National climate: Zhu Kezhen and the framing of the atmosphere in modern China

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Abstract: Can climate be Chinese, and if so, then how? Drawing on personal writings, popular discourse, and scientific reports, this essay considers the work of early Chinese meteorologists in relation to the revolutionary national politics of the early twentieth century. Historians of China have established that nationalism motivated the pursuit of meteorology and other natural sciences, but I advance the more radical position that there was no clear distinction between the practice of climate science and the political ideology that motivated it. With special attention to the career and legacy of Zhu Kezhen from the Xinhai Revolution through World War II, I test this thesis in two arenas: Chinese meteorologists' production of spatial knowledge, and their production of cultural knowledge. The nation was integral to the questions, methods, and analyses of atmospheric science, which helped to reify the Chinese nation-state.

China "domesticated" the modern sciences of meteorology and climatology not long after the Revolution of 1911, as weather stations and meteorological institutes that were built and run by and for Chinese citizens proliferated across the young Republic. What did China look like from these new weather stations? Did the first generation of Chinese climatologists see a singular "Chinese climate"—or were they more inclined toward trans-national geographies like the famous Köppen classification that presented climate as a series of circum-global zones? Did international standards for interpreting atmospheric phenomena supplant culturally specific ideas about the weather? Put differently: to what extent were meteorology and climatology compatible with national specificity? Drawing on personal writings, public discourse, and scientific reports, this essay considers the work of early Chinese climatologists in relation to the revolutionary politics of the early twentieth century.

Science and nationalism have been an awkward pair in China since at least the "metaphysics and science" controversy of the 1920s, when certain intellectuals who were wary of scientism felt that the spiritual work of building the nation ought to be the domain of a subjective "metaphysics" quite apart from the material inquiry of the sciences.[1] Not all agreed—yet a similar distinction between the spiritual and the material is often replicated in the way we write and teach about the young Chinese republic today. Unsurprisingly, present-day scholars of Chinese history and literature grant precedence to humanists over scientists in the revolutionary canon. Leading English-language surveys like *The Search for Modern China* and *Modern East Asia: A Brief*

History prominently feature such figures as Lu Xun, who famously abandoned his medical studies in favor of literature because he felt that it was China's spirits, and not bodies, that most needed treatment, as well as Hu Shih, who traveled to Cornell to study agricultural science but switched tracks to philosophy and emerged as a champion of the Chinese vernacular, while omitting Zhu Kezhen, who, after taking passage on the same vessel that carried Hu Shi to America, completed degrees in agriculture and meteorology and helped to revolutionize China's understanding of the atmosphere—probably because the atmosphere of greater interest to most historians is not the gaseous atmosphere of meteorological concern, but rather, the metaphorical "atmosphere and political mood that emerged around 1919" during what is known as the New Culture Movement.[2] This tendency in the literature on China is consistent with broader approaches to the study of nationalism: surveying the field, Lloyd Kramer observes that nationalisms are assumed to be "historical rather than natural phenomena," such that "the study of nationalism leads to historical analysis rather than to biology or physical geography."[3]

Of course, historians of science will recognize that there has long existed a deep and complementary relationship between the rise of nationalism and the growth of scientific institutions. Hiromi Mizuno introduced the concept of "scientific nationalism" in her trenchant study of the Japanese empire to denote "a kind of nationalism that believes that science and technology are the most urgent and important assets for the integrity, survival, and progress of the nation."[4] Zuoyue Wang has similarly identified a vein of scientific nationalism in Republican China that was characterized by a "desire to create a strong, unified, and prosperous Chinese nation… based in part on the utilization of science and technology."[5] Relating this broad trend to the particularities of climate science, Clark Alejandrino observes that the emergence of Chinese-run weather stations in Republican China ushered it into an era of "meteorological sovereignty."[6] Zhu Kezhen's nationalism is a focal point in the aforementioned works by Wang and Alejandrino as well as a recent encyclopedic entry on Zhu by Iwo Amelung, who comments that "patriotic feelings… were a major motivation for Zhu's work."[7]

Even these studies, however, situate scientific nationalism mainly on the administrative side of science such that the *practice* of scientific observation remains largely exterior to the ideological work of nationalism (and vice versa). In doing so, they reinforce the conceptual divide between scientific and non-scientific developments. This essay advances the more radical position that there was and could be no clear distinction between the practice of climate science in

Republican China and the revolutionary politics that motivated it. Here my approach departs from Amelung's contribution on the "localization" of meteorology under Zhu, which emphasizes the symbolic value of "meteorological sovereignty" for the Chinese nation-state, to look at how "China" itself was baked into the knowledge that Zhu and his colleagues produced in the early twentieth century.

The first two sections of this essay address the place of the nation in climatologists' production of *spatial* knowledge and their production of *cultural* knowledge respectively, without drawing too firm a boundary between the two. In the first section, I argue that the premises and methods of early twentieth-century climate science lent themselves to descriptions of climate in spatial terms that corresponded well with the imagined geography of the Chinese nation-state.[8] Climatologists collated data from over 100 ROC meteorological stations to produce an image of the "Chinese climate" that encompassed all of the territory within national borders but emphasized the capital region along the eastern Yangtze valley, and later, around the wartime capital of Chongqing. They also variegated that image by outlining "climatic provinces" within the borders of the nation-state.

The second section demonstrates that the use of instruments at meteorological stations did not simply displace culturally specific "ways of knowing" about weather and climate. Instead, scientists promoted the value of classical texts for gleaning phenological data and adapted historical frameworks for thinking about seasonality. Here again it is impossible to establish a neat horse-and-carriage relationship between politics and scientific practice: the use of "China" as a frame of analysis emerged from a sustained engagement with Chinese-language texts among scholars who were steeped in these texts from early childhood. At the same time, the synthesis of modern science with millennia of Chinese-language scholarship inspired Zhu and his colleagues to speak triumphantly of their country's unique contributions (and potential contributions) to the global imperative of *qiu zhen*, or "pursuing truth."

The final section contends that atmospheric phenomena played a role in affirming the notion of China as a natural object. I consider two large-scale weather patterns that were tremendously important to climate scientists of the early twentieth century: the monsoon or *jifeng*, and the plum rains or *meiyu*. The former of these confronted climate scientists with a conundrum: should the monsoon be analyzed as a transnational phenomenon that extended across "monsoon Asia," or were the Indian and Chinese monsoons qualitatively different? I show how the interaction of the summer monsoon with the late-spring "plum rains" supported the perspective that China was both exterior to the Indian monsoon system and partly integrated with an East Asian system of cyclonic rainfall. Zhu's analysis of monsoons and plum rains took into account both their relative influence on the Chinese nation and their behavior as registered on scientific instruments, illustrating a point that unifies this essay: climatology depended on simultaneous reference to global standards and culturally specific categories of analysis. This nexus of national frameworks with atmospheric forces in the practice of climatology is what I term the "framing of the atmosphere."

Before proceeding, a note on terms: it makes little sense to draw a sharp distinction between "meteorology" and "climatology" in Republican China, and I do not. Meteorology functioned initially as an extension of geography (increasingly influenced by physics and mathematics) and the study of climate as an extension of meteorology. Thus, Zhu was at once a geographer, a meteorologist, and a climatologist. As a rule, I refer to "meteorology" (*qixiang xue*) when discussing the use of instruments to measure atmospheric phenomena (*qi xiang*), and "climatology" (*qi hou xue*) when discussing scientists' use of that same meteorological data in combination with other sources to analyze long-term patterns.

Climate and Space

As in the United States and elsewhere, Chinese meteorology began with a series of isolated stations that gradually coalesced into a national network. For example, it appears that individuals in north China's notoriously arid Shanxi Province had begun constructing their own psychrometers—a primitive instrument for measuring humidity that is normally constructed of two thermometers—by 1921, when the provincial government disseminated two documents intended to "benefit the entirety of Shanxi province": a chart explaining how to standardize and synchronize psychrometer readings with the rest of the province, and visual instructions for constructing a "hundred leaf box" (*baiye xiang*), known in the English-speaking world as a Stevenson screen, for sheltering the psychrometers from direct sunshine per international standards.[9]

Though the *baiye xiang* was a rare sight in China during the 1920s, these little white boxes popped up on farms, hilltops, and school grounds across the ROC in the 1930s and became one of the general population's most accessible interfaces with science. Inside their louvered walls went an expanding suite of instruments that would transform the categories by which the Chinese perceived the atmosphere: thermometers, barometers, and hygrometers or psychrometers were the most common.[10] Authorities promoted the *baiye xiang* as agricultural aides, but as county-level stations implemented national standards and connected to regional headquarters, their data helped leading climatologists to assemble a mosaic-like image of the "Chinese climate" and its regional components, while the geographical breadth of China's meteorological administration made it worthy of participation in the International Meteorological Organization.

Prior to the 1920s, the scope of meteorology in China (and before 1912, the Qing empire) reflected the "carving up" of China by foreign empires that began with the Opium War (1939-1942), the Second Opium War (1856-1860) and the international suppression of the Boxer Uprising (1899-1901). The first scientific weather stations in the Qing empire were concentrated along the eastern seaboard in the British colony of Hong Kong and a number of foreign concessions. The 1873 founding of the Zikawei (or Xujiahui) Observatory by French Jesuits just outside of Shanghai's French concession roughly coincided with the establishment of the meteorological branch of the British Maritime Customs Service at ports and lighthouses along the coast of southeast China, which began to collect readings in 1874. These efforts were followed by the German founding of Qingdao Observatory (1898), which passed into Japanese hands during the First World War. After the Russo-Japanese War of 1904-1905, when the two powers defined their respective spheres of influence in Manchuria, Japan's Kwantung Army began to establish weather stations in southern Manchuria and the Russian empire established its own in northern Manchuria.[11]

Although some foreign-established stations, such as the Zikawei Observatory, were clearly sites of scientific collaboration between Chinese and foreign nationals, Chinese institutional histories of the Republican era generally treated these foreign establishments as historically and spatially external to what they called "Chinese" or "domestic" meteorology (*Zhongguo qixiang xue*, *guonei qixiang xue*). This foreign/domestic distinction is perhaps most explicit in the lament of the 1947 *Meteorology Report* (*Qixiang cebao*) that "Chinese meteorology fell into the hands of foreigners who meddle in others' affairs, and to speak of it is shameful."[12] Further, though many of these foreign establishments continued to operate into the 1930s and beyond, they were generally not the stations whose data populated the pages of *The Meteorological Magazine* (*Qixiang zazhi*) and other Chinese meteorology periodicals. In Zhu's view, foreign meteorologists in China were mere guests whose "voice has overpowered that of the host."[13] Zhu would play an outsized role in domesticating meteorology through his roles as head of the Academia Sinica

Institute of Meteorology, an author and editor of many volumes on meteorology and climatology, and a frequent contributor to such prominent journals as *Science* and *The Meteorological Magazine*. As he worked to build a national network of weather stations from 1929 onward, he was partly motivated by a sense of shame over the fact that foreign-run stations produced most of China's meteorological data, and a desire to achieve what Clark Alejandrino has labeled "meteorological sovereignty," or Chinese control of meteorology within China.[14]

Today, Zhu is celebrated in the PRC as a scientist, patriot, and educator who embodied not so much a rejection of foreign influence over China as a desire to place Chinese science, and especially Chinese climate science, on the world stage.[15] A native of southeast China's Zhejiang province, he pursued his secondary education at the Tangshan School of Rail and Mining in Shanghai, where he became "Student 127" in his science classes because, by his account, his American teachers would not learn his name. In 1908, the United States Congress moved to annul nearly 12 million dollars of the indemnity that the U.S. had demanded from China after the Boxer Uprising on the condition that the refunded amount be used to fund education. One outcome was a Boxer indemnity scholarship program that began in 1909 and sent exceptional young Chinese men to pursue higher education in the United States. Zhu was one of 70 students to test into the second cohort of indemnity scholars and, after chopping off his queue in a secret act of rebellion against the Qing dynasty, he boarded the *S.S. China* for San Francisco.[16]

Zhu's prior training had emphasized civil engineering, but he felt that China, unlike the United States, was "a country founded on agriculture" and chose to pursue a degree in agriculture at the University of Illinois at Urbana-Champaign. A two-month summer practicum on farms in the southern U.S. convinced him that American farm practices—which involved much Black sharecropping and vast tracts of land–were of little relevance to the situation in land-choked China, and thus he left the study of agriculture behind to pursue his doctorate in meteorology at Harvard University in the hope that this would benefit Chinese farmers.[17] This was a reasonable move: the U.S. national weather service had been under the authority of the Department of Agriculture since 1891, and it was widely understood that agriculture was the primary application of meteorological science. At Harvard, Zhu studied under Robert DeCourcy Ward, a pioneer of climate science in the United States, but meteorology was then a fledgling discipline, and so Zhu was housed in the department of Geography. Given Zhu's background and interests it should be no surprise he studied the atmosphere with eyes to the earth. In 1916 while still a graduate student at Harvard he wrote that "climate (*tianshi*) difers on the basis of geography, and in fact it is one element of geography."[18]

Upon returning to China in 1918, Zhu held a series of posts that included chair of the Geoscience (*Di xue*) department at Southeastern University (later renamed Nanjing University). There he was an active member of the Science Society of China, published frequently in the journal *Science* (*Kexue*) and trained several of China's most influential intellects, including the climatologist Lü Jiong and the geographer Hu Huanyong. In 1929, Cai Yuanpei selected Zhu to head the Institute of Meteorology at the new Academia Sinica (*Zhongyang yanjiu yuan*), a position he held until 1936.[19] During his last year in Nanjing he published a concise "Plan to Establish Meteorological Stations through the Country" with the aim of setting China on par with Japan, the United States, Germany, France, and Great Britain. To justify his costly plan, he outlined benefits in five areas: (1) agriculture, (2) maritime operations, (3) aviation, and (4) dispelling "superstitions" about the weather.[20]

Zhu's tenure at Academia Sinica was marked by rapid institutional growth: in 1932 the Institute of Meteorology promulgated a set of "Nationally Implemented Regulations for Meteorological Observation" that knitted China's growing hodgepodge of weather stations into a centralized, hierarchical network: each provincial government was to designate or establish a "tier two" or "tier three" station and each city and county government was to designate or establish a "tier four" station, all of which were ultimately linked via an information network to the "tier one" station in the capital.[21] The inaugural issue of *The Meteorological Magazine* in 1935 raved that "more meteorological stations are established by the day, and meteorological materials [ie, reports] increase by the day." By 1936 there were over 300 state-run meteorological stations (*qixiang cehou suo*) across China from Lhasa to Xi'an to Beijing, though they remained concentrated along the eastern seaboard.[22]

In the process, Chinese meteorology became a polycentric affair organized around nine regional headquarters with their own Tier Two stations (figure 1, table 1). The building of state-run weather stations during the 1930s and 40s is best understood as an effort to produce detailed images of the regional centers by extending their apparatuses of observation both laterally, through telegraph and postal connections to lower-tier stations in the hinterlands, and vertically, by releasing sounding balloons into the stratosphere. The justifications for this decidedly uneven mode of development were mostly practical: ongoing civil war, and by 1937, international warfare and a Japanese shipping embargo as well as runaway inflation, ensured that the optimal operating conditions at the regional Tier Two stations—with their disposable sounding balloons, barometers, hygrometers, and evaporimeters, and personnel to record instruments and perform calculations—were impossible to extend beyond the handful of urban centers where Guomindang capital and the Chinese population were most concentrated.

Figure 1. Map of the administrative regions of the Central Meteorological Bureau showing communication lines between the Central station, regional headquarters, and outlying stations.

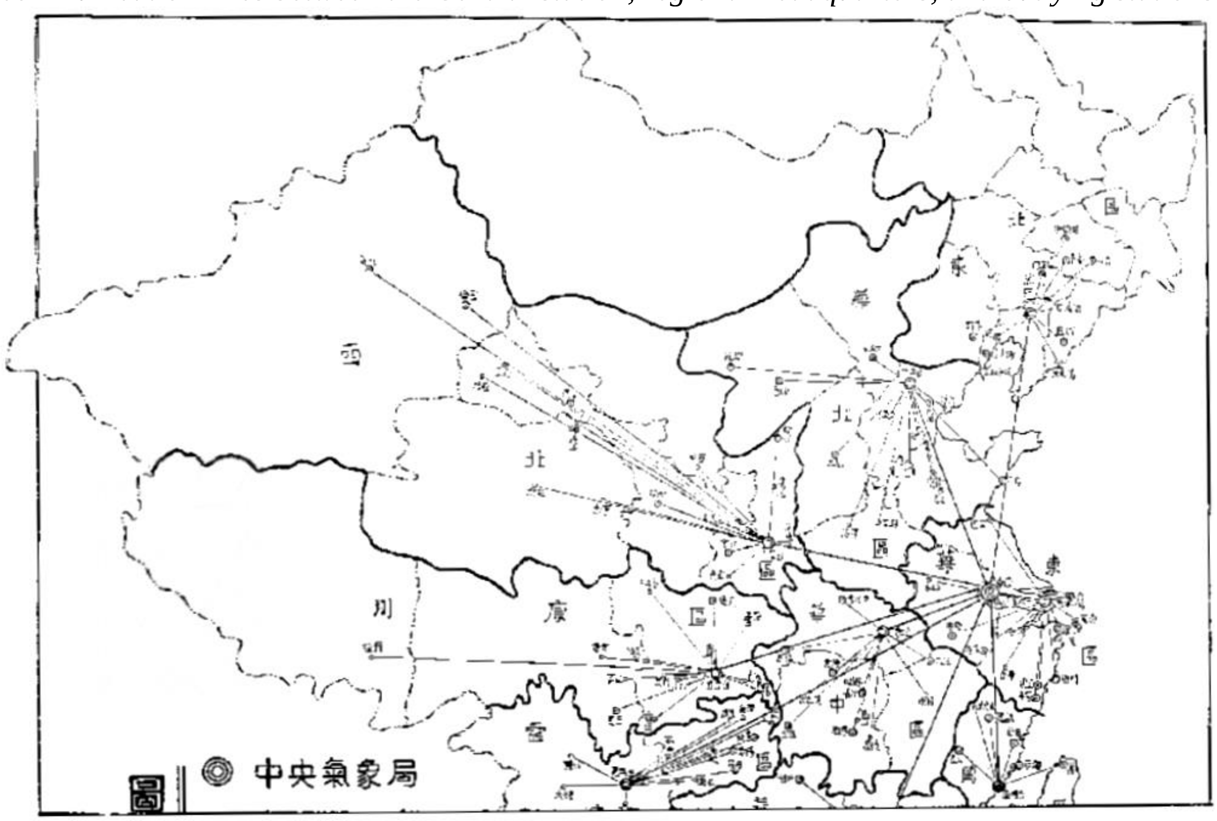


Table 1. The meteorological administrative regions of the Republic of China in 1947 and their regional headquarters (Qixiang cebao, pp. 6-7).

Region	**Provinces/Territories**	**Managing Station**
East China Region 華東區	Jiangsu, Anhui, Zhejiang	Shanghai
South China Region 華南區	Macao, Guangxi	Guangzhou
North China Region 華北區	Hebei, Henan, Shandong, Shanxi, Chahar, Suiyuan	Beiping
Min-Tai Region	Fujian, Taiwan	Xiamen

閩臺區		
Chuan-kang Region 川康區	Sichuan, Xikang, Tibet	Chongqing
Northwest Region 西北區	Gansu, Xinjiang, Qinghai, Sha'anxi	Xi'an
Central China Region 華中區	Jiangxi, Hunan, Hubei	Hankou
Yun-Gui Region 雲貴區	Yunnan, Guizhou	Kunming
Northeast Region 東北區	Manchuria[23]	Shenyang (Mukden)

Nevertheless, the core-periphery framework generated an atmospheric geography that was thoroughly rooted in the urban political geography of the Republic of China. Consider a rather ordinary rainstorm that inundated the Sichuan basin on April 20, 1938: *The Meteorological Magazine* pieced together a detailed narrative of its origin and movements by sourcing balloon readings of the troposphere and stratosphere over the Tier Two stations in urban Chongqing and Xi'an (both well outside of the basin) as well as multiple instrument readings from the Tier Two station in Chengdu (in the middle of the basin) and wind and rainfall readings from four peripheral stations around Chengdu. In other words, a weather event with important economic implications for the myriad rural counties of the Sichuan basin was reported mainly in terms of its measurable effects over a select few urban settings with large Guomindang contingents. That report—typical of its time—illustrates the extent to which knowledge about atmosphere was "grounded" in the political landscape.[24]

By the mid-1930s, the extensive but nationally bounded geographical coverage of China's weather stations prompted two scientific developments that might at first glance seem contradictory. On one hand, regional reports from disparate settings like the Sichuan basin and the Altaic plain underscored the diversity of climates within Chinese borders. On the other hand, certain climatologists drew on much of the same data to produce grand theories about "the Chinese climate." How do we explain this?

It is tempting to assume that ideology, rather than data, drove such discussions, but the reality is more complex: to a certain extent, the notion of a "Chinese climate" emerged from the methods and material conditions of climatology as it was practiced in this era. From the late 19th century until the late 20^{th} century—at which point meteorology was revolutionized by physics-based models of global atmospheric circulations aided by satellite imagery—the study of climate emphasized regional “centers of action.” These were geographical locations where seasonal high or low pressure, created by the variable heating and cooling of the earth’s surface, prompted long-range airflows from high-pressure zones to low-pressure zones.[25] The case for a Chinese climate as espoused by Zhu and others held that China featured a *dalu xing* or “continental” climate controlled by four centers of action outside the nation or on its fringes: a winter high-pressure system in central Asia sent air streaming eastward toward a low-pressure system in the vicinity of the Aleutian Islands, while a summer high-pressure system over the mid-Pacific sent winds gushing toward a low-pressure center in northeast India.[26] The result was a “monsoonal” pattern of seasonally changing winds whose effects on precipitation were complicated by slower-moving fronts as discussed later in this essay. Historian Zhihong Chen has noted that many Chinese intellectuals of the early twentieth century viewed the Chinese as a people of the middle; for example, by way of a double entrendre, the geographer Zhang Qiyun—a onetime student of Zhu—construed *Zhongguo ren*, or Chinese people, as “people of the middle realm,” which included the middle latitudes and middle altitudes.[27] The scientific view of China as situated between four climatic centers of action certainly resonates with that view of the nation.

If the “centers of action” model supported the notion of a “Chinese climate,” temperature and rainfall readings from China’s hundreds of weather stations projected a different image. By one analysis, average temperatures in Urumchi in the far north and Qiongzhou in the far south differed by nearly 40 degrees centigrade during the first five days of January.[28] That sort of difference was well modeled by the internationally popular Köppen classification system, which designated a series of international climate bands—from tropical to polar—several of which overlapped with the Republic of China.[29] Was the Köppen system incompatible with the notion of a national climate?

The response of Zhu and several other leading climatologists to this tension was not to dismantle the “Chinese climate” into a series of transnational Köppen zones, but conversely, to subsume the Köppen system into the national climate by designating a number of “climatic provinces” analogous to (but not coterminous with) the political provinces of the nation.[30] In his 1949 essay on “The Climatic Provinces of China,” Lü A argued that “the Köppen climatic types, especially BS, Cwa, Cfa and Dw, covering too vast an area, can hardly be recognized as climatic unities," and that they should be fine-tuned within a national framework. Drawing on recently identified isotherms (regions experiencing the same temperature at the same time) and isohyets (regions experiencing the same amount of rainfall at the same time) as measured by Chinese stations, Lü proposed a series of 10 climatic provinces in China, some of which were divided into sub-provinces (table 2).[31] For reasons that likely involved both national interests and the relative difficulty of accessing foreign data, these climatic provinces ended at the Chinese border, excluding regions in the same Köppen zone on the other side of the border.

Table 2. The climatic provinces of China as identified by A. Lu, "The Climatic Provinces of China," pp. 467-473.

Climatic province	**Koppen classification**	**Defining characteristics**
The Northeast Type	Dw	Severely cold winter, rainy hot season, spring sandstorms.
The Northern Steppes	BSkw	Severely cold winter, low rainfall, warm or hot summer.
The Northwest Mountain type	Variable	Dramatic variation with altitude.
The Northwest Deserts	BW	Very little precipitation, severely cold winter, severely hot summer, and spring sandstorms.
The North China Type	BSkw – Cwa/Cfa	Hot and rainy summer, cold and sunny winter, moderate rainfall.
The Central China Type	Cfa and Cwa	Highly variable rainfall from year to year.
The Shantung Hills and Hweiho Plain	Cwa and Cfaw	Heavy plum rains (*mei yu*) in late spring/early summer, and spring and winter cyclones.
The South China Type	Cwa and Cfa	Heavy rainfall, high humidity, typhoons in late summer and early autumn.
The Hainan Type	Aw and Am	Heavy rainfall, extreme humidity, typhoons or storms in late summer, with temperatures rarely dropping below 18 degrees Celsius.
The West China Type	Variable	Dramatic variation with altitude.

An unintended consequence of World War II was that it dramatically accelerated the production of climatological knowledge about west China. In 1937, the imminent Japanese invasion of Nanjing forced the Academia Sinica Institute of Meteorology to flee west, first to Wuhan, and eventually to Chongqing, where the Guomindang established the Republic of China's new wartime capital.[32] Thus far, meteorology had been a mainly academic affair, but 1941 saw the creation of the Central Meteorological Bureau (*Zhongyang qixiang ju*) in Chongqing under the direct authority of the Administrative Yuan. This bureau began to network with observation stations in multiple provinces, though these were all situated in China's far west—Qinghai, Gansu, Sichuan, Xikang and Yunnan—because of territorial loss in the east. The scholar and refugee Zhang Baokun, who first achieved prominence as a Nanjing meteorologist, quickly developed an interest in "certain peculiar characteristics of the Szechuan climate" and produced a detailed outline of the "climatic regions" of Sichuan province that drew its inspiration from Zhu Kezhen's climatic provinces, and its data from Sichuanese weather stations operating between 1937 and 1940.[33] Another east-coast meteorologist, Lü Jiong, developed an interest in the climate of the Tibetan plateau and its impact on local society. As inaugural head of the Central Meteorological Bureau he oversaw the growth of meteorological institutions in eastern Tibet, including a tier-two station in Kangding. But he also personally analyzed and published new data from Tibet pertaining to its distinctive air pressure and rainfall patterns. Overall, Lü's analyses underscored Tibet's status as an exotic national frontier rather than its affinities with the climate of China proper; it was a place where the "terrain is very high, the climate is relatively cold, and the amount of rainfall is extremely small."[34]

Zhu had himself acknowledged that the Tibetan plateau was elevated above the influence of the high- and low-pressure centers of action that generally controlled the "Chinese climate," and that it more closely resembled a polar climate.[35] But in a strategy resembling the "minorization" of ethnic groups within a national framework, Chinese climatologists evaluated extreme climate outliers in the context of other regions under Chinese observation and typically *not* in the context of contiguous regions beyond national borders, such as northeast India (contiguous with Tibet) and southeast Asia (contiguous with southwest China). On the high end of the Celsius scale, Zhu noted that only 2.4% of the area of China, on its southern margins, belonged to the tropical belt.[36] This framing of the frontier not only enabled the notion of a "Chinese climate" to persist, but positively reinforced it: the heights of Tibet and the heat of Guizhou appeared to form the natural fringes of the national climate, and as we shall see, the material limits of culture. Perceived atmospheric influences on culture, and cultural lenses on the atmosphere, further reinforced a national framework for climate study.

Climate and Culture

The growth of native meteorological institutions promoted and countervailed China's unique identity in different ways, reflecting a broader trend in the history of science. We have seen that the coverage of Chinese weather stations came to resemble China's national territory by the 1930s, while the adoption of international scientific standards granted the Republic of China entry into international bodies like the International Meteorological Organization, where it was theoretically one nation among equals. On the other hand, new institutions and beliefs threatened to supplant received ideas about the environment that might otherwise have been celebrated as part of China's national culture. For instance, while yin-yang theory was important to older ideas about the weather, it had little place in scientific meteorology as advocated by Zhu Kezhen.

The replacement of local sciences with what historian Joseph Needham calls "the universality of modern science" is hardly inevitable (consider that "traditional" Chinese medicine is a thriving industry today), yet such convergence can appear to be a natural process, as suggested by Needham's pet metaphor in which local bodies of knowledge are like "rivers flowing into the ocean of modern science."[37] While Needham devoted considerable attention to pinpointing the chronological "fusion point" between Chinese and Western scientific ideas, a recent essay by Fiona Williamson calls for historians to track culturally specific ideas about climate in a more holistic way to better understand "the cultural assimilation of climate across different geographic and temporal frames."[38] In what follows I attempt such a task with attention to the way that modern climate scientists grappled with what they perceived as distinctly Chinese traditions.

So much of what we might call "traditional" Chinese knowledge about the weather affirmed the idea that terrestrial beings played an active role in celestial phenomena. The principle of "resonance between heaven and humanity" (*tian ren ganying*) became integral to political philosophy as early as the second century BCE under the imperial chancellor Dong Zhongshu. Emperors, literati, and others in dynastic China cited both disastrous and auspicious weather as reflecting the virtue of the state, which practice Mark Elvin has called a sort of "moral meteorology" that was "on the edge of attempted science."[39] But there were (and are) also folkloric notions about weather beyond the politicized realm of moral meteorology. For example, a story recorded in the 17th-century *Encyclopedic History of Love* (*Qing shi leilue*) tells of a merchant's bride, Lady Shi, who implored her new husband not to travel without her. Ignoring her, he left and never returned, and she died of her grief—but her ghost promised the wives of the earth to send forth a wind whenever merchants traveled abroad.[40] In a different tack, the ancient *Book of Changes* claimed that "clouds follow dragons, and winds follow tigers."[41]

Twentieth-century meteorologists were quick to label such ideas as "superstition." From the 1920s onward there were numerous efforts to educate Chinese public about the difference between weather science and weather superstition, including a volume on *Meteorology and Superstition* published by the Kunming Meteorological Observation Bureau in 1938, which juxtaposed various meteorological phenomena in classical texts with explanations from the modern science of meteorology. Wind, the book explained, was neither the effluence of tigers nor the curse of a woman scorned, but rather, the result of differences in temperature and pressure from place to place. Rainbows were produced not by the illicit mingling of yin and yang, but rather, by the refraction of light by rain droplets in the air.[42] Zhu Kezhen himself adopted a respectful stance on the "ancients" (*guren*), crediting their active interest in the world around them but questioning their methods of observation. Ancient Chinese scholars were "remarkably curious" about geography, he pointed out in an early essay, but the empirical basis of their geographical writings was usually unclear.[43] He similarly introduced a 1923 textbook on meteorology by pointing out that collections of ancient songs were replete with observations about atmospheric phenomena, but that these should be distinguished from meteorology:

> Since ancient times, human beings have wandered about in the atmosphere, pointing out that which they heard with their ears, that which they saw with their eyes, and that which they felt, from wind, rain, thunder, and lightning, to clouds, frost, snow, and hail, to cold, heat, dryness and moisture. All of these things are related to meteorology (*qixiang*), and they occupied the hearts of the ancients. [But] although meteorology has early origins, its development into a science does not precede affairs of the past fifty years. The songs that the ancients recorded were gleaned mostly from the observations of the common folk and were not calculated using standardized instruments.[44]

If Zhu and other climate scientists recognized that conflict between new and received ideas about the atmosphere was inevitable, they nevertheless attempted serious engagement with received knowledge and often asserted the scientific relevance of classical texts that could easily have been dismissed as prescientific. Zhu's attention to classical literature surely stemmed in part from his upbringing in the twilight of the Qing empire. His elder brother Shaojia achieved the rank of licentiate (*xiucai*) in the civil service exams when Zhu was nine *sui* (eight or nine years old), becoming the latter's role model by his own later admission. Much of Zhu's childhood was spent studying the classics and composing traditional eight-legged essays before the civil service exams were abolished in 1905 as part of the late Qing reforms.[45] Although he turned to more technical pursuits as a teenage student in Shanghai and then the United States, Zhu continued to refer to the classics throughout his career. On the eve of the Japanese invasion in November 1936, in his Hangzhou quarters, he read and reflected on *Laozi* and *Mencius* in light of current events: Laozi, he felt this time around, was an advocate of non-resistance and an inspiration to the "Han traitors" that would collaborate with the Japanese. It was better that academics meditate on Mencius.[46]

Just as Zhu himself embodied a melding of classical and scientific education, the intellectual climate he promoted as a leading figure in the Chinese academy of the 1930s and 40s was characterized by cautious veneration for China's storied philosophical tradition, and the Confucian (*Ru*) tradition in particular. This is especially apparent in *An Overview of Modern Academic Culture*, a 1948 four-volume collection that Zhu edited as president of Zhejiang University. In the opening essay of the first volume (*Humanities*), Zhu concurred with a recent statement by the Irish scientist and historian J.D. Bernal that China was one of the four ancient centers of civilization such that its present scientific backwardness was something of an enigma, but also that China's rich tradition of moral and political philosophy—as exemplified by the *Doctrine of the Mean*—predisposed it to attaining a scientific standing on par with the United States and Europe if only the Chinese embraced inductive logic. He echoed the French mathematician Henri Poincare that "the pursuit of truth should be the goal of our activities," but he also ruminated on Poincare's naiveté regarding the practical applications of science in warfare.[47] He pondered rhetorically: what would Poincare, who died in 1912, think about science if he were to come back to life in 1948, after two World Wars had subjected thousands of civilians to the terrors of technologically advanced aerial bombardment? Zhu resolved that as China took a leading position in the scientific community, it must also pave the way for a global ethics of science based on millennia of moral introspection in the Confucian tradition. "How can we allow the world of the future continue to develop modern science on the one hand," he pondered, "and also realize peace on the other? This is an extremely important problem for the present, and it is also an issue to which our China should make a special contribution."[48]

These sentiments were echoed by Zhejiang University mathematician Qian Baocong in the pursuant chapter of Zhu's edited volume, which called for the integration of the "old humanities" with scientific knowledge to create a "new humanities" (*xin renwen xue*) that would join the sciences in pursuit of truth. An *unideal* scenario, according to Qian, was a China in which humanists dominated education but eschewed science while scientists dominated material life with little regard for humanistic concerns. He viewed the history of science (*kexue shi*) as the natural nexus between the sciences and the humanities, but notably, he envisioned a history of science that made room for China's storied Confucian tradition. Highlighting Xunzi's dictum that "to conform to heaven and regale it is not so good as to command the rules of heaven and employ them," Qian rejected the notion that Confucianism was antithetical to science and argued that China's scientific deficiency relative to the west was an anomaly of the past 300 years. According to his utopian vision, Chinese science would heal national and class divides because "our people have five thousand years of experience and can utilize the scientific pursuit of truth to unite the hearts of humanity."[49] Here Qian was invoking the principle of *qiuzhen*, or "pursuing truth," a phrase Zhu Kezhen was especially fond of. On November 19, 1938, as the relatively new president of a Zhejiang University that was in exile from Japanese-occupied China, Zhu delivered a speech on "The *Qiuzhen* Spirit" at a campus-wide meeting that also saw the institution of *qiuzhen* as the school motto (compare with the Harvard motto: *Veritas*).[50] The following year he also published an essay that ended with this intellectual call to arms: "presently if we want to rescue our China, we can only depend on our own strength, and this spirit of pursuing truth will cultivate our strength and save our homeland."[51] It is clear from Zhu's writings that *qiuzhen* was at once a scientific, humanistic, and revolutionary ideal.

In fact, while climatology was usually understood to be a natural science, Zhu and others were keenly aware that it was guided by human concerns. This is well illustrated by the issue of seasons: a central concern of climatology was the length and timing of seasons and their variations from region to region, but the criteria by which scientists identified the seasons were necessarily ethnocentric in nature, and thus, a robust study of the seasons required a certain amount of historical literacy. For example, while it was generally agreed upon that the Chinese term *qiu* corresponded to the English term *autumn*, and that both were of particular relevance to the harvesting of grain, the relationship of *qiu* to *autumn* was not one of semantic equivalence: the Chinese tended to recognize *qiu* as beginning somewhat earlier than European autumn. Nor, for that matter, was the Chinese term *qihou* perfectly equivalent to *climate*. The term *qihou* derived etymologically from the Chinese imperial calendar that was fixed by the second century CE, and which, in addition to designating lunar months, divided the year into twenty-four solar intervals, or *qi*, and further into 72 pentads (five-day periods), or *hou*. Encapsulated in the names of the twenty-four *qi* was a wealth of climate-related information about the timing of rains and snows as well as periods of "great cold" (*da han*) and "great heat" (*da shu*). Comparing temperature data from 84 meteorological stations throughout China—from Fujian to Inner Mongolia—with the dates of *da han* and *da shu* on the Chinese calendar, the meteorologist Zhang Baokun determined that the *qi* interval system predicted Chinese temperature trends to a high degree with minor regional variations, prompting him to remark that it provided "indubitable proof of the superiority of the ancient Chinese culture."[52]

In a groundbreaking 1934 paper, Zhang proposed a method for determining the onset of the seasons that attempted to reconcile inherited Chinese knowledge with scientific observation. He noted that the American tendency to fix the dates of the seasons according to solstices and equinoxes largely disregarded both practical considerations and regional variations, while the English tendency to associate seasons with months on the Gregorian calendar, and the Chinese tendency to associate seasons with lunar months on the Chinese calendar, were similarly arbitrary. Zhang preferred to align his seasonal thresholds with common *phenological* cues—environmental events such as bird migrations and flower blooms—that people in central China commonly recognized as markers of seasonal change.[53]

Nanjing was Zhang's primary reference point, as it was for the prewar work of Zhu Kezhen. For Nanjing folk, the telltale signs of spring included the sight of cherry blossoms and the sound of cuckoos, both of which seemed to coincide with temperatures of about 10 degrees Celsius, while the end of the cherry and plum seasons seemed to coincide with temperatures above 22 degrees. With reference to these and other phenomena, Zhang proposed 10 degrees and 22 degrees as the upper and lower thresholds of the four seasons: for example, spring was to be defined as beginning at 10 degrees and ending at 22 degrees. His other major innovation was defining the *hou wen* or five-day temperature average—mapped to the *hou* (pentads) of the traditional calendar—as the basis for identifying these thresholds. Applying his method to recent data from Chinese meteorological stations, Zhang determined that autumn arrived in Nanjing and Shanghai during the first *hou* of the *li qiu* period (approximately September 23) and in Beijing somewhat earlier, during the first *hou* of the *bai lu* period (approximately September 8).[54] Zhang tabulated his full set of calculations in a lengthy appendix, which inferred that much of southern China experienced no winter at all while the northern city of Harbin enjoyed only 30 days of summer.[55]

What I wish to emphasize here is the way that Zhang's system enlisted received knowledge to lend coherence to the remarkably varied "Chinese climate." By interpreting thermometer readings in relation to the *qi-hou* system of the traditional calendar and the phenology of Nanjing, his system affirmed the Chinese nation-state as the frame of scientific analysis and reified the center-periphery relationship of the capital region to the outlying provinces. Zhang justified his Nanjing-centric method on the basis that "some standard has to be adopted in order to show how the four seasons are divided in various regions."[56] But it was not an entirely arbitrary or ethnocentric choice: the capital region's seasonal phenology aligned particularly well with the internationally-recognized solar equinoxes and solstices when compared with, say, the phenology of Beijing to the north or Fuzhou to the south.

Phenology and classical texts played an even more significant role in the defining intellectual pursuit of Zhu Kezhen's career: reconstructing an image of the Chinese climate over several millennia of its history.[57] In 1931 he attempted a preliminary comparison of modern phenological records with ancient counterparts. For ancient phenology he relied mainly on the chapter entitled "Instruction on the Seasons" in *The Lost Book of Zhou* (ca. 100 BCE) because its adherence to the *qi-hou* system of solar periods rather than the lunar months made it easy to convert dates to the Gregorian calendar. "Instruction on the Seasons" predicted certain non-human events during each pentad of the year. Consider its forecast for the period known as *Chunfen*, whose onset roughly coincides with the vernal equinox: "On the day of *Chunfen*, the swallow appears. Five days later, thunder sounds. Five days later, lightning begins."[58] The appearance of the swallow was useful for theorizing about climate change because, as Zhu noted, the Institute of Meteorology in Nanjing had recorded the first annual appearance of the house swallow in Nanjing in recent years. Noting that the *The Lost Book of Zhou* placed the animal's appearance between a week and a month earlier than Nanjing records of the last two years, and that the text was most likely composed near and for the middle Yellow River valley—which was considerably north of

Nanjing—Zhu theorized that Chinese spring must have begun somewhat earlier two millennia ago, implying a long-term cooling trend.[59]

Even as Confucian tradition grew professionally inexpedient in China under Communist Party rule (1949-present), Zhu defended the importance of phenological records as sampling the experience of the "laboring people" two thousand years hence.[60] In 1973 he published what would become his most renowned work, entitled "A Preliminary Study of Climate Fluctuations during the Last 5,000 Years in China."[61] Drawing on a diverse array of textual records including Shang oracle bones, dynastic histories, local gazetteers, and post-1900 instrument readings, he pieced together an outline of China's climate from approximately 3,000 BCE to the present, which included the precocious observation that much of China experienced a period of relative cold from the 1620s through the early eighteenth century—a find that predated Euro-American writings on the "little ice age."[62] His data suggested that major weather events played a substantial role in China's dynastic history, including the fall of the Ming dynasty and rise of the Qing dynasty in 1644.

But Zhu was skeptical toward classical notions of causality, which is evident not only from his explicit denunciations of "superstition," but also, and more subtly, from his tendency to ignore large portions of the ancient texts that he cited. Consider once more the *Chunfen* portion of "Instruction on the Seasons," this time in full:

> On the day of *Chunfen*, the swallow appears. Five days later, thunder sounds. Five days later, lightning begins. If the house swallow does not appear, [it is because] wives are not with child. If the thunder does not sound, [it is because] the dukes have lost their subjects. If the lightning does not commence, [it is because] the lords do not inspire awe.[63]

Lost in Zhu's citations of phenological texts is the kind of resonance between the moral and meteorological realms that features so clearly in the passage above. His sanitized version of the passage suggests a commentary on causality: if the ancients espoused a sort of "moral meteorology" in which the human realm both influenced weather events and suffered (or enjoyed) the consequences, for Zhu, it was Chinese climate that uni-directionally influenced Chinese culture in all its historical and regional variations. This, of course, was the heyday of modern climate determinism, engendered by such scholars as the American geographer Ellsworth Huntington, who wrote in 1913 that "among the phenomena of nature none affect mankind so directly and vitally as those which pertain to climate," and the Japanese philosopher Watsuji Tetsuro, who wrote in 1935 that "all of us live on a given land and the natural environment of this land 'environs' us whether we like it or not."[64]

Huntington's 1915 *Civilization and Climate* had an outsized influence on Chinese climatologists beginning with Zhu Kezhen, who cited the Yale professor extensively in a 1916 essay on "The Relationship Between Geography and Culture" while still a doctoral student at Harvard. Zhu argued that race and geography were the two dominant factors in cultural development, which he understood to exist on a scale from less to more cultured after the manner of the anthropologist E.B. Tylor. Wrote Zhu, "geographical climate (*dili tianshi*) and the development of a race are directly related, and we cannot distinguish one as less important, and the other as more important."[65] Central to Zhu's worldview was the idea that agriculture was the precondition of civilization, which prompted him to declare that the civilized countries of the world, including China, were all situated in the temperate zone, the Congo was only semi-civilized, and the "Eskimo" (ie, Inuit) had no culture to speak of.[66] Later he would apply an environmental-determinist lens to ROC ideology by analyzing the influence of weather on Sun Yat-sen's doctrine of the "needs of the people's livelihood" (*minsheng xuyao*), namely, clothing, food, shelter, and transportation.[67] Weather, in this analysis, produced differences between national cultures as well as within them: for instance, he surmised that the round collar of the Zhongshan suit was better suited to a northern Chinese winter than the straight collar of the western suit, but also that the climates of northern and southern China fostered very different culinary habits as exemplified by the fact that "southerners eat rice and northerners eat wheat."[68]

Zhu distanced himself from environmental determinism in later years, but his early writings influenced later generations of climatologists, including his colleague and frequent collaborator Lü Jiong. Lü was environed from an early age by the landscape of southeast Jiangsu province: he grew up in the ecologically diverse Wuxi county, where farmers alternately grew wheat and rice and raised silkworms on a flat plain surrounded by hills, forests, and the majestic Tai lake.[69] In 1937, near the peak of the second Sino-Japanese war, Zhu edited a volume on *Scientific National Revival* and included an essay by Lü on "The Relationship between the Chinese Nation and Climate." Lü —who was then Zhu's colleague in the meteorology department at Zhejiang University—argued that heredity and environment were the primary factors in human development, and proposed that scientists should first determine the relationship between climate and human beings in general, and then apply that knowledge to understanding the Chinese nation in particular.[70] Drawing inspiration from Zhu as well as foreign climatologists including Ellsworth Huntington and Edwin (E.G.) Dexter, he conjectured that climatology could offer a deeper understanding of health, human activities, crime, madness, suicide, alcoholism, agriculture, migration, unrest, and culture.[71] This version of climatology verged on a theory of everything.

Lü was not without skepticism. Some of the international scientists whose work Lü cited in support of China's national revival could just as easily be cited against that endeavor. One of the central aims of Huntington's *Civilization and Climate*, for instance, was to demonstrate scientifically that climate advantaged the United States and western Europe over most of Asia and the colonized world. Huntington first evaluated the relationship between certain climates—with a particular emphasis on temperature averages—and the availability of "human energy" based largely on the output of factory workers in various regions of the United States. He then extrapolated this model to climate data from 1100 meteorological stations around the world that appeared in the Austrian meteorologist Julius von Hann's *Handbook of Climatology* (*Handbuch der klimatologie*, last revised 1911) to estimate the levels of human energy around the world on the basis of their climates.[72] In a parallel study, Huntington enlisted 50 participants to rate the level of civilization in various nations on a scale of 1 to 10, producing a map of "The Distribution of Civilization." Finally, he juxtaposed the two maps of human energy and civilization (figure 1), establishing, to his own satisfaction, that the availability of human energy based on climate in a given region was the greatest factor in determining its level of civilization. The secondary importance of race in determining level of civilization was evidenced by disparities in the two maps, argued Huntington, and those disparities revealed "the effect of a strong race upon regions which it rules or colonizes."[73] It was an analysis that seemed to justify the depredations of the industrial world on the non-industrial at a time when Chinese nationalists called for "national revival" out of the ruins of foreign imperialism. Lü decried Huntington's study as "not very scientific": of the fifty individuals surveyed, he noted, no fewer than 24 were American, while China and Japan provided just three responses each. Most were not scientists, he claimed, through several were members of suspect professions: colonial officials, missionaries, businessmen.[74] In other words, what Lü objected to was not Huntington's deterministic line of inquiry, but rather, his methods.

Climate determinism helped figures like Lü to rationalize the incredible diversity of cultures within the *Zhonghua minzu*, or Chinese nation. As one progressed from the national core to the periphery, the transition from temperate to "extreme" climates paralleled a transition from more to less advanced societies; in other words, climate set the natural margins of agrarian Chinese civilization. For instance, Lü's 1947 essay on "The Relationship between the Chinese Nation and Climate" articulated that the "shortcoming" of the Yunnan plateau was that it lacked proper seasons, while the Tibetan plateau was so high that "it is not conducive to agriculture, and the human population cannot flourish."[75] Tibet in this vision resembles what Lucian Boia identifies as an "uninhabitable zone" in global discourse, which represents "the extreme expression of a comprehensive system that brought together geographic, climatic and biological factors and arranged them progressively (and hierarchically) in a pattern linking the *centre* to the *periphery*."[76] Lü's objection to the Huntington study on human energy and civilization study suggests a critique that could just as well be trained on his own work: that claims about the relationship between climate and culture are themselves expressions of cultural values.

In sum, when meteorologists turned their attention to climate, they broadened their scope to include not only myriad weather stations (as we saw in the previous section), but also multiple ways of knowing and thinking about weather patterns. Ironically, this process of methodological broadening tended to constrict the geographical and cultural scope of inquiry within national lines. The use of classical Chinese-language sources (like the "Instruction on the Seasons") and distinctly Sinitic frameworks derived from classical models (like the *hou wen* system) at least periodically trained climatologists' attention on "China" as the geographical frame of analysis, while theories of climate determinism reinforced the idea that Chinese culture was itself an artifact of the Chinese climate.[77] To this day, seasons in the PRC are legally defined using a modified version of Zhang's *hou wen* system, which both distinguishes their timing from international standards and differentiates the national core—marked by four distinct seasons of roughly equal length—from the national periphery, where certain seasons may be short or non-existent.[78]

Defying Borders/Defining Borders: Monsoons and Plum Rains

From what we have seen in the previous two sections it might be argued that the emergence of "Chinese climate" as a category of scientific analysis had more to do with cultural and political frameworks for interpreting meteorological phenomena than with the phenomena themselves. Indeed, ROC meteorological papers can be read against the grain in a manner that would seem to unravel the very notion of a "Chinese climate" that they intended to promote. To begin with, while

Chinese meteorologists generally agreed that China was characterized by a *dalu xing* or "continental" climate, Lu A's effort to the map climatic provinces of China according to the Köppen classification scheme incidentally revealed greater climate variance within the Republic of China than between China and other nation-states, even across continental divides. For instance, the *Cfa* or "humid subtropical" climate of Nanjing was more akin to those of Milan and Charleston than to the *BSk* or "cold semi-arid" climate of the Inner Mongolian steppe, while Inner Mongolia more closely resembled independent (outer) Mongolia and its other central Asian neighbors than it did Nanjing. By the same token, meteorology revealed the existence of large-scale weather patterns that defied national borders between contiguous states. Euro-American climatologists have historically viewed the monsoon as one such border-crossing phenomenon, resulting in the concept of "monsoon Asia."

"Monsoon Asia" is an *exonym*, in that it was adopted first by people from outside of Asia and has never been widely recognized therein. Its origin appears to be recent: In 1941 the Stanford economists V.D. Wickizer and M.K. Bennett adopted the phrase as a "convenient term" for describing the transnational zone in which people practiced wet rice cultivation under the influence of monsoons, or strong seasonally-reversing winds.[79] In the intervening years, there have been numerous studies of monsoon Asia, usually emerging from western institutions. Most recently, the popular textbook *A History of Asia* (currently in its seventh edition) designates monsoon Asia as its scope—a region that it defines as including India, southeast Asia, Japan, Korea, and much of China, but excluding Tibet, Xinjiang, and much of Inner Mongolia.[80] In such texts the monsoon serves as the basis for a transnational, or at least multinational, geography.

Figure 2. Huntington's map of "The Distribution of Human Energy on the Basis of Climate," from Civilization and Climate, p. 200.

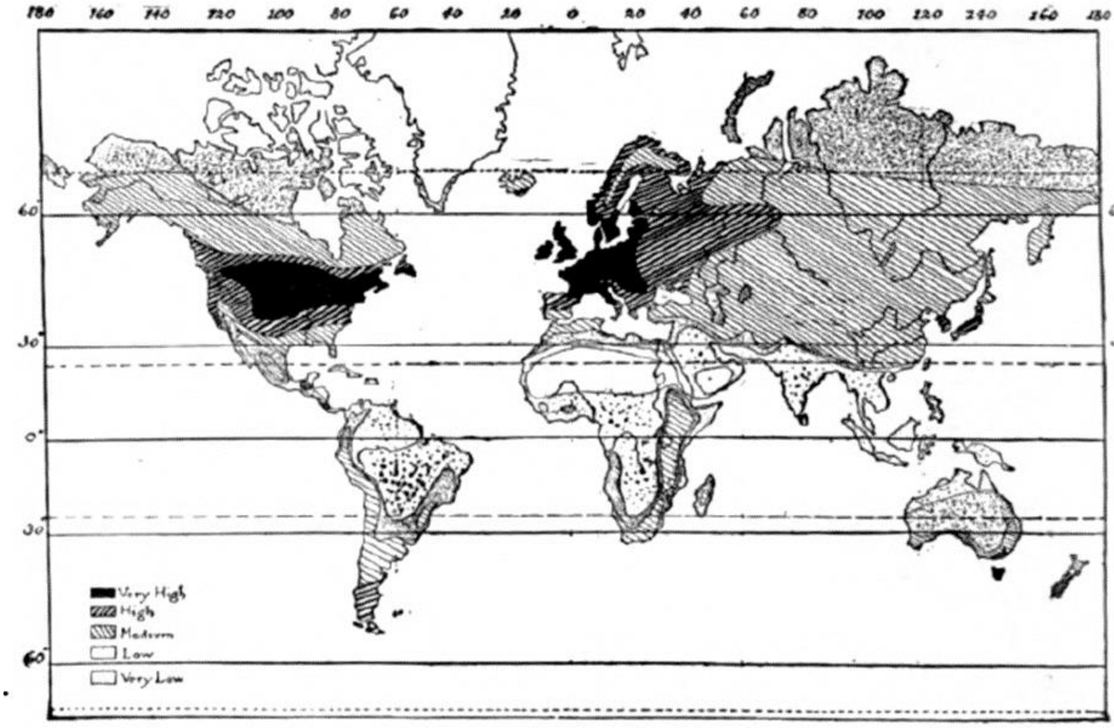
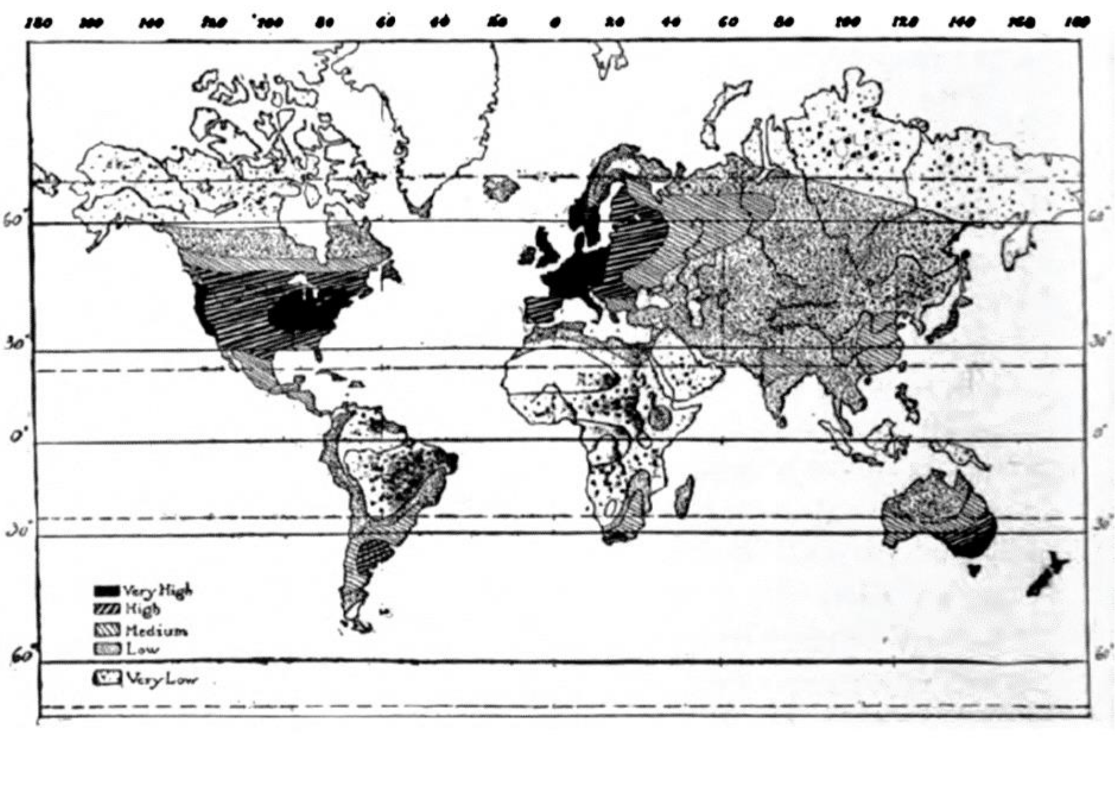


Figure 3. Huntington's map of "The Distribution of Civilization," from Civilization and Climate, p. 200.



However, this is hardly the only way of reading Asian geography against the monsoon, which could just as well serve as a basis for dividing Asia. An earlier view held by both British colonial scientists of the late nineteenth century and Chinese scientists of the early twentieth century was that the monsoon in fact distinguished India from its Asian neighbors. Historian Sunil Amrith notes that observations about the monsoon moved meteorologists and geologists to propose the concept of an "Indian subcontinent" characterized by atmospheric linkages between lowlands and highlands, and thus, extending beyond the empire's maritime sphere of interests.[81] Moreover, the monsoon as experienced on the Gangetic plain was both bounded and partially caused by two enormous mountain ranges: the Himalayas and the Western Ghats. Colonial studies of the monsoon supported a sort of Indian exceptionalism: for example, William Thomas Blanford of the Geological Survey of India conceived of India as "a secluded and independent area of atmospheric action."[82] Significantly, this understanding of the monsoon both coincided with the collapse of South Asia's myriad polities into a single "India" under the British Raj and prefigured the emergence of India as a nation-state in the twentieth century.

Similarly, Chinese climatologists of the early twentieth century were concerned with distinguishing what they called the "Chinese monsoon" from its Indian counterpart. The problem was at once both semantic and scientific: although China was commonly said to experience a seasonal monsoon, the English word *monsoon* emerged from the Indian context and was derived from the Arabic *mausim*, meaning "season," while Chinese sources referred instead to a *xin feng*, or "constant wind." Of what relation was the *xin feng* or "Chinese monsoon" to the Indian monsoon?

When Zhu Kezhen scrutinized classical sources, an interesting pattern emerged: strong summer monsoonal winds were said to bring drought to southeast China, unlike India where they delivered several weeks of intense rain to the Gangetic plain. The heaviest rainfall in central and southeast China came not from the summer winds but rather from the *mei yu* or "plum rains" that usually commenced in mid-June as plums ripened and ended in mid-July just as the trade winds approached. Drawing on both new meteorological data and old literary sources, including the writings of Song dynasty literatus Su Dongpo, Zhu identified a direct relationship between the two phenomena: monsoonal winds from the Pacific Ocean in fact drove the plum rains north toward the Yellow river valley, such that a particularly strong summer monsoon *reduced* rainfall in central and southeast China. The divergent behaviors of the Chinese and Indian monsoons, explained Zhu, were related to orographic rain, in which air masses release their moisture as they are forced upward by mountainous topography. In India, monsoon winds from the Arabian Sea and the Bay of Bengal released heavy rains after being lifted by the Western Ghats and the Himalayas respectively. By contrast, there were few large mountain ranges in China proper and orographic rain was thus less important to precipitation than cyclonic activity, which is produced by the mingling of warm and cool air masses.[83]

If the monsoon threatened to blur the lines between Indic and Sinic climates, the *meiyu*, by contrast, were understood to be a distinctly East Asian phenomenon. It is interesting to think that the distribution of the plum rains roughly corresponds to the distribution of Sinitic writing before the modern era (China, Japan Korea), or for that matter, the distribution of sites in which students might study Tang writer Du Fu's poem "The Plum Rains" in school. The Chinese term *meiyu* worked as a double-entendre: with the swap of a single character, it could mean either "plum rains" (*meiyu* 梅雨) or "mold rains" (*meiyu* 霉雨), reflecting the proliferation of mildew on furniture and clothing that followed them. The people of southern Japan, as Zhu noted, experienced the plum rains in a very similar fashion to south and central China and referred to them by the same Chinese characters (which in Japanese were pronounced *tsuyu*). The Japanese meteorologist Okada Takematsu had described the rains as follows: "the sky remains wholly overcast with clouds and more or less rain falls every day. The air is so moist that walls, pavements, etc. become damp, and furniture and clothes get moldy."[84]

Still, we must consider the possibility of a constructivist explanation: did China and Japan share a written term for this phenomenon because they experienced the same phenomenon, or did shared terminology conversely *generate* the impression of a shared weather phenomenon? Literary scholar Lydia Liu reminds us that the appearance of linguistic "equivalence," such as between the words *meiyu* and *tsuyu*, is always the result of historical and deliberate acts of translation.[85] In this case, however, we can account for the deliberate equation of the *meiyu* and *tsuyu* without resorting to a purely constructivist account of the phenomena in question: Zhu deemed that the data supported an equivalence between (Indian) *monsoon* and (Chinese) *xin feng* on one hand, and between (Japanese) *tsuyu* and (Chinese) *mei yu*) on the other. If the plum rains superficially resembled monsoon showers, Zhu and other meteorologists determined that they were both causally and chronologically distinct from the monsoon. The origin of the plum rains was not the rapid passage of ocean air over mountains, as in the case of the Indian monsoon, but the mingling of a quasi-stationary polar front originating in the Sea of Japan with warming air south of the Yangtze to produce cyclonic activity.[86] Although the plum rains were not a purely Chinese phenomenon, their physical distribution paralleled the regional exchange of weather concepts through Chinese writing. It was their interaction with the southeastern monsoon - and specifically the tendency of the monsoon to counteract the plum rains - that typified the Chinese climate.

Conclusion

The curious case of the "Chinese climate" sheds light on two major problems: What manner of thing is a nation-state? And what manner of thing is a climate?

For a climate scientist today, the answer to the latter question may be charmingly simple. According to the popular textbook *Weather Studies*, climate is "weather conditions at some locality averaged over a specified time interval."[87] For a humanist, the answer is more complicated. Surveying recent histories of climate, Fiona Williamson observes an apparent split: some historians embrace a scientific understanding of climate and cite scientific sources, or "the archives of nature," while others, representing a "cultural turn" in climate history, approach climate as a matter of "philosophies, belief systems, customs, and social behaviors of people at particular places and times" and draw on qualitative sources, or the "archives of society."[88] In the latter camp, Mike Hulme resists the World Meteorological Organization's clinical definition of climate as "statistical description in terms of the mean and variability of relevant meteorological quantities over a period of time ranging from months to thousands or millions of years," and prefers to define climate as "an idea which mediates between the human experience of ephemeral weather and the cultural ways of living which are animated by this experience."[89] Hulme's is an expansive definition capable of encompassing scientific and other common usages of the word; what all notions of climate have in common is that they entail expectations about the weather that exist in a "dyadic" or mutually-constituting relationship with human culture. "Put simply," writes Hulme, "climate allows humans to live culturally with their weather."[90] Here I wish to make two brief comments on Hulme's critique of climate scientism and others like it.

Firstly, it is not the case that climate scientists have always cordoned off questions of culture. As we have seen, Zhu and other Chinese climatologists of the early twentieth century drew readily and openly from both the "archives of nature" and the "archives of society," including ancient calendars, poetry, and folk knowledge about phenological cues. Their willingness to engage qualitative sources would seem to anticipate Williamson's call to integrate scientific and humanistic knowledge into a more holistic study of climate.[91] However, in practice it also fostered a Sinocentric climatology that adopted the Chinese nation-state as a dominant geographical and cultural framework—perhaps *the* dominant framework—for the study of atmospheric forces. This history should raise questions about the possibility of practicing culturally sensitive science without succumbing to a nationalist or ethnocentric framework.

Secondly, it is not the case that Zhu or anyone else fit some sort of value-neutral climate science *into* a nationalist framework. Nor can we say that science exist parallel to but in concert with national concerns. Rather, as we have seen, the nation was integral to the questions, methods, and analyses of meteorology and climatology, and thus climatology, in a sense, helped to reify the Chinese nation-state. This has much to do with the technological features of meteorology during the early twentieth century: scientists by necessity drew nearly all of their data from the Chinese state-run network of weather stations and from Chinese-language textual sources, all of which offered geographically expansive but also restricted perspectives on the atmosphere.

This would soon change. In 1959 the United States launched the *Explorer I* satellite and inaugurated an era of surveilling the atmosphere from above. China followed suit with 17 launches in the Fengyun Satellite Program between 1970 and 2020, including polar-orbiting and geostationary satellites. Of course, satellites are not incompatible with nationalism; indeed, the China Meteorological Administration describes Fengyun as "a national cause" resulting from "the efforts from many institutions."[92] But the global and hemispheric perspectives they offer have diminished the relevance of national culture to scientific climatology, in concert with two other major developments: synoptic meteorology and machine computation. Already by 1898 the Norwegian physicist Vilhelm Bjerkness had embarked on what would ultimately be a successful quest to predict the movement of air masses with mathematical precision, reinventing meteorology as what he later called the "physics of the atmosphere" and effectively founding the field of synoptic meteorology.[93] Deborah Coen writes that Bjerkness' polar front theory helped to divorce meteorology from physical geography beginning in the 1920s, and that it made little room for "observations and abstractions that resisted abstraction and quantification."[94] However, the computational demands of this "physics of the atmosphere" initially made it impractical on a global scale. By 1955, electronic computers, using synoptic formulae and data from the lower and upper atmospheres, produced the first computerized weather forecasts.[95] With the addition of satellite data, synoptic meteorologists modeled weather patterns on vast scales with little respect for local cultures or national borders.

Zhu himself seemed to recognize this paradigm shift by the late 1940s: the inherently *global* physics of the atmosphere was poised to supplant the more geocentric and regional approach that we might call the “geography of the atmosphere.” Zhu and his teachers, of course, had emerged from the geographical tradition, but in 1944 he recommended Zhao Jiuzhang, a former student and trained physicist, as his replacement in the position of director of the Institute of Meteorology, stating that “physics is fundamental training for meteorology, and henceforth its progress cannot but be guided by physics.”[96] And in 1957 he promoted a Chinese polar expedition on the basis that “the earth is an integrative whole; the formation and evolution of China's natural environments took place in the context of that of the earth.”[97] In the same period, Zhu would explicitly disavow his earlier Huntington-inspired forays into environmental determinism, a theory that fit poorly with the anthropocentric ideology of the Mao era, citing Soviet plans to alter the climate of the lower Volga basin as inspiration for a new philosophy of human-climate relations not driven by “capitalist countries.”[98] Chinese atmospheric science was as patriotic as ever when the PRC launched its first space satellite, Dong Fang Hong 1 (The East is Red 1), in 1970, but discussion of a “Chinese climate” had mostly ceded to theories of global circulations in a planetary atmosphere.

Notes

[1] Here I refer to a famous debate between the philosopher Zhang Junmai (or Carsun Chang) and the geologist Ding Wenjiang, and its aftermath. Joseph Ciaudo writes that the debate “progressively open up to a large array of topics such as the scientific method, the difference between spiritual and material sciences, the place of psychology, how China ought to be reformed, how students ought to be educated, and which attitude should be upheld toward Chinese and Western cultures.” See Joseph Ciaudo, “Some Remarks on the 1923 ‘Controversy Over Science and Metaphysics,’ ERCCS—Research Notes 3(2019): 3.

[2] Consistent with the overall historiography of China’s early twentieth century, Rana Mitter writes that “the atmosphere and political mood that emerged around 1919 are at the centre of a set of ideas that has shaped China’s momentous twentieth century.” See Rana Mitter, “A Bitter Revolution: China’s Struggle with the Modern World,” (Oxford: Oxford University Press, 2005), p. 12.

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[3] Lloyd Kramer, "Historical Narratives and the Meaning of Nationalism," *Journal of the History of Ideas* 58.3 (1997), p. 526.

[4] Hiromi Mizuno, *Science for the Empire: Scientific Nationalism in Modern Japan* (Palo Alto: Stanford University Press, 2008).

[5] Zuoyue Wang, "Saving China through Science: The Science Society of China, Scientific Nationalism, and Civil Society in Republican China," *Osiris* 17 (2002): 299.

[6] Clark Alejandrino, "Weathering History: Storms, State, and Society in South China Since the Fifth Century CE" (PhD dissertation, Georgetown University, 2019), pp. 162-164.

[7] Iwo Amelung, "Zhu Kezhen 竺可楨 (1890-1974)," *Oxford Research Encyclopedias: Climate Science*: 5. DOI: https://doi.org/10.1093/acrefore/9780190228620.013.839. Accessed September 1, 2022.

[8] I borrow the phrase "imagined geography" from Emma Teng, who uses it to "distinguish between the geography that exists on the ground and geography as a cultural construct." Teng writes that the imagined geography of Qing rulers and officials "delineated the territory that belonged to the 'our land' of the Qing empire, in distinction to the 'barbarian lands' that lay beyond its boundaries." See Emma Teng, *Taiwan's Imagined Geography: Chinese Colonial Travel Writing and Pictures, 1683–1895* (Leiden: Brill, 2020), pp. 15-16.

[9] "Ge di zhengjiao xiankuang xieyao: banfa baiye xiang tubiao" (Selections from Political Education in Various Places), *Lai Fu* 183 (1921): 4-5.

[10] For images and brief descriptions of newly erected Stevenson screens in China during the 1930s, see "Ge xian cehou suo shying: Lugou er deng cehou suo baiye xiang" (Photographs of observation stations in various counties: The Lugou tier-two observation station Stevenson screen), *Jiangsu sheng zheng jianshe yuekan* (Jiangsu province political establishment monthly) 4.5 (1937): 1; "Qixiang shebei zhi yi bu: Baiye xiang" (A component of meteorological equipment: the Stevenson screen), *Zhejiang sheng jianshe yuekan* (Zhejiang province development monthly) 5.4: 1; "Ge di zhengjiao xiankuang xieyao: banfa baiye xiang tubiao" (Selections from Political Education in Various Places), *Lai Fu* 183 (1921): 4-5.

[11] *Qixiang cebao* (Meteorology report, Nanjing: Xingzheng yuan xinwen ju, 1947), pp. 1-2; see also Clark Alejandrino, *Weathering history*, pp. 155-160.

[12] *Qixiang cebao*, p. 1.

[13] Quoted in Alejandrino, *Weathering history*, p. 163.

[14] Alejandrino, *Weathering history*, p. 162.

[15] On Zhu's reputation in the PRC, see Iwo Amelung, "Zhu Kezhen 竺可楨 (1890-1974)," p. 3. Amelung notes of Chinese publications on Zhu that "While offering very valuable insights, most of this work is rather hagiographic in nature and refrains from putting Zhu and his achievements into a broader perspective or evaluate it in a more critical way."

[16] Wang, "Saving China through science," pp. 293-294.

[17] Li Yuhai (ed.), *Zhu Kezhen nianpu jian bian* (The Concise Zhu Kezhen Yearbook, Beijing: China Meteorological Press, 2010, p. 4).

[18] Zhu Kezhen, "Dili yu wenhua zhi guanxi" (The relationship between geography and culture), *Kexue* 2.8 (1916): p. 898.

[19] Alejandrino, "*Weathering history*," p. 162.

[20] Zhu Kezhen, "Quan guo sheli qixiang cehou suo jihua shu" (A plan for establishing meteorological observation stations throughout the country), *Dili zazhi* 1.2 (1928): 1-3.

[21] Neizheng bu (Ministry of internal affairs), "Quanguo qixiang guance shishi guicheng" (Nationally implemented regulations for meteorological observation," *Jiangxi jianshe yuekan* 6.9-10 (1932): 10-14.

[22] *Qixiang cebao*, p. 2.

[23] The *Meteorology Report* describes the Northeast administrative region as including "the various provinces of the northeast" (*Qixiang cebao*, p. 6). This territory, including the Japanese puppet state of Manchukuo, was mostly under Japanese occupation at the time of publication—hence the vague description.

[24] This is especially clear in comparison with our present era, when most knowledge about atmospheric circulations comes from geostationary satellites positioned above the earth as well as automated technology scattered across the surface of the earth, and the importance of regional centers to weather reporting is thus greatly diminished.

[25] On the "centers of action" concept, see George Adamson, "Imperial Oscillations: Gilbert Walker and the Construction of the Southern Oscillation," in Martin Mahony and Samuel Randalls (eds.), *Weather, Climate, and the Geographical Imagination: Placing Atmospheric Knowledges* (Pittsburgh: University of Pittsburgh Press, 2020), pp. 51-52. Adamson explains that the French meteorologist Léon Teisserenc de Bort introduced the concept in 1881, and that it was subsequently expanded by the English mathematician and meteorologist Gilbert Walker in the 1920s.

[26] Zhu Kezhen, "Zhongguo qihou zhi yaosu" (The elements of the Chinese climate), *Dili xuebao* 2.1 (1935): 1; A. Lu, "Chinese Climatology," in *Collected Scientific Papers: Meteorology* 1919-1949 (Beijing: Academia Sinica, 1954), pp. 441-445.

[27] Zhihong Chen, "Climate's moral economy: geography, race, and the Han in early Republican China," in Thomas Mullaney et al (eds.), *Critical Han Studies*, Berkeley: University of California Press, 2012, pp. 80-82.

[28] Chang Pao-Kun, "On the Duration of the Four Seasons in China," in in *Collected Scientific Papers: Meteorology* 1919-1949 (Beijing: Academia Sinica, 1954), pp. 300-301.

[29] For an overview of the Köppen classification, see Joseph M. Moran, *Weather studies: Introduction to atmospheric science, Fifth Edition* (Boston: American Meteorological Society, 2012), pp. 553-559.

[30] From 1931 to 1949, a number of leading climatologists, including Zhu Kezhen, Du Zhangwang, and Lu A, produced studies of the "climatic provinces of China." These "climatic

provinces" were not coterminous with the political provinces of the Republic of China, but they were always depicted as regions within China's national borders.

[31] A. Lu, "The Climatic Provinces of China," pp. 467-473.

[32] Sun Yibo, "Minguo Zhongyang yanjiuyuan qixiang yanjiusuo yanjiu (1928-1949)" (A study of the Republican Academia Sinica Institute of Meteorology), MA thesis, Hebei Shifang Daxue (2015), p. 15.

[33] Chang Bao-Kun, "Climatic regions of Szechuan province," in *Collected Scientific Papers: Meteorology* 1919-1949 (Beijing: Academia Sinica, 1954), pp. 393-394.

[34] Lu Jiong, "Zhonghua minzu yu qixiang de guanxi" (The relationship between the Chinese nation and meteorology"), in Zhu Kezhen, Lu Yudao, and Li Zhenbian (eds.), *Kexue de minzu fuxing* (Scientific national revival, Shanghai: Zhongguo kexue she, 1937), p. 139.

[35] Zhu, "Zhongguo qihou zhi yaosu," p. 4.

[36] Zhu, "Zhongguo qihou zhi yaosu," p. 1.

[37] Joseph Needham, Ho Ping-Yü, and Lu Gwei-Djen, *Science and Civilisation in* China: Volume 5 (Cambridge: Cambridge University Press, 1974), p. xxxi; see also Joseph Needham, Lu Gwei-Djen, and Nathan Sivin, *Science and Civilisation in China: Volume 6* (Cambridge: Cambridge University Press, 2000), p. 13; Joseph Needham, Kenneth Girdwood Robinson, and Ray Huang, *Science and Civilisation in China: Volume 7* (Cambridge: Cambridge University Press, 2004), p. 25.

[38] Fiona Williamson, "The 'cultural turn' of climate history:An emerging field for studies of China and East Asia," *WIREs Climate Change* 11.3 (2020), https://doi.org/10.1002/wcc.635.

[39] Mark Elvin, "Who was responsible for the weather? Moral meteorology in late imperial China," *Osiris* 13 (1998): 213-214.

[40] *Qing shi leilue* (Encyclopedic history of love), CText <https://ctext.org/wiki.pl?if=gb&res=703902&searchu=%E7%9F%B3%E5%B0%A4&remap=gb>, (November 17, 2020).

[41] Quoted in *Xian Qin liang Han* (The former Qing dynasty and the two Han dynasties), CText, <https://ctext.org/pre-qin-and-han/zh?searchu=%E9%9B%B2%E5%BE%9E%E9%BE%8D%E9%A2%A8%E5%BE%9E%E8%99%8E> (November 17, 2020).

[42] *Qixiang yu mixin* (Meteorology and superstition, Kunming: Yunnan shengli Kunming qixiang cehou suo, n.d.), pp. 1-4, 18-19.

[43] Zhu, "Dili yu wenhua zhi guanxi," p. 895.

[44] Zhu Kezhen, *Qixiang xue* [Meteorology] (Shanghai: Shangwu yinshu guan, 1923), p. 1

[45] Li, *Zhu Kezhen nianpu jian bian*, pp. 1-2.

[46] Li, *Zhu Kezhen nianpu jian bian*, p. 40.

[47] Henri Poincare, *The foundations of science: Science and hypothesis, The value of Science, Science and method* (New York: The Science Press, 1913), p. 205. There is a subtle but significant difference between Poincare's original statement and Zhu's translation into Chinese. Poincare states that "The search for truth should be the goal of our activities; it is the sole end worthy of them." In translating the same edition of that book, Zhu writes that "the purpose of the scientific enterprise (*kexue shiye*) is the pursuit of truth." See Zhu Kezhen, "Kexue zhi fangfa yu jingsheng" (The methods and spirit of science), in Zhu Kezhen (ed.), *Xiandai xueshu wenhua gailun* (An outline of modern academic culture) (Huaxia tushu chuban gongsi, 1948), p. 9.

[48] Zhu, "Kexue zhi fangfa yu jingsheng," p. 9.

[49] Qian Baocong, "Kexue shi yu xin renwen zhuyi" (The history of science and the new humanism), in Zhu Kezhen (ed.), *Xiandai xueshu wenhua gailun* (An outline of modern academic culture) (Huaxia tushu chuban gongsi, 1948), p. 13.

[50] Li, *Zhu Kezhen Nianpu Jianbian*, p. 48.

[51] Zhu Kezhen, "Qiu shi jingshen," *Kexue huabao* 5.21-22 (1939): 1.

[52] Chang Pao-Kun, "On the duration of the four seasons in China," in *Collected Scientific Papers: Meteorology* 1919-1949 (Beijing: Academia Sinica, 1954), p. 286. Here I quote Zhang's own translation of his text for Zhu Kezhen's 1954 edited volume, though in my interpretation the original Chinese-language paper is slightly more modest: "who says that the academic thought of ancient China is inferior to the scientifically advanced modern Europe and America?" See Zhang Baokun, "Zhongguo si ji zhi fenpei" (The division of the four seasons in China), *Dili xuebao* 1.1 (1934): 15.

[53] Zhang, "Zhongguo si ji zhi fenpei," especially pp. 2-3.

[54] Zhang, "Zhongguo si ji zhi fenpei," p. 7; Chang Pao-Kun, "On the duration of the four seasons in China," p. 278.

[55] Chang, "On the duration of the four seasons in China," pp. 289-293.

[56] Chang, "On the duration of the four seasons in China," p. 279.

[57] Today the study of historical climate relies heavily on the use of climate proxies, such as ice cores and tree rings, that are neither linguistically nor culturally specific, but those techniques were not well developed until the late twentieth century. Since decades before that, climate scientists have turned to the textual record of phenological cues. To give one recent example, an interdisciplinary team of scientists used the flowering dates and quantities recorded by Henry David Thoreau in the woods of Massachusetts to gauge the effects of climate change by comparing Thoreau's 19th-century figures with present-day figures from the same region. See Abraham Miller-Rushing and Richard B. Primack, "Global Warming and Flowering Times in Thoreau's Concord: A Community Perspective," *Ecology*, 89.2 (2008): 332–41.

[58] *Yi Zhou shu: Shi xun jie* (Lost book of Zhou: Instruction on the seasons), Ctext, https://ctext.org/lost-book-of-zhou/shi-xun/zhs, accessed November 17, 2020.

[59] Chu Co-ching, "Climatic changes during historic time in China," in *Collected Scientific Papers: Meteorology* 1919-1949 (Beijing: Academia Sinica, 1954), pp. 266-267.

[60] For example, in a 1963 essay on phenology, Zhu wrote that "several thousands of years ago, the laboring people noticed that the growth and decay of the plants and trees, the coming and going of the birds, and other natural phenomena had a relationship with climate, and it seemed like nature was telling them to hurry up and plow the earth." See Zhu Kezhen, "Yi men fengchan de kexue: wuhou xue" (A high-yielding science: phenology), *Kexue dazhong* 1 (1963): 6. Iwo Amelung notes that new phenological observations during the early PRC in fact "went far beyond what had been achieved in Republican times"; see Amelung, "Zhu Kezhen 竺可楨 (1890-1974)," p. 11.

[61] Zhu Kezhen, "A Preliminary Study on the Climatic Fluctuations during the Last 5000 Years in China," *Scientia Sinica* 16.2 (1973), pp. 226 – 56.

[62] Marks, *China: Its Environment and History*, p. 21.

[63] *Yi Zhou shu: Shi xun jie* (Lost book of Zhou: Instruction on the seasons), Ctext, https://ctext.org/lost-book-of-zhou/shi-xun/zhs, accessed November 17, 2020.

[64] See Ellsworth Huntington, *Civilization and Climate* (New Haven: Yale University Press), p. 213; Watsuji Tetsuro, *A Climate: A Philosophical Study*, trans. Geoffrey Bownas (Tokyo: Japanese Government Printing Bureau, , 1962), p. 1.

[65] Zhu, "Dili yu wenhua," p. 897.

[66] Zhu, "Dili yu wenhua," p. 898.

[67] Zhu Kezhen, "Tianqi he rensheng" (Weather and human life), *Guofeng* 4.8: 1-3.

[68] Zhu, "Tianqi he rensheng," pp. 1-2.

[69] Lu Jiong, "My native place," *Xuesheng* 7.11 (1920): 1-2.

[70] Lu, "Zhongguo minzu yu qihou de guanxi," p. 113.

[71] Lu, "Zhongguo minzu yu qihou de guanxi," pp. 124-131.

[72] Huntington, *Civilization and Climate,* p. 142.

[73] Huntington, *Civilization and Climate,* p. 202.

[74] Lu, "Zhonghua minzu yu qihou de guanxi," p. 124.

[75] Lu, "Zhonghua minzu yu qihou de guanxi," pp. 138-139.

[76] Lucian Boia, *The Weather in the Imagination* (London: Reaktion Books, 2005), p. 21.

[77] The phrase "climate determinism" here may be misleading, since it implies a distinction between climate and culture, whereas understandings of climate are inherently cultural; as Mike Hulme explains so eloquently, climate is "an idea which mediates between the human experience of ephemeral weather and the cultural ways of living which are animated by this experience." See Mike Hulme, "Climate and its Changes: A Cultural Appraisal," *Geo: Geography and Environment* 2.1 (2015), p. 3.

[78] The national "Division of Climatic Seasons" (*Qi hou ji jie hua fen*) manual issued by the Chinese Meteorological Administration (CMA) adheres approximately to Zhang Baokun's 1934

system for marking the start and end of each season, including the use of five-day averages and seasonal temperature thresholds of 10 and 22 Celsius respectively, with the result that certain seasons officially do not exist in certain parts of China; see Chinese Meteorological Association, *Qihou jijie huafen* (Beijing: Qixiang chuban she, 2012), pp. 1-2. This would seem to marginalize many borderland regions as "lacking" one or more seasons, such as Inner Mongolia, where the provincial version of the manual stipulates the existence of "regions without summer" (*wu xia ji qu*); see Nei Menggu zizhi qu shichang lindu guanli ju, *Qihou jijie huafen*, 2019, <http://nm.cma.gov.cn/zfxxgk/fdzdgknr/flfgbz/qxbz/202011/W020201123464002618198.pdf> (September 7, 2022). Unlike Zhang's 1934 system, however, the current system uses a five-day moving average and does not average the pentads of the lunisolar calendar. While the CMA manual does not cite Zhang Baokun as the originator of its current system, media reports sometimes do; for example, a 2021 article from the Chinese Meteorological Administration states that "the *hou wen* system is the basis of the division of climatic seasons which Mr. Zhang Baokun proposed in 1934, and to this day it is still in use by the meteorology profession"; see Zhongguo qixiang ju, "Yiju houwen huafen si ji" June 13, 2016, <http://k.sina.com.cn/article_2117508734_7e369e7e001001xk1.html#/> (September 7, 2022).

[79] Vernon Dale Wickizer et al, *The Rice Economy of Monsoon Asia* (California: Food research institute, 1941), pp. 1-2.

[80]Rhoads Murphey and Kristin Stapleton, *A History of Asia, 7th edition,* (New Jersey: Pearson Higher Education, 2013). Here I refer especially to the map on p. 2, which indicates the extent of "monsoon Asia" with a dotted line.

[81] Sunil Amrith, *Unruly waters: how mountain rivers and monsoons have shaped South Asia's history*, (Penguin, 2020), pp. 108-109.

[82] Amrith, *Unruly Waters*, p. 109.

[83] Zhu Kezhen, "Dongnan jifeng yu zhongguo zhi yuliang" (The southeastern monsoon and rainfall in China), *Dili xuebao* 1 (1934): 1-27. For a concurring analysis, see A. Lu, "Chinese climatology," pp. 452-453.

[84] Coching Chu, "The climate of Nanking during the period 1905-1921 (Berkeley: University of California Libraries, 1921), p. 8.

[85] Lydia Liu, *Translingual Practice: Literature, National Culture, and Translated Modernity—China, 1900-1937* (Stanford: Stanford University Press, 1995), pp. 3-4, 26.

[86] A. Lu, "Chinese climatology," p. 453; see also Zhu, "Dongnan jifeng yu zhongguo zhi yuliang," pp. 16-18.

[87] Moran, *Weather studies*, p. 4.

[88] Williamson, "The 'cultural turn' of climate history," p. 2.

[89] Hulme, "Climate and its Changes," p. 3.

[90] Hulme, "Climate and its Changes," p. 3.

[91] Fiona Williamson writes that "combining [scientific and cultural] approaches is the best way to fully grasp the interdependence of climate and people in the past." See "The 'cultural turn' of climate history," p. 2.

[92] China Meteorological Administration, "50th Anniversary of Fengyun Satellite Program" September 10, 2020, <http://www.cma.gov.cn/en2014/news/News/202009/t20200930_564281.html> (November 17, 2020).

[93]Robert Friedman, *Appropriating the Weather: Vilhelm Bjerknes and the Construction of a Modern Meteorology* (Ithacha: Cornell University Press, 1989), pp. 33-34, 87.

[94]Deborah R. Coen, "Climate in Motion: Science, Empire, and the Problem of Scale" (Chicago: University of Chicago Press, 2018), p. 335.

[95] Moran, *Weather Studies*, p. 549.

[96] Zhu Kezhen, *Zhu Kezhen quan ji* (The complete works of Zhu Kezhen, Shanghai: Shanghai keji jiaoyu chuban she, 2006) P. 367.

[97] Quoted in Zuoyue Wang, "China Goes to the Poles: Science, Nationalism, and Internationalism in Chinese Polar Exploration," in Keith R. Benson and Helen M. Rozwadowski (eds.), *Extremes: Oceanography's Adventures at the Poles* (Sagamore Beach: Science History Publications, 2007), p. 3.

[98] Zhu Kezhen, "Preface," in Zhongguo kexue yuan (ed.), *Collected Scientific Papers: Meteorology 1919-1949* (Beijing: Academia Sinica, 1954), p. ix.