(September 30th) 2024

GBON National Contribution Plan of (*Republic of Cuba*)

Systematic Observations Financing Facility

Weather and climate data for resilience

GBON National Contribution Plan
[Republic of Cuba]

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Module 1. National Target toward GBON Compliance

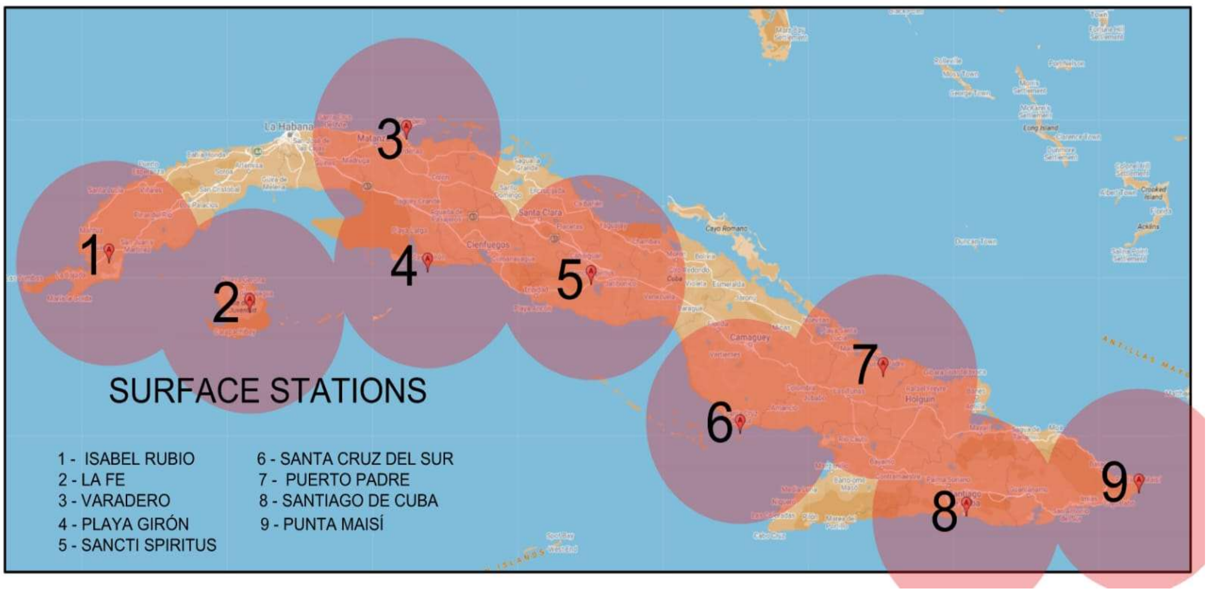
(Summarize the national target toward GBON compliance in the table below and provide the technical details as needed)

Table 1. GBON National Contribution Target

Type of station	WMO GBON Global Gap Analysis, June 2023				GBON National Contribution Target	
	Target	Reporting	Gap		To improve	New
			To improve	New		
	[# of stations]				[# of stations]	
Surface	2	12	2	0	8	1
Upper-air	1	0	1	0	0	2
Marine	***when applicable**					

(Add here a map of existing and proposed surface and upper-air stations with 200km/500 (**diameter**) km circles (500km/1000 km for SIDS) to indicate the coverage of the stations and provide the explanation as needed [1])

Figure 1. Map of existing and proposed surface and upper-air stations. Please use horizontal resolution as diameter = radius is half the horizontal resolution.




UPPER-AIR STATIONS
1.- MARIEL
2.- CAMAGÜEY
Radius 250 Km
1 x
2 x
23°09'32.8"N 81°13'50.9"W
22°08'53.9"N 84°06'51.8"W
22°04'16.0"N 81°01'55.9"W
21°33'45.0"N 82°33'27.7"W
22°32'19.0"N 78°22'04.0"W
21°44'21.8"N 79°13'57.0"W
21°12'32.0"N 76°36'58.0"W
20°44'13.9"N 78°00'01.8"W
20°00'00.1"N 75°46'28.1"W
Matanzas
Sagua la Grande
Santa Clara
Artemisa
Viñales
San Cristóbal
Parque Nacional Ciénaga de Zapata
Nueva Gerona
Trinidad
Cuba
Camagüey
Holguín
Banes
Moa
Bayamo
Manzanillo
Islas Caimán
Rokers Point Settlement
George Town
Clarence Town
Google

Module 2. GBON Business Model and Institutional Development

Currently it is very expensive to provide meteorological services. Even if it is of optimal quality, a service does not generate economic and social value unless users benefit from the decisions they make with the information provided by it.

In this sense, the generation of benefits from meteorological services can be described as a value chain that links the production and provision of services with the decisions of users and the results and values that are obtained as a consequence of these decisions.

2.1. Assessment of national governmental and private organizations of relevance for the operation and maintenance of GBON

INSMET is the Cuban governmental institution in charge of providing authorized, reliable and updated meteorological and climatological information on the present and future behavior of the atmosphere, which is aimed at ensuring the safety of human life and reducing the losses of material assets due to natural disasters of meteorological origin, contributing directly to the well-being of the community and sustainable socioeconomic development.

By identifying the main institutions in charge of providing and operating meteorological observation data, we see that they are divided into two potential groups for analysis, these will be governmental institutions and private sector operators.

In the case of governmental institutions, in Cuba there are, in addition to INSMET, two institutions that manage hydrometeorological networks, the Institute of Hydraulic Resources (INRH), which manages the hydrological observation network, and the Institute of Civil Aeronautics of Cuba (IACC), which manages the network of meteorological stations installed at airports, with both institutions interested in carrying out the implementation of the stations included in the SOFF project for Cuba, to improve their products and services derived from its meteorological data.

In the case of private sector operators, there is currently no information available on equipment installed by private institutions and there is no procedure to validate the measurements of such equipment if available in said sector, as well as the use of this information.

There is a group of experts on climate change and sustainable development, which provides scientific recommendations to INSMET, made up from specialists of the institution itself, as well as others belonging to the Ministry of Public Health, the Ministry of Agriculture, the IACC, the Agency for Environment, the Institute of Tropical Geography, the Institute of Geophysics and Astronomy and the University of Havana, which encourages not only the continuous improvement of the services provided, but also their quality, as well as mutual exchange.

The implementation of this project would provide the possibility of considerably improving weather and climate forecasts, due to the progressive improvement of global models as more countries join this initiative. INSMET would also take advantage of this to expand its portfolio of services and strengthen existing links with national sectors that traditionally benefit from meteorological data services and encourage the inclusion of new economic actors in said catalogue.

Among the institutions that have traditionally benefited from the use of meteorological data services are:

1. National Civil Defense Staff.
2. Ministry of Agriculture.
    - ✓ Institute of Pastures and Forages.
    - ✓ Grain Institute.
    - ✓ Ranger Corps.
3. Ministry of Public Health.
4. Ministry of Energy and Mines.
    - ✓ Electrical Union
5. Ministry of Transportation.
6. Cuban Telecommunications Company (ETECSA)

It is convenient to implement the WIGOS program at a national level to systematize collaboration between the institutions that manage the observation networks.

Exploring the possibility of incorporating private sector operators into the project, through MSMEs (Micro, small and medium-sized enterprises and voluntary observers), especially small farmers, will undoubtedly mark one of the challenges of this project. In this sense, INSMET can provide useful and updated meteorological and climatological information for their daily work, as well as advise on the acquisition of meteorological equipment for this sector, while MSMEs and TCPs (Self-employed workers) can provide support in software development and the acquisition of spare parts, as well as providing data to INSMET.

On the other hand, with the gradual improvement and updating of the calibration laboratory, it is intended to restart the provision of services to national and international entities and individuals interested in calibrating and repairing instruments in the variables measured in GBON. To make the laboratory viable and sustainable, investments must be made.

2.2. Assessment of potential GBON sub-regional collaboration

INSMET has a long tradition of collaboration with other NMHSs in the region, especially with ONAMET from the Dominican Republic, which is also currently in a similar process of designing the SOFF project. Likewise, there is close collaboration with the Haiti Meteorological Service (UHM).

INSMET, being a pioneer in the implementation of data dissemination through WIS 2.0 in the region of Latin America and the Caribbean, and having one of the participants in the "Training workshop on version 2.0 of the Information System the WMO" for English-speaking countries, will be one of those in charge of disseminating the knowledge of this course for the region (Spanish-speaking countries). INSMET can support the implementation of this system in other NMHSs in the region. On the other hand, INSMET is open to receive help from other NMHSs in other vital tasks for the implementation of this project, such as the installation of new high-altitude observation systems, in which INSMET has little experience.

One of the objectives of the project in Cuba is to update the equipment of the calibration laboratory, which has real potential to become a Regional Calibration Center for the ARIV, which could allow, in addition to providing a fundamental service to the NMHSs of the region, an increase of its strength in view of its future sustainability, and that of the project.

INSMET has a collaboration on climate modeling issues with the Caribbean Community Climate Change Center (CCCCC). In the same way, INSMET, as NMHS of Cuba, belongs to the Conference of Ibero-American NMHSs (CIMHET), an entity that encompasses all the meteorological services of the Ibero-American Community and that prepares annual plans, both regional and subregional, for the institutional strengthening, the provision of meteorological, climatological and hydrological services and capacity building.

The Regional Center for Hydraulic Resources (CRRH) is made up of the Central American NMHSs, constituting an institution, together with the CIMHET and the WMO, of great interest to carry out subregional projects in which INSMET could be included. The Caribbean Meteorological Organization (CMO), which encompasses the NMHSs of the English-speaking Caribbean islands and which develops numerous meteorological development projects in the region, is another institution that could include INSMET in its multiple collaboration projects.

Regarding this last institution, it is advisable to establish agreements, especially on issues related to training for adequate exploitation of the region's observation networks, and it is also recommended to strengthen collaboration with ONAMET from the Dominican Republic, both to coordinate activities that may be common during the implementation of the SOFF project, related to training, as well as to adequately design the capabilities of the INSMET calibration laboratory taking into account the possibility of providing service to this and other institutions in the region, as well as taking advantage of the experience that ONAMET has regarding the needs of high-altitude observation that can be applied to the installation of the two stations planned in Cuba in the implementation of the project.

2.3. Assessment of a business model to operate and maintain the network

The financing for the maintenance of the INSMET observation network comes fundamentally from the budget assigned to the institution by the Cuban Government, which has been affected in recent years by the economic crisis suffered by the country.

When two observation stations are installed at height, the corresponding budget item must be considered for the acquisition of the radiosondes and balloons that must be launched daily.

INSMET can support, through the corresponding service charge, the assembly of meteorological equipment in other interested national and subregional institutions, which can be a source of additional financing, as well as in the event of converting the calibration laboratory into a regional center of calibration, would be an additional source of financing by charging for services to the different national and international institutions and individuals that make use of this service.

On the other hand, INSMET plans to increase its portfolio of services towards previously unexplored sectors in the country, taking advantage of the economic boost provided by this opportunity to update the technological and telecommunications infrastructure of the institution through the implementation of the SOFF project, as well as diversify and promote other existing traditional services, improving the quality of all specialized services provided, as a result of said implementation.

INSMET's goal is to hold different workshops with small and medium-sized Cuban producers, to identify possible mutually beneficial exchanges, as well as other institutions belonging to the private sector, which is gaining more and more strength in the current economic context. INSMET intends to carry out beneficial exchanges in key areas for the development of the country such as agriculture (mentioned above), renewable energies, transportation, tourism, as well as data management and software development ; areas, where the Cuban private sector is gaining more space and where INSMET could participate together with this sector in some collaboration projects of common benefit.

INSMET currently has contracts with national companies, which can be responsible for the installation and maintenance of grounding and protection systems against electric shocks, photovoltaic modules and generating sets and although another of the goals that INSMET proposed with the implementation of this project is that the maintenance of the different measurement systems implemented would be carried out entirely by INSMET staff, the help that these institutions can provide together with INSMET is necessary in these other vital systems that directly impact the observation system.

Different training actions will also be proposed for all INSMET personnel in these afore mentioned systems, to improve the quality of the institution's own workforce and make it less vulnerable to different contingencies in the implementation compliance phase of this project, enabling the solution, by technical specialists, of small problems related to the power supply and grounding systems and lightning rods, thus avoiding the generation of additional costs in the solution of said problems by other entities.

a. On the other hand, the implementation of the SOFF project will also partially and gradually resolve one of the most serious problems that INSMET currently has, which is the technological obsolescence of its equipment, both referring to the measurement system in some cases, as well as the infrastructure and telecommunications system intended for the processing of meteorological data, which is why it is planned to significantly rehabilitate the services that the institution can provide derived from said investment, as well as the promptness and opportunity to increase said services, which would also have a significant impact on the project, because compliance with the sustainability goal set by the bases of this project would become viable.

2.4. Assessment of existing national strategies and projects related to observing networks

The national strategy carried out by the country with respect to hydrometeorological observation networks is to strengthen the Early Warning Systems for everyone, to allow these Early Warnings to be more accurate and unerring so that decision makers can protect the population and the economic and material assets of the country.

To this end, INSMET participates every month in a national meeting where the modernization program for radars and meteorological stations in the country is discussed, together with the rest of the national institutions that intervene in the sustainability of each of the systems that are integrated into this program, where some of the topics summarized below are analyzed with respect to meteorological stations:

1. Meteorological instruments calibration program.
2. Maintenance of power units.
3. Investments in weather stations.
4. Constructive maintenance.
5. Optical fiber connectivity with ETECSA.
6. Computing resources, air conditioning and furniture.
7. AWS installation.

Representatives from the highest levels of management in the country attend these meetings, demonstrating the importance given to these issues in the country. These meetings do not have a published online document, because they discuss vital issues of the country's national security.

All projects that are in execution or in planning are also discussed in those meetings. Currently there are projects such as “Resilience to climate change in the coastal zone of Cuba through ecosystem-based adaptation” known as “Mi costa” (also implemented by UNDP) or “Building Resilience to Drought in Cuba” known as “Sin sequía”, where INSMET participates and whose objectives are in a certain way related to GBON, because one of their common final objectives is to strengthen the country's surveillance and early warning systems.

The aforementioned projects are always aimed at ensuring as a fundamental premise the strengthening of the hydrometeorological surveillance and monitoring systems of the national observation networks. The technical team in charge of the design and implementation of the surface and altitude stations by INSMET is the same technical team in charge of the technical tasks of the rest of the projects in which INSMET participates, thus ensuring coherence and complementarity in the technical execution criteria and selection of the different systems that make up the observation networks, which in the long term can have a positive impact on the GBON stations, since some of these projects foresee the reinforcement of some of the variables that are measured at these stations, ensuring greater sustainability.

Furthermore, all these projects ensure the coherence and complementarity of the planned investment plans, because most of them are analyzed by the different specialists and areas of intervention of the institution itself. In addition, these are then subjected to an exhaustive discussion phase in the meetings of the country's radar and meteorological station modernization program, as well as before the group of climate change and sustainable development experts, where, following the suggestions and proposals of these specialists give a better finish to the investment plan.

2.5. Review of the national legislation of relevance for GBON

The activities of INSMET are regulated in Resolution 24, of September 2nd, 1965 of the President of the National Commission of the Academy of Sciences of Cuba. On the other hand, Resolution 106, of December 6th, 1999 of the Minister of CITMA establishes the general rules of direction, organization and operation of INSMET.

The role of INSMET with respect to meteorological alerts is included in Decree 279, of March 19th, 2007 of the Executive Committee of the Council of Ministers (https://www.gacetaoficial.gob.cu/es/gaceta-oficial-no-31-ordinaria-de-2007), which regulates the general principles of organization, preparation and assurance of the hydrometeorological system for exceptional situations, indicating what must do each institution in each of the phases of the situation.

INSMET is recognized as the national warning authority on hydrometeorological hazards in Cuba.

On the other hand, INSMET is also governed by other legislation, such as Law 150 of 2022 (https://legaliscuba.org/normativa/ley-150-de-2022-de-asamblea-nacional-del-poder-popular) “On the Natural Resources and Environment System”, which is contemplated in its Article 101, of Title V “Confronting Climate Change” Chapter I section c), topics such as strengthening monitoring, diagnosis, surveillance and early warning systems to confront climate change, in which INSMET is a leader.

A national project will be prepared, following the country's regulations. This project must contain all investment activities, as well as compliance schedules. This project will be presented to the Cuban Ministry of Foreign Trade, the entity that regulates cooperation in Cuba, for approval. This Ministry is in charge of coordinating the execution of this project nationally and endorsing the implementing entity (in this case the UNDP) nationally.

Mechanisms will be established to monitor the project, as well as the annual work plan will be updated, as well as the challenges and mitigation measures for its fulfillment within the planned deadlines.

In addition, the implementing entity will carry out the processes of acquiring goods, as well as contracting consulting services and others related to training activities, installation of equipment and monitoring missions. The process of nationalization of the merchandise will be carried out by EMIDICT, which is the Specialized Importer, Exporter and Distributor Company for Science and Technology. Customs costs will be covered by the INSMET budget, so it will not represent an additional cost for the project. These processes will be carried out following the technical requirements of the counterparts and under the UNDP standards and procedures, which can be consulted at:

https://popp.undp.org/SitePages/POPPRoot.aspx.

In general sense, the legislations evaluated do not show limitations that could significantly impede the development of the project.

Module 3. GBON Infrastructure Development

3.1. Design the surface and upper-air observing network and observational practices

The Cuban Institute of Meteorology (INSMET) is responsible for operating and maintaining 69 Surface Synoptic-Climatic Meteorological Stations deployed throughout the country. Each of these stations is made up of a measurement system with conventional instruments, where observations are made by observers every three hours, and a location where an automatic meteorological station is located, with observations made every 10 minutes.

Currently the 69 synoptic-climatic stations are in operation, but only 21 AWS are in operation, of which 14 already report through WIS2.0 (as shown in theAnnex I). INSMET does not have an operational network of upper air observation stations.

Details of the INSMET surface and upper-air observation station network are provided in Table 3. At the beginning of June 2024, data began to be updated on the WIGOS Data Quality Monitoring System platform (14 stations exchanging via WIS 2.0), which was previously not possible because it only accepted transmissions through GTS.

Table 3: Details of the network of surface and upper-air observation stations

Station type	Total stations	OSCAR/Surface		WIS 2.0 (Stations with interchange)	WDQMS
		declared status	Evaluated status		
Surface	69 synoptic-climatic stations (21 AWS operating)	69 declared stations	69 operational stations	14 stations	14 stations
Upper air	n/a	n/a	n/a	n/a	n/a

The design of the GBON surface and upper-air observation network is based on the design principles of the WIGOS network and INSMET plan to provide, in the best possible way, a horizontally well-distributed network throughout the Cuban archipelago, to achieve greater impact of numerical weather prediction on global models.

3.1.1 Surface Observation Network and Observation Practices

The analysis of the GBON gaps, approved by the WMO, concluded that 9 ground surface stations and 2 radiosonde stations would be included to form the Cuban global basic observation network.

Of the 9 proposed stations, one is newly installed and the remaining 8 are already installed but due to the obsolescence of the equipment in 5 of them a partial rehabilitation of the equipment is needed, and in the remaining 3 a complete rehabilitation is required to the fulfillment of GBON requirements.

3.1.1.1 Maps of the surface observation network and list of new or rehabilitated stations.

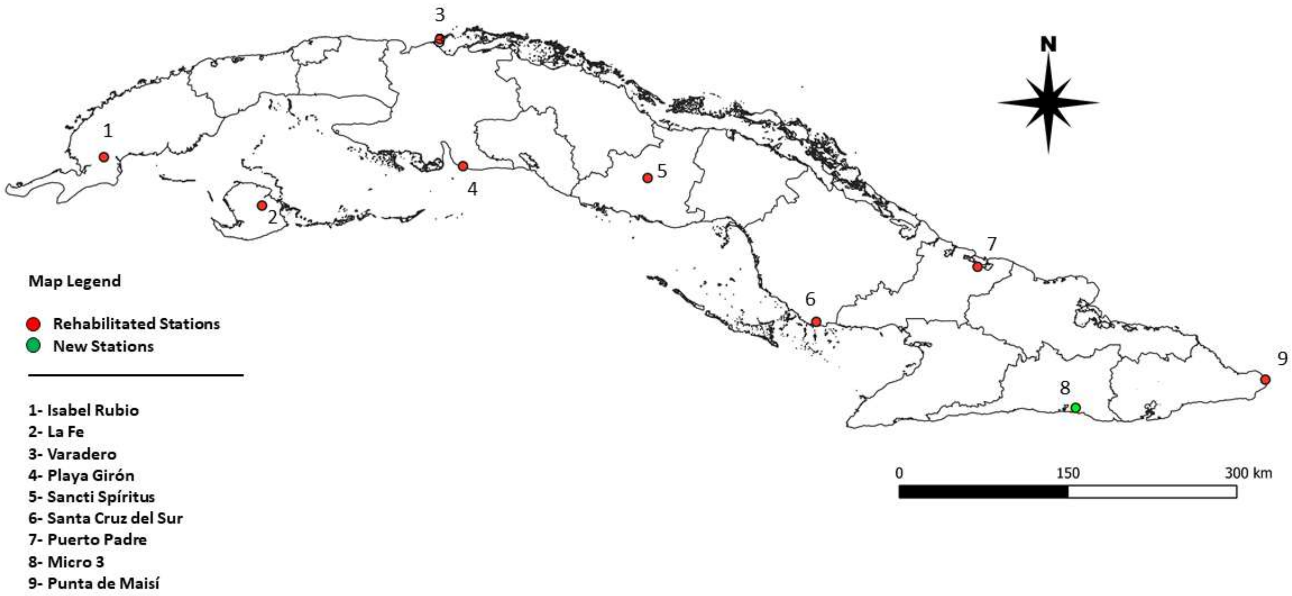


Figure 3: Distribution map of new (green) and rehabilitated (red) surface stations

Table 4: List of new or rehabilitated surface observation stations.

Station name	WIGOS-ID	Station type (S/UA)	Owner (NMHS/ 3rd party)	Funding source	GBON Compliant (Y/N)	Type	Installation Date	Required
Isabel Rubio	0-20000-0-78313	S	NMHS	RPCH	Y	AWS	2012	Rehabilitate
La Fe	0-20000-0-78321	S	NMHS	Cuba INSMET	N	Manual	2012	Rehabilitate
Varadero	0-20000-0-78328	S	NMHS	Cuba INSMET	Y	AWS	2002	Rehabilitate
Playa Girón	0-20000-0-78333	S	NMHS	Cuba INSMET	Y	AWS	2002	Rehabilitate
Sancti Spíritus	0-20000-0-78349	S	NMHS	Cuba INSMET	Y	AWS	2002	Rehabilitate
Santa Cruz del Sur	0-20000-0-78351	S	NMHS	RPCH	Y	AWS	2012	Rehabilitate
Puerto Padre	0-20000-0-78358	S	NMHS	CCCCC	N	Manual	2002	Rehabilitate
Micro 3	-	-	-	-	-	-	-	New
Maisí	0-20000-0-78369	S	NMHS	OXFAM International	N	Manual	2002	Rehabilitate

3.1.1.2 List of instruments and observing systems by site

The technical evaluation of the network of surface stations identified to make up the GBON network indicated that 8 of the stations have Automatic Meteorological Stations and 1 station, Micro 3 (in Santiago de Cuba), must be built entirely from the foundations. It was also found that 5 of the 8 stations mentioned above are working and therefore have dataloggers whose transfer protocol is TCP/IP, while the remaining 3 stations use the FTP transfer protocol, because the AWS are damaged, and they carry out observations with conventional (manual) instruments. Table 5 presents a description of the instruments that are currently in each of the stations that will make up the GBON network.

Table 5: Current status of the instrumentation that makes up the EMA observation systems by site

Stations name	Atmospheric pressure	air temperature	Humidity	Wind speed	Direction of the wind	Precipitation Quantity/ Intensity	data logger	Communications protocol	Central node access technology
Isabel Rubio								TCP/IP	ADSL
La Fe								FTP*	ADSL
Varadero								TCP/IP	ADSL
Playa Girón								TCP/IP	ADSL
Sancti Spíritus								TCP/IP	ADSL
Santa Cruz del Sur								TCP/IP	ADSL
Puerto Padre								FTP*	ADSL
Micro 3								New	ADSL installation pending
Maisí								FTP*	ADSL

Legend: Working | Working with Technological Obsolescence | Does not have or damaged

*The in-situ personnel of these stations transmit an FM12 message to the INSMET Central Node via FTP

The technical evaluation carried out also included an analysis of other important components that make up the observation system in each of the stations that will be in the GBON, highlighting the non-existence or deterioration of the components of the grounding and protection system against discharges, the instability of the electrical backup system with batteries, as well as the infrastructure of some basic elements such as fencing, solar panel supports and battery cabins at all stations. The status of these components is detailed in Tables 6 and 7.

Table 6: Current status of other components (I) that make up the observation systems by site

Stations name	AWS Cabin	Feeding/ electrical network	diesel generator	Solar panel	Battery	Download protection	Grounding system	Terminal and junction box	Cables and connectors
Isabel Rubio									
La Fe									
Varadero									
Playa Girón									
Sancti Spíritus									
Santa Cruz del Sur									
Puerto Padre									
Micro 3									
Maisí									

Legend: In functional condition | Not installed or deteriorated for various reasons

Table 7: Current status of other components (II) that make up the observation systems by site

Stations name	AWS Mast	Temperature/Humidity Support	Rain Gauge Support	Perimeter fence	Solar panel support	Battery cabin	AWS Mast Hardware and Accessories
Isabel Rubio	Green	Green	Red	Red	Red	Red	Red
Faith	Green	Red	Red	Red	Red	Red	Red
Varadero	Green	Green	Green	Red	Red	Red	Green
Giron Beach	Red	Red	Red	Red	Red	Red	Red
Sancti Spiritus	Red	Red	Red	Red	Red	Red	Red
Santa Cruz del Sur	Red	Red	Red	Red	Red	Red	Red
Puerto Padre	Red	Red	Red	Red	Red	Red	Red
Micro 3	Red	Red	Red	Red	Red	Red	Red
Maisi	Red	Red	Red	Red	Red	Red	Red

Legend: Green — In functional condition; Red — Not installed or deteriorated for various reasons

3.1.1.3 Investments and activities necessary for the installation of new stations and the improvement of existing stations.

To clearly explain and thus achieve a better understanding of the process designed for the implementation of the necessary investments and activities, for the installation and rehabilitation of the new and existing stations that will make up the GBON, it is necessary to divide the observation system by site in several different subsystems, adapting these to the needs of each of the surface stations treated. The subsystems will be:

- ✓ Instrumentation System.
- ✓ Power supply system.
- ✓ Grounding and lightning rod.
- ✓ Communications System.
- ✓ Infrastructure.

Instrumentation System

The technical evaluation of the sensors indicated that in 8 of the 9 stations (excluding Micro 3, which is not installed and therefore all the equipment must be purchased) the useful life of the instrumentation has been exceeded and its update is necessary. The main objective is to achieve homogenization of this network.

It is also necessary to note that 5 of these 9 stations chosen for GBON are already exchanging data through WIS 2.0, but if the deadline for compliance and execution of the project is analyzed, to achieve better sustainability and reliability of these stations (which would be Isabel Rubio, Varadero, Playa Girón, Sancti Spíritus and Santa Cruz del Sur) it is better to replace their instruments from the beginning to minimize erroneous values in the short term and thus improve the quality of the data. For this reason, Table 8 lists the atmospheric pressure, air temperature and relative humidity instruments in these stations as needing rehabilitation.

It would be valid to consider the possibility of having additional spare parts for the instruments installed in the stations (whether or not they need immediate rehabilitation), to facilitate subsequent cycles of calibration, maintenance and breakdowns, and thus make viable and optimize these processes and reduce response times. In this way, a solution to the main sustainability problem that the institution presents would be achieved, which is the acquisition of spare parts.

Table 8: Installation of the instrumentation system

Stations name	Atmospheric pressure	Air temperature	Relative Humidity	Wind speed	Wind Direction	Precipitation Quantity/ Intensity	datalogger
	600-1060hPa	-40°C to +60°C	0-100%	Max: 0-75m/s	0-360°	0-500mm/h	
Isabel Rubio	✓	✓	✓	x	x	✓	✓
La Fe	✓	✓	✓	✓	✓	✓	✓
Varadero	✓	✓	✓	x	x	x	x
Playa Girón	✓	✓	✓	x	x	x	x
Sancti Spíritus	✓	✓	✓	✓	✓	x	x
Santa Cruz del Sur	✓	✓	✓	x	x	x	✓
Puerto Padre	✓	✓	✓	✓	✓	✓	✓
Micro 3	✓	✓	✓	✓	✓	✓	✓
Maisí	✓	✓	✓	✓	✓	✓	✓

Legend: ✓: Needs immediate installation or rehabilitation X: Does not need immediate

Power Supply System

All stations have general mains electric supply, and most stations have a diesel power generator set as backup (except the new Micro III station and Maisi station). To save costs and given the country's fuel shortage problems that cause prolonged power outages, the installation of a photovoltaic system in all stations is required. As an additional contribution to maintain the vitality of the operation of the communications system in the face of prolonged power outages that may exist, this would reduce the carbon footprint and thus effectively strengthening sustainable the stable work of the AWS,

The solar panels must be temporarily 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). In any case, it is necessary to have diesel generators at the stations as a backup in extreme situations.

Table 9: Power Supply System Installation

Stations name	diesel generator	solar kit	Materials for solar panel support	Battery bank	Battery cabin	Materials for channeling and wiring	Accessories for electrical distribution board	Solar Regulators
Isabel Rubio	x	✓	✓	✓	✓	✓	✓	✓
La Fe	x	✓	✓	✓	✓	✓	✓	✓
Varadero	x	✓	✓	✓	✓	✓	✓	✓
Playa Girón	x	✓	✓	✓	✓	✓	✓	✓
Sancti Spíritus	x	✓	✓	✓	✓	✓	✓	✓
Santa Cruz del Sur	x	✓	✓	✓	✓	✓	✓	✓
Puerto Padre	x	✓	✓	✓	✓	✓	✓	✓
Micro 3	✓	✓	✓	✓	✓	✓	✓	✓
Maisí	✓	✓	✓	✓	✓	✓	✓	✓

Legend: ✓: Needs immediate installation or rehabilitation X: Does not need rehabilitation

Grounding and lightning rod

The deterioration or absence of the grounding and protection systems against discharges in the INSMET AWS network is one of the problems that have historically caused the most damage to the correct functioning of said network, fundamentally due to the intense activity of electrical discharges that It occurs in the Cuban archipelago throughout the year. This system is considered basic and essential in the development of any required strategy that contemplates the installation of new or rehabilitated stations of the GBON.

Having explained this, the incorporation of active lightning rods with greater coverage than the passive type, as well as the improvement of the grounding systems of each of the locations, is considered the best option. In addition, it is necessary to incorporate protection in electrical distribution panels against lightning strikes due to their high density in the treated areas. These measures are essential to avoid the constant loss of damaged sensors due to this cause, as had already been explained previously, and which is based on the experience of the technical personnel in charge of these tasks at the institution.

Table 10: Installation of the grounding system and lightning rod

Stations name	Active lightning rod	Lightning rod installation kit	Mast for installation	Accessories for installing ground connections	Protections against transients
Isabel Rubio	✓	✓	✓	✓	✓
La Fe	✓	✓	✓	✓	✓
Varadero	✓	✓	✓	✓	✓
Playa Girón	✓	✓	✓	✓	✓
Sancti Spíritus	✓	✓	✓	✓	✓
Santa Cruz del Sur	✓	✓	✓	✓	✓
Puerto Padre	✓	✓	✓	✓	✓
Micro 3	✓	✓	✓	✓	✓
Maisí	✓	✓	✓	✓	✓

Legend: ✓: Needs immediate installation or rehabilitation

Communications System

INSMET has an exclusive private data network (VPN), financed by the institution's own budget. This financing also covers the repair and maintenance expenses of the Cuban Telecommunications Company (ETECSA), a state agency in charge of servicing telecommunications in Cuba. This private network is supported through copper pair, optical fiber or VSAT. The stations suggested for the GBON network: 9 (surface) + 2 (upper air) already have these communications available in their locations (In Micro 3 it is in process).

In the 11 stations proposed to form the GBON, there is availability of a data network for 2G/3G/4G cellular telephony. INSMET also has a private APN, so that data sent through the network flows more quickly and safely through Internet gateways. All these expenses are also financed by the INSMET budget.

In many cases, the last section of the communications network is aerial, so it presents a high risk of breakdown in cases of extreme adverse events, which is when data is most needed. The redundancy of the communications network is essential, so the acquisition of communications interfaces via mobile telephony (3G/4G Router) and VSAT, as a backup, would be convenient. Financing the costs of communication transmission is not necessary, it would only require the acquisition or renewal of the currently existing hardware.

In the case of the satellite redundancy solution (VSAT), it would be necessary to acquire a transmission system for each of the stations, both surface and upper air, as well as another for the INSMET node, whose operation would be used as backup communications interface (only necessary in critical cases of failure of the remaining communications systems, given that under the current situation of fuel deficit in the country, prolonged power outages usually occur, and ETECSA does not have sufficient electrical backup, in many cases, to keep mobile telephone radio bases operational) or in the face of the scourge of extreme adverse phenomena. The INSMET budget will finance the costs of transmitting these communications.

In Annex II The information flow planned for the GBON stations is described in a general way.

Table 11: Installation of equipment for the communications system

Stations name	3G/4G modem	Router and Switch	Optical fiber cabling*	Optical fiber converters	VSAT	Tools, accessories and materials for installation
Isabel Rubio	✓	✓	✓	✓	✓	✓
La Fe	✓	✓	✓	✓	✓	✓
Varadero	✓	✓	✓	✓	✓	✓
Playa Girón	✓	✓	✓	✓	✓	✓
Sancti Spíritus	✓	✓	✓	✓	✓	✓
Santa Cruz del Sur	✓	✓	✓	✓	✓	✓
Puerto Padre	✓	✓	✓	✓	✓	✓
Micro 3	✓	✓	✓	✓	✓	✓
Maisí	✓	✓	✓	✓	✓	✓

Legend: ✓: Needs immediate installation or rehabilitation

*The mentioned optical fiber cabling includes the section from the terminal equipment of the ADSL link (located in the meteorological station building) to the AWS cabin (located in the AWS tower). It would be approximately 100 meters at each station.

Infrastructure

The proposed stations are located in enclaves where buildings owned by INSMET already exist, where communications rooms, energy, warehouses, personnel rooms, etc. are located. It should be taken into account that many of the automatic weather stations have been in operation for more than 20 years, so some of their structural components such as the perimeter fence and the AWS wind pole, the support for the rain gauge and the lightning rod, as well as the channeling of the cables are in a state of significant deterioration, so the possibility of allocating a fund for repairs and maintenance of the infrastructure will be considered, but also to improve the living conditions of the observers (who play a fundamental role because they represent the first level of preventive maintenance), and thus solve the problems described to prolong the functionality of the structures and achieve greater resilience in the face of extreme adverse phenomena.

Table 12: Installation of the infrastructure system

Stations name	AWS Mast	Cabin for AWS	Temperature/ Humidity Support	Rain Gauge Support	Wind speed and direction support	Perimeter fence	Installation accessory kit	Maintenance of communications and energy premises
Isabel Rubio	x	x	x	√	x	√	x	√
La Fe	x	x	x	√	x	√	x	√
Varadero	x	x	x	x	x	√	x	√
Playa Girón	√	√	√	√	√	√	√	√
Sancti Spíritus	√	√	√	√	√	√	√	√
Santa Cruz del Sur	√	√	√	√	√	√	√	√
Puerto Padre	√	√	√	√	√	√	√	√
Micro 3	√	√	√	√	√	√	√	√
Maisí	√	√	√	√	√	√	√	√

Legend: √: Needs immediate rehabilitation X: Does not need immediate

Taking into account the necessary components analyzed and detailed in each of the subsystems previously considered, Table 13 below presents the investment proposal made for the installation of the new and rehabilitated stations that will make up the Cuban GBON.

Table 13: Investment required for the installation of the new and rehabilitated surface stations chosen to be part of GBON

Goals	Component	Amount	Cost (USD)
Instrumentation	Atmospheric pressure	9	46,550
	Air temperature	9	20,610
	Relative Humidity		
	Wind speed	5	7,200
	Wind direction	5	8,000
	Precipitation	5	10,250
	Datalogger	6	33,000
	Accessory kit	9	27,000
	Installation costs	9	55,800
Power Supply System	Diesel Generator	2	40,000
	Solar Kit	9	108,000
	Materials for the support of the Solar Panel Kit	9	14,400
	Battery bank	9	19,800
	Battery Cabin	9	5,850
	Materials for channeling and wiring	9	26,550
	Accessories for electrical distribution board	9	27,000
	Solar Regulators	9	9,000
	Installation costs	9	55,700
Grounding system and lightning rod	Active lightning rod	9	63,000
	Lightning rod installation kit	9	27,000
	Pole	9	22,500
	Accessories for ground connections	9	18,000
	Protection against transients	9	27,000
	Installation costs	9	76,800
Communications System	2G/3G/4G modem	9	10,800
	Router and Switch	9	8,100
	Optical fiber Cabling	9	28,395
	Optical fiber Converters	9	13,500
	VSAT system	9	81,000
	Tools, accessories and materials for installation	9	6,750
	Installation costs	9	46,700
Infrastructure system	AWS Wind Pole	6	30,000
	Cabin for AWS	6	6,600
	Temperature and Humidity Support	6	10,200
	Rain Gauge Support	8	4,400
	Wind Speed and Direction Support	6	4,500
	Perimeter fence	9	27,000
	Installation accessory kit	6	9,000
	Maintenance of communications and energy premises	9	63,000
	Installation costs	9	50,000
			1 148 955

Table 14: Distribution phases of the actions to be carried out for the fulfillment of the planned activities in the installation of new and rehabilitated surface observation networks

Activities	Actions
Acquisition of materials and equipment	1.1 Acquisition Process by the implementing entity
	1.2 Transfer of equipment
Station identification, evaluation and preparation	2.1 Visit of technical specialists to the station to plan the design for the assembly of the different systems
	2.2Execution of the required basic construction works (new and rehabilitated stations)
	2.3 Creation of installation capacities in the Regional Technical Centers to support Maintenance
	2.4 Technology and knowledge transfer
	3.1 Assembly and certification of the acquired grounding and lightning rod system
	3.2 Assembling the purchased power supply system
	3.3 Assembly of the acquired communications systems
Preparation of equipment for installation	4.1 Configuration and assembly of AWS equipment
	4.2 Calibration and verification of the equipment to be installed
	4.3 Transfer of AWS equipment
Equipment installation	5.1 Installation of the purchased instrumentation system
	5.2 Checking the rest of the subsystems that make up the observation system
	5.3 Communication test and correct operation of the installation
Other activities necessary to complete the observation system	6.1 Training of on-site personnel in required observation practices
	6.2 Monitoring of the tasks necessary for the correct operation of the station according to the essential requirements for a station in the GBON.

Table 15: Distribution of the activity plan designed for the installation of new and rehabilitated surface observation networks

Activities	Year 1				Year 2				Year 3				Year 4				Year 5			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
1.1 Acquisition Process by the implementing entity																				
1.2 Transfer of equipment																				
2.1 Visit of technical specialists to the station to plan the design for the assembly of the different systems																				
2.2 Execution of the required basic construction works (new and rehabilitated stations)																				
2.3 Creation of installation capacities in the Regional Technical Centers to support Maintenance																				
2.4 Technology and knowledge transfer																				
3.1 Assembly and certification of the acquired grounding and lightning rod system																				
3.2 Assembling the purchased power supply system																				
3.3 Assembly of the acquired communications systems																				
4.2 Configuration and assembly of AWS equipment																				
4.3 Calibration and verification of the equipment to be installed																				
4.4 Transfer of AWS equipment																				
5.1 Installation of the purchased instrumentation system																				
5.2 Checking the rest of the subsystems that make up the observation system																				
5.3 Communication test and correct operation of the installation																				
6.1 Training of on-site personnel in required observation practices																				
6.2 Monitoring of the tasks necessary for the correct operation of the station according to the essential requirements for a station in the GBON.																				

3.1.1.4 Observational practices for the surface observation network.

The optimal performance of a surface observation network depends on the skills, training and competencies of the technical personnel responsible for said network. Their main tasks include the installation of instrumentation and communication systems, the maintenance of instruments and other systems, as well as fault diagnosis, repair of defective systems and monitoring the performance of communication and instrumentation systems.

Equally important is understanding the operation of meteorological instruments and observation methods, classifying sites for specific variables, performing preventive and corrective maintenance of instruments and other systems in accordance with Standard Operating Procedures (SOPs) to ensure the quality and availability of observations, as well as instrument calibration and metadata management.

Therefore, it is recommended that INSMET personnel responsible for the first level of maintenance of the GBON surface ground stations receive training on the management of AWS. Equally important is the creation of an instruction manual for these same personnel, which must be in line with the standard operating procedures (SOP) to guarantee the quality and availability of the observations, as well as their quality, in the event of small breakdowns.

Currently, the technical personnel in charge of the installation and commissioning of the observation systems reside at the INSMET Headquarters in Havana. It is proposed to establish a second technical center to cover the stations in the eastern part of the island, which would considerably reduce the distance, the immediacy of the response to breakdowns and, in turn, the fuel consumption when making trips for corrective and preventive maintenance. INSMET technical staff would be in charge of their training.

3.1.1.5 Preliminary maintenance plan for existing and new improved stations, including network calibration practices.

So that the quality of meteorological observations made by automatic meteorological stations is maintained at the required level throughout their useful life, by the standards established by the World Meteorological Organization (WMO), a specific maintenance plan was developed for the surface stations that will be part of the INSMET GBON.

INSMET has been managing the current observation network since its founding in 1965, thus ensuring the availability of data for national and international exchange, with limited resources. The country is continually affected by extreme natural phenomena, which, added to the deficit of accessories and spare materials necessary due to the country's own economic conditions, hinders the stability of the operation of surface observation networks, through automatic weather stations.

GBON imposes strict data availability and quality requirements that are very difficult to keep stable with current resources, therefore the stability of the weather stations will depend largely on the existence and availability of spare parts available at the Regional Technical Centers from INSMET. It is recommended to improve the capacity of the Regional Technical Centers to support Maintenance, as well as the Calibration Laboratory, to guarantee compliance with the minimum requirements demanded by the GBON network.

On the other hand, the organization of the system of surface meteorological observations in Cuba makes the response times for the restoration and maintenance activities of the surface stations, in the face of all types of threats or extreme situations, to be short, if there are the necessary resources for its mitigation.

The technical specialty is currently concentrated in the Central Headquarters of the institution, located in the town of Casablanca, in Havana. At said headquarters, there is the technical Center to support the National Maintenance of the surface observations network, as well as the Calibration Laboratory in charge of the calibration and verification of all the instruments belonging to the network of automatic meteorological stations in the country. The instrument test chambers of this Laboratory require their measurement patterns to be exported from time to time, resulting in prolonged periods without the necessary systems to validate the accuracy of the field test equipment, this being one of the main problems of sustainability of its functionality, so it is necessary to improve the capacity to maintain the traceability of the patterns.

The maintenance intervals and activities planned by INSMET are defined for each observing system independently, all in accordance with WMO manuals, guides and SOPs and as recommended by equipment manufacturers or suppliers.

For a correct explanation of the design of the maintenance Plan, we will divide it into the two fundamental stages that make it up: Maintenance (corrective and preventive) and Calibration (in the Laboratory and Field), which will be explained below.

Maintenance

There are INSMET personnel on site 24 hours a 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 on the location These personnel provide support to the technicians/specialists as the first step and immediate response by carrying out basic checks in the event of breakdowns. Even so, it is necessary to travel for the institution's expert specialists in cases of serious damage, installations or calibrations.

INSMET plans to implement a 90-day preventive maintenance schedule for GBON stations in accordance with its national operation and available resources. Corrective maintenance activities are carried out to solve technical or communication failures of GBON stations. System breakdowns are expected to be addressed within a period of no more than three days to ensure that the station meets the monthly data availability performance objective of the WMO and the country.

Currently all installation and maintenance activities are carried out by the technical team located at the INSMET headquarters in Havana. This plan seeks to ensure that daily preventive maintenance is carried out by the staff of the stations themselves and advanced fault diagnosis by the technical staff of the Regional Technical Centers for Maintenance Support. Preventive maintenance should also include field calibration and verification activities.

The creation of a second technical maintenance center, located in Camaguey (See **Annex VI** for greater precision.) near the Eastern Region of the country, would considerably reduce the distance, the immediacy of the response to breakdowns and, in turn, the fuel consumption when traveling for corrective and preventive maintenance (For example, the distance between Santiago de Cuba and Havana is more than 900 km by road, while between Camaguey and Santiago it is only about 330 km.). The above and taking into account the serious energy situation in the country (due to the fuel deficit), makes it necessary to establish a mechanism that ensures the supply of fuel to travel to the stations. With the creation of this 2nd Technical Center, INSMET would take advantage of the existing infrastructure in the Provincial Meteorological

Center of Camagüey, as an alternate center of the Central Headquarters, in the event of disaster and emergency situations (thus stated in the Organic Regulations of INSMET in its Article 10 of Chapter I), therefore if we are guided by the scheme that will be presented in Figure 5, the infrastructure and qualified human resources of the technical departments located in said institution would be taken advantage of, which would be the department of instruments and methods of observation, so that The investment is minimal and is fundamentally aimed at the revitalization of these work groups, which is why it is necessary to equip both centers with vehicles and equipment for the installation, maintenance, field calibration and operation of the GBON network.

Once a year, specialized personnel will replace all the stations' instrumentation with spare instrumentation calibrated in the Calibration Laboratory of the Headquarters, thus closing the maintenance cycles per station to reduce measurement errors and guarantee the quality of the data, the removed instruments will be sent to the Calibration Laboratory where they will be maintained and calibrated, then becoming part of the replacement instrumentation of the station itself, thus repeating the cycle every year for each station.

Table 16: Analysis of updating resources for maintenance in the Regional Technical Centers to support National and Regional Maintenance

Name of the center	Accessories, materials and tools for maintenance	Backup equipment for AWS	Traveling patterns	Construction maintenance	Vehicles: acquisition and maintenance	Fuel
National Maintenance Technical Center	✓	✓	✓	✓	✓	✓
Technical Center to support Regional Maintenance	✓	✓	✓	✓	✓	✓

Legend: ✓ Needs rehabilitation or purchase

Table: 17: Stations assigned to each Regional Technical Center for Maintenance (according to planning, Annex VII)

Station name	WIGOS-ID	Corresponding Regional Technical Center
Isabel Rubio	0-20000-0-78313	National (West)
La Fe	0-20000-0-78321	National (West)
Varadero	0-20000-0-78328	National (West)
Playa Girón	0-20000-0-78333	National (West)
Sancti Spíritus	0-20000-0-78349	National (West)
Santa Cruz del Sur	0-20000-0-78351	Regional (East)
Puerto Padre	0-20000-0-78358	Regional (East)
Micro 3	-	Regional (East)
Maisí	0-20000-0-78369	Regional (East)

Table: 18: Types of Maintenance and execution intervals

Maintenance Type	Place	Responsibility	Interval
Preventive-daily	In the place	Station staff	daily
Preventive-quarterly/ Field calibration	In the place	Technical staff of the Technical Regional or National Maintenance Center	90 days
Corrective	In the place	Technical staff of the Technical Regional or National Maintenance center	less than 3 days

Table: 19: Operational Maintenance Costs

Items	Number of visits (5 years)	Number of stations	Total Cost (USD)
Preventive Maintenance	14	9	102,600
Calibrations/Field Verifications (performed in parallel to preventive maintenance)	14	9	34,200
Corrective maintenance	n/a	n/a	24,800
			161,600

Table: 20: Costs of other resources necessary to perform maintenance

Items	Cost (USD)
Accessories, materials and tools for maintenance	18,800
Spare parts for surface land stations	440,100
Traveling patterns	52,000
Installation maintenance	10,000
Vehicles: acquisition and maintenance	170,000
Fuel	108,000
	798 900

Instrument Calibration Center

INSMET has an instrument calibration center at its Headquarters in Casablanca, which is a candidate to become a Regional Calibration Center 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 center could support the numerous SOFF and NMHS projects in the Caribbean and Central America region.

The instrument management system of INSMET Laboratory complies with the ISO 17025 standard, where its technical staff is the same person in charge of the installation and maintenance of automatic weather stations, some with more than 20 years of experience in datalogger configuration and calibration of sensors of different manufacturers. These personnel could participate in future exchanges with different countries in the region to support the implementation of their SOFF projects and provide installation, maintenance and calibration services for meteorological stations where required.

For the Laboratory, a complete replacement of the pressure calibrator would be required as it is currently defective. In the case of the climatic chamber, a replacement is also necessary due to the number of years of its operation, which has caused various technical problems that prevent the full exploitation of its capacities, which would guarantee a substantial improvement in the calibration quality.

On the other hand, it is necessary to incorporate a system for the calibration of the bucket rain gauges, to ensure that the country and the region of Latin America and the Caribbean can have the calibration of each of the 5 essential variables of the GBON. A small budget would also be needed to carry out infrastructure maintenance and lighting improvement, as well as maintenance of the wind tunnel and consumable accessories for the correct functioning of the Laboratory in general.

Currently, the Calibration Laboratory does not have instruments that can be used as equipment to perform field calibrations, so their acquisition is necessary, both for the headquarters Laboratory and for the Regional Maintenance Support Center of Camaguey.

Table 21: Current status of the calibration equipment of the Instrument Calibration Laboratory

Caliper	Pattern	Variables	Last calibration date	State
Wind tunnel	Pitot tube with WestiBox flow calculation system	Horizontal wind speed	11-2018	Well
Climatic chamber	Fluke 1502A Digital Thermometer	Temperature and Humidity	03-2018	Regular
pressure chamber	745-A digital barometer	Atmospheric pressure	10-2018	Out of service

Table 22: Equipment update analysis for the Instrument Calibration Laboratory

Name	Atmospheric Pressure Calibration System	Temperature and Humidity Calibration System	Precipitation calibration system	Wind tunnel maintenance	Infrastructure maintenance	Air conditioning	Office equipment and supplies	Calibration Patterns
Calibration Laboratory	✓	✓	✓	✓	✓	✓	✓	✓

Legend: ✓: Needs rehabilitation or purchase

Table: 23: Costs of the resources necessary for calibration in the laboratory

Items	Cost (USD)
Atmospheric Pressure Calibration System	75,000
Temperature and Humidity Calibration System	210,000
Precipitation calibration system for the laboratory	42,000
Wind tunnel maintenance	45,000
Infrastructure maintenance	45,000
Air conditioning	39,000
Office equipment and supplies	21,400
Calibration Patterns	27,000
Laboratory protection system	16,000
	520,400

Table 24: Distribution phases of the actions to be carried out for the fulfillment of the planned activities in the maintenance and calibration of the new and rehabilitated surface observation networks

Activities	Actions
Acquisition of materials and tools	1.1 Acquisition Process by the implementing entity
Creation of capacities in the different systems of the observation network	2.1 Procedure designs aimed at achieving adequate practices for good maintenance, verification and repair of instruments
	2.2 Development of software to control maintenance, calibration and breakdown repair activities.
	2.3 Technology and knowledge transfer
	2.4 National training of personnel in the various systems that make up the surface observations network
Performing maintenance	3.1 Ensuring daily and quarterly preventive maintenance, as well as corrective maintenance
	3.2 Ensuring instrument calibrations

Implementation of the maintenance plan is subject to the availability of field test equipment, spare parts, transportation and fuel.

- It is expected that the process of acquiring resources, as well as the installation of equipment, will take place until the 2nd Quarter of Year 2.
- Starting in the 3rd Quarter of Year 2, quarterly maintenance is planned for all stations.
- Since Micro 3 is a new station, it is expected that its installation will still be taking place during the 3rd Quarter of Year 2 and therefore no maintenance is planned for that quarter.
- In the case of La Fe, as it is located on an island far from the main island of Cuban territory, the maintenance will be carried out in the Quarter itself, but a month later, although the deadlines will continue to be quarterly.

The planned maintenance schedule for the GBON surface ground stations will be carried out as follows:

Table 25: Distribution of the activity plan designed for preventive maintenance of new and rehabilitated surface observation networks

Station name	Year 1				Year 2				Year 3				Year 4				Year 5			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Isabel Rubio																				
La Fe																				
Varadero																				
Playa Girón																				
Sancti Spíritus																				
Santa Cruz del Sur																				
Puerto Padre																				
Micro 3																				
Maisí																				

Table 26: Distribution of the activity plan designed for the maintenance and calibration of new and rehabilitated surface observation networks (This plan is contemplated from the beginning of the execution phase)

Activities	Year 1				Year 2				Year 3				Year 4				Year 5			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
1.1 Acquisition Process by the implementing entity																				
2.1 Procedure designs aimed at achieving adequate practices for good maintenance, verification and repair of instruments																				
2.2 Development of software to control maintenance, calibration and breakdown repair activities																				
2.3 Technology and knowledge transfer																				
2.4 National training of personnel in the various systems that make up the observations network																				
3.1 Ensuring daily and quarterly preventive maintenance, as well as corrective maintenance																				
3.2 Ensuring instrument calibrations																				

3.1.1.6 List of instruments and observing systems by site

Tabla 27: Summary of Technical specifications for new instruments and observing systems for the procurement process.

Variable	Measuring range	Sampling Frequency	Operating conditions	Report Resolution	Maximum Uncertainty	Measurement unit
Air Temperature	´-80 to 60 °C	1s	Temperature (0 to 55°C) Humidity (0 to 100% RH) Wind Speed (up to 50 m/s)	0.1	0.2°C	°C
Relative Humidity	0-100% RH	1s		1	3% RH	%RH
Atmospheric pressure	500 to 1100 hPa	1s		0.1	0.3hPa	hPa
Wind speed	0 to 75m/s	1s		0.1	0.5m/s	m/s
Wind direction	0 to 360°	1s		1	5th	°
Precipitation	-	1s		0.1	0.1mm	mm

Note: For more details on this section, go to **Annex IV**.

3.1.2 Upper-air observation network and observation practices

Currently, INSMET does not have operational upper air stations. For these radiosonde stations, GBON requires a spatial resolution of 500 km, so the plan consists of establishing and implementing an upper-air network composed of two new observation stations, due to the geographical characteristics of the island of Cuba.

3.1.2.1 Map of the upper-air observation network and list of necessary new or rehabilitated stations

The stations chosen to be part of the network of radiosonde stations will carry out 2 surveys per day and according to the study carried out in the National Gap Analysis, the sites identified for the installation of said stations will be Mariel and Camagüey, as shown in Figure 4.

The technical evaluation carried out in one of the sites chosen to form the network of upper air stations (Camagüey) indicated that previously altitude measures were carried out at the site, but none of the material and equipment used then to carry out the radiosondes now exists, thus cannot be reused for this project, it is only possible to use the premises previously used to carry out the procedures, although these require a strong investment in infrastructure maintenance (almost from scratch), so the station is proposed as completely new. In the case of Mariel, it is also proposed as new because no station of this type has ever existed on this site and the complete civil works must be carried out for said station. The characteristics of the working regime of these stations are shown in Table 28.

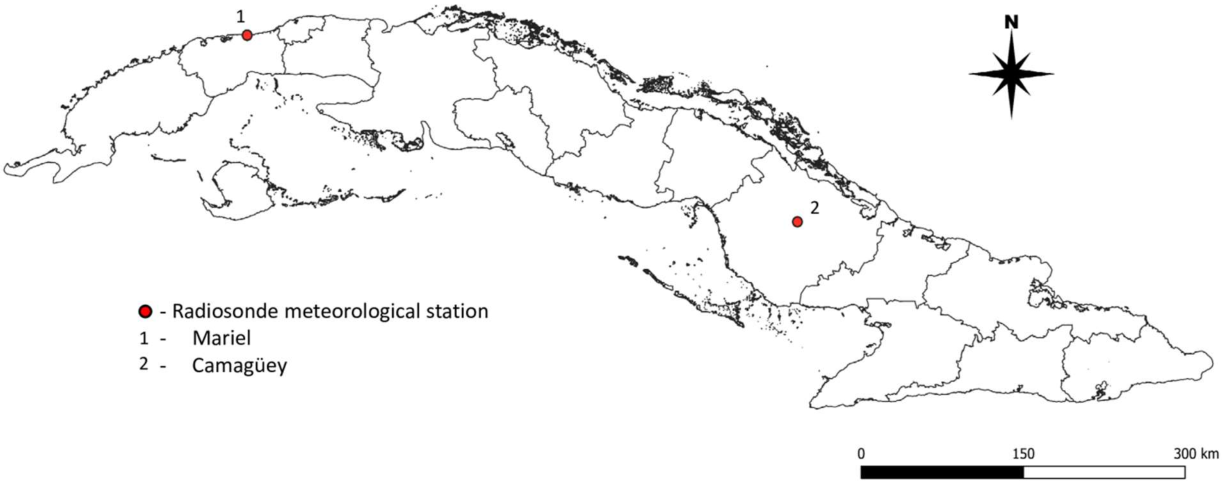


Figure 4: Distribution map of radiosonde stations

Table 28: Planned working regime for the upper-air observation stations of the GBON network

Station name	WIGOS-ID	Station type (S/UA)	Owner (NMHS/ 3rd party)	Number of reports (daily/annual)	Required
Mariel	**-**	**U.A.**	**NMHS**	**2/732**	**New**
Camaguey	**-**	**U.A.**	**NMHS**	**2/732**	**New**

3.1.2.2 List of instruments and observing systems by site

Both stations proposed for the creation of the network of upper air stations for this project will be new because there are no stations of this type in operation in the country, therefore the current state of the rooms and the necessary equipment will be as shown in Table 29

Table 29: Current status of the rooms for the location of the equipment necessary to form the observation systems by site

Station name	Balloon inflation site	Consumables Storage Room	Hydrogen generation room	Operation room	Equipment
Mariel	x	x	x	x	x
Camaguey	x	x	x	x	x

Legend: X: Does not exist (Mariel) or is in very poor condition

3.1.2.3 Investments and activities necessary for the installation of the new stations.

Table 30: Investment required for the installation of the radiosonde stations chosen to form the GBON

Goals	Items	Total Cost (USD)
Buildings and Facilities (Infrastructure and protections systems)	Infrastructure	113 200
	Shock protection system	40,000
	Grounding system	20,000
	Accessories for electrical supply	9,000
	Electric generator	40,000
	Direct water supply system	7,000
Hydrogen generation system	Hydrogen generator	679,000
Hardware, Power Supply and Communications Systems	radiosonde system	158,000
	Hardware	5,000
	VSAT system	18,000
	Execution Costs	59,300
Parts and consumables	Consumables	1,587,000
		2,735,500

Table 31: Distribution phases of the actions to be carried out to fulfill the planned activities in the installation of upper air observation network

Activities	Actions
Acquisition of materials and equipment	1.1 Acquisition Process by the implementing entity
	1.2 Transfer of equipment
Station identification, evaluation and preparation	2.1 Visit of technical specialists to the station to plan the design for the assembly of the different systems
	2.2Execution of the required basic construction works
	2.3 Technology and knowledge transfer
	3.1 Assembly and certification of the acquired grounding and lightning rod system
	3.2 Assembling the purchased power supply system
	3.3 Assembly of the acquired communications systems
Preparation of equipment for installation	4.1 Configuration and assembly of radiosonde station equipment
	4.2 Transfer of radiosonde station equipment
Equipment installation	5.1 Installation of the purchased instrumentation system
	5.2 Checking the rest of the subsystems that constitutes the observation system
	5.3 Certification of radiosonde station security systems
	5.4 Communication test and correct operation of the installation
Other activities necessary to complete the observation system	6.1 Training of on-site personnel in required observation practices
	6.2 Monitoring of the tasks necessary for the correct operation of the station according to the essential requirements for a station in the GBON.

Table 32: Distribution of the activity plan designed for the installation of upper air observation network

Activities	Year 1				Year 2				Year 3				Year 4				Year 5			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
1.1 Acquisition Process by the implementing entity																				
1.2 Transfer of equipment																				
2.1 Visit of technical specialists to the station to plan the design for the assembly of the different systems																				
2.2 Execution of the required basic construction works																				
2.3 Technology and knowledge transfer																				
3.1 Assembly and certification of the acquired grounding and lightning rod system																				
3.2 Assembling the purchased power supply system																				
3.3 Assembly of the acquired communications systems																				
4.1 Configuration and assembly of radiosonde station equipment																				
4.2 Transfer of radiosonde station equipment																				
5.1 Installation of the purchased instrumentation system																				
5.2 Checking the rest of the subsystems that constitutes the observation system																				
5.3 Certification of radiosonde station security systems																				
5.4 Communication test and correct operation of the installation																				
6.1 Training of on-site personnel in required observation practices																				
6.2 Monitoring of the tasks necessary for the correct operation of the station according to the essential requirements for a station in the GBON.																				

3.1.2.4 Observational practices for the upper air observations network.

Based on the experiences of other countries used as a reference, as well as guided by the guidelines described in the Manual of the WMO Integrated Global Observing Systems, as well as other documents that serve as a guide for the correct design of observation networks, national observational practices have been defined for the INSMET upper air stations.

Currently there are no qualified personnel in INSMET to operate the radiosonde stations that are intended to be installed in the country, because there is no operating network of upper air stations. INSMET intends to equip its 2 radiosonde stations with 4 observers each, who must receive training in the procedures necessary to carry out radiosonde launches, as well as in the safety check and basic maintenance tasks that must be considered when operating this type of stations.

The competency requirements for the correct performance of upper air observations using a balloon consist of the following practices and procedures:

- ✓ Prepare and deploy balloons and their payload.
    - ➢ Balloon Shed Safety Check.
    - ➢ Preparation and filling of balloons.
    - ➢ Instrument ground verification.
    - ➢ Balloon release.
- ✓ Tracking the balloon flight.
- ✓ Calculate and record upper-air observations and other specialized upper-air observations as required.
- ✓ Calculate and transmit upper air observations using prescribed codes and methods.
- ✓ Care and handling of instruments.

The work regime for these stations, as already explained, must be 2 radiosonde launches per day. See Annex III to know in detail the information flow proposed for radiosonde stations.

3.1.2.5 Preliminary maintenance plan for upper air stations, including calibration practices.

The skills and knowledge of INSMET personnel acquired through training and courses will be fundamental for the sustainable, effective and efficient operation of the network, to comply with GBON requirements. The resources necessary to carry out correct maintenance of the elements of the network of upper air stations are presented in Table 33, in which it is necessary to clarify that only the accessories, materials and tools were added, as well as the recertification of the systems. Other means necessary to carry out the maintenance have already been included in the maintenance of the surface stations, and their request is not necessary again because the calculation made at that time contemplated the maintenance of these stations as well (this is the case of the fuel, traveling standards for the calibration of the AWS instruments associated with the radiosonde station and the vehicles).

Table 33: Analysis of updating resources for maintenance in the National and Regional Maintenance Centers

Name of the center	Accessories, materials and tools for maintenance	Systems recertification
National Maintenance Center (Mariel)	✓	✓
Regional Maintenance Center (Camagüey)	✓	✓

It is advisable to carry out daily safety checks for the balloon room/shed and the hydrogen generation system. In addition, regular training should be provided, at least every 2 years, to ensure that all personnel are up to date on the standards and practices required for these types of stations, as well as for hydrogen generation systems, which must also be maintained and be recertified at 2-year intervals to ensure safety and reliability.

Below are several tables (Table 34, Table 35, Table 36, Table 37) indicating the operational maintenance regime required for the upper air stations of the designed network, as well as which regional center will be in charge of it, the costs of operation of these and the amount of investment necessary for inputs to carry out these tasks.

Table: 34: Stations assigned to each Technical Center for Maintenance (according to planning)

Station name	WIGOS-ID	Corresponding Regional Maintenance Center
Mariel	-	**National**
Camaguey	-	**Regional**

Table: 35: Types of Maintenance and execution intervals

Maintenance Type	Place	Responsibility	Interval
Preventive-daily	In the place	Station staff	daily
Preventive-semi-annual	In the place	Technical staff of the Technical Regional or National Maintenance center	180 days
Corrective	In the place	Technical staff of the Technical Regional or National Maintenance center	less than 3 days

Table: 36: Operational Maintenance Costs

Items	Number of visits (5 years)	Number of stations	Total Cost (USD)
Preventive Maintenance	5	2	7 420
Calibrations/Field Verifications (performed in parallel to preventive maintenance)	5	2	2 480
Corrective maintenance	n/a	n/a	3 100
			13 000

Table: 37: Costs of the resources necessary to perform maintenance on the hydrogen generator

Items	Cost (USD)
Accessories, materials and tools for maintenance	50,000
Systems recertification	70,000
	120,000

Table 38: Distribution phases of the actions to be carried out for the fulfillment of the planned activities in the maintenance of the radiosonde observation networks

Activities	Actions
Acquisition of materials and tools	1.1 Acquisition Process by the implementing entity
Creation of capacities in the different systems of the observation network	2.1 Designs of procedures aimed at achieving adequate practices for good maintenance and verification of systems.
	2.2 Development of software to control maintenance, calibration and breakdown repair activities.
	2.3 Technology and knowledge transfer
	2.4 National training of personnel in the various systems that make up the radiosonde station
3.1 Ensuring daily and semi-annual preventive maintenance, as well as corrective maintenance	3.1 Ensuring daily and semi-annual preventive maintenance, as well as corrective maintenance
	3.2 Assurance of calibrations of the associated AWS instruments

Implementation of the maintenance plan is subject to the availability of field test equipment, spare parts, transportation and fuel.

- It is expected that the process of acquiring resources, as well as the installation of equipment, will be carried out in the first 12 months in Camagüey and 24 in Mariel.
- Starting in Month 9 of Year 2, semi-annual maintenance is expected to be carried out at the Camagüey station, and in Mariel it would begin in month 3 of year 3.
- Because the premises of the radiosonde stations are at risk of explosion, every year a recertification process will be carried out for all the equipment used to comply with ATEX standards.

The planned maintenance schedule for the GBON radiosonde stations will be carried out as follows:

Table 39: Distribution of the activity plan designed for the maintenance of radiosonde observation networks

Station name	Year 1				Year 2				Year 3				Year 4				Year 5			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8
Mariel																				
Camaguey																				

Table 40: Distribution of the activity plan designed for the maintenance and calibration of the radiosonde observation networks (This plan is contemplated from the beginning of the execution phase)

Activities	Year 1				Year 2				Year 3				Year 4				Year 5			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
1.1 Acquisition Process by the implementing entity																				
2.1 Designs of procedures aimed at achieving adequate practices for good maintenance and verification of systems.																				
2.2 Development of software to control maintenance, calibration and breakdown repair activities.																				
2.3 Technology transfer and knowledge related to maintenance																				
2.4 National training of personnel in the various systems that require maintenance at the radiosonde station																				
3.1 Ensuring daily and semi-annual preventive maintenance, as well as corrective maintenance																				
3.2 Assurance of calibrations of the associated AWS instruments																				

3.1.2.6 List of instruments and observing systems by site

Tabla 41: Summary of Technical specifications for new instruments and observing systems for the procurement process

Variable	Measuring range	Sampling Frequency	Operating conditions	Report Resolution	Maximum Uncertainty	Measurement unit
Air Temperature	´-95 to 60 °C	1s	Temperature (-95 to 60°C) Humidity (0 to 100% RH) Wind Speed (up to 180 m/s)	0.1	0.4°C	°C
Relative Humidity	0-100% RH	1s		1	4% RH	%RH
Atmospheric pressure	3 to 1013 hPa	1s		0.1	1 hPa	hPa
Wind speed	0 to 180 m/s	1s		0.1	0.15m/s	m/s
Wind Direction	0 to 360°	1s		1	2nd	°

Note: For more details on this section, go to **Annex V**.

3.2. Design of the ICT infrastructure and services

3.2.1 Detailed description of telecommunications infrastructure and services

INSMET operates a network of surface stations, composed of manual synoptic weather stations and an AWS at the same location. The observations that are made manually in real time from the synoptic stations are sent every 3 hours to the national node, using the FTP protocol, through the INSMET private data network.

There is a 24-hour work group, in charge of monitoring the traffic of manual observations, where the operator, after receiving them, has to interact with a software in charge of validating this data and forming a block with the stations that were exchanged with the Regional Telecommunications Hub (RTH) that for almost two decades the NHMS of Cuba has not been able to carry out due to technical problems.

Manual observations, in addition to being sent via ftp, are stored in the stations and at the end of the month they are sent via FTP for storage in the climatological database (this procedure is not carried out automatically), just like the printed books of observations for analysis in the provincial groups of attention to the station network.

The current ICT infrastructure is obsolete, so to meet the GBON requirements, the system must be renewed and updated from the stations to the INSMET Central Node, including the acquisition systems, database, climatological data management, nodes of WIS 2.0, as well as the data quality verification process.

3.2.2 Technical specifications for the data collection system from the observation station to the collection point

INSMET has an exclusive private data network (VPN), financed by the institution's own budget (see Annex II and Annex III). This financing also covers the repair and maintenance expenses of the Cuban telecommunications company (ETECSA), a state agency in charge of servicing telecommunications in Cuba. This private network is supported through copper pair, optical fiber or VSAT.

The AWS data flow begins with the sampling of data in the datalogger, its storage and statistical calculations, all of this is done automatically every 10 minutes.

In the central node there is software in charge of surveying the recording equipment to request the data and then receive it, either through the 2G/3G/4G mobile telephone network or the VPN. Said data, received every 10 minutes, are then stored in a database, from where they are published on the INSMET website. The data quality verification process is currently not being carried out.

As explained in section 3.1.1.3 in the section on communication systems, in all stations it is intended to install several redundant communication routes, to guarantee that, in the event of any damage, for example due to a meteorological disaster, the loss or delay of existing data related to this factor can be reduced to a minimum. For this, it is necessary to acquire equipment to renew transmission via mobile telephony through the purchase of new 2G/3G/4G modems for each station; also acquire all the necessary elements for optical fiber transmission, from the AWS tower to the station building; as well as to acquire the necessary equipment for VSAT transmission from the station to the INSMET Central Node, which would remain as an emergency backup in the event of failure of the mobile telephony. On the other hand, it is essential to emphasize that all information transmission expenses are financed by the INSMET budget.

3.2.3 Technical specifications for data services (compatible with WIS 2.0 requirements)

Since December 2023, INSMET has been carrying out international data exchange with WIS 2.0. The mere fact of having operating and exchanging data through WIS 2.0 reflects that the design of INSMET's telecommunications infrastructure and services is functional and compatible with the WIS 2.0 requirements imposed for the GBON. In this sense, only an update of the servers that directly intervene in the data control services and guarantee electrical backup would be needed, thereby achieving greater resilience.

3.2.4 Detailed description of measures to ensure the resilience and continuity of the entire data processing chain

To guarantee the resilience and continuity of the entire data processing system, the following actions will be undertaken:

I. **Establish a reliable system for data acquisition**
   - Guarantee the redundancy of communications at the AWS by installing different communication sistems such as optical fiber and VSAT.
   - Acquire an additional VSAT reception system to install in the Central Node so that the information sent by the stations through that communications channel can be received directly there.
   - Acquire an additional server that functions as redundancy for the primary acquisition system.

II. **Establish a secure and reliable system for data storage**
   - Guarantee the acquisition of equipment for the necessary storage of data, achieving traceability of the climatological database.
   - Provide redundant storage with the objective of guaranteeing national and international access to data used by operational applications in real time.

III. **Electric backup**

- Guarantee the operation of the AWS, the radiosonde stations and their communications systems, increasing their battery bank and solar charging system.
- Purchase some UPS and a hybrid solar power system for the server room.
- Acquire a diesel generator for the Central Node.

Proposed activities

I. Meetings with the telecommunications company (ETECSA) to define the technical parameters of the VSAT systems

II. Prepare the necessary technical specifications for the design and programming of the update of the Automatic Weather Monitoring System (SISMAT).

III. Update the SISMAT acquisition module, which includes redundant communications paths.

IV. Update SISMAT to take into account climatological data management systems, data quality control and metadata from all stations.

V. Design and programming of a data dissemination system with visualization tools and real-time monitoring of observation platforms

VI. Establish reliable and redundant connectivity, as well as ensure appropriate power backup

VII. Training of specialists with the different communication channels.

VIII. Training of specialists in different power sources.

IX. Training of staff in the use of the WIS 2.0 data collection system.

X. Training of staff in the use of data management software.

3.3. Design the data management system

Currently, most of INSMET's systems and databases work in isolation, even within the headquarters premises in Casablanca. The lack of integration causes a significant loss of efficiency and does not allow information from various sources to be concentrated for better analysis. The integration of all observation and information systems within a data flow would allow the full potential of INSMET to be fully exploited in terms of available data and human resources.

The lack of integration of systems and data flows is also linked to the absence of redundancy that allows data to be saved and service maintained in the event of computer equipment failure. Therefore, the design and implementation of this new proposal, based on modern redundant systems, is a priority to guarantee the security and sustainability of INSMET data.

The current climatological data management system uses input data from stations [assisted manual weather stations and automatic weather stations (used in these cases to read three-hourly measurements)]. However, the system does not have the ability to receive data automatically without human intervention. These data are sent to the National Center during the three-hourly observation times, through FTP (via an FM12 SYNOP message) and/or telephone.

The data quality control, data processing, analysis, and product generation are performed manually. This option is labor-intensive, time-consuming, and compromises data quality due to human intervention when recording data at the station and entering it into the system.

In view of the existing challenges and risks related to data quality and loss, there is a need to improve said system with the capacity for automation of all its processes, including data reception, quality control, data processing, data analysis (including big data processing and analysis) and product generation. The system is proposed to include a climatological data collection node, which will automatically receive and store data from weather stations, to prioritize elements of the GBON.

Updating the Database Management System (DBMS) through SOFF will add significant value in the implementation of this project, as it will improve INSMET's ability to perform quality control of the information received from the station before being archived and processed in the WIS 2.0 central node.

Another of the great solutions planned for this project is to provide redundant centralized storage of all the services provided, achieving better operability and access to said services in real time, as well as greater availability and storage capacity for the maintenance of climatological databases.

The WIS 2.0 node is already working (although it does not present redundancy which must exist), but the 14 stations that are currently exchanging data, are operating in a simplified version, as there were not the necessary resources for a good design when it was conceived. It can be guaranteed that with all the resources planned in the designed solution, it will work much better. The flow of this process consists of:

1. Create a BUFR file in sets of all our stations.
2. Upload that BUFR file (following a specific path and name format) to an S3 server created using Minio.

3. Wis2box is then responsible for creating a separate BUFR file for each station from the original and, through the MQTT service inside, sends a publication for each station file with a download link from our server for said file.
4. The global caches subscribed to our publications by MQTT then download those files, cloning the same structure of our publication and then send their own publication regarding our data changing the download links to the files that were cloned in the cache so that they are for global use.
5. Anyone who is subscribed to the global Cuba topic through any of the services offered for this purpose then receives the notification issued by the global cache and can download the data if desired.

Table 43 presents the investment proposal to improve the infrastructure, telecommunications services and the control and data management system at INSMET.

Below is a table (Table 42), which provides detailed information on the tasks of each of the systems that composes the Data Control System.

Table 42: Summary of tasks carried out by the different systems that composes the Data Control System

Component	Completed tasks
Acquisition system	Perform remote communication with the stations using mobile telephony, VPN or VSAT.
Quality control system	Carry out quality controls through verification and monitoring of: ✓ Instrumental or physical limits. ✓ Climatological limits. ✓ Maximum temporal variability allowed. ✓ Consistency checks between variables.
Database system	Store measurements of meteorological variables on the Database server.
Monitoring system	Monitor the operational status of the stations through SISMAT.
	Maintain high availability of services.
Configuration system	Configuration of the monitoring system indicators.
	Station metadata configuration.
Publishing system	WIS 2.0 node.
	Visualization of data in real time (forecast).
	Climatological database.
	INSMET website.

3.4. Environmental and sustainability considerations

INSMET will strive to minimize the environmental impact of observing technologies and will also strive to comply with GBON. Surface observation networks will be designed, implemented and operated with the objective of having sustainable meteorological and climatological observation systems. Consumables for upper air stations will comply with environmental regulations for batteries, packaging and hazardous substances, considering the use of biodegradable packaging whenever possible.

INSMET will also consider the use of instruments that have the option of replacing subcomponents or subsystems instead of disposing of the entire instrument. The plan is to develop a SOP that guides the reuse of instruments and the disposal of single-use plastics or all-in-one sensors. Technicians will also be trained in instrument repair and advanced fault diagnosis in support of this initiative. Other specific sustainability considerations include:

AWS: It is recommended that rehabilitated AWSs that already have civil infrastructure (for example, electricity, wind mast, etc.), can reuse it and can have environmentally friendly maintenance. With preventive and corrective maintenance, as well as scheduled calibration, the life cycle of the sensors will be extended as much as possible. Renewable solar energy will be used with the aim of reducing the country's carbon footprint and going in line with global and national policies on the use of renewable energy.

Upper air station: The radiosonde stations will be located in places where permanent personnel work daily, despite these being semi-automatic, this will reduce prolonged and unnecessary trips of personnel in the event of minor breakdowns and the great financial implications that may be associated with this aspect. Regular (i.e. almost permanent) care can be guaranteed. The bidding process will also emphasize quality criteria related to material selection, where applicable. The investment in a radiosonde system will be made over 20-30 years and therefore care must be taken to ensure annual maintenance throughout its life cycle. This has high financial cost implications for the operation. Local generation of hydrogen, which the balloons need, at the station will make the operation more environmentally sustainable.

Table 43: Investment proposal to improve infrastructure, telecommunications services and the data control and management system at INSMET

Goals	Component	Amount	Cost (USD)
Updating infrastructure and power supplies	Power supply backup in adverse situations	1	70,000
	Solar Kit	1	26,800
	Electric Backup System	-	53,940
	Air conditioning	2	5,000
	Construction maintenance	1	9,000
	Complete active protection system against electric shock and grounding	1	20,000
Update of telecommunications services	VSAT system	1	9,000
	Communications equipment	-	46,400
Updating data management services	Servers	4	124,000
	(NAS) for redundancy purposes	2	24,000
	Assurance for software development and licenses for the software used	1	60,000
	System for visualization and monitoring in real time	1	12,000
			460,140

Module 4. GBON Human Capacity Development Modul

4.1. Assessment of human capacity gaps

INSMET is a national institute with a vertical structure and management, which has independent legal personality and its own assets; It is directed by a General Director who is the one who appoints the other leaders of the Central Headquarters of his institution and with the approval of the Territorial Delegates of CITMA, appoints the Directors of the Provincial Meteorological Centers. INSMET, in turn, has a general directorate, a deputy director, five directorates, nine national centers, fourteen CMPs, twenty-eight subdirectorates distributed in the CMPs, and five departments subordinate to the CMP of Camagüey. This distribution can be better seen in Figure 5.

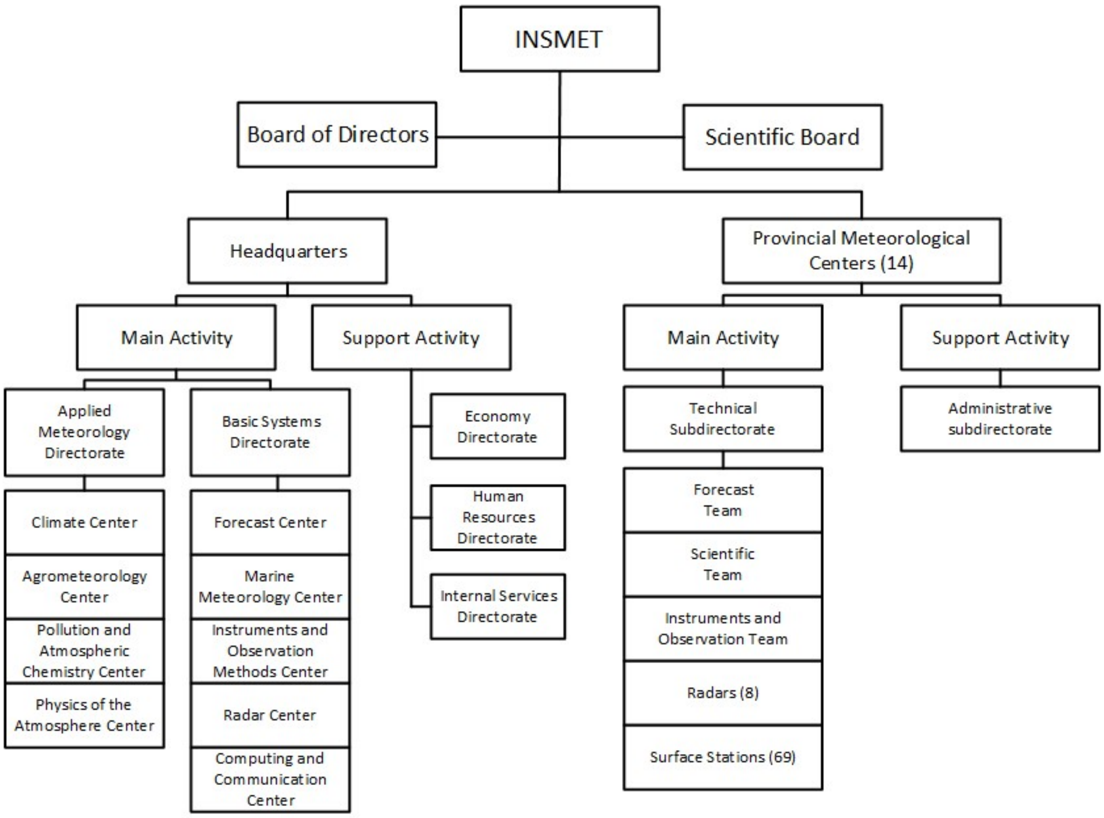


Figure 5: Composition of the different INSMET centers

The total number of workers at the institution is 1,245, of which 564 are university graduates (45.3%) and 596 are technicians (47.8%), 548 are women (44%) and 60 are managers. It also has in its ranks a total of 54 trained, 36 doctors and 138 masters in science, as well as various categorized professionals, of which 67 are categorized in research and another 57 are in teaching. The salary of INSMET workers is financed by the budget that the Cuban state dedicates to said institution, of which approximately 37.6% of the institution's total salary fund is dedicated to the instruments and observations working groups that serve to the country's weather stations.

In Cuba, the personnel hiring system by INSMET is not centralized, that is, there are several ways to recruit a new workforce in the different areas served by the institution. The main way to enter new personnel is through agreements with the main universities in the country, mainly in

Havana, (the only place in the country where meteorology is studied) so that some of the graduated students carry out their work practices at the institution. , ensuring that in many cases these university students complete their diploma work at the institution and then become an active part of it, once they graduate. The remaining ways are through calls on social networks or the mass media of job offers or through the dissemination channels of the Ministry of Science, Technology and Environment or the Ministry of Labor and Social Security.

In the case of the necessary places in the meteorological stations, each year local calls are launched in the places where these facilities are located, to fill the places for meteorological observers in need. A training course is prepared for those interested and at the end of it they are given an exam, which is sent to the CMP, and they in turn forward it to the Headquarters, for review by the technical specialists of the National Observation Instruments and Methods Group. Once the results are concluded, those approved occupy the position and continue in training by the most experienced observers. The positions of Station Chief and Station Inspector can only be occupied by personnel who already have previous observer experience.

The main operational needs of the technical staff at this time are transportation to the stations, the lack of supplies, materials and tools to adequately meet maintenance deadlines, as well as the lack of financing to cover these needs, it is considered that through the correct implementation of this project, as stated in module 3, these gaps and results will be covered. Currently the state budget is the one that covers the payment of the workers and technical personnel in charge of the INSMET stations, therefore it is an issue that will not be charged to the project.

4.2. Design capacity development activities for technical staff

To guarantee the proper functioning of the activities related to observations, INSMET, through the Directorate of Basic Systems, more specifically through its Center for Observation Instruments and Methods, guarantees that all meteorological instruments used to carry out the observations observations are in good condition, and in turn have a valid calibration certificate, from the Calibration Laboratory located at the headquarters of the center itself. This center will be the governing body for all the technical activity developed throughout the framework designed to meet the requirements demanded by GBON.

The Center for Instruments and Methods of Observation (CIMO) is divided into three fundamental working groups, these are the observation methods group in charge of verifying and ensuring that the standards required by the WMO are fully met at the stations. meteorological; the Calibration Laboratory group in charge of verification, calibration and certification of the instruments of the meteorological station network; and the technological introduction and automation group in charge of assembly, integration, configuration, maintenance, software development and automation of the different systems that make up the network of surface stations in their manual and automatic variants in the country.

These groups are assisted by the Group of Instruments and Methods of Observation (GIMO) located in each Provincial Meteorological Center and are made up of a Chief, an inspector, a specialist-reviewer and an instrumentalist whose main job is to periodically review the correct operation. of the different systems of the station network and detect possible deficiencies promptly.

At the stations there is a station chief, a conductor and 4 observers, in constant communication with both the provincial GIMO and the CIMO, in order to resolve any breakdown that arises in the course of the work, which depending on its magnitude and scope, It may or may not be resolved by the station workers themselves. This entire explanation can be seen in more detail in Figure 5.

However, taking into account the modernization of equipment and the substantial changes in some of the technologies currently used, it is essential and a priority to create capabilities in the groups in charge of instrument maintenance, repair of new types of instruments, monitoring and maintenance of communications equipment, as well as updating methods for assembly, calibration (laboratory and on-site), integration and configuration of the new technologies acquired through this project.

To ensure that these operations are carried out in a fluid and sustainable manner, in pursuit of compliance with GBON requirements, the project will guarantee the creation of the necessary capabilities for existing experts (engineers) to maintain all the designed infrastructure.

The main areas where actions aimed at developing the capabilities of technical personnel must be carried out will be:

- ✓ Assembly, integration and maintenance of automatic surface weather stations.
- ✓ Update of the state of the art of the observations system infrastructure.
- ✓ Assembly, certification, integration and maintenance of grounding and protection systems against electric shocks.
- ✓ Assembly, certification, integration and maintenance of hybrid power systems.
- ✓ Assembly, certification, integration and maintenance of calibration systems for the laboratory and the field.
- ✓ Update of the state of the art of calibration techniques.
- ✓ Assembly, integration and maintenance of communications equipment.
- ✓ Repair and maintenance of meteorological instruments.
- ✓ Assembly, integration, monitoring and maintenance of daily security of upper air stations.
- ✓ Update of information collection techniques through the use of WIS 2.0.
- ✓ Real-time monitoring of data from weather stations.
- ✓ Update of the state of the art of data quality techniques.
- ✓ Creating a work incentive package

4.3. Design capacity development activities for senior management

To ensure an improvement in INSMET's strategic organization, each senior executive requires superior skills to manage all resources within the organization effectively. Therefore, the development of capabilities for senior management must include as fundamental aspects:

- Understand and use strategic planning tools.
- Prepare and develop strategic planning.
- How to react effectively and quickly to technological changes within the organization.
- Analytical tools available to help identify the cause of problems.
- Develop appropriate strategies for greater personal, team and organizational effectiveness.
- Project management skills.
- Quality management skills.

To provide members of senior management with the necessary skills, the project will ensure the training of management personnel in the aforementioned aspects.

4.4. Gender and CSOs considerations

In Cuba, the inclusion of all individuals in society in national plans has always been a task of capital importance for the government. INSMET, being a government institution, meets these requirements as a fundamental premise. Varied is the composition of individuals at all levels of organization of said institution, as well as their academic level, race, gender, etc.

Meteorology in Cuba enjoys a certain relevance gained on its own merits, over the years by the different specialists who fulfill this role in society. This, added to the importance that the government attaches to preparation to prevent risks and disasters related to extreme weather phenomena, and their timely dissemination in all mass media in the country, means that all Cuban Civil Society Organizations have a direct or indirect link with INSMET.

In most of the municipalities of Cuba, the place where the different meteorological stations are located, are nerve centers for the development of science in said region, carrying out activities of all kinds throughout the year to promote the care and protection of the environment. environment, the development of science and innovation, as well as the connection of individuals from different communities with these activities.

4.4.1 Gender

INSMET will continue to make efforts to ensure gender equality in the promotion of meteorological and climatological services. In Cuba, the empowerment of women is a premise of the government, framed and contemplated by the Constitution through the Law for the Advancement of Women, which has as its fundamental objective that Cuban women have the same opportunities as men in the performance of management and development functions in the main branches of the country, thus breaking with contemporary sexist foundations, and giving modern Cuban society an inclusive air.

INSMET will work with project partners and stakeholders to promote gender equality in meteorology, thus ensuring gender participation as an active part of the project itself. In accordance with the recommendations identified by the WMO Infrastructure Technical Commission (INFCOM), project partners will work to develop strategies for the promotion of gender balance in project activities. In particular, partners will take active measures to ensure that capacity development opportunities, participation in coordination activities and promoting the visibility of gender contributions serve to encourage young women scientists to take an interest in meteorology and science. climatic.

This gender consideration has been included in the results framework, to ensure that there is at least 50% female representation in capacity development activities. Gender consideration has been addressed from the beginning of the implementation of the SOFF project, that is, from its early stages, including the SOFF preparation activities in which the participation of men was considered by the project team and participants in the organized activities. and women, as well as different age groups.

4.4.2 Civil Society Organizations (CSOs)

Both INSMET and UNDP have excellent relations with the different Cuban civil society organizations, so as in this project, both INSMET and UNDP will work together, it will be much easier to involve these organizations in the identification of its potential to contribute to GBON and thus raise awareness about the relevance of the different aspects that GBON comprises, having as its fundamental objective the strengthening of associations with all civil society organizations and the private sector.

Through the SOFF initiative, efforts will be made to expand the partnership between INSMET and the private sector, practically non-existent at this time, to explore mechanisms that support the execution of the SOFF Investment Program where appropriate.

Table 44: Estimated cost of activities designed for capacity development

Goals	Activities to develop	Amount of people	Total Cost (USD)
Capacity development for technical staff	Assembly, integration and maintenance of automatic surface weather stations.	6	30 960
	Update of the state of the art of the observations system infrastructure.		
	Training in updating the acquired measurement systems.	4	31 680
	Repair and maintenance of meteorological instruments.		
	Assembly, certification, integration and maintenance of grounding and protection systems against electric shocks.	3	15 480
	Assembly, certification, integration and maintenance of hybrid power systems.	3	15 480
	Assembly, certification, integration and maintenance of calibration systems for the laboratory and the field.	8	90 735
	Update of the state of the art of calibration techniques.		
	Assembly, integration and maintenance of communications equipment.	4	13 320
	Assembly, integration, monitoring and maintenance of the security of upper air stations.	6	58 080
	Training in radiosonde practices.		
	Training in the acquired radiosonde systems.		
	Update of data transmission and reception techniques through the use of WIS 2.0.	4	20 640
	Real-time monitoring of data from weather stations.	4	20 640
	Update of the state of the art of data quality techniques.		
Development of senior management capabilities	Creation of skills of INSMET senior managers in the identified needs	6	24 960
	Conducting national training workshops	-	90,000
	Transfer of technology and national knowledge	-	55,000
	Long-term technical support and consulting	-	120,000
			586 975

Module 5. Risk Management Framework

5.1 Assess the risks of the observing network and propose mitigation measures

Risk	Risk level	Probability	Impact	Action to mitigate risk
Impossibility of meeting the deadlines set in the project due to delays in the purchasing and supply processes	Moderate	Infrequent	Half	✓ Carry out the equipment acquisition process through direct purchases with suppliers (of meteorological instruments) approved by INSMET.
Problems with the availability of construction materials for infrastructure works	High	Very likely	High	✓ Arrange to collect the required materials as far in advance as possible.
Availability of fuel in the country for execution	Half	Likely	High	✓ Have a fuel reserve in the Regional Technical Centers to support Maintenance, in case of emergency. ✓ Have advance planning of activities.
Vandalism/Theft of installed equipment	Low	Unlikely	Low	✓ Apply the necessary security measures in storage places before being installed.
Lack of national visibility of the project	Low	Unlikely	Low	✓ Conduct outreach workshops to promote project results ✓ View the project on the INSMET website.
Delay in delivery times in software development	Low	Unlikely	Low	✓ Hire well-known institutions, with previous work history, to ensure the quality and delivery of the projects.
Compatibility of the acquired technology with the existing one	Low	Unlikely	Low	✓ Ensure in the technical specifications the possibility of installing new measurement systems, according to their operating principle.

Risk	Risk level	Probability	Impact	Action to mitigate risk
Delay in the calibration processes of the INSMET Laboratory standards and traveling standards	Half	Unlikely	Half	✓ Have redundancy of equipment available so as not to stop the calibration processes due to lack of standards in the Laboratory.
Outdating of acquired systems	High	Very likely	High	✓ Consider equipment hardware and software updates in the acquisition process.
Lack of training for weather station personnel	Half	Likely	Half	✓ Design a national training schedule that includes improving the capabilities of surface and radiosonde station personnel.
Difficulty of maintaining weather stations	Half	Likely	High	✓ Ensure the deadlines of the resources necessary to carry out maintenance
Outdating of laboratory equipment	Half	Likely	Half	✓ Prioritize the acquisition of equipment for the Calibration Laboratory

Module 6. Transition to SOFF investment phase

The members involved (INSMET, UNDP and AEMET) will work together to prepare the financing request for the investment phase, based on the recommendations provided in this plan.

The main efforts will focus on carrying out, together with the implementation of this Contribution Plan, the preparation of a national project (following the country's regulations) that must contain all the investment activities, as well as the compliance schedules. This entire national project is presented in parallel to the Ministry of Foreign Trade of Cuba, for approval. This Ministry is in charge of coordinating the execution of this project nationally and endorsing the implementing entity (in this case the UNDP) nationally.

For a better analysis and understanding of the Contribution Plan, with respect to the use and availability of financing during the duration of the project, 2 tables have been designed. Table 45 summarizes the total project investments by category, and references where to find the detailed investment breakdown of each category in this document. In the case of Table 46, this shows in detail the INSMET Investment Plan, where all the elements analyzed in the remaining Modules of this project are taken into account, dividing it into three phases throughout the execution time, which will be :

1. Installation (Expected financing, necessary per year for operational expenses, acquisition and installation of all equipment).
2. Maintenance (Planned financing, necessary per year for operational expenses, acquisition and maintenance of all equipment).
3. Training (Planned financing, necessary per year for the training of INSMET personnel on issues related to equipment maintenance).

This will provide a clearer idea of the use of the investment throughout the project execution period.

Table 45: Summary of planned investments by category

Category	Component	Location	Cost (USD)
Surface Stations	1.1 Instrumentation System	Module 3 (Table 13)	208,410
	1.2 Power Supply System	Module 3 (Table 13)	306,300
	1.3 Grounding System and Lightning Rod	Module 3 (Table 13)	234,300
	1.4 Communications System	Module 3 (Table 13)	195,245
	1.5 Infrastructure System	Module 3 (Table 13)	204,700
	1.6 Strengthening Regional Installation and Maintenance Centers	Module 3 (Table 20)	798,900
	1.7 Maintenance operating expenses	Module 3 (Table 19)	161,600
	1.8 Calibration Laboratory	Module 3 (Table 23)	520,400
			2,629,855
Radiosonde Stations	2.1 Buildings and facilities (Infrastructure and protection systems)	Module 3 (Table 30)	229 200
	2.2 Hydrogen generation system	Module 3 (Table 30)	679,000
	2.3 Equipment, Power Supplies and Communications System	Module 3 (Table 30)	240,300
	2.4 Spare Parts and Consumables	Module 3 (Table 30)	1,587,000
	2.5 Operational Maintenance Expenses	Module 3 (Table 30)	13,000
	2.6 Expenses of materials to carry out maintenance on radiosonde stations	Module 3 (Table 30)	120,000
			2,868,500
TIC	3.1 Updating Infrastructure and Power Sources	Module 3 (Table 43)	184,740
	3.2 Update of telecommunications services	Module 3 (Table 43)	55,400
	3.3 Updating data management services	Module 3 (Table 43)	220,000
			460,140
Human resources training	4.1 Capacity development for technical staff	Module 4 (Table 44)	297,015
	4.2 Development of senior management capabilities	Module 4 (Table 44)	24,960
	4.3 Operating costs of activities to promote capacity development in the country	Module 4 (Table 44)	265,000
			586,975
			6,545,470

Table 46: Estimated distribution of investments within the 5 years of project implementation

Phase	Necessary financing				
	Year 1	Year 2	Year 3	Year 4	Year 5
Facility	1,382,780	867,890	501,925	5,000	0
Maintenance	912,860	998,160	506,093	385,493	398,294
Training	227,205	180,250	78,160	56,000	45,360
	2,522,845	2,046,300	1,086,178	446,493	443,654
	6,545,470				

Summary of GBON National Contribution Plan

Component	Section	Recommended activities
Module 2.GBON business model and institutional development	2.1 Evaluation of national governmental and private organizations of relevance to the operation and maintenance of GBON	1. Strengthen ties with national institutions and especially private sector operators that may be interested in supporting GBON stations.
		2. Conduct workshops to evaluate the potential of national institutions as well as private sector operators interested in supporting the implementation and sustainability of GBON stations.
		3. Identify different national governmental and private organizations that can carry out specific tasks in the implementation of the project.
	2.2 Evaluation of possible GBON subregional collaboration	4. Support the implementation of other SOFF projects in the region in specific areas identified in this plan.
		5. Strengthen Cuba's leadership in the region.
		6. Coordinate data exchange actions between the NMHSs of the region.
		7. Identify the areas of greatest exchange interest in the region.
	23 Evaluation of a business model to operate and maintain the network	8. Expand the services provided by the calibration laboratory nationally and internationally.
		9. Approve the calibration laboratory as a regional calibration center.
		10. Expand the provision of services by updating the equipment necessary for data processing.
	2.4 Evaluation of existing national strategies and projects related tocaught up with network observation	11. Closely monitor policies that may affect the implementation of the project, and take the necessary measures to reduce their risks.
		12. Continuously engage with the government and its institutions in the development of development and common benefit strategies.
	2.5 Review of national legislation relevant to GBON	13. Be governed by current regulations and legislation to facilitate and enable the implementation of the project without setbacks.
		14. Procure all the necessary documentation for the presentation of the national project derived from the implementation of this international project.

Component	Section		Recommended activities
Module 3.GBON infrastructure development	3.1 Design the surface and altitude observation network and observation practices.	Surface Stations	1. Establish the necessary technical specifications in the new and rehabilitated surface stations in each of the 5 subsystems analyzed in this plan.
			2. Install a new surface station, almost completely rehabilitate another 4 and partially rehabilitate another 5, of the total of 9 surface stations approved in the national gap analysis.
			3. Renew the equipment installed with many hours of operation for the surface stations, in order to guarantee the future sustainability of the measurements.
			4. Guarantee the resilience of the stations, inserting certified grounding and lightning rod systems, renewable energy sources and redundant communications routes, to reduce the impact of extreme adverse phenomena.
			5. Establish a new Regional Maintenance Center in the eastern region of the country, to minimize response times to network breakdowns and guarantee the maintenance and calibration deadlines outlined in the plan.
			6. Strengthen and ensure the maintenance and calibration tasks of the stations, as a basis for the final quality of the data obtained.
			7. Train personnel in all the technical tasks necessary to guarantee the proper functioning of the observation network.
		Radiosonde Stations	8. Ensure compliance with activities 1, 4, 5, 6 and 7 previously described as part of Module 3 of this summary for radiosonde stations.
			9. Install 2 new radiosonde stations.
			10. Establish observational practices appropriate to their recommendations and international standards.
			11. Guarantee with the suppliers of the consumables for the radiosondes the security of providing the radiosondes during the duration of the project.
Component	Section		Recommended activities
Module 3.GBON infrastructure development	3.2 Design of ICT infrastructure and services		12. Guarantee the resilience of INSMET's infrastructure and telecommunications systems.
			13. Seek appropriate technical specifications for data collection systems.
			14. Implement the transmission of all information through WIS 2.0, guaranteeing the necessary quality rates according to GBON requirements.

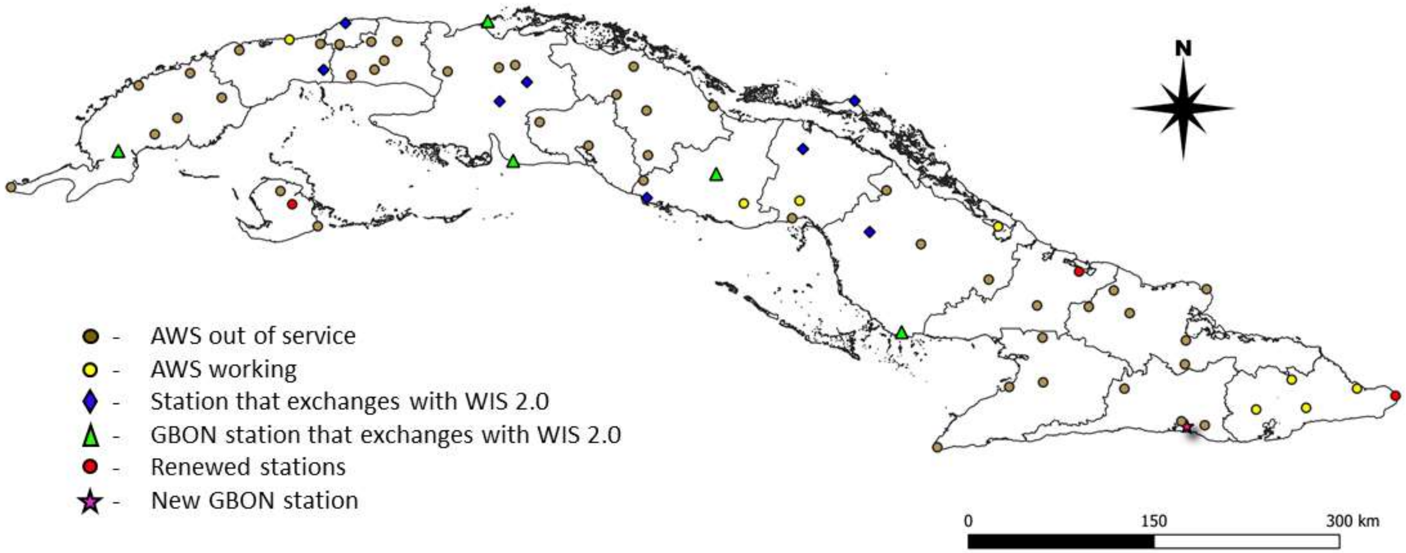
		15. Seek real-time monitoring and visualization tools for installed observation platforms.
		16. Train the technical personnel in charge in all the tasks necessary for the correct functioning of this section within the observation system.
	3.3 Data management system design	17. Update the computational elements that make up the data management system to eliminate the obsolescence that these systems currently have in INSMET.
		18. Design the INSMET data management system taking into account key elements such as equipment redundancy, storage of database files and data processing, as well as the quality of the processes.
		19. Train the necessary personnel in data management systems to guarantee the correct functioning of this section within the observation system.
	3.4 Environmental and sustainability considerations	20. Select environmentally friendly materials during the development and day-to-day operation of GBON stations.
		21. Guarantee that the technical characteristics of the acquired equipment meet the environmental requirements of the project.
		22. Integrate project sustainability considerations into the management of GBON station operations, including the installation, calibration and maintenance phases.

Component	Section	Recommended activities
Module 4. Development of human capabilities	4.1 Assessment of human capacity gaps	1. Carry out continuous evaluations of capacity gaps in areas related to the configuration, calibration, installation and maintenance of meteorological instruments, as well as the remaining subsystems that make up the observation system of meteorological stations.
		2. Explore areas of collaboration to address identified capacity gaps
	4.2 Design of capacity development activities for technical staff	3. Carry out the technological and knowledge transfer necessary for the exploitation of the resources acquired directly from their suppliers.
		4. Coordinate the training tasks of technical personnel in the configuration, calibration, installation and maintenance of meteorological instruments, as well

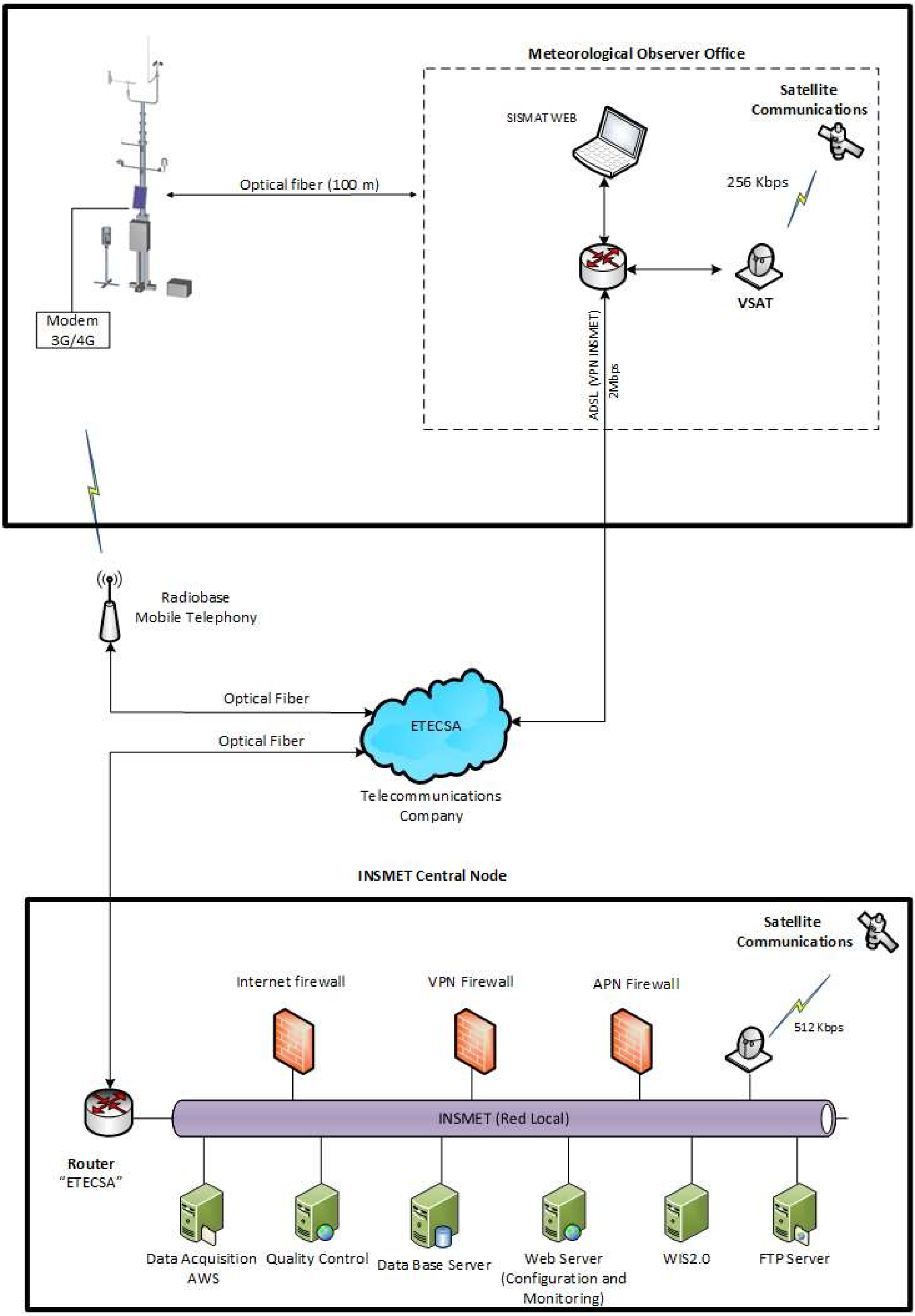
		as the remaining subsystems that make up the meteorological station observation system.
		5. Coordinate the training tasks of the technical personnel in charge of the meteorological data processing and quality systems.
	4.3 Design of activities for capacity development for management personnel	6. Train the personnel in charge of senior management in the identified needs.
	4.4 Gender considerations and Civil Society Organizations (CSOs)	7. Organize workshops with stakeholders to raise awareness about the role of civil society organizations in the implementation of SOFF, as well as their contribution to GBON.
		8. Organize awareness seminars with university students from careers related to the project profiles in order to insert them into the project tasks.
		9. Emphasize gender considerations, according to the dynamics of the country's policies in this aspect.
		10. Raise awareness among the local authorities of the communities surrounding the stations included in this project of the global importance of the project and the importance that its care and preservation must have.
Component	Section	Recommended activities
Module 5. Risk management model	-	1. Consider the main issues that could entail risks in the execution and investment phase in the different project scenarios, as well as the activities proposed to mitigate said risks.
Module 6. Transition to the SOFF Investment Phase	-	1. Prepare the financing request for the investment phase of the SOFF project.
		2. Evidence the anticipated start of project execution.
		3. Create an investment table where the necessary financing is differentiated into two phases: 1st: Installation 2nd: Maintenance and broken down in relation to the duration of the project.

Annexes

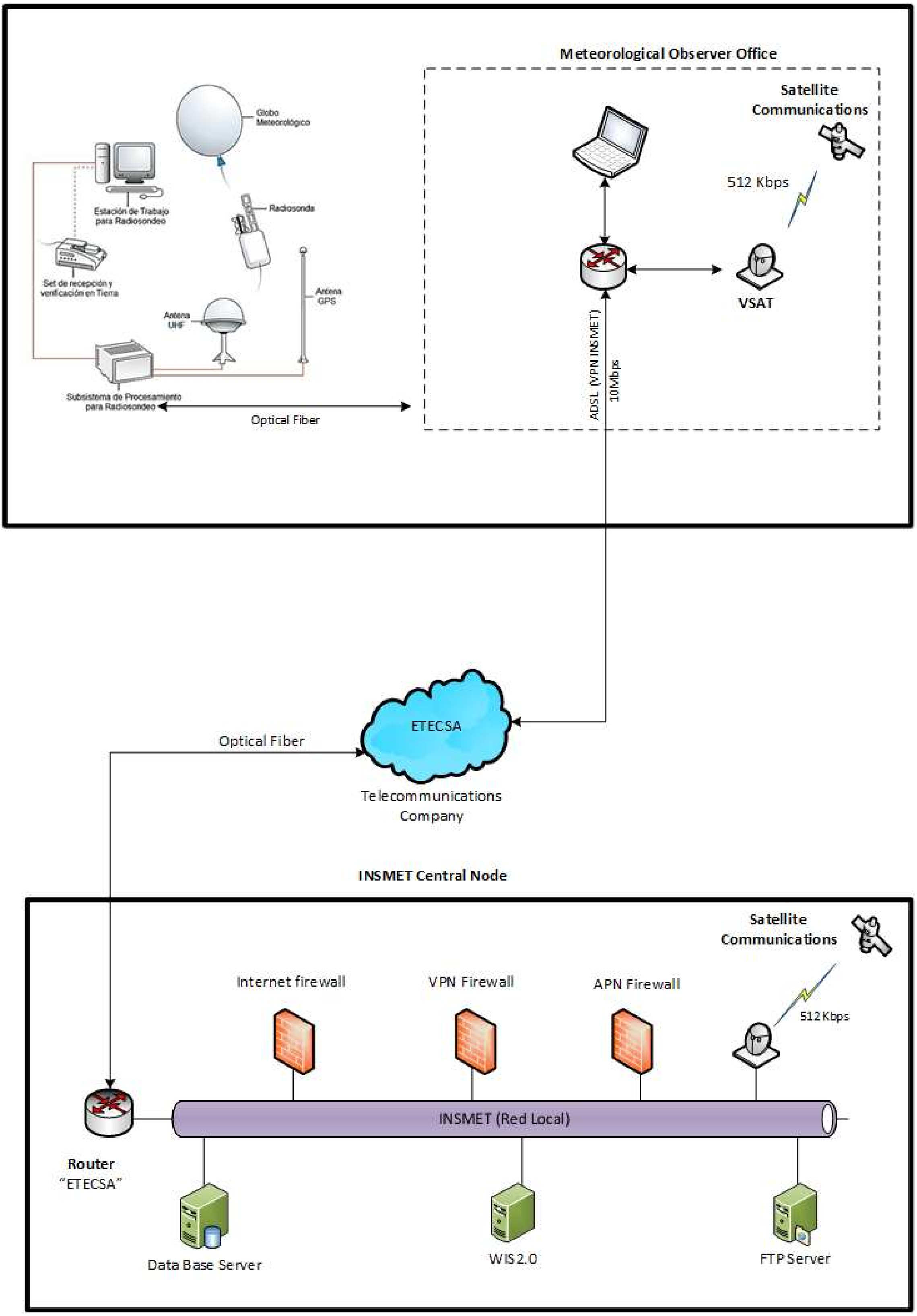
Annex I "Location map of the AWS of the INSMET surface observation network"



Annex II “Information flow from surface stations”



Annex III "Information flow from radiosonde stations"



Annex IV "Technical characteristics required for sensors installed in the network of new or rehabilitated surface stations"

Atmospheric Pressure

ID	Requirement Heading	Requirement
27	Measurement Range	The measurement range must be 500 – 1080 hPa (for both station pressure and mean sea level pressure).
29	Sensor Performance Constant	The instrument time constant, under controlled conditions must be 2 s or shorter.
31	Operational Conditions	As a minimum, the equipment installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH, Non-condensing] and Wind Speed up to 50 m/s. Resistance to (vibration) shocks must be included.
508 and 40	Achievable Sensor Uncertainty	The sensor uncertainty must be 0.15 hPa or better. For the tendency it must be equal or better than 0.2 hPa. Maximum difference: 0.3 hPa/year. No more than 0.3 hPa/30 °C temperature change. For the tendency it must be equal or better than 0.2 hPa. Hysteresis less than 0.3 after change of 50 hPa and back again..
42	Static Head	To achieve the required uncertainty of the pressure measurements, a static head, should be used. If used, the static head should be located in an open environment, not affected by the proximity of buildings. The supplier should provide documentation specifying any additional uncertainty introduced by the use of their static head.
502	Sensor Type	The sensor/instrument for measuring pressure must be based on an electronic pressure sensor. However, any sensor type compliant with the requirements in this section must be considered
524	Temperature Correction in Calibration	If the instrument is applying a correction for the ambient air temperature (measured internally or with a separate thermometer), the temperature compensation function should be fully taken into account in the calibration procedure.
28	Reporting Resolution	The resolution of reported measurement and tendency must be 0.1 hPa.
30	Sampling Frequency	The pressure should be sampled at least 4 times over the interval of the sensor time constant. For example, if the sensor time constant is 2 seconds, then there should be a sample at least every 0.5 s.
56	Units	Whatever physical quantity measured, pressure must be presented in/by the instrument/ system in hectopascals (hPa).
32	Calculated Parameters	Averages of all valid samples of pressure must be produced over 1-minute intervals. The 1-minute average must be used as the instantaneous value for pressure.
35	Rate of Change Check	After each signal measurement, the current value should be compared to the preceding one. If the difference between two samples is more than 0.3 hPa, the

		current sample is identified as suspect and is not used for the computation of an average.
38	Stuck Sensor	If over a 60-minute interval the value of 1-minute values of pressure have not changed by 0.1 hPa, then the data should be flagged as suspect for further investigation
39	Jump Check	If the difference between consecutive 1-minute averages is more than 0.5 hPa, then the data should be flagged as suspect for further investigation. If the difference is more than 2 hPa, then the data should be flagged as erroneous for further investigation
949	Derived Parameters	The pressure tendency should be determined using the difference between the current pressure measurement, and the pressure values over the previous 3 hours

Air Temperature

ID	Título del requisito	Requisitos
1	Measurement Range	**The measurement range must be -80 °C to +60 °C**
4	Sensor Performance Constant	The instrument time constant under controlled conditions must be 20 s or shorter over the entire operational range. For field measurements in non-actively aspired radiation screens this may not be achievable.
6	Operational Conditions	As a minimum, the equipment installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH, Non-condensing] and Wind Speed up to 50 m/s. Resistance to (vibration) shocks must be included.
25	Sources of Error	The Tendered equipment must demonstrate that the following common sources of error have been adequately compensated for: a) Self heating of the thermometer element b) Inadequate compensation for lead resistance c) Inadequate compensation for non-linearities in the sensor or processing instrument d) Sudden changes in switch contact resistance.
400	Achievable Sensor Uncertainty	The sensor uncertainty must be 0.2 ºC or better.
2	Units	Whatever physical quantity is measured Air Temperature must be presented in/by the instrument/system in degrees Celsius (°C).
3	Reporting Resolution	The resolution of the reported temperature must be 0.1 °C.
5	Sampling Frequency	The air temperature should be sampled at least 4 times over the interval of the sensor time constant. For example, if the sensor time constant is 20 seconds, then there should be a sample at least every 5 seconds
7	Calculated Parameters	Averages of all valid samples of Air Temperature must be produced over 1-minute intervals. The 1-minute average must be used as the instantaneous value for air temperature.
8	Observation Extremes	The maximum and minimum temperature 1-minute (average) temperature values measured over a 24-hour period must be determined [=daily maximum/minimum]. The time of occurrence must also be stored.

34	Rate of Change Check	After each signal measurement, the current value should be compared to the preceding one. If the difference between two samples is more than 2 °C, the current sample is identified as suspect and is not used for the computation of an average
36	Jump Check	If the difference between consecutive 1-minute averages (calculated one minute part) is more than 3 °C, then the data should be flagged as suspect for further investigation. If the difference is more than 10 °C, then the data should be flagged as erroneous for further investigation
37	Stuck Sensor	If over a 60-minute interval the value 1-minute values of air temperature have not changed by 0.1 °C, then the data should be flagged as suspect for further investigation

Humidity

ID	Título del requisito	Requisitos
69	Sensor Performance Constant	The instrument time constant under controlled conditions must be 40 s or better over the entire operational range. If used for Dewpoint Temperature measurement, then the sensor time constant must be 20 s.
160	Operational Conditions	As a minimum, the equipment installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH, Noncondensing] and Wind Speed up to 50 m/s. Resistance to (vibration) shocks must be included.
475	Sensor Type	The sensor/instrument for measuring RH should be based on an electrical capacitance measurement probes. Sensors for measuring Dew Point directly are usually based on dewpoint mirror.
481	Achievable Sensor Uncertainty	The sensor measurement uncertainty must be better than 3 %RH. If the sensor reports directly a Dew Point Temperature, the sensor uncertainty must be 0.25 °C.
57	Units	Whatever physical quantity measured, humidity must be presented in/by the instrument/system in %RH.
61	Measurement Range	The maximum measurement range must be 0-100 %RH. If presented as Dew Point Temperature, the maximum temperature range must be -80 °C to +35 °C.
68	Reporting Resolution	The Reporting Resolution for humidity must be 1 %RH (or better). If reported as Dew Point Temperature, the reporting resolution must be 0.1 °C
138	Sampling Frequency	The humidity should be sampled at least 4 times over the interval of the sensor time constant.
139	Calculated Parameters	Averages of all valid samples of humidity must be produced over 1-minute intervals. The 1-minute average must be used as the instantaneous value for relative humidity
141	Rate of Change Check	After each signal measurement, the current value should be compared to the preceding one. If the difference between two samples is more than 5 %RH, the current sample is identified as suspect and is not used for the computation of an average
142	Jump Check	If the difference between consecutive 1-minute averages if more than 10 %RH, then the data should be flagged as suspect for further investigation. If the

		difference is more than 15 %RH, the data should be flagged as erroneous for further investigation.
143	Stuck Sensor	if over a 60-minute interval the value of the one-minute values of RH have not changed by 1 %RH and RH < 95 %, then the data should be flagged as suspect for further investigation.
462	Dewpoint Temperature calculations from Air Temperature and RH	If Dewpoint Temperature is calculated from Humidity and Air Temperature, the 1 and 10-minute averages of Dewpoint Temperature should be calculated from the instantaneous Humidity and Air Temperature measurements, after which the averages for Dewpoint Temperature can be calculated. It is not allowed to calculate averages for Dewpoint Temperature from averages of Air Temperature and Humidity.
947	Derived Parameters	If relative humidity is measured, then a Dew Point Temperature should also be calculated, using the formula from the Guide to Instruments and Methods of Observation (WMO-No. 8), Volume I, Chapter 4, Annex 4.B.

Horizontal Wind Direction

ID	Título del requisito	Requisitos
71	Sensor Performance Constant	For Mechanical Wind Sensors, the Sensor Damping Ratio must be > 0.3.
157	Operational Conditions	As a minimum, the equipment (and supporting infrastructure) installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH Non-condensing] and Wind Speed up to maximum wind speed required to be observed. Resistance to (vibration) shocks and lightning protection must be included.
650	Sensor Type	The sensor/instrument for measuring WD must be an electrical recording wind direction instrument. The most common instruments in use are vanes, combined propeller anemometers/vane and ultrasonic instruments for measuring both wind speed and wind direction. However, any sensor type compliant with the requirements in this section must be considered.
657	Achievable Sensor Uncertainty	The sensor uncertainty must be 5°.
973	Sampling Frequency	If the sensor is to be used to report wind gust, then wind speed should be sampled at 1 Hz or greater (4 Hz is preferred).
59	Units	Whatever physical quantity measured, Wind Direction must be presented in/by the instrument/system in degrees clockwise from true north
63	Measurement Range	The maximum measurement range must be 0-360 degrees.
66	Reporting Resolution	The Reporting Resolution for Wind Direction must be 1 degree.
651	Wind Direction Sensor Orientation	Wind direction is defined as and must be reported as the direction from which the wind blows, and it is measured clockwise from geographical north, namely, true north (referred to the World Geodetic System 1984 (WGS-84) and its Earth Geodetic Model 1996 (EGM96)).

654	Practical Range	The maximum measurement range must be 0 – 360°. If two successive samples differ by more than 180°, the difference is decreased by adding or subtracting 360° from the second sample to obtain a wind direction between 0 – 360°.
78	Vector Averaging	Vector averaging should be used for the average values of wind speed and direction.
83	Minimum Data	At least 75% of the wind direction samples should be available to enable the computation of both the 2-minute and 10-minute averages. If insufficient data, the 2-, 10-minute average should be marked as invalid/missing
87	Stuck Sensor	If the average values of wind direction do not vary by more than 10 degrees over a 60-minute interval, the data should be flagged as suspect for further investigation.

Horizontal Wind Speed

ID	Título del requisito	Requisitos
70	Sensor Performance Constant	For a mechanical wind speed sensor, the distance constant must be in the range 2-5 m. [A distant constant is not required for an ultrasonic sensor]
73	Sampling Frequency	If the sensor is to be used to report wind gust, then wind speed should be sampled at 1z or greater (4 Hz is preferred)
158	Operational Conditions	As a minimum, the equipment (and supporting infrastructure) installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH Non-condensing] and Wind Speed up to maximum wind speed required to be observed. Resistance to (vibration) shocks and lightning protection must be included.
613	Sensor Type	The sensor/instrument for measuring Wind Speed must be based on an electrical anemometer. The most common instruments in use are cup anemometers, propeller anemometers and ultrasonic anemometers. However, any sensor type compliant with the requirements in this section must be considered.
619	Achievable Sensor Uncertainty	The sensor uncertainty must be 0.5 m/s for Wind Speed ≤ 5 m/s and 10% > 5 m/s.
60	Units	Whatever physical quantity measured, Wind Speed and Wind Gust must be presented in/by the instrument/system in metres per second (m/s).
64	Measurement Range	The maximum measurement range must be 0-75 m/s. In regions of extremely high winds, an extended range of 0-100 m/s should be requested. Wind Gust may reach 150 m/s.
65	Reporting Resolution	The Reporting Resolution for Wind Speed must be 0.5 m/s. The Reporting Resolution for Wind Gust (if measured) must be 0.1 m/s.
72	Calculated Parameters	Averages of all valid wind speed samples over 10-minute intervals must be produced. This 10-minute average must be used as the instantaneous value for wind speed. A standard deviation of wind speed must also be calculated. If the wind sensor is in support of an aerodrome, then an additional 2-minute average must be calculated.
74	Calculated Parameters 2	If an observation of wind gust is required, then this must be the running mean of all valid wind speed samples in a 3-second period.
77	Vector Averaging	Vector averaging should be used for the average values of wind speed and direction.

82	Minimum Data	At least 75% of the wind speed samples should be available to enable the computation of both the 2-minute and 10-minute averages. If insufficient data, the 2-, 10-minute average should be marked as invalid/missing
84	Rate of Change Check	If the difference between a wind speed sample and the preceding one is more than 20 m/s, then the data should be flagged as a suspect for further investigation and not used for the calculation of the average
85	Jump Check	If the difference between consecutive 2-minute wind speed averages is more than 10m/s the data should be flagged as a suspect for further investigation. If the difference is more than 20m/s it should be flagged as erroneous for further investigation.
86	Stuck Sensor	If the average values of wind speed do not vary by more than 0.5 m/s over a 60-minute interval, the data should be flagged as a suspect for further investigation

Precipitation Amount/Intensity

ID	Título del requisito	Requisitos
559	Sensor Type (Intensity)	The sensor/instrument for measuring precipitation intensity must be based on an electronic recording instrument. Any sensor type compliant with the requirements in this section must be considered. The Precipitation Amount and Intensity Sensor should be the same piece of equipment.
110	Collecting Gauge Orifice Area	In case the sensor/instrument for measuring Precipitation is based on collection of precipitation, the area of the collector orifice must be at least 200 cm2 and no larger than 500 cm2. The area of the orifice must be known to the nearest 0.5%, and the construction must be such that this area remains constant while the gauge is in normal use. The construction must be such as to minimize wetting areas. The container must also have a narrow entract and be sufficiently protected from radiation to minimize the loss of water by evaporation
159	Operational Conditions	As a minimum, the equipment (and supporting infrastructure) installed outdoors must be capable of operating in a Temperature Range [-40 °C to +55 °C], Humidity Range [0-100 %RH Non-condensing] and Wind Speed up to maximum wind speed required to be observed. Resistance to (vibration) shocks and lightning protection must be included.
531	Sensor Type	The sensor/instrument for measuring Precipitation must be based on an electronic recording instrument. Any sensor type compliant with the requirements in this section must be considered.
568	Sensor Time Constant (Intensity)	The instrument time constant under controlled conditions must be better than 30 s.
538	Achievable Sensor Uncertainty	The sensor uncertainty must be the larger of 5% or 0.1 mm.
566	Achievable Sensor Uncertainty (Intensity)	The sensor uncertainty must be: • Under constant flow conditions in laboratory: o 5% for > 2 mm/h, o 2% for > 10 mm/h. • In the field:

		o 5 mm/h, o 5% above 100 mm/h
58	Units	Whatever physical quantity measured, Precipitation Amount must be presented in/by the instrument/system in millimetres.
561	Units (Intensity)	Precipitation intensity must be presented in mm/hour (based on a 1-minute average).
62	Measurement Range	The maximum measurement range must be 0-500 mm/day. This should be increased to meet local conditions.
562	Measurement Range (Intensity)	The maximum measurement range must be: 0.02 – 2,000 mm/hour
67	Reporting Resolution	The Reporting Resolution for Precipitation Amount must be 0.1 mm. If reporting daily totals, 0.2 mm should be used. If reporting weekly or monthly totals, 1 mm should be used.
564	Reporting Resolution (Intensity)	The resolution of reported measurement must be: 0.1 mm/hour
111	Calculated Parameters	The individual measurements are providing the instantaneous readings. The system must calculate/make available amounts over 1 minute, 3 hours and 24 hours

Annex V “Technical specifications for new instruments and observing systems for the procurement process”

Environmental Regulatory Compliance

ID	Requirement Heading	Requirement
1-1	General Compliance	The proposed instruments must comply, <u>at a minimum</u>, with recognized European Environmental regulations. Applicable* regulations must apply to the instrument itself, all of its sub-systems, its packaging, and associated consumables. • *’Applicable’ requires knowledge of the materials and components. Where certain materials, chemicals, and components are used – compliance to regulations controlling their use must be confirmed.*
1-2	Batteries	Batteries and Accumulators and Waste Batteries and Accumulators Directive (2006/66EC)
1-3	Packaging	Packaging and Packing Waste Directive (1994/62/EC)
1-4	Hazardous Substances	RoHS 2 - Restriction of Hazardous Substances Directive (2011/65/EU)
1-5	Chemical Registration	REACH – Registration, Evaluation, Authorization, and Restriction of Chemicals (2006/1907/EC)
1-6	Mercury	Minamata Convention on Mercury - COP
1-7	Local Jurisdiction	Where recognized regulations, applicable in the jurisdiction where the instrument is installed, are equivalent to or stricter - the local regulation must be applied over the European regulation.

Material Use – Instrument

ID	Requirement Heading	Requirement
1-8	Material Identification	The material of each component part of the proposed instrument must be identified by its applicable recognized recycling code.
1-9	Recycled Content	The mass and percent of recycled raw material must be disclosed for each component part made of a homogenous material (coatings excluded).
1-10	Biodegradability	Biodegradable* components in the proposed instrument must be identified. **Biodegradability is defined as >90% of the original material is converted into CO_2, water, and minerals by biological processes within 6 months.*

Material Use – Packaging

ID	Requirement Heading	Requirement
1-11	Material Selection	Where packaging material selection allows, without degradation of the instruments' performance or shelf life, only recyclable materials must be used.
1-12	Material Identification	The material of each packaging element must be identified by its applicable recognized recycling code.
1-13	Biodegradability	Where packaging material selection allows, without degradation of the instruments' performance or shelf life, only biodegradable* materials must be used. **Biodegradability is defined as >90% of the original material is converted into CO_2, water, and minerals by biological processes within 6 months.*

Instrument Design

ID	Requirement Heading	Requirement
1-14	Design for Repair	Where instrument performance requirements allow, without degradation of, for example, water intrusion or temperature range, replaceable sub-components and sub-systems of the proposed instruments must be serviceable or replaceable, without the requirement to discard the whole instrument.
1-15	Efficient Packaging	Packaging for the instrument must minimize transport volume and mass wherever possible, without compromising transport durability and equipment performance following long-term storage.
1-16	Recyclability	The instrument design must consider end-of-life disposal and maximize the recyclability of the assembly by facilitating efficient separation of all recyclable materials.

Operation and Maintenance

ID	Requirement Heading	Requirement
1-17	Energy Performance	Where feasible, without degradation to the proposed instrument's performance under its specified operating range, the instrument's energy use must be minimized.
1-18	Chemical Disclosure	All chemicals used in the operation, calibration, and maintenance of the proposed instrument must be disclosed and a Material Safety Data Sheet must be provided. Environmentally harmful chemicals must be avoided or minimized where no suitable alternative is available.
1-19	Internal Batteries	Details of the battery or accumulator design, covering, cell type, voltage, capacity and any necessary safety information must be supplied for the proposed instrument if the design includes a battery or accumulator. Safety information must include instruction for the safe disposal of the battery or accumulator, consistent with local regulations, or the 2006/66/EC directive – whichever is stricter.

Documentation and Training

ID	Requirement Heading	Requirement
2-01	Tender Language	All Tender documents must be in [insert customers' preferred language]
2-02	Project/Tender Schedule	The supplier must provide a Project Schedule/Implementation Plan with the offer.
2-03	Documentation	The supplier should provide documentation in electronic format [with permission for the customer to reproduce for internal use] outlining: basic theory/principles of operation of equipment step by step instructions on the required maintenance and the frequency with which this maintenance is recommended to be performed. - recommended spare parts and test equipment (for maintenance and repair).
2-04	Serial Number	Each instrument must be supplied with a unique serial number.
2-05	Site Drawings	Where the supplier provides Site design, clear site drawings showing the location of cables must be provided to the customer for each site.
2-06	Training	Customer technicians should receive training onsite or at a location designated by the NMHS, on calibration, installation, maintenance, software, QC/inspection [if appropriate], software and operational procedures for the instrument and on all aspects of operation of the upper-air systems.

Maintenance and Operation

ID	Requirement Heading	Requirement
2-07	Maintenance from a remote location	The control/processing system should support maintenance from a remote location. At least the following functions are supported: • inspection of the real time meteorological observations that are ingested/recorded by the upper-air system • inspection of log records • facilities to change parameter settings and/or station configuration To perform these maintenance functions, a system operator password [or other NMHS determined security] is required.
2-08	Reliability detection of failures	The unavailability of either hardware or software parts that could prevent the execution of the systems’ primary function should not go unnoticed.
2-09	Equipment design	The design of equipment and cabinets must facilitate routine inspections.
2-10	Off-line test	The system allows for off-line testing in an isolated environment before and after installation.
2-11	Pre-implementation test	The system allows for testing in the operational environment before implementation, without affecting the operation of the rest of the system.

2-12	Standard components currently in use	It is customer's policy to maintain uniformity in inspection and maintenance procedures for all meteorological facilities, and to keep a minimum level of spare parts. Therefore, it is recommended to consult the list of currently used makes for mechanical, electrical and software components. List of component types currently in use by the customer(Item/Manufacturer) PCs [xxx]; Servers [xxx]; Network components [xxx]; Modems [xxx]; Routers [xxx]; Cabinets [xxx]; Rack equipment [xxx] [xxx to be completed by the customer]

2-13	On-line help	The system should provide built-in help facilities which are able to replace user documentation. The online help should be detailed enough to aid a user trained in the general principles of the system.
2-14	Recommended Spare Parts List	The Contractor must submit a Recommended Spare Parts List (RSPL) based upon the Maintenance Conditions as specified in the Maintenance Conditions document and the required availability (MTBF, MTTR) as specified in the Requirement Specifications document. This list must contain spare parts recommended by the Contractor to support/maintain the System and System Components during their respective lifetimes regarding the following: • For consumables the Contractor must recommend an amount of spare parts sufficient for two years for the System and System Components. • For repairable System Components (or modules of System Components, if applicable), the Contractor must recommend a number of spares based on the mean time between failure (MTBF) for that specific System Component. • For modules that can only be replaced as a whole in case of malfunctioning, the Contractor must recommend a number of spares based on the lifetime of the System and on the MTBF as provided in the Requirement Specifications document. • The Contractor must make a recommendation for COTS-items.
2-15	Design life for the systems	The system should be designed for a life cycle of at least 10 years.
2-16	Operational hours of system components	Under normal circumstances, system components must perform their primary functions 24 hours a day and 7 days a week.
2-17	Requirements for materials and components	All materials and components furnished must be new and designed to meet the customer's requirements. The supplier has to take into consideration that the installation must not cause any damage to installations and systems.

Safety and standards

ID	Requirement Heading	Requirement

2-18	Environment: EMC	Electromagnetic Compatibility (EMC) susceptibility must be according to EC- regulations (or other relevant national or international standards), but special care must be taken to withstand static electric shocks, as well as the use of handheld radio and telephone equipment in the vicinity of the systems.
2-19	Environment: shock and vibration level	The upper-air system should be able to operate in an environment with a shock and vibration level not exceeding 0.1 kB (DIN 4150/ISO 4866).
2-20	Electrical Safety	All installed equipment must comply with applicable local requirements for electrical safety. In the absence of local requirements, IEC 60950-1 is used.
2-21	Electrical regulations	The equipment and installation must conform to the regulations of local authorities. The most common international standards are (latest versions must be applicable): • CE marking • FCC Declaration of Conformity • ISO 9001 : quality management systems and quality assurance In addition, local standards and regulations apply, the supplier to define which ones are valid for the installation region (latest versions): • Safety regulations for low voltage installations, including supplements and alterations • Lighting conductor installations • Telecommunication colours of cores of cables for use inside buildings and for mounting wires Telecommunication regulations for wireless (data)communication, use of available frequencies • Factories built low voltage switch gear and control cabinets • Safety transformers • Electrical symbols The supplier must be responsible for the correct application of local standards (latest editions) and regulations necessary to achieve conformity with local legislation. • In the absence of local requirements, IEC 60950-1 is used.

2-22	Electromagnetic Compatibility	Installed equipment should have suitable electromagnetic compatibility for operation in the installed environment. In the absence of a local standard, IEC 61326:1997 + A1:1998 + A2:2000 + A3:2003 can be used.
2-23	Regulations	The equipment and installation must conform to the latest editions or regulations of local authorities and the customer. The supplier must be responsible for the correct application of valid European/US/applicable standards (latest editions) necessary to achieve conformity with the local legislation on machinery safety. For electrical and control systems particularly, all relevant components, apparatuses, panels, boards, systems and installations, which are part of the scope of work, have to comply with the applicable standards. The work of the supplier will be in conformity with the applicable standards.

2-24	Workmanship Rules	Cabinets are assembled by the supplier. High-qualified workmanship and extreme care should be applied when assembling the equipment. At least the following aspects should reflect this: • All process specification steps should be rigorously followed. • All quality assurance specifications should be rigorously followed. • High quality soldering with a good reflow, it should be free of excessive solder, pits and cracks, and is not subjected to mechanical stress. • All cabling should be properly guided and bundled, and attached every 30 cm (no loose cables, no free hanging cables). Unnecessary extra cable loops should be avoided. Cables have always to be installed as close as possible to grounded surfaces. All cable connections in cabinets should be terminated on connector plugs with metal enclosures. The cabling inside cabinets should be routed in an orderly manner in fixed traces, and tied up. The presence of loose cabling over lengths of more than 30 cm is not permitted. • Bolts should be properly torqued and sealed. • All parts should be properly attached by screws, adhesive or brazing (no loose parts). • Painting and coatings should be applied smoothly and with constant thickness, without the presence of drops and non-treated areas. • All equipment should be adequately cleaned and free of dust and dirt. Cabinets, enclosures and housings should be free of scratches and dents.
2-25	ISO 9001	All suppliers, and their subcontractors were appropriate, should have ISO 9001 certification. Documentary evidence of this certification should be included with the Tender documents.
2-26	Physically disconnection of equipment	When equipment is switched OFF, e.g., by means of a physical ON/OFF switch, the total equipment can be physically disconnected from the power supply. If not so, provisions will be supplied enabling a physical disconnection.
2-27	Minimising risk of injury and damage	The system must be designed in such a way as to prevent the risk of personal injury or system damage.
2-28	Grounding compliance	Grounding must be according to the applicable regulations. The metal frames and casings of the cable runs and the remote control stations must be bonded together and earthed to the earth bars. The grounding must not be connected to the building earth, but to the installation grounding system as provided by the customer. Armoured cables must only be earthed at the power feeding side.

2-29	Cable protection of for local conditions	The NMHS may specify additional cabling requirements to reflect local climatic/soil conditions or regulations - for example on cabling depth, or protection from humidity or vermin
2-30	Installation protection factor for equipment	Degree of protection between panels and between cable compartments and cabinets should be IP 30. When doors are opened protection should be IP 20. Degree of protection between cable compartment and main bus-bar compartment should be IP 40 after

		extension. For cabinets and equipment not installed in cabinets, protection should be IP 55.
2-31	Compliance of cables to local standards, regulations and norms	All cables that are used in the systems delivered by the supplier, must comply to local standards, regulations and norms. It is the responsibility of the supplier to find out what local standards, regulations and norms are applicable and that all cables are compliant with these regulations.

Site Specific Requirements

ID	Requirement Heading	Requirement
3-01	Infrastructure	The infrastructure to house and operate the upper-air system (i.e. buildings and utilities) are not specified in this document. These details must be provided as general information in the technical specification and the vendors should be requested to confirm compatibility with the offered system and any additional infrastructure and utilities that need to be provided.
3-02	Site location(s)	The geospatial location of the site(s) must be provided in the technical specification, along with any relevant metadata (i.e. station identifier), and a full address for International delivery.
3-03	Existing equipment	If the upper-air system is expected to be integrated with existing equipment at the site, this needs to be detailed in the technical specification and the vendor requested to confirm compatibility of their system and the provision of any additional components to allow the equipment to be integrated.
3-04	Station sounding schedule	This order is expected to provide a minimum of ?? months of operations, when meeting the minimum requirement of ?? daily soundings per month with measurements of temperature, humidity and wind to at least ?? hPa.
3-05	Delivery	The cost of DAP delivery to the address in 4-02 must be included.
3-06	Packaging	Packaging must be suitable for the international delivery.

Meteorological Radiosondes

General

ID	Requirement Heading	Requirement
4-01	Radiosonde Intercomparison	The measurement performance of the offered radiosonde must be verifiable by either participation in the latest WMO radiosonde intercomparison, currently China (2010), or directly referenced to a radiosonde that participated, through an independent report recognized by WMO (INFCOM/Standing Committee on the Measurements, Instrumentation and Traceability (SC-MINT).

Temperature Measurement Requirements

ID	Requirement Heading	Requirement
4-02	Temperature Range	The range of temperature capable of being sampled shall not be less than +50 °C to -100 °C.
4-03	Pressure Range	The temperature sensor shall be capable of measuring temperature from 1080 hPa to at least 3 hPa.
4-04	Resolution	The reported resolution shall be 0.1 °C or better.
4-05	Uncertainty	It shall be possible to measure temperatures during ascent with an absolute error of no more than 0.5 °C at all levels.
4-06	Reproducibility	It shall be possible to measure temperatures during the ascent to a reproducibility within: a) 1080 - 100 hPa: 0.2 °C b) 100 - 20 hPa: 0.3 °C c) 20 - 3 hPa: 0.5 °C

Relative Humidity Measurement Requirements

ID	Requirement Heading	Requirement
4-07	Humidity Range	The range of relative humidity capable of being sampled shall not be less than 0% to 100% with respect to water.
4-08	Pressure/ Temperature Range	The humidity sensor shall be capable of measuring humidity in the temperature range of +50 °C to -100 °C and the pressure range of 1080 hPa to at least 100 hPa.
4-09	Resolution	The reported resolution shall be 1% or better.
4-10	Uncertainty	It shall be possible to measure relative humidity during ascent with an absolute error of no more than 5% at all levels.

GPS Derived Pressure Measurement Requirements

ID	Requirement Heading	Requirement
4-11	Pressure Derivation	The radiosonde shall be capable of deriving pressure from GNNS altitude. The manufacturer shall specify how the pressure measurements are calculated.
4-12	Pressure Range	The range of pressure being derived shall be at least 1080 hPa to 3 hPa.
4-13	Resolution	The derived pressure measurements shall have a resolution of at least 0.1hPa.
4-14	Uncertainty	It shall be possible to measure derived pressures during ascent with an absolute error of no more than: a) 1080 - 100 hPa: 1 hPa b) 100 - 3 hPa: 0.6 hPa
4-15	Sampling Rate	The radiosonde shall report GPS derived pressure data with a sampling rate of at least one measurement every 2 seconds.

GPS Derived Geopotential Height Measurement Requirements

ID	Requirement Heading	Requirement
4-16	Geopotential Height Derivation	The radiosonde shall be capable of providing geopotential height measurements derived from GNNS measured geometric height. The manufacturer shall specify the method used to convert between geometric and geopotential height.
4-17	Height Range	The range of geopotential height measurements shall be at least 0 - 40 000 m.
4-18	Resolution	The geopotential height measurements shall have a resolution of at least 0.1 m.
4-19	Uncertainty	It shall be possible to measure geopotential height during ascents with an absolute error of no more than 20 m at all levels.
4-20	Sampling Rate	The radiosonde shall report geopotential height data with a sampling rate of at least one measurement every 2 seconds.

Wind measurement Requirements

ID	Requirement Heading	Requirement
4-21	Wind Range	The system shall measure wind by tracking the radiosonde movement using GNNS navigation signals.
4-22	Wind Speed Range	The range of wind speed that can be sensed shall be 0 to at least 120 m/s.
4-23	Wind Direction 360^0	The range of wind directions capable of being sensed shall be through the full 360 degrees of azimuth.
4-24	Height Range	Winds shall be reported starting no higher than 100 m up to at least 40 000 m.
4-25	Resolution of Wind Speed / Orthogonal Wind	Wind speed and orthogonal wind components shall be measured with a resolution of at least 0.1 m/s.
4-26	Resolution of Wind Direction	Wind direction shall be measured with a resolution of at least 1 degree.
4-27	Wind Speed Uncertainty	It shall be possible to measure wind speed with an absolute error of no more than 0.5 m/s at all levels.
4-28	Wind Direction Uncertainty	It shall be possible to measure wind direction with an absolute error of no more than 3 degrees at all levels.
4-29	Sampling Rate - Wind Data	The radiosonde shall report all wind data with a sampling rate of at least one measurement every 2 seconds.

Physical Design and Launching Requirements

ID	Requirement Heading	Requirement
		Radiosonde Design
4-30	Weight	The radiosonde weight shall not exceed 400 grams, including battery and un- winder.

4-31	Wind Speed Capability	The radiosonde shall be sufficiently robust to withstand launching in winds gusting up to 35 m/s without damaging the radiosonde sensors.
4-32	Suspension Length	The radiosonde shall deploy to a suspension length of at least 30 m +/- 1 m beneath the balloon after launch.
4-33	Consistency of Configuration of Sensor Boom	The radiosonde shall have temperature and humidity sensors mounted externally on at least one boom, which can be consistently deployed in the same orientation.
4-34	Boom Design - Contamination Mitigation	The supplier shall supply details of the boom design, including any features designed to mitigate against the effects of contamination from moisture, exposure to solar radiation, and exposure to heat from the radiosonde body.
4-35	Shelf Life	Radiosondes supplied should be capable of being stored under recommended conditions for a minimum of 3 years.
4-36	Battery capacity	The sonde should have power capacity to maintain radiosonde operation for at least a total period of up to 30 minutes before launch and 3 hours during flight.
Pre-flight preparation		
4-37	Pre-flight Preparation	It shall be possible for a trained operator to unpack a sonde and complete all ground checks and have the sonde ready for launch within 30 minutes.
4-38	Operation via Single Operator	A system shall require no more than one operator to: prepare and launch the radiosonde, monitor and quality control the data, edit and transmit messages.
Calibration & Pre-flight		
4-39	Calibration Certification	The sonde shall be delivered calibrated, and calibration data is to be provided with each radiosonde.
4-40	Ground Check	There should be a specified ground check procedure that shall form part of the pre-flight preparation. This shall identify calibration/sensor faults and may be used to modify the calibration parameters used in subsequent data processing.

Ground Station Requirements

ID	Requirement Heading	Requirement
4-41	Data	The ground station shall include all items necessary to; receive, process, output, archive, and display the data derived from the radiosonde.
4-42	UPS	The ground station shall be supported by an uninterruptable power supply (UPS) and this should be sufficient to operate the system for a period of 60 minutes should the mains power fail.
4-43	Pre-flight Tests	The ground system should be capable of testing the sonde systems prior to launch, ensuring temperature, relative humidity, pressure, and GPS satellite reception are functioning within specification.
4-44	Compliance	The system shall comply with ETSI standard EN 302 054-2 V1.1.1 'Electromagnetic compatibility and Radio spectrum Matters (ERM); Meteorological Aids (Met Aids); Radiosondes to be used in the 400,15 MHz to 406 MHz frequency range with power levels ranging up to 200 mW' and any other statutory requirements as necessary.
4-45	Frequency	The carrier frequency of the transmitted signal shall be operator selectable between 403 MHz and 406 MHz in 100 kHz steps.

4-46	Bandwidth	The modulation bandwidth shall not exceed 100 kHz centred on the carrier frequency.
4-47	Carrier Stability	The carrier frequency shall not drift for any reason during operation, including handling and ground effects at launch, by more than 100 kHz from the selected frequency.
4-48	Effective Radiated Power	This shall not exceed 200 mW.
4-49	Frequency – Reception	The system shall be able to receive and process transmissions within the band 403 to 406 MHz. The reception equipment will be able to sustain satisfactory operations in the presence of transmissions from any other systems in adjacent spectrum bands.
4-50	Slant Ranges / Elevation Angle	The receiving system shall be able to reliably receive data from radiosondes, at slant ranges greater than 200 km from the receiving site, from any direction and any elevation angle equal to, or greater than 5 degrees above the horizon.
4-51	Telemetry – Direction	The manufacturer shall describe the directionality of the telemetry antennae (i.e. omnidirectional, directional, mechanically steered) and the method used to achieve this directionality.
4-52	Wind Failure	Pressure, temperature, and relative humidity shall still be measured, if the wind measurements fail.
4-53	Raw Data Archive	The data stream including GPS signals as received from the radiosonde, shall be stored by the ground station in a raw data archive.
4-54	Processed Data	The fully processed data archive used to generate the upper air reports for the users, shall include as a minimum pressure, temperature, humidity, geopotential height, wind speed, and direction data.
4-55	Descent Data	The system shall continue to record the variables stated in 5-54 after balloon burst, down to the ground or until the radiosonde signal is lost.

Data Processing and Software

ID	Requirement Heading	Requirement
4-56	Algorithms & Compensation Methods	The algorithms used to generate the meteorological variables from the engineering variables shall be described fully, and be available to the operator of the system at all times, including in any subsequent software updates. Any methods used to compensate for the effects of; solar radiation (temperature and relative humidity), water contamination effects on the sensors (temperature, relative humidity), and the variation in internal temperature of the radiosonde during flight (pressure sensor and sensor references), shall also be described.
4-57	Message Creation	The system shall be capable of manually or automatically creating the following message types: FM 94 BUFR using templates 3 09 056/3 09 057 at the minimum required vertical resolution (For GBON this is 100m). FM 94 BUFR using templates 3 09 056/3 09 057 at resolution ≤ 2 s. FM 94 BUFR using template 3 09 056 to report descent data.

4-58	Message Update	The software to create the message must be able to be upgraded to facilitate new versions of the FM 94 BUFR coding and this must be included as part of the software support to the system
4-59	Message transmission	It shall be possible to code and send the BUFR message at preselected times/pressures during the sounding.
4-60	Software Functionality	The system shall provide the following facilities: (a) Radiosonde Calibration Data Input - Input of radiosonde calibration data before launch (if necessary). (b) Surface Observation Input - Input of surface observation by operator (c) Launch Detection - Launch detection. Supplier shall also detail how launch is detected by the software.
4-61	Software Updates	The Supplier shall supply details of the frequency of software updates, and commit to supply details of any changes to software when a new version is supplied, maintaining a change log detailing all changes, which is to be shared with the operator.
4-62	Desktop computer	Bidder to provide a desktop PC with windows operating system and network connectivity to INAM network for each upper air sounding system
4-63	Backup power	The upper air sounding systems and computers (PC's) must be equipped with backup power (UPS's) for running the whole system during mains power failure for a minimum period of two hours

Meteorological Balloons

ID	Requirement Heading	Requirement
5-01	Provision	Provision of xxx Meteorological Balloons for Radiosonde soundings. Details need to be included as to whether one delivery or multiple deliveries over a fixed time period.
5-02	Gas Type	Balloons must be suitable for both Hydrogen and Helium.
5-03	Filling Adapter	If required a balloon filling adapter must be provided with the order (check with station).
5-04	Performance (Burst Height)	Minimum burst height of 30 hPa, when flown under typical conditions, with correct handling and inflation procedures (90% tolerance). Evidence to be provided in tender documents.
5-05	Date Stamp	Date of manufacture must be included with each balloon.
5-06	Evidence of operational use	Evidence that offered product has been used operationally at WMO recognised services/institutes for a period of greater than 1 year. Please provide list of Meteorological Services and/or WIGOS Station identifiers.
5-07	Monitoring	GBON stations will be monitored regularly against the GBON minimum requirements, which include the burst height performance statistics of the balloons. If necessary, these statistics are communicated back to

		the station operators and/or equipment manufacturers for comment and action.

Hydrogen Generation System

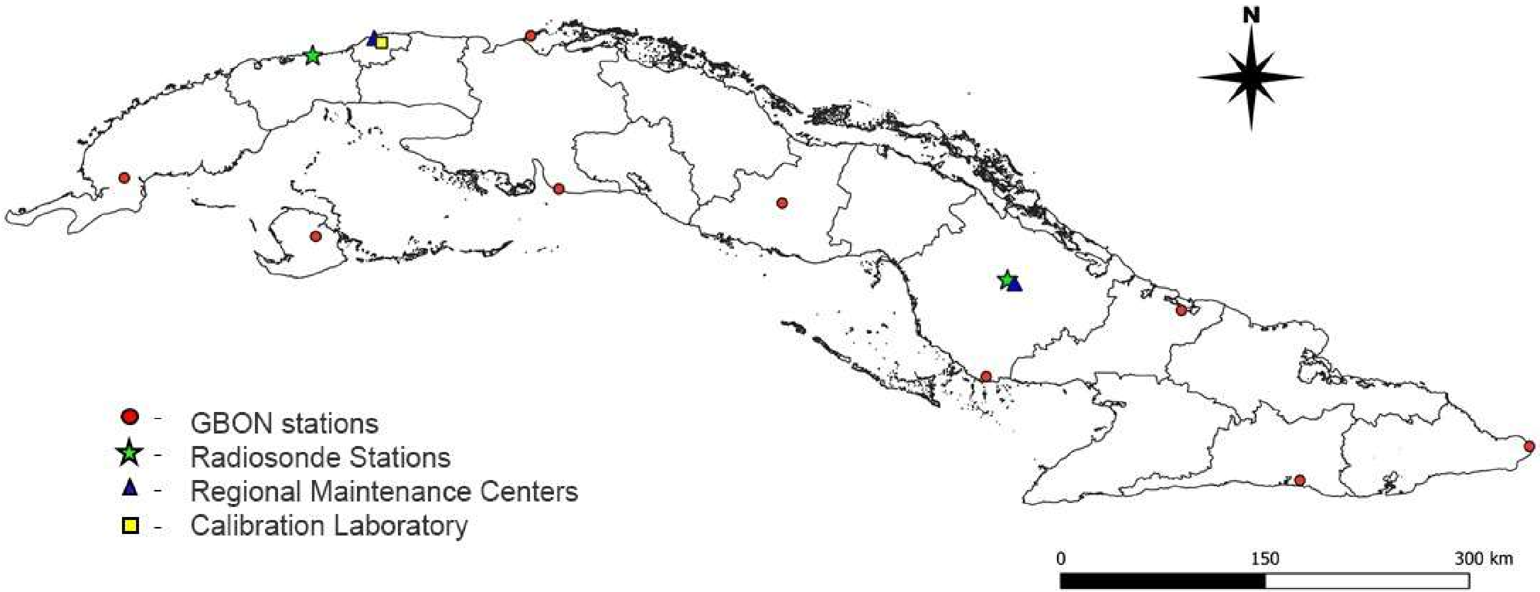
ID	Requirement Heading	Requirement
6-01	Provision	Provision is for the supply of a hydrogen generator for meteorological applications, storage tanks (replacement or compatible with existing), water purifier (replacement or compatible with existing), UPS (if required) and other associated equipment, including the shipment to ???, installation on site and training of the observing staff in the ongoing operation and maintenance of the equipment.
6-02	Site	The ??? observation site is located at the following coordinates: Latitude ??? Longitude ???. The HGS will be housed (update as required), the temperatures in all seasons range from ?? °C to ?? °C. Please confirm the suitability of your proposed solution, to operate in this environment, confirming the dimensions of the equipment to be supplied, and any clearance distances or other dimensions to allow for the safe operation of the equipment and the observing staff involved (Including ATEX regulations). Please indicate any pre-installation requirements in terms of site information, preparation, access, etc. The offered system is expected to completely, or partially, replace the existing system at the station which is detailed as follows: Hydrogen Generator - *Update as required.* Storage Tanks - *Update as required.* Water purification - *Update as required.*
6-03	Power	The Mains power supply at the site is Mains ???V AC nominal. Please confirm the proposed systems capability to run off this type of power supply. Additionally, please indicate UPS capabilities of the system proposed either as standard, or as costed options. The selected solution will as a minimum require UPS back for 10 to 20-minute outages to allow for system shutdown. The unit must include all recommended power systems necessary for the intended locations. These systems may be integral to the unit or installed externally but they must be supplied with the unit.

6-04	Water Purification	If the offered system is compatible with the existing water purification, please state this and any additional requirements (i.e. replacement piping). An option to replace the water purifying system should be included. To ensure the system can produce Hydrogen on an on-going basis, despite potentially varying water quality at the site, please confirm the water standard that is necessary to produce hydrogen in the volumes required (see 7-05) and for the application required. Please include in your proposal the solutions to cope with potential low water quality at the site. The unit must include all recommended water conditioning systems necessary for the intended locations. These conditioning systems may be integral to the unit or installed externally but they must be supplied with the unit.

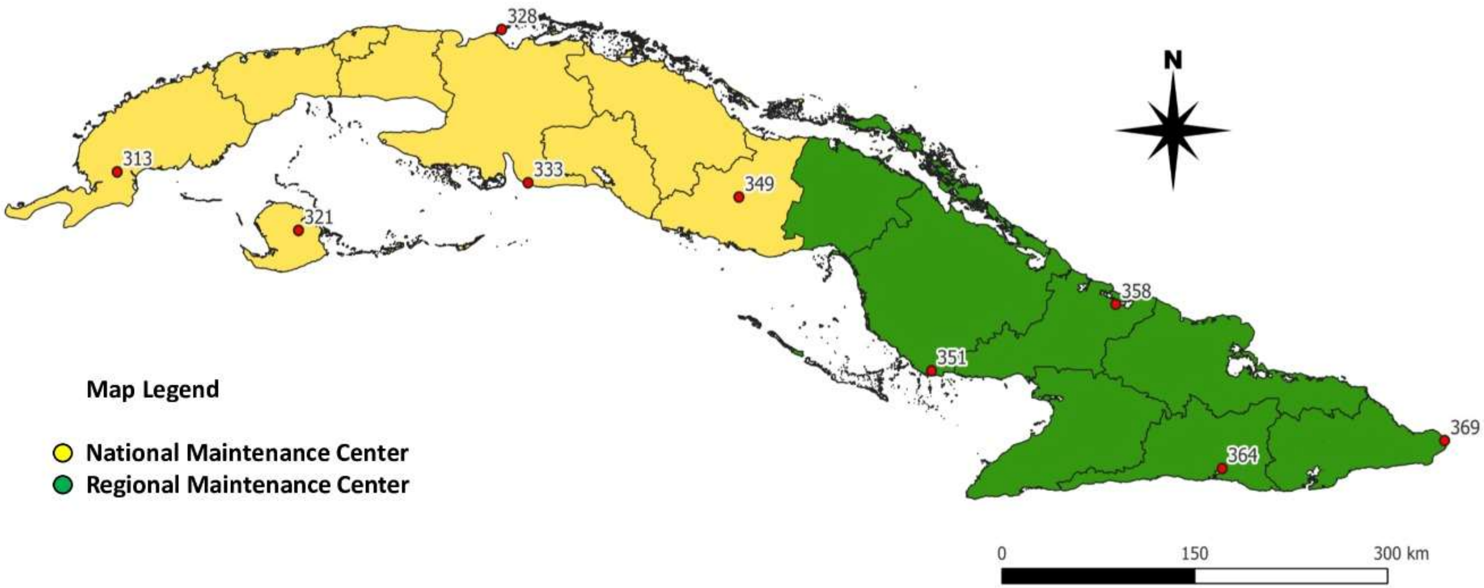
ID	Requirement Heading	Requirement
6-05	Hydrogen Generation and Storage	One hydrogen generator for meteorological applications with capacity at least 0.5 Nm^3/hr (20 SCF/hr). The Electrolytic generators to acquire must use Polymer electrolyte membrane (PEM) in the electrolysis of water, be sealed, tested, and able to operate 24/7 without interruption of service. Chemical type is not acceptable. If the offered system is compatible with the existing storage tanks please state this and any additional requirements (i.e. *replacement of piping and valves*). An option for new storage tanks must be included in the tender and have sufficient capacity to meet the operational need stated below. They should be made of either stainless steel or galvanized steel interconnected so that any one tank can be removed for inspection and testing without impacting the operation of the station. Provide a quote for both types of steel tanks if available. Please specify storage capacity (standard, options) and how long it would take to generate the required volume of hydrogen.
6-06	Storage tanks	If the offered system is compatible with the existing storage tanks, please state this and any additional requirements (i.e. *replacement of piping and valves*). The storage tanks need to be able to withstand salty atmosphere (i.e. hot galvanised or similar). They need to have an isolation capability during refilling. They should be able to be drained to enable the removal of oxygen from the system. They also need to be capable of manual handling, as there is no procedure for lifting the equipment making this impractical.
6-07	Maintenance, tools and safety	The tender documents should specify the required maintenance and servicing requirements for the offered system, including any special requirements for storage and handling. The offer should include the necessary tools for the maintenance of the system and safety equipment (i.e. special garments and hydrogen presence detecting tools).

6-08	Evidence of operational use	The operational performance of the offered system (or equivalent) must be verifiable by its use routinely as a component of at least 3 WMO Members national network for a period of more than 1 year. The contact details of the WMO Member must be included within the tender documents so WMO can seek clarification of the system use and their user experiences.

Annex VI "Location on map of the project's points of interest"



Annex VII "Stations assignment plan by Regional Technical Maintenance Center"



Report completion signatures

Peer Advisor signature	FERNANDO| BELDA| ESPLUGUES Firmado digitalmente por FERNANDO|BELDA|ESPLUGUES Fecha: 2024.10.14 20:08:53 +02'00'
Beneficiary Country signature	Ministerio de Ciencia Tecnología y Medio Ambiente Dr. Celso Pazos Alberdi Director General INSMET CI: 60111404761
WMO Technical Authority signature	