DRAWING CLIMATE

Daniel J. Ryan
Jennifer Ferng
Erik G. L'Heureux
(Eds.)

Visualising Invisible Elements of Architecture

DRAWING CLIMATE

Birkhäuser Basel

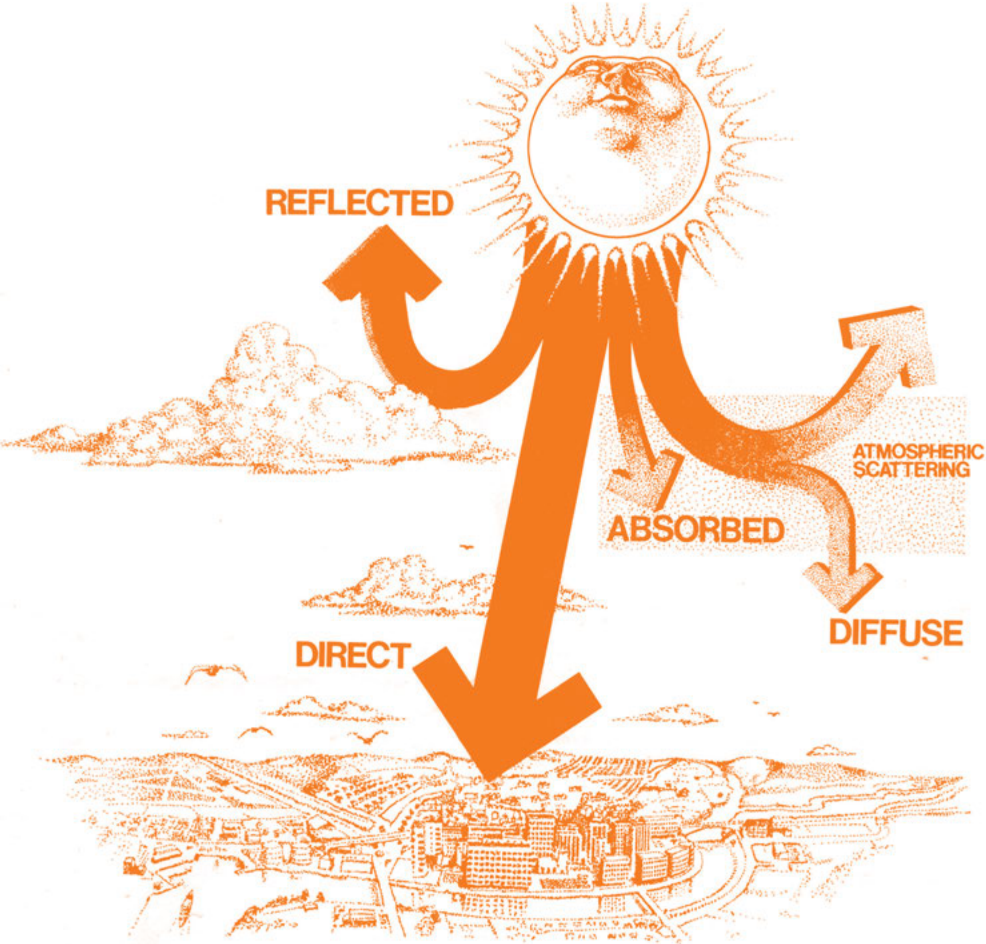
DRY WET

COOL

HOT

CODA

Introduction: redirecting the arrows of climatic design



1 Russel Ball, What happens to solar radiation intercepted by the earth's atmosphere, from Edward Mazria, *The passive solar energy book,* 1979, p. 13.

Climate change has reinvigorated architecture's purpose in the realm of sustainable design. However, its drawings have not adapted to contemporary demands. Open any book about climatic design from the 1950s to today, and the chances are the drawings will have changed very little. The same graphic techniques prevail throughout architectural practice and are transferred into the curriculum of architecture schools. The same obsessions about sunlight, wind and air also persist in the standardised architectural sections that depict sunshine as a smiling yellow circle. Amid an ongoing planetary crisis, architects seem to be stuck.

As visual thinking about climate has become reductive, architects have limited their repertoire of environmental drawings. The drawings that are used, such as site plans, summer and winter environmental sections and heat flow diagrams, have become so banal that few consider their potential beyond explaining comfort and energy. Mostly they remind us that the sun exists and that on a good day wind flows through the building. Even when lacking in content, environmental drawings, particularly those showing climate, give a design some moral authority—they suggest the architect is sensitive to the natural world, even if the design does little to ameliorate conditions.[1] Such drawings touch on how architects position their work, how they leverage the moral weight of environmentalism, but they can give a false assurance that climatic issues are important.[2]

Some of the stagnation in how architects draw climate comes from the uncritical acceptance of the initial premises of mid-century climatic design. Many of the key texts from this period, such as Victor Olgyay's

Design with climate (1963), Baruch Givoni's *Man, climate and architecture* (1969) and Koenigsberger, Ingersoll, Mayhew and Szokolay's *Manual of tropical housing and building* (1974) still hold sway.[3] Today's books on climatic design continue to adapt and re-use their drawings and frameworks.[4] While still useful, the frameworks have many blindspots. For example, Olgyay noted that his book *Design with climate* was based on the provision of thermal comfort, and therefore the effects of moisture received far less consideration.[5] It is little surprise then that while today's architects still emphasise thermal comfort, few environmental architecture books include any mention of rain, snow, frost or fog.

Climate is not just averaged weather conditions but also includes weather events and predictable phenomena. The German meteorologist Rudolf Geiger pointed out that 'the climate of a given site is comprised of the average conditions, the regular sequence of weather events, and the repeatedly observed special phenomena such as tornadoes, dust storms and late frosts.'[6] We might add wildfires into that definition.

So how can we reconsider the way architects draw climate? One option is to be more inclusive, to give greater weight to moisture and weather events. This is the approach that this book takes. It is based on our conviction that we need a broader understanding of climate to address current environmental challenges. While we still see benefits in representing sun, wind and air, we believe that portraying more facets of climate, such as fire, dust or monsoons, creates richer drawings and allows for more thoughtful architecture. Another is to better consider the social effects of climate, as the justifications we offer for moderating climates have political and cultural histories and consequences.[7]

Thirdly, we wish to expand the geographical range of examples. This book brings drawings by Australian and Asian architects into discussion with those from Europe and the USA. It is not that architects have failed to show fire or ice or monsoons in their drawings. It is more that such considerations often happen at the margins. We believe that the long experience of architects in Australia with fire and of those in Southeast Asia with monsoon can highlight productive ways of engaging with climate. We hope furthermore that the range of images and critical analysis will provoke current and future practitioners to reframe how they think and draw climate.

Drawing climate into architecture

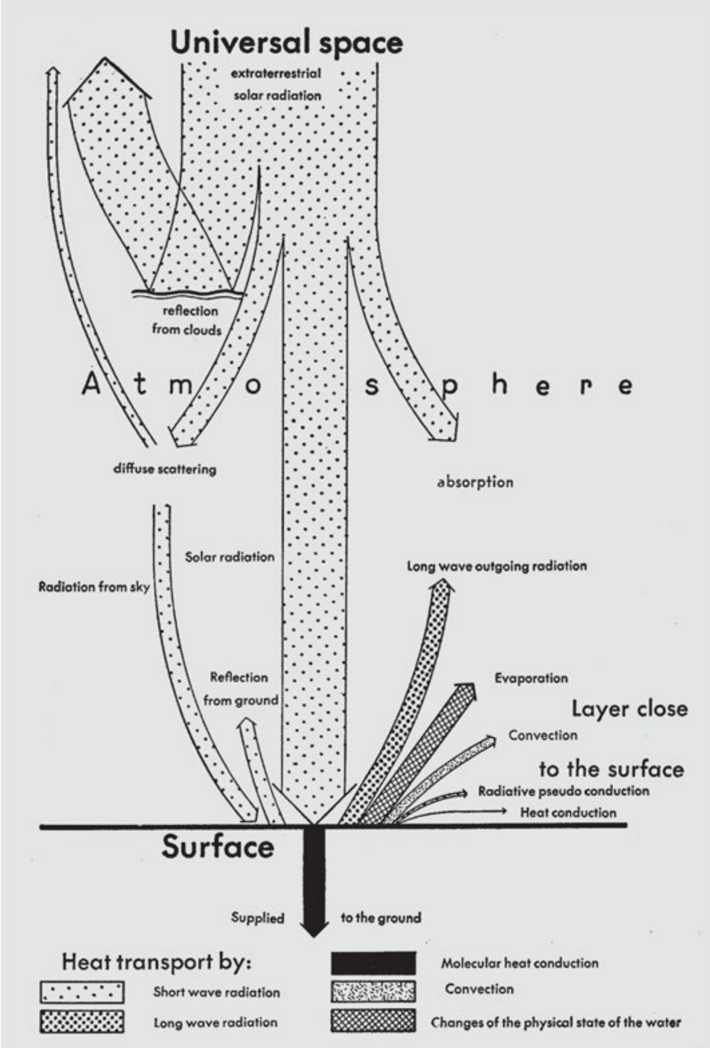
Drawings have many lives, as the following examples show. But like people, they can have a midlife crisis. Looking at drawings depicting heat exchange may serve to explore how this crisis came about.

Scientific phenomena are not always easily understood by a lay audience. It takes skill to break down complex concepts for novice students. Although mathematical equations elegantly explain the relationships of various phenomena, they rarely appeal to uninitiated members of the public. Visual aids can be more effective. We might expect architects trained in science or visual communication to do this well, but this is not always the case. When German meteorologist and climatologist Rudolf Geiger published his ground-breaking textbook on microclimatology, *The climate near the ground* (1927), he filled it with graphs and diagrams explaining key concepts to those entering the field. First published in English in 1950, it introduced generations of students to the environmental sciences. Geiger's text clearly spelt out the concepts and terms needed to understand the field, but it is the afterlife of a small drawing in the book, and its translation into architecture, that is of interest here.

Geiger wanted to explain the earth's radiation energy balance to an American audience; as a result, he created a Sankey diagram filling an entire page (Figure 2). Energy balance is defined as the amount of energy coming from the sun, directly and via the atmosphere, reaching towards the ground and bouncing back again. It assumes that during the day the ground will be warmed by the sun and at night some of that energy is released back to the sky. These drawings were illustrated with directional arrows of various thicknesses, moving to and from the ground. Each arrow represented a different type of heat transport—for example, short-wave radiation, long-wave radiation, eddy diffusion, conduction and evaporation.

For Geiger, the drawings explained the relative importance of radiation compared to other forms of heat exchange.[8] The thickest arrow symbolised the combined effects of short-wave radiation from the sun and the atmosphere. Two more arrows indicated atmospheric long-wave radiation and ground radiation. The other arrows expressed the remaining forms of heat exchange but were much thinner in width, demonstrating that conduction and convection held less impact on the heat balance.

Since its introduction in the late nineteenth century, engineers have used Sankey diagrams to explain material and resource flows.[9] In these diagrams all flows are proportionately scaled and drawn as a stream connecting one process with another. The stream branches out further as it loses energy. The viewer can understand how energy flows by following the arrows at the end of each branch. Geiger carefully grouped different forms of heat transportation together. He introduced hatching for each kind of heat transfer, alternating between curved and straight lines to indicate how energy branched off the main flow. This made it easy to understand how radiant energy was transformed.



Geiger's energy balance drawing experienced multiple lives and was reproduced in 1963 by Victor Olgyay in *Design with climate*, the book that introduced architects and students to the practices of bio-climatic design.[10] In this book, Olgyay developed his own representations of climate, emphasising how people, buildings and climate could be in balance. He also redrew and reprinted other geographers', architects' and physiologists' drawings, giving the impression of a unified visual style. In most cases he improved on the original diagram(s), foregrounding how to understand climate and buildings in terms of people's needs, in a kind of climatic humanism for architects.[11]

Design with climate was both a project of visual curation and a showcase of design methods. It was Olgyay who, in fact, introduced

Geiger's concepts to architects. Few would realise that the diagram on solar radiation flows belonged first to Geiger, not Olgyay — such was the consistency of this image with the rest of Olgyay's drawings.

The diagram (Figure 2) seemed customised for an architectural audience, narrating the story of how radiation travelled from 'Universal space' to 'surface' through an intermediary, the 'atmosphere.' The prominence of these three terms seemed to position the discussion of heat exchange as one concerned with modernist ideals about world-making. After all, 'Universal space' was a term more familiar to adherents of the Bauhaus and de Stijl than those working in climatology.[12] It was this term that Mies van der Rohe used for his indeterminate and flexible long-span spaces. And yet here it was in the middle of an energy balance diagram. It seemed like meteorology was just another branch of modernism.

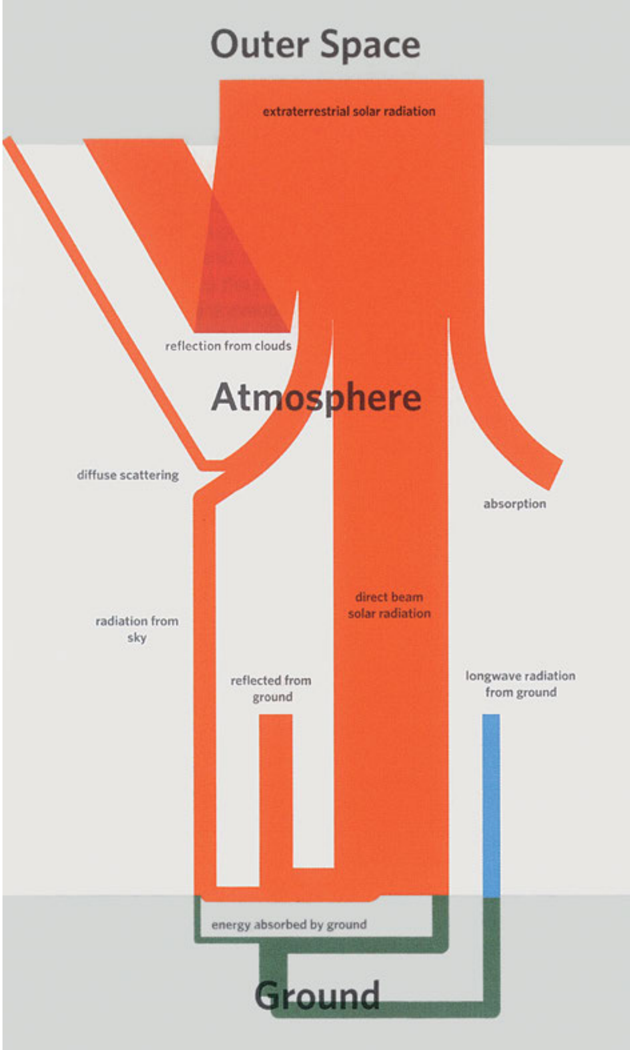
The drawing reappeared in architecture books throughout the 1970s and 1980s, as the sun gained importance as a solution to the energy crisis. However, Geiger's diagram was simplified as climatic design advocates feared that people were turned off by anything too technical. As Ed Mazria noted about passive solar design at the end of the 1970s, presentations up to then were 'too technical, cumbersome and time-consuming in application.' Instead he argued that 'to be useful, information must lead to the necessary degree of accuracy at each stage of a building's design.'[13]

Mazria's *Passive solar energy book* from 1979 tried to change this. Addressing architects, builders and owner-builders, the book was filled with graphs, tables and perspectives by Russel Ball, who used visual analogies and humour to explain the science behind the information. The solar energy balance diagram in the book shows a tarot sun's floating above a city (Figure 1). Tentacles of radiant energy twist from its smiling face. The point that there are different kinds of solar radiation is clearly made, but the diagram has lost its association with the ground. In making the ideas accessible, the diagram tries to balance between presenting facts and engaging an audience through appealing to their experiential knowledge. These quasi-technical images, as Daniel Barber notes, did this to suggest a 'universal validity, and to produce a new image of the world to influence new kinds of expertise.'[14] While not quite scientifically accurate, at least, such drawings added a touch of humour.

2 Rudolf Geiger, Heat exchange at noon for a summer day, from *The climate near the ground*, 1950, p. 3.

Retro-climate

Where Olgyay curated Geiger's ideas for architects, expanding their relevance, recent revisions by architects miss the opportunity to question how the current climate crisis requires a broader and more



considered range of drawings. Instead, as noted earlier, today's drawings pay homage to some golden era of mid-century modernism. In the twenty-first century, environmental drawings lack the humour of their counterparts from the 1970s, as they fight fears of future catastrophe. Faced with a climate crisis of such proportions, architects have returned to more tried and trusted methods. In a recent book, *Architectural Science and the Sun*, Geiger's drawing of heat exchange reappears (Figure 3). However, Geiger is not credited, and the drawing is no longer at noon but, instead, titled 'solar radiation flows.' 'Universal space' has become 'outer space' and 'surface' has become 'ground.' Otherwise, the labelling remains the same, but the drawing has been stripped of any other kinds of heat exchange, which are vital components of Geiger's

3 Greg Arcangeli, Solar radiation flows, from Matt Fajkus and Dason Whitsett, *Architectural science and the sun: the poetics and pragmatics of solar design*, 2018, p. 79.

interpretation. Gone, too, are the directional arrows, leaving the reader a little unclear where the flows start and end. So, what at first sight seems a careful replica has lost both the detail and clarity of Geiger's original synthesis.

This retroactive approach to climatic drawings seems to pine for both an age of technical certainty and novelty. It suggests that, by recovering mid-century methods of climatic design and updating drawing styles, today's architecture students will be able to find a way out of our current predicament. This is only partly plausible, as the challenge of climate change goes beyond comfort and low-energy design.

Structure of the book

This book has been conceived from a sense that architecture needs to take a more expansive interest in climate. The book plays with the history of defining places climatically. Rather than classifying the world into temperate, tropical or extreme, we split the book into four sections—*Dry, Wet, Cool* and *Hot*. Doing so creates new adjacencies between climatic events and climatic elements and how they inform architecture. The selection of images is not meant to be comprehensive or definitive. Instead, it is hoped that each chapter will draw attention to the breadth of imagery available for each theme and some of the representational issues that each phenomenon raises.

In many cases, authors explore climatic representation at multiple scales. The first section, *Dry*, includes chapters on dust and wind. Moving through scales allows us to see climate from below, as Jennifer Ferng shows in her study of dust, linking the microscopic to the global. For every scale at which we examine a phenomenon, there is often a corresponding drawing in circulation. Designers are expected to understand a phenomenon at multiple scales, from global to local, but often intervene at a much more local level. In some cases, as Christhina Candido suggests, the advent of newer and more accurate forms of visualisations has not always improved outcomes. Instead, she argues for greater awareness of how best to intervene.

Many of the chapters deal with the difficulty of representing climatic phenomena and the questions these raise. This is particularly true of wet climates. Lilian Chee considers how our own body can be a register of the weather and how phenomena like monsoons are experienced relationally, as lived experiences. For Nathan Etherington, drawing water is a challenge as it is unpredictable. He shows how attitudes to rainfall's unpredictability have shifted over the past century. Etherington traces how architects once emphasised hydraulics in drawings but today emphasise atmospheric effects. On the other hand, Erik L'Heureux questions how the cloudless, blue sky has come to dominate architectural imagery, even in the tropics. He argues for architects to shed their 'cumulus prejudices.' He shows how, by embracing the dynamics of local cloud formations, architects can more carefully frame a building's setting.

Other chapters address questions related to climate change and risk, particularly in the third and fourth sections on *Cool* and *Hot*. Johanna Sluiter considers how the occupation of the Arctic has fascinated a number of modernist architects and how climate change has opened up the possibility of occupying the vast icefields of the Arctic. In other cases, climate can be read in terms of gendered anxieties surrounding race and temperature, as Nicole Sully and Deborah van der Plaat show in the case of the Queensland bush house. The uncertainty surrounding the future and how this informs representational strategies is the theme of Daniel Ryan's chapter 'Revealing fire.' Ryan connects some of the aesthetic themes about climate change with a longer history of the sublime, drawing parallels between early-nineteenth-century paintings of the apocalypse and recent designs for bushfire-sensitive buildings.

The Coda of the book showcases a range of experimental projects that look at how climatic design can be implemented and visualised in practice. Featuring work by students from Sydney and Singapore, 'Explorations' shows how some of the climatic phenomena explored throughout the book can inform architectural design and representation.

Seeing unseen futures

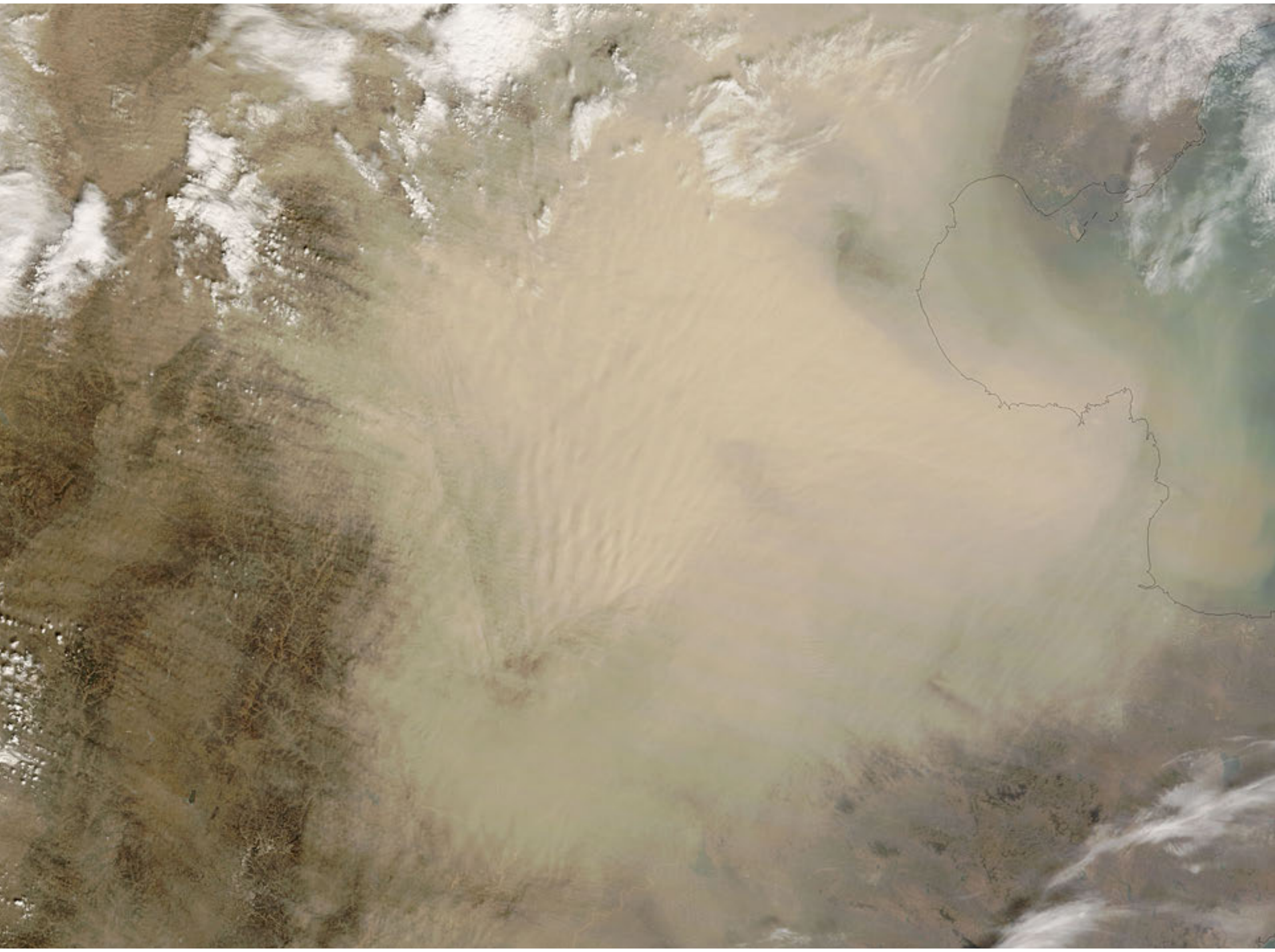
Architectural drawings allow us to see the unseen, to filter and aggregate past experiences into a projected future. They order space and materials and give weight to an architectural idea. Indeed, they also give weight to a particular aspect of climate, to certain kinds of weather. Air is ordered to flow through openings. Shade is given a predictable pattern. Water is channelled out of spouts. If climate is mediatised weather, then architecture mediates the weather and its events. It can make the weather seem hotter or cooler, drier, more humid. It can also make climate seem predictable, as if the building were tuned to every possible weather occurrence. Architecture gives the impression of taming climate, making even the most inhospitable places seem tolerable.

This is a representational challenge as much as a design challenge. If architects seem stuck, in that the same drawings are being repeated *ad infinitum,* then perhaps architects need to rethink what aspects of climate they are drawing and designing for. It is time to redirect climatic design's arrows. We hope this book starts the process.

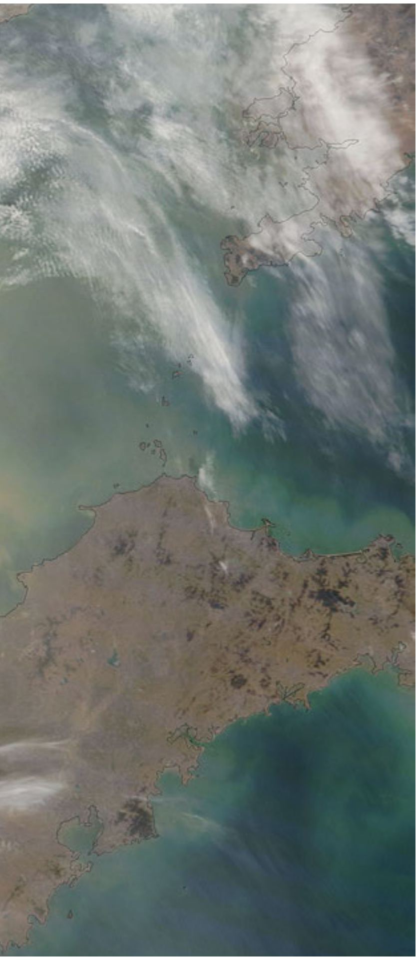
1 I treat technical drawings as analogous to advertising. See Michael B. Beverland, Adam Lindgreen and Michiel W. Vink, 'Projecting authenticity through advertising: consumer judgments of advertisers' claims,' *Journal of Advertising*, 37:1 (2008): 5–15, https://doi.org/10.2753/JOA0091-3367370101.
2 For a broader discussion of environmentalism, capitalism and marketing, see Peter Dauvergne, *Environmentalism of the rich* (Cambridge: MIT Press, 2016), 139–152.
3 Victor Olgyay, *Design with climate: bioclimatic approach to architectural regionalism* (Princeton: Princeton University Press, 1963); Baruch Givoni, *Man, climate and architecture* (Amsterdam: Elsevier, 1969); O. H. Koenigsberger, T. G. Ingersoll, Alan Mayhew and S. V. Szokolay, *Manual of tropical housing and building* (London: Longman, 1974).
4 Vivienne Brophy and J. Owen Lewis, *A green Vitruvius: principles and practice of sustainable architectural design* (London: Routledge, 2nd ed. 2011), and Richard Hyde, *Climate responsive design: a study of buildings in moderate and hot humid climates* (London: Taylor & Francis, 2000).
5 Victor Olgyay, *Design with climate*, 32.
6 Rudolf Geiger, Robert H. Aron and Paul Todhunter, *The climate near the ground* (Braunschweig: Vieweg, 5th ed. 1995), 3.
7 On climatic design's downplaying of the social role of architecture, see Jiat-Hwee Chang, *A genealogy of tropical architecture: colonial networks, nature and technoscience* (Abingdon, Oxon: Routledge, 2016).
8 Rudolf Geiger, *The climate near the ground,* 13.
9 For a history of Sankey diagrams see Mario Schmidt, 'The Sankey diagram in energy and material flow management: part 1 history,' *Journal of Industrial Ecology,* 12:1 (2008): 82–94, https://doi.org/10.1111/j.1530-9290.2008.00004.x.
10 Victor Olgyay, *Design with climate,* 33.
11 See Daniel A. Barber, 'The nature of the image: Olgyay And Olgyay's architectural-climatic diagrams in the 1950s,' *Public Culture,* 29:1 (1 January 2017): 129–164, https://doi.org/10.1215/08992363-3644433.
12 Universal space, or *Allraum* in German architectural theory, was an idea promoted by modernists such as Walter Gropius and, later, Mies van der Rohe. For Gropius it suggested the exterior into which modern architecture dissolved, while for Mies it was a lightly structured interior space or flexible open plan. For a detailed discussion of Gropius' concept of *Allraum,* see Tim Steffen Altenhof, 'Breathing space: the architecture of pneumatic beings,' PhD diss. (Yale University, 2018), 177–181. Available from ProQuest One Academic (2070918889).
13 Edward Mazria, *The passive solar energy book* (Emmaus: Rodale Press, 1979), 2.
14 Daniel A. Barber, 'The nature of the image,' 131.

DRY

Particles to dust storms: seeing climates from below



1 Aerial photography of dust storms over East Asia and pre-monsoon storms moving over India, 2008.



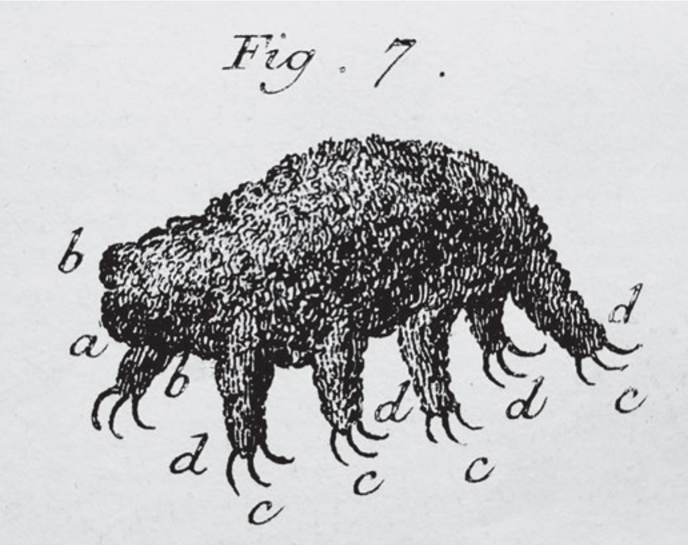
Not surprisingly, dust is defined by its passive nature. Dust particles can be caught in gusts of wind, and lacking any type of agency, they take flight where the air leads them.[1] Dust particles have remained invisible to the human eye, and as a result, over the centuries, their evolving incarnations—film, grime, grit, haze, patina, pollen and pollution—have never been considered a part of climatic design. They belonged instead to the scientific discourse on meteorological phenomena. Architects, in executing climatic design, have openly acknowledged that sunlight, rain and fire are critical elements that architecture must address. However, what about the role of dust? Swirls of dust blowing off desert dunes and sandy clouds billowing from a single road in an abandoned town evoke romantic images of dust as being atmospheric in nature. But buildings, in fact, are designed to keep out dust; dust moving from outdoors to indoors signals an everyday, if not, banal occurrence. Dust represents a part of the natural environment that is more of a hindrance than contemporary architects would like to admit. The accumulation of dust becomes a nuisance for those who must regularly clean built surfaces, wiping the film of dirt from exterior façades. Dust becomes bothersome in its ability to aggregate in every corner.

Dust is also classified as a type of irritant, causing human beings to sneeze, cough and gasp when the air is filled with too many particles.[2] Architectural historian Robin Evans referred to the role of architecture as that of a container excluding foreign matter. For Evans, the 'logic of containment' between private and public spaces was embodied within discrete systems of doors, windows and corridors.[3] Foreign matter, however, tends to spread everywhere—dust always finds a way to seep into a building. It emerges from windowsills, air ducts and laundry vents, blown inside from balconies.

Architectural historians John Ruskin and Jorge Otero-Pailos have explored how dust remains a source of historical fascination for antiquarians, architects and artists.[4] Surface pollution, or what Ruskin called 'the golden stain of time,' remains a challenging problem for experts in heritage conservation.[5] Following developments from the eighteenth century into the present day, this chapter analyses a brief series of visual images from the microscopic level to the scale of a building—from plates of micro-animals and living organisms to nationwide dust storms. Specifically, I argue that dust in itself embodies a type of 'climate from below'—a term I use to explain how meteorological elements engage with the built environment at the microscopic scale and simultaneously, at the broader scales of geographic regions and nations. Dust as a climate from below consists of invisible particles that aggregate into larger masses, impacting how buildings must cope with external forces. The intrusive character of dust remains unstoppable. Dust particles and dust storms are constituted from the same matter; nonetheless, when transformed at an urban scale, their behaviour reflects the way in which architects should address dust. Moving from the microscopic tardigrade to the red dawn that plagued Sydney in 2009, this chapter contends that dust, like many of its elemental counterparts, plays a significant role in twenty-first century climate change. Connected to greater ecological patterns like desertification, industrial pollution and soil erosion, it epitomises one of many meteorological elements that will impact how cities will adopt sustainable measures over the next few decades.

Kleine Wasserbären

Before contemporary concerns around climates were articulated, the eighteenth century remained a rich source of scientific information about the animate nature of dust. Micro-animals, in fact, constituted some of these discoveries made by Protestant pastor Johann August Ephraim Goeze, who stumbled upon a specimen that looked like a little 'water bear' (*Wasserbär*) in 1773 (Figure 2). When examined under a microscope, the water bear resembled an inflated, segmented body with four pairs of legs ending in matching claws (or sucking disks). Water bears lacked a face or any eyes, but only possessed a single mouth-like protuberance. Goeze was thus credited with the first sighting of the tardigrade or water bear, one of many micro-animals who lived in the mountains, deep oceans, volcanoes, tropical rain forests and even



2 Johann August Ephraim Goeze, Tardigrade, from *Über den kleinen Wasserbär, Herrn Karl Bonnets Abhandlungen aus der Insektologie*, 1773.

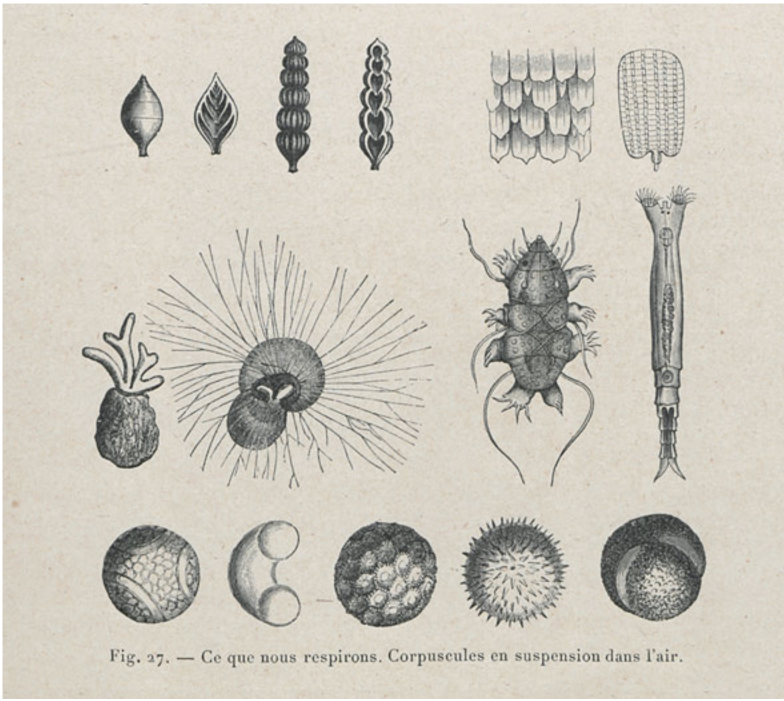
Antarctica. Today, they have been tested as some of the most resilient animals on the planet. Tardigrades are catalogued as a 'pioneer species,' which are able to introduce other species into new environments.[6] Observed by Goeze as well as modern-day scientists, tardigrades are particularly sluggish walkers; their gait is akin to that of a slow-moving bear. Tardigrades have survived long periods of time in extreme climates including outer space; they have been exposed to radiation, dehydration, starvation, air deprivation and extreme pressures and temperatures. Tardigrades are able to subsist on a diet of moss and algae and often prey upon other, smaller species of tardigrade.[7] Yet, despite the extreme characteristics of these environmental conditions, tardigrades have managed to thrive as a species.

Tardigrades were among some of the first discoveries where scientific pioneers were able to detect the presence of microorganisms within air (and consequently, dust). This animate nature of dust runs contrary to its public image of something that is devoid of substances. Practices of modern architecture, in fact, have forgotten about these complexities of the external environment, and dust, like air, has been defined only as a passive occurence within climatic design.

Given this precedent, biological and environmental references from the microscopic world have influenced built design in strange and wonderful ways. Eugene Tssui's Ojo del Sol or Sun's Eye in Berkeley, California, for example, combines the formal aspects of the tardigrade's anatomy and incorporates them into the structure of a family residence. Tssui conducted some zoological research on the tardigrade, discovering

its reputation as the most indestructible creature on the planet. The house was constructed for Tssui's parents, who were worried about the possibility of earthquakes. The architecture of the house revolved around the biology of the tardigrade—Tssui as 'polymath nonpareil' tried to make the house impermeable to fires, earthquakes, flooding and pests (Figure 3). The ovular shell of the house possesses no hard edges or angles, modelled after the tardigrade's ability to diffuse external stress through its body. The gently sloping walls are angled at 4°–5° to create a low centre of gravity in case of an earthquake (while minimising wind and water resistance).[8] Tssui had formerly worked with architects Victor Prus in Montreal, Bruce Goff in Tyler, Texas, and Frei Otto in Germany. The central feature of the house revolves around 4.5 metre oculus window generated from Tssui's 'ethic-biologic' design, finished with stucco mixed with crumbled abalone shell.[9] The Ojo del Sol has never been tested in an earthquake emergency, but Tssui assures sceptics that the house performs in terms of energy conservation, maintaining 18–21°C within its interiors all year round. Tssui has constructed 16 projects in the San Francisco area, with seven residential buildings underway in the USA, another in Portugal. In this extraordinary example, the tardigrade personifies both a formal template for architecture and a structural diagram for the construction of the house.

3 Tssui Design and Research, Ojo del Sol, 1994–1995, Berkeley, California.

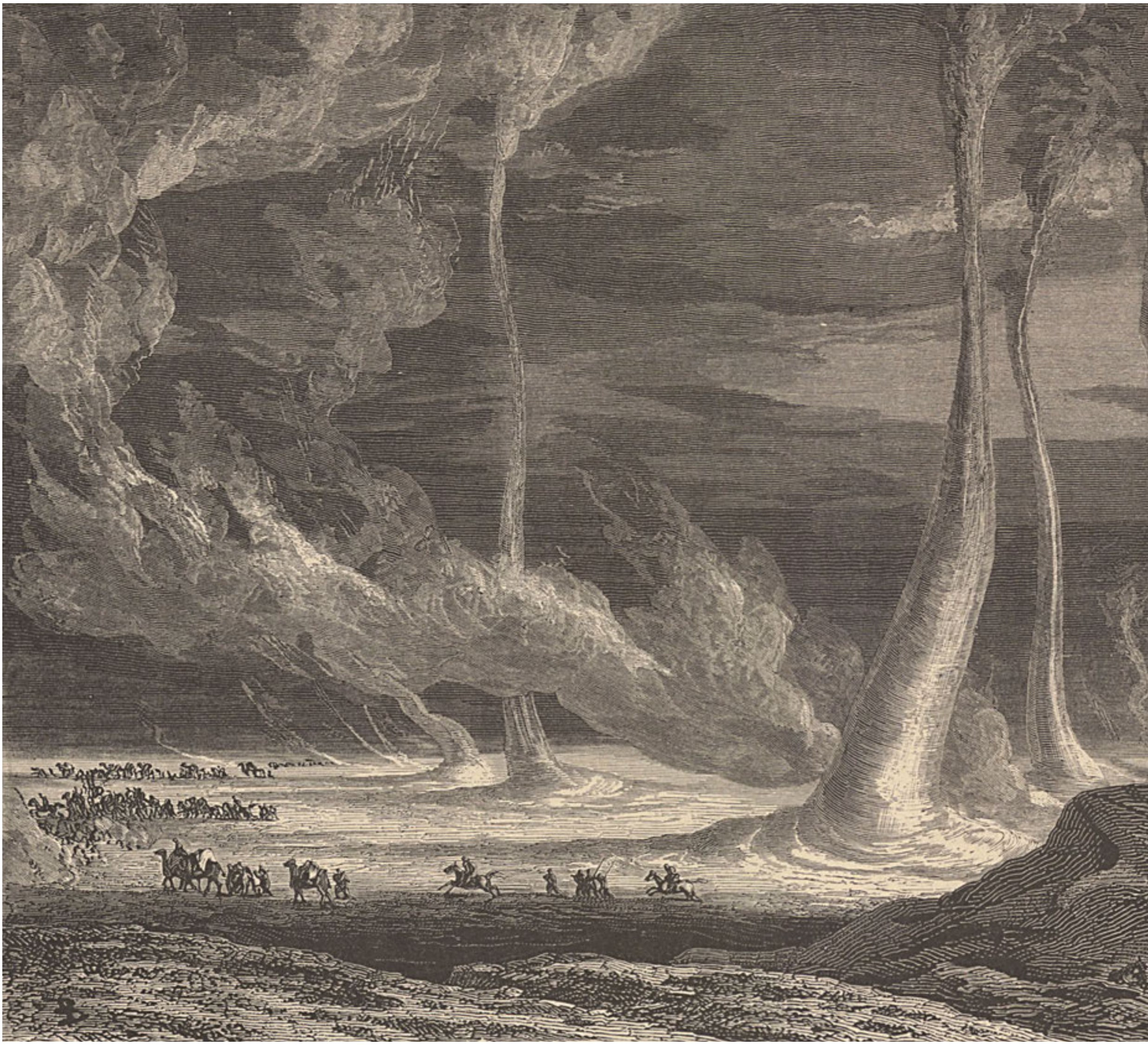


4 Camille Flammarion, What we breathe: airborne corpuscules, 1873, from *L'Atmosphère: Météorologie populaire*.

Des microzoaires vivants

Almost one hundred years later, nineteenth-century French astronomer Camille Flammarion wrote a number of popular books on the nature of science, including science fiction and research on the potential of psychic powers. Flammarion was obsessed with the biological philosophies of Charles Darwin and Jean-Baptiste Lamarck as well as the growing spiritualism associated with mystics and storytellers. In his book *L'Atmosphère: description des grands phénomènes de la nature* (1873),[10] Flammarion trained his gaze upon the invisible dust mite (Figure 4). Substances contained within air represented a relatively new discovery at the turn of the nineteenth century—even the idea of oxygenated air, or what we know now as the ozone and ammonium nitrate, heralded new knowledge related to oxygen's role in combustion. Flammarion described mundane appearances such as a single cloud of dust floating away from a building site:

> When we pass close by a house that is being pulled down, or one in the course of construction, and find ourselves enveloped in a cloud of dust that penetrates down our throats, we, often, beyond a doubt, inhale hundreds of these tiny atoms.[11]



5 Anonymous, Trombes de sable dans la Steppe, from Marie de Ujfalvy-Bourdon, *De Paris* à *Samarkand [...], impressions de voyage d'une parisienne,* 1863.