
**Unsettling Gilded-Age Science:
Vernacular Climatology and Meteorology in the “Middle Border”**

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Introduction

During the Gilded Age, in the states and territories of the interior United States, Euro-Americans interested in establishing weather and climate observation networks faced numerous obstacles. Securing funding ranked high among them. In 1882, for example, Francis Nipher helped introduce a bill before the Missouri State Legislature seeking several thousand dollars of funding for the Missouri Weather Service. “Consideration of this bill,” Nipher later wrote, “furnished an occasion for mirth to some members of that body; but failed to occasion any interest.” The Saint Louis resident found the rejection “so depressing” that he made “no further attempt...in that direction.” Yet Nipher did succeed in expanding the Missouri Weather Service, thanks in large part to a growing network of volunteer observers – weather aficionados who recorded rainfall and temperature data to be collected in reports such as an 1892 study titled “Missouri Rainfall.” According to Nipher, the “patience and self-denial” of volunteer observers allowed his weather service to overcome the indifference of state legislators.¹

State weather services similar to Nipher’s proliferated across the Great Plains and Midwest during the 1870s and 1880s. These regional or meso-scale networks shared many characteristics with the national and transnational data collection networks analyzed by scholars such as James Rodger Fleming, Jamie Pietruska, and Paul Edwards. Like members of the Smithsonian-based initiatives described by Fleming, members of regional weather bureaus perceived their work as contributing to a “system” of “increasing complexity and abstraction” to be used by scientists in

¹ Francis E. Nipher, “Report on Missouri Rainfall, with Averages for Ten Years ending December 1887,” *Transactions of the Academy of Science of St. Louis*, Vol. 5, 1886-1891 (St. Louis, MO: R.P. Studley and Co., 1892), 383.

support of “theoretical, polemical, and practical objectives.”² Like the imperial meteorological networks examined by Pietruska, local networks helped “undergird agricultural improvement, capitalism, and the civilizing mission of American science.”³ And, like the institution-builders in Paul Edwards’s work, they participated in the “messy and incomplete” transition toward more standardized data collection frameworks.⁴ Yet the idiosyncrasies of these local networks merit closer examination. The inner workings of organizations such as Nipher’s highlight eddies amid the seemingly inexorable currents of nineteenth-century science: the shift from settler ecologies and folklore to data-based epistemologies, and the drive to separate positivist “pure science” from the murky realms of boosterism and cultural politics.⁵

As scholars including Philipp Lehmann and Simon Naylor have observed, nineteenth-century data collection efforts did not give rise to stable and certain scientific paradigms. Lehmann has pointed out how attempts to standardize meteorological and climatic data ushered in a “period of reevaluation and uncertainty with regard to the future trajectory of the discipline” of climatology.⁶ Similarly, Naylor has pointed out that vast troves of numbers such as those compiled by Nipher created more questions than answers.⁷ By examining vernacular meteorology and climatology⁸ in the “middle border” region,⁹ I hope to reveal some of the tensions shaping the construction of Gilded-Age American science. Climate theorists from Kansas, Iowa, and other

² James Rodger Fleming, *Meteorology in America, 1800-1870* (Baltimore: Johns Hopkins University Press, 1990), xxi-xxii, see also Fleming, *Historical Perspectives on Climate Change*, (Oxford: Oxford University Press, 1998), 33-41.

³ Jamie Pietruska, “Hurricanes, Crops, and Capital: The Meteorological Infrastructure of American Empire in the West Indies,” *The Journal of the Gilded Age and Progressive Era* 15 (Oct 2016): 432.

⁴ Paul Edwards, “Meteorology as Infrastructural Globalism,” *Osiris* 21 (2006): 230.

⁵ For “pure science” in the Gilded Age, see Paul Lucier, “The Professional and the Scientist in Nineteenth-Century America,” *Isis* 100 (2009): 723. See also Lucier, “The Origins of Pure and Applied Science in Gilded Age America,” *Isis* 103 (2012).

⁶ Philipp Lehmann, “Whither Climatology? Bruckner’s *Climate Oscillations*, Data Debates, and Dynamic Climatology,” *History of Meteorology* 15 (2015): 51.

⁷ In his study of provincial meteorology in Cornwall, Naylor has argued that mass-scale meteorological data collection gave rise to “very real concerns in the late 1860s about how to turn continuous records into numerical results useful to science and government.” See Simon Naylor, “Nationalizing Provincializing Weather: Meteorology in Nineteenth-Century Cornwall,” *British Journal for the History of Science* 39 (2006): 419.

⁸ My aim in using the expansive and admittedly nebulous category of “vernacular science” is to highlight the unevenness of late-nineteenth century scientific bureaucratization, professionalization, systematization, centralization, and standardization. As Kathleen Pandora has argued, “vernacular discursive forms” of science serve as a kind of “intellectual commons” where “social and theoretical comment can circulate without regard for scientific property.” See Katherine Pandora, “Knowledge Held in Common: Tales of Luther Burbank and Science in the American Vernacular,” *Isis* 92 (September 2001): 492. For another elaboration of the concept of “vernacular science,” see Helen Tilley, “Global Histories, Vernacular Science, and African Genealogies; or, Is the History of Science Ready for the World?” *Isis* 101 (March 2010), especially FN 4. Tilley’s notion of vernacular science emphasizes “native” knowledge, and she also outlines how different scholars have employed the term.

⁹ The geographical area of focus for this article is not just the Great Plains but a broader, vaguely defined region some nineteenth-century Americans termed the “middle border,” which included the prairie states as well as much of the West. Author Hamlin Garland popularized the term in the late nineteenth and early twentieth centuries. See Hamlin Garland, *A Son of the Middle Border* (New York: McMillan, 1917). For a recent discussion of the “middle border,” see Aaron Sachs, *Arcadian America: The Death and Life of an Environmental Tradition* (New Haven: Yale University Press, 2013), 210-211.

states attempted to derive meteo-climatic knowledge from sprawling sets of data collected by observers. They sought to answer a range of questions, especially the pressing, politically charged issue of whether Euro-American settlement could modify climatic conditions through agriculture, afforestation, deforestation, and other means.¹⁰ In doing so, they fused naturalistic beliefs with quantitative methods and probabilistic paradigms with experiential and experimental modes of apprehending the natural world.

Conevery Bolton Valenčius has revealed the ubiquity of “everyday science” in early America. In *The Lost History of the New Madrid Earthquakes*, she demonstrates how Antebellum-Era “natural inquiry,” folklore, and other forms of knowledge sometimes dismissed as “derivative and inconsequential” comprised the “unrecognized bedrock” of the Gilded-Age “explosion of invention, innovation, engineering, and institution-building.”¹¹ This article seeks to extend Valenčius’s periodization by showing that vernacular science did not just set the groundwork for later developments. In the late nineteenth-century United States, boundaries between types of knowledge remained porous and contested. I aim to explore the dialectic between the quotidian settler perceptions analyzed by Valenčius and the institutional science chronicled by Fleming.¹²

“Middle border” boosters and newspapermen sometimes deployed, debated, and questioned expansive data sets. “Men of science,” meanwhile, used anecdote and folklore as starting points in deriving hypotheses to explain climatic and meteorological changes. They melded naturalistic wisdom and emerging techno-scientific methods, sometimes seeking legitimacy from their use of local and experiential knowledge.¹³ In order to convey the breadth and depth of Gilded-Age meteo-climatic debates, this article draws from newspapers, amateur

¹⁰ During the Gilded Age, boosters, land speculators, and railroad agents argued that tree plantations and newly planted crops could transform the climate of the Intermountain West and Great Plains, creating a utopia for yeoman farmers. Some scientists, surveyors, and bureaucrats concurred, while others expressed doubts about the ability of forest culture and agriculture to modify weather patterns. For many Euro-Americans, belief in anthropogenic climate change served as a litmus test for faith in American capitalism and Manifest Destiny. For an example of a source arguing in favor of human-induced climate change, see Charles Dana Wilber, *The Great Valleys and Prairies of Nebraska and the Northwest* (Omaha: Daily Republican Print, 1881). For an example of a “middle border” author arguing against climatic changes, see Edgar Guild, “Western Kansas: Its Geology, Climate, Natural History, etc.” *Kansas City Review of Science and Industry* 3 (December 1879).

¹¹ Conevery Bolton Valenčius, *The Lost History of the New Madrid Earthquakes* (Chicago: University of Chicago Press, 2013), see 177 for “bedrock,” 17 for “natural inquiry,” 10 for “derivative” and “everyday science.”

¹² See Valenčius, *The Health of the Country: How American Settlers Understood Themselves and their Land* (New York: Basic Books, 2002) and Fleming, *Meteorology in America*. In her study on folklore and meteorological knowledge in Switzerland, Sarah Strauss argues that “folklore, as well as individual practice, is embedded into the scientific process.” See Strauss, “Weather Wise: Speaking Folklore to Science in Leukerbad,” in Strauss and Benjamin Orlove, eds, *Weather, Climate, Culture* (New York: Berg, 2003), 52-53.

¹³ For “men of science” deriving inspiration from folklore and anecdote, see John Hay, “Atmospheric Absorption and its Effect upon Agriculture,” *Proceedings of the Eighteenth Annual Meeting 1890 of the Kansas State Board of Agriculture* (Topeka, 1890), and Harvey Culbertson, “Meteorology,” *Annual Report of the Nebraska State Horticultural Society 1885* (Lincoln: State Journal Company, 1887). For a study on the complex meaning of the term “professional” in the Gilded Age, see Lucier, “The Professional and the Scientist.” Lucier argues that late nineteenth-century “men of science” sought to distinguish themselves from “professionals” tainted by economic dealings. I am not taking issue with Lucier’s point. By using “professional” in this context, I am using the current meaning of the term to refer to climatic and meteorological thinkers who earned salaries for their scientific endeavors.

weather reports, and local and regional agro-scientific societies, as well as the papers and writings of experts and semi-trained polymaths. Exponents of vernacular meteorology and climatology did not create a discrete branch of knowledge; instead, they operated within a network of mutually influencing epistemologies.¹⁴ Indeed, the diffuse nature of data collection projects and the popularization of scientific discourse reveal the inadequacy of the category “vernacular science.” In some ways, all Gilded-Age science was vernacular.

I depict vernacular climatology and meteorology not as fixed categories but as a series of negotiations between academics, bureaucrats, technocrats, volunteer observers, agriculturalists, newspapermen, and others. These figures contested the legitimacy of newly produced scientific knowledge. They appropriated climatic and meteorological theories to serve their interests, which ranged from agricultural boosterism to institution-building to the settling of personal squabbles. Relocating meteorology and climatology to the “middle border” highlights the unsettled nature of Gilded-Age scientific cultures.

Gustavus Hinrichs, Mercurial Polymath

Gustavus Hinrichs, the founder and head of the Iowa State Weather Service, stood at the intersection of the often contradictory intellectual currents shaping Great Plains meteo-climatic science. At times, he upheld the work of “practical” men over that of institutional scientists, railed against the dogma of empiricism, and advanced boosterish, promotional climatology. But at other times, he policed the borders of science, issuing vehement denunciations of anyone straying beyond the bounds of “real science.” Hinrichs also issued seemingly conflicting statements about human-induced climate change and about the role of statistical uncertainty in climate science.¹⁵ Aside from occasional credits for coining the term “derecho” (a large, straight-line windstorm), he has received little attention from historians of climatology and meteorology.¹⁶ A mercurial and paradoxical figure, Hinrichs offers a glimpse into contentious Gilded-Age debates over who qualified as legitimate creators of climatic and meteorological knowledge. His work merits closer

¹⁴ In *Victorian Popularizers of Knowledge: Designing Nature for New Audiences* (Chicago: University of Chicago Press, 2007), Bernard Lightman offers a nuanced interpretation of the relationship between popular and elite science: “Popular culture can actively produce its own indigenous science, or can transform the products of elite culture in the process of appropriating them” (14).

¹⁵ For Hinrichs’s defense of “real science,” see Hinrichs, “Faith and Science,” Lecture delivered by Prof. Gustavus Hinrichs before the students of the [Iowa] State University, undated, likely 1867, G. Hinrichs papers, Box 1, University of Iowa Library. University Archives, RG. 99.0039. For Hinrichs’s skepticism, see Hinrichs, “Rainfall and Timber in Iowa,” *Transactions of the Iowa State Horticultural Society for 1879* (Des Moines: F.M. Mills, State Printer, 1880), 199-200.

¹⁶ See Stephen F. Corfidi, Michael C. Coniglio, Ariel E. Cohen and Corey M. Mead, “A proposed revision to the definition of ‘derecho,’” *Bulletin of the American Meteorological Society* 97.6 (June 2016). W.P. Palmer’s piece on Hinrichs surveys his contributions to chemistry and offers some details about his life, but does not explore his philosophy of science or delve into his climatic and meteorological work. See “Dissent at the University of Iowa: Gustavus Detlef Hinrichs – Chemist and Polymath,” *Chemistry* 16, 6 (2007).

examination because, despite its idiosyncrasies, it is representative of “middle-border” knowledge-making. By fusing experiential and statistical evidence, Hinrichs managed to cope with the seemingly intractable problems facing Gilded-Age climate theorists: burgeoning but incomplete and unreliable data sets, multiplicities of contradicting climatic hypotheses, and growing, but occasionally hostile and alienating bureaucracies.

Hinrichs was born in 1836 in Lunden, a city then located in Denmark, and immigrated to the United States in 1861 because of political turmoil surrounding Prussian unification. First settling in Davenport, he then moved to Iowa City in 1863 to work as a professor at the State University of Iowa, where he taught foreign languages and physical sciences. A polymath, Hinrichs conducted research in minerology, meteorology, medicine, geology, physics, and chemistry, earning some renown for his work on periodic laws.¹⁷ In 1875, Hinrichs established the Iowa State Weather Service and later took pride in having organized what he termed “the *first* State Weather Service of America.”¹⁸ His weather service operated continuously until 1889, when Hinrichs moved to Saint Louis and his network was supplanted by the rival Iowa Weather and Crop Service, an organization affiliated with the US Weather Bureau.¹⁹

A mixture of personal, utilitarian, and theoretical goals motivated Hinrichs’s efforts to develop the Iowa State Weather Service. Hinrichs envisioned his weather service and data-gathering network as a project undertaken by the people of Iowa, for the people of Iowa. By collecting temperature, wind, and rainfall statistics, he argued, the weather service would “secure a faithful record of the conditions on which Iowa’s prosperity depends and will continue to depend.”²⁰ In his *Biennial Reports*, Hinrichs stressed the importance of producing meteo-climatic information of immediate use to agriculturalists and others working in his adoptive state. While long-term climatic observations would inform the ongoing process of farming-based settlement,

¹⁷ For biographical information on Hinrichs, see the obituary by Charles Keyes in the *Iowa Academy of Science* 30, 1923, 28-31. G. Hinrichs papers, Box 1, biography folder, University of Iowa Library, University Archives, RG. 99.0039.

¹⁸ Gustavus Hinrichs, *Rainfall Laws Deduced from Twenty Years of Observation*, Published by the authority of the Secretary of Agriculture (Washington, DC: Weather Bureau, 1893), 77.

¹⁹ Hinrichs moved to St. Louis in 1889 and began teaching at Washington University. In his *Sixth Biennial Report of the Central Station of the Iowa Weather Service* (Des Moines: G.H. Ragsdale, State Printer, 1889), Hinrichs criticized the Weather Bureau for its poor scientific practices and its efforts to undermine his project. In one of his first reports, J.R. Sage, the head of the Weather Bureau-affiliated Iowa Weather and Crop Service, fired back against Hinrichs’s organization, citing the “defect in its management” and explaining how the Iowa general assembly changed its support from Hinrichs to his rivals. *Annual Report of the Iowa Weather and Crop Service in Co-Operation with the U.S. Department of Agriculture, Weather Bureau, for the Meteorological Year 1890* (Des Moines: G.H. Ragsdale, State Printer, 1891), 6-7.

²⁰ Gustavus Hinrichs, “A Few Facts About the Iowa Weather Service,” Feb 2, 1888, Gustavus Hinrichs papers, Box 3, University of Iowa Library, University Archives, RG99.0039. Although Hinrichs’s institutional home, the State University of Iowa (later renamed the University of Iowa, not to be confused with Iowa State University in Ames), predated the Morrill Act of 1862, his utilitarian outlook fits the guiding ethos of the new land grant schools. Hinrichs’s emphasis on usable knowledge also mirrors the approach of late nineteenth and early-twentieth century “field stations” chronicled by Jeremy Vetter in his book *Field Life: Science in the American West During the Railroad Era* (Pittsburgh: University of Pittsburgh Press, 2016). Vetter writes that the “raison d’être of the station was often to satisfy a perceived demand for useful knowledge” (280). Like the biological surveys and agricultural field stations described by Vetter, Hinrichs’s network helped bridge “experiential and cosmopolitan knowledge” (155).

short-term meteorological studies would help Iowans understand, cope with, and potentially predict destructive storms and tornadoes.²¹ Hinrichs's 1877 report offered a rousing defense of the Iowa State Weather Service. Data collected by his network, he claimed, had "conclusively demonstrated" the "intimate relation between the percentage surface covered with timber and the distribution of rainfall as to amount, frequency, and intensity, as well as the distribution of fertilizing thunder-storms." Hinrichs viewed weather patterns as dynamic and susceptible to human influences – mostly afforestation and deforestation – so he believed Weather Service "results" should "form the basis of rational legislation...having for its object the increase of healthfulness and fertility of entire regions of our State."²² In other instances, however, Hinrichs characterized the data supporting theories of human climatic influences as "apparently contradictory." But he presented these doubts and contradictions as proof that his Weather Service should continue to carry out its work "by extended observation and reduction."²³

Hinrichs constructed climatology as both a utilitarian endeavor and as a noble, esoteric science driven by curiosity for the unknown. He fused Valenčius's "everyday science" with the "pure science" described by Paul Lucier, seeking immediate material rewards while also uncovering mysteries and raising new questions about the sources of environmental and climatic changes.²⁴ *Rainfall Laws Deduced from Twenty Years of Observation*, published in 1893, represents the culmination of Hinrichs's work in Iowa and his efforts to meld citizen science and practical knowledge with complex statistical methods. In this work, Hinrichs outlined a series of logarithmic equations for determining the relative agricultural utility of rainfall events. His experiences working in his "large garden" near the "bluffs of the Iowa River" piqued his interest in juxtaposing the success of agricultural endeavors with rainfall statistics provided by volunteer observers. Noting the inadequacy of simple precipitation totals and the influence of evaporation and runoff, Hinrichs wrote that the "thrashing [sic] machine seemed to be entirely independent of my rain gauge." As an alternative to simple rainfall numbers, Hinrichs devised a series of "laws" and parameters that would transform meteorological statistics into dynamic tools in the service of agriculture. Categories such as "total utilizable rains" and "total useless or damaging rains" would facilitate efforts to assess crop prospects. It is unclear whether Hinrichs's efforts succeeded in rendering multitudes of new weather statistics more useful and legible to farmers. Still, *Rainfall Laws* highlights Hinrichs's belief that climatic laws and meteorological statistics would only beget uncertainty unless paired with material, quotidian realities.²⁵

Although the US Weather Bureau published Hinrichs's statistical tome, the Iowan had a contentious relationship with the Washington, DC-based scientific establishment. In 1891, the civilian U.S. Department of Agriculture took over the U.S. Army Signal Service's weather

²¹ Since Hinrichs viewed meteorological and climatological research as intertwined, I use the term meteo-climatic to characterize his work.

²² Gustavus Hinrichs, "Second Annual Report of the Iowa State Weather Service," Printed as Appendix to the Report of the Iowa State Agricultural Society for the year 1877, 624.

²³ Gustavus Hinrichs, "Rainfall and Timber in Iowa," 199-200.

²⁴ Lucier, "The Origins of Pure and Applied Science."

²⁵ Hinrichs, *Rainfall Laws*, see 17 for "large garden," 13 for "thrashing machine," and 15 for "total utilizable."

reporting network. The national network had been growing throughout the course of the 1870s and 1880s, sometimes collaborating with local and state-based organizations such as Hinrichs's. In Iowa, however, scientific and personal conflicts prevented smooth cooperation. George E. Curtis, a prominent federal bureaucrat and meteo-climatic theorist, published a scathing review of *Rainfall Laws*, calling various portions of the book "obscure" and "unnecessary." Curtis also took issue with Hinrichs's probabilistic approach to statistics, climate, and meteorology.²⁶ Hinrichs cast similar aspersions upon the work of the "national weather bureau" and defended his choice to establish an independent state weather service in Iowa. As if their "indifferent, if not hostile" attitude toward the Iowa State Weather Service was not bad enough, Hinrichs wrote, the US Army Signal Corps, the Weather Bureau, and the Smithsonian Institution also carried out shoddy meteo-climatic science. In an 1887 report, he admonished the national weather bureaucracy for emphasizing "the production of so-called indications and probabilities" to "the detriment of real climatological study." The Iowan added that he hoped "a broader, a more scientific spirit" would "in time prevail in the management of the national weather service."²⁷

The conflict between Hinrichs and national institutions may have arisen from his sometimes pugnacious personality. During his time at the State University of Iowa, Hinrichs clashed with administrators and fellow professors. In a decade-long effort to have the polymath dismissed, other faculty members at the university presented lists of grievances against Hinrichs to the Board of Regents. They claimed that Hinrichs belittled his colleagues "in his classrooms, on the street, at home, and abroad" even "to the extent of using profane language." Other disputes centered on Hinrichs's purportedly excessive salary and his supposed appropriation of university equipment, including an "electric lantern" and a "heliostat."²⁸ Though his colleagues succeeded in having Hinrichs dismissed from the Collegiate Faculty in 1886, students and several local newspapers came to Hinrichs's defense. The *Iowa City Post*, for example, decried the "most desperate and dastardly assaults upon the good name of Dr. Hinrichs." The climate theorist lamented his dismissal, saying that he was "neither invited nor allowed to defend" himself.²⁹ In the decades following his firing, many Iowans and others sought to rehabilitate Hinrichs. A 1923 obituary indicates that his allies and admirers to some extent succeeded in reclaiming the polymath's reputation. Its author, Charles Keyes, enumerated Hinrichs's scientific achievements in climatology, chemistry, and crystallography, while adding that the Iowan had been "coldly received" in his home state but had garnered "loud applaudits everywhere throughout intellectual Europe."³⁰

²⁶ See George E. Curtis, "Review of Rainfall Laws, Deduced from Twenty Years' Observation," *The American Meteorological Journal* 10 (Apr 1894). For a study on the politics of probability and prediction in turn-of-the-century American meteorology, see Jamie L. Pietruska, "US Weather Bureau Chief Willis Moore and the Reimagination of Uncertainty in Long-Range Forecasting," *Environment and History* 17 (2011).

²⁷ See Hinrichs, "Fifth Biennial," 5.

²⁸ See *Daily Register* July 6, 1875, Hinrichs Papers, Box 1, and "Documents Relating to the Dismissal of Dr. Gustavus Hinrichs," Hinrichs Papers, Box 1.

²⁹ "Documents Relating to..." Hinrichs papers, Box 1.

³⁰ Keyes, *Iowa Academy of Science* 30 (1923).

Hinrichs's personal squabbles notwithstanding, disagreement over the proper scale for conducting meteo-climatic research drove his clash with national scientific institutions. As Phaedra Daipha has argued, "the relative ease with which a wide variety of data could be collected intensified jurisdictional wars...over the merit of local weather versus local atmospheric systems, observation versus speculation, reportage of unusual weather versus global atmospheric systems."³¹ James Bergman has chronicled one such struggle over scale in his recent study on the Blue Hill (Massachusetts) Meteorological Observatory. Bergman demonstrates that late nineteenth-century efforts to centralize and "scale up" observation networks often raised new questions about the relationship between lay knowledge, local beliefs, and "universal" scientific knowledge.³²

In the Great Plains, some scale-based "jurisdictional wars" centered on extreme weather events. Hinrichs had a special interest in "destructive great storms," and especially tornadoes. In an 1889 article, he published a map showing all recorded tornado tracks in Iowa between 1875 and 1888, asking government scientists to "stop the manufacture of dire tornadoes" – in other words, to cease issuing exaggerated reports about tornado dangers in Iowa.³³ Only local experience, he argued, would allow for a proper tracking and warning system. After describing a system of "weather flags" meant to communicate barometric changes to the community, Hinrichs stated, "It is of supreme importance that our people should learn to help themselves, and not vainly rely upon a distant power which even at best cannot reach them until too late. Weather telegrams are of greatest possible value, but only as aids to properly organized local work."³⁴ New technologies, he insisted, would be effective only if implemented on a state scale and in conjunction with local knowledge. As to the question of whether Iowa "is big enough for a weather service," Hinrichs

³¹ Phaedra Daipha, "Weathering Risk: Uncertainty, Weather Forecasting, and Expertise," *Sociology Compass* 6 (2012): 18. For scale and climatology, see also Deborah Coen, "Imperial Climatographies from Tyrol to Turkestan," *Osiris* 26 (2011).

³² James Bergman, "Knowing their Place: The Blue Hill Observatory and the Value of Local Knowledge in an Era of Synoptic Weather Forecasting, 1884-1894," *Science in Context* 29 (2016).

³³ For "destructive great storms," see Hinrichs, "Second Annual Report," 655. See also Hinrichs, "Tornadoes and Derechos." *American Meteorological Journal* Vol 5, No. 9 (Jan 1889). For a history of tornado forecasting and warning, see Marlene Bradford, "Historical Roots of Modern Tornado Forecasts and Warnings" *Weather and Forecasting* 14 (August 1999).

³⁴ Gustavus Hinrichs, "First Biennial Report of the Central Station of the Iowa Weather Service," (Des Moines: F.M. Mills, State Printer, 1880), 22-23. Jeremy Vetter's case study on early twentieth-century Kansas analyzes the influence of telegraphs on amateur weather observation networks. See Vetter, "Lay Observers, Telegraph Lines, and Kansas Weather: The Field Network as a Mode of Knowledge Production," *Science in Context* 24 (June 2011). Vetter develops the concept of the "field network" – a "mode of knowledge production in modern science that has linked together geographically dispersed lay people whose activities are coordinated and directed from a central location" (259). He focuses on the "top-down coercive authority exerted by [US Weather] Bureau staff over subordinate collaborators" (275). Technologies such as the telegraph, Vetter argues, helped make weather observation networks ever more centralized and hierarchical. Earlier organizations such as Hinrichs's shared many characteristics with the networks described by Vetter. Back in the 1870s and 1880s, however, local observation networks still struggled to incorporate telegraphy and other novel technologies into their quotidian scientific practice. As shown by Hinrichs's quote, the advent of telegraphy did not immediately give rise to large-scale systematization and national or regional-scale centralization.

answered, “indeed it is,” because it was far bigger than “England, Portugal, Switzerland,” each of which had separate, state-supported weather services.³⁵

Though he invoked other nation-states to legitimize his work, Hinrichs and his weather service cannot be cast as simple vehicles for state-driven modernization and centralization. National weather prediction systems and all-explaining theories of storm formation and climatic changes did not inspire Hinrichs so much as the task of keeping a “faithful exposition of the actual conditions of the weather in Iowa, so that our Weather Reports will continue to be of value long after views and theories shall have passed away.” Hinrichs sought to “simplify and systematize” institutions and flows of information. In 1870, he founded the *American Scientific Monthly*, and stated that the journal would act as “an exponent” of “modern science,” “the spirit which is fashioning this age.”³⁶ Yet he espoused a capacious brand of modern science, one that included polymaths and resisted the hardening of discrete disciplines.³⁷ Perhaps Hinrichs’s expansive interests made it hard for him to find a niche in the growing national scientific bureaucracy and meteo-climatic network. The friction between the Iowa State Weather Service and the American scientific establishment also underscores Pietruska’s interpretation of center-periphery theory. Without flattening hierarchies of scientific infrastructure, Pietruska demonstrates the constant contestation and renegotiation of centers and peripheries.³⁸ Data did not simply flow from the interior to nodes of knowledge production on the eastern seaboard and then, reconstituted as “science,” trickle back to the peripheries.³⁹

While resisting encroachment from the national metropole, Hinrichs created his own center of calculation in Iowa City.⁴⁰ His house in Iowa City served as the “Central Station” of the data collection network.⁴¹ Hinrichs’s home featured a three-story tower, its top two floors dedicated to

³⁵ Hinrichs, “Second Annual Report,” 623.

³⁶ For “simplify and systematize,” see “First Annual Report,” 22. For “modern science” see Gustavus Hinrichs, *American Scientific Monthly*, Edited and published by Prof. Gustavus Hinrichs. Vol. 1, No. 1 (July 1870), State Historical Society of Iowa (Q1.A8), 3.

³⁷ David Cahan describes the solidification of scientific titles and designations in nineteenth-century science in “Looking at Nineteenth-Century Science: An Introduction,” in David Cahan, ed., *From Natural Philosophy to the Sciences: Writing the History of Nineteenth-Century Science* (Chicago: University of Chicago Press, 2003), 4; see also “Institutions and Communities,” in Cahan, *From Natural Philosophy...*, 297. Along with “full-time devotion to and pay for scientific work” and “advanced well-defined educational credentials,” Cahan views the university as the “principal institutional setting for science.” It is noteworthy that even though Hinrichs worked for the State University of Iowa, his weather service remained somewhat independent from the university’s institutional umbrella. This separation, I argue, reveals the persistence of popular and amateur science in an era of institutionalization.

³⁸ Pietruska, “Hurricanes, Crops, Capital,” 410.

³⁹ See Ralph R. Hamerla, *An American Scientist on the Research Frontier: Edward Morley, Community, and Radical Ideas in Nineteenth-Century Science* (Dordrecht, the Netherlands: Springer Press, 2006), 2, and Naylor, “Nationalizing Provincial Science,” 409.

⁴⁰ The concept of “center of calculation” is from Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Cambridge, MA: Harvard University Press, 1987).

⁴¹ Hinrichs’s home was built in 1879. See handwritten note on 1909 photograph of Hinrichs’s house in University of Iowa archives, Hinrichs Papers, photographs file. Before his house was built, Hinrichs used another observatory on Church and Clinton Streets in Iowa City. See Ray Wolf’s “Brief History of Gustavus Hinrichs, Discoverer of the Derecho” <http://www.spc.noaa.gov/misc/AbtDerechos/hinrichs/hinrichs.htm>

the Weather Service, and a rooftop balcony complete with weathervane, thermometer, hygrometer, and rain gauge (see Figure 1).

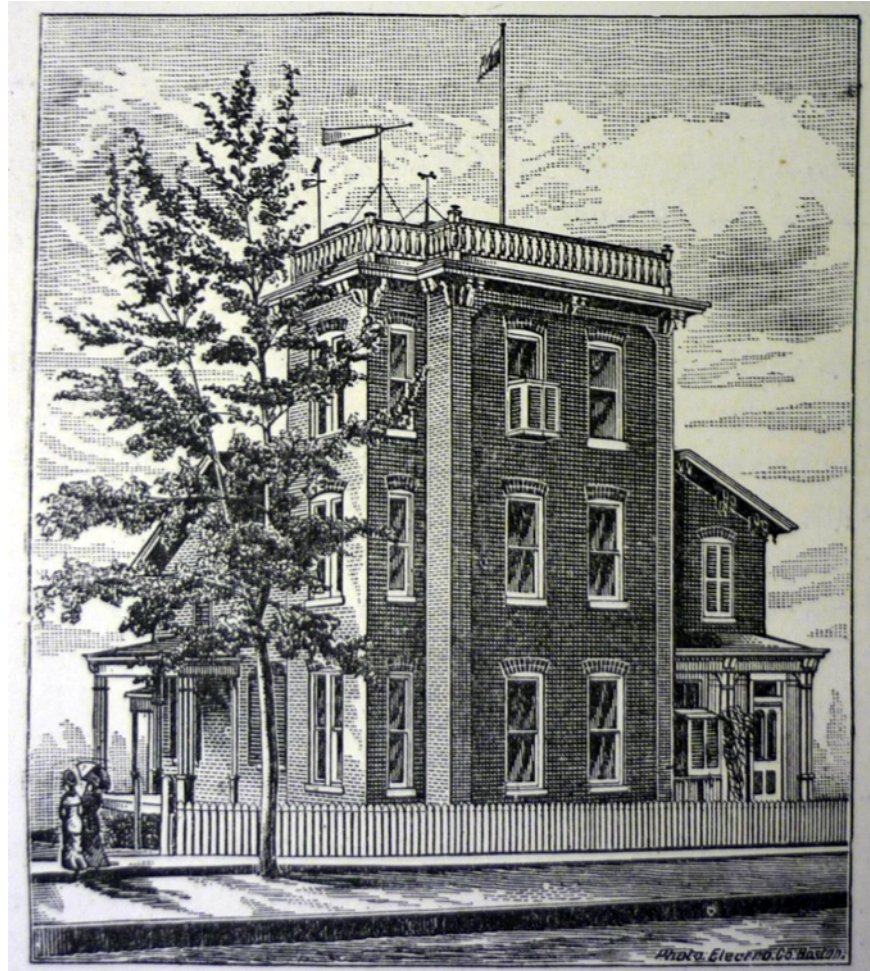


Fig. 1. Central Station of the Iowa State Weather Service, Iowa City. From Hinrichs, *Second Biennial Report of the Central Station of the Iowa Weather Service* (1882).

Though Hinrichs conducted his own observations, his most arduous task was managing his network of volunteer observers. By 1877, Hinrichs wrote, he could count on “eighty-seven volunteer observers representing as many *Stations*.” I was unable to find archival evidence about these citizen scientists, their views on science, climate, weather, and politics, or about the nature of their relationship with the weather service’s founder. But the fact that Hinrichs termed each observer a “station” indicates that he accorded some measure of respect and gratitude to the volunteers upon whom he depended. The Weather Service’s second annual report (1877) included a map showing the location of each volunteer observation station (see Figure 2).



Fig. 2. Stations of the Iowa State Weather Service. From Hinrichs, *Second Annual Report of the Iowa State Weather Service* (1877)

In his reports and articles, Hinrichs offered a glimpse into the challenge of creating an imagined community of science over such an expansive territory.⁴² He described Iowa as a settler society marked by transience: “In our comparatively new State people change residence more frequently than in older states.” Volunteer observers dropped out because of death, disease, or “neglect.”⁴³ Adding insult to injury, he complained, the national Weather Bureau “attempted to estrange our volunteers” during the 1880s.⁴⁴ Despite these difficulties, volunteers provided Hinrichs with a flood of data. The polymath lamented the dearth of “clerical help” and spent long hours mailing, copying, and “office printing.” In 1878 alone, he claimed, “44,502 copies were made from 166 stencils.”⁴⁵ Creating tables, maps, and reports from data provided by volunteers presented another herculean task. “It should be remembered,” Hinrichs wrote, “that in this work there is no cessation; every day brings its load of facts and data which have to be properly classified, recorded and disposed of.”⁴⁶ Hinrichs created a system of forms intended to facilitate correspondence with observers and ease the translation of data from the field into charts and

⁴² David Cahan discusses the formation of “imagined communities of science” in the nineteenth century. See David Cahan, “Introduction” in *From Natural Philosophy to the Sciences*, 11.

⁴³ Hinrichs, “First Biennial Report,” 6.

⁴⁴ Hinrichs, “Sixth Biennial Report,” 5.

⁴⁵ Hinrichs, “First Biennial Report,” 24.

⁴⁶ Hinrichs, “Second Biennial Report of the Central Station of the Iowa Weather Service” (Des Moines: F.M. Mills, State Printer, 1882), 31.

eventually maps.⁴⁷ The cartographic process, however, remained tedious. For example, an 1883 series of maps correlating timber areas with rainfall averages contained a staggering 26,082 rainfall measurements.⁴⁸ The work proved so onerous that Hinrichs wondered if it would be “imprudent” for him to continue his “personal sacrifice” and “expenditure of labor and money.”⁴⁹

Despite his rhetoric about advancing “modern science,” Hinrichs sometimes agonized that his work might be “thoroughly useless.”⁵⁰ With the popularization of science across the United States, new journals and meteo-climatic theories proliferated, creating a cacophony of voices.⁵¹ The contributions of the Iowa State Weather Service risked being lost in this chaotic scientific cauldron. Hinrichs reassured himself and his volunteers with the hope that “every true observation made by any of our observers at any station in Iowa will... constitute an additional link in the chain which binds the past to the future.”⁵² Since Hinrichs found hope in the notion of a growing web of meteo-climatic knowledge, he may have been reassured to find that in 1893, Corydon P. Cronk of the Maryland State Weather Service cited the contributions of his weather service: “In the state of Iowa it has been conclusively proven, by the records of the State Weather Service, that the annual rainfall is more evenly distributed throughout the year in the more heavily wooded portions of the state.” Bolstered by data from Iowa, Cronk made strident claims about forests’ influence on climate patterns. He even speculated that afforestation and reforestation might offer “protection from the tornado” by preventing the “overheating of the earth’s surface” and thus diminishing the “energy of these storms and...lessen[ing] the frequency of tornadoes.”⁵³ Cronk likely derived his inferences from cartographic series created by Hinrichs (see Figure 3), perhaps the map series that required over 26,000 observations. Yet his claims maintained none of the uncertainties and qualifications that appeared in Hinrichs’s work.

⁴⁷ Hinrichs, “Second Annual Report,” 622.

⁴⁸ Gustavus Hinrichs, *Notes on Cloud Forms and the Climate of Iowa*, Central Station, I.W.S. (Iowa Weather Service), 1883.

⁴⁹ Hinrichs, “Second Annual Report,” 625. Though the state of Iowa provided some financial support after 1878, Hinrichs shouldered much of the weather service’s financial burden himself. See Wolf, “Brief History of Gustavus Hinrichs.”

⁵⁰ For “thoroughly useless,” see Hinrichs, “Third Biennial Report of the Central Station of the Iowa Weather Service” (Des Moines: George E. Roberts, State Printer, 1883), 5.

⁵¹ For an overview of the dramatic rise of popular science in the Gilded-Age United States, see Rebecca Edwards, *New Spirits: Americans in the Gilded Age, 1865-1905* (Oxford: Oxford University Press, 2006), 151-169. Citing magazines such as *Popular Science Monthly*, *Scientific American*, and *Science*, Edwards argues that “America became a nation of scientific enthusiasts” (160).

⁵² Hinrichs, “Third Biennial Report,” 5. Hinrichs’s doubt over his work’s significance underscores the historian Jeremy Vetter’s argument about the paradoxical nature of scientific universalism. “The desire to attain knowledge that can be applied to all times and places,” he writes, “has been an overriding ambition of modern science.” But the drive to create universalist knowledge “has not always worked to produce pragmatically useful and environmentally sustainable knowledge on the ground in particular places.” See Vetter, *Field Life*, 338. Hinrichs and his network show that the modern drive to create universally applicable knowledge both created and relied upon cryptic, uncertain forms of local knowledge.

⁵³ C. (Corydon) P. Cronk, “Influence of Forests on Climate and Agriculture,” *Maryland State Weather Service Monthly Report* 3, 6 (US Department of Agriculture, Weather Bureau, October 1893), 57-58.

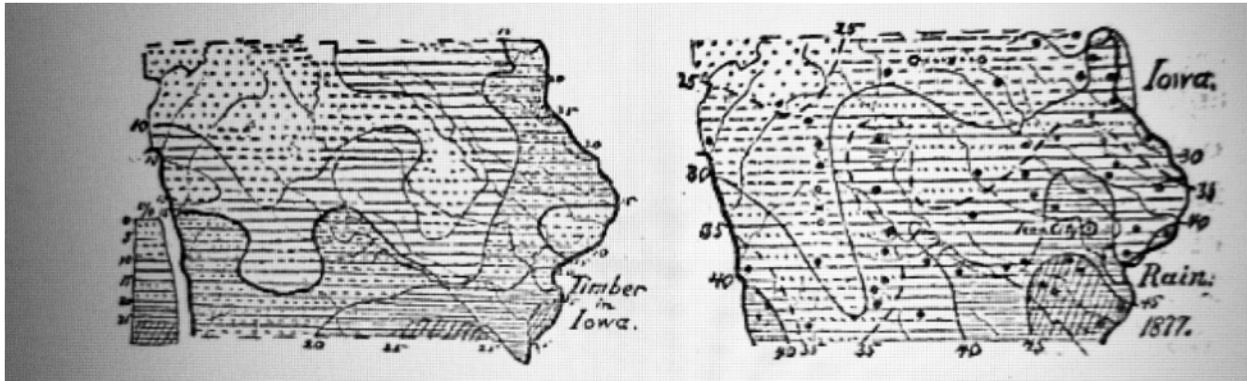


Fig. 3. Hinrichs, *Second Annual Report of the Iowa State Weather Service* (1877), 624. Cronk may have been referring to these maps (or to similar map series made by Hinrichs) in his 1893 article. Hinrichs wrote that the “distribution of the shading expressing the amount of rainfall (in inches) shows a close relation to the distribution of the shading marking the percentage of the surface covered with timber.” Thus, he argued, the maps “furnish abundant material support” for the theory that society could influence climatic patterns through afforestation and deforestation.

Though the Iowan did pronounce that he had “conclusively demonstrated” forest influences on climate, he often followed his statements with calls for further research. Cronk’s use of Hinrichs’s research offers a glimpse into the circuitous networks of knowledge circulation in the Gilded-Age United States. The diffusion of information and its interpretations was not one-way: climate theory sometimes flowed from West to East along with data. And the re-use and re-framing of information at each center of calculation created layer upon layer of uncertainty.

Syncretic Science

Historians have sometimes characterized theories of local and regional forest-climatic influences as “mythological conceptions,” as the last vestiges of naturalistic, folkloric, and pseudo-scientific paradigms.⁵⁴ Yet Gilded-Age climatological and meteorological writings from the “middle border” offer more evidence of continuity and syncretism than of a straightforward transition from naturalistic beliefs to data-derived scientific knowledge. As David Livingstone and Charles Withers have observed, nineteenth-century scientific thinkers inhabited multiple spaces and “operated different moral and epistemic economies.”⁵⁵ Cronk, Hinrichs, and others employed both quantitative and anecdotal, observational evidence. After invoking Hinrichs’s statistical studies,

⁵⁴ Paul Travis, “Changing Climate in Kansas: A Late 19th-Century Myth.” *Kansas History* Vol. 1, No.1 (Spring 1978): 50.

⁵⁵ Charles Withers and David Livingstone, “Thinking Geographically About Nineteenth-Century Science” in Withers and Livingstone, eds, *Geographies of Nineteenth Century Science* (Chicago: Chicago University Press, 2011), 5.

for example, Cronk remarked, “The traveler who now crosses the continent through the states of Iowa, Kansas, or Nebraska will see the strong belts of forest trees which the laws of the states have compelled the owners of land to plant. The results have been marked. The rainfall is more evenly distributed.”⁵⁶ Cronk and Hinrichs appealed to agriculturalists and potential volunteer observers while also attempting to elucidate complex natural laws. They employed different lexicons to engage with different audiences in seeking financial, institutional, and moral support. Despite – and at times because of – their syncretic approach, Hinrichs and his contemporaries took part in “boundary work,” the strategic practice of attempting to exclude other authorities from the scientific realm.⁵⁷ Some proved adept at a peculiar juggling act: policing the boundaries of science while also working to “translate” between different ways of knowing.⁵⁸

In addition to polymaths and institution-builders such as Hinrichs, other Euro-Americans engaged in a vigorous debate over the proper parameters of meteo-climatic science. S.L. Doshier, a Manistee, Michigan, based observer for the national Weather Bureau, found fault with the persistence of naturalistic impressions in climatological studies. In 1893, Doshier penned a letter to the *American Meteorological Journal*, a periodical that published contributions from prominent government scientists as well as Hinrichs and similar figures. Vague impressions drawn from hazy memories, Doshier insisted, could only give rise to fallacious climatic theories. “Whenever there occurs a period of extreme heat, a long wet spell or dry spell or even a period of exceedingly fine weather,” he wrote, “people will always claim that no such weather ever occurred before.” Doshier alleged that such misconceptions engendered the “general opinion prevailing that the climate of our country is changing, especially with reference to the winters, which, it is often claimed, are growing milder.” Doshier found no evidence of climatic change, anthropogenic or otherwise, in the records of multiple Weather Bureau stations.⁵⁹

Some “middle border” climate theorists shared Doshier’s belief that only data collection could offer definitive solutions to scientific quandaries. In 1878, for example, the Kansan Isaac Noyes expressed his belief that efforts to collect “daily facts” would “enlighten mankind with the mysteries that preside over the natural phenomena that govern the weather.” Quantitative triumphalism, however, did not always foster consensus on the contentious question of human-induced climatic changes. Unlike Doshier, Noyes allowed for the possibility of climatic changes

⁵⁶ Cronk, “Influence of Forests,” 58. Cronk may be referring to the federal Timber Culture Act of 1873 or to state-sponsored afforestation initiatives such as the Arbor Day movement.

⁵⁷ See Thomas Gieryn, *Cultural Boundaries of Science: Credibility on the Line* (Chicago: Chicago University Press, 1999), 15-18. Gieryn identifies three types of boundary work. My main concern here is with the category he terms “exclusion” – the exclusion of certain figures, methods, and practices as unscientific.

⁵⁸ For “translation,” see Tilley, “Global Histories, Vernacular Science...,” 112, 117. As Sara B. Pritchard has argued, boundary work “has the potential to be generative and empowering, sometimes even counter-hegemonic.” See Pritchard, “Joining Environmental History with Science and Technology Studies: Promises, Challenges, and Contributions,” in *New Natures*, eds. Pritchard, Finn Arne Jorgensen, Dolly Jorgensen (Pittsburgh: University of Pittsburgh Press, 2013), 13.

⁵⁹ Letter from S.L. Doshier, *American Meteorological Journal* 9, 10 (Feb 1893).

and supported the notion that society could influence weather patterns.⁶⁰ The decade and a half that elapsed between the publication of Noyes and Doshier's pieces cannot entirely explain this difference of opinion, as Hinrichs and many others employed data-based approaches to support theories of anthropogenic climate change well into the 1890s.⁶¹

Like Doshier, some Great Plains climate theorists sought to purge climate discourse of what one Iowa horticulturalist termed "moonshine notions."⁶² At the same time, climate-related newspaper stories such as the Topeka Daily Tribune's 1879 "Bogus Science Against Experience and Common Sense" show that some Great Plains Euro-Americans valued "practical knowledge" over "science."⁶³ Much of this hostility toward high science and its exponents originated in suspicion of Eastern elites, a resentment that would find political expression in the Populist Party of the 1890s.⁶⁴ But a broad cross-section of Gilded-Age scientific thinkers attempted to incorporate folkloric beliefs within quantitative methodologies such as those employed by scientists in eastern metropolises. Some Great Plains polymaths, horticulturists, newspapermen, and university "men of science" seemed to take their cue from John Trowbridge.

An Easterner and professor of physics at Harvard, Trowbridge authored an 1872 *Popular Science Monthly* piece arguing that "great fires" have "with some probability of truth...an influence upon the production of rain." He derived his hypotheses from folkloric notions about rainstorms following fires and admonished colleagues who dismissed folk beliefs out of hand: "The attitude of scientific men in regard to so-called popular fallacies and superstitions is not, in general, a praiseworthy one. A belief needs only to be widespread among the people at large to be denounced." Trowbridge conducted a series of electrical experiments in his laboratory in an effort to simulate the effect of fires on atmospheric conditions. Though unable to rule out uncertainties arising from his methods, he found that the experiments affirmed naturalistic impressions about large-scale fires triggering rainstorms.⁶⁵ As a proponent of laboratory experiments, Trowbridge participated in an ongoing debate about the relationship among natural philosophy, pure science, applied science, and engineering. The historian of science Ronald Kline has highlighted the fluid,

⁶⁰ Isaac P. Noyes, "A New View of the Weather Question," *The Kansas City Review of Science and Industry* 2 (July 1878), see 218-219 for "weather mystery," 227 for a discussion of climate change.

⁶¹ Hinrichs, *Rainfall Laws*; for another 1890s source using measurements to endorse climatic influences, see "Influence of Groves on the Moisture Content of the Air" by L.C. Corbett (West Virginia University, Morgantown, WV), *The Forester* 3, 4 (April 1, 1897).

⁶² For a description of forest-climate influence theories as "moonshine notions," see Mr. Foster's remarks in "Discussion of Meteorology," *Transactions of the Iowa State Horticultural Society for 1879* (Des Moines: F.M. Mills, State Printer, 1880), 486.

⁶³ *Weekly Tribune* (Topeka, KS), Mar 27, 1879, Kansas State Historical Society, Rain and Rainfall Clippings.

⁶⁴ See, for example, Mr. Holton's remarks quoted in Wilber, *Great Valleys and Prairies*, 81. Holton voiced his disdain for "philosophers" and "a certain class of scientists," experts who disputed theories of human-induced climatic improvement. For a recent study on Populism, see Noam Maggor, *Brahmin Capitalism: Frontiers of Wealth and Populism in America's First Gilded Age* (Cambridge, MA: Harvard University Press, 2017).

⁶⁵ John Trowbridge, "Great Fires and Rain-Storms," *The Popular Science Monthly* (December 1872), 206, 211. The Great Chicago Fire, Peshtigo fire, and other massive conflagrations of the early 1870s spurred an interest in investigating the role of fires in shaping weather patterns. See also Jonathan Periam, "Forest Tree Planting, as a Means of Wealth," *Transactions of the Illinois State Horticultural Society for 1871* (Chicago: Reade, Brewster, & Co., 1872), 34-35.

ever-evolving meaning of each of these fields.⁶⁶ On the one hand, contestation over the boundaries of emerging disciplines gave rise to purity discourses: efforts to expunge purportedly illegitimate epistemologies. On the other hand, it created openings for people such as Trowbridge to draw from folklore and popular impressions.

Trowbridge used popular beliefs and anecdotes only as a starting point, as a means of devising a hypothesis to be tested in a laboratory. Some “middle border” climate writers, by contrast, considered evidence drawn from experience and observation alongside evidence obtained by measurement.⁶⁷ In the work of J.L. Budd, a member of the Iowa Board of Forestry, experiential evidence filled gaps and voids in the statistical record. Budd presented a paper titled “Possible Modification of Our Prairie Climate” to the 1887 meeting of the American Forestry Congress in Illinois. His presentation aimed to find explanations for recent crop failures in Iowa. “Ordinary meteorological tables,” he argued, “are not sufficiently detailed to throw light on the influence of the weather on agricultural and horticultural crops.” Making no apparent reference to the efforts of his fellow Iowan Hinrichs, Budd described Iowa’s statistical record as too brief to reveal anything more than “*probable* causes for *known* effects.” He relied on the evidence of personal experience for proof of these “*probable* causes.” Ironically, Budd’s experiences and observations prompted him to identify plowing as the cause of Iowa’s agricultural and climatic troubles. Since vast swaths of the state’s land had been “turned with the plow,” winds “from all westerly points now literally pass over a dry heated soil in a dry period, which drinks up with hungry avidity the moisture of the air.” According to the Iowan, “methodical forestry planting” could act as a “complete or partial remedy” for the “climatic troubles” created by plowing. The crux of Budd’s argument – the causal factor at the core of the purported “modification” of climate – originated from naturalistic impression and observation. In the absence of empirical evidence, he relied on his own experience on the land to prove plowed soil’s ability to draw moisture from passing air masses. For Budd, experience and anecdote served to infuse some certainty into the probabilistic frameworks of statistical climatology.⁶⁸

Great Plains climate theorists invoked popular impression and the weight of experience for varying purposes, sometimes to endorse theories of human influence on climate and sometimes to cast doubt on such notions. In 1878, for example, William Tompkins of the *Larned Press* (Kansas) cited anecdotal evidence of dew formation to show climatic continuity. The newspaper claimed that dew formed with as much frequency in 1873, when Native Americans still “roamed over the land,” as in succeeding years, after Euro-Americans had plowed thousands of acres of soil near Larned.⁶⁹ As shown by Tompkins’s piece, the eclectic range of Gilded-Age climate discourse

⁶⁶ Ronald Kline, “Construing ‘Technology’ as ‘Applied Science’: Public Rhetoric of Scientists and Engineers in the United States, 1880-1945,” *Isis* 86 (1995): 194-198.

⁶⁷ For a classic study on the politics and implications associated with invoking the “evidence of experience,” see Joan Scott, “The Evidence of Experience,” *Critical Inquiry* 17 (1991).

⁶⁸ J.L. Budd, (Iowa Board of Forestry), “Possible Modification of Our Prairie Climate,” *Sixth Annual Meeting of the American Forestry Congress*, (Springfield, IL: State Register Book and Job Print, 1887) 20-22.

⁶⁹ *Larned Press* (Kansas), Aug 8, 1878.

cannot be distilled into a simple dichotomy: folkloric proponents of climatic improvement or desiccation versus quantitative modernizers who refuted climate change theses.

Perhaps no figure better reflects the syncretic character of Great Plains meteo-climatic science than Frank H. Snow. Snow's views on climate mirrored Budd's theories more than those of his fellow Kansan Tompkins. A polymath with interests ranging from entomology to botany to meteorology, Snow published a series of articles on climate and climatic change between the 1870s and 1890s. Though his career in some ways paralleled Hinrichs's, Snow proved more adept at climbing institutional hierarchies than his contemporary from Iowa. He began teaching mathematics and natural sciences at the University of Kansas in 1866 and ascended to the position of chancellor in 1890. Like Hinrichs, Snow earned greatest renown outside the fields of meteorology and climatology, garnering recognition for his discovery of a fungus useful in combatting chinch bugs, a scourge on agriculture.⁷⁰ Snow's wide-ranging interests informed his approach to meteo-climatic questions: he employed different methodologies and sought to reconcile experiential evidence with statistical records. In 1873, Snow trumpeted the "self-registering instruments" and "automatic [apparatuses]" employed by the University of Kansas's meteorological station. Although he supplemented data from the university observation station with numbers from Smithsonian Institution observers, Snow believed that 50 years of weather records would be necessary to determine the accuracy of climate change hypotheses. In the absence of such statistics, Snow made recourse to popular sentiments. He viewed naturalistic impressions as a stopgap but implied that they carried inherent weight and authenticity, especially when attributed to the "oldest residents of Kansas."⁷¹

Snow believed that Euro-American settlement had increased rainfall amounts in Kansas through a variety of means, ranging from plowing to prairie fire prevention to the replacement of "short buffalo grass" with "longer and heavier grasses."⁷² Lacking statistical proof for increases in annual rainfall, Snow offered experiential evidence that human agency had rendered his state's climate more equable. In an 1871 letter to his fellow Kansan C.C. Hutchinson, Snow argued that "it certainly would be legitimate to cite the evidence of many of our 'old settlers' to the fact that the rain fall is more evenly distributed now than ten years ago, coming at shorter intervals and more gently, and that single storms, or showers, extend more hours than formerly." "This belief," Snow added, "I have often heard from our most intelligent citizens."⁷³ For a primarily agricultural society such as 1870s Kansas, rainfall distribution mattered nearly as much as annual rainfall totals. As Hinrichs observed in *Rainfall Laws*, brief and violent rainfall events could cause more harm than good. The allure of reliable climates could act as a strong enticement for prospective

⁷⁰ For biographical information on Snow, see F.H. Snow file 2/6/6 and finding aid, Spencer Library, University of Kansas.

⁷¹ Frank H. Snow, "Climate of Kansas." Report Submitted to Alfred Gray, Secretary State Agricultural Society, January 1st, 1873, see 1 for "instruments" and "apparatus" and 8 for "oldest residents." Snow alluded only to the memories of the oldest Euro-American residents, entirely eliding Native American experience and knowledge.

⁷² Snow, "Climate of Kansas," 7-8.

⁷³ A letter from F.H. Snow is cited by Clinton Carter Hutchinson's *Resources of Kansas: Fifteen Years Experience* (Topeka, KS: published by the author, 1871), 37.

settlers, and Kansans such as Snow had an interest in attracting more emigrants and development to their state. Indeed, it is telling that Hutchinson published Snow's assessments in *Resources of Kansas*, a document meant to attract agricultural settlers. He may have been more willing to gesture toward settler perceptions in a general audience publication than in a more formal scientific publication. Yet Snow cannot be dismissed as a booster-scientist or mere huckster. In an 1885 piece, Snow tempered optimistic expectations for human-induced climatic improvement. He described society's influences on climate as "local oscillations" and voiced his skepticism about the notion that Euro-American settlement would transform semi-arid regions such as Western Kansas.⁷⁴

In the same 1885 article, Snow identified a frustrating aspect of data-driven climatology. He lamented that the US Army Signal Corps had used incomplete records to question possible climatic changes in the Great Plains. Snow seemed to grasp some of the problems at the core of Gilded-Age meteo-climatic science: quantification created an unquenchable thirst for ever more data while sets of numbers could be deployed to prove any number of theories. Faced with these obstacles, theorists such as Snow created a holistic form of meteo-climatic science that included folklore, anecdote, and experience. The fusion of quantitative and qualitative methods allowed Snow and some of his contemporaries to cope with the uncertainty inherent to meteorology and climatology.⁷⁵

By the 1890s, however, Snow began to change his approach. He presented a paper at the 1895 annual meeting of the Kansas State Board of Agriculture titled "Periodicity of Kansas Rainfall and Possibilities of Storage of Excess Rainfall." After 27 years of consistent observation and measurement at his station in Lawrence, Kansas, Snow claimed to have found a regular, seven-year repeating pattern of dry and wet periods. In this instance, Snow argued that "the common people failed to recognize the periodicity of rainfall" before remarking that "Eastern meteorologists have called attention to a similar periodicity."⁷⁶ His shift away from folkloric and experiential evidence attests to the changing nature of Great Plains vernacular science. Impressionistic evidence continued to shape meteo-climatic discourse long after the turn of the century. Yet it took on an ever more peripheral role, underscoring the crystallization of scientific disciplines and the standardization and quantification of meteorology and climatology in the early twentieth century.

⁷⁴ F.H. Snow, "Is the Rainfall of Kansas Increasing?" *Kansas City Review of Science and Industry* 8. (Kansas City: Press of Ramsey, Millet, and Hudson, 1885), 458.

⁷⁵ For a discussion of "regimes of high uncertainty" in meteorology, see Daipha, "Weathering Risk," 15-16.

⁷⁶ F.H. Snow, "Periodicity of Kansas Rainfall and Possibilities of Storage of Excess Rainfall," *Ninth Biennial Report of the Kansas State Board of Agriculture* (Topeka: Edwin H. Snow, State Printer, 1895), 338-339. Perhaps because of its biblical undertones, the notion of seven-year cyclicity resonated with Great Plains climate theorists during the 1890s. The severe droughts of the late 1880s and early 1890s, which followed a series of wet years, may also have helped give rise to cyclical climate theories. For another example of a Kansan espousing theories of seven-year climatic cycles, see E.C. (Edward Charles) Murphy, "Is the Rainfall in Kansas Increasing?" *Transactions of the Kansas Academy of Science*, Vol. 13 (Topeka: Press of the Hamilton Printing Company, 1893), 19. See Lehmann, "Wither Climatology" for a study of repeating patterns and oscillations in turn-of-the-century climatology.

Snow's 1895 presentation also bore the hallmarks of turn-of-the-century Progressivism: concerns with utilitarian efficiency and careful resource management. Building reservoirs, he wrote, would allow Kansas to store rainfall from wet years "in such a way as to be of service in the following months or seasons when the precipitation is below average." Snow speculated that these storage reservoirs might also "increase the humidity of the atmosphere" and "reduce to an injurious minimum" damaging hot winds.⁷⁷ Hinrichs and Cronk's reports certainly prefigured Snow's Progressive turn toward efficiency. But the Kansan's later work reflects a shift away from sweeping efforts to induce and catalog climatic changes and toward a potentially systematized management of climatic variability. Snow never implemented his reservoir construction plan, and his theory of seven-year cycles did not gain much traction beyond the Great Plains. Still, his shift away from experiential vernacular science reflects the increasing, if incomplete, marginalization of folkloric climate discourse around the turn of the century.

Conclusion

Snow's adoption of Progressive utilitarianism shows that "middle border" scientific syncretism involved more than just the fusion of quantitative and qualitative methods. Other intellectual currents shaped Gilded-Age meteo-climatic science. Medical geography and enviro-climatic determinism, for example, found their way into Snow's work.⁷⁸ In an 1876 essay on "Climate and Brains" published by the Kansas Academy of Science, M.V.B. Knox invoked Snow's climatic expertise: "It has been suggested by Prof. F.H. Snow, that the general dryness of the atmosphere in Kansas may prove favorable to brain-workers." Knox also explained how countries located in areas with propitious climates, especially those located in Northern Europe, had surpassed other areas in terms of cultural productions.⁷⁹ According to Knox and Snow's logic, only Euro-Americans benefited from Kansas's salubrious climate, or else Native American inhabitants of the state would have eclipsed them in intelligence. In some instances, as in Snow and Hinrichs's work, medical geography appeared alongside theories of human-induced climate improvement. Hinrichs, a cautious proponent of forest-induced climate improvement, cited the influence of changing climates on "the state of health of the body and mind" as a rationale for supporting "special institutions for...accurate observation," such as his own Iowa State Weather Service.⁸⁰ Yet Hinrichs's stance vis-a-vis climatic influences on society differed from those of Knox and Snow. His theories of climatic dynamism and his support of complex climate improvement theses prevented him from endorsing simplistic and deterministic climate theories.

⁷⁷ Snow, "Periodicity," 339-340.

⁷⁸ For a discussion of geographies of health in the late nineteenth-century West, see Gregg Mitman, "Geographies of Hope: Mining the Frontiers of Health in Denver and Beyond." *Osiris* 19 (2004).

⁷⁹ M.V.B. Knox, "Climate and Brains," *Transactions of the Kansas Academy of Science* 5 (Topeka, Kansas: George W. Martin, Publishing House, 1877), 5-9.

⁸⁰ Hinrichs, "First Biennial Report," 5.

Though not all Gilded-Age vernacular scientists endorsed them, deterministic climate theories such as Knox's proliferated throughout Gilded-Age culture. In *The Mississippi Valley*, a triumphal and expansionist book intended for popular audiences, J.W. Foster echoed Knox by writing that "however much he boasts of his dominion over matter, [man] is the creature of climate."⁸¹ By depicting Euro-Americans as the sole beneficiaries of climatic influences, writings including Knox and Foster's served to legitimize capitalist expansionism as well as the dispossession and genocide of Native Americans. The political and cultural implications of climatic determinism underscore the imbrication of science and politics in the Gilded Age. As David Singerman has argued, in the late nineteenth century United States, increasing numbers of people realized that "scientific knowledge, far from being the inevitable ally of accountability and good governance, could just as easily be deployed to obfuscate and confuse, and thereby to wrest control of social and economic power."⁸²

In a sense, the syncretic and eclectic character of Gilded-Age climate science may have facilitated the strategic obfuscation described by Singerman. In another sense, perhaps, it may have flattened social hierarchies and allowed more people to participate in the contestation and production of scientific knowledge. Throughout this piece, I have tried to emphasize continuity, the persistence of experiential, anecdotal science, as well as the messiness and false dawns that marked local, participatory data collection projects such as Hinrichs's. Yet the project of "relocating meteorology" in the Gilded-Age "middle border" remains incomplete. Even embattled and sometimes reviled figures such as Hinrichs wielded far more influence than volunteer observers. The voices of Hinrichs and his rivals still dominate those of farmers, agriculturalists, and others who contributed to the project of vernacular science as much as bureaucrats and polymaths. At the same time, however, the writings of figures such as Hinrichs and Snow offer a fleeting glimpse into an intricate scientific universe that has largely gone unrecorded.

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⁸¹ J.W. Foster, *The Mississippi Valley* (Chicago: S.C. Griggs and Company, 1869), xi, see also 356-357.

⁸² David Singerman, "Science, Commodities, and Corruption in the Gilded Age," *Journal of the Gilded Age and Progressive Era* 15 (2016): 290.