23.10.2023

# GBON National Contribution Plan of RWANDA

Systematic Observations Financing Facility

Weather and climate data for resilience

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# Abbreviations

AWS – Automatic Weather Station

GBON – Global Basic Observing Network

GTS – Global Telecommunication System

IE – Implementing Entity

QA/QC – Quality Assurance/Quality Control

RSB – Rwanda Standards Board

UNDP – United Nations Development Programme

# GBON National Contribution Plan
# RWANDA

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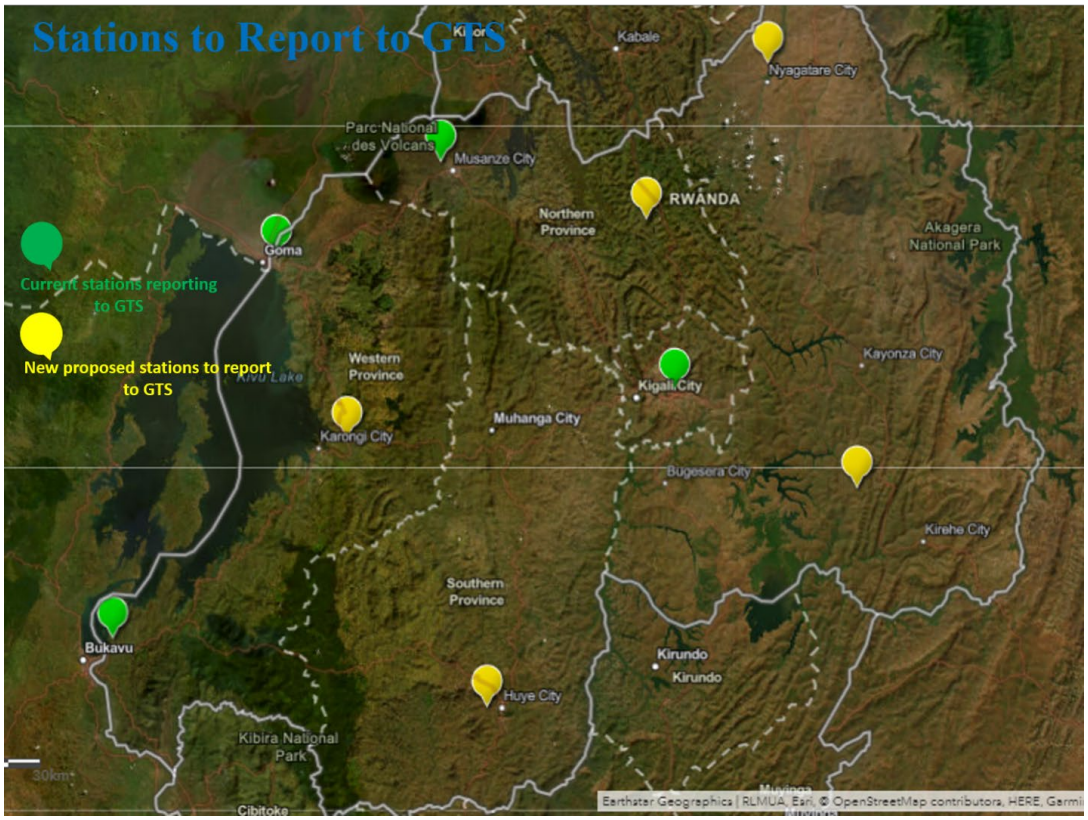
# Module 1. National Target toward GBON compliance

*Table1. GBON National Contribution Target*

| Type of station | Baseline (Results of the GBON National Gap Analysis) | | | | GBON National Contribution Target | |
|---|---|---|---|---|---|---|
| | Target (# of stations)[1] | GBON-compliant stations (#) | Gap | | To improve | New |
| | | | New | To improve | | |
| **Surface** | 1 | 0 | - | 1 | 1 | - |
| **Upper-air** | 1 | 0 | 1 | - | - | 1 |
| **Marine** | **when applicable** | | | | | |

*Figure 1. Map of existing and proposed surface stations: Green markers indicate surface weather observation stations at airports and are registered in WDQMS. Yellow markers represent the potential locations for improved surface stations. The figure is also presented in GAP analysis.*




[1] For SIDS, for the WMO GBON Global Gap Analysis in January 2022, the EEZ area has been added to the total surface area which is the basis for the target number of stations. The standard density requirements for SIDS have been calculated with 500 km for surface stations and 1000 km for upper-air stations.

# Module 2. GBON Business Model and Institutional Development

The business model of Meteo Rwanda relies on public-private partnership. This is the model that the organization is recommended to continue with and further strengthen.

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

Private and public organizations can carry out meteorological observations for their needs. Before starting to collect meteorological observations, the Meteo Rwanda must be consulted to ensure that deployed sensors and methods would produce observations with sufficient quality. This is important because anyone making meteorological observations is responsible for sharing them with the Meteo Rwanda a free of charge. As an example, Rwanda Aviation Company does observations at airports for the needs of aviation sector and data is shared with the Meto Rwanda. **Meteo Rwanda is recommended to seek further partnerships among this kind of private sector actors to support widening and carrying out GBON compliant observations.**

Apart from Rwanda Airport Company, there is no other private sector that provides weather services in Rwanda. However, there are some companies that own land-based stations that collect data to be used for their own purposes. Those companies enter into service agreement with Meteo Rwanda to provide with the collected data and to ensure the standard and quality of observations at those stations. The list of private companies owning climatic weather stations include the following:

- Pfunda Tea company
- Gisakura Tea Compan
- Mulindi Tea company
- KABUYE Sugar company
- Garden Fresh
- Esperance school

These companies are not allowed to share data to the general public. The data must be sent to Meteo Rwanda for quality check and archive. Thereafter Meteo Rwanda can share those data with any interested party free of charge.

The Meteo Rwanda collaborates with civil society in collecting weather observations. Such collaborations are driven by mutual benefit. Altogether 18 communities measure rain and temperature in their area. These observations are delivered monthly, and thus, serve as an important additional source of information for climatological studies. In addition to collaboration with communities, the Meteo Rwanda has 132 volunteer observers for making manual rain and temperature observations. These observers report observations every day through USSD, and submit a hard copy of observations once per month. **Unless making community and volunteer observations hourly or data transfer automatic, these observations will not be able to support the aims towards GBON compliance.**

Based on discussions it became clear that there is no real possibility to outsource a technical (preventive and/or malfunction) maintenance of AWS nor upper air sounding station to private sector in Rwanda. There have been discussions that technical schools could include a maintenance of meteorological sensors in their curriculum for relevant applied subjects. It, however, remains to be seen in future when such development will take place in technical schools. **In addition to strengthening independent internal training programme and competence criteria for own staff, collaboration with technical school(s) is fundamentally important for the Meteo Rwanda in gaining and sustaining its aims**

**with respect to GBON.** The Meteo Rwanda is, additionally, recommended to look for possibilities to collaborate with organizations with technically highly skilled staff to support in station maintenance and problem solving as outsourced work. Such collaboration institutes could include e.g., Rwanda Environment Monitoring Agency (REMA), Rwanda Aviation company and the University of Rwanda.

Rwanda Standard Board (RSB) is responsible for all calibration activities in the country (including meteorological sensors), and thus, Meteo Rwanda has signed MoU on calibration with RSB. This legislative background supports Meteo Rwanda, in collaboration with RSB, to ensure good quality observation and compliance with GBON. The organisations are currently in a process of making agreement on practicalities (e.g., price for conducting calibration work, schedule) to carry out the calibration of meteorological observation sensors for temperature, humidity, rain, and pressure in the laboratory. **The partnership in calibration is in a key role to support the aims and ambition of Meteo Rwanda in relative to GBON.**

An establishment of calibration facilities in RSB follows a long-term roadmap, and by now, has preceded a development project through National Adaptation Plan (NAP) in collaboration with RSB, Meteo Rwanda, and REMA. The development project has procured calibration equipment for temperature, humidity, rain, and pressure for laboratory conditions. The project is still looking for funding sources for e.g., primary standards, field calibrators and hydrological sensors.

Data processing (e.g., QA/QC) and analysis are areas where both private and public sectors as well as academia have knowledge capacity to support the Meteo Rwanda to reach and maintain GBON compliance. **The organization is encouraged to explore potential partnerships to support in data processing (e.g., QA/QC) and analysis.**

## 2.2. Assessment of potential GBON sub-regional collaboration

**Four main topics for collaboration with East-African neighbour countries were identified: 1) subregional distribution of GBON compliant observation stations, 2) radiosounding, 3) calibration laboratory, and 4) international observational data distribution.** The existence of GBON compliant stations in the East-African region is small[2], and thus, currently there is a lack of sufficient spatial distribution for observations in the region. The SOFF task team (Meteo Rwanda, FMI, and UNDP) will communicate with other SOFF countries (namely with Tanzania) in the region to ensure that implementation of new stations will fulfil the minimum spatial requirement for GBON stations.

GBON will be about to facilitate an investment of the very first radiosounding system into Rwanda. This means that sharing experience and expertise (including benchmarking operation and maintenance practices) with the sister organizations in the region will be very important and recommended when implementing the Plan.

Kenyan Meteorological Department has a calibration laboratory, which however, is not operational to serve the region. At the same time RSB and Meteo Rwanda are in a process of investing calibration equipment and initiating operational calibration activities in the country. Collaboration to build human capacity in the field of calibration is foreseen as critically important for the national meteorological services in the East-African region.

Kenya and Tanzania serve as regional hubs for international data sharing. This collaboration is essential, as long as, data distribution is done through the hubs. Additionally, data sharing in the region between sister organizations and worldwide (GTS and in future WIS2.0) is fundamental collaboration and equals with GBON requirements.

[2] WDQMS

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

**The business model of Meteo Rwanda relies on public-private partnership. This is the model that the organization is recommended to continue with and further strengthen.**

The following represents the considerations of Governmental fiscal year in Rwanda:

- A preliminary Governmental budget outline based on the strategic goals of organization is set out for one fiscal year.
- A fiscal year with new, detailed budget starts in the beginning of July.
- Planning activities and subsequent budget allocation for next fiscal year starts in November. The plans and budget allocations will be approved around March.
- Each organization is obliged to coordinate with the most relevant governmental stakeholders that activities are in line and in collaboration to avoid any duplication. The Meteo Rwanda coordinates its activities on meteorological observations especially with Rwanda Space Agency, Rwanda Airport Company, and Civil Aviation Company.
- As an example, **the Meteo Rwanda plans to coordinate the operation and lifecycle investments of GBON radiosounding observation station with Rwanda Space Agency, Rwanda Airport Company, and Civil Aviation Company.** The organizations will be the key benefiters of sounding observations. This is foreseen as an essential concept for sustainable operation and is very much supported by WMO (guide no. 1258[3]).
- Further partnerships and related recommendations were discussed in the submodule 2.1.

The financial status of the Meteo Rwanda to carry out GBON compliant operations and development consists of Governmental budget funding, international development collaboration projects and financial support from UNDP (IE) for station maintenance (including financial support for maintenance missions). Thus, the maintenance, operational and development cost of land-based observation network is supported through ordinary budget from the government as well as the international funded projects such as UNDP, CREWS, the Volcano Community Resilience Project funded by World Bank.

The Governmental budget funding is primarily allocated for staff salaries (ca. 54%) and the other related services (44%) of operations (i.e., electricity, infrastructure). In the year 2022, the total budget for the branch of observation was 120 million RWF, including spare parts. Development is made through national and international collaboration projects. To overcome obvious risks for the value chain of observation from station to end user interface, that may arise from the existing funding scheme, the organization must justify systematically budget and project funding allocations for maintenance, replacing sensors at stations, procuring calibration services from RSB as well as updating IT hardware. The effective justification can be made through **developing a lifecycle plan for AWS, radiosounding station and related IT hardware**.

The Meteo Rwanda is not currently allowed for cost-recovery mechanism for its services. The organization, however, is **in a process to establish such a mechanism to ensure financial flexibility to independently support the activities of organization** (such as development, including meteorological observations). This kind of development is strongly supported. However, operational activities should not be based just on cost-recovery as they require sustainable budget.

[3] WMO guide no. 1258

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

The Meteo Rwanda, REMA and RSB have a roadmap to establish a robust technical and human capacity foundation to carry out the systematic calibration of meteorological, hydrological and air quality observation equipment. **The SOFF programme is foreseen as an appropriate platform for increasing human capacity** (technical and scientific) **on calibration both in RSB and the Meteo Rwanda** (easy fix).

AWS network was established during years 2010-2014. The civil infrastructure is robust, however, there is a need for a replacement of all sensors and data loggers of network. This is one of the primary focus areas in the Meteo Rwanda. **To systematically operate and maintain all observation stations, a lifecycle plan together with tight connection to annual and long-term budgeting must be developed where SOFF programme is foreseen as right platform** (*easy fix*). The lifecycle plan also supports better coordination between budget funding allocation, projects and working towards the strategic goals of organization.

On-going projects to support the Meteo Rwanda in its efforts towards GBON compliance.

- FINKERAT: The project is funded by the Ministry for Foreign Affairs of Finland. The Meteo Rwanda benchmarks the operation, maintenance, and calibration process for AWS in Finnish Meteorological Institute. The aim of benchmarking is to have possibility to reflect points for improvement in the respective processes of Meteo Rwandan QMS.
- Volcano Community Resilience Project: The project is funded by the World Bank. The Meteo Rwanda will be able to replace 10 AWS trough the project within the northern, volcanic part of Rwanda. Meteo Rwanda foresees sharing observations from these stations with GBON.
- The United Nations Development Programme (UNDP) has been working with the Rwanda Meteorology Agency (Meteo Rwanda) and other partners to enhance the human and infrastructure capacity for the weather observation network to collect reliable and timely data on weather and climate conditions in Rwanda. So far, UNDP supports Meteo Rwanda to pay for maintenance and operational cost for automatic weather stations. The cost includes travel expenses and spare parts. In addition, UNDP project supported Meteo Rwanda to develop and operationalize a web-based Climate Data Management System, which stores, processes, and disseminates climate data and information products using USSD. The system enables Meteo Rwanda to receive timely climate data from different volunteer observers manned stations. Furthermore, the project supports Meteo Rwanda in data rescue (the salaries of data entry staff are covered). The project is expected to close by the end of the year 2024.
- CREWS East-Africa: The project is funded by WMO. The project is foreseen to support in capacity building on data dissemination through WIS2.0 and some remaining capacity gaps concerning OSCAR data base.

The Meteo Rwanda is now in a process of getting permission for cost-recovery mechanism. It is expected that the cost-recovery mechanism can be included in the next strategy of organization in 2025. The flexibility in budget would support a sustainable operation of planned investments.

## 2.5. Review of the national legislation of relevance for GBON

According to PRESIDENTIAL ORDER N° 031/01 OF 06/05/2022 GOVERNING RWANDA METEOROLOGY AGENCY, Meteo Rwanda has the mandate to carry out meteorological observations and openly share them, including those related to GBON. Additionally, the Meteo Rwanda has mandate to supervise and receive meteorological observations by third parties. Supervision includes ensuring that utilized sensors are adequate to produce good quality observations.

UNDP (IE) will carry out the tender and procurement process by following its processes. The customs and taxes for imported items include several different costs, namely:

- Customs duty (0.4 % of total taxes on import)
- Value added taxes (VAT; 0.3 % of total taxes on import)
- Withholding taxes (74.1 % of total taxes on import)
- African Union taxes (3 % of total taxes on import)
- Infrastructure Development Levy (22.2 % of total taxes on import)

IT hardware and AWS sensors are exempted for VAT according to the Law N° 37/2012 of 09/11/2012. Exemption for other taxes will have to be claimed through online system upon importing the goods. **The Meteo Rwanda together with IE is recommended to double check the tax exemption process. Subsequently, in the case of potential hindrance in tax exemption with some items to be imported, they are recommended to look for solutions with relevant ministries before tender process.**

Investing, installing, and operating new sensors in the existing surface weather stations are not foreseen to meet any legislative roadblocks since no changes in law or regulations have been put in force since last time implementing a station improvement. Radiosounding technique has not been deployed earlier in Rwanda. Therefore, IE and beneficiary are recommended to clarify required permissions (e.g., license for radio frequency) and potential restrictions to operate radiosounding system before proceeding to investment. Additionally, Meteo Rwanda must carefully familiarize with any legislative and regulatory information on **describing the minimum safety requirements for workplaces and equipment used in** explosive atmospheres (ATEX).

# Module 3. GBON Infrastructure Development

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

The aim of SOFF investment phase project is to maximize the impact of observations on global numeral weather prediction (NWP) skill through:

- Installing or rehabilitating upper-air sounding stations.
- Installing surface weather stations in significantly under-observed regions (far from currently reporting stations).
- A sub-regional optimization of the network design.

**One improved surface-based station** (Table 1): As indicated in the Gap Analysis for Rwanda, the existing civil infrastructure (wind mast, electricity etc.) at potential GBON weather station(s) is in good condition. The required hardware investment within SOFF programme will only include new observation sensors and data logger which will replace existing ones. The current AWS observation network includes aged components and consists of sensors and loggers from two different manufacturers. Furthermore, none of the stations are compliant with GBON due to a capacity gap in automatic data delivery.

Considering the topography of Rwanda, Meteo Rwanda has 4 stations reporting to GTS and wishes to add 5 new stations to global distribution (Fig. 1). However, based on GBON requirements, only one station meets the global needs. Technical specifications provided by GBON task team[4], but not limited to them, will be utilized when supporting IE in preparing tender documents during investment phase.

**One new upper-air station** (Table 1): The information of the atmospheric state (temperature, humidity, pressure, and horizontal wind) in the vertical profile is critically important when initializing weather forecast models and for air navigation. Upper-air sounding has proven to produce observations in good quality. A requirement of spatial resolution for upper-air sounding is 500 km or better with sufficient temporal resolution for observation per location being 1-4 sounding in 24 h.

The basic principle of measurement includes releasing measurement device (sonde) for temperature, humidity and pressure with a balloon filled with gas lighter than air (hydrogen or helium). This sonde-balloon package will be carried by air motion while lifting upwards. Typically balloon bursts somewhere at 24-30 km altitudes. The observations from descending path are also collected. Based on the drifting of sounding system, wind speed and direction can be calculated.

Two types of upper-air radio sounding systems are available: semi-automatic with manual launching and fully automatic. Both types of systems use the same sonde models (manufacturer specific), and thus, produce equally accurate observations. Daily operation with manual launching is laborious, and thus, salary costs are a burden with semi-automatic sounding system. The fully automatic system does not require daily attention from technical staff, but it requires annual preventive maintenance which, due to need for advanced level skills, is recommended to be made by manufacturer (operational cost implication). Corrective maintenance may also require remote and/or on-site support from the technical team of manufacturer. When the system ages care must be taken to avoid long data gaps.

[4] GBON Tender Specifications for AWS and radiosounding

Before entering the SOFF investment phase, the project execute team evaluated carefully budget schemes for investment and operation. The following were included:

- The cost of initial investment (semi vs. fully automatic station)
- The cost of establishing sounding station (needed civil infrastructure work)
- The cost of consumables (sounder, balloon, rope, and winder)
- The cost of operating the sounding system (daily human work, maintenance, and relevant spare parts)

Based on the financial analysis an investment cost of fully automatic sounding system is typically higher compared to semi-automatic system. However, the difference in the investment costs will be quickly exceeded by operational costs (i.e., salary costs). **After careful considerations, the beneficiary is confident that the best operational model and way to ensure fulfilling GBON requirements in short-, medium- and long-terms is to operate fully automatic upper-air sounding system.**

Technical specifications provided by GBON task team will be utilized when supporting IE in preparing tender documents during investment phase. In addition to system technical specifications, tender process must include civil and construction/cultivation work needed for gas storage, and the radiosounding ground system. Budgeting guidance for an initial investment of automatic upper-air station from SOFF secretariat is acknowledged.

Based on the Gap Analysis, the SOFF project executive team of Rwanda is recommending the following initial investments for Meteo Rwanda to produce GBON compliant observations

- **Renew one AWS with**
  - Temperature sensor
  - Humidity sensor
  - Atmospheric pressure sensor
  - Rain sensor
  - Wind sensor
  - Data logger including solar panel.
  - One spare sensor for temperature, humidity, atmospheric pressure, and wind delivered one year after the initial delivery of AWS for making periodical maintenance.
- **One fully automatic upper-air radiosounding station including**
  - Hydrogen generator and required shelter (ATEX requirements apply)
  - Consumable parts (balloons, sondes etc.) for the first year of operation
  - Required civil infrastructure
  - Include annual maintenance during warranty period
- **IT hardware for data transfer to WIS2.0. Corresponding open access software and capacity building are requested from WMO.**
  - Minimum system specifications[5] for WIS2.0 IT hardware given by WMO will be acknowledged when procuring IT hardware.
  - IT hardware and software for a database will come through the parallel CREWS East-Africa project.
  - WMO support[6] in implementing WIS2.0 for data sharing including the associated capacity building of IT staff are requested.

[5] WIS2.0 system specifications
[6] WIS2.0 in a box training

The IE will be supported to carry out tender process by following WMO guidance (WMO no. 8[7], Report no. 136[8]) and GBON instructions for tendering AWS and upper-air radiosounding station.

**The operation of AWS and radiosounding station** require a robust process including preventive and corrective maintenance together with Standard Operation Procedures (SOP). The beneficiary has over 10 years history for making measurements with automatic weather stations, and subsequently, the process for operation and maintenance including SOPs. Radiosounding, however, will be a new observation type requiring development of process and SOP. The peer adviser will support in updating and developing operation procedures during the implementation phase.

Operating an upper-air radiosounding station during the investment phase requires annual investments on consumable parts and budget for annual maintenance, and thus, investment phase funding request must consider that. The beneficiary is recommended to outsource the annual maintenance of radiosounding station to manufacturer.

The Meteo Rwanda is in a process of confirming a location of stations where AWS will be updated and invest in new radio-sounding station. The location depends both on regional investments and national constraints (i.e., permissions from authorities, an availability of staff, a safety of operation (e.g., theft by outsiders)).

## 3.2. Design of the ICT infrastructure, services and the data management system

In addition to automatic and/or manual meteorological observations on site and transfer, a modern, functional Data Management System (DMS) is a key element in the value chain of observation from measurement station to end user interface. The ICT infrastructure should be able to support a principle of automatic data delivery from station to international and stakeholder distribution through a database including an automatic Quality Control (QC) of observation.

**The following specifies general key elements to consider in technical and budgetary perspectives when investments will be made through the CREWS East-Africa project.** Care must be taken to ensure the compliance of any further investments and supplementary implementations with the Climate Data Management System, which stores, processes, and disseminates climate data and information products using USSD recently procured through the UNDP project.

**Technical specifications for database:** Data management system should use open-source technologies and open protocols (e.g., Open CDMS[9]) to ensure sustainable and redundant operation, maintenance, and development throughout their lifecycles and beyond. Based on communication with WMO, OpenCDMS will be fully available starting from 2025. As default, OpenCDMS will allow seamless processing of real-time and non-real time data to WIS2.0.

DMS can be built cloud-based or on premises-based depending on national legislation and regulation, staff capacity as well as a decision of the organization. DMS must meet the following criteria/specifications:

- Ability to ingest and store multiple different types of weather observation data formats. Including, but not limited to, the following:
    - Surface weather observations
    - Upper-air radiosounding observations
    - Aviation weather observations

[7] WMO no. 8
[8] Report no. 136
[9] OpenCDMS

- Lightning observations

Weather radar data have such a big volume and requires much more from storage capacity than a single point/profile data and is thus beyond the considerations of this document. Data ingestion to the data warehouse (database) should be made with a modular approach so that new data feeds may be added with minimal effort and modification to the already existing components and database structures.

For smooth data acquisition, database system must provide relevant APIs for data ingestion. Supported protocols for data transfer must include at least MSQT and SFTP, as defined in GBON specifications. An ability to receive and decode messages from 3rd party data collection systems must be provided. Additionally, a www-based tool for manual observation entry from stations must be provided.

A data quality control (QC) module should be an independent and/or modular part of the system. The QC module must be made so that it is capable of producing quality control regardless of the underlying database system. Additionally, the quality control module must be able to perform real-time quality control and should enable non-real-time manual quality control.

The database system should support queries of timeseries with adequate performance. System must be able to serve as real-time and long-term (climatological) data storage.

Modules to calculate added value parameters and use of data from the archive should be made possible. These may include aggregate parameters like daily means, minimums, and maximums.

The data management system must be made capable of offering data to a standard API for a retrieval of the database contents. The API could include the following but not limited to

- WFS
- EDR
- WMS
- Export to SYNOP & BUFR message format and delivery to GTS-network
- WIS 2.0[10] (requirement for GBON compliance)

System must be able to store relevant metadata regarding stations, station networks and observations. Automatic updates to the WMO/OSCAR -system are preferred.

The delivery of GBON hourly observations should be reported by following WMO guidance (no. 306[11]) and GBON practices[12].

**Budget considerations; Resilience and the continuity of the full data processing chain:** Budget must consider the infrastructure needed to run a DMS and store the data. Also, a solution for a backup of essential data needs to be accounted for when making investments. A valid support contract with a hardware vendor is advisable during the lifetime of the hardware. The lifespan of such hardware may be estimated to be between 5-8 years before the need of renewal of the systems.

Resilience will be supported by two main resource factors: skilled staff and IT hardware including sufficient lifecycle plan and budget. Meteo Rwanda will be solely responsible for taking care of the complete data pipeline. Thus, development of ICT infrastructure for a value chain of automatic observation network is recommended to begin with building required human capacity and resources. Enough staff to ensure resilience should be tasked and trained in skills and knowledge relevant to IT in

[10] WIS2box
[11] WMO no 306
[12] GBON link

meteorological observation. The organization is recommended to gain knowledge and skills in meteorological data, data processing principles and tools, data formats (e.g., NetCDFv4 and BUFR), system architecting, software developing, database, API, network management, WIS2.0 as well as web developing. Please find further considerations on human capacity resilience in section 4.

## 3.3. Environmental and sustainability considerations

**The key success factor of sustainable investment, and day-to-day operation of GBON stations relay on highly competent and motivated management and staff in the organization.** Further system specific considerations include at least:

**Upper-air sounding station:** The GBON compliant sounding system (despite of being fully or semi-automatic) is recommended to be located at a site where permanent staff works daily. This will decrease unnecessary travelling and burdening financial implications when the sounding station requires an attention of staff. Such regular attention will include e.g., filling the system with sondes. The tender process should emphasize quality criteria related to composability in material selection where applicable.

The investment in sounding system is made for 20-30 years, and thus, care must be taken to ensure that annual maintenance is ensured throughout its lifecycle. This has high financial cost implication for the operation, especially in the case of fully automatic sounding systems.

Generation of hydrogen, needed by balloons, locally at the station will make the operation more environmentally sustainable and independent from importing gas by the 3rd party.

**AWS:** The GBON compliant weather station is recommended to replace an existing AWS with civil infrastructure (e.g., electricity, wind mast etc.) that is reusable. With scheduled preventive maintenance and calibration, the lifecycle of sensors will be lengthened as long as appropriate.

Scheduled preventive maintenance and calibration routines require, as a rule of thumb, about 1.3 times more sensors than there are stations. As an example, for 100 stations with temperature sensor, the organization is recommended to own 130 temperature sensors, when 30 of them are in storage or under calibration procedure. In the case of GBON compliance in Rwanda, only one surface weather station will be invested in, and thus, each sensor must accompany a spare sensor in initial investment to ensure a sustainable operation of station. Frequency for preventive maintenance may rarefied based on the scientific experience and statistics gained through calibration.

Use of solar panels support environmental sustainability through an availability of renewable energy.

# Module 4. GBON Human Capacity Development Modul

### The key indicators for SOFF implementation phase

- Enhanced competence building process in Meteo Rwanda (**supported by peer adviser**)
- Benchmarked and developed an observation process and lifecycle plan of upper-air sounding (**supported by peer adviser**)
- Benchmarked good practices on archiving, transferring, and QA/QC observation data, and subsequent SOPs as well as roadmap for implementing automatic QA/QC methods developed (**supported by peer adviser**)
- Training given on upper-air system (basic level) and surface weather station (advanced/supplementing) operation and lifecycle maintenance. (**vendor, supported by peer adviser**)
- Basic programming skills enhanced throughout the value chain of observation (**outsourced by IE**)
- Benchmarked mature project and portfolio management and coordination culture (**supported by peer adviser**)
- Organized high-level dialogues and stakeholder engagement events to support SOFF implementation and operation in Rwanda (**supported by IE**)
- Organized gender workshop together with relevant stakeholders (**supported by peer adviser**)

### General

A successful and sustainable human capacity building of an organization depends on three main components:

1) the individual him/herself
2) the organization
3) the availability of training opportunities

Learning is a self-driven process. This means that every staff member is responsible for his/her own learning results when participating in training events or doing self-studying through online courses and other material. Motivation, attitude, in-advance preparedness, understanding the benefit of learning new skills, as well as undistracted and concentrated participation in training events are in key role to gain sufficient and sustainable learning results. Acting as a trainer by him/herself further strengthens the capacity of the staff member.

The organizational culture and support from the management ensure the competence of staff members and their possibilities for sustainable learning results, and further, facilitate the operation and development of organization through enhanced human capacity. The organization must determine the necessary competence of staff in each task, as well as it must ensure that the staff is competent through appropriate education, training, and exercise. The organization should also have and develop an internal competence development process to support the main service provision processes of quality management system. Special emphasis is recommended to give for guiding new staff members into their duties with the appropriate evaluation methods of required skills. Additionally, the management must ensure that staff members can participate in training events without requirement to carry out daily duties or any other distraction.

The availability of training opportunities depends on internal competence development process, annual development planning of individuals, and access to training outside the organization (e.g., through national and international partnership and development collaboration). The organization must ensure equal access to training events despite gender, age, or position.

In the following, capacity development needs and proposed activities will target both technical staff who operate and maintain the observing network as well as senior management who implements the Plan.

## 4.1. Assessment of human capacity gaps

The staff members relevant to operate and maintain observation networks, take care of data transfer and archiving include the following.

- **Observers** at the manual stations: Their educational background varies from university diploma to university degree. The observers receive one year training for their work by working together with experienced colleague.
- **Technical staff members:** They have educational background in electronics and mechanics. The training is normally of higher level than secondary school. Technical staff members typically receive additional, specific training on meteorological sensor maintenance abroad by manufacturers through international collaboration projects and as part of investment in observation infrastructure. Based on experience, training by sister organizations brings advanced benefits compared to training only by manufacturers.
- **IT experts:** They have educational background in applicable fields at the university level.

*Table 2. The number of staff members in different tasks in Meteo Rwanda.*

| **Staff information** | **Total number** |
|---|---|
| Managers (All adminsitration support staff) | 10 |
| Met (Forecasters, Met Application, Data quality control specialist, 2 Division managers) | 28 |
| Met Techn (Observation officers and supervisors, Instruments Maintenance and Calibration Officer) | 23 |
| Research | 1 |
| Technology and Information (IT) | 11 |
| Others (Data quality control officer, Obs Processing Officer, Big Data Specialist) | 7 |
| **Total current employee** | **80** |

| **Staff Disagregated by Gender** | Number | Percentage |
|---|---|---|
| Male | 56 | 70% |
| Female | 24 | 30% |

All staff members have sufficient background education. The number of staff in different tasks is indicated in table 2 (from CHD analysis). Even though, the number of staff seems sufficient, they have capacity gaps in specific job/task related areas: the installation, maintenance, and calibration of observation networks. In a similar way, capacity gaps exist in automatic data transfer, handling, and quality control. There is an increasing demand in meteorological skills in the country, and thus, trained staff change their positions and employers. This leads to a high turnover rate of staff in Meteo Rwanda. Hence, a continuous internal capacity and training is needed to adequately fil in the gaps.

The primary reason for changing jobs is to gain a better development of salary. A Governmental organization cannot itself influence on the development of salaries. However, by developing opportunities in the organization, updating job descriptions, and increasing the feeling that tasks are rewarding, the organization could lower the turnover rate.

The members of Meteo Rwanda management have degrees from university or equal.

The Meteo Rwanda does not have gender policy. Balance between female and male staff members is 24 (30%) and 56 (70%), respectively. Based on discussion, the job opportunities are equal for female and male in Meteo Rwanda. One must, however, remember that getting children often requires strengthened attention from mother at home. In Rwanda there are only a few day care centres at village level. Every institution (public and private) should have an early childhood development centre as required by the Government of Rwanda. In this regard, Meteo Rwanda has a plan to include that centre in the new building. This development would evidently increase the job opportunities of females. Additionally, there is still a lack of universities/training centres to provide training in meteorology in Africa (only 5). Rwanda does not have any such training opportunities. This is an additional factor limiting the possibilities of female.

## 4.2. Design capacity development activities for technical staff

The competence building process of the Quality Management System in the Meteo Rwanda is immature and is recommended to be enhanced within the framework of SOFF (*easy fix*). **The Meteo Rwanda is strongly recommended to develop and enhance competence building process by following WMO guidance** (no. 1205[13]). Additionally, the current competence building process lacks systematic internal training programme, and unfortunately, almost all training depends on external funding, projects, and trainers. The agenda for internal training programme will be determined through developing competence criteria. Material for training programme can be developed e.g., based on material shared in international capacity building projects. WMO (no 1114[14]) guides internal trainers.

**Recommendations on training activities within SOFF framework** to support work towards gaining minimum competence relative to WMO guiding no. 1083[15]. The training needs were identified during Gap Analysis.

- **Quality management system (QMS):** Effective and continuously developing QMS is the basis for the systematic operation and maintenance of observation network(s). The organization has strong understanding and knowledge about QMS, as well as trained staff for internal auditing. An effective development of observation process including lifecycle planning, however, require support through benchmarking mature sub-processes for upper air sounding and surface weather stations in other organizations. The Meteo Rwanda is recommended to enhance the existing surface station sub-process, where needed, and develop upper air sounding sub-process (*easy fix*).
- **Data archiving:** Programming skills of staff members must be strengthened to support strong and effective data archiving. Additionally, Meteo Rwanda is recommended to benchmark other organizations with mature data archiving system and tools to learn best practices.
- **Data transfer:** Programmers need training on the automatization of data transfer from stations to data base, and subsequently, to WMO WIS2.0 interface, which will replace GTS system. Complementary training to manage and update information in OSCAR surface service is much needed by staff members (*easy fix*).
- **Data quality control and assurance:** Basic programming skills and scientific understanding must be upgraded to sufficient level to apply QA/QC methods and algorithms. The relevant staff members need capacity building to manage scientific background behind different QA/QC methods. Benchmarking QA/QC methods in other organizations would provide substantial

[13] WMO guide no. 1205
[14] WMO guide no. 1114
[15] WMO guide no. 1083

benefits for the Meteo Rwanda. A roadmap for implementing relevant automatic QA/QC methods must be developed.

- **Instrument and station maintenance at site:** Once sufficient technical training for maintaining different sensor types has been received, the technical staff would benefit from good quality SOPs and competence requirement criteria. Both the SOPs and owning required competence support self-confidence at any work. Training on upper-air system operation and lifecycle maintenance is needed since it will be a new measurement technique in the organization.
- **Calibration and maintenance at workshop:** Rwandan Standard Board is responsible for calibrating meteorological observation sensors in Rwanda**.** They have received technical training how to use calibration and testing equipment in laboratory/field. They, however, require support and capacity building in scientific understanding and handling calibration results (*easy fix*). Meteo Rwandan technicians require capacity building in understanding a concept of quality through calibration and how calibration information must be inserted in the value chain of observation (*easy fix*). It is critically important that scientists are capable of analysing calibration results to support lifecycle and maintenance planning. Here benchmarking sister organizations would support in developing this area in the beneficiary organization.
- **Network monitoring and ICT system operations:** The staff members responsible for ICT need upgrade in their capacity (e.g., programming skills and technical understanding) to ensure the 24/7 automatic operation of data pipeline from station to international distribution.

## 4.3. Design capacity development activities for senior management

Based on discussions, the whole project organization (from the management to project contact points/project managers) would benefit from capacity building in portfolio and project management and coordination, as well as ensuring that project portfolio is aligned with the strategy of organization. The organization is recommended to consider training through at least the following:

- international development collaboration
- benchmarking organizations with mature project and portfolio management and coordination culture
- by certifying key staff members for portfolio and project management with an internationally recognized certificate.

## 4.4. Gender and CSOs considerations

Climate change and extreme weather events are not gender neutral, but they affect women, girls, men, and boys differently[16,17]. This is due to socioeconomic circumstances, cultural beliefs or traditions that can all contribute to inequality, resulting in women being put in situations of disadvantage when disasters strike. Therefore, it is important that in the pre-disaster context, those who likely will be the most affected by crisis, are also included in the preparedness process. This includes having equal access on political, social, and economic levels as well as being able to participate in decision making. Not only is it fair, that population is equally engaged in climate change adaptation and resilience building, but there is also substantial evidence that shows that women are often the most resilient members of society and the powerful agents of change in the event of a disaster. They also have historic coping mechanisms that can be of use when designing and tailoring local grass-root level early warning systems or other climate change adaptation services and activities. Including women in designing hydrometeorological

[16] Gender adaptation and disaster risk reduction
[17] GFDRR

and climate services directly leads to saving lives and livelihoods, as the needs of different groups have been better identified.

Regarding to the rational for organisations to pursue gender equality in governance, strategy, programmes, and decision making, is highlighted in WMO's recently updated Gender Action Plan[18]. It emphasizes that organizations that respect and value gender equality and diversity attract and retain talented staff and improve overall organizational performance, have more satisfied employees, are more innovative and have better governance. Teams that have gender diversity have better decision-making processes and attract more external partnerships, as well as have better access to local communities. Encouraging women to take up leadership positions has also shown to lead to important achievements in the field of climate change adaptation and disaster preparedness.

The politics of Rwanda encourage the institutions to gender balance, and furthermore, to have at least 30% of staff female/male employees. In the Meteo Rwanda the balance between female and male is 30/70. The Meteo Rwanda does not have gender policy nor measures for gender non-discrimination. According to the discussions with division managers responsible for hiring employees, new staff members are hired based on their competence, not based on gender. In Rwanda, male study topics like IT, engineering, electronics, physics, and meteorology more often compared to female. This can cause natural gender unbalance in different tasks.

Recommendations on the activities, consultations, and areas of collaboration for the implementation of the National Contribution Plan to ensure active CSOs participation, as well as the promotion of gender balance and opportunities at work are discussed in the following.

### Gender balance, women empowerment, and non-discrimination

Considerations on gender balance and women empowerment are inspired by the WMO Gender Action Plan[19]. The beneficiary is recommended to consider the following.

- **Assessing gaps** in human capacity through summarising staff skills, education levels, and capacity gaps for technicians, experts, and management, accommodating gender balance and gender opportunities including the following but not limited to
    - Are women given credit in the same way as male counterparts?
    - Are women overlooked for promotions or awards?
    - Is the workplace designed so that all will be comfortable?
    - How does your organization help with work/life balance?
    - Are women compensated equitably?
    - Is there a gender balance in the organization's leadership?
    - Are there policies about discrimination, harassment etc.?
    - Compile sex-disaggregated statistics, especially with respect to governance, human resources, and service provision (2.3.1(c) in WMO Gender Action Plan).
- **Preparing gender balance and women empowerment actions together with measures for non-discrimination for the organization.** Together with an internal gap analysis of organization, the WMO Gender Action Plan provides the following supporting guidance to be considered:
    - Increase the participation of women by: (i) identifying and nominating female experts from NMHSs or other national institutions to participate in the work of WMO governance bodies and their working structures and (ii) seeking equality in the composition of delegations to sessions (1.1.1(c) in WMO Gender Action Plan).

[18] WMO Gender Action Plan
[19] WMO Gender Action Plan

- Strive for gender balance, including in management and working structures (1.1.2(c) in WMO Gender Action Plan).
- Encourage and support female networks of experts (1.1.3(c) in WMO Gender Action Plan).
- Designate NMHS gender equality focal points (1.3.4(c) in WMO Gender Action Plan).
- Develop monitoring mechanisms at the national level by (i) adapting the WMO gender monitoring indicators or (ii) using an existing national framework (2.4.1 in WMO Gender Action Plan).
- Include gender equality (including the WMO Policy, GAP, link to online trainings and gender webpage, information on key activities) in the induction of new PRs and NMHS staff (3.1.4(c) in WMO Gender Action Plan)
- Develop the capacity of NMHS staff on unconscious bias, inclusive leadership, gender mainstreaming, and gender responsive service delivery through trainings and workshops (3.1.5(c) in WMO Gender Action Plan)
- Offer internships to young professionals, especially female, and secondments of staff from meteorological services on a rotational basis. (3.4.2(c) in WMO Gender Action Plan)
- Engage with international organizations field offices, such as UN Women, UNDP, etc. (5.1.4 (c) in WMO Gender Action Plan)
- Conduct research and provide the Secretariat with case studies, stories, and examples of gender mainstreaming, including in service provision, for the development of a compendium of good practices (5.3.3(c) in WMO Gender Action Plan).
- (i) Customize weather and climate services to the particular needs and roles of women and men and (ii) Provide education and training to target female users in accessing and using weather and climate information and products (7.3.1(c) in WMO Gender Action Plan).

During SOFF investment phase strong recommendation is to promote 50% of women participating in the capacity building activities and 50% of women participating in consultations with civil society organizations. It must be noted that 50% women participation is not feasible in training events for IT staff or management. In Meteo Rwanda, these personnel groups are currently represented by male only. Specific gender balance related activities during the SOFF investment phase will include the following:

| Activity | Indicator |
|---|---|
| Conduct two gender workshops to assess gaps in gender balance and gender opportunities (including gender discrimination, harassment) and provide recommendations accordingly. | Outline of the gender assessment with recommendations for actions in Meteo Rwanda |
| Organize stakeholder engagement workshops/consultations including, where possible, civil society organizations (CSOs) promoting gender equality by establishing minimum threshold for female participation | Stakeholders' engagement activities that involve CSOs with 50% female and male participants invited |
| Promote gender equality by establishing minimum thresholds for female participation in SOFF-related training events | Women should represent at least 20 % of all participants in SOFF-related and supported training events. |

### Active participation of CSOs

It is foreseen that during and after the SOFF implementation phase the following engagement activities together with CSO will bring mutual benefit and grounds for sustainable operation and financial background in short-, medium, and long-terms.

- Conduct stakeholder engagement workshops on the implementation of the SOFF project deliverables (observational data exchange to support weather/climate and water services and products). Promote an equal participation of women and men.
    - A special focus is recommended to be given for seeking partnerships from CSO to support operating and maintaining GBON station(s) in short-, medium- and long-terms. Such support could be found from the communities already carrying out climate measurements.
- Organise high level dialogues including representation from CSO on benefits, co-production, and ownership of the new national GBON infrastructure.
- UNDP (IE) and Meteo Rwanda (beneficiary) are recommended to develop and disseminate communication materials (i) highlighting the role of women in meteorology, hydrology, and climatology, (ii) promoting female role models, and (iii) advocating for gender responsive weather, hydrological and climate services (5.1.3(c) in WMO Gender Action Plan).

# Module 5. Risk Management Framework

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

### General

WMO recommends its members to establish a Quality Management System (QMS) to ensure that customer and end user requirements are met (WMO no. 1100[20]). Meteo Rwanda has ISO9001:2015 certified QMS, and subsequently, comprehensive risk matrixes for AWS and ICT operation and maintenance. During the NCP document preparation, the peer adviser reviewed the existing risk matrixes and proposed updates, where necessary (shared with confidence only between Meteo Rwanda and FMI). In general, the risk-based thinking (including the risk matrix) is at a high level in the organization. The main finding recommends Meteo Rwanda to give additional attention to risks related to 3rd party operators and their role in the value chain of observation. The risk management should be developed to include upper-air radiosounding as it is completely new observation branch in the organisation and country.

### Recommendations for risk management during SOFF investment implementation and operation period

As stated in the SOFF Operations Manual[21], the risk mitigation procedures of the IE will be relied upon for SOFF implementation during the Investment phase. The Operational phase is supported by the risk mitigation procedures of beneficiary.

The following summarises overarching key risks for investment and operation phase to be carefully considered and handled by IE, beneficiary, and peer adviser.

| **Potential key risks for investment and operation during SOFF implementation** | **Mitigation measures and responsibilities** | **Monitoring and evaluation** |
|---|---|---|
| **Investment phase** | | |
| Insufficient technical specification of items and other quality criteria in tender process. Price should not be only criteria for choosing a vendor. | Seamless collaboration between IE (responsible for tender process), peer adviser (responsible for technical sensor specification), beneficiary (responsible for supporting in setting up quality requirements and technical specifications to best support the needs in the country) | IE (on request with support from beneficiary and peer adviser) will be responsible for monitoring and evaluating the quality of documents before opening the tender process. |
| Failure in tax exemption when importing the goods | Before shipment IE will be responsible to ensure that shipper and freight agent are aware of tax exemption process in Rwandan border. Beneficiary is responsible for providing all required documentation, | IE will be responsible for following up the shipment process until it has been tax exempted in the Rwandan customs. |

[20] WMO guide no. 1100
[21] SOFF operations manual

| | | |
|---|---|---|
| | information, and support for tax exemption declaration process. | |
| **Operation phase** | | |
| Decrease in funding support for operations | Sufficient lifecycle planning, and subsequent, annual budget planning combining different funding source (SOFF, budget, UNDP support, cost-recovery) | IE and the management of Meteo Rwanda are responsible for monitoring and taking required corrective actions. |
| Insufficient staff competence, changes in staff members | The beneficiary develops internal training programme including the criteria of competence requirements for technical staff. A duplication of skilled staff members for critical tasks. | The management of beneficiary organization is responsible for monitoring and evaluation. |
| The management of observation and data processes is insufficient. | Frequent follow up how strategic goals and annual targets have been achieved. | The management of beneficiary is responsible for reviewing and monitoring that work has been conducted as intended according to QMS. |

# Module 6. Transition to SOFF investment phase

**The transition to SOFF investment phase is recommended to carry out by following the Gap Analysis and National Contribution plan** (this document). The peer adviser, IE and beneficiary have together filled in funding request for SOFF implementation phase. This supports the best coordination in the transition phase.

# Summary of GBON National Contribution Plan

| Components | Recommended activities |
|---|---|
| **Module 2.** GBON business model and institutional development | The business model of Meteo Rwanda relies on public-private partnership. The organization is active in partnering with public and private sectors as well as with academia. There is still room for further enhancing and widen partnerships nationally and internationally to ensure GBON compliance throughout the value chain of observation (from operation and maintenance to QA/QC).<br><br>The financial status of the Meteo Rwanda to carry out GBON compliant operations consists of Governmental budget funding, international development collaboration projects and financial support from UNDP (IE) for station maintenance (including financial support for maintenance missions).<br><br>To systematically justify budget and project funding allocations for maintenance, replacing sensors at stations and procure calibration services from RSB, the Meteo Rwanda must develop lifecycle plan for AWS and radiosounding station. Lifecycle plan will support sufficient financing for timely maintenance. |
| **Module 3.** GBON infrastructure development | The GBON compliant observation infrastructure and subsequent data pipeline is recommended to build and develop by following WMO guidance, the existing good practices, enhancing operation processes and SOPs in the beneficiary organization, as well as by benchmarking equivalent operations in other organizations. |
| **Module 4.** GBON human capacity development | The gap in capacity of Meteo Rwandan staff is in specific job/task related areas: the installation, maintenance, and calibration of observation networks. In a similar way, a capacity gap exists in automatic data transfer, handling, and quality control. The staff turnover is also an issue in Meteo Rwanda which causes continuous need for an internal training of capacity.<br><br>The main gap in human capacity development includes immature competence building process in Meteo Rwanda. This fact has several significant negative impacts: gained capacity pours out when staff changes, new staff members receive a familiarization of inhomogeneous quality while management and staff member him/herself remain uncertain of competence level, as well as all training depends on external funds and projects. The enhancement of the competence building process is recommended as an urgent and very first task which is supported with specialized trainings. |
| **Module 5.** Risk Management | As recommended by WMO no. 1100[22], Meteo Rwanda has ISO9001:2015 certified Quality Management System, and subsequently, comprehensive risk matrix for AWS and ICT operation and maintenance. During the NCP document preparation, the peer adviser reviewed the existing risk matrix and proposed updates, where necessary. As a conclusion, a summary of key risks and their mitigation measures relevant to SOFF implementation and operation phases are given. |

[22] WMO guide no. 1100

| | |
|---|---|
| **Module 6.**<br>Transition to SOFF investment phase | **The transition to SOFF investment phase is recommended to carry out by following the Gap Analysis and National Contribution plan** (this document).<br><br>The peer adviser, IE and beneficiary have together filled in funding request for SOFF implementation phase. This supports the best coordination in the transition phase. |

## Report completion signatures

| |
|---|
| **Peer Advisor signature**<br>Harri Pietarila |
| **Beneficiary Country signature**<br>GAHIGI Aimable<br>Director General |
| **WMO Technical Authority signature** |