosphère » en suivant d'abord, puis en perturbant les protocoles de visualisation des flux scientifiques.

Lisa Moffitt

Disrupting Scientific Flow Visualization Protocols: Photographing Architecture's Atmospheres

When I was a student of architecture two decades ago, the process of designing architecture entailed working primarily between two media—hand-drawing and physical modelling. The representational dialogues between these two primary media generated a design proposal. Design focused on process over product, and the context of a project was largely reduced to its physical geography rather than its wider socio-political situation. The referent of representations in the design process hinted at a possible future building but never fully committed to what the future building might fully be. The 'final' project presented at a design review was merely a stationary point in a sequence of operations that in principle could go on forever.

This generative representational mode of working, which informed much of Western architectural educational pedagogy in the late 1990s and early 2000s, was best described by Robin Evans's well-known essay "Translations from Drawing to Building", written in 1986 and published in the canonical book of the same title in 1997. A fundamental premise of Evans's essay was to acknowledge that, unlike for visual artists, the primary project of the architect was not to build the future building being designed but to make representations of that building. For Evans, the distance between the flat, materially mute conventions of architectural drawing and that of building were what made drawing such a powerful medium of exploration. Evans notes that

> ***recognition of the drawing's power as a medium turns out, unexpectedly, to be recognition of the drawing's distinctness from and unlikeness to the thing that is represented, rather than its likeness to it, which is neither as paradoxical nor as dissociative as it may seem.*** (Evans, 1997: 156)

One of the traits that make drawing—which is inevitably reductive and abstract—so valuable is that it traverses scales, from the detail to the building. The capacity to visually translate ideas across scales is a fundamental skill set for the architect, who does not build buildings, Evans reminds us, but represents their construction.

While Evans's essay is well established in the canons of architectural theory, the media and contexts of architecture have prolifically expanded in the past two decades. Evans's emphasis on abstraction and productive distance between representational media and building has been replaced by interest in hyperrealism offered by digital modelling and increasingly collapsed distinctions between the digital and the real. Moreover, the design and production of architecture today generates a proliferation of visual material—drawings, models, photographs, renderings, videos, etc.—and the venues for this visual material have expanded

substantially both in digital and physical platforms. Not only have the media of the discipline expanded well beyond that of the two primary modalities of hand-drawing and physical model, the scales of spaces, range of sociocultural concerns, and timescales of engagement that architects embed as critical concerns into the design process have proliferated. Architecture is paradoxically both more preoccupied with its own image and more politically engaged than it has probably ever been.

I offer this brief, to some degree autobiographical, overview of my architectural training to situate my work, which draws on these formative educational experiences of working generatively and representationally across scales, but within a complex contemporary context marked by the climate emergency. My practice-based research explores dialogues between two enduring architectural media, physical models and photography, to elucidate the fluid dynamics of airflow as both a scientific process and an experiential phenomenon. My research asks how contemporary representational techniques can engage with the material complexities of full-scale environmental processes, many of which operate across radically divergent spatial and temporal scales.

To address these questions, I design, build, operate, and then photograph *environmental models* as tools for thinking about architectural environmental mediation across scales. I use the term environmental model in the absence of an existing, more established term in architecture specifically. I define environmental models as instruments that create controlled environments that make the phenomena of airflow visible in relation to an architectural model.[1] I have prototyped dozens of these models, including wind tunnels, water tables, and filling boxes. Each model makes airflow visible as a moving material system. This paper focuses on the intermedial dialogues between my environmental models and photographs of them, speculating about how the photographs of the models start to make comprehensible some of the seemingly incomprehensible scales and material complexities associated with atmospheric constructions underpinning the climate crisis.

I begin the essay by elaborating on two diverging conceptions of constructed 'atmospheres' that emerged around the time of Evans's essay: the subjective and experiential 'atmospheres' theorized by Gernot Böhme and the technoscientific rationalization of the atmosphere, the gaseous bubble surrounding the earth, as a fragile, shifting chemical construction reinforced by Intergovernmental Panel on Climate Change reports and climate prediction models. I then elaborate on the broader lineage of my environmental models by first establishing their origins as engineering experimentation devices and then as tools of architectural speculation.

Through my design research, I have found that environmental models have the capacity to merge the two conceptions of the atmosphere that have evolved over the past three decades in architectural discourse by both building on and disrupting scientific flow visualization protocols. These conceptions are facilitated through the intermedial dialogues between the source model and photographs of them. I conclude the paper by reflecting on these dialogues as they played out in the prototyping, photographing, and exhibiting process of my work. I suggest that the implications of these intermedial dialogues extend beyond the internalized world of the model to engage with wider questions of significance today about how architecture makes evident the construction, revelation, and mediation of its many constructed atmospheres.

1 The term "environmental model" has currency in natural scientific disciplines such as ecology, hydrology, and geology, referring to physical modelling or digital simulation of dynamic natural processes for analytic and predictive purposes. Some landscape architects build on these scientific methods, modelling environmental systems as a means of monitoring, analysing, or designing in response to watershed management, urban heat island effects, erosion and sedimentation patterns, and storm surge effects, among other things.

Two Atmospheres

In *Translations from Drawing to Building*, Evans recognizes that "not all things architectural can be arrived at through drawing" (Evans, 1997: 159). He refers specifically to visual artist James Turrell's visceral light sculptures, which are materially and ephemerally so complex that any attempt to render them through drawing would be too impoverished to be of much explanatory, experiential, or projective value. This representational dilemma is as much a function of the limitations of the medium of drawing as it is about the complexities of replicating a particular environmental phenomenon—in this case light. This challenge applies to other equally, if not more, complex environmental systems such as the flow of water, the movement of air, or the transfer of heat. Architectural theorist Christopher Hight refers to environmental conditions such as airflow and thermal exchange as "non-visual phenomena object(s)"; these phenomena are resistant to representation because they are invisible, and they follow fluid and thermodynamic principles that are not always intuitive (Hight, 2009: 26). Fundamentally, drawing just doesn't suffice to capture either the material complexity or the experiential viscerally of these conditions. These complexities have compounded as scales and consequences of climate breakdown escalate. As Emily Eliza Scott suggests, climate change prompts "profound representational dilemmas…compounded further by our immersion in this ever accelerating 'everything-ness,' the edges of which are challenging, if not impossible, to sense" (Scott, 2016: 130–131).

The reference to Turrell's light works—which challenge and heighten perception and experience of space through the careful calibration of certain ineffable, immaterial qualities of natural or artificial light—in Evans's essay was timely. The essay "Translations from Drawing to Building" was written in 1986, but the canonical book of the same title was published in 1997. This interim period saw a rise of two charged conceptions of 'atmospheres' that in recent years started to converge into a single thread. On the one hand, this period saw the increasing theorization of the notion of the 'atmospheric', initiated by the publication in 1993 of Gernot Böhme's essay "Atmosphere as a Fundamental Concept of New Aesthetics". In the essay, Böhme explores the ontology of the term *atmosphere* in aesthetic discourse. He identifies attributes of atmospheres—primarily that they are indeterminate and diffuse and that they emanate from objects while also being experienced by subjects. Böhme's theoretical framework informed phenomenological accounts of the atmospheric in architecture, best exemplified by Peter Zumthor's book *Atmospheres: Architectural Environments. Surrounding objects*, published in 2006. In the book, Zumthor reflects on architectural conditions that have the capacity to elicit an emotional response of feeling overwhelmed by beauty. These qualities—which emanate from building spaces and surfaces and are perceived by the sensing subject—are often produced through environmental affects related to light, sound, texture, and heat. In Zumthor's framing, the atmospheric in architecture is experiential, often interior, and is marked by the convergence of the material with the meteorological.

The convergence of the material and the meteorological arose in a different guise in roughly the same period as a second wave of environmentalism swelled in architecture, building on earlier grass-roots movements of the 1960s and 1970s. The term "sustainability" gained currency through the publication of the 1987 Brundtland Report and with it, the gaseous bubble surrounding the earth—chemically altered through anthropogenic intervention—became a topic of spatial consideration. Widespread pollution due to increasing globalized processes of industrialization, growing holes in the ozone layer, the 1986 nuclear accident at Chernobyl, and recognition that burning fossil fuels contributed to global warming, all supported the rise of the sustainability movement in architecture. A major response in the discipline was the development of metrics for quantifying resource consumption, depletion, and degradation. Qualitative and experiential emphasis on materiality and environmental effects

were replaced by a reductive emphasis on measurable performativity.

These two 'atmospheric' agendas were distant cousins three decades ago. Practitioners such as Zumthor sat at one end of the spectrum and those such as William McDonough, author of the influential book promoting circular economies, *Cradle to Cradle*, on the other. And their representational approaches differ substantially. On the one hand, Zumthor's atmospheric architectural qualities are represented largely through moody charcoal drawings or grainy black and white photography of buildings in meteorologically charged contexts. On the other hand, the turn towards sustainable metrics gave rise to quantitative representations of the sky dome that included maps of air movement akin to meteorological maps, statistical graphs of atmospheric emissions, and sankey diagrams of energy consumption. Similarly, architectural representations of environmental systems borrowed from protocols in meteorology including swarming vectors akin to wind barbs and isotherms indicating thermal gradients.

We know now that these two atmospheric concerns—one predicated on the qualitative and experiential and the other on the technical and measurable—are not so distant from each other. Architecture as a discipline has matured substantially in the intervening years and any divide between 'atmospheric' thinking as being either experiential affect or quantifiable effect has largely collapsed. As both practitioners and academics grapple with architecture's many entanglements with climate breakdown, there has been a corresponding expansion of epistemologies and methods for thinking about the scales, timeframes, and material politics of architecture as an enterprise that both metaphorically and literally constructs (the) atmosphere(s).

Examples of this expansion range from revisited histories of architecture, such as architectural historian Daniel Barber's historical framing of environmental agendas associated with modernism in *Modern Architecture and Climate: Design Before Air Conditioning* and Sylvia Benedito's contextualization of landscapes in microclimatic terms in *Atmosphere Anatomies: On Design, Weather, and Sensation*, to the emergence of design practices that foreground the design of atmospheres, such as those of Philippe Rahm Architectes, to the rise of contemporary art practices that are devoted to environmental activism using atmospheric media, such as those of Tomas Sáraceno and Olafur Eliasson. While divergent in discipline and method, collectively these practices negotiate conceptions of the air we collectively breathe and the atmosphere we collectively inhabit as being experiential and palpable as well as being measurable phenomena with verifiable chemical traits, meteorological dispositions, and planetary-scale consequences. A consensus seems to be emerging that making sense of the incomprehensible magnitude of the climate crisis requires negotiating a delicate balance between experiential imagination and scientific rigour. Photographs of my environmental models contribute to this discourse by revealing technical principles about fluid dynamics while also making environmental effects visible as material systems—across scales—that are immersive and consequential. They do so by first following the protocols of scientific flow visualization and then by disrupting them.

Flow Visualization

I am an architectural designer who designs, prototypes, and photographs engineering experimentation devices: wind tunnels, which are essentially ducts that channel and straighten air drawn through a testing bed; water tables, which create a sheet of moving water over an inclined surface; and filling boxes, which are tanks of water within which acrylic models are submerged and denser, dyed salt water is injected. Wind tunnels and water tables make air flow related to differences in pressure evident. Filling tanks make air flow related to difference in buoyancy evident. I refer to these devices collectively as environmental models.

There are two primary media in my work: the physical environmental models and photographs of them. The source media is the model, or the full-scale apparatus generating steady-state airflow. Over time, my models

have gained refinement, transitioning from following ad hoc DIY guidance online to utilizing digital fabrication tools and techniques available in architectural workshops. This increase in precision was a response to the need for tight construction tolerances required to construct air and watertight assemblies that generate steady flow. The second medium in my work is photography. Once the prototypes function as mechanical artefacts, they are photographed. My photographic methods are intuitive and to some degree dependent on camera availability from the loan pool at the architecture school where I teach; I often use a smartphone.

At face value, photographs of environmental models most closely align conceptually with photographs of architectural models. As architectural theorist Davide Deriu notes, "The photograph of an architectural model is an intriguing yet somewhat intractable type of image which has thus far eluded close analysis" (Deriu, 2012: 159). Deriu elaborates on the curious process of building a physical model—a three-dimensional representation—and then reducing this three-dimensional state to the flat surface of a photograph. He notes,

The most obvious implication of this process of intermediality is that a solid object is reduced to the flat surface of a picture. Once the model is framed by the camera, it enters a different field of perception, where its original properties of form, texture and scale are reconfigured. (*ibid.*)

The inclusion of moving air, smoke, water, and dye in my models adds an element that is rarely theorized in relation to architectural models, which prompted my focus on flow visualization strategies used in the applied sciences.

My models expand the role of experimental devices beyond being applied scientific verification tools to being design tools that make environmental systems legible as visible material systems with wider consequences. Through this expanded epistemological lens, environmental models can be read at several scales: the one-to-one scale of the instrument as a detailed physical construction; the scale set by the architectural model on the testing bed; and the ambiguous scale of the controlled space of air and water flow running through the testing bed. Strategic photography enables these readings, reinforcing the role of the photograph as a mode of scientific verification as well as of speculative, sometimes abstracted, spatial immersion. In this way, photographs of the environmental effects generated in the testing bed of the models allude to processes that play out from the micro to planetary scales.[2] The next section elaborates on how my photographs of the source model offer new scalar and material readings about architectural environmental mediation that takes place in the wider world. Fundamentally, photographs reveal some of the many ways in which architecture mediates between its interior and exterior environments across scales from the seam (that leaks) to the building (that mediates) to the world (that immerses).

The invention of early engineering experimentation devices is entwined with developments in photography. In the late 19th and early 20th centuries, these devices were developed to test and visualize vehicular movement—initially of boats and then of planes—through air and water, fluids with similar physical characteristics. Testing aerodynamic characteristics of buildings soon followed; Gustav Eiffel is credited as being

2 When considering air movement, as scales of observation scope out, the consequences of atmospheric alterations become more ominous. At meso- and macro-scales, the shifts and courses of wind determine the path and distribution of airborne particulates such as dust, sand, and snow, as well as of airborne contaminants. As global weather patterns become more erratic, wind drives many catastrophic events, increasing the spread of wildfires, the intensity of hurricanes and floods, and the extent of erosion and desertification.

the first to use a wind tunnel to test wind loads on buildings in 1908.[3]

French polymath Étienne-Jules Marey, best known for his development of graphic methods and chronophotographic techniques for capturing the movement of birds in flight, developed some of the first smoke stream wind tunnels between 1899–1902 **(Fig. 1)**. The wind tunnels mark a shift in Marey's career, from a focus on animate motion to the medium through which motion takes place. Marey's wind tunnel photographs are beguiling, capturing transitions between steady streamlines of air movement reflecting laminar flow and the trailing eddies, vortices, and more chaotically dispersed particles reflecting turbulent flow. While Marey's wind tunnels did little to advance the field of aeronautics, they did epitomize a scientific empirical tradition of learning through observation as well as validating the "mechanical objectivity" offered by photography (Daston and Galison, 2007).

Flow visualization photographic conventions have changed little since Marey's time. A good flow visualization in scientific terms provides empirical verification of principles that are further analysed in relation to either full-scale experiments or digital simulation to triangulate results. While there are more complex optical strategies for visualizing flow, often the introduction of a new material such as smoke or dye is used as the visualizing medium. Flow visualization photographs tend to follow certain conventions. They are frontal, with the camera placed perpendicular to the testing bed to capture orthogonal views. The extent of the photograph includes the testing bed only, cropping out any traces of the model apparatus. Photographs are high contrast. Wind tunnel testing beds, for example, are often matte black, receding from view, focusing attention instead on white smoke trails moving around physical models. Photographs are also free of light reflections—a challenge given that testing beds tend to be covered with reflective surfaces like Plexiglas. Camera shutter speeds are calibrated to ensure photographs are crisp despite the inclusion of moving, diffuse material systems.

Resultant photographs appear to have been effortlessly taken despite the technical difficulty required to achieve them, supporting their role as artefacts bearing 'objective' scientific truths (Daston and Galison, 2007).

In the early stages of my research, I tried to emulate scientific flow visualization strategies to capture flow patterns related to the technical principles of building ventilation. Streamline photographs reveal how physical objects like buildings alter and shape flow. Movement of the smoke or dye around architectural models illustrate fluid dynamics processes such as how air flows around complex geometries, where air transitions from being laminar (non-deviating) to turbulent (chaotic), and where wind shadows devoid of air movement exist. Understanding these variables is important because the skilful design of building position, orientation, shape, and location of operable windows and doors impacts flow patterns. In this way, understanding the mechanics of airflow enables designers to develop low-energy, passively cooled space through skilful design of natural ventilation.

My first wind tunnels were measured against the scientific protocols and flow visualization methods noted above; they attempted to emulate the smoke stream technique refined by Marey. My progress was continually stymied. The smoke that I used lacked the density and clarity of Marey's and the fan speed in my wind tunnel was so strong that smoke dissipated too quickly to be legible **(Fig. 2)**. Moreover, obstructions in the inner surfaces of the wind tunnel

3 The use of wind tunnels and heliodons as research and pedagogical tools in architecture peaked in the 1950s and 1960s, with many schools of architecture developing dedicated environmental experimentation facilities. Physical experimentation in both architecture and engineering has largely been replaced by digital simulation in the last half century. However, engineers and building scientists still rely on physical experiments to test building ventilation and urban airflow patterns. Such aerodynamic research tends to focus on acquiring numeric results that can be scaled up to predict full-scale performance to a high degree of accuracy. In this context, physical models, often in conjunction with digital simulations, are used to predict full-scale performance with a high level of numeric precision.

1

Fig. 1
Étienne-Jules Marey's photograph of a 21-tube smoke stream wind tunnel. Inclined plane, print from glass negative, 12 × 9 cm (engraved in the emulsion). Inv. MPN 342. Public domain. Source: Didi-Huberman and Mannoni, 2004.

Fig. 2
Wind Tunnel Prototype 1 Smoke Visualization Studies. Video stills illustrating flow patterns through opaque and transparent architectural models in the first wind tunnel prototype. Vapour from an off-the-shelf smoke machine generated visible flow patterns through the testing bed. This technique lacked the clarity and density of the smoke streams in Marey's wind tunnel. The fan speed caused the vapour to dissipate too quickly to yield legible results. Visualization studies by Lisa Moffitt, video and photography assistance by Emma Bennett. © Lisa Moffitt, 2017.

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Fig. 3
Detail photograph of flow visualization in water table prototype 3. The third water table prototype succeeded in creating a surface of steady streamlines. The effect was brief, a function of the limited capacity of the ink reservoir, and quickly dissipated. The photograph emulated the flow visualization protocols that I measured my work against in the early stages of research.

introduced turbulence, generating dispersed smoke within the testing bed.

I began prototyping water tables at the same time as the wind tunnels and found that visualizing steady streamlines was far more achievable in water than in air. Through the careful calibration of light, shutter speed, and camera position, I captured clear streamline photographs of my third water table prototype. These photographs marked a significant achievement in the development of my work, fixing at a moment in space and time an image of a steady-state condition marked by continuously flowing lines deviating around the model on the testing bed **(Fig. 3)**. In the photographs, dye patterns transition from steady lines to those that alter course around the model profiles, pooling in interior pockets, dispersing around edges and corners, and leaving behind areas devoid of movement. They revealed the complex fluid dynamics principles that techniques such as static diagrams often neglect.

I noticed, however, in the process of trying to emulate flow visualization protocols that streamline photographs conceal as much as they reveal. Flow visualization photographs are devoid of context. On the one hand, the focus of the flow visualizations is on the interior steady-state environment in the model, which represents *anywhere* in the sense that the abstracted airflow could in principle represent any place in the world with the same air speed. The need to replicate many places—anywhere—is a defining feature of an experimental chamber. On the other hand, the interior environment in the testing bed of the model represents *nowhere* in the sense that the steady-state condition in the testing bed simulates an exterior condition that is fictional, often devoid of the boundary layer effects or larger contextual conditions present in the real world. The steady linear flow that appears in streamline photographs is a spatial fiction. The airflow of the built environment is, in fact, marked by extreme turbulence generated by surface characteristics of the ground, paving, vegetation, and buildings.

From Flow Visualization to Atmospheric Immersion

In 2018, I curated an exhibition entitled *Working Prototypes* in a concrete casting workshop at the University of Edinburgh; the act of curating the work in the space prompted expanded ways of thinking about the role that photography might play in capturing other atmospheric effects. The exhibition featured my physical prototypes as well as flow visualization photographs of them. Curated within the idiosyncratic space of the workshop, the exhibition raised questions about context which to that point had been occluded by the protocols of scientific visualization. The exhibition opened new ways of recontextualizing the models, viewing them from the outside in rather than the inside out. From the outside in, models took on new presence as material artefacts in their own right.

There was an ambiguity as to where the artefacts of the exhibition started and ended in the space. One water table was integrated into an existing sink. Wind tunnels and adjacent mechanical ducts became visually analogous. Reflections off Plexiglass surfaces extended materiality and views of the space beyond. Other reflections blurred distinctions between model interior and building exterior. Strategic lighting focused views rather than occluding them, creating focal points of intensity and shadowy pause. The models became at times extensions of existing infrastructure, at times receptacles for projections, and at times backdrops for suspended dust particles highlighted by projector lights. Enlarged photographs were attached by magnets to ducts that ran above sinks akin to photographic enlargements hung to dry post processing in a dark room. Videos projecting the models in operation hummed in the background.

The curation of photograph, moving image, and physical model in the exhibition inverted the logics of scientific flow visualization protocols. In photography, the combination of light intensity, focal length, and shutter speed establish varying depths of field. This, in turn, either occludes or reveals effects surrounding or beyond the subject of a photograph. In scientific photographic

protocols, the field of view is deliberately flattened and conditions beyond the testing bed removed. Moreover, flow visualization photographs deliberately occlude external environmental conditions, which are deemed visually distracting. For example, light baffles integrated into model frames eliminate reflections of surrounding spaces. Overhead lighting is turned off, eliminating background reflections of the spaces in which the models sit. Diffuse artificial or natural light is instead carefully controlled through direct integrating into the prototypes. Point sources of light, physical artefacts, and clutter that might reflect on the testing bed surfaces are liabilities requiring erasure.

In the exhibition, calibration of lighting led instead to the construction a particular *atmosphere*, to use Böhme's term, within the workshop space **(Fig. 4)**. One visitor to the exhibition commented that the exhibition reminded them of a photographic dark room because of the careful control of light and the proliferation of small, serial photographs hung in continuous strips akin to photographic contact sheets **(Fig. 5)**. Rather than occlude context beyond, the exhibition was designed to deliberately immerse the viewer within clouds of floating dust, exposed ducts, raw stone, and gauzy backlighting. In other words, the exhibition constructed a visceral material atmosphere through the careful control of lighting, moving image and material artefacts. My focus began to shift from thinking about environmental exchanges as being either *anywhere* or *nowhere*, as the logics of scientific photography suggest, to being *everywhere*, at any given time, in any given place.

When I first started setting up the models in the exhibition space, I also began to photographically capture abstracted, more immersive, photographs of the models. Prior to the exhibition, any photograph that disrupted the protocols of flow visualization was considered a failure. When setting up the exhibition, however, I noticed that a slight shift in camera vantage point away from the testing bed transformed the flattened and compressed space of air movement—the objectified world of fluid dynamics—to a seemingly inhabitable spatial condition. In these photographs, cropped perspectival views reveal spatial conditions that could be read as abstracted landscapes or interior environments.

In one photograph, the camera frames a perspectival scene: a field of rudders shimmers and flutters within a space that appears to hover somewhere between a land art installation and an infrastructural intervention **(Fig. 6)**. In photographs of the undercarriage of one of the water tables that is lit from below and is slowly filling with dyed water, the viewer is invited into an eerie, watery underworld, a perspectival expanse of glowing pools **(Fig. 7)**. This photograph is reminiscent of photographer Hélène Binet's interior photographs highlighting water and glowing light in Peter Zumthor's Therme Vals project. Spatial and immersive rather than frontal and flattened, the photographs suggest that a skilful design of air movement or thermal exchange are immersive and experiential. The photographs capture Lisa Heschong's notion of "thermal delight" or Philippe Rahm's framing of architecture as an active space of meteorological exchange. The photographs effectively immerse the viewer in an occupiable space charged with environmental effects.

From Atmospheric Immersion to Destruction

Building interactions with airflow are neither always quotidian, as scientific flow visualization photographs suggest, nor desirable, as the atmospheric immersive detail photographs suggest. Fundamentally, buildings alter the chemical composition of the gaseous bubble surrounding the planet through seams that leak hot or cold air and through emissions generated through energy-intensive mechanical processes. As profligate energy consumers, buildings are responsible for approximately 35% of all global greenhouse gas emissions related to both embodied and operational energy consumption. Any building that relies on the combustion of fossil fuels emits carbon dioxide into the atmosphere, slowly and invisibly altering the atmosphere's chemical composition, and ultimately fuelling global warming and the climate catastrophe.

4

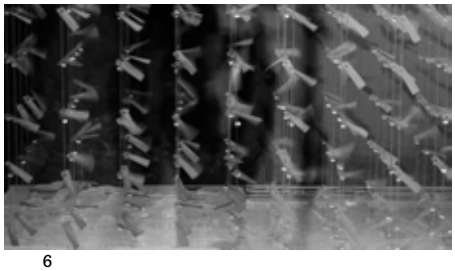
5

Fig. 4
Working Prototypes Exhibition photograph. Setting up an exhibition of my work focused attention on environmental models as objects in collusion with many nested environments. This image captures wind tunnel prototypes one and four hovering in front of a series of filling tank mirrored model images. Rather than lacking context, here the models are situated with many nested environments. © Lisa Moffitt, 2019.

Fig. 5
Working Prototypes Exhibition photograph. Taken from a mezzanine level through a steel mesh guardrail, the image captures fragments of wind tunnel components and a series of photographic stills that hang in strips like contact sheets drying in a photography darkroom. In the exhibition, the careful control of light constructed an aesthetic experience, an 'atmosphere' using Böhme's term. © Lisa Moffitt, 2019.

Fig. 6
Wind Tunnel Prototype 4 Testing Bed. A field of interior rudders register air movement visually within the testing bed of wind tunnel 4, drawing the viewer into a gridded field of turbulence akin to a land art installation or a vast infrastructural landscape. This photograph captures a detail from a vantage point that immerses the viewer in the scene. © Lisa Moffitt, 2019.

Fig. 7
Detail photograph of water table prototype 4. Water leaked through faulty seams on the testing surface into the undercarriage below, gradually flooding the gridded cells at different rates. The photograph immerses the viewer within an ethereal, glowing underworld. © Lisa Moffitt, 2018.



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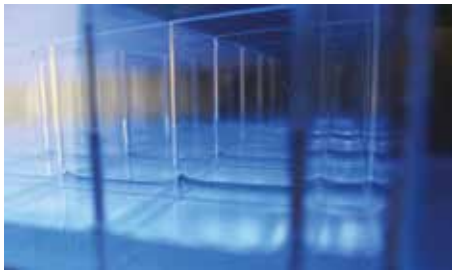

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In some cases, my model photographs highlighted the role that buildings play as active agents of environmental destruction. When reviewing the exhibition setup photographs, I realized that several of the immersive photographs appeared ominous, particularly those of the filling box models submerged within tanks of water. The models, which slowly drain from model to tank, make processes of buoyant airflow visible in a way that is both evidentiary—illustrating the mechanics of buoyant airflow—and cautionary, revealing degradative exchanges between buildings and their wider atmospheric surroundings. The mechanics of filling box models are straightforward. Plexiglas models are submerged in a tank of fresh water. They are then injected with dyed salt water. The denser dyed water falls, and ultimately leaks out of the model into the tank of water beyond **(Fig. 8)**. The tank is synonymous with the atmospheric sky dome. As the model drains, it recedes from view and the leak shifts focus from the source of the leak to the destination of the leak **(Fig. 9)**. Resultant photographs read as buildings exhausting heavy black plumes of smoke, contaminating the sky dome in which they sit. The reading of the scale of the environment in which the building sits oscillates between that of the scale of the model and that of something much more expansive.

Building emissions that contribute to planetary-scale climate changes can be read in relation to Susan Stewart's cultural category of "the gigantic" Stewart suggests that the gigantic is profoundly and distinctively exterior; it is unwieldy, difficult to contain, disorderly. It is beyond the scale of the body, subsuming it (1992). Architectural models, on the other hand, are miniatures. As Stewart reminds us, miniatures are distillations that reduce complexity through a reduction in size that is legible at the scale of the human body. By containing and controlling the gigantic atmospheric world in model form, environmental models construct new, manageable environments that are legible in relation to the scale of the human body. The filling box model photographs disrupt relationships between size and scale of atmospheric effects, effectively 'miniaturizing' the 'gigantic'. They make legible at the scale of the body processes of environmental mediation that play out at scales all the way up to the planetary.

Architects are trained to work representationally across scales; they learn how to both conceive of and to represent buildings from the scale of the building detail to that of the site or region. This capacity to think and visualize, to read and misread visual material across radically divergent scales, is also valuable when visualizing diffuse environmental conditions. The scale of flow fields in environmental models is ambiguous, enabling readings across many spatial scales all the way up to the atmospheric sky dome. This scalar dissonance is heightened in environmental models due to a technical feature of flow scaling. Unlike many physical properties—particularly structural properties of building materials—that perform very differently across scales, flow patterns are self-similar, behaving across scales as small as a centimetre all the way up to planetary in a similar fashion. For example, the vortex patterns visible in cloud formations behave similarly to those on the surface of water caused by moving water striders. In this way, fluid dynamic processes generated in the models allude to processes that play out from the micro to planetary scales.

Conclusion

The previous section outlined four types of photographs that emerged in my research on designing and photographing environmental models. I began my research by drawing from scientific photographic protocols; as my work progressed, new photographic techniques began to disrupt and alter those protocols, expanding the role of buildings as agents that construct many atmospheres. Streamline photographs followed scientific flow visualization strategies and illustrate fluid dynamics processes that impact building thermal comfort and energy consumption patterns. Exhibition photographs of the models situated them as artefacts within a wider context of nested 'atmospheric' environments heightened by careful control of light. Perspectival photographs of model

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Fig. 8
View into the filling tank from a photographic hood attached to prototype 1. The filling tank models slowly leak, receding from view and drawing attention to the dyed water slowly contaminating fresh water in the tank. The photograph suggests degradation or contamination of the skydome in which the building sits. © Lisa Moffitt, 2018.

Fig. 9
Enlarged photograph of flow patterns through an architectural model in filling box prototype 2. This photograph was taken just after dye was injected into the model, capturing agitated plumes of dye flowing ominously into the tank beyond. The photograph is an austere reminder that the built environment is a substantial contributor to climate breakdown. Through their emissions, buildings contaminate and alter the very chemical composition of the atmosphere. © Lisa Moffitt, 2019.

fragments enable imaginative engagement of larger-scale spatial conditions activated by environmental processes. Finally, frontal views of filling tank models appear to contaminate the atmospheric sky dome in which they sit, hinting at wider-scale anthropogenic alterations underpinning the climate crisis. Each photograph type communicated a different matter of concern regarding architecture's role in mediating atmospheric conditions.

The epistemological value of working with environmental models is that they offer insights about environmental mediation across scales and in different capacities. Dialogues between physical model and photograph facilitate these insights. The model generates complex systems in miniature; the photograph fixes them in space and time, offering new readings of both the artefact (model) and phenomena (airflow). The transition in media from model to photograph facilitate several readings. Flow visualization photographs reveal 'objective' truths about fluid dynamics, revealing, for example, transitions between laminar and turbulent flow or illustrating how buoyancy impacts flow through spaces with complex geometries. Here the photographs operate more as records of complex fluid dynamics principles, making them legible to the designer and thus making possible skilful design in response to these principles. But this flattened and distilled representation of airflow and atmospheric exchange is reductive, failing to communicate other ways in which buildings construct atmospheres. Photography of the models also makes possible immersion into worlds suggested by model fragments, evoking the 'atmospheres' characterized by Böhme and Zumthor. Here, the camera lens captures moments in which we are transported into spatial conditions, possible futures, or speculative environments charged by the flows made visible around them. Models and photographs collapse scales and make legible processes that are often difficult to apprehend. Models make gigantic, often invisible, processes legible in miniature, and photography rescales and recontextualizes the miniature back to the perceptually gigantic. The photographs are atmospheric in the sense that they viscerally capture material effects and atmospheric exchanges, enabling imaginative speculation about architecture as a medium that, through its degradative emissions, literally constructs atmospheres. In this way, they merge the two conceptions of the atmosphere—one as a physical construction and the other as an experiential effect—noted in the introduction.

On the surface, both physical models and photography may seem anachronistic media for engaging with complexities associated with building environmental exchanges. Yet both are of value when considering the challenges of designing within vast, complex systems because both distil complexity and recontextualize scale. They make complex fluid dynamics processes visible for closer inspection. In this way, the medium of photography is a productive counterpoint to the delicacy and capriciousness of moving air generated in the model, fixing in space and time that which is otherwise fleeting and often invisible. Environmental models and their photographs make legible at the scale of the body that which is expansive and often beyond cognitive grasp. Buildings act as influential—rather than merely neutral—mediators between two constructed environmental systems: the controlled interior and the erratic exterior. Photographs of environmental models make the incomprehensible scales, effects, and material systems of these mediations legible—if even for a fleeting moment.

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