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HURRICANES, CROPS, AND CAPITAL: THE METEOROLOGICAL INFRASTRUCTURE OF AMERICAN EMPIRE IN THE WEST INDIES[1]

This article examines the mutually reinforcing imperatives of government science, capitalism, and American empire through a history of the U.S. Weather Bureau's West Indian weather service at the turn of the twentieth century. The original impetus for expanding American meteorological infrastructure into the Caribbean in 1898 was to protect naval vessels from hurricanes, but what began as a measure of military security became, within a year, an instrument of economic expansion that extracted climatological data and produced agricultural reports for American investors. This article argues that the West Indian weather service was a project of imperial meteorology that sought to impose a rational scientific and bureaucratic order on a region that American officials considered racially and culturally inferior, yet relied on the labor of local observers and Cuban meteorological experts in order to do so. Weather reporting networks are examined as a material and symbolic extension of American technoscientific power into the Caribbean and as a knowledge infrastructure that linked the production of agricultural commodities in Cuba and Puerto Rico to the world of commodity exchange in the United States.

In July 1898, U.S. minister to Haiti W. F. Powell requested permission for the United States Weather Bureau to establish a reporting station at Mole St. Nicholas, citing the value of weather reports to international commerce and public safety and suggesting a moral imperative for "'co-operation in this advancement in the world of science.'" When Secretary of State for Foreign Affairs Brutus St. Victor conveyed Haiti's refusal based on a fear of American imperial ambitions, U.S. Secretary of Agriculture James Wilson reacted to this "'exceedingly unfriendly'" response and "'suspicio[n] of ulterior motive on the part of this Government'" by ordering the suspension of all U.S. weather reports to Haiti. The *New York Times* headline trumpeting "Haiti to be Cut Off from Favors" underscored the way in which the U.S. weather reporting network was deployed as an instrument of empire: the United States displayed its political and technoscientific power by controlling access to meteorological information.[2]

Wilson's strategy paid off when a September 1898 hurricane traced a devastating northwesterly trajectory from Martinique and Trinidad to Barbados, St. Kitts, St. Thomas, and Cuba. In Barbados, 83 people were killed, 150 injured, and $2.5 million lost in damages to what the *Advocate* called the most "appalling calamity" in the island's history. But the New Orleans *Times-Democrat* deemed these losses

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"infinitesimal" compared with what might have transpired had the U.S. Weather Bureau not issued hurricane warnings at noon on September 10, 9 hours before the winds reached their maximum force. The Kingston *Daily Gleaner* praised the Weather Bureau's cables to Barbados, Martinique, St. Kitts, and St. Thomas for providing "sufficient warning beforehand to prepare masters of vessels for impending danger," and the Philadelphia *North American* proclaimed, "The Information Was the Salvation."[3] After the Weather Bureau issued a statement testifying to the "hundreds if not thousands of lives and millions of dollars worth of property [that] were protected," Haitian Minister Legere promised to "co-operate in the fullest degree" and exchange weather observations and storm signals with the United States.[4] Similarly, the French islands of Martinique and Guadeloupe, which had previously rejected the presence of U.S. weather stations amid their own but volunteered their data, formally requested access to the U.S. network.[5] As this episode reveals, storm warnings functioned as a political weapon in the service of American expansionism, and contests over meteorological infrastructure were mapped onto geopolitical conflicts in the Western Hemisphere.[6]

This article examines the mutually constitutive relationship between government science and American empire through a history of the U.S. Weather Bureau's West Indian weather service at the turn of the twentieth century.[7] The Weather Bureau, established in 1891 in the U.S. Department of Agriculture, took over the administration of the first national weather service from the U.S. Army Signal Service, where it had resided since its creation in 1870.[8] As Weather Bureau officials in the 1890s realized, the creation of a meteorological infrastructure involved, in addition to the construction of far-reaching sociotechnical networks, controversies over institutional politics and contests over professional and scientific authority between government and private forecasters.[9] But establishing an American weather service in the West Indies also required attention to geopolitics: since weather knows no national boundaries, the U.S. Weather Bureau needed to form cooperative relationships with existing weather services and obtain permission to establish its own stations.

The original impetus for the United States' West Indian weather service was to protect naval vessels from hurricanes during the Spanish-Cuban-American War, but what began as a component of military security in 1898 became, within a year, an instrument of economic expansion. A meteorological infrastructure initially established to provide hurricane warnings was subsequently expanded to produce climatological data and agricultural reports for American investors in sugar cane and tobacco, as the U.S. Weather Bureau's Climate and Crop Reporting Service aggregated climatological data that would be used in a predictive capacity in the world of agricultural commodity speculation. The meteorological infrastructure of American empire connected government officials and investors, commodity exchanges, ship captains, Weather Bureau and local observers in the West Indies, climate and crop reporters, Cuban meteorologists, newspaper editors, and residents of the West Indies and Gulf Coast to forms of future knowledge that protected lives and capital while also exploiting them. The humanitarian and commercial imperatives of the U.S. Weather Bureau's West Indian weather service were intertwined from its inception.

The Weather Bureau's West Indian weather service was, I argue, a project of imperial meteorology that sought to impose a rational scientific and bureaucratic order on a region that American officials considered racially and culturally inferior. The meteorological

infrastructure of American empire in the Caribbean between 1898 and 1902 consisted of a system of observation and calculation that translated environmental data into predictive knowledge with economic value, as well as an information network that relied on the labor of local observers and meteorological experts. Yet it also restricted public access to daily forecasts and storm warnings in the West Indies, ultimately extracting agricultural and climatological information for the benefit of American investors.[10]

The history of meteorological infrastructures in the West Indies at the turn of the twentieth century reveals interlocking conflicts over military and political power, government authority, and scientific expertise that characterized American expansion on both sides of the globe.[11] The Weather Bureau's West Indian weather service epitomized the "asymmetries in … regimes of spatial ordering" that Paul Kramer has identified as one of the constitutive elements of *the imperial*, particularly in the way that weather information networks embody "the material, institutional, and discursive organization of space."[12] The creation of an American meteorological infrastructure in the West Indies involved an imperial spatial politics in which the U.S. Weather Bureau sought to impose scientific and administrative order on these multiple registers: the material (telegraph networks, meteorological instruments, and reporting forms), the institutional (new observers, offices, and reporting stations), and the discursive (control over the publication of official Weather Bureau forecasts in Cuban newspapers). In its focus on how weather reporting networks aligned with American military, political, and economic aims in the Caribbean, this article follows the historiographical shift away from abstract debates over definitions of *empire*, emphasizing instead analysis of *the imperial* as it operates in specific historical contexts.[13] Although some historians have abandoned the category of *imperial science* and its center-periphery model in favor of a global framework of knowledge production, I retain it here, suggesting that meteorological infrastructures are characterized by imperial hierarchies of power as well as local networks of knowledge production. Meteorological infrastructures in the West Indies in the 1890s included telegraph networks controlled by the United States, Spain, Britain, France, and the Netherlands, multiple and overlapping networks analogous to what Leida Fernández Prieto terms a "global archipelago of scientific knowledge" produced in Latin America and the Caribbean.[14] Although U.S. Weather Bureau officials indeed attempted to create a "center of calculation" in Washington, D.C., to control the circulation of weather forecasts in the West Indies, a singular center-periphery framework does not adequately capture the region's various meteorological infrastructures, both existing and newly created, in which centers and peripheries were "contingent and continually contested and renegotiated."[15]

Historians have recently identified the importance of an imperial context for hurricane prediction to histories of state-building and to global environmental history. James Francis Warren's study of the transformation of the Manila Weather Observatory into the United States' Philippine Weather Bureau reveals the interconnectedness of meteorological infrastructure, global capitalism, and empire in the turn-of-the-century American state. Warren depicts the combination of American bureaucracy and Philippine labor as "a marriage between Jesuit science and American imperialism" in an account centering on the celebrated Jesuit meteorologist José Algué's successful top-down administration of a weather reporting network in the first decade of the twentieth century in which forecasts had unquestioned economic value.[16] In a recent essay, Gregory T. Cushman adopts a global framework for the history of hurricane tracking in the nineteenth-century Pacific

and the Caribbean from 1839 to 1900 that demonstrates how hurricane prediction both reflected and transcended geopolitical competition among nation-states. Cushman's global environmental history of hurricanes and empire illuminates the relationships among nation-states, scientists, and missionaries across the globe who contributed to the "scientific internationalism" of hurricane prediction before 1900.[17]

While acknowledging the Atlantic World as the broader geographical framework for the history of hurricanes as well as the longer historical trajectories of natural disaster and hurricane prediction that have shaped the Greater Caribbean, this article focuses more narrowly on the American occupation of Cuba at the turn of the twentieth century in order to analyze the creation and contestation of meteorological infrastructures on the ground.[18] This approach shifts the focus away from a macro-scale analysis of infrastructure and toward the micro- and meso-scales that are vital but sometimes obscured elements of what Paul Edwards has described as a "multiscalar analysis" of infrastructure.[19] This article's analysis of imperial meteorology from the bottom up and from the middle reveals that hurricane tracking and agricultural statistics were inextricably linked components of the U.S. Weather Bureau's meteorological infrastructure in the West Indies from its creation, which has not previously been acknowledged. This historical connection between weather and crop reporting reflects the interlocking imperatives of humanitarianism and capitalism that structured the American meteorological infrastructure in the West Indies. While sharing Warren's and Cushman's thematic focus on hurricane prediction in the context of imperial expansion, this article uses archival sources to offer a more fine-grained account of imperial meteorology in the West Indies that includes the voices of historical actors who debated the scientific, economic, and geopolitical stakes of hurricane forecasting. The archival record reveals how American imperial meteorology was met with not only resistance but also negotiation and cooperation on the part of elite Cuban scientists who sought to align themselves with the Weather Bureau as it established an official presence in the region.[20] The decentralized, local, and cooperative nature of weather reporting networks meant that the meteorological infrastructure of American empire would depend on hierarchies of imperial power and scientific authority as well as collaborative relationships with scientists, observers, and the press in the West Indies. (See Figure 1.)

TRACKING HURRICANES BEFORE THE U.S.S. MAINE

Military conflict between the United States and Spain, which lasted from late April to mid-August of 1898, ended just as the worst of the hurricane season began. But Weather Bureau chief Willis L. Moore offered a moral explanation for the absence of storms during American naval operations: "Providence seemed to be on the side of those who fought against the oppressors of humanity … It seemed that nature was … letting the winds burst in one terrific hurricane after the American fleet had sailed north."[21] Moore's connection between natural disasters and national security was a logical one in 1898, when American expansionism and the Weather Bureau's scientific aims converged, and fears of Spanish naval attacks and tropical hurricanes legitimated the extension of weather information networks into the West Indies. After the *U.S.S. Maine* explosion on February 15, 1898, Moore warned the president of the threats posed by the weather to seagoing vessels, and shortly thereafter, McKinley famously

declared, "I am more afraid of the West Indian Hurricane than I am of the entire Spanish Navy."[22]

The U.S. Weather Bureau's extension into the West Indies took place in the context of turn-of-the-century expansionism, but both the United States and the Weather Bureau had sought an official presence in the region long before. The United States had made formal offers to purchase Cuba, under James Polk in 1848 and Franklin Pierce in 1854, and the Weather Bureau had long hoped that its information network would reach into the West Indies, as eminent meteorologist Cleveland Abbe noted in 1893:

> The need of more reports from the West Indies, especially during the hurricane season, was very deeply felt in 1871, and the establishment of regular stations, manned by enlisted men of the Signal Service, was very exceedingly desirable; but this invasion of foreign countries, and especially the transmission of cipher dispatches presented many objections which could only be overcome by international courtesy.[23]

This would-be "invasion" was more accurately a gradual expansion that yielded a meteorological infrastructure dependent on volunteer reports and hampered by financial constraints. Jamaican magistrate Maxwell Hall had tried unsuccessfully to establish a volunteer International West Indian Service, so the United States relied on hurricane and storm warnings from Havana's Belen College Observatory, and, in the late 1880s, on observations from U.S. consuls in the West Indies and Bermuda.[24] The weather information exchange between the United States and the West Indies was at times reciprocal. In 1889, the United States and the Spanish naval meteorological service worked on "the prospect of being able to exchange reports," after which Spanish representatives of the Naval Observatory in Havana arranged to have U.S. consul observations telegraphed there, and by 1892, American and West Indian observers freely exchanged "special message[s]" of "unusual disturbances" during hurricane season.[25] However, the U.S. Weather Bureau's network in the early 1890s did not extend throughout the West Indies, and the dissemination of the information it did collect was limited. In 1892, the Bureau's Washington, D.C., office received information from paid observers in San Domingo, Kingston, St. Thomas, and Santiago de Cuba, as well as reports from Jesuit Benito Viñes in Havana and a voluntary observer in Bermuda. The Bureau also benefited from an agreement with the Bahamas that allowed free exchange of daily weather reports from Nassau to Jupiter, Florida.[26] Similar arrangements continued through 1895 and 1896, when the Bureau paid a few observers in Kingston, Santiago de Cuba, and St. Thomas, and received storm warnings from the Spanish Naval Meteorological Service and the Belen College Observatory.[27] Until 1898, the United States relied on this combination of existing telegraph networks, local weather observers, and voluntary international exchange of weather warnings.

Although unpredictable but inevitable hurricanes have been central to the history of the Caribbean—and appeared more numerous after the advent of improved data-gathering in the late eighteenth century—it was not until the late nineteenth century that new methods for hurricane forecasting emerged.[28] As Louis A. Pérez, Jr. notes, "The hurricane entered the cosmology of Cuba as a fact of life, a specter against which people were obliged in the ordinary course of events to mediate the possibility of potential catastrophe with the needs of daily life."[29] The centuries-old epistemological tradition of ascribing hurricanes' existence and force to divine Providence was augmented,

beginning in the late seventeenth century, by conceptions of hurricanes as natural forces governed by natural laws.[30]

The late nineteenth century marked the emergence of systematic empirical observation of storms combined with the use of telegraphy to track and predict what one writer called "the weather freaks of the West Indies."[31] The presence of a hurricane was indicated by a slight rise and then a drop in barometric pressure; fluctuating humidity and dew points; observations of long, rolling swells at sea; visible changes in cloud formations and the sky at sunrise and sunset; and dramatic changes in wind and weather. Forecasters then used cloud movements to project storm tracks relative to these observations. As Francis Watts, government chemist and agricultural official for the Leeward Islands, explained at the turn of the twentieth century, "Much is heard about the prediction of hurricanes. It should be clearly understood what is meant by such an expression. The prediction of a hurricane weeks or months before its formation is clearly a thing impossible in the present state of our knowledge. All that can be done is to ascertain the existence and predict the probable course of a cyclone already existing."[32] This method often worked quite well, as the Havana newspaper *La Marina Cubana* noted in a laudatory account: "formation, track and intensity [of hurricanes] can be determined, and forecast with nearly mathematical exactness—this the United States Weather Bureau does from the very valuable data which it has at its disposition."[33]

Cuban meteorological expertise became internationally renowned in the late nineteenth century through the work of Father Benito Viñes, a Spanish-born Jesuit who fled to France after the 1868 revolution and then came to Havana in 1870 to run the Belen College Observatory, where he built organizational and technoscientific infrastructures that transformed hurricane forecasting.[34] Jesuit observatories worldwide played a pivotal role in establishing educational institutions and meteorological reporting networks throughout the nineteenth century. Viñes fit into this history of what Gregory T. Cushman has characterized as "missionary science" as well as an established tradition of Jesuit scientific education in Havana at the Colegio de Belén, founded in 1854.[35] After publishing his first hurricane forecast in 1875, Viñes embarked on four "scientific inspection trip[s]" throughout Cuba, Santo Domingo, and Puerto Rico to systematically survey the destruction wrought by the hurricanes of 1876. He collected data on felled trees and floodwaters in addition to interviewing local residents and reading press accounts of the storms, noting that "[i]t is through the combination of all these methods that I was able to gather more or less complete data on the event," which he published in his widely read 1877 *Apuntes Relativos a los Huracanes de las Antillas en Septiembre y Octubre de 1875 y '76* (*Notes Concerning the Antilles Hurricanes of September and October of 1875 and 1876*).[36] Following his individual observations of hurricane-ravaged landscapes, Viñes established the first weather reporting network in Cuba, a knowledge infrastructure that linked Belen College, Jesuit and lay observers, high-quality instruments, and the newspaper editors who published Viñes's hurricane warnings.[37] Viñes, seeking funding from the Spanish colonial government for such a network, which would finally be operational in 1887, emphasized the importance of a knowledge infrastructure to hurricane forecasting: "In the case of hurricanes, it is of utmost importance to acquire data in as many locations as possible … It is necessary for all to realize that without the availability of simultaneous observations made at different locations it is not possible to solve the problems that arise in each particular case."[38] By the late 1880s, Viñes's

publications and forecasting acumen had made him a leading figure in an internationalizing meteorological community, and his work was of particular interest to the United States, which exchanged observations and forecasts with him beginning in 1877.[39] Viñes's studies, which were excerpted and published in English, French, and German, were published in the United States starting in 1885 and frequently through the 1890s. The U.S. Weather Bureau chief endorsed one "as the most satisfactory statement of the laws and phenomena of these storms which has yet been made."[40]

Viñes's foundational principle of hurricane motion, what he called the "law of cyclonic currents at different altitudes," emerged from his method of using daily cloud observations to track hurricanes. Viñes identified "cirro-stratus plumiformes," which resembled "white and delicate feathers or like great and showy plumes crossing the firmament," as unmistakable signs of an impending hurricane.[41] Once a storm had formed, Viñes used observations of clouds at different altitudes—from low clouds to a middle layer of alto-cumulus, cirro-stratus, and cirro-cumulus clouds to the highest light cirrus clouds—to calculate its probable direction based on the motion of air currents that tended to move low clouds perpendicularly to the storm center, while the uppermost cirrus clouds diverged from the storm center.[42] According to Viñes, cloud movement revealed the path of a storm "as if these clouds form an extension of the body of the hurricane itself," and hurricanes followed predictable parabolic tracks westward through the West Indies before recurving—at different latitudes depending on the date—eastward into the Atlantic.[43]

Viñes's projections of storm paths were generally reliable, as shown by favorable accounts of his forecasts in the Cuban press and the U.S. Weather Bureau's republication of

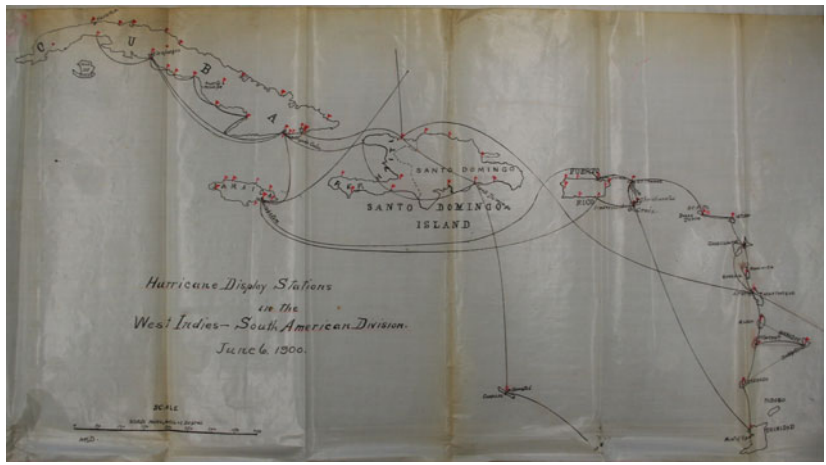


FIGURE 1. This map drawn by U.S. Weather Bureau personnel in June 1900 depicts the information networks (lines indicate undersea cables linking the islands, and flags indicate stations where hurricane warnings were displayed) that were the most crucial component of American meteorological infrastructure in the West Indies during the U.S. occupation of Cuba. Reproduced from Weather Bureau Correspondence 1870–1912, box 1407, Records of the U.S. Weather Bureau, Record Group 27, National Archives, College Park, MD.

his theories in their own bulletins, but not universally accepted.[44] In 1902, Weather Bureau official W. H. Alexander cited sailors' demand for a "Storm Chart" showing typical paths of hurricanes, which he then produced using Viñes's correlations between the calendar and the latitude of recurving and included as part of his Weather Bureau bulletin entitled *Hurricanes: Especially Those of Porto Rico and St. Kitts*, published in 1902.[45] (See Figure 2.) Although Viñes's work appeared in multiple U.S. Weather Bureau bulletins, not all Bureau officials endorsed his laws of hurricane motion. As head forecaster E. B. Garriott wrote to Alexander, "There is no 'usual or normal track of the West Indian hurricanes at the different periods of the hurricane season.' … Neither have the most intense and destructive hurricanes followed the 'normal paths,' nor have they described a parabolic curve." Garriott cited the historical charts of hurricanes the Weather Bureau had published in its 1900 bulletin on *West Indian Hurricanes* (see Figure 3), as evidence of twenty-three years' worth of hurricanes that defied predictable parabolic storm tracks.[46] Viñes acknowledged that his projections of storm tracks were "approximate" and average but maintained that they also "offer[ed] in many cases great probabilities of truth," forecasts that were clearly valued by his contemporaries, who considered him "among the foremost contributors to modern meteorology."[47] Viñes died in 1893, two years before the final phase of the Cuban insurgency, but he had established a meteorological infrastructure in the West Indies that the United States would both rely on and appropriate during war with Spain and the subsequent American occupation.

MAKING "A SINGLE, COMPREHENSIVE SYSTEM"

Between the Spanish surrender at Santiago de Cuba on July 17, 1898, and the start of U.S. military occupation of Cuba on January 1, 1899, Weather Bureau personnel and Cuban meteorologists envisioned themselves as architects of a new meteorological infrastructure. Two prominent Cuban residents offered their expertise as the Bureau was beginning to establish its institutional presence: Jesuit Lorenzo Gangoiti, professor of meteorology and Viñes's successor at Belen College; and retired Spanish naval captain Luis Garcia y Carbonnell, director of the Spanish Naval Meteorological Service for the West Indies, who had previously worked in an informal capacity for the United States. While Gangoiti and Carbonnell were vying for recognition, the Weather Bureau was preparing to build an information network that would rely on local expertise but ultimately locate its authority in its Washington, D.C. office. The Weather Bureau's relationships with Gangoiti and Garcia y Carbonnell revealed the imperatives of a centralized bureaucratic order that privileged a distant rather than local authority, while at the same time complicating the framework of imperial power and local resistance, as Cuban elites sought to become part of a new American meteorological infrastructure.

Carbonnell had been making weather observations in Cuba since 1889, and by 1892 he was transmitting hurricane season reports from Santiago de Cuba and San Juan to the United States without charge.[48] Recognizing the opportunity for funding and prestige after the Spanish surrender, Carbonnell sought a formal role in the Weather Bureau as a mediator between the existing Spanish meteorological infrastructure and a new American one. Beyond recording and transmitting weather observations, Carbonnell offered to broker the purchase of instruments from Spain, hire a local forecaster, and help

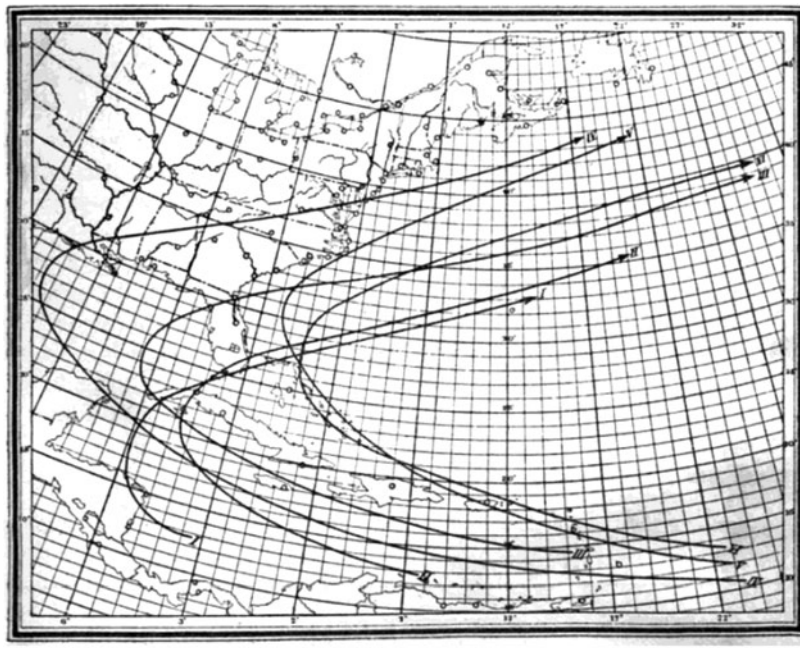


TABLE I.—*Normal directions of the tracks at different dates in different latitudes, as given by Viñes.*

Dates.	Directions.						
	W.		WNW.		NW.		NNW.
	°	°	°	°	°	°	°
August	10	15	15–20	20–25	25–27	.....	28
July and September	10	15	15–24	.....	25	.....	26
June 21–30 and October 1–10	10	15	15–20	.....	21	.....	22
June 11–20 and October 11–20	10	.....	12–14	.....	15–16	17	18–19
June 1–10 and October 21–31	10	12	13	.....	13–14	.....	15

Dates.	Directions.						
	N.		NNE.		NE		ENE.
	°	°	°	°	°	°	°
August	29–33	.....	34	.....	35–40	.....	.....
July and September	27–29	.....	30	.....	32	33–35	35–40
June 21–30 and October 1–10	23–26	.....	27	28	29	30	31–40
June 11–20 and October 11–20	20–23	.....	24	25	26–30	.....	.....
June 1–10 and October 21–31	16–20	.....	22	23	24–30	.....	.....

FIGURE 2. Reprinted from William H. Alexander, *Hurricanes: Especially Those of Porto Rico and St. Kitts* (Washington, D.C.: Government Printing Office, 1902), 19–20.Weather Bureau official William H. Alexander, stationed at St. Kitts and Puerto Rico at the turn of the century, published a bulletin in 1902 in response to widespread demand among navigators for a chart of the typical paths of hurricanes and a set of guidelines for anticipating and navigating storms. This chart depicts Viñes's calculations of the "Law of the normal direction of the tracks at the different dates and altitudes," which predicted a parabolic "recurve" at different latitudes and longitudes throughout the hurricane season. Track I indicates average storm tracks for June 1–10 and October 21–31; Track II, June 11–20 and October 11–20; Track III, June 21–30 and October 1–10; Track IV, July; Track V, August; Track VI, September.

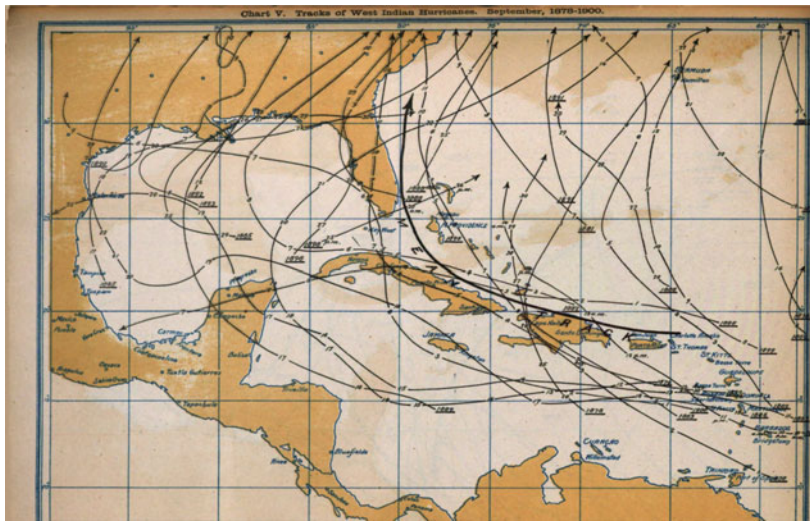


FIGURE 3. Reprinted from E. B. Garriott, *West Indian Hurricanes* (Washington, D.C.: Weather Bureau, 1900), 75. E. B. Garriott, the head of the U.S. Weather Bureau's forecasting division, authored a bulletin that included historical charts, like this one for September from 1878 to 1900, mapping the tracks of West Indian hurricanes throughout the late nineteenth century, with the "mean track" indicated by a heavy black line.

implement an experimental program involving the use of carrier pigeons to transmit weather data.[49] Initially, the Bureau was interested, and in September 1898 Moore asked Carbonnell to assess Spanish weather stations and instrumentation and send twice-daily observations from Havana to Key West in exchange for a new set of instruments, telegraphy costs, and "reasonable compensation."[50] Carbonnell agreed but had greater ambitions, including plans to incorporate the morning and evening observations of well-regarded private forecaster Julio Jover y Anido; create a new station at Santiago de Cuba (which the Bureau already had established, unbeknownst to Carbonnell); and collect weekly or biweekly reports from Havana, Santa Clara, and Santiago de Cuba, "giving the maxima, minima and mean daily barometric pressure and humidity of the air, duration and force of the prevailing winds, kind and amount of clouds, with any other data that you may desire." The enterprising Carbonnell also offered the pigeon house he had built in the Antilles Central Station observatory, his connections to pigeon breeder Dr. Chaquacedo, and his own breeding expertise, gleaned from "a good treatise of pigeon raising which [he had] studied."[51] Moore, however, imagined a more limited role for Carbonnell, proposing to designate him an official Weather Bureau representative with the authority to conduct local administrative inquiries but declining to purchase Spanish instruments that weren't compatible with American instruments, employ Jover, or authorize anything beyond maintaining the continuity of daily observations.[52] Still, Carbonnell was seemingly on his way to, at the very least, a paid observer's position and official status within the Weather Bureau.

Carbonnell's major competition was Father Lorenzo Gangoiti of Havana's Belen College Observatory, who made two formal overtures in the winter of 1898, appealing

first to fellow Jesuit J. G. Hagen of the Georgetown College Observatory, and then to Moore. For the political interim, Gangoiti proposed that Belen College be designated an official U.S. Weather Bureau station, citing its many advantages: its prominence in the network of Cuban observation stations, its ability to transmit at least one daily set of observations from Belen and other Cuban stations (and more frequent observations during hurricane season), and superior accuracy in measuring barometric pressure.[53]

This competition between local experts posed a logistical and epistemological problem for the Weather Bureau. As head meteorologist Cleveland Abbe wrote to Moore,

> there are in Havana three conflicting institutions and interests, all striving for recognition by you, namely: the Jesuit College; the remnants of the Spanish Marine and the remnants of the 'Society of Planters' with its meteorological library. The latter is a popular Cuban institution, but the two others … have not the popular support.[54]

This existing meteorological infrastructure, which meant "at least three sets of differing observations, and … the respective observers … not working in entire harmony," required, as head forecaster Garriott explained to Moore, an administrative consolidation in which meteorological work in Cuba would be overseen by one "who is thoroughly familiar with the methods and policy of this Bureau."[55] Moore accordingly rejected Gangoiti's offer in December 1898, explaining that Carbonnell had an existing relationship with the U.S. Weather Bureau, his reports were "fairly accurate," and "there [had] been no break in the continuity of his observations, which have always been satisfactory to us."[56]

Moore's dismissal of Gangoiti reflected the Bureau's imperative for standardization and centralized control of its weather network. Uncertain about the Weather Bureau's role in Cuba under U.S. occupation, Moore noted to a colleague, "If we establish a meteorological service of our own there it will undoubtedly be placed in supreme charge of some trained official sent from the United States, as we must have some one in charge of the work who is thoroughly acquainted with our methods, etc."[57] Despite his efforts to secure instruments and office space and his tendency to submit copious amounts of data, Carbonnell received notification from Moore in January 1899 that his observations would no longer be necessary. The Weather Bureau's Kingston headquarters would be moving to Havana under the oversight of former Kingston forecast official H. H. C. Dunwoody and the daily management of Bureau official William B. Stockman. The Bureau had dismissed Gangoiti on the grounds that Carbonnell was more reliable, but then passed over Carbonnell in favor of Stockman, whom writer Erik Larson has deemed "a ponderous bureaucrat, given to writing immense reports about tiny things."[58]

The Weather Bureau encountered a range of obstacles—environmental, bureaucratic, and geopolitical—in building its West Indian meteorological infrastructure. An 1898 study of Cuba's climate noted that precipitation and temperature in the West Indies did not exhibit any kind of "tropical uniformity," which underscored the need for a weather service to protect the two hundred vessels the United States had dispatched to Havana in the spring and early summer of 1898.[59] Congress approved the expansion of the West Indian weather service on July 7, 1898, only a week before hurricane season began, authorizing funding for new Weather Bureau stations at Kingston, Santiago de Cuba, Santo Domingo, St. Thomas, Barbados, Port of Spain, Curaçao, and Barranquilla, where hurricane warning signals were posted and observations were recorded

twice daily and telegraphed to Kingston and Washington.[60] At a minimum, each station would be equipped with two anemometers (to measure wind velocity), an anemoscope (to register wind direction), two barometers, a set of thermometers, a rain gauge, and an instrument shelter.[61] However, the Bureau did not have enough instruments on hand for these stations and had to order them from vendors in Washington, D.C., and New York, and when the first Bureau officials arrived in Kingston on July 22, 1898, Stockman could not find any office space because Cuban refugees had taken shelter in any available structure. Stockman finally found an office outside of the city and set up headquarters there on August 7, 1898; and two days later, offices in Trinidad, Curaçao, Santo Domingo, and Santiago de Cuba were telegraphing weather reports twice daily to Kingston.[62] By 1901, the U.S. weather network spanned the West Indies, reaching from Port of Spain, Trinidad, to Havana, Cuba, with observations coming into Havana daily at 8 a.m. during hurricane season.[63] The Havana headquarters, which also received reports from various British weather stations as well as a few Mexican coastal stations, produced daily charts and compiled these observations for transmission to Washington, D.C.[64]

The telegraphic cable linking West Indian weather reporting stations was itself a contested entity, given the political geography of the islands. At first the Weather Bureau encountered resistance from a few telegraph company managers who insisted upon prepayment for cables. Another problem involved coordinating the operating hours of West Indian cable offices, most of which closed before 6 p.m., with the Bureau's regular observation times. The Bureau shifted its evening observation one hour earlier but still could not convince the West India and Panama Telegraph Company to remain open later than 7:30 p.m. The Bureau appealed to the governor of Jamaica, who instructed the colonial secretary to confront the telegraph company directors with a warning "calling attention to the great detriment the early closing of the cable offices in the West Indies was to the efficient transmission of reports and warnings, particularly during seasons of unsettled conditions or the presence of storm conditions."[65] The company agreed to change its policy for the next hurricane season by keeping its offices open until the Bureau's Kingston headquarters sent out a signal permitting them to close, thereby conforming the local communications network to the Weather Bureau's system for collecting and transmitting observations.[66]

In March 1900, Secretary of Agriculture James Wilson explained to Secretary of War Elihu Root the Weather Bureau's plan to simplify and control the meteorological infrastructure in Cuba. He listed the various individuals and institutions that circulated weather reports and hurricane warnings, including sixteen reporting stations under Carbonnell's direction during Spanish rule, the Belen College Observatory, as well as private forecasters and other educational institutions. Wilson argued that only "a single, comprehensive system" of significant geographical scope should have the authority to make storm warnings, and his emphasis on infrastructural reach was echoed several months later by Moore, who commented on the "gigantic scale" of a West Indian weather reporting network and insisted that "no one can make forecasts for the West Indies without a comprehensive survey over a large area which must embrace all of our stations about the Caribbean Sea and the Gulf of Mexico and in the interest of commerce such forecasts should be made only by one institution."[67] Their logic was driven by an economic imperative that Wilson made clear to Root: "There are many scientific men and many deserving institutions that are ambitious to issue weather warnings, but I am of the

opinion that the welfare of the individual or the institutions should be subordinated to that of international commerce."[68] Indeed, American officials emphasized the commercial benefits of a West Indian weather service from the very start, as the *New York Times* observed in July 1898: "The weather authorities explain that the service is aimed at the future great commerce expected to be built up there."[69] And the long-term operation of a meteorological infrastructure in the West Indies would serve American interests above all, as Wilson noted: "I believe it will be imperative upon this Government, for all time to come, no matter who may be in charge of the local administration of Cuba, to insist on maintaining at least three meteorological observatories to form a part of the general West Indian service, which service is of more importance to the commerce of our Gulf and south Atlantic ports than it is to any of the islands of the West Indies."[70]

Creating a "single, comprehensive system" in the service of commerce required the construction of a singular scientific authority. U.S. Weather Bureau officials in the West Indies relied on reports of local observers to produce forecasts and storm warnings, but, just as they had done in the United States from the 1890s well into the twentieth century, attempted to suppress competition from private forecasters who challenged the Bureau's authority by policing their own infrastructure, the press, and the circulation of unofficial forecasts.[71] The Cuban press was the most visible site of contests over scientific authority, and Weather Bureau officials monitored press coverage accordingly, as they did in the United States. To take one example, in September 1899, two weeks after a hurricane left "[t]he desolation and ruin wrought by this monster in the West Indies … fresh in the minds of all," a Bureau official wrote to the editor of Cuba's *Diario de la Marina* to protest the publication of Gangoiti's forecasts from the Belen College Observatory under the heading "El Tiempo" with the subheading "Departamento de Agricultura de los Estados Unidos—Weather Bureau" and to request that future reports "be so placed in your paper that there may be no doubt in the minds of your readers as to the source from which it emanates and that there may be no danger of confounding the official bulletins with those originating from a private source."[72] Bureau officials also maintained tight control over access to their infrastructure for the same reason. In August 1900, Gangoiti requested current Weather Bureau data telegraphed from New Orleans but was told that "it would be manifestly unfair to the public and unjust to the Bureau to furnish individuals and institutions competing for public favor, with the data."[73]

Of course no weather service, however comprehensive or authoritative, can prevent storms, and when hurricanes did form, the Weather Bureau produced predictive storm warnings and retrospective calculations of damage sustained and avoided. Although the Bureau regularly published testimonials to the value of forecasts and storm warnings, hurricanes brought the greatest threat to human life and property and thus the most visible occasion for demonstrating, and sometimes debating, the efficacy of a government weather service. To take one example, the hurricane that swept from Puerto Rico to Florida between September 28 and October 2, 1898, was preceded by Weather Bureau advisory messages and storm signals from Key West to Norfolk, Virginia. The storm made landfall between Jacksonville and Savannah on October 2, causing widespread damage and loss of life, as crops, livestock, farmland, boats, railroad track, and telegraph lines were destroyed.[74] The Bureau's Florida section director A. J. Mitchell cited "incalculable damages" on the Georgia coast, but in most areas the damages were indeed calculated. Mitchell reported that "[a] conservative estimate of the damages in Florida may

be placed at $500,000," and estimated the probable cost of the hurricane absent Weather Bureau warnings as at least 10 ships (that heeded warnings and remained in port), with 56 crew members and $380,000 in cargo.[75] The value of hurricane warnings was also cited by those who did not receive them, including W. A. Bessey of Stewart, Florida, 20 miles north of Jupiter, who inquired on behalf of his neighbors why no warnings were issued in their area, observing that "[t]he severity of these storms and the terrible destruction … make it all most necessary that we know when they are approaching."[76]

Bessey's words would ring true again approximately two years later, when the deadliest hurricane in U.S. history devastated the booming port city of Galveston, Texas, on September 8, 1900. The Weather Bureau's Galveston forecast official, Isaac M. Cline, despaired that "the ruin which it wrought beggars description," counting his wife among more than six thousand residents who drowned as floodwaters over ten feet high carried away bodies and debris, destroying 2,636 houses and causing an estimated $30 million in property damage.[77] Given the severity of the hurricane and the extensive loss of life and property, scholarly and popular accounts of hurricanes have ascribed to Galveston singular and unparalleled significance. However, in the context of meteorological infrastructures, Galveston was, in three important respects, not exceptional at all.[78]

First, multiple and contradictory forecasts attempted to predict the hurricane's path and intensity, just as rainstorms and snowstorms in the United States were predicted by the U.S. Weather Bureau (and before it the U.S. Army Signal Service) along with myriad private short-term and long-range forecasters. There was no single Galveston forecast but rather multiple and changing forecasts produced by competing knowledge infrastructures, which Weather Bureau officials documented as a threat to Wilson's goal of a "single, comprehensive system." A compilation of daily forecasts from August 30 to September 6, 1900, issued by the U.S. Weather Bureau, the Belen College Observatory headed by Lorenzo Gangoiti, and private forecasters Jover and Faquineto revealed a spectrum of risk ranging from the Weather Bureau's conservative description of a "disturbance" of "moderate energy" through September 4, to Jover's warning of a cyclone beginning on August 31. On September 4, Belen College noted that a "cyclonic disturbance" was atypically "preparing to recurve" toward the northeast, and the U.S. Weather Bureau maintained two days later that the storm center was continuing on a northeastward trajectory toward Florida; however, the hurricane had not recurved but rather had intensified and was headed northwest, straight for Galveston.[79]

Second, although the Galveston hurricane made visible contestations over the relative accuracy of American and Cuban weather reports, controversy over forecasters' authority and expertise in the aftermath of a storm was commonplace in the nineteenth century, as it has remained to the present day. Disputes over who had failed to correctly predict the intensity and track of the hurricane quickly emerged in American and Cuban newspapers. The *Houston Post* denounced "the failure of an adequate warning" from the congressionally funded Weather Bureau while praising the work of commercial long-range forecaster Rev. Irl Hicks, whose almanac had foretold—nearly a year earlier—"'a decided storm period'" from September 6–11, 1900, and called particular attention to September 8 and 9 as days when "[i]t will be wise for dwellers on the south seas, islands and coasts to heed all signals of West India hurricanes at this time." The editorial further suggested that a long-range forecaster like Hicks "take charge of the bureau and shake it up."[80] Moore soon fired back in the pages of the *Post*, listing the warnings that his agency had provided

by telegraph and signal flags before launching into the vigorous repudiation of long-range forecasting for which he became well known during his tenure as Weather Bureau head from 1895 to 1913.[81] This exchange between the head of the federal government's weather forecasting service and a newspaper editor over the value and legitimacy of short-term versus long-range forecasting was hardly unique to Galveston and occurred repeatedly in the aftermath of major storms, including the historic blizzard of 1888 and the Inauguration Day snowstorm in 1909.[82] Cuban newspapers also judged the Weather Bureau's tracking of the Galveston hurricane a failure. Havana's *La Discusión* faulted the Bureau for a "phenomenal error" in tracking and judging the severity of the Galveston hurricane, "which he [Moore] persisted in calling a little storm in all the advices [and predicted] was central in the north Atlantic when it was causing in Galveston the tremendous destruction that it did."[83]

Third, the Galveston hurricane revealed continuity rather than disjuncture in that it did not transform meteorological infrastructures or debates over forecasting in the region. Rather, Weather Bureau officials continued their existing efforts to achieve the ideal of a "single, comprehensive system" of weather forecasting in the Caribbean. In the summer of 1900, Bureau official H. H. C. Dunwoody had issued an order shutting down telegraphic transmission and publication of non-Weather Bureau forecasts—to the great objection of "cranks on the island," he noted—but by mid-September Governor General Wood overturned Dunwoody's order.[84] Wood had, in the judgment of Bureau officials, yielded to pressure from private forecasters in Cuba and thereby "place[d] the Weather Bureau … on an equal footing with several little institutions, none of which is properly equipped to perform this important function for commerce." Moore complained to the Secretary of Agriculture that "this Department cannot carry on an efficient Weather service and properly attend to the needs of commerce if the public prints of Cuba are to be filled with irresponsible forecasts from half a dozen sources, many of which forecasts are attributed by the public to the Weather Bureau."[85] When Cuban meteorologists and editors sought to expand their own information networks, they continued to face resistance from Weather Bureau officials who, as Moore admitted, "feel like jealously guarding against the issuing of storm warnings by irresponsible persons or by those that have not sufficient data at their command."[86] And editors of *La Discusión* alleged that Bureau official William Stockman had refused them weather data because the newspaper regularly featured forecasts by Gangoiti and Jover, a charge Stockman denied.[87]

MAKING THE WEST INDIES LEGIBLE

In the mid to late 1890s, the U.S. Weather Bureau's meteorological infrastructure rendered the West Indies more legible by translating local weather observations into a systematized, centralized, and bureaucratized form of knowledge with economic value for American markets and investors. The West Indian weather service produced environmental and economic legibility through mapping, climatological data collection, and crop reporting—all forms of knowledge production that undergirded agricultural improvement, capitalism, and the civilizing mission of American science.[88]

As the United States' government weather service expanded and professionalized in the late nineteenth century, its research activities included mapping projects that

aggregated data for use in long-range climatological studies and for inclusion on daily weather maps. In the mid-1870s, "hoping … to entirely surround the areas of high and low pressure that appear in our extreme northwestern border," the U.S. Army Signal Service sought to extend its reach to the "distant territory" of Manitoba through the establishment of five regular observation stations in cooperation with the Hudson Bay Company. The Signal Service provided instruments for the prospective stations in 1874, but observations were never submitted, and in 1893, the government's leading meteorologist, Cleveland Abbe, lamented what was still a "blank upon the Daily Weather Map of North America."[89] Regions south of the United States were also meteorologically illegible, Abbe noted:

> To the south of the United States the meteorology of Mexico was almost a *terra incognita*; we knew something of its climatology, but the dynamic meteorology could not be understood without a daily representation of its conditions on the weather map. The United States series of stations stopped abruptly at the Mexican boundary … but although the extension of our isobars and isotherms over Mexican territory was desired … and even attempted … in 1882, from Brownsville southward to Panama and beyond, it is still unaccomplished; it is to be hoped that this important extension of the work of the Service may be carried out by the Weather Bureau under the Department of Agriculture. There is evidently still a great expansion to be desired in the immediate future of the Daily Weather Map.[90]

Abbe's concerns about unmapped regions reflected the Weather Bureau's scientific aims as well as symbolic value of the daily weather map.[91] Collecting weather data beyond national boundaries would extend the physical reach of the Bureau's information network, but more points plotted on the daily map would also signify the nation's geopolitical reach and the professional legitimacy of a federal agency that had faced its share of public scrutiny.[92]

Cuba in particular was environmentally illegible to the United States at the start of war with Spain. In May 1898, Weather Bureau officials confronted "scant" and "fragmentary meteorological data" and noted "very little precise and accurate information obtainable regarding the climate of Cuba."[93] The rest of the West Indies was far more legible, with "a good deal of [precipitation and temperature] data" available for various proximate locations: "[t]o the north, Key West, Fla., and Nassau, Bahamas; to the east, Port au Prince, Haiti, San Juan, Puerto Rico, and St. Thomas; and to the south, Kingston and other stations in Jamaica."[94]

As Weather Bureau personnel noted their lack of climatological knowledge, American imperialists invoked a rhetoric of colonial improvement that linked the physical and moral transformation of the Cuban landscape from "'hell … into a paradise,'" as Congressman Henry F. Gibson put it, justifying the Platt Amendment, which stipulated U.S. control over Cuban affairs beyond the end of occupation, to his House colleagues in 1901.[95] As Louis A. Pérez, Jr. has noted, popular accounts depicted a chaotic Cuba in need of modernizing infrastructure and celebrated the transformation of Havana through "'an almost inconceivable amount of reconstruction, sanitation, reformation and improvement.'"[96] War had ravaged Cuba's agricultural landscape, eliminating 500,000 acres from overall production between 1895 and 1898; displacing farmers and laborers; destroying 903 out of 1,110 sugar mills; damaging warehouses, farm machinery, and machine shops; and weakening the transportation infrastructure of roads,

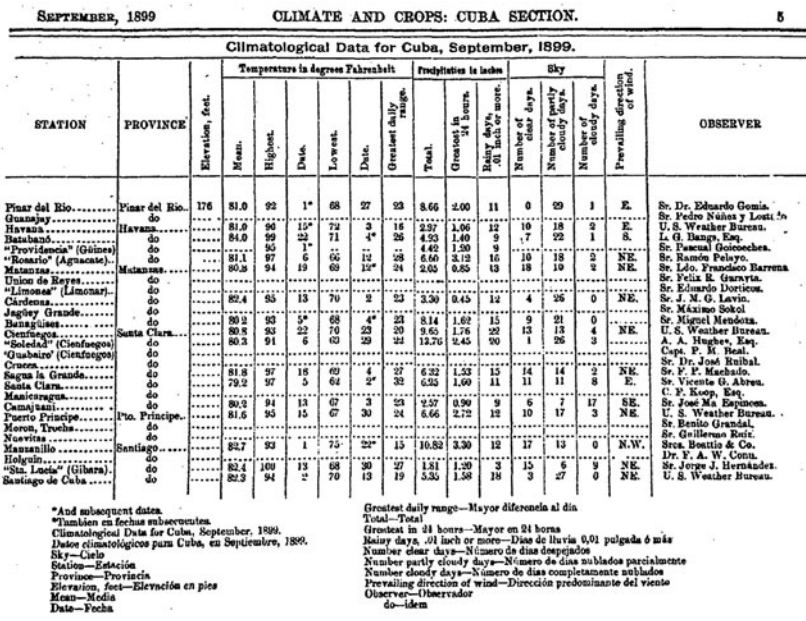
bridges, and railroads.[97] Cubans condemned U.S. policy that left landowners with heavily mortgaged property and little hope of an influx of investment capital. In 1901, Secretary of Agriculture, Commerce and Industry Perfecto Lacosta lamented, "'Up to the present time, nothing has been done toward the improvement of our agricultural situation.'"[98]

Agricultural improvement was, however, an aim of the West Indian weather service, which was expanded to monitor agricultural production in Cuba and Puerto Rico through a climate and crop reporting network. As the *New York Times* announced, the Weather Bureau's Havana headquarters would afford unprecedented economic legibility: "our people will be fully informed as to the condition of everything meteorological and agricultural in the various portions of the island, and as to the progress of the rehabilitation of the industries which, during the recent war, were either suspended or completely annihilated."[99] Contemporary observers judged climate and crop reports for American investors in West Indian sugar and tobacco production more valuable to the United States than the transmission of hurricane warnings for the safety of local inhabitants. In December 1898 the *New York Tribune* reported that climate and crop reports from Puerto Rico would "be published for the benefit of the people of the United States," and a Weather Bureau official stationed in Havana commented in 1901 that "[w]hile the value of the service to the islands of the West Indies is great, it is all incidental, in a way, when we

FIGURE 4. This representative photograph of a U.S. Weather Bureau station in the Philadelphia Bourse, c. 1900, indicates the prominence of predictive weather and climate data in the spaces of finance capitalism. Climate and crop reports from Cuba and Puerto Rico are posted to the right of the weather map, in the bottom row. Reproduced from Administrative and Fiscal Records, Records Relating to Opinions Concerning Emerson Hough's Article on the Weather Bureau, 1909, box 2, RG 27, NA-College Park, MD.

consider the benefits of this branch of the weather service to us at home."[100] (See Figure 4.)

The Weather Bureau initiated its climate and crop reporting work in Puerto Rico in October 1898 and in Cuba in early 1899, providing thermometers, rain gauges, and standardized reporting forms for stations that were staffed by a group of "efficient observers," including planters and other volunteers. By 1902, twenty-five observation stations and eighty-six crop correspondents comprised the climate and crop reporting network, and the Weekly Climate and Crop Bulletin was published in English and Spanish by January 1899 in Puerto Rico and May 1899 in Cuba. It included summary paragraphs describing rainfall and temperature and their effects on sugar cane, tobacco, corn, rice, and other crops, in addition to excerpts from observers' remarks. Monthly summaries of meteorological data and observers' comments, in both English and Spanish, came shortly thereafter.[101] Climatological charts included mean, highs, and lows for temperature, as well as total precipitation, precipitation highs, and the number of rainy days for each observation station. (See Figure 5.) Climate and crop reports were circulated by mail, newspaper, and telegraph, and the list of Cuban and American subscribers was lengthy.[102] Although the Bureau suggested that climate and crop reports would be instrumental in diversifying agriculture, the reports' most important audience was potential investors in large-scale sugar cane and tobacco production since, as a Bureau official noted in 1901, "[n]aturally the first information sought by homeseekers or those contemplating the placing of capital in Cuba is about its climate."[103] As U.S. military governor general



SEPTEMBER, 1899 — CLIMATE AND CROPS: CUBA SECTION. — 5

Climatological Data for Cuba, September, 1899.

STATION	PROVINCE	Elevation, feet.	Temperature in degrees Fahrenheit: Mean.	Highest.	Date.	Lowest.	Date.	Greatest daily range.	Precipitation in inches: Total.	Greatest in 24 hours.	Rainy days, .01 inch or more.	Sky: Number of clear days.	Number of partly cloudy days.	Number of cloudy days.	Prevailing direction of wind.	OBSERVER
Pinar del Rio	Pinar del Rio	176	81.0	92	1*	68	27	23	8.66	2.00	11	0	29	1	E.	Sr. Dr. Eduardo Gomia.
Guanajay	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Sr. Pedro Núñez y Lostt &c
Havana	Havana	.....	81.9	96	15*	72	3	15	2.57	1.06	12	10	18	2	E.	U. S. Weather Bureau.
Batabanó	do	.....	84.0	99	22	71	4*	26	4.93	1.40	9	7	22	1	S.	L. G. Bangs, Esq.
"Providencia" (Güines)	do	.....	.....	93	1*	...	...	...	4.42	1.90	9	.....	.....	.....	.....	Sr. Pascual Goicoechea.
"Rosario" (Aguacate)	do	.....	81.1	97	6	66	12	28	6.60	3.12	16	10	18	2	NE.	Sr. Ramón Pelayo.
Matanzas	Matanzas	.....	80.8	94	19	69	12*	24	2.05	0.85	13	18	10	2	NE.	Sr. Ldo. Francisco Barrena
Union de Reyes	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Sr. Felix R. Garayta.
"Limones" (Limonar)	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Sr. Eduardo Dorticos.
Cárdenas	do	.....	82.4	95	13	70	3	23	3.30	0.45	12	4	26	0	NE.	Sr. J. M. G. Lavin.
Jagüey Grande	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Sr. Máximo Sokol
Banagüises	do	.....	80.2	93	5*	68	4*	23	8.14	1.62	15	9	21	0	.....	Sr. Miguel Mendoza.
Cienfuegos	Santa Clara	.....	80.8	93	22	70	23	20	9.65	1.76	22	13	13	4	NE.	U. S. Weather Bureau.
"Soledad" (Cienfuegos)	do	.....	80.3	91	6	69	29	22	13.76	2.45	20	1	26	3	.....	A. A. Hughes, Esq.
"Guabairo" (Cienfuegos)	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Capt. P. M. Beal.
Cruces	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Sr. Dr. José Rubal.
Sagua la Grande	do	.....	81.8	97	18	69	4	27	6.32	1.53	15	14	14	3	NE.	Sr. F. P. Machado.
Santa Clara	do	.....	79.2	97	5	62	2*	32	6.35	1.60	11	11	11	8	E.	Sr. Vicente G. Abreu.
Manicaragua	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	C. F. Koop, Esq.
Camajuaní	do	.....	80.2	94	13	67	3	23	2.57	0.90	9	6	7	17	SE.	Sr. José Ma. Espinosa.
Puerto Principe	P'to. Principe	.....	81.6	93	15	67	30	24	6.66	2.72	12	10	17	3	NE.	U. S. Weather Bureau.
Moron, Trocha	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Sr. Benito Grandal.
Nuevitas	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Sr. Guillermo Ruiz.
Manzanillo	Santiago	.....	82.7	93	1	75	22*	15	10.82	3.39	12	17	13	0	N.W.	Srcs. Bonfils & Co.
Holguin	do	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Dr. F. A. W. Conn.
"Sta. Lucía" (Gibara)	do	.....	82.4	100	13	68	30	27	1.81	1.39	3	15	6	9	NE.	Sr. Jorge J. Hernández.
Santiago de Cuba	do	.....	82.3	94	2	70	13	19	5.35	1.58	18	3	27	0	NE.	U. S. Weather Bureau.

*And subsequent dates.
*También en fechas subsecuentes.
Climatological Data for Cuba, September, 1899.
Datos climatológicos para Cuba, en Septiembre, 1899.
Sky—Cielo
Station—Estación
Province—Provincia
Elevation, feet—Elevación en pies
Mean—Media
Date—Fecha
Greatest daily range—Mayor diferencia al día
Total—Total
Greatest in 24 hours—Mayor en 24 horas
Rainy days, .01 inch or more—Días de lluvia 0.01 pulgada ó más
Number clear days—Número de días despejados
Number partly cloudy days—Número de días nublados parcialmente
Number cloudy days—Número de días completamente nublados
Prevailing direction of wind—Dirección predominante del viento
Observer—Observador
do—idem

FIGURE 5. William B. Stockman, *Report for September, 1899, Cuba Section of the Climate and Crop Service of the Weather Bureau* (Havana, Cuba: Weather Bureau Office, 1899), 5.

John R. Brooke observed, the key to postwar economic development was to ensure that "'capitalists [were] assured as to the future.'"[104]

The climatological data that assured capitalists of their future did not have the same predictive value for local agricultural producers, according to Weather Bureau officials who deemed climate and crop reports useless to Puerto Rican farmers on the grounds that they were not legitimate participants in modern markets, modern information networks, or modern agriculture. Bureau officials produced a technoscientific legibility by constructing rigid boundaries between what Bureau personnel perceived as their own modern scientific rationality and the irrational behavior of primitive island residents when it came to anticipating agricultural and meteorological futures. A Bureau representative in Puerto Rico noted that

> The greater part of the masses … pay no attention whatever to the reports. They can't read. They perform all the labors incident to farming with a machete. They are not educated up to the fact that the reports are of value, and they will not be for some generations yet to come. We must consider that we in the United States raise crops in the most modern fashion possible, to the best interests of agriculture. But in Porto Rico methods are primitive; crops are put in and if they fail from lack of attention, such as being choked by weeds, or washed out by torrential rains from want of proper ditching, the planters shrug their shoulders and complain of fate. So we see how difficult it is to ascertain how much value the climate and crop service is to the large number of the islanders at least.[105]

Similarly, hurricane warning signals announced not only an approaching storm but also American scientific and cultural superiority. In 1901, a Bureau official reported that skeptics in Puerto Rico were quickly converted into fervent believers in the authority of American meteorology:

> When the hurricane signal was hoisted in the island the first and, thus far, the only time there was some scoffing by native "amateur meteorologists:" for, "How could Americans know anything about tropical hurricanes, having been here such a short time?" But the warning was so timely and the justification so absolute, that now almost any American red flag will have the effect of the *bona fide* hurricane signal. When the usual red flags are hoisted over the military rifle range for target practice the telephone rings, and terror-stricken inquires are made as to the (supposed) approaching cyclone.[106]

Such panicked reactions were derided by Weather Bureau officials who did not intend their daily forecasts for circulation in the West Indies, according to the "rule [that] no public forecast is made unless disturbed or stormy conditions exist."[107] The Bureau issued two types of public warnings for the West Indies: advisory messages and storm warning messages—the former intended to warn outgoing vessels of stormy conditions elsewhere, the latter to indicate a more serious and immediate local storm.[108] In urgent situations, the Bureau flew a storm warning flag, but, as an official acknowledged, "frequently the information is intended solely for the benefit of vessels ready to leave port and need not be communicated to the general public (as it might cause unnecessary alarm)."[109] When forecasts were more widely disseminated, Bureau officials blamed residents for failing to interpret them correctly, thereby causing "confusion and unnecessary alarm."[110] Bureau personnel also denounced private forecasters' "sensational and alarming reports" in favor of their own "conservative and reassuring" reports, justifying their

tight control over local weather information and policy of "disseminat[ing] with discretion" by blaming a cultural "tendency on the part of the people to misunderstand them [storm warnings]."[111] Stockman, the Bureau official in charge of Havana headquarters, faulted Cubans for not acknowledging the value of U.S. government storm warnings: "At first it was difficult to interest the people in the warning service, since they are by nature very conservative and slow to adopt any change in their accustomed methods and mode of living. The issue of warnings of hurricanes was a most radical change, the inhabitants being accustomed to hear of these phenomena only upon their near approach."[112] With this racialized logic of the capacity to comprehend knowledge of the future, Bureau officials legitimized their decision not to disseminate routine forecasts, thereby rendering Cuba less meteorologically legible to its own people.

After U.S. occupation of Cuba ended in 1902, its West Indian weather service continued in what Weather Bureau officials characterized as a mode of "mutually beneficial cooperation" in which the United States would allow Cuba access to its entire West Indian network in exchange for Cuban management of the four U.S. reporting stations in Cuba, located in Havana, Cienfuegos, Puerto Principe, and Santiago.[113] Bureau chief Moore noted in March 1902 that "[t]he proper protection of our own seaports on the Gulf and South Atlantic Coasts against the approach of West Indian hurricanes makes it necessary that we have a few observation stations under our control on the island of Cuba."[114] Secretary of Agriculture Wilson offered to telegraph the Bureau's regular observations from its West Indian network and any additional U.S. stations the Cuban government desired, as long as Cuba's meteorological service restricted its own forecasts to the island. Further, the U.S. offered to notify Cuba of hurricane warnings for other islands in the West Indies and, in return, requested receipt of any hurricane warnings posted for Cuba. The United States was also granted permission to maintain its observation stations in Jamaica, Dominica, Barbados, and Santo Domingo in exchange for transmitting hurricane warnings to their governments and major shipping companies.[115] The end of American occupation, then, allowed the U.S. Weather Bureau to expand its reach and maintain its institutional presence throughout the West Indies.

But this is not to say that such an institutional presence faced no resistance. Moore observed in the aftermath of the Galveston hurricane that "people do not appreciate our service, that the only thing they want is to kick us and say good-bye."[116] Moore's assessment was confirmed in July 1902, when private forecaster Julio Jover y Anido was asked by the editor of *Diario de la Marina*, the most widely read newspaper in Cuba, to comment on the U.S. Weather Bureau's official role in the new republic. Jover's response, subsequently published, conveyed a critique of imperial meteorology and recognition that an American observatory in Cuba would have "a great bearing with regard to our people, not only from a scientific point of view, but also from a politico-international one." Jover resented the implication that Cuban meteorological traditions and the Belen College Observatory were in any way inadequate and professed, "I cannot understand how an official organization of such a nature was aimed at in a foreign country." Jover went on to underscore the economic and political consequences of meteorological infrastructure, noting that "[t]he influence of a Central Observatory in a nation is of greater importance than it may appear at first sight. It has to deal with the calculations of the exact hour; it is in close relations with the Merchant and War Marine; it has a

bearing on other geographical studies and many other questions of … international character. Can all this be entrusted to a foreign government? To grant Washington's demands would be in flat contradiction with the personality that Cuba actually enjoys."[117] Jover's letter makes visible not only local resistance to scientific imperialism, but also how conflicts over meteorological infrastructure were embedded in a spatial politics of American empire.

The other part of the American meteorological infrastructure in the West Indies, the climate and crop reporting network, was officially transferred at the end of April 1902 from the U.S. Weather Bureau to the Cuban Department of Agriculture, where it was put under the leadership of Carbonnell, the former director of the Spanish naval weather service.[118] Although Bureau officials in Havana described the transition as formally "severing our connection" with local voluntary observers, the connection between American and Cuban meteorological infrastructures would endure.[119] By 1905, the Weather Bureau had scaled down its West Indian weather service, eliminating seven of fourteen stations and replacing Weather Bureau personnel with "non-commissioned employees," namely operators at local telegraph companies, at the remaining stations.[120] Between 1906 and 1912, the Weather Bureau maintained between seven and nine such stations until expanding its reach between 1913 and 1918 to encompass the West Indies, the Caribbean Sea, and the Panama Canal Zone. In 1915 the Weather Bureau's annual report reiterated the connection between weather reporting, commerce, and military security that was the impetus for the creation of the West Indian weather service in 1898: "[t]he commercial as well as the naval and military interests of the country fully justify the improvement and extension of the work of the Bureau in the Panama Canal and the region of the Caribbean Sea."[121]

* * *

The history of the U.S. Weather Bureau's West Indian weather service is the history of a knowledge infrastructure that linked, in addition to weather observers and their instruments, the mutually reinforcing imperatives of imperial, scientific, and commercial expansion at the turn of the twentieth century. The meteorological infrastructure that produced hurricane warnings was a material and symbolic extension of American technoscientific power into the Caribbean, but the creation and operation of that infrastructure hinged on both cooperation with and control of forecasters and volunteer observers throughout the region. In constructing overlapping technical and professional networks that produced short-term hurricane warnings and climate and crop reports, the Weather Bureau relied on local knowledge and labor but then sought to control the circulation of its forecasts according to racial and scientific ideologies that cast residents of the West Indies as incapable of comprehending the work of American science.

As American policy makers anticipated the political future of U.S.-Cuba relations, short-term hurricane warnings and long-range economic calculations based on climate and crop reports constituted a form of environmental and economic foreknowledge that connected the United States to the West Indies. As Louis A. Pérez, Jr. has observed, "It became all but impossible for the Americans to contemplate their future-well-being without the presumption of possession of Cuba. … To have imagined the island as essential to the endurance of the nation … was to have implicated Cuba in the North American

sense of future, which meant, too, that the future of Cuba was a matter over which the Americans laid claim as a function of their interests."[122] The meteorological infrastructure that produced this knowledge about the future played a crucial role in the networks of scientific and commercial exchange linking the United States to the West Indies and beyond, thereby suggesting that historians might think productively about American empire in not only spatial but also temporal terms.

Just as narratives of interconnected American and Cuban futures circulated at the turn of the twentieth century, so too did narratives of the U.S. Weather Bureau's West Indian weather service. Government scientists published accounts of the new American meteorological infrastructure in which scientific collaboration and "international courtesy" achieved the humanitarian aims of a hurricane warning network.[123] In April 1899, the *Monthly Weather Review* celebrated the "international comity" of the West Indian weather service, noting that "[n]o act is allowed that could in any way be interpreted as an effort or willingness on our part to override local rights and the authority of the sometimes long-established local meteorological officials." The article went on to declare, "It is disastrous to science whenever one man or institution overrides, absorbs, or destroys the honest work of his neighbors. 'Cooperation and not monopoly,' is the only principle that can lead to success in the study and practice of meteorology."[124] Yet, as this article has revealed, principles of cooperation and monopoly were inextricable in the extension of an American meteorological infrastructure into the West Indies, and indeed U.S. officials relied on cooperation with Cuban scientists and observers precisely in order to create the "single, comprehensive system" envisioned by U.S. Secretary of Agriculture James Wilson that sought to suppress and control local scientific authorities. In this way the U.S. Weather Bureau's West Indian weather service depended on not only the construction of telegraph reporting networks but also the construction of narratives of technoscientific progress that at once legitimated and concealed the operation of a meteorological infrastructure in the service of American empire.

NOTES

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[2]"Haiti Fears Aggression," *New York Times*, Aug. 25, 1898.

[3]U.S. Department of Agriculture, *Report of the Chief of the Weather Bureau, 1898–99*, vol. 1 (Washington, D.C.: Government Printing Office, 1900), 3–4; "Warned of the Storm's Coming," *North American* (Philadelphia), Sept. 16, 1898.

[4]"Weather Bureau Warning," *New York Times*, Sept. 16, 1898; "West Indian Weather News," *New York Times*, Sept. 18, 1898.

[5]"West Indian Weather Service," *New-York Tribune*, July 29, 1898; USDA, *Report of the Chief of the Weather Bureau, 1898–99*, 1:9.

[6]I rely on Paul Edwards's definition of *knowledge infrastructure*: "Instead of thinking about knowledge as pure facts, theories, and ideas … an infrastructure perspective views knowledge as an enduring, widely shared sociotechnical system. … *Knowledge infrastructures comprise robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds*." Paul Edwards,

A Vast Machine: Computer Models, Climate Change, and the Politics of Global Warming (Cambridge, MA: MIT Press, 2013), 17–25, quotation on 17.

[7]The literature connecting science, environment, and empire is extensive. See, for example, Jorge Cañizares-Esguerra, *Nature, Empire, and Nation: Explorations of the History of Science in the Iberian World* (Palo Alto, CA: Stanford University Press, 2006); Helen Tilley, *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870–1950* (Chicago: University of Chicago Press, 2011); D. Graham Burnett, *Masters of All They Surveyed: Exploration, Geography, and a British El Dorado* (Chicago: University of Chicago Press, 2000); Richard Drayton, *Nature's Government: Science, Imperial Britain, and the "Improvement" of the World* (New Haven, CT: Yale University Press, 2000).

[8]On the creation of the national weather service in the United States, see James Rodger Fleming, "Storms, Strikes and Surveillance: The U.S. Army Signal Office, 1861–1891," *Historical Studies in the Physical and Biological Sciences* 30:2 (2000): 315–32.

[9]Jamie L. Pietruska, "U.S. Weather Bureau Chief Willis Moore and the Reimagination of Uncertainty in Long-Range Forecasting," *Environment and History* 17 (Feb. 2011): 79–105.

[10]Nineteenth-century weather services relied on decentralized networks of reporters who telegraphed local observations that were aggregated and translated into daily forecasts and storm warnings by government forecasters in a central office and then disseminated through telegraph reporting networks. On the "collective science" of the mid-century British Meteorological Department, see Katharine Anderson, *Predicting the Weather: Victorians and the Science of Meteorology* (Chicago: University of Chicago Press, 2005), ch. 3, quotation on 10.

[11]On the formation of "the American imperial state," see Alfred W. McCoy, Francisco A. Scarano, and Courtney Johnson, "On the Tropic of Cancer: Transitions and Transformations in the U.S. Imperial State" in *Colonial Crucible: Empire in the Making of the Modern American State*, eds. Alfred W. McCoy and Francisco A. Scarano (Madison: University of Wisconsin Press, 2009), 3–33, quotation on 5. Historians of science have recognized the strategic value of weather and climate information to military and colonial powers. On military weather forecasting, see James Rodger Fleming, "Sverre Petterssen and the Contentious (and Momentous) Weather Forecasts for D-Day," *Endeavour* 28 (June 2004): 59–63; Kristine C. Harper, *Weather by the Numbers: The Genesis of Modern Meteorology* (Cambridge, MA: MIT Press, 2008), ch. 3. For an account of India as Britain's "ideal natural laboratory" for conducting meteorological research, showcasing the value of government science, and legitimating British rule, see Anderson, *Predicting the Weather*, 250–63, quotation on 250.

[12]Paul Kramer, "Power and Connection: Imperial Histories of the United States in the World," *American Historical Review* 116 (Dec. 2011): 1349.

[13]Kramer, "Power and Connection," 1350.

[14]For a list of nations that controlled telegraph networks in the West Indies, see Gregory T. Cushman, "The Imperial Politics of Hurricane Prediction: From Calcutta and Havana to Manila and Galveston, 1839–1900" in *Nation-States and the Global Environment: New Approaches to International Environmental History*, eds. Erika Marie Bsumek, David Kinkela, and Mark Atwood Lawrence (New York: Oxford University Press, 2013), 150–51. Quotation in Leida Fernández Prieto, "Islands of Knowledge: Science and Agriculture in the History of Latin America and the Caribbean," *Isis* 104 (Dec. 2013): 789.

[15]On centers of calculation, see Bruno Latour, *Science in Action* (Cambridge, MA: Harvard University Press, 1988), ch. 6; quotation in Stuart McCook, "Introduction" to "Focus: Global Currents in National Histories of Science: The 'Global Turn' and the History of Science in Latin America," *Isis* 104 (Dec. 2013): 774.

[16]James Francis Warren, "Scientific Superman: Father José Algué, Jesuit Meteorology, and the Philippines under American Rule, 1897–1924" in *Colonial Crucible*, eds. McCoy and Scarano, 508.

[17]Cushman, "The Imperial Politics of Hurricane Prediction," 137–62, quotation on 157.

[18]On the centrality of hurricanes to the history of this region, see Stuart B. Schwartz, *Sea of Storms: A History of Hurricanes in the Greater Caribbean from Columbus to Katrina* (Princeton, NJ: Princeton University Press, 2015); Sherry Johnson, *Climate and Catastrophe in Cuba and the Atlantic World in the Age of Revolution* (Chapel Hill: University of North Carolina Press, 2011); Matthew Mulcahy, *Hurricanes and Society in the British Greater Caribbean, 1624–1783* (Baltimore: Johns Hopkins University Press, 2006). On meteorological infrastructure, see Paul N. Edwards, "Meteorology as Infrastructural Globalism," *Osiris* 21 (2006): 229–50.

[19]Paul N. Edwards, "Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems" in *Modernity and Technology*, eds. Thomas J. Misa and Philip Bray (Cambridge, MA: MIT Press, 2003), 218–24.

[20]On the cultural politics of Cuban resistance and accommodation to American imperialism, see Marial Iglesias Utset, *A Cultural History of Cuba during the U.S. Occupation, 1898–1902*, trans. Russ Davidson (Chapel Hill: University of North Carolina Press, 2011).

[21]Willis Moore, "Topic No. 4—West Indian Hurricane Service" in James Berry, ed., *Proceedings of the Convention of Weather Bureau Officials, Held at Omaha, Nebraska, October 13–14, 1898* (Washington, D.C.: U.S. Weather Bureau, 1899), 56. U.S. Weather Bureau personnel defined hurricane season in the West Indies as lasting from mid-June to November 1, with August as the most active month for hurricanes throughout the region. William H. Alexander, *Hurricanes: Especially Those of Porto Rico and St. Kitts* (Washington, D.C.: Government Printing Office, 1902), 8, 11.

[22]Quotation in James B. Elsner and A. Birol Kara, *Hurricanes of the North Atlantic: Climate and Society* (New York: Oxford University Press, 1999), 49.

[23]Louis A. Pérez Jr., *The War of 1998: The United States and Cuba in History and Historiography* (Chapel Hill: University of North Carolina Press, 1998), 5; quotation in Cleveland Abbe, "The Meteorological Work of the U.S. Signal Service, 1870 to 1891" in Oliver L. Fassig, ed., *Report of the International Meteorological Congress, Held at Chicago, Illinois, August 21–24, 1893* (Washington, D.C.: Weather Bureau, 1895), 249.

[24]Abbe, "The Meteorological Work of the U.S. Signal Service, 1870 to 1891," 249.

[25]U.S. Weather Bureau, Records Describing Weather Stations, 1883–1904, vol. 10 (1889–1991), 464–65, 192–93, Administrative and Financial Records, Records of the Weather Bureau, Record Group 27, National Archives, College Park, MD.

[26]Mark W. Harrington, *Report of the Chief of the Weather Bureau for 1892* (Washington, D.C.: Government Printing Office, 1893), 560.

[27]USDA, *Report of the Chief of the Weather Bureau, 1895–96* (Washington, D.C.: Government Printing Office, 1896), xviii; Willis L. Moore, *Report of the Chief of the Weather Bureau for 1895* (Washington, D.C.: Government Printing Office, 1895), 69.

[28]On improved hurricane reporting after 1750, see Louis A. Pérez Jr., *Winds of Change: Hurricanes and the Transformation of Nineteenth-Century Cuba* (Chapel Hill: University of North Carolina Press, 2001), 35.

[29]Pérez, *Winds of Change*, 11.

[30]On the persistence of religious explanations for hurricanes alongside scientific accounts in the eighteenth century, see Matthew Mulcahy, "'A Tempestuous Spirit Called Hurri Cano,': Hurricanes and Colonial Society in the British Greater Caribbean" in *American Disasters*, ed. Steven Biel (New York: New York University Press, 2001), 21.

[31]F. L. Oswald, "Weather Freaks of the West Indies," *Popular Science Monthly* (Oct. 1898): 789–93.

[32]Alexander, *Hurricanes*, 26. On hurricane forecasting, see Kerry Emanuel, *Divine Wind: The History and Science of Hurricanes* (New York: Oxford University Press, 2005); Elsner and Kara, *Hurricanes of the North Atlantic*; Bob Sheets and Jack Williams, *Hurricane Watch: Forecasting the Deadliest Storms on Earth* (New York: Vintage, 2001).

[33]"El Weather Bureau," *La Mariana Cubana*, Aug. 26, 1900, newspaper clipping and translation in box 1476, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[34]The Belen College Observatory, which had been making daily weather observations and publishing annual data since 1859, was headed by Viñes from 1870 until his death in July 1893. W. F. R. Phillips, *Climate of Cuba, Also a Note on the Weather of Manila* (Washington, D.C.: Weather Bureau, 1898), 5. On Viñes's training in Europe, see Luis E. Ramos Guadalupe, *Father Benito Viñes: The 19th-Century Life and Contributions of a Cuban Hurricane Observer and Scientist*, trans. Oswaldo García (Boston: American Meteorological Society, 2014), 55–59.

[35]On the distinction between "missionary science" and "imperial science," see Cushman, "Imperial Politics of Hurricane Prediction," 142.

[36]Guadalupe, *Benito Viñes*, 11, 31; Benito Viñes, *Apuntes Relativos a los Huracanes de las Antillas en Septiembre y Octubre de 1875 y '76* (Havana, 1877), quoted in Guadalupe, *Benito Viñes*, 36.

[37]Guadalupe, *Benito Viñes*, 28–29, 66–67, 93, 108–10.

[38]Benito Viñes, *Apuntes Relativos a los Huracanes de las Antillas en Septembre y Octubre de 1875 y '76* (Havana, 1877), quoted in Guadalupe, *Benito Viñes*, 110, 116–17, quotation on 110.

[39]Guadalupe, *Benito Viñes*, 125.

[40]U.S. Weather Bureau, *Investigation of the Cyclonic Circulation and the Translatory Movement of West Indian Hurricanes, By the Late Rev. Benito Viñes, S. J.* (Washington, D.C.: Weather Bureau, 1898), 3.

[41]Benito Viñes, *Practical Hints in Regard to West Indian Hurricanes*, trans. George L. Dyer (Washington, D.C.: Government Printing Office, 1885), 6.

[42]Viñes compared his law to William Redfield's 1831 "law of storms," which had first described the counterclockwise circular rotation of winds in the northern hemisphere, by emphasizing that his law offered a more comprehensive picture of air currents and focused on higher-altitude air currents, which he maintained had more predictive value than the more irregular winds at sea level. U.S. Weather Bureau, *Investigation of the Cyclonic Circulation and the Translatory Movement of West Indian Hurricanes, By the Late Rev. Benito Viñes, S. J.*, 8.

[43]Viñes, *Apuntes Relativos*, 149, quoted in Guadalupe, *Benito Viñes*, 104.

[44]On newspapers' praise for Viñes's forecasts, see Guadalupe, *Benito Viñes*, 117.

[45]William H. Alexander to Chief of Weather Bureau, Feb. 24, 1902, Weather Bureau Correspondence 1870–1912, box 1600, RG 27, NA-College Park.

[46]E. B. Garriott, memorandum, Mar. 6, 1902, Weather Bureau Correspondence 1870–1912, box 1600, RG 27, NA-College Park.

[47]U.S. Weather Bureau, *Investigation of the Cyclonic Circulation and the Translatory Movement of West Indian Hurricanes, By the Late Rev. Benito Viñes, S. J*, 19; *New York Herald*, July 25, 1893.

[48]U.S. Weather Bureau, *Records Describing Weather Stations, 1883–1904*, vol. 10 (1889–1991), 193, RG 27, NA-College Park.

[49]Willis Moore to Luis Carbonnell, Sept. 27, 1898; Carbonnell to Moore, Oct.14, 1898; Carbonnell to Moore, Nov. 29, 1898; Carbonnell to Moore, Dec. 20, 1898; all in box 1325, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[50]Moore to Carbonnell, Sept. 27, 1898, box 1325, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[51]Carbonnell to Moore, Oct. 14, 1898, box 1325, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[52]Moore to Carbonnell, Nov. 26, 1898, box 1325, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[53]J. G. Hagen to Moore, Dec. 10, 1898, box 1333; Hagen to Moore, Dec. 10, 1898, box 1333; Lorenzo Gangoiti to Moore, Nov. 30, 1898, box 1325, all in Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[54]Abbe to Moore, Dec. 8, 1898, box 1333, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[55]Garriott to Moore, Dec. 10, 1898, box 1333, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[56]Moore to Gangoiti, Dec. 12, 1898; Moore to Hagen, Dec. 13, 1898; both in box 1333, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[57]Moore to Hagen, Dec. 13, 1898, box 1333, Weather Bureau Correspondence, 1870–1912, RG 27, NA-College Park.

[58]Erik Larson, *Isaac's Storm: A Man, a Time, and the Deadliest Hurricane in History* (New York: Vintage, 2000), 103.

[59]Phillips, *Climate of Cuba,* 6–7.

[60]USDA, *Report of the Chief of the Weather Bureau, 1897–98*, 11; "To Extend Weather Service," *New York Times*, July 14, 1898; USDA, *Report of the Chief of the Weather Bureau, 1898–99* (Washington, D.C.: Government Printing Office, 1900), 8.

[61]USDA, *Report of the Chief of the Weather Bureau, 1895–96*, 8.

[62]USDA, *Report of the Chief of the Weather Bureau, 1898–99*, 8.

[63]M. W. Hayes, "Value of the Climate and Crop and Storm Warning Services of the Weather Bureau to the Industries of Cuba and Other Islands of the West Indies" in James Berry and W. F. R. Phillips, eds., *Proceedings of the Second Convention of Weather Bureau Officials Held at Milwaukee, Wisconsin, Aug. 27, 28, 29, 1901* (Washington, D.C.: Government Printing Office, 1902), 58.

[64]Alexander, *Hurricanes*, 43.

[65]USDA, *Report of the Chief of the Weather Bureau, 1898–99*, 9.

[66]R. T. Brown to Moore, Dec. 16, 1898, box 1337, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[67]Moore to W. T. Blythe, July 30, 1900, box 1468, General Correspondence of the Weather Bureau, 1894–1912, Letters Received, 1894–1911, RG 27, NA-College Park.

[68]James Wilson to Elihu Root, Mar. 17, 1900, box 1439, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[69]"To Extend Weather Service," *New York Times*, July 14, 1898.

[70]James Wilson to Elihu Root, Mar. 17, 1900, box 1439, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[71]On the policing of private long-range forecasters, see Pietruska, "U.S. Weather Bureau Chief Willis Moore and the Reimagination of Uncertainty in Long-Range Forecasting." On the Victorian context, see Katharine Anderson, "The Weather Prophets: Science and Reputation in Victorian Meteorology," *History of Science* 37:2 (1999): 179–216.

[72]Alexander, *Hurricanes*, 79; Montrose W. Hayes, letter to the editor, *Diario de la Marina*, Sept. 2, 1899, box 1402, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[73]W. T. Blythe to Lorenzo Gangoiti, Aug. 1, 1900, box 1468, General Correspondence of the Weather Bureau, 1894–1912, Letters Received, 1894–1911, RG 27, NA-College Park.

[74]E. B. Garriott, "Forecasts and Warnings," *Monthly Weather Review* 26:10 (Oct. 1898): 440.

[75]A. J. Mitchell to Chief of Weather Bureau, Oct. 26, 1898, box 1324, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park; Garriott, "Forecasts and Warnings," 440.

[76]W. A. Bessey to Supt. Weather Bureau, Oct. 8, 1898, box 1324, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[77]Cline's own report was reprinted and excerpted in numerous publications, including Isaac M. Cline, "Special Report on the Galveston Hurricane of September 8, 1900," *Scientific American Supplement*, vol. 50, Oct. 27, 1900, pp. 20756–57; E. B. Garriott, "West Indian Hurricane of Sept. 1–12, 1900," *Monthly Weather Review* 28:9 (Sept. 1900): 371–77, at 372–74; Clarence Ousley, ed., *Galveston in Nineteen Hundred* (Atlanta: William C. Chase, 1900), 39–46. Subsequent estimates of the death toll have ranged from 8,000 to 12,000.

[78]On Galveston as the culmination of "the imperial politics of hurricane prediction," see Cushman, "The Imperial Politics of Hurricane Prediction," 154–56. On the role of the Red Cross in administering disaster relief, as well as the inequities of race and class in disaster response, see Schwartz, *Sea of Storms*, 212–22. For the best-selling popular account of Cline's life and work in Galveston, see Larson, *Isaac's Storm*.

[79]William B. Stockman to H. H. C. Dunwoody, Sept. 7, 1900, box 1475, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[80]"The Weather and its Prophets," *Houston Daily Post*, Sept. 14, 1900.

[81]"The Late Hurricane," *Houston Daily Post*, Sept. 28, 1900. Larson, *Isaac's Storm* mentions this exchange in the *Houston Post* in the context of a dispute between Moore and Cline over whether and when the Weather Bureau formally issued a hurricane warning (pp. 250–51). For the purposes of my argument, the *Houston Post* articles are not exceptional but rather typical of the public debates over the relative accuracy of short-term government weather forecasting and widely popular long-range forecasting.

[82]Jamie L. Pietruska, *Looking Forward: Prediction and Uncertainty in Modern America* (University of Chicago Press, forthcoming), ch. 3.

[83]*La Discusión*, Nov. 14, 1900. Translated newspaper clipping enclosed in Montrose W. Hayes to Moore, Nov. 18, 1900, box 1475, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[84]H. H. C. Dunwoody to W. B. Stockman, Sept. 5, 1900; W. B. Stockman to Moore, Sept. 15, 1900, both in box 1475, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[85]Moore to the Secretary of Agriculture, Sept. 21, 1900, box 1475, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[86]Moore to Thomas T. Eckert, Sept. 20, 1900, box 1468, General Correspondence of the Weather Bureau, 1894–1912, Letters Received, 1894–1911, RG 27, NA-College Park.

[87]"Mr. Stockman," *La Discusión*, Oct. 27, 1900, newspaper clipping in box 1475, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park. Translation in "Down went Mc Ginty's to the Bottom of the Sea," *Diario de la Marina*, Oct. 30, 1900, newspaper clipping in box 1475, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[88]On legibility and the "politics of measurement," see James C. Scott, *Seeing like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven, CT: Yale University Press, 1999), 27–33.

[89]Prof. Cleveland Abbe, "The Meteorological Work of the U. S. Signal Service" in Fassig, ed., *Report of the International Meteorological Congress Held at Chicago, Illinois, Aug. 21–24, 1893*, 249.

[90]Ibid., 249–50.

[91]On the scientific and symbolic value of the weather map, see Mark Monmonier, "Telegraphy, Iconography, and the Weather Map: Cartographic Weather Reports by the United States Weather Bureau, 1870–1935," *Imago Mundi* 40 (1988): 15–31.

[92]The U.S. Army Signal Service, the predecessor to the U.S. Weather Bureau, was embarrassed by an embezzlement scandal in 1881, had its military administration unfavorably assessed by a congressional commission in the mid-1880s, and faced persistent critique of the accuracy and timeliness of its forecasts throughout the late nineteenth century. Donald Whitnah, *A History of the United States Weather Bureau* (Urbana: University of Illinois Press, 1961), 46–60; Pietruska, "U.S. Weather Bureau Chief Willis Moore and the Reimagination of Uncertainty in Long-Range Forecasting."

[93]Phillips, *Climate of Cuba*, 3, 5.

[94]Ibid., 5–6.

[95]Quotation in Louis A. Pérez, Jr., "Incurring a Debt of Gratitude: 1898 and the Moral Sources of United States Hegemony in Cuba," *American Historical Review* 104 (Apr. 1999): 373.

[96]Hyatt Verill, *Cuba of Today* (New York, 1931), 157–58, quoted in Ibid., 385.

[97]Louis A. Pérez, Jr., "Insurrection, Intervention, and the Transformation of Land Tenure Systems in Cuba, 1895–1902," *Hispanic American Historical Review* 65 (May 1985): 229–36.

[98]Perfecto Lacosta, "Report of the Department of Agriculture, Commerce, and Industry," Mar. 15, 1901, United States War Department, *Annual Reports of the War Department for the Fiscal Year Ended June 30, 1900* (Washington, D.C., 1900), I, part 11, section 4, p. 9, quotation in Ibid., 237–38.

[99]"West Indian Weather Service," *New York Times*, Dec. 29, 1898.

[100]"Weather Bureau Work in Cuba," *New-York Tribune*, Dec. 29, 1898; M. W. Hayes, "Value of the Climate and Crop and Storm Warning Services of the Weather Bureau to the Industries of Cuba and Other Islands of the West Indies" in Berry and Phillips, eds., *Proceedings of the Second Convention of Weather Bureau Officials Held at Milwaukee*, 59.

[101]USDA, *Report of the Chief of the Weather Bureau, 1898–99*, 9; USDA, *Report of the Chief of the Weather Bureau, 1901–1902* (Washington, D.C.: Government Printing Office, 1902), xiii.

[102]Hayes, "Value of the Climate and Crop and Storm Warning Services of the Weather Bureau to the Industries of Cuba and Other Islands of the West Indies," 59.

[103]Ibid., 60.

[104]John R. Brooke to Adjutant General, Oct. 1, 1899, in Brooke, *Civil Report of Major-General John R. Brooke, U.S. Army, Military Governor, Island of Cuba, 1899*, 13–14, quotation in Pérez, "Insurrection, Intervention, and the Transformation of Land Tenure Systems in Cuba, 1895–1902," 235.

[105]G. Harold Noyes, "Value of the Climate and Crop and Storm-Warning Services of the Weather Bureau to the Industries of Porto Rico" in Berry and Phillips, eds., *Proceedings of the Second Convention of Weather Bureau Officials Held at Milwaukee*, 61.

[106]Ibid.

[107]Hayes, "Value of the Climate and Crop and Storm Warning Services of the Weather Bureau to the Industries of Cuba and Other Islands of the West Indies," 58.

[108]Alexander, *Hurricanes*, 43–44.

[109]Hayes, "Value of the Climate and Crop and Storm Warning Services of the Weather Bureau to the Industries of Cuba and Other Islands of the West Indies," 58.

[110]Alexander, *Hurricanes*, 43.

[111]C. G. Talman to Chief of the Weather Bureau, Sept. 4, 1899, box 1395, Weather Bureau Correspondence 1870–1912, RG 27, NA–College Park, Ibid., 44.

[112]USDA, *Report of the Chief of the Weather Bureau, 1898–99*, 8.

[113]USDA, *Report of the Chief of the Weather Bureau, 1901–1902*, xiii.

[114]Moore to Wilson, Mar. 25, 1902, box 1616, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[115]James Wilson to The Honorable Secretary of Agriculture, Commerce, and Industry, Havana, June 23, 1902, box 1616, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[116]Moore to Wilson, Sept. 21, 1900, Weather Bureau Correspondence 1870–1912, box 1475, RG 27, NA-College Park.

[117]Julio Jover y Anido to Sr. Director of the Diario de la Marina, July 15, 1902, Weather Bureau Correspondence 1870–1912, box 1635, RG 27, NA-College Park.

[118]W. B. Stockman, *Report for April, 1902, Cuba Section of the Climate and Crop Service of the Weather Bureau* (Havana: Weather Bureau Office, 1902), 2.

[119]William B. Stockman, circular, May 31, 1902, box 1616, Weather Bureau Correspondence 1870–1912, RG 27, NA-College Park.

[120]Willis L. Moore, *Report of the Chief of the Weather Bureau for 1905* (Washington, D.C.: Weather Bureau, 1905), 34.

[121]See *Report of the Chief of the Weather Bureau* for the years 1906–1918, available at NOAA Central Library: www.lib.noaa.gov/collections/imgdocmaps/reportofthechief.html (accessed Mar. 28, 2014); quotation in USDA, *Report of the Chief of the Weather Bureau for 1915* (Washington, D.C.: Government Printing Office, 1915), 2.

[122]Louis A. Pérez, Jr., *Cuba in the American Imagination: Metaphor and the Imperial Ethos* (Chapel Hill: University of North Carolina Press, 2008), 25–26.

[123]"International Courtesy," *Monthly Weather Review*, Apr. 1899, pp. 160–61. For one of many examples of public justifications of the Weather Bureau's West Indian weather service, see Willis L. Moore, "How Science Under Direction of the Federal Authorities Warns Us on the Freaks and Fancies of the Weather," *San Francisco Call*, Apr. 27, 1901.

[124]"International Courtesy," *Monthly Weather Review*, Apr. 1899, quotations on 160, 161.