Systematic Observations Financing Facility

29th September 2023

GBON National Gap Analysis

Maldives

Systematic Observations Financing Facility

Weather and climate data for resilience

WEATHER CLIMATE WATER

Screening of the National Gap Analysis (NGA) of Maldives

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

Following iterations with the peer advisor and beneficiary country, WMO Technical Authority confirms that the National Gap Analysis is consistent with GBON regulations.

While the WMO GBON Global Gap Analysis identified the need for 4 surface land and 1 upper air stations, the **WMO Technical Authority confirms the NGA results which indicate the need for 5 surface land and 1 upper air stations to ensure adequate horizontal resolution for GBON.**

Date: 27th Oct 2023

Signature:

Albert Fischer
Director, WIGOS Branch, Infrastructure Department, WMO

GBON Gap Analysis Report
Maldives

Beneficiary Country Focal Point	Ali Shareef, MMS
Peer Advisor Focal Point and Institute	Marilla Visuri, FMI
WMO Technical Authority	

1 Country information from the GBON Global Gap Analysis

The Maldives is an approximately 1000 km long north-south oriented chain of small Islands in the Indian Ocean. The overall area of Maldives is roughly 90,000 square kilometers (35,000 sq mi), of which only 298 km2 (115 sq mi) is dry land, making this one of the world's most dispersed countries. There are 22 geographical atolls comprising of about 1200 islands which are divided into 20 administrative units. However, not all islands are inhabited, and in fact only about 200 islands are inhabited. Surrounded by large ocean territories with only limited land area, the importance of weather observations for global numerical weather predictions models is perhaps higher than in many other countries.

Based on the WMO Global WIGOS Data Quality Monitoring System there are currently 5 (manual) surface observation stations reporting from the country. However, the temporal reporting interval of the stations is only 3 hours, as the GBON requirement is one hour. The horizontal coverage with 5 stations is barely fulfilling on average the GBON criteria of 200 km station interval.

There is also one upper air sounding station in Gan, in the Southern part of Maldives, however it doesn't deliver data into any international distribution. The nearest sounding sites are in Diego Garcia (British Indian Ocean Territories) and in Minicoy Island (India), either of them not reporting currently to WIGOS, approximately 1000 km from Gan Sounding station. The distance of the sounding stations would barely fulfil, the GBON requirement of 1000 km in marine area (applied in SIDS), however not the 500 km requirement of land area. Moreover, none of the stations in the neighboring countries in the area are reporting.

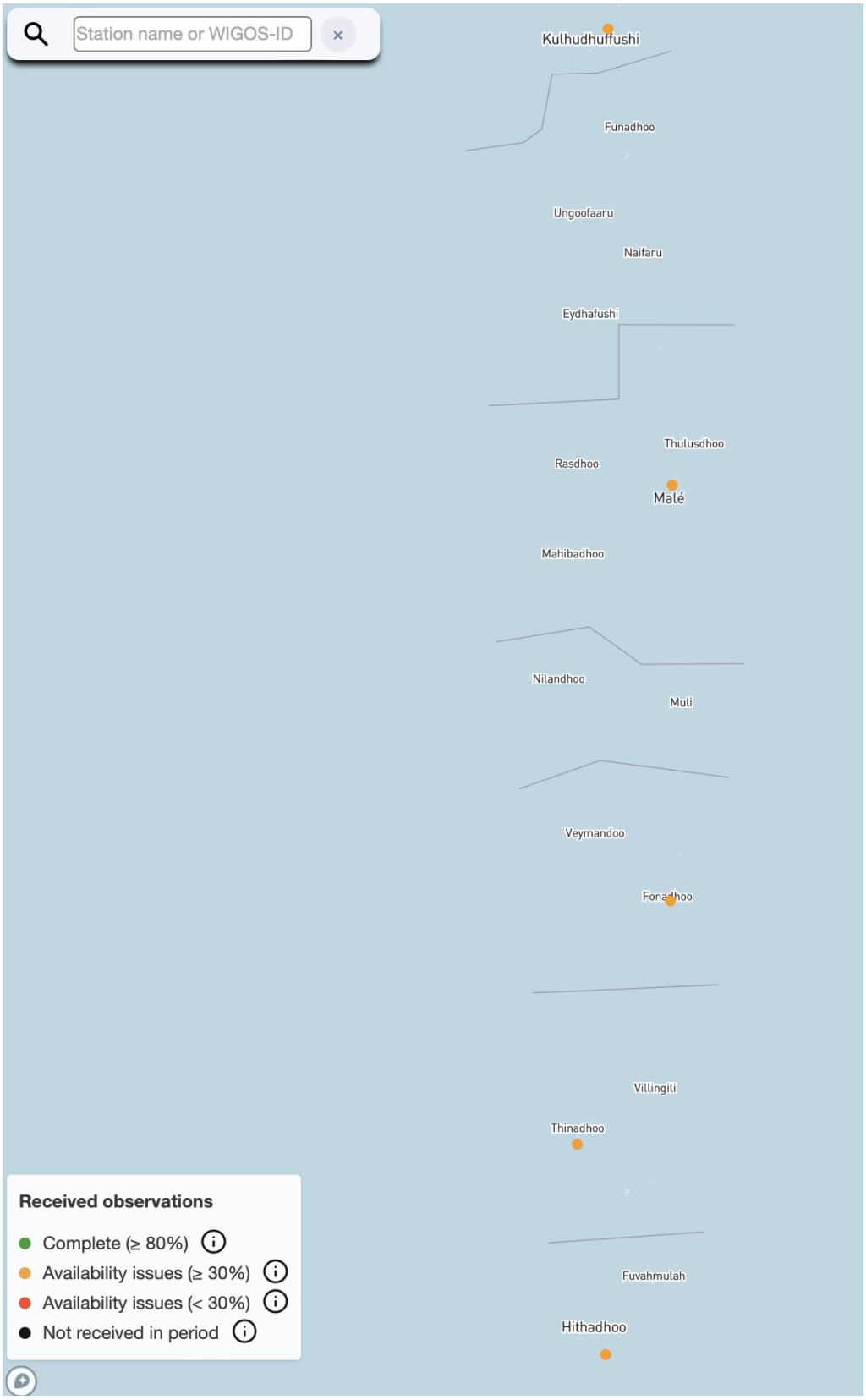

Figure 1 Map of observation station network reporting to the GTS/WIS

Table 1. WMO Global Gap Analysis (June 2023). Illustration of the information that the WMO Secretariat provides to each country

GBON horizontal resolution requirements	GBON target	Reporting	Gap improve	Gap new	Gap total
Surface stations Horizontal resolution: 500km (SIDS)	4	5	4	0	4
Upper-air stations Horizontal resolution: 1000km (SIDS)	1	0	1	0	1

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

Currently Maldives has 5 GBON-eligible stations, however the stations produce observations only every three-hours and the cycle needs to be shifted to hourly to meet with the GBON and SOFF requirements. Some of the equipment is also obsolete, for example the mercury thermometers need to be replaced with digital technology, as the spare parts are no longer available.

Although the GBON requirements are fulfilled in horizontal manual station density on average, there are distances that exceeds these limits between individual stations. For example, this is the case between Hanimaadhoo (43533) and Male (43555) synoptic stations. Therefore, one additional station with basic instruments (tentatively at Maafaru) is recommended to be installed by SOFF to reach the compliance with GBON between all stations in Maldives.

The one and only one upper-air station in the country (WMO location indicator-43555) needs to be upgraded. The current Hydrogen Generator is old and non-functional and needs to be replaced with a new one. The current sounding station is manufactured by International Met Systems company by some 20 years ago, and according to the manufacturer, the version and model is no longer manufactured and supported and thew system is therefore obsolete.

Table 1. Assessment of existent GBON stations per their operational status and network ownership

GBON Requirements	Existing observation stations (# of stations)			
	NMHS network		Third-party network	
	Reporting	Improve	Reporting	Improve
Surface stations Horizontal resolution: 500km (SIDS) Variables: SLP, T, H, W, P, SD	**5**	**4**	**0**	**0**
Upper-air stations Horizontal resolution: 1000km (SIDS) Vertical resolution: 100m, up to 30 hPa Variables: T, H, W	**0**	**1**	**0**	**0**

Table 2. Assessment of existing GBON stations per station characteristics. Station type: S: Surface, US: Upper-Air; Owner of the station: NMHS or name of third-party; GBON variables: SLP: Sea-level pressure; T: Temperature; H: Humidity; W: wind; P: Precipitation; SD: Snow depth; Reporting cycle: Number of observation reports exchanged internationally per day (0-24); GBON compliance: weather the station is GBON compliant or not (see GBON guide on compliance criteria).

Station name	Station type (S/UA)	Owner (NMHS/third-party)	Funding source	GBON variable measured						Reporting cycle	GBON Compliance (Y/N)
				SLP	T	H	W	P	SD		

HANIMAADHOO	S	NMHS	NMHS	x	x	x	x	x		8	N
MALE	S	NMHS	NMHS	x	x	x	x	x		8	N
KADHDHOO	S	NMHS	NMHS	x	x	x	x	x		8	N
KAADEDHDHOO	S	NMHS	NMHS	x	x	x	x	x		8	N
GAN	S	NMHS	NMHS	x	x	x	x	x		8	N
GAN	UA	NMHS	NMHS		x	x	x	x		0	N

3 Results of the GBON National Gap Analysis

3.1 GBON surface stations

Requirement of basic horizontal resolution of the GBON surface stations (500 km, for SIDS) is fulfilled on average with 4 stations. However, there is an over 300 km interval between the stations in Hanimaadhoo and Male and considering the scarcity of the observation stations in the Indian Ocean in general an additional station is recommended to be financed through SOFF to fill this gap.

There is also a gap in the surface observation data delivery process to GTS/WIS -networks, mostly due to the three-hour observation cycle. There are also some randomly occurring issues with the New Delhi GTS-center, as the data is not always forwarded to the GTS from there. Currently MMS uses Corobor Messir system to share the data with the New Delhi Center. There is a plan to install new version of the Message Switch software, that enables sending of data to other GTS centers as well, and it would most likely fix these issues. Moreover, technology for WIS2.0 should be implemented, in case such is not existing in with the Corobor system.

To reach the required reporting interval of one hour and to replace obsolete technology (especially mercury thermometers), it is recommended that the selected GBON stations will be automated regarding the GBON variables (SLP, T, H, W, P).

Data availability of the proposed stations and from existing network can be increased or ensured by addressing lack of spare parts for maintenance and operation. Currently MMS has 8 technicians responsible for the station maintenance, which is not sufficient for sustainable operation and regular maintenance of the network. It is recommended to recruit 4 technicians to join the team. MMS also lacks stock of spare parts and in case of sensor or station failure in some station may cause a long delay in data acquisition.

Also, lack of basic calibration laboratory facilities and human capacity with MMS to operate these facilities is a challenge for station maintenance and data quality. It is recommended that MMS seeks to cooperate with some nearby country in establishing systematic calibration procedure.

3.2 GBON upper-air station

The one and only one upper-air station in Maldives (WMO location indicator-43555, manufactured by International Met Systems) needs to be upgraded. According to the manufacturer, manufacturing this type of station is discontinued and therefore the support for the old system is limited or even non-existent. Moreover, the current Hydrogen Generator (manufactured by Proton energy Systems) is old and non-functional and needs to be replaced with a new one. This would fulfill the GBON requirement of the sounding station network with 1000 km (marine, applied in SIDS) density.

Table 3. Results of the GBON national gap analysis

SLP: Sea-level pressure; T: Temperature; H: Humidity; W: wind; P: Precipitation; SD: Snow depth

GBON requirements	Target (# of stations)	GBON Compliant stations (#)	Stations gap	
			New	Improved
Surface stations • **Horizontal resolution**: 500km (SIDS) • **Variables**: SLP, T, H, W, SD • Observation cycle: 1h	5	0	**1 (MAAFARU)**	**4 (HANIMAADHOO, MALE, KADHDHOO, GAN)**
Upper-air stations • **Horizontal resolution**: 1000 km (SIDS) • **Vertical** resolution: 100m, up to 30 hpa **Variables**: T, H, W • **Reporting cycle**: twice a day	1	0	**0**	**1 (Gan)**

Table 4 GBON observation stations in Maldives to be improved

Name	Lat	Lon	Variables	Reporting cycle
Hanimaadhoo	6°44'53.7"N	73°10'10.3"	SLP,T,H,P,W	8
Hulhule (Male)	4°11'34.0"N	73°31'39.4"	SLP,T,H,P,W	8
Kadhdhoo	1° 51' 36.3"N	73° 31' 12.8"	SLP,T,H,P,W	8
Gan	0°41'24.4"S	73°08'59.3"	SLP,T,H,P,W	8

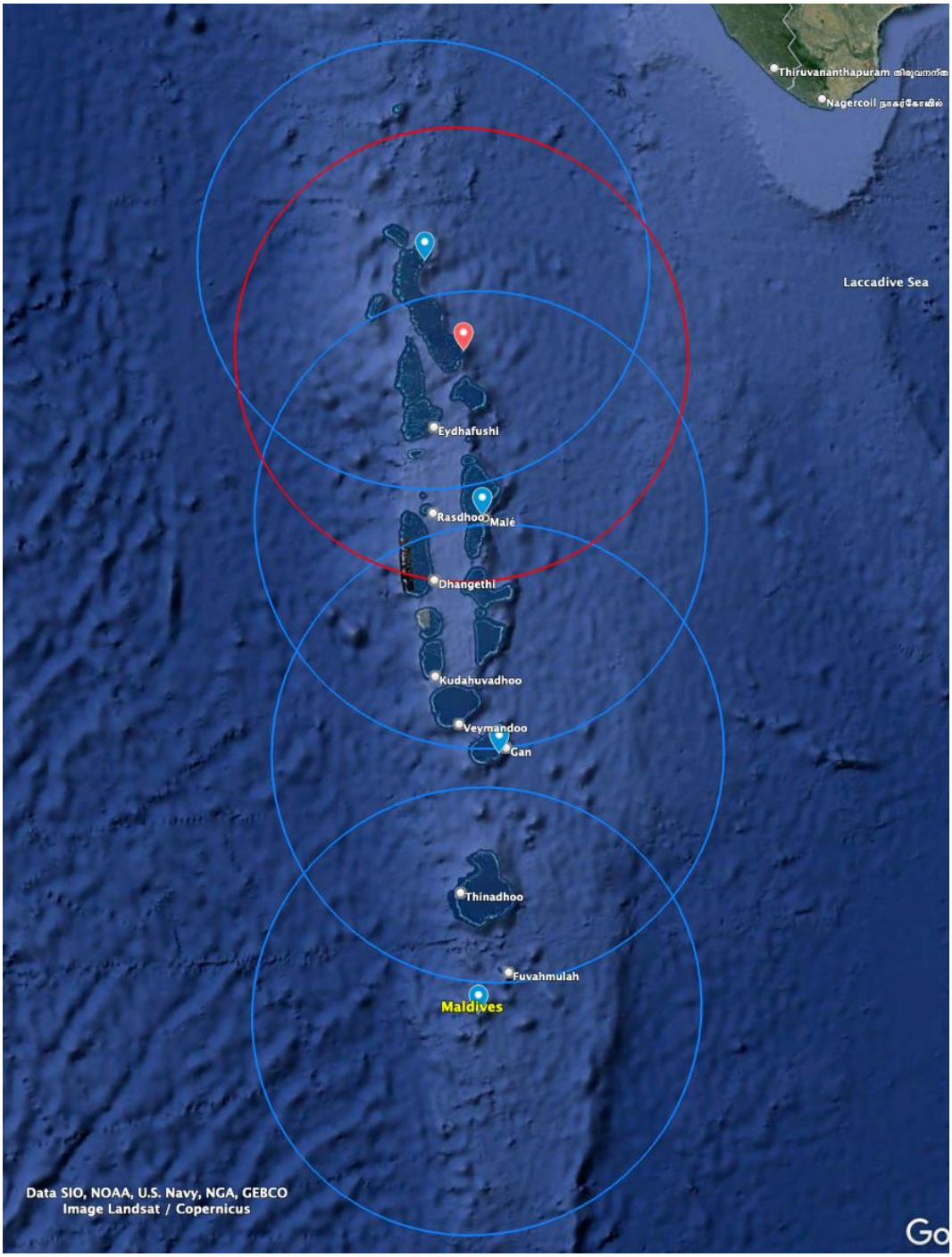

Figure 2 Geographical visualization of the distribution of proposed GBON surface stations to be supported by SOFF. Existing stations in blue markers and proposed new station (tentatively in Maafaru) in red, all with diameter of 500 km.

Table 5 GBON sounding stations in Maldives

Name	Lat	Lon
Gan	0°41'24.4"S	73°08'59.3"

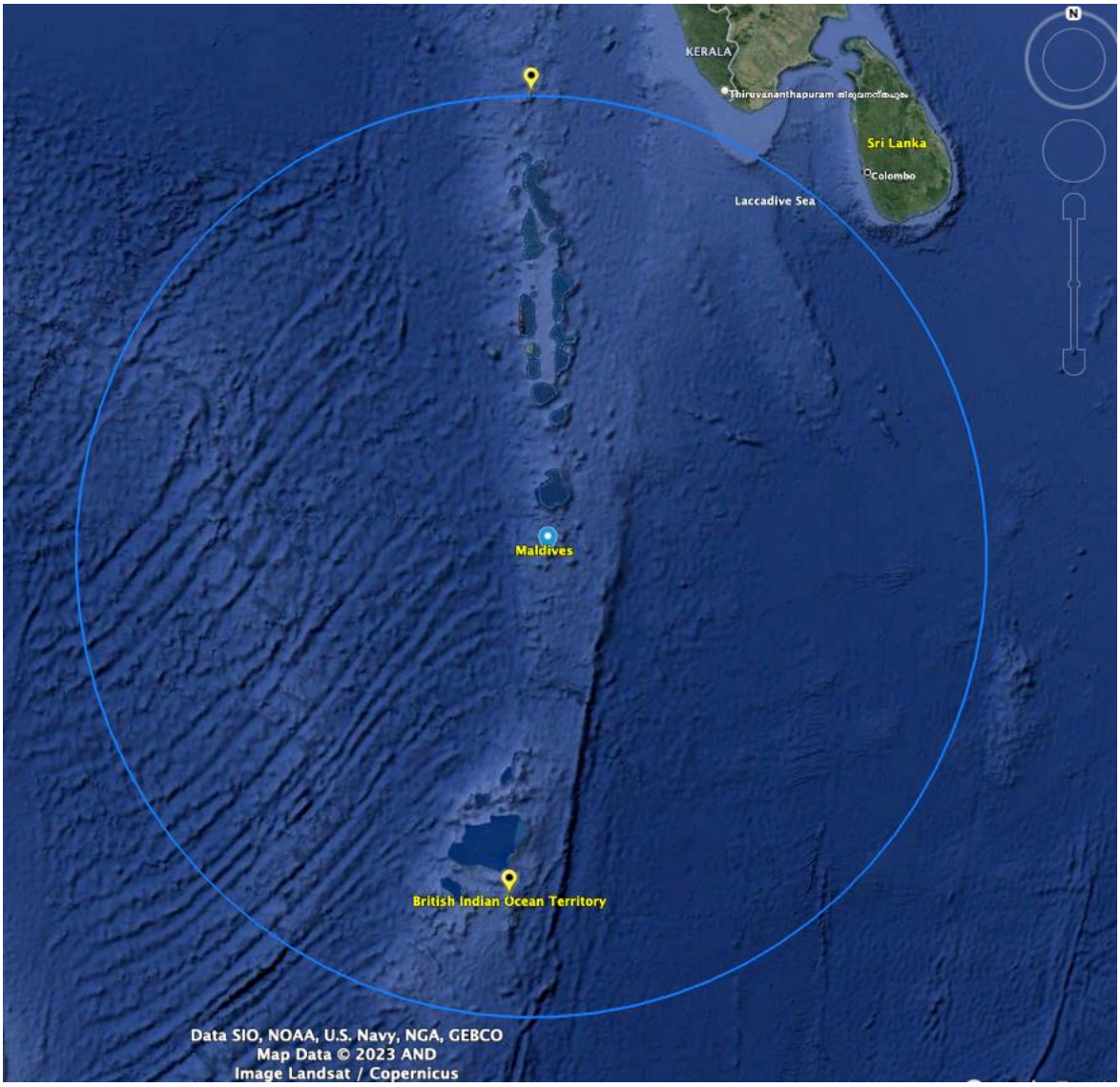

Figure 3 Sounding station network in the region. Gan sounding station in blue dot and circle of 1000 km radius. Neighboring counties' sounding stations in yellow.

3.3 Summary of recommendations

The following lists the key-recommendations of actions during the SOFF investment and compliance phase. More detailed recommendations and actions will be listed in the national contribution plan document.

- Renewal of the Gan sounding station
- Renewing the thermometers and wind sensors in all GBON stations, including automating the stations in terms of GBON variables
- Installation of new surface observation station (in Maafaru)
- Starting one-hour observation/data sharing cycle in all GBON stations.
- Implementation of WIS2.0 compliant data sharing
- Establishing spare part stock, design calibration procedures and training of the staff

4. Report completion signatures

Peer Advisor signature

Julia Warley, Project Manager
Finnish Meteorological Institute

WMO Technical Authority screening remarks and signature

Beneficiary Country remarks and signature

Excellent report by the peer advisor with constructive consultations (online and face to face) between parties during the past few months. This report thoroughly conversed on surface, upper air observation status, instrument maintenance, calibration, data sharing and required capacity building.

Ali Shareef

Annex 1.

Review of GAPs in capacity

In addition to number of GBON compliant observation stations, the discussions of Gap Analysis included a short review of Quality Management System (QMS), the status and capacity gaps in data transfer, database management, sensor maintenance and calibration, metadata, and quality control.

QMS

The MMS has QMS based on ISO9001:2015.

No identified gaps.

Central database

The MMS is currently lacking central database system. With the proposed upgrades in the GBON observations stations to AWS's, implementing such system is critically important. The system should be able for data management, provision of different network monitoring information, running quality control mechanism, to communicate through different APIs and for importing and exporting open data. It will be important that data from different sources is stored in one place to simplify the system of data pipeline as a whole.

Identified gaps

- No centralized database system with data transmission, quality control, processing and archiving. Hardware and there a need for a more robust software for database management)
- Insufficient staff capacity and programming skills
- Benchmarking other organizations

Data transfer

The data reading and transfer processes are currently manual; including synoptic observations. Especially, MMS has lack of skills to automate data transfer processes to share data with international data sharing collaborations (GTS etc.). In the future and as required by the GBON and SOFF, the WIS2.0 compatible data sharing system should be implemented. The data is currently sent to New Delhi GTS center. The MMS seems to be punctual with the sharing of the data, however there are occasionally problems with sharing the data onwards from New Delhi Center.

Identified gaps

- Further training and improving staff capacity, especially programming skills
- Data transfer software
- Benchmarking other organizations

- Lack of training on WIS 2.0 which will replace GTS system

Metadata

Please refer to < https://oscar.wmo.int/surface/ > for available metadata.

Identified gaps

- Metadata table is not complete
- Need to update some fields in the metadata table.

Data quality control and assurance

Data quality control is currently made manually at moment when observations are made. In the future, especially when implementing automated observation technology, there is a strong need to improve the capacity for automated data quality assurance (QA) and control (QC) throughout the whole value chain of observation.

Identified gaps

- Training in staff capacity, especially in automated systems
- Automated QC/QA methods and algorithms
- Programming skills
- Benchmarking other organizations

Sensor maintenance and calibration

MMS does not carry out calibration of sensors in laboratory, however occasional field calibrations are made. In order to carry out calibration, sufficient capacity and infrastructure has to be built first or an agreement with some neighbouring or nearby country should be made for subcontracting the instrument calibration services. At the same time the MMS staff members should receive training on the maintenance of the observation infrastructure and particularly the Automatic Weather Stations. The sensor maintenance procedures are part of the Quality management system of the MMS and are well documented.

Identified gaps

- Further training in staff capacity and additional staff members
- Improved knowledge on sensor maintenance and calibration
- Calibration infrastructure/collaboration with neighbouring countries
- Lack of budget for maintenance