



MONSOON ASSEMBLAGES FORUM

Drinking the Winds: Monsoon as Atmospheric Spring

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This paper explores monsoons as a set of atmospheric-orographic dynamics productive of water resources and as a site of actionable concern for landscape practice. From study to representation to design, the term “landscape practice” is used to describe a way of positioning environments as both subject and object of concern. While monsoons are constituents of many geographies, dynamics, materials and experiences, this paper focuses on the South Asian monsoon and its relationship with the Tibetan Plateau. In this region, freshwater resources are dependent on the monsoon; however, as rising global temperatures and rapid urban development significantly impact the behavior of the monsoon and the Plateau’s ability to store freshwater, the monsoon—as a kinetic body of freshwater—becomes the focal point of visual media productions and extractive technologies that require a shifting of perspective from one that privileges land to one that centers the atmosphere. The inclusion of meteorological and atmospheric material and dynamics within the space of landscape practice, constructively challenges the spatial discipline’s engagement with exploitable resources; and the monsoon provides a tangible site and set of conditions that is in urgent need of this exploration. **Key Words:** environmental design, landscape, landscape architecture, Monsoon, Tibetan Plateau.

Few, if any, historical Western accounts of crossing the Tibetan Plateau and the Himalayan ranges that bound its southwestern border do not mention the clouds, rains, snow and ice that animate the otherwise sparsely populated landscape. Riddled with delays and forced returns, expeditions into the unpredictable weather-worlds of the world’s highest-altitudes are depicted both verbally and graphically. Each form of depiction prioritizes a different set of primary characters in the narration and assessment of values and risks held within the terrain. In the literature, one can hardly decipher which element—rock face or cloud—poses the higher degree of risk; while illustration after illustration, negates the *figure* of weather altogether, opting to draw the landscape’s significance out of its geologic sense of time and material form. Accounts like those of Edward Frederick Knight (1893) give weight to the embodied experience of being gripped by thinning air and extreme cold, bedeviled by the whims of blinding

sand storms, menacing cloud formations, and track-stopping sleet as intrinsic to understanding the significance of the landscape; while also making a point to note that even the most verdant moments within this landscape “would be looked upon as little better than a howling wilderness,” without the help of a “good map” that draws-out the extraordinary cover of glaciers and snowfields that signify the meeting of three empires: India, China, and Pakistan (234, 230). Through surveyed and drawn reconstructions of the meteorological materiality of this territory, Western explorers like Sven Hedin drew the glaciers and snowfields of the region into the heart of landscape practice—constructing future pathways for the reconsideration and reconstruction of the material territory’s socio-spatial distribution. Anthropologist Barbara Bender (2002) claims that people create landscapes—again and again, as understandings and engagements shift overtime; and when these embodied perspectives are used to frame, or position, material territories as sites of concentrated attention, both the physical geography and its visual representation become a site of design or landscape practice. In “The Landscapists,” Ed Wall (2020) curates a conversation between contemporary landscape practitioners and exposes the varied set of practices that constitute the discipline of landscape architecture and their shared reliance on drawing or visual-making, as a form of claiming and projecting landscape futures (7). In the context of climate destabilization, practices of landscape visualization increasingly field urgent calls to reposition material resources within geopolitical and socioeconomic structures of decision-making. Due to the delicacy and strength of the Tibetan Plateau’s agency in global climate systems, particularly as a driving component of the South Asian monsoon, historical and contemporary representations of this landscape portend significant shifts in geopolitical and geo-design momentums that deserve attention.

Barbara Bender’s reminder that landscapes and their visualizations are not records of conditions but are “recordings” of the ongoing creative process of *constructing* landscapes or material-social relations, lays an important foundation for the examination of Tibetan Plateau recordings (2002, S103). This paper does not intend to present a full account of all authors and illustrations of the Plateau, nor of all authors and forms visual representation conducted by landscape practitioners; however, it will focus on the illustrative introduction of the Plateau into Western recordings by Alexander von Humboldt and Sven Hedin while attempting to position these stepstones of knowledge within the evolving field of landscape practice and its growing responsibility to address climatological-environmental conflicts. Humboldt and Hedin’s illustrations provide a scaffold and baseline from which situated, historical accounts and contemporary experiences of Leh, the capital city of Ladakh, can draw together—through the monsoon—a region’s impending water scarcity challenges with a hyper-local, two-week shift in weather patterns. A physical, cultural, social, political, and economic resource, water is perhaps the most obvious element of landscape that humans and non-humans embody; less obvious, perhaps, is the monsoonal atmosphere as a material source landscape. If, as Silvia Benedito claims in *Atmospheric Anatomies* (2021), the “interdependency of atmospheric processes and their meteorological element[s]” can be recognized as “spatial media,” sensed and embodied, then the material weight of the atmosphere—in effect and affect—should be included in any assessment of “material culture” as a “tool to transform” landscape practice (17–18; Hutton 2018, 21; Salzman 2017, 47). As productions of visual medium evolve to answer Wall’s (2020) call “to make explicit the many ways” that landscapes may be constituted in bodies and practices, Donna Haraway’s (2019) assessment of Ursula K. Le Guin’s storytelling methods offers guidance: “it matters what stories we tell to tell

other stories with” and “what concepts we think to think other concepts,” just as it matters what images we use to imagine new images.

LANDSCAPE AND VISUAL MEDIA

The roots of contemporary landscape practice can be traced back to the early nineteenth-century and the multimedia, multi-observational depictions of landscapes by Alexander von Humboldt. By merging scientific observation techniques and data with the “affectively and aesthetically” meaningful impressions and experiences of landscape, Humboldt developed a self-proclaimed “modern” practice (von Humboldt cited in Lubrich 2018, 78). As both scientific and cultural constructions, the landscapes drawn by Humboldt positioned the geological, atmospheric, and geophysical dynamics of Earth through the lens of human relation—creating human-centered compositions of material and emotional attachment to environment. In this way, one of the most commonly practiced modes of landscape study and communication has always been a call “to reflect upon ourselves” as designers of and within a changing world (Girot 2021, 11). Considered either “art geography” or “landscape science,” Humboldtian methods of seeing, thinking, and depicting landscapes as cultural, political, and economic constructions transitioned quickly into a method of identifying material resources (Aira 2006, 10–11; Cosgrove 2004, 61). Today, these methods remain a cornerstone of the spatial design discipline of landscape architecture, and have played a significant role in defining the practice of landscape that foregrounds the location, extraction, and protection of resources.

Much attention has been paid to the types of data and methods of layering used by Humboldt in his landscape illustrations; however, positioning Humboldt’s techniques within the thought-collaborations of his time may shine additional light on this well-trodden terrain. One of the most poignant examples of Humboldt’s method can be seen in the “Outlines of Botanical Geography” and “The Geographical Distribution of Plants” in Alexander Keith Johnston’s *Physical Atlas* published in 1849. In these illustrations [Figure 1], Johnston abstracts five of the world’s most significant mountain chains from their geographic context. Each mountain peak is located within a shared space of enumerations, listing the various forces or determinate features of landscapes in general, such as: extents of particular flora and fauna, temporal dimensions of seasonal weather, glacial zones, altitudinal relationships between mountain peaks, and human activities relative to habitation and agricultural production. Looking at the page, one might consider the mountain peaks the primary subjects of Humboldt’s concern, but from his own writings—and that of his contemporaries—it may be understood that these figures were only a scaffold for the actual field of study (Debarbieux 2012). Mountains structured and held the plant-, animal-, and water-bodies that enlivened the atmospheres—meteorological, material, and affective—of the landscapes he illustrated.

From the equatorial reach of the South American Andes to the arctic reach of Finland’s northernmost mountain range, Humboldt used these mountain peaks and the river basins to which they give form to determine the general topography of the implicated continents; thus, generating an early understanding of the relationship between the continents and planetary-scale wind patterns (Von Humboldt 1843, XIX-XX). Bearers and form-givers of resources, Humboldt considered mountains as only one of many signifiers of Earth’s dynamism; and,

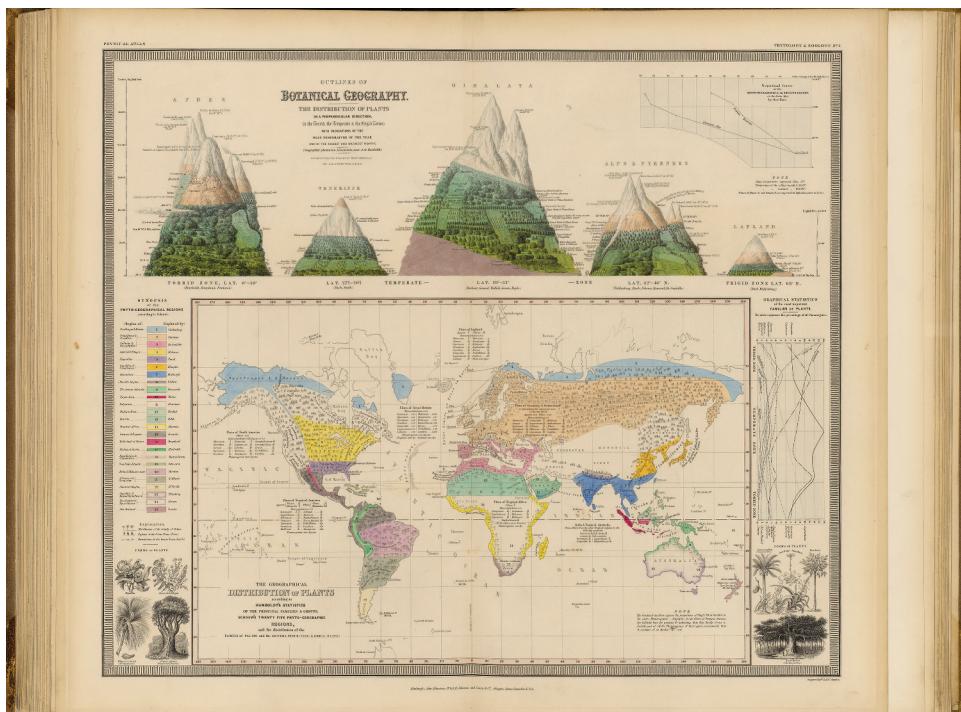


FIGURE 1 “Outlines of botanical geography” and “the geographical distribution of plants” engraved map and illustrations within one border with added color from Johnston’s *The Physical Atlas* (1849). Johnston incorporated and expanded data from both Humboldt and Berghaus for this plate which is based on the *Physicalischer Atlas* of Professor H. Berghaus (Johnston 1848). Reproduced with the permission of the National Library of Scotland.

placed less value on their infamous crest lines and peaks than on their relation to one another, to their interactions with air currents at various heights, and to the stories of Earth’s shifting of space and time as told by the thrust and formation of rock and plain (*ibid.*, 53, XXXII-XXXIII). As demarcations of global climate zones, these mountains allowed Humboldt to position significant elements of the geophysical landscape within the milieu of meteorological activity. This investigation and depiction of landscape helped develop a mode of meteorological or atmospheric, cartography—the isothermal map—that remains the foundation of weather and climate representation (Edwards 2010, 31). It might be said that the significance of the Humboldtian mountain lies in its narration—and activation—of the space above and below the earth’s surface.

Of his many intellectual contemporaries, including Johann Wolfgang von Goethe, Georges Cuvier, Charles Darwin, and Franz Bopp, Humboldt’s work exemplifies the “transition from taxonomies to dynamic historicization” that the nineteenth-century saw taking shape across the fields of philosophy, science, and linguistics—together, drawing a new image of the Earth and

an emergent understanding of climatic interconnectedness (Lubrich 2018, 89). Citing Humboldt, Michel Foucault describes this key moment in the fundamental rearrangement of the structure, meaning, and work of knowledge production as a shift in perspective: "... language [knowledge] is neither an instrument nor a product—an *ergon*, as Humboldt termed it—but a ceaseless activity—an *energia*" (Foucault 2002, 316). As neither scaffolding nor product of the climate-conducting winds, for Humboldt, mountains were nestled into "the midst of the agitations of the atmospheric ocean" and, as such, were drawn as carrier bags of knowledge and as meters of the winds—active and ever-evolving speculations on land's atmospheric relations (Von Humboldt 1854, 6). Along with the work of contemporaries like Heinrich Wilhelm Brandes and Heinrich Wilhelm Dove, Humboldt's landscape studies helped birth the science of meteorology and climatology (Edwards 2010, 30–31). Belonging to a lexicon of cartographic explorations of climatological systems that were constructed on the back of Sir Edmund Halley's 1686 map of the Tradewinds, or "the first Western visualisation of monsoon winds," the study of both landscape and atmospheres was woven into and from monsoon representation (Cullen and Geros 2020, 4). In Figure 1, the mountain peaks along the top of the page operate as registrations of empirical data for the speculative map, and chart of climatic zones that occupies the lower half of the page. When those same mountainous registrations are contextualized within contemporary monsoonal cartographies, as in Figure 2, their significance as atmospheric actors is more clearly expressed. Although Humboldt may not have known that monsoon dynamics stretch around the globe, nor the role that the monsoon plays in shaping the weather and climate that gives form to these mountains, by situating landscapes within the milieu of atmospheric dimensions—material and affective—he helped to build a practice of landscape that is telescopic by way of its embodied engagement of sites and resources.

Enter Ladakh

Humboldt's conception of earth's climatic zones evolved without the benefit of decades of historical, global, and systematically collected meteorological data, the inclusion of situational elements within landscape illustrations hinted at the potential significance of local stories of people and place. On July 24, 2018, I landed in Leh, the capital city of the Ladakh region of India, to explore how the southwestern edge of the Himalayan massif was entangled within the atmospheric activity of the monsoon. Nestled into the valleys of the Great Himalayan Massif that bounds the western edge of the Tibetan Plateau and pushes the monsoon winds back toward the seas, Leh occupies one of the highest inhabited elevations of the central peak in Humboldt's mountain array. From Humboldt's illustrative abstractions to Sven Hedin's detailed cartographies, I was curious to find out if the landscape of the Ladakh had been drawn in relation to the meteorological phenomenon that defines the various life worlds of this little-accessed terrain.

If, as Oliver Lubrich (2018) suggests, landscape can be considered "interdisciplinary, or better, a post-disciplinary concept," then the practice of landscape architecture must also read from and contribute to a cross-disciplinary approach to design that uses multi-perspectival analysis to generate multilayered readings of environments. As the scientific understanding of the monsoon transitioned from the navigational space of maritime exploration to the measured space of cultivated land to the calculated space of militarized air movements, its illusive

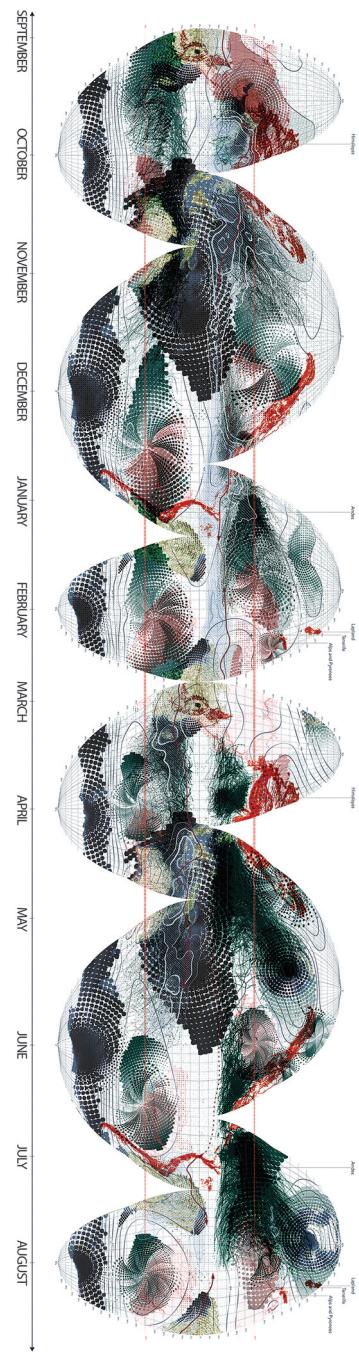


FIGURE 2 Christina Leigh Geros, 2019, “The Global Monsoon” with annotated reference to Humboldt’s peaks: Depicting the formation of the meteorological material and atmospheric movement of the monsoons and monsoon troughs that wrap around the earth and act over the course of an annual cycle; using publicly available climate data from the NOAA/NCEP CFSv2 Climate Forecast System + NASA Earth Observations.

boundaries and dynamic exchanges across the lived sphere made it one of the most studied meteorological phenomena in the world (Amrit 2018; Cullen and Geros 2020; David 2002). Entangled within an increasingly urban and networked global terrain, the erratic behavior of the monsoon and its evasion of scientific and predictive measures forced an expansion of the cross-disciplinary methods and knowledge-sharing techniques used to engage with the monsoon as a “site” of investigation (Cullen and Geros 2020). Long believed to be the northernmost agent in the Asian monsoon’s land-air exchange, the Tibetan Plateau—the highest elevated landmass in the world—has been a site of monsoon exploration and study since the early twentieth century (*ibid.*). Through its making, materiality, and active role as the “Rooftop of the World,” the Tibetan Plateau exerts enormous control over global climatic, political, and economic systems; acting, simultaneously, as a driver of global warming and an amplifier of its consequences (Xie et al. 2009). In Ladakh, a high-altitude desert on the edge of the Plateau, the consequences of a destabilized weather phenomena are visible and taking a toll on the delicate environment and hydrological resource management systems of the region. In this dry urban landscape, unsuited to monsoon rains, the region’s urban settlements now face an annual two-week period of summer monsoon rainfall from late July to early August. Arriving in Ladakh during this environmental change, it was impossible not to wonder about the ways in which this landscape had been drawn in the past: how had the landscape and atmosphere—material and affective—been imagined and how had that imagination shaped concern for this landscape?

First drawn into Western geography at the turn of the twentieth century by Sven Hedin, the relationship between Ladakh’s soils and skies have changed far more radically than the rocky terrain itself. Hedin, a Swedish explorer and geographer who received funding from the British colonizers of India to voyage into Central Asia at the turn of the twentieth century, focused his attentions on terrestrial resources and relationships; most significantly for the British, Hedin located the origin of the Brahmaputra River. Like Humboldt and others of his time, Hedin understood the importance of landscape representation, or illustration, in the project of acquiring access and commanding control of resources. While the methods and ambitions of Humboldt and Hedin differed, when approaching today’s changing Himalayan landscapes, each practice shines a light on the project of resource definition in this delicate landscape. For Humboldt, the use of both precise and vague drawing methods allowed a drawing to suggest more than was empirically known, while limiting exposure to error. When applied to mountains, specifically, the combined work of lines—some tight with intentionality and others loose with gesticulation—emphasized the importance of the earth’s movement and relation-making, rather than the specific formation of rock, itself (Von Humboldt 1877 (1845), 290). Contrastingly, Hedin’s drawing methods were precise and oriented toward the production of illustrated instructions for locating and securing land-based resources. Of the two, only Hedin would inquire into the Ladakh valley, specifically; but each practice’s unique approach to seeing and drawing landscapes into knowledge production shaped my own reading of this changing terrain.

Over the past decade, as this two-week window of monsoon rainfall has opened onto the carefully managed lifeways of the Himalayan high plains and valleys, Ladakh’s material composition and surface water management regimes have struggled to adjust—exposing a growing incompatibility with the moisture-filled clouds above. Nuisance and disaster for some, the shifting zone of delivery for one of the earth’s most needed resources—freshwater—

presents new opportunities for others. Today, on the approach of resource limits and new technological heights, relationships between epistemological infrastructures, topographies, and natural resources are being redefined, from a focus on products, *ergons*, to their ever-evolving, productive *energia*. For Ladakh and other locations along the Tibetan Plateau, this shift is one that draws-out the possibility of a future of extractive pioneering that changes the relationship between the Plateau and the airs above its surface. Learning from Humboldt and Hedin to draw the landscape of Ladakh with a centered gaze on its evolving relationship with resource is to draw the active monsoon and its changing relationship with earth's soils [Figure 3]. This requires a perspectival shift in the conception of landscape from one that focuses on the population, formation, and evolution of earth's surface to one that centers on the co-construction of weather-ecologies and economies.

UNDERSTANDING LADAKH AS A SHIFTING LANDSCAPE OF RESOURCES

A center of activity and linkages between the landscapes and economies of the East with the markets in the West, Ladakh's history and significance as a nexus of trade along the Silk Road helped to draw the Ladakh Range into western geographic imagination (Barrett and Bosak 2018). Such sites of exchange have long been grounds of cultural assimilation, bringing old customs into "new processes of modernity" (Brower and Johnston 2007). Due to the geophysical characteristics of the Ladakh region, its history is entangled in networks of power, capital, and resource exchange (Barrett and Bosak 2018). Today, as economies and climates destabilize at alarming rates, the same features that bound Ladakh to international markets now draw the region into meteorologically uncertain futures and pioneering markets of power, capital, and resources. With shifting climate patterns and growing population demands across the Asiatic region, these speculative futures and emerging markets bring new dimensions and concerns to a little-traversed part of the globe with enormous geopolitical and climatic significance.

The Ladakh region of India is classified as a high-altitude desert with an average elevation of over 3000 m, shielded from wind and rain—between peak and plateau—by its location in the Trans-Himalayan rain shadow. The backbone of India's highest plateau, the Ladakh Range, extends through the center of the region—stretching from the confluence of the Indus and Shyok Rivers in Pakistan (northwest) to the Tibetan border in the southeast (Negi 1998, 14). Crossing into Tibet, the Ladakh Range becomes the Kailash Range—home of Mount Kailash, which is known as the "legendary centre of the world" the summit of which remains out of reach of human conquest—a claim few mountain peaks can stake (Allen 2003, 23–26; Thurman and Wise 1999, 3–4 cited in Chellaney 2011, 102; Snelling 1983; Times of India 2001). Mount Kailash stands at 6,638 m high along the western Himalayan Range and near the origin of the Indus, the Sutlej, the Brahmaputra, and the Ganges Rivers. Before reaching this junction, the Ladakh Range forms the ribs of the Indus River's north-eastern bank and the western bank of one of its tributaries, the Shyok River (Mehra 1992, 14)—each river then proceeding across the Ladakhi plateau. From the perspective of hydro-political dynamics, this southern extension of the Karakoram Range—a small, yet significant, piece of the Trans-Himalayan Range—plays a foundational role in the creation of several transboundary water basins responsible for sustaining more than half a billion people (IPCC 2007). For this reason alone, the landscape



FIGURE 3 John Cook, 2019, an excerpt from “A Section through the Indian Subcontinent”: Read from right to left, this geologic and atmospheric cross-section cuts through India along 77.5E longitude, portraying the gathering and advancement of the summer monsoon from June to August, 2016; using publicly available climate data from the NOAA/NCEP CFSv2 Climate Forecast System + NASA Earth Observations.

of Ladakh figures into a form of spatial practice that structures a contentious landscape of geopolitical and hydrological concern.

Along the length of the Ladakh Range, several peaks reach above 6,000 m and shield the plateau that lies to the northeast from the monsoon winds that approach from the southwest (Mehra 1992, 14). As the spine of the entire range crests above cloud cover, a horizon of snow and glaciers extends north and south, feeding several river basins—particularly the Indus and the Brahmaputra—whose flows are reliant on glacial-melt (Mehra 1992, 14; Chellaney 2011). These rivers and their sources loom large in the histories of both religious pilgrimage and colonial conquest. Mount Kailash, for example, may be known as either the abode of the father and mother of the planet; the God Shiva and Goddess Uma; the place of Buddha's most blissful manifestation; or the place of nirvana for Rishabha, the first prophet of the Jain religion (Allen 2003; Thurman and Wise 1999). A muse for poets and philosophers since the 4th century CE, the Indus, Sutlej, Brahmaputra, and Ganges Rivers all rise within the folds of Mt. Kailash's formation (Chamaria 2003). By the turn of the 20th century, cartography's "white spaces" had captured the imaginations of Western explorers; of them, Sven Hedin mapped several key glaciers—sacred origins of gods and goddesses—along the Trans-Himalaya by capitalizing on colonial enterprise for resource and territorial domination (Allen 2003; Ryder 1908; Shell 2009). Between art and religious practice; between science and geography; between conservatory and extractive ambition, the inking of these white spaces into the collective imagination brought glaciers into the realm of landscape practice.

Between 1885 and 1935, Sven Hedin embarked on 10 separate expeditions across Central Asia, intent on locating water bodies and identifying their histories of change (Foret 1997, 53). On August 14 of 1906, after spending several weeks in the capital city preparing for his journey, Hedin left Leh and headed east toward the Plateau on what would be his third attempt to reach Tibet. All along his route, Hedin made topographically and geologically accurate maps that included data from astronomical, meteorological, hydrographic and botanical observations; these maps were significant contributions toward building cultural and geographical knowledge of Tibet, the Plateau, and the Trans-Himalayan Range (*ibid.*; Montell 1954). While not layered into singular, multi-media compositions, like Humboldt's, Hedin's maps were accompanied by drawings and photographs of the landscapes and peoples that he encountered along the way—each indexed to reference the other. Of significant value to India's British colonizers, he was able to locate and document the sources of the Indus and Brahmaputra Rivers—shedding light on the continent's hydrology (*ibid.*; Ryder 1908). Hedin's published reports, particularly those in *Southern Tibet*, which document his expeditions from 1906 to 1908, make regular note of weather patterns and impacts of heavy or slight rainfall across the landscape, with particular mentions of the relationship between the monsoon and the successive mountain chains wrapping the western and southern borders of the Plateau (Hedin 1922, 45, 123, 190). However, outside of the written narrative, Hedin's illustrations make little note of anything above the ground plane.

From the Hydrological to the Meteorological View

Before leaving Leh, Hedin made two photographs of the city [Figure 4 & Figure 5]. When viewed side-by-side with photographs from similar locations, made approximately 100 years later [Figure 6 & Figure 7], the lack of atmospheric representation is remarkably noticeable.

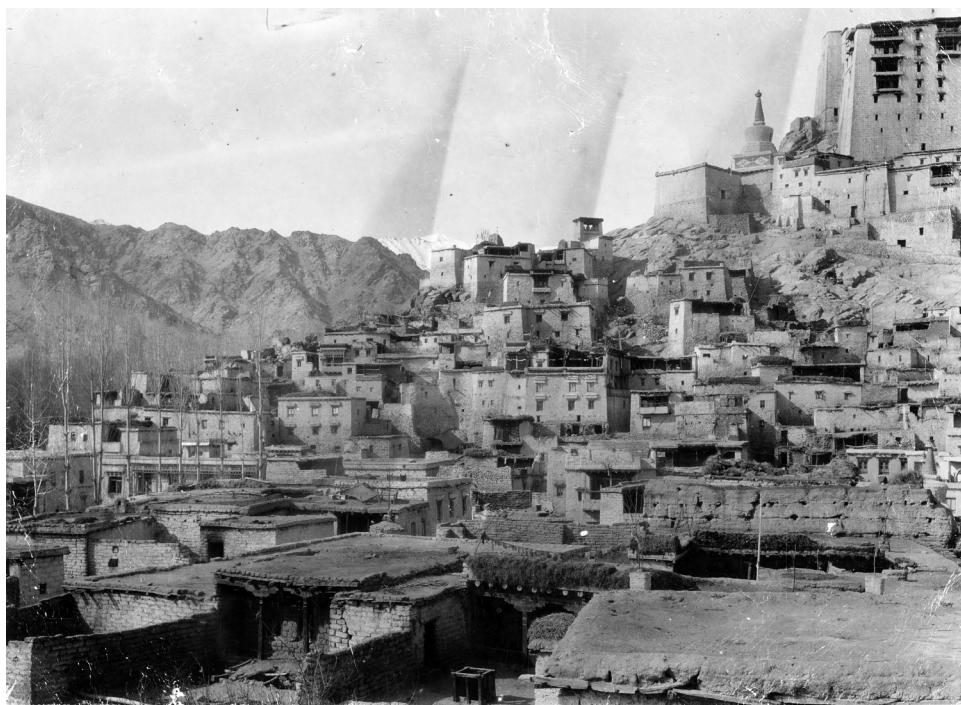


FIGURE 4 Sven Hedin, 1902, photograph of “A Part of Leh, Capital of Ladakh” (Hedin 1922, 5). Images are published with the permission of the Sven Hedin Foundation at the Museum of Ethnography, Stockholm.

Certainly, many factors contribute to the differences between these images; however, in conjunction with weather data and local narratives which evidence significant changes to Leh’s weather patterns, an exceptional weight seems to hang in the air above the city. If the city of Hedin’s illustration seems to exist in a setting that does not need to consider the activity of the skies, photographs of the same city, taken nearly a century later, portray a deep relationship between sky and ground as the central figure in this urban landscape. These images exhibit the historic exclusion of atmosphere and weather in the consideration of landscape space, while alluding to a possible change in the orographic-atmospheric dynamics of the Trans-Himalayan Range.

In the context of the monsoon, the vertical ridges of the Ladakh Range visibly register themselves as a turning point for the seasonal winds that rise from the ocean and move toward the Plateau. As the summer monsoon glides across the subcontinent, from the Bay of Bengal and the Arabian Sea toward the Great Himalayan Range, the rising mountains block their advancement—effectively defining the northern limits of the monsoon’s reach (Chellaney 2011, 103). This orographic-atmospheric dynamic is the primary reason for the concentration of water resources along the southern belt of the Himalayas and the Tibetan Plateau. As heat accumulates on the Plateau, it calls to the monsoon winds—pulling them inland until they reach the Himalayan Massif; as the monsoon winds encounter the successively taller mountain peaks that



FIGURE 5 Sven Hedin, 1902, photograph of “The Principal Street of Leh” (Hedin 1922, 7). Images are published with the permission of the Sven Hedin Foundation at the Museum of Ethnography, Stockholm.

prevent them from reaching the Plateau, the moisture they carry is released as they turn back toward the sea (*ibid.*; Anders et al. 2006; Hedin 1922, 45, 123, 190). Bounded to the north and east by the Ladakh Range and by the Zanskar Range to the south and west, Leh, historically, receives monsoon winds that have already released their moisture (Shafiq et al. 2016); yet, increased moisture content and the expulsion of water by these winds as they reach Leh indicate a marked change in the relationship between land and sky. In 2018, the city of Leh received 45.6 cm of rainfall and 278 cm of snowfall. On trend with average annual rainfall data, the more significant shift shown in precipitation data pertains to the timeline of rainfall (Shafiq et al. 2016). On average, from data-driven studies of weather observations from 1901 to 2000, the rainiest months have been July and August “with mean rainfall of 15.2 and 15.4 mm, respectively”; however, during 2018, the highest rainfall accumulations occurred during October and November with 95.8 and 73.7 mm, respectively. These observations support claims of long-term studies that have noted a decrease in summer rainfall and an increase in winter rainfall—indicating a significant seasonal shift (Shafiq et al. 2016). Such seasonal shifts support narratives of the monsoon’s inclusion of Leh to its annual traversal across the subcontinent.

Although Ladakh had entered this study as the turning point of the *dry* monsoon winds, while in Leh it became apparent that those winds were, in fact, carrying a new visual and



FIGURE 6 Christina Leigh Geros, 25 July 2018 at 15:30:30, photograph of a part of Leh, taken nearing the hilltop site of the Palace; similar to Hedin's photograph taken in 1902.

material weight with them on arrival. Since 2010, parts of Leh have experienced several events of heavy rainfall, known as “cloudbursts,” that have caused significant changes to the landscape and, in some instances, left high death tolls in their wake (Bahn, Devrani, and Sinha 2015; BBC News 2010). A tourist destination and hub for regional economies, urban development in Leh has been on the rise in recent years; and, after meeting with several NGOs in the city, it was clear that these unusual rainfall events had become the focus of much concern and design activity. The Ladakh Ecological Development Group (LEDeG), established in 1983, is a local and multi-disciplinary organization focused on securing a sustainable future for Ladakh’s culture and environment through a diverse set of projects across the region (www.ledeg.org). In July 2018, I spoke with a member of LEDeG’s Watershed Development Programme design team; and his description of the project’s evolution noted that since the project’s inception in 1995, consideration of Ladakh’s two-week monsoon season had become the driving factor in the design of urban form and material selection, at both regional (rural) and local (urban) scales. In response to flooding caused by cloudburst events, the design team has had to prioritize strategies to mitigate soil erosion and flood risk. In particular, the urban environment of Leh was not designed to handle high intensities of rainfall; and, as one architect on the LEDeG team explained, traditional building forms *and* the use of local construction materials



FIGURE 7 Christina Leigh Geros, 25 July 2018 at 11:20:00, photograph of main pedestrian promenade of Leh; the same principal street of Hedin's photograph taken in 1902.

across the region must now be reconsidered for both snow *and* rainfall accumulation. Returning to Hedin's 1922 illustrations of Leh [Figures 4 & Figures 5] and the photographs taken nearly a century later [Figures 6 & Figures 7], I wondered what new relationships might be constructed in another 100 years.

For Leh, like other settlements in the region, glaciers and snowpacks serve as primary sources of freshwater. Since 1973, temperatures in Leh have increased by 1°C; and as a result, the past 100 years have seen the snow line recede by nearly 500 ft. and glaciers retreat by as much as 6.2 Miles (Barrett and Bosak 2018; Vince 2010). According to the Intergovernmental Panel on Climate Change (IPCC) and other researchers, shifts in precipitation type, from snowfall to rainfall, have a negative impact on the annual renewal of the region's perennial snowpack zones (Archer and Fowler 2004; IPCC 2013); thus, strategies for rainfall retention are needed to slow the pace of change. Due to the gap between the meltwater and agricultural timetables, it is common for lower-elevations to experience a two-month period of insufficient water supply—making modern life difficult in Ladakh's delicate climate (Nüsser et al. 2018, 1328). Over the past three decades, the construction of “artificial glaciers,” or “ice reservoirs,” has been widely employed in central Ladakh to ease seasonal transition—particularly as changes in weather patterns and an increased demand for

agricultural products have exacerbated shortages (*ibid.*). The glaciers, belts of snowpack, lakes and rivers that the region relies upon owe their existence, largely, to the monsoon. Historically, the health of this freshwater resource has been mapped and monitored like any other grounded material body; however, the need to create artificial glaciers illustrates that freshwater is not a grounded resource—it is *captured* from the moving air. As the growing presence of the monsoon within Leh shows, understanding this resource requires us to revisit the lessons of Humboldt and the foundations of landscape practice. As the twin challenges of rapid urban expansion and climate destabilization increase pressure on issues of water access and sovereignty, particularly across the Asian sphere, renewed interest in mapping the sources of these water bodies may reimagine this high-altitude terrain as an atmosphere, itself. Experiments in visualizing the unseen, unquantifiable resources of the atmosphere, [Figure 8](#) and [Figure 9](#), redraw the Plateau through the vertical layering and movement of atmospheric moisture as it approaches the Himalayan high peaks from the Bay of Bengal.

VISUALIZING ATMOSPHERIC RESOURCES

As the third-largest store of perennial ice mass on the planet, after the Arctic and Antarctic, the Tibetan Plateau is known as the “Third Pole.” In the context of rising global temperatures, the local effects and global effects of a destabilized climate are more acutely realized by the earth’s three centers of ice mass. At the North and South Poles, mean annual temperatures have risen by about two to three degrees Celsius since the 1950s; meanwhile, the Tibetan Plateau is warming at an alarmingly faster pace and the effects are even more visible—impacting the freshwater resources of 10 nations across Asia (Chellaney 2015, 150–157). These densely populated and rapidly urbanizing nations are struggling to secure enough freshwater resources; and, as insecurity mounts, issues of sovereignty over the Plateau present conflicts that extend into the atmosphere.

Animated by grasslands and rivers that are fed by the ice and snowfields that are scattered across the Plateau, the large volume of “water-rich air currents,” skirting around the edges of the Plateau daily, deposit little moisture onto one of the driest places on earth; thus, while surrounded by a potential source of freshwater, the Plateau—and the millions who depend on its freshwater flows—remains reliant on the climatic dynamics that encourage those resources to land. In China, recent developments toward the identification of water resources in the atmosphere have directed scientific experiments toward the reduction of cloudwater into

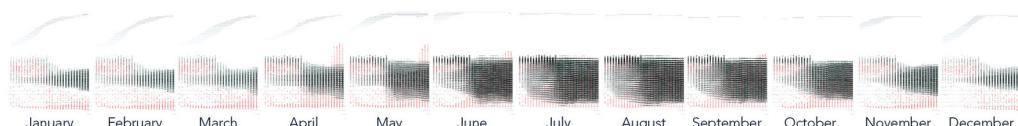


FIGURE 8 Christina Leigh Geros, 2019, Layers of Atmospheric Moisture from the Bay of Bengal (right) to the Tibetan Plateau (left); using publicly available climate data from the NOAA/NCEP CFSv2 Climate Forecast System + NASA Earth Observations, monthly averages from 1998.



FIGURE 9 John Cook, 2020, “Monsoonal Bangladesh: Terra–Aqueous Land”: A speculative sectional drawing through Dhaka (90.4125E longitude), from the Bay of Bengal to the Tibetan Plateau, simulated using computational fluid dynamics software depicting the complex forces and interactions between tectonic and climatic materials and flows.

accessible freshwater, as a means of alleviating drought issues (Chen 2018; Wang et al. 2018, 109). An alternative method for the South-to-North Water Diversion Project, a group of Chinese researchers are attempting to reach into the skies and transfer water through the atmosphere—avoiding the hassles of moving water on land (Wang et al. 2018, 109). In the 1990s, a group of MIT scientists identified bands of water vapor transiting through the troposphere—a meteorological phenomenon they named “atmospheric rivers” (Zhu and Newell 1998); the *Tianhe*, or Sky River, Project proposes to manipulate the movements, flow rates and quantities of these bands of water vapor by manufacturing rainfall in specific locations (Gimeno et al. 2014; Pike 2018). Since 2015, with political support and institutional funding, the Sky River Project team—a multi-disciplinary partnership between Qinghai University, Tsinghua University, and the Qinghai province’s meteorological bureau—has moved ahead, unhindered, with their research. China’s Ministry of Science and Technology has supported this project as a beacon of technological innovation and international import; furthering the project’s national significance, in 2016 the state-owned China Aerospace Science and Technology Corporation joined the team’s efforts, as the development of a low-cost weather modification system falls within the scope of the nation’s defense technology regime (Chen 2018; Pike 2018). However, according to Guangqian Wang, the president of Qinghai University and the leader of the Sky River Project, the project faces the critical challenge of defining the temporal and spatial dimensions of atmospheric resources and their ownership before the project can proceed toward technological strategies of implementation (Wang et al. 2018, 109–110). For Wang, these theoretical issues are not separate from the technical issues of atmospheric water extraction; in fact, the resolution of spatial and temporal questions around cloudwater availability amounts to the production of an atmospheric atlas of sky rivers and sky basins—a roadmap for extraction.

The development of a comprehensive hydrological management system requires a level of certainty about quantities, behaviors, and locations of atmospheric water resources alongside surface water resources (Wang et al. 2018, 109). Unlike geophysical rivers, atmospheric rivers cannot easily be understood as having regional limitations or operating within watersheds; rather, the physical dynamics that determine their locations and temporalities and the atmospheric moisture budget that helps determine their flow rates need to be calculated on a global scale (Gimeno et al. 2014; Simmonds, Bi, and Hope 1999). While observational and modeling systems have improved, the unpredictable distribution of cloud cover and rain makes for unreliable projections of available water resources in the atmosphere (Wang et al. 2018, 110). To further address the challenges that lie ahead for the research team, Wang explains: when analyzing a three-dimensional, atmospheric body of water molecules, the task of determining the precise moment to take action toward a specific space within that body of moisture in order to transform water-in-the-air into water-on-the-ground is beyond the science of both meteorology and hydrology (*ibid.*). Early water vapor transport studies enabled scientists to recognize that fluctuating patterns of water vapor transport are related to recurring patterns of barometric exchange or atmospheric pressure cycles (Zhu and Newell 1998). Correspondingly, the study, analysis, and representation of water vapor transport systems have relied on the same short-term temporal scale that generates synoptic representations of barometric activity (*ibid.*; Simmonds, Bi, and Hope 1999). However, as the Sky River team attempts to define atmospheric water as an “exploitable resource,” methods of temporal modeling and charting must account for both short- and long-term fluxes (Wang et al. 2018, 110). While existing models

and synoptic charts based on short-term data help to generate an atmospheric cartography of the physical conditions that may define the current status of atmospheric flow basins, similar to Hedin's documentation of the Ladakh valley, long-term projections of either historical or future data are needed to gain an understanding of the spatial and temporal shifts that may occur over time, across seasonal and decadal scales.

Importantly, the region of the Asian summer monsoon is characterized by a significant quantity of water vapor that is transported by the mean easterly flux, or atmospheric river, that fuels the movement of monsoon winds from the Arabian Sea and Bay of Bengal toward the Tibetan Plateau (Zhu and Newell 1998, 726). To tap this potential water resource, the Sky River project is sited in relation to the monsoon—to meet its southwestern arrival to the edge of the Plateau, along the Indian border, and within the Xinjiang Province of China. The project aims to shift monsoon rainfall beyond the Himalayan Massif so that it may feed the headwaters of the Yangtze and Yellow Rivers (Chen 2018). On site, the project consists of a network of cloud-seeding burn chambers that produce an updraft of chemical particles that the monsoon winds mix into cloud formations, encouraging precipitation. The Chinese government estimates that this system will eventually cover 62,000 square miles and generate up to 10 billion cubic meters of annual rainfall (Nace 2018). As currently designed, the system could generate a massive network of clouds able to travel more than 1,000 m above the Himalayan Massif, with an eventual rainfall cover of nearly 1.6 million kilometers (Chen 2018). If the project is successful, it will relocate the watershed of the Indian monsoon onto the Tibetan Plateau—effectively starving the rivers of the Himalayan Range of their life-sustaining waters.

In November 2018, China's Aerospace Science and Technology Corporation expanded the physical network of the Sky River Project into the atmosphere; publicly announcing the planned launch of six monitoring satellites, to be started in 2020 and completed in 2022 (Pike 2018). The project's network of sensors would also extend into the air above the Indian Ocean, collecting data from another 30 satellites with their "eyes" focused on monsoon activities (Chen 2018). If atmospheric rivers are to be classified as conventional water sources and brought into a system of hydrological modeling and monitoring, these upper-air currents of moisture must be "seen" before they make themselves visible. According to Wang et al. (2018, 110), atmospheric rivers are visible as "narrow cloud or rain bands," which are formed as the surfaces of two different air masses meet one another, creating an opportunity for water vapor to transition into cloud droplets, and possibly rainfall. So far, attempts to draw the meeting of these surfaces have remained in the cartographic language of rivers [[Figure 10](#)][—\[Figure 11\]](#)each with an unpredictable origin point, direction and quantity of flow. If Hedin's "white space" cartographies identified the monsoon's solid deposits as freshwater resources, the Sky River Project is attempting to identify the monsoon winds as an exploitable and untapped fount of freshwater.

STRUCTURING THE MONSOON AS RESOURCE

As climate further destabilizes, reliance on the monsoon's freshwater deposits may not sufficiently—and reliably—meet the water demands of Asia's growing populations. In order to fully exploit the monsoon's *potential*, the project of drawing-out its spatial and temporal dimensions needs a scaffold on which knowledge of the monsoon's structure can be spatially constructed as a visual medium. The Tibetan Plateau, as a central figure in the life cycle of the monsoon and

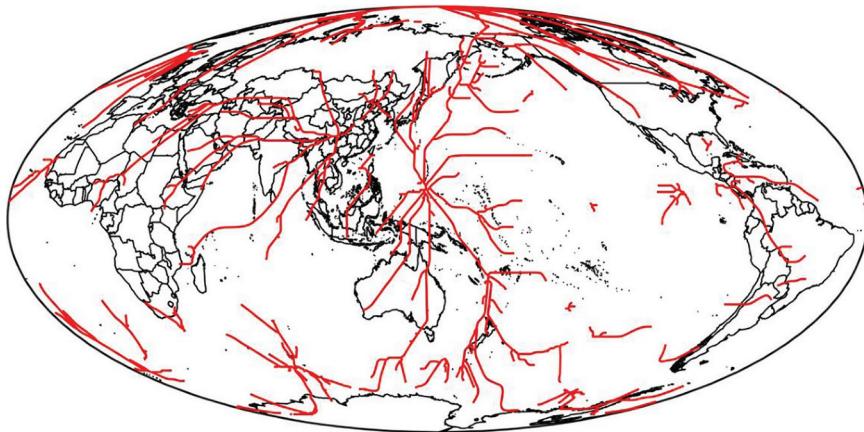


FIGURE 10 (Wang et al. 2018), “The global distribution of sky rivers on July 21, 2012” (112).



FIGURE 11 Advertisement for Tibet Spring 5100 bottled water. Image source: <https://www.zcool.com.cn/work/ZMjI1NjA1ODQ=.html?switchPage=on>.

a register of changing climatic factors could operate as a baseline and scaffold on which to draw the monsoon. Although not an explicit example, Figure 9 offers insight into how the dematerialization of the Plateau might provide a canvas for the visualization of a resource—and the dynamics of its production—that are in constant flux.

The Tibetan Plateau reaches the mid-layer of the earth's troposphere, where it directs, shields, and connects weather patterns of disparate regions around the globe by deflecting winter winds outward and pulling summer winds inward (Chellaney 2011, 96). With the world's tallest mountains concentrated in the uplift zone of the Plateau, a 3,500-km stretch of

crest lines that extend from Myanmar to the Hindu Kush of Afghanistan—the dominant, physical border between India and China—inserts itself into global jet stream circulations, creating two branches of low-level westerlies that circle the Plateau (Korner and Ohsawa 2005, 686; Chellaney 2011, 99; Murakami 1981, 41). The two branches are asymmetrical in force and flow; and along the Plateau’s southern border, the stronger upper-level jet stream eventually meets a coupling of anti- and cyclonic vorticity cells that hold cooler air in the mountain peaks, allowing warmer air to rise over the mountains and heat the Plateau (Murakami 1981, 41). The Plateau sits just above the dominant air circulations of the Northern Hemisphere and disrupts the mingling of northern and southern airs; simultaneously, the heat that accumulates on the Plateau pulls the warm air of the equator into higher elevations and latitudes, and together, these actions help to create the climatic relationships once drawn by Humboldt (Cui et al. 2007; Chellaney 2015, 157). Although recognized as a significant factor in the construction of the global climate, the full range of the Plateau’s agency is still under study (Murakami 1981, 41–42); however, as an agent within the Asian monsoon system, its role is more clearly understood.

Each year, the push and pull of the Tibetan Plateau constructs both oscillations and intensity difference in India’s winter and summer monsoons—constructing time, space, and Asia’s supply of freshwater (Hahn and Manabe 1975, 1515–41; Hsu and Liu 2003, 2066; Wang 2006). Acting as a “high-elevation heat pump,” the Plateau uses monsoonal currents to pull moisture into the hinterlands of the Asian landmass (Chellaney 2011, 99). The materiality of the Plateau—rock and sand—attracts and intensifies heat from the sun and as this heat source interacts with the air above it, a low-pressure air system forms and calls to the monsoon currents out at sea—insuring the delivery of precipitation to Asia’s two wettest regions: the Indian subcontinent and the IndoChina peninsula (*ibid.*; Duan and Wu 2005, 793–807; Sato and Kimura 2007). Considered on the grounds of urban architecture, the Tibetan Plateau operates as a nexus of resource collection, management and distribution.

Acting as a mediator between the earth’s surface and the upper limits of the inhabited atmosphere, the Plateau structures geopolitical and climatological relationships across Asia in the creation of the meteorological monsoon. Scientific studies suggest that the tectonic uplift of the Tibetan Plateau birthed the Indian monsoon system; and with it, the freshwater repository, supplier, and “rainmaker”—literally and figuratively—of the Asian sphere (Chellaney 2011, 99; Molnar, England, and Martinod 1993). Meanwhile, on the crisis horizon, water scarcity is projected to be the “defining” issue of Asian life and politics; and, if the relationship between the Plateau, the monsoon, and the world’s drinking water were properly understood—and represented—its protection would, necessarily, be a top-priority (Chellaney 2011, 1). However, over the past two decades, China’s consumption of bottle water—the highest in the world—has necessitated the nation’s rise as one of the world’s largest producers of bottled water; with the snow-capped peaks of the Tibetan Plateau being represented as an ideal, pure source of freshwater (Hongqiao 2015). With increasing pressure to industrialize the extractive potential of the Tibetan Plateau, development projects endanger the top layer of permafrost essential to the survival of the delicate ecology. For example, the expansion of China’s national railway network to include Tibet’s capital city cut across 550 km of permafrost and its destruction is the suspected cause of reduced groundwater levels at the sources of both the Yangtze and Yellow Rivers (Chellaney 2011, 115). Ironically, China’s Ministry of Industry and Information Technology and Tibet’s provincial government announced major incentives to attract investors and entrepreneurs to Tibet’s natural freshwater

resources—licensing 28 companies by the end of 2014 (Sala 2017). One of those companies, Tibet Water Resources Ltd. (formerly known as Tibet 5100 Water Resources Holdings Ltd.) has located its sourcing home at 5,100 m above sea-level in one of The Tibet’s “most remote, pristine, and untraversed locations” to source and bottle natural spring water from the Plateau (Tibet Water Resources Ltd 2016). Promoting itself as a luxury bottled water provider, the commercial imagery that TibetSpring5100 produces [Figure 10], draws the concept of atmospheric rivers into popular imagination as an ever-flowing—divinely ordained—water source; and makes a dangerous contribution to a knowledge-building process about earth systems that further entangles the monsoon in an extractive industrial process.

CONCLUSION

The Sky River Project is not the only large-scale strategy for “mining the air” that is currently in operation or under development (Buck 2019, 128). As Holly Jean Buck’s *After Geoengineering* describes, the development of technologies able to extract carbon and energy from the atmosphere have been in the works since the 1970s; and each one, like the Sky River Project, must first colonize the airspace through the production of visual media that makes new processes of extraction “seem natural, right, then beautiful,” creating a new industrial promise of survival (Mirzoeff 2014, 220; Buck 2019). The political, ecological, and economic restructuring of the relationship between the Tibetan Plateau and the Asian monsoon will not only redraw the boundaries of access to drinking water, it may also create a dangerous legal precedent that enables the atmosphere to be treated as a medium that can be privatized and transformed. While the global water budget is regionally distributed variably, the total amount of water available within the atmosphere is fixed; and to change the flow of atmosphere-to-surface recharge is to wield “power through the language of landscape and the media of ecology” (Belanger and Arroyo 2016, 34). As the 21st century is well underway and global events—environmental, political, and social—call attention to the dramatic pace of earth system destabilization, Benedito’s (2021, 14) call to consider weather and atmosphere, together, as co-constructive actors and elements of the “space” of landscape may prove to be a profound, and much-needed, shift in landscape practice. Certainly, design should consider the physical and emotional aspects of embodied weather and climate; but it must also address the ever-expanding and re-composing project of extraction that requires a “different kind of imaging and imagination, action and retroaction” to engender solidarity within and among our more-than-human milieu (Belanger and Lister 2018, 26). One of the most storied and historically tracked meteorological phenomena, the monsoon may be a fitting and “capacious” bag “for collecting, carrying, and telling the stuff of the living” so that as “worlding gets on with itself in dragon time” landscape may be drawn back into a more inclusive project of knowledge-building, rather than resource extraction (Haraway 2019, 10). At pace with the continued calls for landscape practice to expand its *space* into new mediums and media, revisiting its foundations may help us to design a practice that can operate as a scaffolding into uncertain futures, markets, and imaginations.

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REFERENCES

- Aira, C. 2006. *An episode in the life of a landscape painter*. New York, NY: New Directions Books. trans. C. Andrews.
- Allen, C. 2003. *A mountain in Tibet: The search for Mount Kailash and the source of the great rivers of Asia*. London: Abacus.
- Amrit, S. 2018. Risk and the South Asian Monsoon. *Climate Change* 151 (17):17–28. doi:[10.1007/s10584-016-1629-x](https://doi.org/10.1007/s10584-016-1629-x).
- Anders, A. M., G. H. Roe, B. Hallet, D. R. Montgomery, N. J. Finnegan, and J. Putkonen. 2006. Spatial patterns of precipitation and topography in the Himalayas. In *Tectonics, climate and landscape evolution: Geological society of America special paper* 398, ed. S. D. Willet, N. Hovius, M. T. Brandon, and D. M. Fisher, 39–53. Boulder, Colorado: Geological Society of America.
- Archer, D., and H. Fowler. 2004. Spatial and temporal variations in precipitation in the Upper Indus Basin, global teleconnections and hydrological implications. *Hydrology Earth System Science* 8 (1):47–61. doi:[10.5194/hess-8-47-2004](https://doi.org/10.5194/hess-8-47-2004).
- Bahn, S. C., A. K. Devrani, and V. Sinha. 2015. An analysis of monthly rainfall and the meteorological conditions associated with cloudburst over the dry region of Leh (Ladakh), India. *MAUSAM* 66 (1):107–22. 551.578 (540.11).
- Barrett, K., and K. Bosak. 2018. The role of place in adapting to climate change: A case study from Ladakh, Western Himalayas. *Sustainability* 10 (4):898. doi:[10.3390/su10040898](https://doi.org/10.3390/su10040898).
- BBC News. 2010. Death toll from flash flooding in India rises to 185. Accessed July 25, 2018. <https://www.bbc.co.uk/news/world-south-asia-10937196>.
- Belanger, P., and A. Arroyo. 2016. *Ecologies of power: Countermapping the logistical landscapes and military geographies of the U.S. department of defence*. Cambridge, MA: MIT Press.
- Belanger, P., and N.-M. Lister. 2018. *Extraction empire: Sourcing the scales, systems, and states of Canada's global resource empire*. Cambridge, MA: MIT Press.
- Bender, B. 2002. Time and landscape. *Current Anthropology* 43 (S4):S103–S112. 0011-3204/2002/43supp-0009.
- Benedito, S. 2021. *Atmosphere anatomies: On design, weather, and sensation*. Zurich: Lars Muller Publishers.
- Brower, B., and B. Johnston. 2007. *Disappearing peoples? Indigenous groups and ethnic minorities in South and Central Asia*. Walnut Creek, CA: Left Coast Press.
- Buck, H. J. 2019. *After geoengineering: Climate tragedy, repair, and restoration*. London and New York: Verso.
- Chamaria, P. 2003. *Kailash Manasarovar*. India: Abhinav Publications.
- Chellaney, B. 2011. *Water: Asia's new battleground*. Uttar Pradesh, India: Harper Collins.
- Chellaney, B. 2015. *Water, Peace, and War: Confronting the global water crisis*. Lanham, MD: Rowman & Littlefield.
- Chen, S. 2018. China needs more water. So it's building rain-making network three times the size of Spain. *South China Morning Post*, March 26. Accessed July 25, 2018. <https://www.scmp.com/news/china/society/article/2138866/china-needs-more-water-so-its-building-rain-making-network-three>.
- Cosgrove, D. 2004. Landscape and Landschaft. *GHI Bulletin* 35:57–71.
- Cui, X., H. Graf, B. Langmann, W. Chen, and R. Huang. 2007. Hydrological impacts of deforestation on the Southeast Tibetan Plateau. *Earth Interactions* 11 (15):1–18. doi:[10.1175/EI223.1](https://doi.org/10.1175/EI223.1).

- Cullen, B., and C. L. Geros. 2020. Constructing the Monsoon: Meteorological Cartography, 1844–1944. *History of Meteorology* 9:1–26.
- Davis, M. 2002. *Late Victorian holocausts: El Nino Famines and the making of the Third World*. London and New York: Verso.
- Debarbieux, B. 2012. The various figures of Mountains in Humboldt's Science and Rhetoric. *Cybergeo: European Journal of Geography* 618. doi:10.4000/cybergeo.25488.
- Duan, A. M., and G. X. Wu. 2005. Role of the Tibetan Plateau thermal forcing in the summer climate patterns over subtropical Asia. *Climate Dynamics* 24 (7/8):793–807. doi:10.1007/s00382-004-0488-8.
- Edwards, P. N. 2010. *A vast machine: Computer models, climate data, and the politics of global warming*. Cambridge, MA: MIT Press.
- Foret, P. 1997. The Swedish conquest of Tibet: Sven Hedin's moral mapping of white unexplored patches. *Himalaya, the Journal of the Association for Nepal and Himalayan Studies* 17 (1):53–54.
- Foucault, M. 2002. *The order of things*. New York, NY: Routledge Classics.
- Gimeno, L., R. Nieto, M. Vázquez, and D. A. Lavers. 2014. Atmospheric rivers: A mini-review. *Frontiers in Earth Science* 2 (2):1–6. doi:10.3389/feart.2014.00002.
- Girot, C. 2021. Foreword: Breathing shades of design. In *Atmosphere anatomies: On design, weather, and sensation*, ed. S. Benedito, 6–11. Zurich: Lars Muller Publishers.
- Hahn, D. G., and S. Manabe. 1975. The role of the mountains in the South Asian Monsoon circulation. *Journal of the Atmospheric Sciences* 32 (8):1515–41. doi:10.1175/15200469(1975)032<1515:TROMIT>2.0.CO;2.
- Haraway, D. 2019. Introduction. In *The carrier bag theory of fiction*, ed. U. K. Le Guin, 9–22. UK: Ignota Books.
- Hedin, S. 1922. *Southern Tibet, Vol. IIII*. Stockholm: Lithographic Institute of the General Staff of the Swedish Army.
- Hongqiao, L. 2015. China's bottled water industry eyes up the Tibetan Plateau. *The Guardian*, November 16. Accessed September 15, 2019. <https://www.theguardian.com/sustainable-business/2015/nov/16/chinas-bottled-water-industry-eyes-up-the-tibetan-plateau>.
- Hsu, H. H., and X. Liu. 2003. Relationship between the Tibetan Plateau heating and East Asian summer Monsoon rainfall. *Geophysical Research Letters* 30 (20):2066. doi:10.1029/2003GL017909.
- Hutton, J. 2018. Material as method. In *Landscript 5: Material culture, assembling and disassembling landscapes*, ed. J. Hutton, 13–22. Berlin: JOVIS Verlag.
- Intergovernmental Panel on Climate Change (IPCC). 2013. Climate change 2013: The physics science basis. In *Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. T. F. Stocker et al. Cambridge, UK and New York, NY, USA: Cambridge University Press.
- IPCC. 2007. Climate change 2007: Impacts, adaptation and vulnerability. In *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. M. L. Parry, O. Canziani, J. Palutikof, P. Van Der Linden, and C. Hanson, 469–506. Cambridge, UK: Cambridge University Press.
- Johnston, A. K. 1848. Outlines of botanical geography. In *The physical atlas: A series of maps & notes illustrating the geographical distribution of natural phenomena*. Edinburgh: William Blackwood & Sons. <https://maps.nls.uk/view/index.cfm?id=135678718>.
- Knight, E. F. 1893. *Where three empires meet: A narrative of recent travel in Kashmir, Western Tibet, Gilgit, and the adjoining countries*. 2nd ed. London: Longmans, Green, and Co.
- Korner, C., and M. Ohsawa. 2005. Mountain systems. In *Ecosystems and human well-being: Current state and trends, volume 1, millennium ecosystem assessment*, ed. R. Hassan, R. Scholes, and N. Ash, 681–716. Washington D.C.: Island Press.
- Lubrich, O. 2018. Humboldtian Landscapes. In *Natura: Environmental aesthetics after landscape*, ed. J. Andermann, L. Blackmore, and D. C. Morell, 73–109. Zurich: Diaphanes. doi:10.4472/978303580061.0005.
- Mehra, P. 1992. *An "agreed" frontier: Ladakh and India's northernmost borders, 1846–1947*. Oxford: Oxford University Press.
- Mirzoeff, N. 2014. Visualizing the Anthropocene. *Public Culture* 26 (2):213–32. doi:10.1215/08992363-2392039.
- Molnar, P., P. England, and J. Martinod. 1993. Mantle dynamics, uplift of the Tibetan Plateau, and the Indian Monsoon. *Reviews of Geophysics* 31 (4):357–96. doi:10.1029/93RG02030.
- Montell, G. 1954. Sven Hedin the explorer. *Geografiska Annaler* 36 (1/2):1–8. doi:10.1080/20014422.1954.11880856.
- Murakami, T. 1981. Orographic Influence of the Tibetan Plateau on the Asiatic Winter Monsoon Circulation: Part I. Large scale aspects. *Journal of the Meteorological Society of Japan* 59 (1):40–65. doi:10.2151/jmsj1965.59.1_40.

- Nace, T. 2018. China is launching weather-control machines across an area the size of Alaska. *Forbes*, May 10. Accessed September 15, 2019. <https://www.forbes.com/sites/trevornace/2018/05/10/china-is-launching-a-massive-weather-control-machine-the-size-of-alaska/>.
- Negi, S. S. 1998. *Discovering the Himalaya, volume one*. New Delhi: Indus Publishing Company.
- Nüsser, M., J. Dame, B. Kraus, R. Baghel, and S. Schmidt. 2018. Socio-hydrology of “artificial glaciers” in Ladakh, India: Assessing adaptive strategies in a changing cryosphere. *Regional Environmental Change* 19 (5):1327–37. doi:10.1007/s10113-018-1372-0.
- Pike, L. 2018. China’s scientific community confronts “rogue science.” *China Dialogue*, December 17. Accessed September 17, 2019. <https://www.chinadialogue.net/article/show/single/en/10986-China-s-scientific-community-confronts-rogue-science->.
- Ryder, C. H. D. 1908. Dr. Sven Hedin’s expedition in tibet. *The Geographical Journal* 32 (6):585–90. doi:10.2307/1777520.
- Sala, I. M. 2017. Bottled water from Tibet: How Hong Kong consumers are contributing to an environmental disaster. *Hong Kong Free Press*, September 17. Accessed September 15, 2019. <https://hongkongfp.com/2017/09/17/bottled-water-tibet-hong-kong-consumers-contributing-environmental-disaster/>.
- Salzman, J. 2017. *Drinking water: A history*. New York and London: Overlook Duckworth.
- Sato, T., and F. Kimura. 2007. How does the Tibetan Plateau affect the transition of Indian Monsoon rainfall? *Monthly Weather Review* 135 (5):2006–15. doi:10.1175/MWR3386.1.
- Shafiq, M. U., M. S. Bhat, R. Rasool, P. Ahmed, H. Singh, and H. Hassan. 2016. Variability of precipitation region in Ladakh region of India from 1901–2000. *Journal of Climatology & Weather Forecasting* 4 (2):165. doi:10.4172/2332-2594.1000165.
- Shell, O. 2009. The Thaw at the roof of the world. *New York Times*, September 25. Accessed September 15, 2018. <https://www.nytimes.com/2009/09/26/opinion/26Schell.html?searchResultPosition=3>.
- Simmonds, I., D. Bi, and P. Hope. 1999. Atmospheric water vapor flux and its association with rainfall over China in summer. *Journal of Climate* 12 (5):1353–67. doi:10.1175/1520-0442(1999)012<1353:AWVFAI>2.0.CO;2.
- Snelling, J. 1983. *The sacred mountain*. United Kingdom: East-West Publications.
- Thurman, R., and T. Wise. 1999. *Circling the sacred mountain: A spiritual adventure through the Himalayas*. New York: Bantam Books.
- Tibet Water Resources Ltd. 2016. Accessed January 13, 2021. https://www.twr1115.net/pages/corporate_profile.
- Times of India. 2001. China to ban expeditions on Mt. Kailash. *Times of India*, June 7. Accessed September 15, 2018. <https://web.archive.org/web/20110718190919/http://www.tew.org/archived/kailash.ban.html>.
- Vince, G. 2010. A Himalayan village builds artificial glaciers to survive global warming. *Scientific American*, May 24. Accessed July 25, 2018. <https://www.scientificamerican.com/article/artificial-glaciers-to-survive-global-warming/>
- Von Humboldt, A. 1843. *Asie centrale: Recherches sur les chaines de montagnes et la climatologie comparee*. Paris: Gide.
- Von Humboldt, A. 1854. *Volcans des Cordillères de Quito et du Mexique*. Paris: Gide et J. Baudry.
- Von Humboldt, A. 1877. *Cosmos: A sketch of the physical description of the Universe*. In *Kosmos (1845)*, ed. E. C. Otte. London: Harper & Brothers.
- Wall, E. 2020. Introduction. In *Architectural design: The landscapists*, ed. E. Wall, 6–13. Oxford: Wiley.
- Wang, B., ed. 2006. *The Asian Monsoon*. Berlin and New York: Springer Verlag and Praxis Publishing.
- Wang, G., D. Zhong, T. Li, Y. Zhang, C. Meng, M. Zhang, X. Song, J. Wei, and Y. Huang. 2018. Study on sky rivers: Concept, theory, and implications. *Journal of Hydro-environment Research* 21:109–17. doi:10.1016/j.jher.2018.09.003.
- Xie, H., J. Ye, X. Liu, and E. Chongyi. September, 2009. Warming and drying trends on the Tibetan Plateau. *Theoretical and Applied Climatology* 101 (3–43–4):241–53. doi:10.1007/s00704-009-0215-9.
- Zhu, Y., and R. E. Newell. 1998. A proposed algorithm for moisture fluxes from atmospheric river. *Monthly Weather Review* 126 (3):725–35. doi:10.1175/1520-0493(1998)126<0725:APAFMF>2.0.CO;2.

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