March 2024

GBON National Gap Analysis-CUBA

Systematic Observations Financing Facility

Weather and climate data for resilience

Screening of the National Gap Analysis (NGA) of Cuba

WMO Technical Authority screens the GBON National Gap Analysis to ensure consistency with the GBON regulations and provides feedback for revisions as needed. *The screening of the NGA is conducted according to the SOFF Operational Guidance Handbook, version: 04.07.2023 and the provisions in Decision 5.7 of the SOFF Steering Committee.*

Following iterations with peer advisor and beneficiary country, WMO Technical Authority confirms that the National Gap Analysis is consistent with GBON regulations. While the WMO GBON Global Gap Analysis identified the need for 2 surface stations and 1 upper air station over land to meet the GBON horizontal requirement, the **WMO Technical Authority confirms the NGA results which indicate the need for 9 surface land stations and 2 upper station based on specific national circumstances.**

Date: 31 October 2024

Signature:

Albert Fischer

Director, WIGOS Branch, Infrastructure Department, WMO

GBON National Gap Analysis Cuba

Beneficiary Country Focal Point and Institute	Celso Pazos Alberdi DG INSMET
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1. Country information from the GBON Global Gap Analysis

Table I. WMO GBON Global Gap Analysis (June 2023) for Cuba.

A. GBON horizontal resolution requirements	B. GBON Target (# of stations)	C. Reporting to req.	D. Gap to improve	E. Gap new	F. Gap total
Surface stations Horizontal resolution: 200 km SIDS: For surface station- land area+EEZ/500 km2	2	0	2	0	2
Upper-air stations over land Horizontal resolution: 500km SIDS: For upper air station- land area +EEZ/1000 km2	1	0	1	0	1

Cuba is the 8th country at the UN list of Small Island Developing Countries (SIDS) but its characteristics are far from Small Island with 109,884km^2 country surface with very long and irregular coasts including hundreds of small islands and "cayos" extending for 6073 km. The island stretched along 1200 km in a curved arc starting at the Gulf of México, bordering the Caribbean Sea and ending at the Atlantic Ocean.

Additionally to those geographical facts, Cuba territory is at a "hurricane crossroad" between three water bodies mentioned above. Adequate observation coverage for extreme weather phenomena affecting Cuba including hurricane evolution and path will improve Early Warning System for all the neighboring WMO RAIV countries, including the USA, who are at the final path of many hurricanes crossing by or near Cuba. This justify a different approach rather than considering a SIDS case. More technical details supporting this, are provided with a detailed description of the geography and climate of Cuba at Annex I.

For the sake of regulation applications and to provide equal and fair treatment for SOFF countries, the reference document is INFCOM-3/Doc. 8.1(1) updating the WIGOS Manual. There, at Chapter 3/3.2 are the rules for the Global Basic Observing Network and an alignment with Resolution 21 (Cg-19) on GBON design clarifying the small island resolutions for land surface stations

For all those climate, geographical and regulatory reasons, we are proposing to apply for Cuba GBON design the rule of 200 km as horizontal resolution for surface stations and 500 km resolution for upper-air stations. Below you can find the map with an appropriate distribution for a grid of 200Km for surface stations and 500Km for upper air stations.

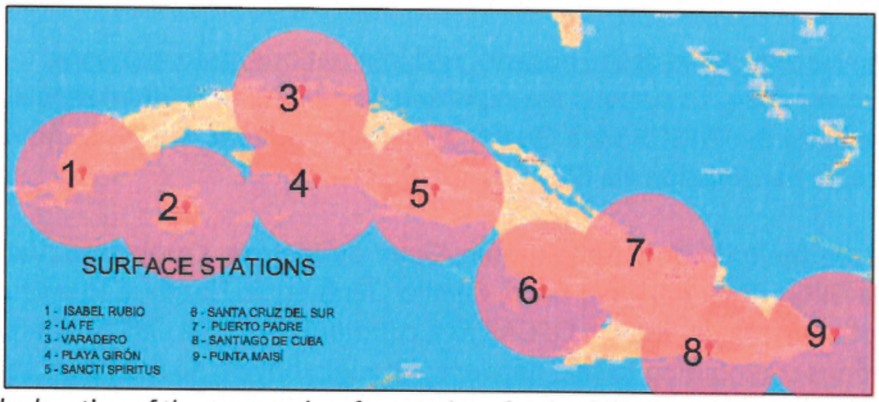


Fig.1. Map of the location of the proposed surface stations for the GBON network. 200 Km circles centered on surface stations.

Fig.2. Map of the location of the altitude stations proposed for the GBON network. 500 Km circles centered on surface stations.

2. Analysis of existing GBON stations and their status against GBON requirements

The Cuban meteorological institute (INSMET) operates and maintains 69 nationally deployed automatic meteorological stations (AWS), as well as 68 manual weather stations. 22 of these AWS are operational, 12 already report through WIS2.0. 11 of these surface stations could be included in the national GBON network under the standard density criterion of 200Km horizontal resolution. The entire infrastructure of the stations has already been financed by INSMET itself.

Table II. Assessment of existent stations per their operational status and network ownership

GBON Requirements	Existing observation stations (# of stations)			
	NMHS network		Third-party network	
	Reporting to req.	To improve	Reporting to req.	To improve
Surface land stations Standard density 200km Variables: SLP, T, H, W, P, SD	12	0	0	0
Upper-air stations operated from land Horizontal resolution: 500km Vertical resolution: 100m, up to 30 hPa Variables: T, H, W	0	0	0	0

Details on the current status of the network and international data exchange.

As of late January 2024, 12 stations are reporting data via WIS2.0 internationally, yet it is not being received into the WIGOS Data Quality Monitoring System, which has not been updated and only accepts transmission via GTS.

The stations are the following: Isabel Rubio, Guira de Melena, Casablanca, Varadero, Colón, Jaguey, Playa Girón, Trinidad, Cayo Coco, Camilo Cienfuegos, Florida, Santa Cruz del Sur. See figure 3. All of them are declared in OSCAR as a contribution to the GBON. There are therefore 12 active stations contributing to said network although they do not currently strictly meet the resolution criteria.

Of these, those highlighted in yellow have been selected to be improved within the framework of the SOFF project of the GBON network, due to their location, because they belong to the country's climate reference network and because of their appropriate spatial distribution according to the GBON criteria, together with another 5 stations to cover the entire territory of the country with the demanded horizontal resolution of 200Km.

Fig.3. Map of stations sharing data internationally via WIS2.0 as of end-January 2024. http://wis.insmet.cu/urn:x-wmo:md:cub:insmet:surface-weather-observations

Table III. Assessment of existing GBON stations per station characteristics. Station type: S: Surface, UA: Upper-Air; M: Marine; Owner of the station: NMHS or name of third-party; GBON variables: SLP: Atmospheric pressure; T: Temperature; H: Humidity; W: wind; P: Precipitation; SD: Snow depth; SST: Sea surface temperature; Reporting cycle: Number of observation reports exchanged internationally per day (0-24); GBON compliance: weather the station is GBON compliant or not (see GBON guide on compliance criteria).

Station name	Station type (S/UA)	Owner (NMHS/3rd party)	Funding source	GBON variable measured							Reporting cycle (obs/day)		GBON Compliant (Y/N)
				SLP	T	H	W	P	SD	SST			
Isabel Rubio	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Guira de Melena	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Casablanca	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Varadero	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Playa Girón	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Colón	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Cayo Coco	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Santa Cruz del Sur	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Jaguey	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Trinidad	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Camilo Cienfuegos	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Florida	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y

Remarks on the stations proposed for the GBON network

There are 2 types of surface stations proposed:

A-Conventional

They are the ones that have an asterisk in the measurements, since they are being taken manually from traditional instrumentation that does not meet the specifications described in the document "TT-GBON Operating Plan Deliverable 6.1 – GBON Tender Specifications for AWS". However, in all of them, there is the infrastructure of an automatic station that, for various reasons specified in Annex II, is not reporting data. These stations must be updated to ensure the GBON standards, and take data from this source. The Santiago de Cuba station is currently undergoing a transfer project.

B-Automatic

They are the ones with the measurements marked with a cross, since these are taken in an automated manner, based on current instrumentation that would meet the requirements of the GBON network. Although the adoption of additional measures is necessary to standardize sensors and strengthen resilience for the future of the network.

Detailed information on the status of each station can be found in Annex II.

3. Results of the GBON National Gap Analysis

Table IV. Results of the GBON national gap analysis. SLP: Atmospheric pressure; T: Temperature; H: Humidity; W: wind; P: Precipitation; SD: Snow depth; SST: Sea surface temperature. * **Exception requested**

GBON requirements	Global GBON target	GBON Compliant stations	Stations gap (*)	
			To improve	New
Surface land stations. Standard density 200 km	2	12	8	1
Upper-air stations operated from land Standard density 500 km	1	0	0	2

In the SOFF mission to Cuba carried out between January 22 and February 2, the team conducted interviews with INSMET personnel to obtain information on the current status of the observation network and international data exchanges. The existing information on the OSCAR and WIGOS pages has been analysed and the existing list of stations has been reviewed. The elements of the communications systems, personnel capacity, maintenance protocols and capacity of the existing calibration centre have also been analysed.

Four field activities have been carried out in visits to the observatories of Mariel, Santiago de las Vegas (as an example of a manually operated station), Varadero and Playa Girón. Details of the results of the visits and photos are found in Annex III.

The conclusions of the evaluation after the mission are the following.

All proposed surface and upper air stations need to address the following needs to optimize their operation and ensure the continuity of the project in the long term.

a) Sensors and data acquisition units: In conventional stations, the existing AWS must be updated, replacing damaged components and installing improved ones that meet the measurement requirements of the GBON network. In Santiago de Cuba, a complete AWS must be installed, including civil works. In automatic stations, obsolete sensors/data acquisition units that have exceeded their useful life and need to be updated to homogenize the network must be replaced. For all stations it is necessary to ensure the acquisition of spare parts in the event of breakdowns and/or future updates in the short/medium term to safeguard possible future difficulties in this regard. It is proposed to have a stock of spare parts in Havana, in a second technical centre in the eastern region and to a lesser extent in the provincial meteorological centres (PMC) that host a GBON station. At upper air stations, consumables (radiosondes, balloons, parachutes) must be financed. The country's ability to obtain supplies on a regular basis is highly vulnerable. This is a key point for the sustainability of the project.

b) Electrical supply: Most stations have a diesel-powered generator set. To save costs and given the country's fuel shortage problems, renewal and installation of solar panels and batteries in all stations is required as an additional contribution to reducing the economy's carbon footprint. The solar panels must be provisionally removed in the event of a hurricane alert, to avoid damage, which implies that the battery bank must have sufficient capacity to support the system during an episode of these magnitudes (2-3 days). It must be taken into account that for upper air stations the energy consumption of the hydrogen generator

(≈5KW) is higher. In these places, a small solar energy producing park can be installed, although it is essential to allocate a fuel fund for the generating set.

c) Lightning: It is necessary to incorporate protection in electrical panels against lightning strikes due to the high density of lightning in the area. These measures are essential to avoid the constant loss of sensors, damaged due to this cause. The incorporation of active lightning rods with greater coverage than the passive type is considered as the best option. Figure 4 shows that Cuba has one of the highest lightning densities per Km^2 in the world. Figure 5 represents the number of downloads on an active day over Cuba. The total downloads equals that registered over Spain on an active day, with Cuba being five times smaller.

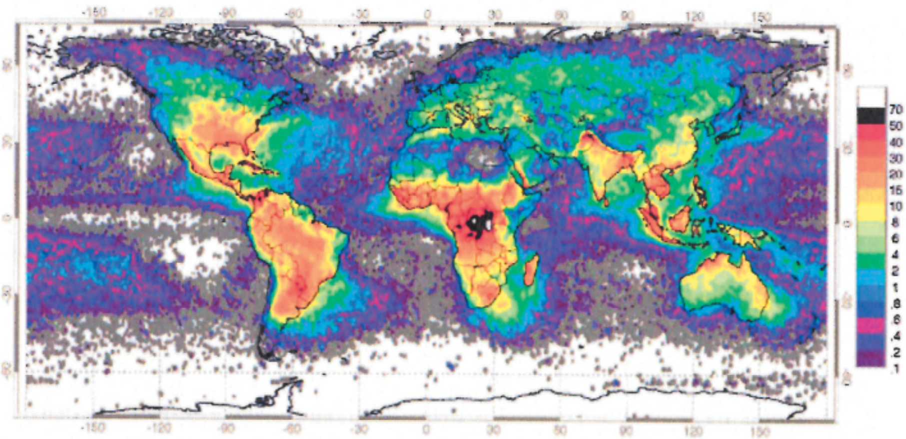


Fig.4. Global distribution of annual lightning density (lightning/km^2, period April 1995 to February 2003) with combined observations from NASA's OTD sensor (up to March 2000) and LIS sensor (since January 1998). Source: GHRCNASA

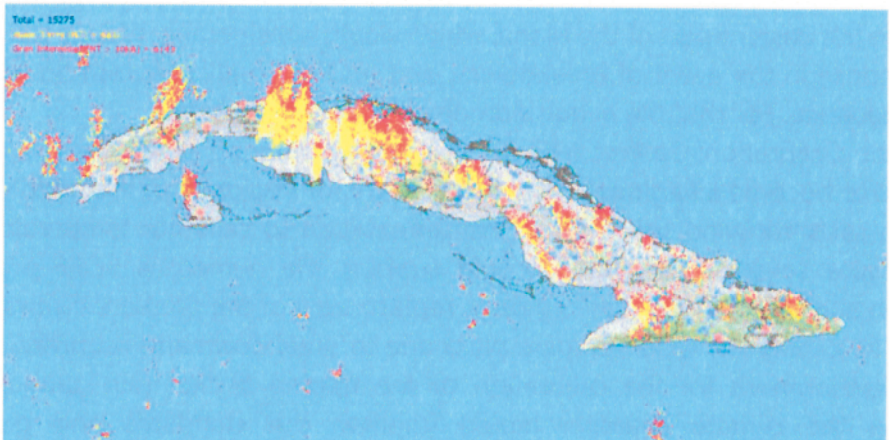


Fig.5. Map of lightning and intra-cloud discharges over Cuba on September 14, 2020. Out of a total of 15,275 recorded, there were a total of 6,143 high-intensity lightning strikes distributed over numerous points on the island.

d) Communications: In the country there is a private data network exclusive to INSMET (see Annex IV), financed by the Cuban Meteorological Institute itself. They also have personnel from the Cuban telecommunications company (ETECSA), a state agency, for the maintenance of said network. Whether through copper pair, fibre optics or VSAT, the stations: 9 (surface) + 2 (upper air) proposed, already have these communications available at the sites (In Santiago de Cuba it is in process). It is recommended to bury the final aerial section of the communications network since it has a high risk of breakdown in cases of extreme adverse phenomena, which is when data is most needed. In the country there is already an investment process so that the last mile is buried underground. Although the first option is in process, the redundancy of the communications network is essential, so the acquisition of communications interfaces via mobile telephony (3G/4G Router) or VSAT as a backup would be convenient. Financing of communication transmission costs is not necessary. INSMET has a private access point on the telecommunications company's own 3G/4G network, all of these expenses are self-financed. It would only be necessary to update the AWS hardware.

e) Infrastructure: The proposed stations are located at sites where buildings owned by INSMET already exist, where communications rooms, energy, warehouses, personnel rooms, etc. are located. The construction of facilities to carry out radiosondes is required, in particular, the sheds to house the hydrogen generators and inflate the balloons. The calibration of the radiosondes could be carried out in the facilities of the Meteorological Centres and the reception equipment installed there. The possibility of allocating a fund for small repairs, building maintenance and guaranteeing the survival of personnel in the event of damage from extreme phenomena is considered.

f) Maintenance: There are INSMET personnel on site up to 24 hours/day at the stations, who apart from carrying out daily preventive maintenance, also carry out manual synoptic observation every 3 hours providing complementary data on visibility, clouds, etc... In addition to other tasks depending of the location. These personnel provide support to specialist technicians as a first step and immediate response by carrying out basic checks in the event of failure. Even so, it is necessary to send expert specialists in cases of serious damage, new implementations or calibrations. That is why it is necessary to establish a mechanism that ensures the supply of fuel to travel to stations that are at distances of up to 1000km from Havana. It is proposed to establish a second technical centre to cover the stations in the eastern part of the island, which would considerably reduce the distance and time response in the event of breakdowns, and also the fuel consumption when traveling for maintenance. For this, the acquisition of vehicles is necessary.

g) Instrument Calibration Centre: INSMET has an instrument calibration centre and is a candidate to become a Regional Calibration Centre for Region IV of the WMO. It has a wind tunnel to calibrate wind sensors and instrumentation to calibrate temperature, humidity and pressure sensors. This centre could support the numerous SOFF projects in the Caribbean and Central American region. A replacement of the pressure calibrator would be required as it currently requires spare parts due to breakdown and is unreliable. To have a simple development for the calibration of the tipping bucket rain gauges, as well as improving the climate chamber would improve the standards and guarantee the traceability. The instrument management system complies with ISO 17025.

h) Server room: The equipment involved in communications has reached its period of technological obsolescence. It would be advisable to update it, as well as the air conditioning of said room and the acquisition of UPSs.

3.1 Recommended existing surface, upper-air and marine stations to be designated to GBON.

Table V. Recommended existing surface, upper-air and marine stations to be designated to GBON.

Station name	Station type (S/UA)
Mariel	UA
Camagúey	UA
Isabel Rubio	S
La Fe	S
Varadero	S
Playa Girón	S
Sancti Spíritus	S
Santa Cruz del Sur	S
Puerto Padre	S
Santiago de Cuba	S
Punta Maisí	S

The main feature of the proposed observatories is that they are all operated by INSMET. There is a high number of possible users of the information at the level of sectors such as port management, pollution monitoring, tourism sector and agricultural production. These sectors will be invited to validate the national contribution plan to the GBON, which is expected to be carried out next June.

The strength of the proposal for the SOFF project in Cuba is that the sites are owned by INSMET, they are all equipped with support personnel and close or very close to Territorial Meteorological Centres that can provide support at the first level of maintenance. The exception is the Santiago de Cuba observatory, where the automatic meteorological station with its corresponding security and transmission system would first be installed and then the Provincial Meteorological Centre would be moved to that location.

The planned radiosonde stations have electricity, security, nearby buildings and sufficient terrain for launching balloons. It would only be necessary to create a small building to house the hydrogen generator and the safe inflation of the balloons.

Another strength is the technical level of the INSMET staff in maintenance issues, with the additional bonus of the existence of the Calibration Laboratory and the willingness expressed by the INSMET management to support Region IV as a Regional Calibration Centre under technical coverage of the WMO.

For all these reasons, taking into account the particularity of the island's extension in length of more than 1200 km and the enormous inequalities in width, ranging between 40 and 150 km, the existence of numerous capes and entrances into the sea, and diverse topology, the distribution of stations by square meters of the country's total surface is not applicable to Cuba. With the proposed distribution of 9 surface stations and 2 radiosonde stations, it is considered that the minimum requirements of the GBON are met.

The distance between stations ranges between 150 and 200 Km. Removing one or two stations would lead to the appearance of areas in which the nearest station would be more than 200 Km away of the nearest one. Furthermore, all the proposed stations are located in areas that are very sensitive to the passage of distant or nearby hurricanes, so this network, well maintained, can be of capital importance in monitoring the development and trajectory of hurricanes using numerical models. All this measures would reinforce the activities being carried out at the INSMET and would also improve the visibility of the INSMET in front of national and international partners.

Fig.6. Visit to the Varadero station of the GBON network proposed for improvement. INSMET-AEMET joint team.

4. Report completion signatures

Peer Advisor signature

□ □
□ □
□

Ministerio para la Transición Ecológica
Dirección de Planificación, Estrategia y Desarrollo Comercial
Área de Relaciones Internacionales
Agencia Estatal de Meteorología

SIGNED: JOSE LUIS [illegible]
30 - April - 2024

WMO Technical Authority screening signature
Beneficiary Country signature Ministerio de Ciencia Tecnología y Medio Amb... Dr. Celso Pazos Alberdi Director General INSMET CI: 60111404761

Annex 1 – Geography and climatology of Cuba

Cuban geography

The Cuban archipelago is made up of the island of Cuba, the Isle of Youth and numerous islets and cays, with a total area of 109,884 km2. Its coasts are very irregular and extend for 6073 km, where more than 280 beaches are located. From the political-administrative point of view, the Republic of Cuba is divided into 15 provinces and 168 municipalities, including the Isla de la Juventud Special Municipality. There are mountain massifs distributed throughout the island, alternating with plains and marshes, highlighting the Sierra Maestra in the east crowning the 1974-metre-high peak Real del Turquino.

Cuba lies to the west of the North Atlantic, to the north is the Straits of Florida and the Old Channel of the Bahamas; to the east, the Paso de los Vientos; to the south, the Strait of Columbus and the Caribbean Sea and to the west, the Yucatan Channel. The island of Cuba makes up most of the territory of the Cuban state. It stretches 1250 km across, 191 km at its widest point and 31 km at its narrowest point. The largest island of the Cuban state, outside of it, is the Isle of Youth to the southwest, with an area of 2,204 km^2 (327 km of coastline). The nearest territories are: The Bahamas (Cayo Lobos) at 22.5 km, Haiti at 78 km, Jamaica at 148 km, United States (Key West) at 150 km, and Mexico at 210 km.

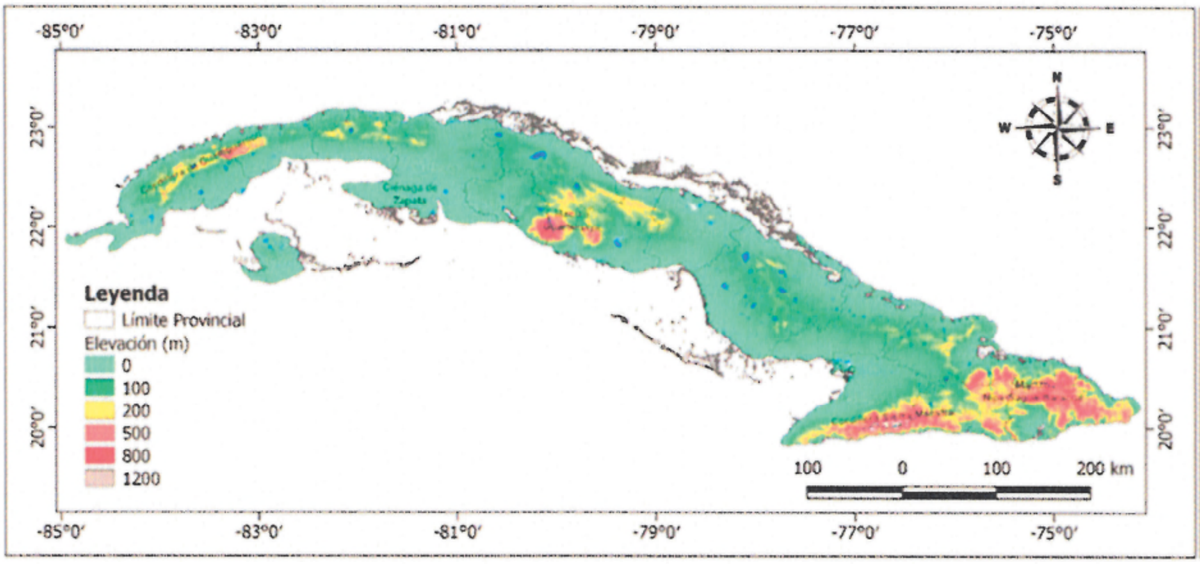


Figure 1. Cuban orography. Source: IPF, INSMET y ASTER Global DEM (ASTER GDEM) versión 3 2019

Cuban climate. General characteristics

The climate is defined as tropical, seasonally humid, with maritime influence and features of semi-continentality (Iniguez and Mateo, 1980). The average annual air temperature varies from 26 °C in the plains to 24 °C in the mountainous areas. Records of the average maximum temperature fluctuate between 27 °C and 32 °C, and the average minimum temperature between 17 °C and 23 °C (Insmet, 2018) with notable differences between the eastern and western provinces due to the great extension in length of the country. The average annual rainfall is 1335 mm (INRH, 2016) with notable geographical differences due to the orography. Climate and weather extremes, including drought processes, heavy rainfall and tropical cyclones, play a defining role in the country's climatic characteristics and in the influence of climate on the development of natural and human ecosystems established in the national territory.

Tropical cyclones and local severe storms are the weather events associated with one of the greatest disaster hazards, and are responsible for some of the observed climate extremes, most notably heavy rainfall, large rainfall accumulations and flooding of coastal areas. The hurricane season runs from June 1 to November 30, and in it, the September-October two-month period is the one with the highest number of intense hurricanes.

In recent years, important changes have been observed in Cuba's climate, which have been influencing the climatic characteristics described above. The greatest evidence is the increase in the average annual temperature, conditioned by the increase in the minimum temperature; the decrease in cloud cover; more intense and prolonged, but less frequent, droughts; increase in rainfall greater than 50 mm; and a greater anticyclonic influence.

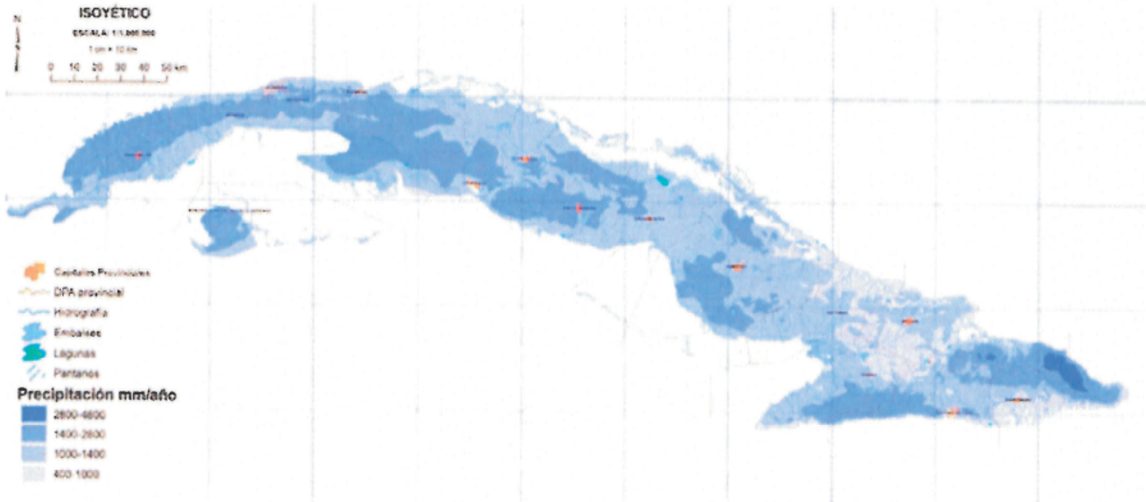


Figure 2. Annual rainfall distribution for Cuba in four cathegories. Source INSMET.

It is important to note that the island is located on the border between the tropical and extratropical circulation zones, receiving the influence of both seasonally. In the season that runs approximately from November to April, the variations in weather and climate become more noticeable, with abrupt changes in the daily weather, associated with the passage of frontal systems, the anticyclonic influence of continental origin and extratropical low pressure centers.

Since 1899, institutional meteorological stations began to be established in our country. The first seven stations were located in Havana, Matanzas (both on the north coast), Cienfuegos and Santiago de Cuba (on the south coast), and Pinar del Río, Santa Clara and Camagüey in the interior of the territory. These stations were established by the United States Bureau of Meteorological Observations and later assimilated by the Cuban Bureau of Meteorological Observations. In 1908 the National Observatory of Cuba was created, which took over the aforementioned office. However, in 1959 there were only 11 stations, mainly coastal, whose purpose was to provide informational support for hurricane forecasting. Since then, the country's meteorological service has been strengthened, and the number of meteorological stations has increased significantly, as well as their instruments and the training of the observers who worked at the stations. Since then, the country's meteorological service has been strengthened, and the number of meteorological stations has increased significantly, as well as their instruments and the training of the observers who worked at the stations. There are currently 68 weather stations in operation.

<u>Annex II. Detail of the status and needs of the stations.</u>

Station name	Station type (S/UA)	Owner (NMHS/3rd party)	Funding source	GBON variable measured							Reporting cycle (obs/day)		GBON Compliant (Y/N)
				SLP	T	H	W	P	SD	SST			
Camagúey	UA	NMHS	Cuba INSMET	-	-	-	-	-			-	-	N
Mariel	UA	NMHS	Cuba INSMET	-	-	-	-	-			-	-	N
Isabel Rubio	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Santa Fe	S	NMHS	Cuba INSMET	*	*	*	*	*			3h	8obs/day	N
Varadero	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Playa Girón	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Sancti Spíritus	S	NMHS	Cuba INSMET	*	*	*	*	*			3h	8obs/day	N
Santa Cruz del Sur	S	NMHS	Cuba INSMET	X	X	X	X	X			10min	144obs/day	Y
Puerto Padre	S	NMHS	Cuba INSMET	*	*	*	*	*			3h	8obs/day	N
Santiago de Cuba	S	NMHS	Cuba INSMET	*	*	*	*	*			3h	8obs/day	N
Punta Maisí	S	NMHS	Cuba INSMET	*	*	*	*	*			3h	8obs/day	N

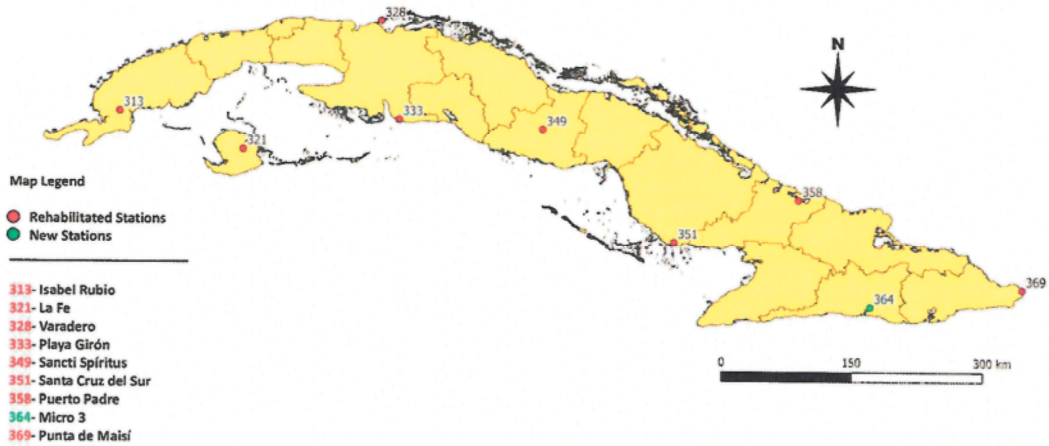


Fig.1. Map of the location of the proposed surface stations for the GBON network.

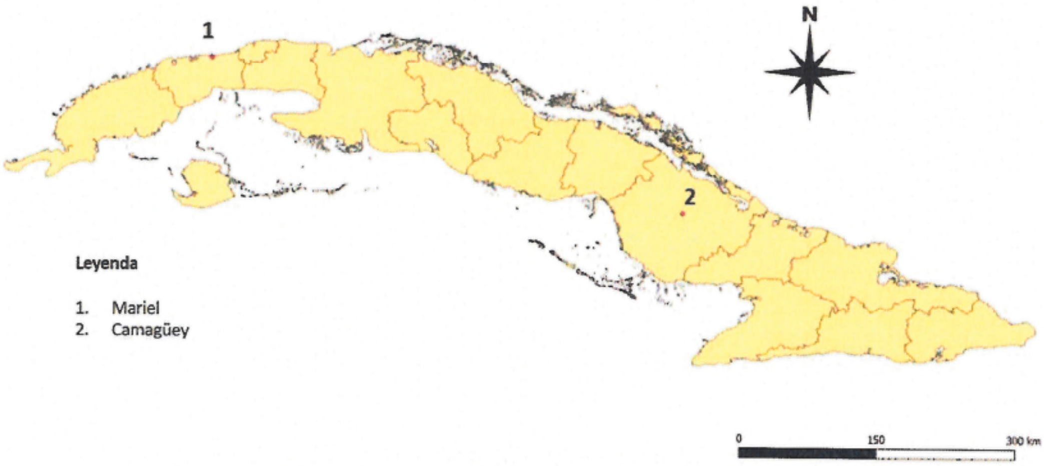


Fig.2. Map of the location of the proposed upper air stations for the GBON network.

Table I. General Data

General Data				
PROVINCIAS	**ID**	**Station Name**	**AWS install date**	**Measurement type**
Pinar del Río	78313	Isabel Rubio	2012	Automatic
Artemisa	78156	Mariel	2021	Automatic
Matanzas	78328	Varadero	2002	Automatic
Matanzas	78333	Playa Girón	2002	Automatic
Sancti Spiritus	78349	Sancti Spiritus	2002	Automatic
Ciego de Avila	78339	Cayo Coco	2023	Automatic
Camagüey	78351	Santa Cruz del Sur	2012	Automatic

Las Tunas	78358	Puerto Padre	2002	Manual
Santiago de Cuba	78364	Micro 3	-	Manual
Guantánamo	78369	Maisí	2002	Manual
Isla de la Juventud	78324	Punta del Este	2002	Manual

Table II. Equipment

Station Name	Equipment											
	Datalogger		Presure Sensor		Temperature and humidity Sensor		Wind speed Sensor		Wind direction Sensor		Pluviometer	
	State	Needs	State	Needs	State	Needs	State	Needs	State	Needs	State	Needs
Isabel Rubio	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement
Mariel	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement
Varadero	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement
Playa Girón	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement
Sancti Spiritus	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement
Cayo Coco	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement
Santa Cruz del Sur	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement	Operational	Replacement
Puerto Padre	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement
Micro 3	Planning	Assembly	Planning	Assembly	Planning	Assembly	Planning	Assembly	Planning	Assembly	Planning	Assembly
Maisí	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement
Punta del Este	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement	No operational	Replacement

Station labelled as Micro 3 is Santiago de Cuba new site

Table III. Support Systems

STATIONS	Comunications		Personnel	Infraestructure			Power supply			
	Comunications Support		Asociated staff	Wind pole for AWS		System Earth Ground Connection	Generator Group		Solar power system	
	Current	Coberage 3G/4G		Existence	State	Existence	Existence	Maintenance Needs	Existence	Replacements
Isabel Rubio	Twisted pair cable - ADSL	Yes	Yes	Yes	Maintenance need	No	Yes	Yes	Yes	Yes
Mariel	Fiber Optic - ADSL	Yes	Yes	Yes	Maintenance need	No	Yes	Yes	Yes	Yes
Varadero	Fiber Optic - ADSL	Yes	Yes	Yes	Maintenance need	No	Yes	Yes	Yes	Yes
Playa Girón	Fiber Optic - ADSL	Yes	Yes	Yes	End of useful life	No	Yes	Yes	Yes	Yes
Sancti Spiritus	Twisted pair cable - ADSL	Yes	Yes	Yes	End of useful life	No	Yes	Yes	Yes	Yes
Cayo Coco	Twisted pair cable - ADSL	Yes	Yes	Yes	Maintenance need	No	Yes	Yes	Yes	Yes
Santa Cruz del Sur	Twisted pair cable - ADSL	Yes	Yes	Yes	Maintenance need	No	Yes	Yes	Yes	Yes
Puerto Padre	Twisted pair cable - ADSL	Yes	Yes	Yes	End of useful life	No	Yes	Yes	Yes	Yes
Micro 3	Twisted pair cable - ADSL	Yes	Yes	No		No	No	Yes	No	Yes
Maisí	Fiber Optic - ADSL	Yes	Yes	Yes	End of useful life	No	Yes	Yes	Yes	Yes
Punta del Este	Fiber Optic - ADSL	Yes	Yes	Yes	End of useful life	No	Yes	Yes	Yes	Yes

Station labelled as Micro 3 is Santiago de Cuba new site

Annex III. Pictures reporting INSMET facilities and observatories

La Habana – Casablanca – INSMET HQ

Opening session at INSMET HQ with Dr. Celso Pazos INSMET Director, technical staff and AEMET SOFF mission team. Calibration Laboratory. Pressure sensor calibrator. HQ INSMET

Datalogger y field box AWS Habana-Casablanca

Stándar double tipping bucket raingauge at INSMET AWS network

Mariel – Province Meteorological Center (PMC) and new AWS proposed for GBON

Panorama: meteorological observation park and PMC Artemisa province building in Mariel. Wide and clear area for radiosonde balloons operation.

Picture at the top of PMC Artemisa with staff and team INSMET-AEMET. At the background, the AWS mast with wind sensor could be seen. This new AWS is proposed for GBON network

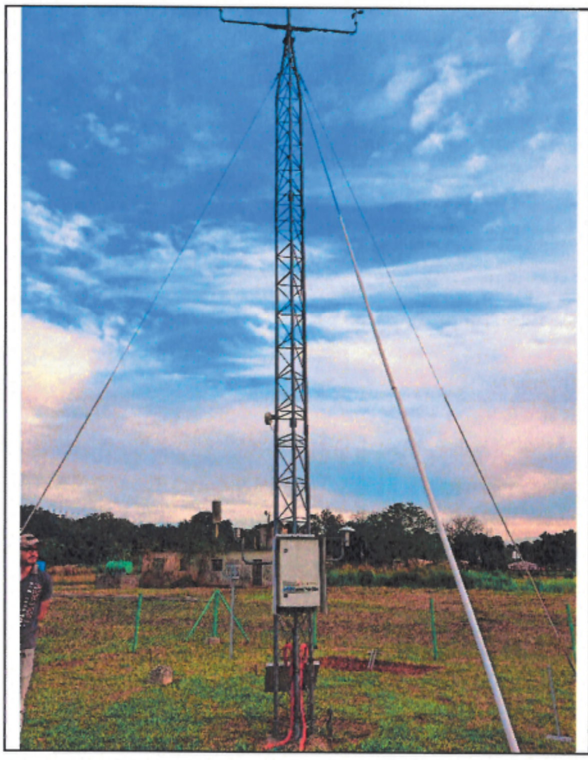
Meteorological garden with EMA Mariel. Solar panels and batteries are working. No conventional instruments since the beginning. A pollution measurement station is operating inside the park. There are room enough to host other instruments from external research or operational networks.

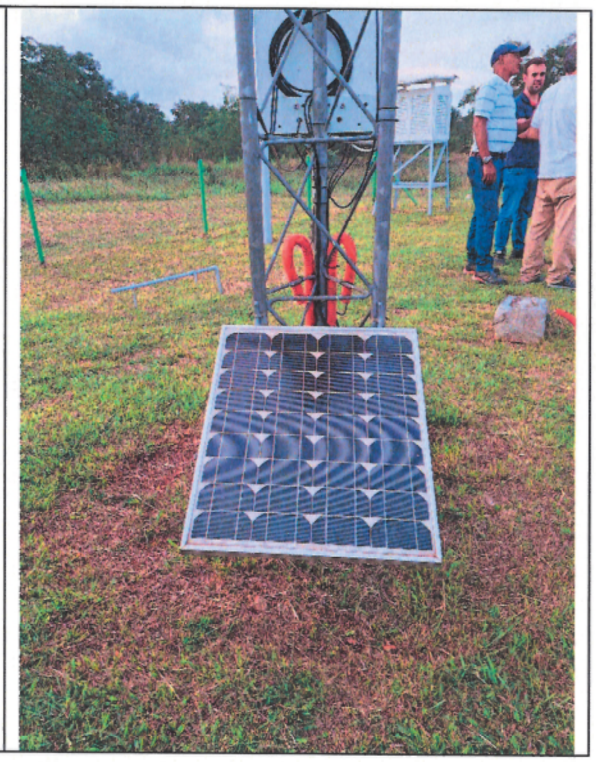
 

Thies TH sensor with radiation shield.

Tipping bucket raingauge (Inside details at Casablanca pictures)

Santiago de las Vegas – A typical observation station mixing conventional and automatic practices at INSMET observation network.





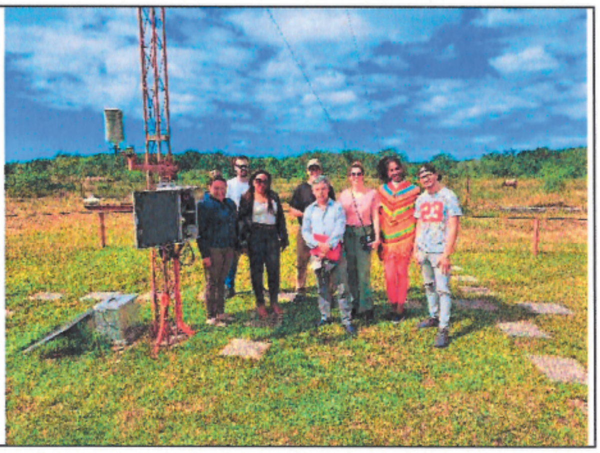
AWS estándar at INSMET

Solar panel for data taking and communications. A wifi device connects datalogger with router placed at the Observatory building.

Data logger and communications field box

Director PMC Artemisa, Observatory staff and CHF evaluator from AEMET

Playa Girón – A present GBON station proposed for improvement



Observatory Playa Girón with old anemocinemograph Dines tower. The building hosts communication equipment and staff. No conventional observations are made but staff keeps working AWS providing maintenance and deliver information to external users

Meteorlogical garden, AWS, Director PMC Matanzas, Observatory staff and team INSMET-AEMET

Datalogger, communication equipment, TH sensor and Observatory building at the background. Metallic elements such as towers and sensors arms need to be marine air corrosion proof.

Solar panel for datalogger and communications power supply.

PMC Matanzas

Visit to PMC Matanzas from where Varadero and Playa Girón Observatories are managed

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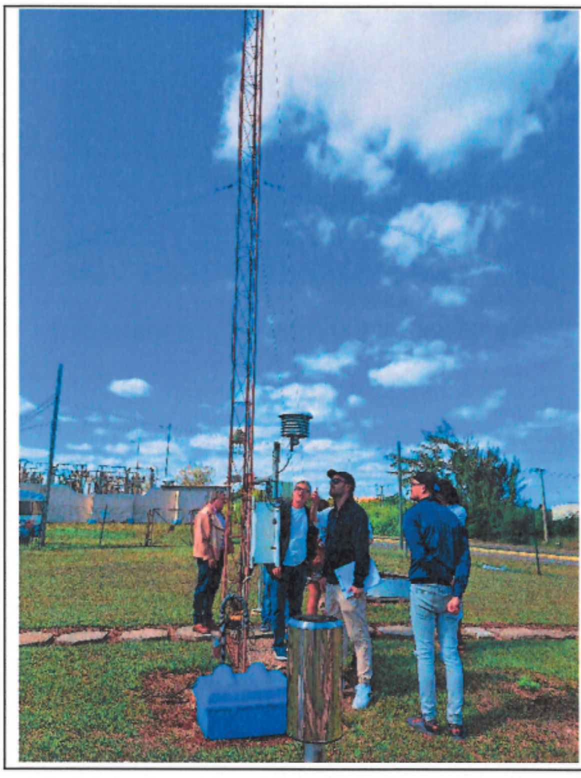
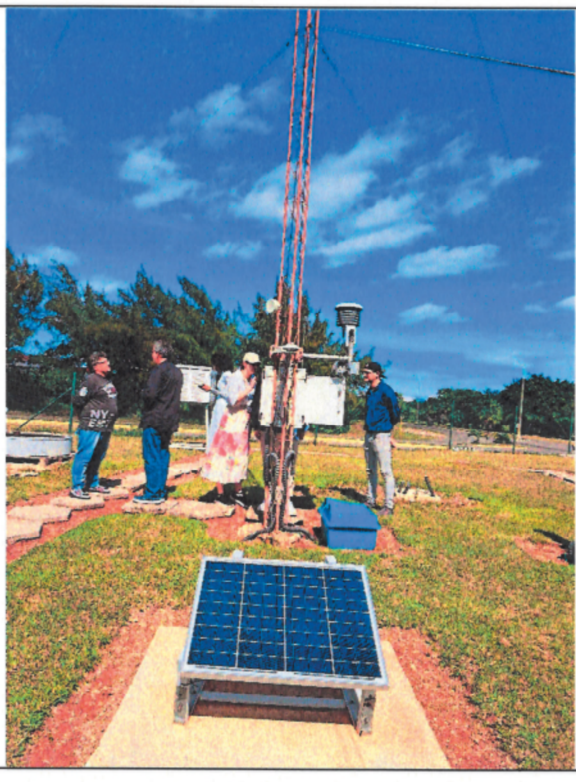
Varadero – A present GBON station proposed for improvement

Panorama: meteorological observation park and Observatory building. 50 meters away from the coastline


Observatory building as seen from the AWS. Top left could be seen the WIFI directional antenna to ensure the link of the datalogger with the router in the observatory.

The observatory has an EMA but also conventional equipment that is being discontinued in use. INSMET is committed to the full automation of the observation network. Director of INSMET, Dr. Celso Pazos and Director of PMC Matanzas.

AWS sensors configuration and battery box.

Another view of the EMA including the solar panel

ANNEX IV -COMMUNICATIONS

The communications of the INSMET, from the automatic meteorological stations (AWS) follow a very similar pattern in all of them, to try to secure the data in the face of the passage of hurricanes it uses two different ways:

1. From the sensors that measure the meteorological variables, the information is sent to a datalogger (fig.2) and this through WIFI (fig.3), sends the information to the observer's office a few meters away and from there using the private data network to the central node according to the experience of the INSMET technical team, this system is solid and does not give failures. This subsystem is generally in good condition and only needs occasional improvements.
2. From the sensors that measure the meteorological variables, the information is sent to a datalogger and this through a 2G, 3G or 4G modem, sends the information to the central node, using the private access point to the 2G, 3G or 4G network of the telecommunications company. This subsystem is in good condition and only needs occasional improvements.

The communications support on which the INSMET VPN is installed, from the observer's office to the central node, follows a very similar pattern in all of them.

1. Through the telecommunications company's physical fiber optic
2. Copper wire and twisted pair cable
3. VSAT in more remote locations.

This part of the communications is in charge of ETECSA, the Cuban Telecommunications Company.

Note: it should be noted that the network is buried for most of the route but in the last mile it goes through poles that are susceptible to falling in the passage of hurricanes

Once the data is in the central node, they only disseminate their data through WIS 2.0; According to INSMET technicians, it is currently not transmitted or received by GTS, due to some problem in the RTH in Washington, causing problems with the flow of information to and from Cuba of the meteorological information that is used to feed global models.

The processing of the data in the central node of INSMET for dissemination is as follows:

1. A BUFR file is created in sets of all our stations.
2. That BUFR file is uploaded (following a specific path and name format) to an S3 server created using Minio.
3. Wis2box then creates a separate BUFR file for each station from the original and through the MQTT service inside it sends a publication for each station file with a download link from our server of that file.
4. The global caches subscribed to our MQTT posts then download those files, cloning the same structure of our post, and then send their own post with respect to our data by changing the download links to the files that were cloned in the cache to be for global use.
5. Anyone who subscribes to the topic of global Cuba through any of the services offered for it then receives the notification issued by the global cache and can download the data if they wish.

This entire subsystem of processors and servers can be renewed at the end of the useful life of these components (fig. 4).

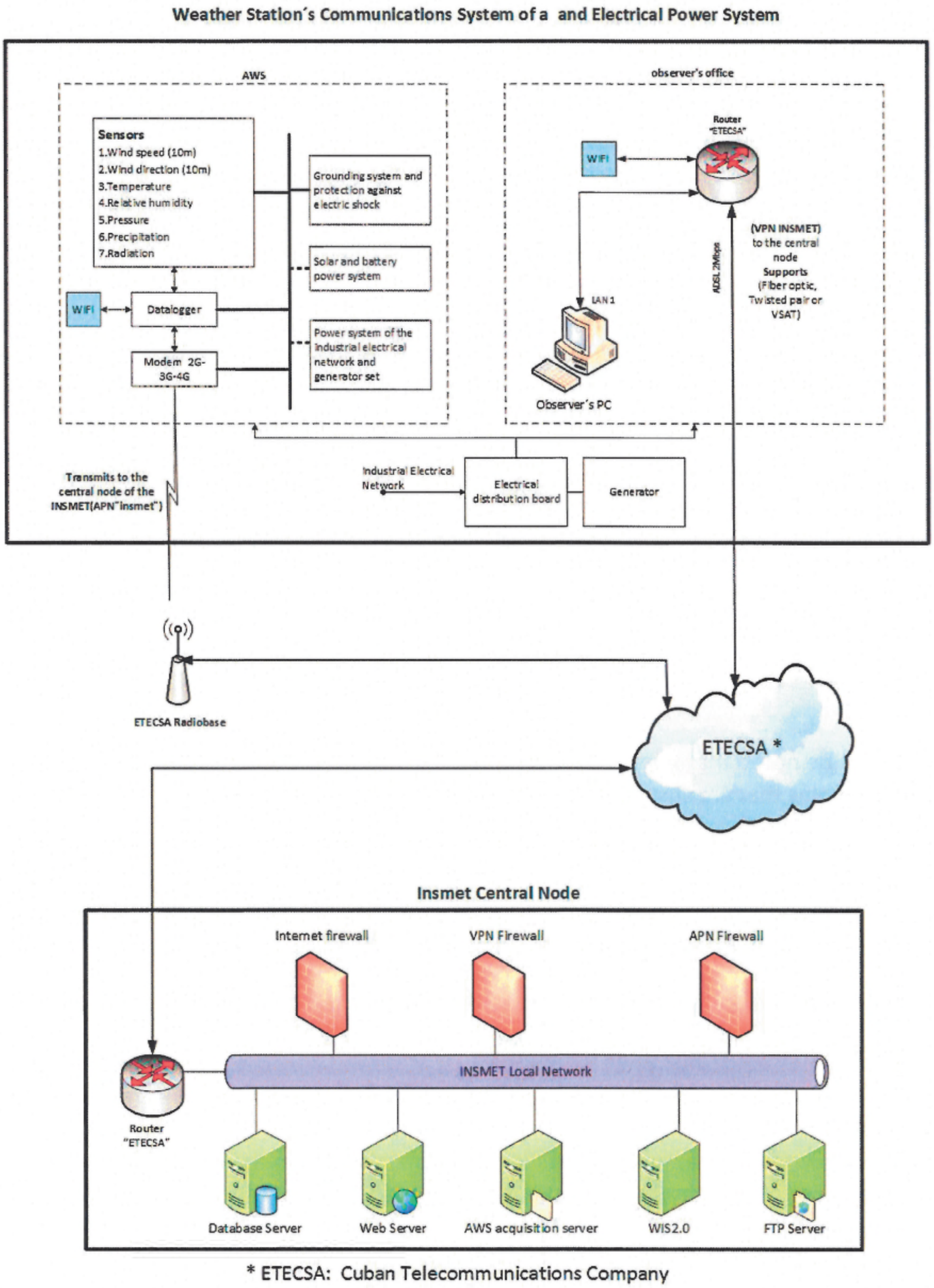


fig.1 global telecommunications scheme

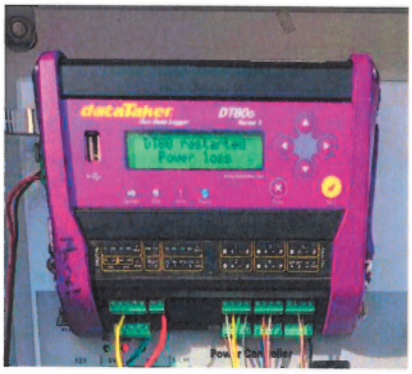


fig. 2 Datalogger

fig. 3 Wifi antenna

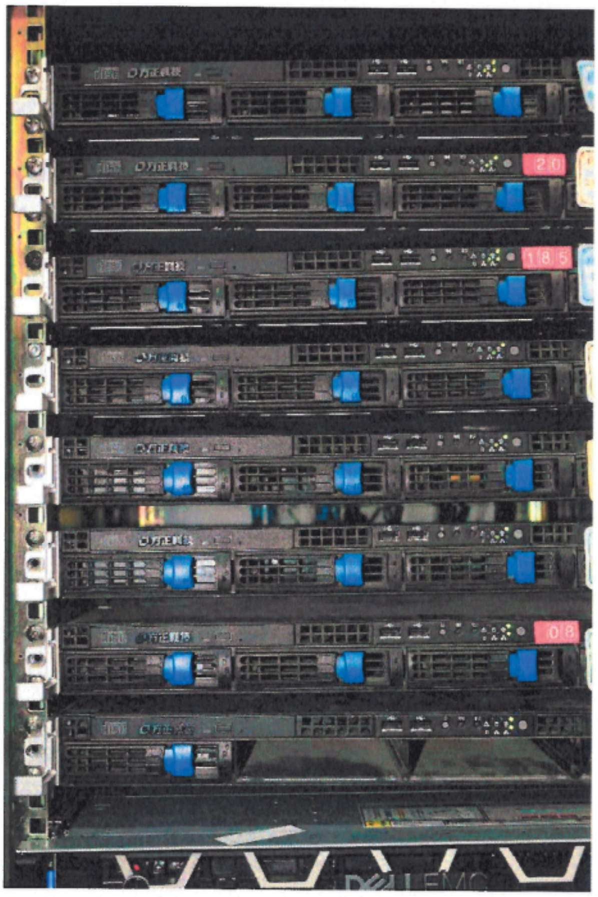


fig. 4 Servers

ANNEX V- POWER SUPPLY AND ELECTRICAL PROTECTIONS

POWER SUPPLY

The automatic weather stations are all powered by the industrial electricity grid, but they are backed up by an uninterruptible power supply system, consisting of 50W solar panels (fig. 1) and batteries (fig. 2) that would ensure communications for a short time and in the event that the power outage is longer, there are diesel electric generators (fig. 3) that consume around 6 l/h with tanks (fig. 4) of 1500 liters that ensure the power supply for several days.

The system is generally in good condition, but the capacity of the solar panels and batteries would need to be expanded.

fig. 1 Solar panel

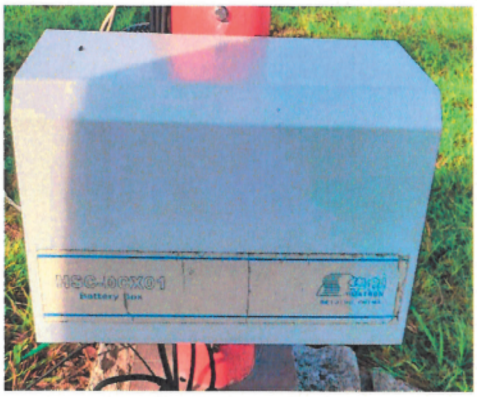


fig.2 Battery

fig.3 Diesel electric generator

fig.4 Diesel tank

ELECTRICAL PROTECTIONS

Due to the high density of lightning strikes over Cuba, all AWSs are protected in the first instance by a lightning rod system that can be active or passive (fig.5), together with a lightning counter (fig.6) and secondly with earth leakage protection (fig.7).

The protection system in general is good, but the lightning rod system and protection components should be improved

fig. 5 Lightning rod

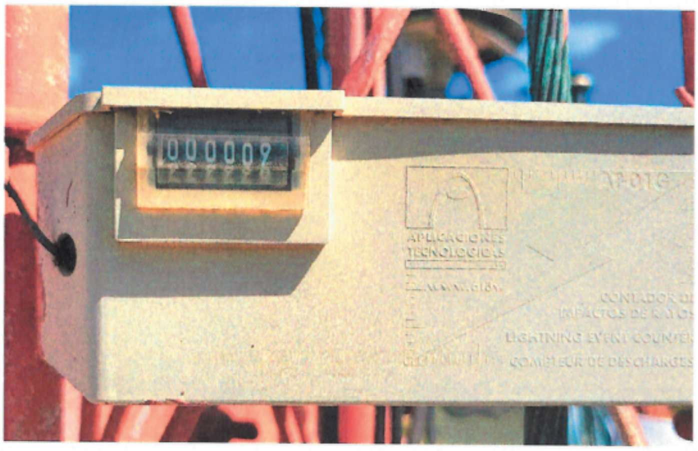


fig.6 Lightning counter

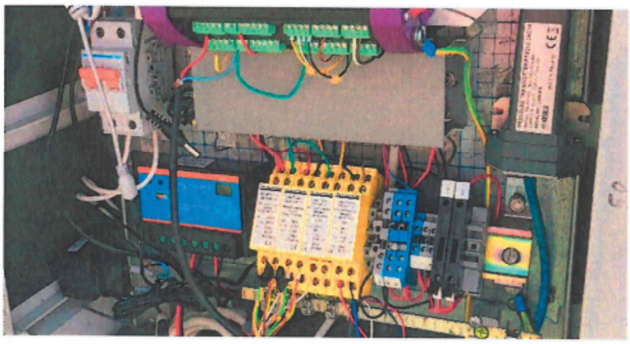


fig.7 Earth leakage protection