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Cuba–USA cooperation in Meteorology (1850-1961)

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Abstract

The initial attempts to establish effective cooperation between scientists and institutions in the field of tropical meteorology of both, Cuba and the USA, are described and analyzed, as well as further efforts to widen and consolidate those first steps. This study focuses on the more relevant actions during three periods that correspond broadly with the colonial era, the first decades after the establishment of the Cuban Republic, and the new context that is defined by World War II and its aftermath, until the moment when diplomatic and commercial relations between both countries were severed. Significant factors that promote this cooperation in each stage, like the geographic situation of the Cuban archipelago, Cuban proximity to the US, the proficiency of Cuban meteorologists; tropical hurricanes and the need to increase the efficacy of both, forecasts and early warning systems, for natural events that affect both countries were taken into account.

Keywords: *cooperation, meteorology, forecasts, hurricanes*

Introduction

Beyond the human interest in sharing knowledge for mutual benefit and the common good that the generalization of advances in science and technology brings to nations, the primary reason and starting point for Cuban-US collaboration in meteorology arises from their geographic proximity. Their natural and political-administrative borders converge at the northern limit of the tropical belt, where both states share a marine sector between the Old Bahamas Channel and the Yucatan Channel, just at the entrance to the Gulf of Mexico.

The ports of southern North America and those of northern Cuba have the Straits of Florida as a route, where the Gulf Stream stimulates the development of thunderstorms and tropical cyclones that often intensify into hurricanes. In their different spatial-temporal scales, the effects of Ian, Idalia and Milton, all in the 2020-2024 quadrennial, exemplify these phenomena that equally impact the society and economy of both countries, and reach the entire region.

In order to focus on the subject that motivates this article —always from a Cuban perspective—, we will refer to three stages delimited by relevant events in the political context. The first two intervals in our periodization cover, respectively, from 1850 to 1898, and from 1899 to 1941; while the third and last one is developed over nineteen years, from 1942 to 1961.

In the initial stage, framed in the final years of the colonial regime in Cuba, the first links between Cuban and American meteorologists were established, generally at the initiative of the Creoles, without any agreements or legal instruments. This is explained, among other reasons, by the opposition of the Spanish Crown to promote the development of an autochthonous science and its application to the territory of "the Island of Cuba", since it was understood that any intellectual freedom could mean an expression of independence and sovereignty. In

addition, Spain foresaw among other threats the one represented by "the Americans", and placed certain limits to its objectives and interests in Cuba.

In keeping with its political status, the representation of the "Island" in the nascent international forums on weather and climate was in charge of the officials from Madrid, as it happened in the Maritime Meteorological Conference held in London from September 10 to 16, 1874 (WMO/WMO, 1973), where Spain and its overseas territories were represented by the mariner, astronomer and meteorologist from Cadiz, Cecilio Pujazón García (Mohn, 1878).

As alternatives, the Sociedad Económica de Amigos del País (1793-present) and the Real Academia de Ciencias Médicas, Físicas y Naturales de La Habana (1861-1961) were exceptions in the promotion and application of a science with indigenous roots; however, they were limited to the capital and lacked the authority to establish lines of collaboration with foreign countries.

In the second stage, at the beginning of the Republic, the interest of the North Americans in Cuba was reinforced, including the incentive of the tropical nature. The end of the war against Spain and the relationship of political and economic dependence that gravitated towards the United States, opened the possibility of seeking new knowledge in a nearby and easily accessible country.

In the third stage, a new context arose which required the United States to seek from science a better knowledge and forecast of the tropical systems that affected the economic activity and the operability of its military forces, oriented to a broad spectrum of interests in the continent.

Once this methodological framework has been defined, we will characterize each interval, under the premise of not considering the scientific collaboration or cooperation at that time, in the manner and form that these terms currently acquire with respect to international programs and projects. The following is a synthesis of how this interaction was expressed in the three moments already mentioned.

Development

Havana Observatories, the Smithsonian Institution and the Signal Service

The first Cuban who had exchanges in meteorological matters with an American colleague was Andrés Poey Aguirre (1825-1919), who established ties with Joseph Henry (1797-1878), secretary of the famous Smithsonian Institution in Washington, D.C. These ties were created in 1850, when Poey learned that since the previous year Henry had been promoting a network of volunteer weather observers in North America, Central America and the Caribbean (Smithsonian Institution Archives, 2024). The relationship was channeled from the epistolary exchange that Henry and Felipe Poey Aloy —Andres' father— had previously had on topics of mutual interest in the natural sciences (Pruna, 2006, pp. 122-123).

Relations between Andrés and Henry acquired a more formal character in January 1861, when the Spanish authorities created the Physical-Meteorological Observatory of Havana and elevated the young Cuban to the position of director (Cuban National Archives, 1856- 1862). This led to the exchange of serial publications, observations and special works, such as the one related to the intense geomagnetic storm that occurred in August 1859, which produced aurora borealis and extreme phenomena in North America. The auroras were observed in Havana at lower latitudes and Poey made a study of them which is today among the most complete on this event (Kimbal, 1960).

The first comparative study based on meteorological data from Cuba and the United States appears in a monograph by Poey focused on thunderstorms and their effects in both territories (Poey, 1856).

In the early 2000s, Cuban researcher Pedro M. Pruna Goodgall visited the Smitsonian Institution, and in the documentation related to Cuba he found evidence of the epistolary exchange between the two scientists. The links were interrupted in 1869, when the colonial government removed Poey from the direction of the Observatory. After his dismissal, Andrés left Cuba for the United States, where "he got in touch with Joseph Henry and Luis

Agassiz" (Pruna, 2006). He stayed two years in North America, before settling definitively in France (Ortiz, 1979).

The most important institution in terms of meteorological research in Cuba in the 19th century was the Observatory of the Royal College of Belen, run by Spanish Jesuit priests. As a private educational institution, and under the protection of the Church, it enjoyed a certain independence from the Government. In the field of Earth and atmospheric sciences, its authority was almost unquestionable. The Jesuits had 33 observatories spread throughout the world (Udías, 2003), and the one in Havana was undoubtedly the largest and best equipped in the tropical zone.

For the daily operational work, its director, Father Benito Viñes Martorell, S.J. (1837-1893) collected data and oral or written reports from the pilots and captains of ships docked or anchored in Havana harbor, including U.S. ships traveling between Central America, the Caribbean, and the Gulf and Atlantic ports. Most of these ships were consigned to Galveston, New Orleans, or New York, and whenever he could, he took notes from the binnacle of ships bordering the Atlantic in the months of the hurricane season, and compared the storm reports with his own observations in Havana (Ramos, 2023).

Since September 1867, Cuba had an international telegraphic link by submarine cable (Altshuler, 2014, p. 20), and the data folders of the Belen Observatory show the method of meteorological surveillance based on the reports received by the cable between Havana and Key West. In the months of greatest danger during the hurricane season, Viñes took into account the telegrams sent from Washington by the old Signal Service (Gutiérrez- Lanza, 1904), and later by the Weather Bureau (now the National Weather Service). The exchange of serial publications, mainly the Yearbooks with the tables of variables measured at the Havana observatory, deserves a special mention. Thanks to the sending of these volumes, it is now possible to recover and access these data, available in the digitized collections of the National Oceanic and Atmospheric Administration of the United States (NOAA), and accessible on Google platforms (NOAA, 2023). The Bethlehem College observation series spans nearly a century and is a valuable reference in climate change research.

A problem linked to hurricane forecasts was the weather reports in the Caribbean, which required paying for the telegrams that were sent daily from the Lesser Antilles, using the submarine cable. Regarding this antecedent of the current early warning systems, Father Mariano Gutiérrez-Lanza, S. J. (1865-1943), Viñes' successor at the Belen Observatory, points out:

> It was indeed a precious help and an extraordinary deference on the part of the Signal Service in Washington to allow Fr. Viñes to copy the telegrams sent to that central office by his observers in the West Indies [...] however, the assignment to send warnings whenever Fr. Viñes of any cyclone that was dangerous for the Great Republic [United States] continued until 1898, both during the life of Fr. Viñes and in the time of Fr. Gangoiti, his immediate successor. (Gutiérrez-Lanza, 1904, p. 20).

In 1886, when several shipping and marine insurance companies decided to jointly pay for the payment of messages to and from Havana, limiting them to the months of greatest frequency in the formation of hurricanes. Among these insurers, the New York Board of Underwriters stood out, which adjusted the value of the policies to the months of the hurricane season (*El León Español*, 1886, p. 2). On occasions, the officers of the American ships came to compare their chronometers with the instruments of the Belen Observatory; and even, before setting sail, they went to inquire about the potential hurricane danger in the Caribbean, the Gulf or the Atlantic (Gutiérrez-Lanza, 1904, p. 29).

At the end of the 19th century, important scientists visited the Belen Observatory; among them Louis Agricola Bauer (1865-1932), Chief of the Division of Terrestrial Magnetism of the United States; and Edward Everett Hayden (1858-1932), Chief of the Division of Marine Meteorology of the Hydrographic Office of that country, who came to Havana in October 1888 to exchange data and reports on the intense hurricane that the previous month had crossed over the Strait of Florida (Gutiérrez-Lanza, 1904, p. 103). Both visits presuppose a discussion of criteria, methods, observational data and the exchange of publications.

When Spanish sovereignty in Cuba ceased and U.S. intervention and occupation began, the U.S. government ordered the Weather Bureau to create a district section in Havana, mainly oriented to the forecast of hurricanes and the study of the weather (Stockman, 1899). The bureau had meteorological stations in the Cuban territory; and its chief, William B. Stockman, held the position of "Weather Bureau Official in the Havana Forecast District". Stockman occupied this responsibility until the end of the Interventory Government.

The Republic and the North. Meteorological information and competing interests

After the Intervention, one of the first decisions of the Cuban government was to create the National Meteorological Service. For this purpose, it reproduced the structure of the former Weather Bureau Office. The new entity adopted the name of Central Meteorological, Climatological and Crop Station, and in tune with the U.S. Weather Service, it was subordinated to the Secretariat of Agriculture, Industry and Commerce (Republic of Cuba, 1902). Its first director was the Cuban sailor Luis García Carbonell (1840-1921), chosen not only for his proven knowledge of nautical meteorology, but also to mark a line of continuity with the American office, since Stockman had incorporated Carbonell to the Weather Bureau, to be in charge of the computation of climatological data.

With the influx of U.S. capital and its large investments in the sugar industry and other sectors, studies on Cuba's climate came to the forefront. In the weekly reports elaborated and published by the Station, we find reports on rainfall, temperatures and humidity sent by Americans living in the country; almost always administrators, technicians and assistants of the sugar mills, mines and estates. They acted, in fact, as volunteer meteorological observers.

In 1908, the Central Station adopted the name of National Observatory and established its headquarters on the heights of Casa Blanca, where today the buildings of the Institute of Meteorology are located. In 1921, after Carbonell's death, the young José Carlos Millás Hernández took over the direction of the Observatory. Millás had attended high school in New York, and after graduating in civil engineering and architecture from the University of Havana, he obtained a postgraduate degree in Celestial Mechanics from the University of Chicago (Millás, 1917-1961). With such a background, his relationship with his North American colleagues was evident.

Among the first Cuban-US links in the 1902-1941 period was the process of agreement, design and manufacture of a telescope for the astronomical section of the National Observatory. The idea arose in 1915, when a large official Cuban delegation participated in the Second Pan-American Scientific Congress (Republic of Cuba, 1915), held in Washington and aimed at promoting alliances and shaping relations between the United States and the republics of the Hemisphere.

In the process of building the instrument, Millás had as his technical counterpart Professor John Brashear, in charge of machining the optical elements that were assembled by The Warner & Swasey Company, in charge of the manufacture (Rodríguez, 2001). It was a long and arduous process, delayed by the First World War; but once the conflict was over, the 508 mm diameter refractor was installed in Havana and is now in the safekeeping of the Cuban Institute of Geophysics and Astronomy, awaiting its future restoration.

Later, in 1925, the meteorological section of the Observatory introduced the pinball technique, aimed at improving forecasts by incorporating data from the "upper air", i.e., conditions in the middle and upper troposphere (Millás, 1926).

The Secretary of Agriculture financed part of the technical infrastructure, but the money was only enough to buy the balloons, the gas to charge them, the reticulated planchettes to set the balloon positions during the ascent, and some other equipment. In view of this, Millas sought support from meteorologist Charles Frederick Marvin, of the Weather Bureau, and obtained the shipment of an aerological scale to measure the volume of gas in the filled balloons, and a drawing board to work with the charts where the ascent of the balloon was plotted (Millás, 1926). In reciprocity, since January, 1926, Cuba began to send to Washington the upper air data, adding them to the cablegram with the general state of the local weather.

At the stage we are analyzing, the relations between the National Observatory and the Weather Bureau were developed at the behest of the meteorologists, and not by the political will of the respective governments. Finally, the Cubans were trying to fulfill their mission in a country lacking state programs for the science sector.

An example of such inconveniences is provided by history in the 1927-1928 biennium, when it was learned that transmissions from the radiotelegraph station located in the small archipelago of Swan or Santanilla Islands, would cease definitively. The observations on those islands, carried out by U.S. personnel, were of paramount importance for monitoring the weather in the Caribbean Sea, mainly in its western region, cradle and path of dangerous hurricanes.

The radio transmitter installed there was owned by Tropical Radio, an affiliate of the United Fruit Company, which used it to manage refrigerated merchant ships carrying agricultural products and cargo between Central America and the United States. However, in view of the boom and expansion of radio telegraphy, United Fruit installed radio equipment on all its ships, and the Swan station became unnecessary; it was no longer profitable, and they opted to close it. The collateral effect was the loss of meteorological data, which left a vacuum of sensitive information for the National Observatory (*Diario de la Marina*, 1928, p. 1).

The eventual solution to the problem seemed to lie in an agreement between the United States Department of Agriculture and Tropical Radio Corporation. Miguel Angel de la Campa y Caraveda, Undersecretary of State of the Republic of Cuba, made arrangements with the State Department to resume sending data as soon as possible (Millás, 1932), and both agreed that the Cuban side could provide transmitting equipment and, if necessary, send a radiotelegraph operator qualified as a meteorological observer.

The disclosure of the news prompted a reaction from the Consul of the Republic of Honduras in Havana, who in a diplomatic note addressed to the Cuban Foreign Ministry made it known that, although some U.S. citizens were de facto occupying part of Swan, the sovereignty of the islands corresponded to the Honduran state, by virtue of which it would assert its jurisdiction (Pavlidis, 2011). This was equivalent to saying that the Cuban government was obliged to conduct any negotiations related to Swan through the Honduran government and not with the United States; and that as long as the dispute was not settled, the Cuban Meteorological Service could not place equipment or send its technical personnel, under the risk of becoming involved in an international diplomatic conflict.

Months earlier, in 1927, Millás had taken advantage of an event held at the Academy of Sciences to ask the U.S. Ambassador, Noble Brandon Judah, for his intercession to keep that station active, which was as important for Cuban meteorology as it was for the United States. References indicate that Brandon Judah included the matter in the agenda he took to President Herbert Hoover, on the occasion of a trip to Washington for consultations in mid-1928 (*El Mundo*, 1928, p. 1).

On August 16 of that year, the diplomat returned to Havana, and reporters came to wait for him to listen to his statements or comments. It should be remembered that, at that time, any statement made by the U.S. ambassador had a special political connotation that the newspapers were eager to pick up and interpret. Questioned by the reporters, Judah said first of all: "There already exists, at the expense of the United States government, a Radiotelegraph Station and Meteorological Observatory on Swan Island. This is the best news I have" (*El Mundo*, 1928, p. 1). He then explained that an official of the Department of Agriculture of his country had traveled to Swan, in order to reach an agreement on the telegraphic transmissions with the directors of Tropical Radio Corporation.

It is in keeping with historical truth to point out that the Ambassador kept his word to the Cuban Meteorological Service, acting proactively, as befitted his duties in a matter of interest to Cuba. In spite of everything, communications from Swan continued to experience interruptions; and sometimes, when it was most needed, the air was off the air. Four years later, it was business as usual, as hurricane season was upon us and Brandon Judah had been replaced in his position (*Diario de la Marina*, 1932).

This was the situation on June 11, 1932, when Professor Charles Marvin, Chief of the Weather Bureau, announced that due to the economic crisis hitting the United States, they were forced to withdraw the telegrapher and observer in Swan (*El Mundo*, 1932), thus, the hopes of the Cuban Meteorological Service were abandoned.

During the stage we are analyzing, hurricane forecasters in the United States were part of the general structure of the Weather Bureau, which prioritized inland weather systems, typical of subtropical and temperate zones; while hurricanes were considered transitory phenomena with an impact limited to the Atlantic and Gulf coasts. It was the deadly Labor Day Storm or Florida Keys hurricane that led to change this vision and to design a specific forecasting and warning system for tropical systems. On September 2, 1935, the intense hurricane swept through the island chain and southern Florida, with a death toll of half a thousand (McDonald, 1935). In response to the impact, hurricane forecasts were decentralized in four areas with their respective offices; one of them in Jacksonville, Florida.

The eyes of U.S. cyclonologists turned to focus on Cuba, faced with the need for more information from the country's observatories, equipped with instruments and personnel that, although not numerous, were competent and experienced in the field of hurricanes. All this was happening at a time when relations between Cuba and the United States were being resized after the longed-for elimination of the Platt Amendment (1934) and the signing and enforcement of the controversial Trade Reciprocity Treaty. In this context, the National Observatory increased the volume of time it dedicated to surface weather and upper air.

> Three daily cablegrams are sent by the National Observatory to Washington; four from June to November 15. A radiogram is sent to Mexico every day, including upper atmosphere data; and in case of bad weather, additional cables and telegrams are transmitted to both Mexico and Washington (Millás, 1930, pp. 186-191).

For all these reasons, it became necessary to strengthen and consolidate the data exchange system, and Professor Willis Ray Gregg, Chief of the National Weather Service of the United States, came to Havana. The U.S. Embassy made the official announcement, and the Associated Press confirmed the news:

> Miami, Florida. December 7, AP. Dr. Willis Gregg, chief of the Washington Weather Bureau, said today that on Thursday he will confer in Havana with Cuban meteorologists on the means by which specialists of both countries can assist each other in charting the course of a storm (*Diario de la Marina*, 1936a, p. 1).

The Chief of the Weather Bureau arrived in Havana on December 8, 1936, with the main objective of obtaining and systematizing the data from the Cuban meteorological and radiotelegraphic stations in the Caribbean Sea. Likewise, the United States would increase the volume of data transmitted daily. Undoubtedly, the Americans knew that Cuba operated a weather station of its own in Grand Cayman, and had others in the pipeline for the Caribbean area. Gregg offered to do what he could to keep the Swan Islands station operational, to reorganize the system for broadcasting weather messages from ships en route in the Caribbean, and to structure a "complete circuit of meteorological information" to be activated in the next hurricane season (*Diario de la Marina*, 1936b, p. 9).

At the time of the visit, the Belen College Observatory continued to focus on tropical cyclone studies and forecasting. Given the make-up of its faculty with priests and professors of Spanish origin, it was not considered an institution close to the United States. However, Father Gutiérrez-Lanza had a degree in Science from Georgetown University; and the young priest Eulogio Vázquez Vales, S.J., who then directed the meteorological observatory of the Jesuit school in Cienfuegos, had arrived in Cuba with a master's degree in Meteorology obtained at the Massachusetts Institute of Technology (MIT) (Vázquez, 1939).

Vázquez's relationship with the high scientific center led him to invite to Cuba a team of specialists, attracted by the objective of testing the new techniques of atmospheric sounding with radio-meteorographs raised by free balloons. This technique, known as radiosondes, surpassed the pilot balloons, since they were capable of transmitting from great heights and in real time, data on temperature, atmospheric pressure, and wind direction

and speed. The tests were carried out between September 19 and 20, 1938, taking the terraces of the College in Buena Vista, Marianao, as the experimental site. The experts from Belen and the North Americans from MIT participated in them, and the event goes down in history as the first time that this novel technique was applied and tested jointly in Cuba (*Diario de la Marina*, 1938, p. 12).

From War to Crisis

As is well known, World War II transformed global dynamics in every sense. When the United States entered the world conflict, Cuba was immersed in its vicissitudes, and this configured a new scenario of cooperation between the respective meteorological services. With the increase of war operations, and the commitments made by the country with respect to the doctrine of "continental defense", it became necessary to transfer the direction and personnel of the Cuban Meteorological Service to the Navy Reserve, as ordered by a presidential decree signed on May 13, 1942 (Republic of Cuba, 1942). The National Observatory and its facilities were detached from the Ministry of Agriculture, and part of its personnel enlisted in the Navy. With this, the Observatory became subject to the Cuban-US military cooperation agreements, resulting from the bilateral negotiations carried out between 1942 and February 1943 (Camacho, 1954, pp. 107-109).

With the arrival of the troops, ships and planes of the U.S. Army and Navy, the work of the observers and radio operators of the Meteorological Service multiplied under the war regime, and they now had to be permanently in tune with the radiotelegraphic stations of the Cuban Navy and the Weather Bureau centers, at preset transmission schedules.

As the war activity around Cuba was focused on the fight against German submarines, the first recipients of meteorological information were the air bases and naval posts that Cuba ceded for the training of U.S. pilots and sailors, and for the surveillance and protection missions of the coastal naval routes and towards the Panama Canal. Meanwhile, the Weather Bureau was determined to complete its network of atmospheric sounding stations on the North American continent (Weather Bureau, 1946).

During the course of these events, the now Lieutenant Commander José Carlos Millás, director of the National Observatory of the Cuban Navy, and Francis Wilton Reichelderfer (1895-1983), Chief of the Weather Bureau, maintained frequent communication focused on the exchange of meteorological information between the respective institutions. It is obvious that Millás identified the opportunity to expand the capabilities of the Cuban Service, something that the senior U.S. executive wholeheartedly supported. Among the actions planned was the transfer to Cuba of the radio probes technique and the training of Cubans in it; talks to that effect began at the end of 1943 (Higgs, 1950).

The basis of the agreement is set forth in a memorandum signed by Ambassador Spruille Braden, addressed to Jorge Mañach Robato (1898-1961), Secretary of State of the Republic of Cuba. The two diplomatic notes are dated July 17 and August 2, 1944. Let us see an excerpt from the first one:

> The American Ambassador to the Cuban Secretary of State.
>
> Embassy of United States of America.
>
> No. 632. Habana, July 17, 1944.
>
> Excellency:
>
> I have the honor to inform Your Excellency that preliminary discussions have taken place between representatives of the United States Weather Bureau, Department of Commerce, and the Cuban Meteorological Service regarding the cooperative establishment and operation of a radiosonde station in Cuba, to be located in the vicinity of Habana.
>
> Since that time, Dr. F. W. Reichelderfer, Chief of the Weather Bureau, has corresponded with Dr. José Carlos

> Millás, Director of the Cuban Meteorological Service, on the subject, and my Government is informed that as result the Weather Bureau and the Cuban Meteorological Service had agree in principle that it would be desirable for their respective governments to cooperate in the establishment and operation of the station… (U. S. Department of State, 1944, pp. 1225-1226).

In this connection, the U.S. Congress authorized the $18,240.00 required to finance the project, channeling it into the programs of the Interdepartmental Committee for Cooperation with the Republics of America. This amount would be included in the expenditures for fiscal year 1944-1945, and would finance the station and its initial logistics. In another paragraph of the document, Braden notes:

> My Government has already established a network of radiosonde observations stations in United States, the West Indies, México and the Canal Zone, y feels that establishment of a station in Cuba would fill a gap in the network. Radio probes observations are needed for the protection of military and commercial aircrafts operating in this area, and also provide advance information on destructive hurricanes that threaten civilian and military installations located in the region of the Caribbean Sea and Gulf of Mexico. (U. S. Department of State., 1944).

In response, Cuba sent an engineer to Washington for training in radio probes operation, and the Cuban Navy appointed an ad hoc representative to the Weather Bureau (Navy, 1945, pp. 5-9).

In the third quarter of 1944, the equipment for the station and the means to receive and transmit data arrived in Havana: a hundred or so radio-meteorographs, balloons, parachutes, as well as the charts and printed models for the upper air reports. In addition, the Weather Bureau undertook to make any necessary repairs and adjustments. The agreement established that the data and copies of the graphs obtained in each sounding would be sent to the offices in Miami and Washington D. C., for which purpose modern teletype machines were installed to link the National Observatory with the offices in Miami, Washington, and some meteorological centers in the continent (Higgs, 1950). Cuba and the United States would pay in equal parts the cost of the transmissions, which were carried out by the American Telegraph and Telephone Company (ATT), owner of the cables. Two specialists from the Weather Bureau traveled to Havana to prepare and advice on the installation of the station.

When this equipment was already in service, the Navy reached another agreement with the Weather Bureau, for an amount of $75,000.00, destined to set up seven "first order" meteorological stations in Cuba, equipping them with radio transmitters to link them with the National Observatory (Roselló, 1944).

After the end of the war, the Observatory received in mid-1946 new means to improve the link with the Weather Bureau headquarters, by means of a much more modern teletype circuit (Masdeu, 1946). At that stage, another station for atmospheric sounding was installed, with the new "rawin" (acronym of radio-wind) technology, which substantially improved the knowledge of the upper air; and in 1947 a similar equipment was sent to the airport of the city of Camagüey (American Embassy, Havana, 1948).

Later, in the 1950s, a WSR-1A (Weather Surveillance Radar) was transferred to Cuba, designed to operate at a wavelength of 10 centimeters, 3 gigahertz, and give a theoretical range of 150 to 240 kilometers (Millas, 1952). According to the scanty documentation available, the radar was in operational condition by the end of July 1952, but the equipment functioned more as an experimental means than as a truly useful radar for daily forecasting.

Finally, the three years between 1959 —the year of the triumph of the Revolution— and 1961, when relations between the two countries were severed, sum up this overview at the Cuba-United States links in the field of meteorology.

At the beginning of that year, exchanges between the National Observatory and the Weather Bureau continued to focus on inputs to keep the measuring equipment and aerological soundings running.

In April 1959, Clarence La Rue traveled to Cuba, the official in charge of advising on the installation of the new "rawin", model SCR-658 (Signal Corps Radiodirection-finder), previously contracted to improve the Casa Blanca

meteorological station and the Camagüey airport. The SCR-658 would come to replace the old Metox, similar, but already obsolete. On that occasion, Captain Millás, now an officer of the Revolutionary War Navy, told La Rue that "cooperation [with the United States] was 100% open" (Millas, 1959).

By that date, most of the expenditures for the Weather Bureau's cooperative programs continued to go to the radio probe service, pilot balloons, and the Havana-Miami teletypewriter circuit. The sum amounted to $ 29 198.70 (Reichelderfer, 1959a). We have before us the letter where Reichelderfer confirms to Millás having received the check for $ 16 000.00 destined to the payment of the supplies for the radio probes (Reichelderfer, 1959b).

However, the most senior official in the U.S. Weather Service who visited Cuba after the triumph of the Revolution was Dr. Gordon Dunn, Chief of the Weather Bureau Office in Miami, then called the Hurricane Warning Center (Millás, 1960), the forerunner of today's National Hurricane Center. Dunn arrived in Cuba on August 10, 1959, and stayed 48 hours in Havana. The topics of work were oriented to the exchange of data and communications, in particular the regularity and content of the information during the night hours. He worked with the Belen Observatory and the aeronautical meteorology office of the International Airport of Rancho Boyeros (today José Martí) (Millas, 1959).

It is apparent that the cooperation between the National Observatory and the Weather Bureau was not completely interrupted during the first years of the Revolution, although little by little limitations began to appear. At the beginning of 1960, the new "rawins" acquired in the United States arrived in Havana (Millas, 1960). They were the last technical means that the Cuban Meteorological Service received from the United States.

Although the blockade/embargo had not reached its extreme rigor, the strained relations between Cuba and the United States determined the cessation of all technological transfer; shipments of helium gas, radio probes and other replacement instruments and components ceased. Notwithstanding, scientists from both countries hoped to maintain cooperation based on the principle of placing science and knowledge above all else, even political reasons, but only correspondence and the exchange of meteorological data continued to flow. Trying to prioritize supplies for the radio probe service, Millás made the necessary arrangements with the Cuban Navy command, but a serious problem put an end to his intentions, when in October 1960 the U.S. Government banned exports to Cuba.

The last climatological report sent to the United States contains the accumulated rainfall in the Cuban meteorological stations in December 1960 (Ministry of the FAR, Revolutionary Navy, 1960). It is recorded that the document arrived at the Weather Bureau offices on March 6, 1961, three months after relations with Cuba were severed.

Conclusions

Meteorologists who in the 19th century and the first half of the 20th century promoted in Cuba the knowledge and development of tropical meteorology, identified the importance of cooperation with their American colleagues, and not only in terms of instruments methods and technologies, but in favor of sharing knowledge and structuring a joint way of acting in the face of phenomena potentially dangerous for society and the economy in both countries.

After the triumph of the Revolution and the emergence of a long-standing dispute between the two governments, collaboration did not stop completely. In a timely manner, scientists from the two nations have found ways to exchange results, and cooperate mainly in tropical cyclone forecasting, climate change studies, and forecasting the impacts of other phenomena of mutual interest in the environmental field.

In this regard, collaboration scenarios have been designed in international congresses, multilateral meetings at a high technical or governmental level and in the programs sponsored by the entities of the United Nations System, particularly the Intergovernmental Panel on Climate Change (IPCC).

The Cuban National Meteorological Service uses online resources hosted in U.S. sites, mainly satellites, despite the fact that some of them are forbidden or limited by the restrictions imposed by the blockade/embargo. In addition, there are many publications jointly signed by specialists from both countries; and to this must be added the participation of Cuban and U.S. academics in congresses held in the respective countries.

When the harmful economic, commercial and financial blockade ends and normalcy is restored in the Cuban-US relations, the products of collective intelligence will emerge with all their potential in order to cooperate in favor of the common knowledge and mutual benefit of our peoples.

Before concluding, the author thanks the Editorial Board of Cuadernos de Nuestra América for the initiative of this issue, dedicated to focus with multiple perspectives on the dimensions and dynamics of relations between Cuba and the United States, a topic a controversial as it is indispensable.

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