



Fifth Steering Committee **20-21 June 2023**

SOFF and GBON Compliance

Decision 5.7

Systematic Observations
Financing Facility

**Weather
and climate
data for
resilience**



Decision 5.7: SOFF and GBON Compliance

The SOFF Steering Committee

Adopts the SOFF and GBON Compliance document.

Requests

- the SOFF Secretariat and WMO as the SOFF Technical Authority to coordinate, as needed, the preparation of the complementary operational guidance notes required to ensure smooth implementation of the provisions stated in this document across all the phases of SOFF support.
- the SOFF Secretariat and WMO as the SOFF Technical Authority to develop a SOFF Compliance Phase Framework, using the provisions described in this document, and drawing on lessons learned from the execution of SOFF Readiness and Investment phase activities, for approval of the SOFF Steering Committee at a future date.

Encourages peer advisors, Implementing Entities, WMO Secretariat, and SOFF Secretariat to join efforts to support SOFF beneficiary countries to bring rapidly as many stations as possible into GBON compliance.

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1. Introduction

This document presents the core provisions of WMO compliance monitoring for the Global Basic Observing Network (GBON) and how this monitoring is used in all phases of SOFF implementation. It also clarifies how the SOFF principle of additionality will be applied, using the GBON compliance tools and an assessed baseline.

This document also responds to the request from the SOFF Steering Committee in its Decision 2.2:

“Notes the request to consider incorporating data quality considerations in the compliance phase and for WMO to incorporate this into an overarching proposal for a compliance framework for Steering Committee consideration by the 5th Steering Committee scheduled to take place June 2023.”

The elements outlined here build on and are based on the GBON technical regulations,¹ which are mandatory on WMO Members (193 states and territories), and guidance material² that helps them interpret these regulations. They are also based on the SOFF Terms of Reference and Operational Manual.³

The WMO, as the SOFF Technical Authority, and the SOFF Secretariat prepared this document. It is proposed that a full Compliance Phase Framework, co-designed by SOFF and WMO as the SOFF Technical Authority, outlining the responsibilities of all the actors in the Compliance Phase, be presented to a future Steering Committee for adoption.

2. SOFF and GBON compliance: requirements, tool, and criteria

All SOFF activities and results are strictly guided by the GBON requirements, the GBON compliance criteria and measured using the WIGOS Data Quality Monitoring System (WDQMS) which monitors the flow of data into global numerical weather prediction systems. This data is then also used in climate reanalyses. SOFF uses the GBON compliance criteria applicable to all WMO Members as the basis to plan and implement activities and monitor and verify results.

The WMO Technical Authority is responsible for the tools to monitor SOFF progress based on GBON compliance monitoring. Monitoring and data collection will be based entirely on WDQMS. The performance data, nationally and station by station, will be available to all interested parties to ensure transparency.

¹ Section 3.2.2 GBON of the *Manual on the WMO Integrated Global Observing System*, Annex VIII to the WMO Technical Regulations ([WMO-No. 1160](#)), which was adopted in 2021 by the extraordinary World Meteorological Congress [Resolution 2 \(Cg-Ext\(2021\)\)](#).

² Guide to The Global Basic Observing Network. (WMO-No. 1314), Seventy-Sixth Session World Meteorological Organization Executive Council - final report in progress. Provisionally available as an approved document at: [https://meetings.wmo.int/EC-76/layouts/15/WopiFrame.aspx?sourcedoc={06B12BCB-0094-451B-9BF2-65D47D6ED4D1}&file=EC-76-d03-2\(3\)-GBON-GUIDE-ANNEX-approved_en.docx&action=default](https://meetings.wmo.int/EC-76/layouts/15/WopiFrame.aspx?sourcedoc={06B12BCB-0094-451B-9BF2-65D47D6ED4D1}&file=EC-76-d03-2(3)-GBON-GUIDE-ANNEX-approved_en.docx&action=default)

³ SOFF Operational Manual available at: <https://alliancehydromet.org/wp-content/uploads/2022/12/FINAL-SOFF-Operational-Manual-.pdf>. SOFF Terms of Reference available at: <https://alliancehydromet.org/wp-content/uploads/2021/10/SOFF-Terms-of-Reference.pdf>

2.1. GBON requirements and SOFF scope

The overall purpose of GBON is to secure an adequate supply of observational data to the global NWP centres that serve all countries with model products. “Adequate supply” means (i) measurement of the most important variables, (ii) measurements made at a sufficient spatial density, and (iii) measurement reported at a sufficient temporal frequency and timeliness to be useful in forecasting.

- **GBON technical regulations:** These consist of two types of requirements: *standard practices*, mandatory and identified in GBON regulations by using the verb “shall”, and *recommended practices*, identified by using the verb “should”.
- **Station types:** GBON standard practices focus primarily on two specific types of land-based stations: surface and upper-air and, where appropriate, marine meteorological observing stations or platforms within the Exclusive Economic Zone (EEZ). SOFF focuses initially on surface and upper-air stations.⁴
- **Horizontal spacing and time resolution:** The GBON technical regulations establish minimum (standard practice) horizontal resolution of 200 km for surface stations with hourly reporting, and 500 km for upper-air stations with reporting twice per day. For simplicity, WMO evaluates the required number of stations for each country depending on their surface area, allowing each Member to choose the sites of stations.
- **Data exchange:** GBON technical regulations require countries to make all GBON observations available internationally through the WMO Information System in real-time or near real-time, according to the overall WMO Unified Data Policy.⁵

The variables to be observed at each surface land station are, at a minimum: atmospheric pressure (SLP), air temperature (T), humidity (H), horizontal wind (W), precipitation (P) and snow depth (SD), where applicable.

The variables to be observed at upper-air stations/platforms over land are, at a minimum: air temperature (T), humidity (H) and horizontal wind (W).

SOFF support is limited to the number of country stations needed to comply with the GBON standard practices (See “horizontal resolution” in Table 1), and as determined by the WMO Commission for Observation, Infrastructure, and Information Systems (INFCOM). Table 1 summarizes the standard practices of the GBON regulations included in the current scope of SOFF support.

⁴ The GBON Technical Regulations also include a requirement for WMO Members to take marine observations of sea level pressure and temperature over their Exclusive Economic Zones. Guidance is in preparation for future application of this requirement, which for the moment are beyond the scope of SOFF support.

⁵ Adopted by Congress in 2021 as [Resolution 1 \(Cg-Ext\(2021\)\)](#)

Table 1. Summary of the standard practices of the GBON regulations.

GBON requirements – per station type	GBON Variables					
	SLP	T	H	W	P	SD
Surface land stations Horizontal resolution: 200km Observing cycle: 1h Real-time data exchange to WMO Information System (WIS)	X	X	X	X	X	X
Upper-air stations operated from land Horizontal resolution: 500km Vertical resolution: 100m, up to 30 hPa Observing cycle: twice a day Real-time data exchange to WMO Information System (WIS)		X	X	X		

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

2.2. WIGOS Data Quality Monitoring System (WDQMS) as the GBON monitoring tool

The [WDQMS web tool](#) is a resource developed by WMO in partnership with global numerical weather prediction centres, to monitor the performance of all WMO Integrated Global Observing System (WIGOS) observing components. It provides accurate, complete, and up-to-date monitoring of GBON.

The WDQMS web tool monitors the *availability* and *quality* of observational data based on near-real-time information from the four participating global Numerical Weather Prediction (NWP) centres: the German Weather Service (DWD), the European Centre for Medium-range Weather Forecasts (ECMWF), the Japan Meteorological Agency (JMA) and the United States National Centers for Environmental Prediction (NCEP). These are four of the ten World Meteorological Centres, designated by WMO to provide global NWP products for all WMO Members.

The tool links the availability and quality of surface-based observational data with the WIGOS station descriptor metadata and user requirements stored in the WMO OSCAR⁶ database, providing information on network/station issues and incidents to WMO Members and to Regional WIGOS Centres (RWCs) for follow up assessment and resolution actions. This ensures that the global NWP products remain anchored to the reality of the ground-based observations, thereby improving their forecast skill.

2.3. GBON Compliance criteria

The definition of GBON compliance includes two parts: (a) station-level compliance and (b) country-level compliance. Acknowledging the circumstances of SOFF beneficiary countries, SOFF supports and rewards progress by focusing on station-level compliance while striving to support countries to achieve country-level compliance as much as possible.

- (a) Station-level compliance: is achieved when a given station reports the required measurements, at the required temporal frequency, with the required reporting quality.

⁶ Observing Systems Capability Analysis and Review Tool

This compliance is judged in a uniform way, using criteria that allow for the realities of operating stations where hardware, power, communications, and security can fail - allowing for short downtimes while these issues are addressed.

- (b) Country-level compliance: is achieved when a given country is operating a sufficient number of compliant GBON stations to satisfy the horizontal density requirements.

The compliance criteria to be met for each GBON surface station are presented in Table 2, while those for GBON upper-air stations are shown in Table 3.

Table 2. Compliance criteria for GBON surface observing station.⁷

Name	Description	Criteria
Monthly Availability (%)	No. of received monthly reports ⁸ /(Days per month*24) ⁹	≥ 80%
Timeliness (%)	No. of late BUFR ¹⁰ reports ¹¹ /(Days per month*24)	< 5%
Monthly Quality (%)	No. of rejected monthly reports ¹² / (Days per month*24)	< 5%

⁷ For simplicity, the GBON Guide defines compliance against these criteria only on the most important variable: atmospheric pressure.

⁸ Monthly aggregation of observed variables from BUFR reports, received by at least two of the NWP centres monitored by WDQMS web tool.

⁹ If a station is manually operated but is not operational 24 hours, this number can be reduced to the operational hours (hourly reporting i.e., 0800 – 1700 = 10 reports) as recorded in OSCAR/Surface. This needs to be registered as an exception to GBON regulations.

¹⁰ Binary Universal Form for the Representation of meteorological data

¹¹ Monthly aggregation of reports that missed time cut-off from NWP centres/WIS.

¹² Monthly aggregation of rejected reports from NWP centres, could also be gross errors or outside of OB-FG threshold.

Table 3. Compliance criteria for GBON upper-air observing station.¹³

Name	Description	Criteria
Monthly Availability (%)	No. of received monthly profile (to 30hPa) reports ¹⁴ /(Days per month*2) ¹⁵	≥ 80%
Vertical Resolution ¹⁶ (Y/N)	Vertical resolution is at least 100 m	Yes
Timeliness (%)	No. of late BUFR ¹⁷ /TEMP reports ¹⁸ /(Days per month *2)	< 5%
Monthly Quality (%)	No. of rejected monthly reports ¹⁹ /(Days per month* 2)	< 5%

The availability and quality of GBON observations is continuously monitored by the WDQMS with the goal that all the required GBON observations are normally assimilated in the global NWP models. These elements allow objective assessment of countries' progress toward GBON compliance, and, therefore, of SOFF's success.

2.3.1 Data availability

The data availability statistics are obtained by WDQMS by comparing the observations received by the NWP Centres via the WMO Information System (WIS) to the expected availability according to the schedule of international exchange declared in OSCAR/Surface and set by the GBON requirements.

The variables monitored for surface stations are: surface pressure (or geopotential height, for some land stations in mountainous areas), 2-meter temperature, 2-meter relative humidity and 10-meter wind (meridional and zonal components). Monitoring of the two other required variables, precipitation and snow depth (where appropriate), will be implemented in the future. For the upper-air stations, they are air temperature, relative humidity and wind, both meridional and zonal components.

2.3.2 Timeliness

Timeliness is the time difference between the nominal observation time (as reported in the BUFR message itself) and the time at which the observation arrives at the WDQMS monitoring centres (see 2.2.). Observations arriving too late to be included in the operational near-real-time processing chain of those NWP centres are considered not timely and will not be counted

¹³ For simplicity, the GBON Guide defines compliance against only one variable of the four required: air temperature.

¹⁴ Monthly aggregation of observed variables from BUFR reports, received by at least two of the NWP centres monitored by WDQMS web tool.

¹⁵ If a radiosonde station is only able to undertake one sounding per day, this number can be reduced to the scheduled as recorded in OSCAR/Surface. This needs to be registered as an exception to GBON regulations.

¹⁶ High Resolution data (BUFR) being received confirmed by at least two of the NWP centres monitored by WDQMS web tool.

¹⁷ Binary Universal Form for the Representation of meteorological data

¹⁸ Monthly aggregation of reports that missed time cut-off from NWP centres/WIS

¹⁹ Monthly aggregation of rejected reports from NWP centres, could also be gross errors or outside of OB-FG threshold.

towards the data availability targets. Late observations do not contribute to the skill of these centre's forecast products. They will still, however, contribute to the skill of climate monitoring re-analyses.

2.3.3 Quality

WDQMS data quality statistics are obtained by comparing the Observation minus Background (O-B) departures, provided by the WIGOS Monitoring Centres, and by counting the number of rejections in their observation data quality control algorithms. These automated algorithms reject data that has drifted out of calibration or is otherwise inconsistent with physical reality. They serve as an operational measure of data quality.

3. SOFF and GBON compliance: operational elements

The key implications of the provisions in this document for the SOFF support phases are outlined as follows:

3.1. SOFF Readiness Phase

During the readiness phase, the peer advisors support beneficiary countries in undertaking the GBON National Gap Analysis and the GBON National Contribution Plan. The assessments and recommendations provided in those two documents must be aligned with the GBON requirements and aim at achieving GBON compliance according to the GBON compliance criteria as stated in the GBON Guide (See Tables 2 and 3).

3.2. SOFF Investment Phase

During the Investment Phase, beneficiary countries and their Implementing Entities should strive to bring as many stations as quickly as possible into GBON compliance, i.e., sharing data internationally following the GBON requirements. Beneficiary countries are supported with the operation and maintenance costs of those stations that become compliant during the Investment phase. These costs are part of the Investment Phase funding envelope. The provisions stated in this document also apply to the monitoring and verification of GBON compliance of such stations.

At the end of the Investment phase, SOFF beneficiary countries can transition to the Compliance Phase when the capacity for sustained operation of all SOFF-funded stations has been demonstrated and the station's "commissioning period" has been completed.

A GBON station commissioning is the process in which GBON data is reliably shared via WIS 2.0²⁰ according to the GBON compliance criteria. The commissioning period will be the last year of the Investment Phase. During the commissioning year, the beneficiary country operates and maintains the network striving to achieve the sustained operation of all the SOFF-

²⁰ The WMO Information System 2.0 (WIS 2.0) is the framework for WMO data sharing for all WMO domains and disciplines. With technical specifications and an implementation plan adopted by INFCOM-2 in October 2022, the new data-sharing infrastructure will gradually replace the Global Telecommunication System (GTS). WMO has developed the open-source software "WIS2 in a box" (<https://docs.wis2box.wis.wmo.int>) to support LDCs and SIDS in implementing WIS 2.0.

supported stations according to the GBON compliance criteria. Supported by WMO Technical Authority, the beneficiary country and the Implementing Entity monitor the performance of the network, and, supported by the peer advisor, troubleshoot any remaining issues. The station will be declared “commissioned” once WMO verifies that the station meets the GBON compliance criteria over the last quarter (three months) of the commissioning period. The upfront Operation and Maintenance costs of the commissioning period are also part of the SOFF Investment phase funding envelope.

In cases of *force majeure* or unforeseen difficulties preventing the country from achieving GBON compliance of the supported stations, the commissioning period may be extended, or additional investment funding may be requested. The Steering Committee decides on these requests.

See the SOFF Investment Phase Framework, Decision 5.8, for more details on the above.

3.3. SOFF Compliance Phase

The Compliance Phase provides results-based finance and peer advisors’ technical assistance to beneficiary countries to operate and maintain the surface-based observation network and the international sharing of data based on the principle of additionality.

The provisions stated in this document are the basis for the SOFF Compliance Phase Framework, to be developed by the SOFF Secretariat and WMO as SOFF Technical Authority, for approval by the Steering Committee.

4. Additionality

4.1. SOFF additionality principle and additionality baseline

According to the SOFF Operational Manual, SOFF is guided by the principle of Additionality: *"An intervention may be described as additional if it results in something that would not otherwise have occurred."*

SOFF support is limited to stations that were not GBON-compliant at the time of the WMO GBON Global Gap Analysis. WMO will undertake an updated Global GBON Gap Analysis as of June 2023, following entry into force of the GBON Technical Regulations on 1 January 2023, and the 19th World Meteorological Congress (22 May – 2 June 2023) and its consideration of GBON. WMO will present this baseline to the SOFF 6th Steering Committee meeting for its consideration and adoption as the “SOFF additionality baseline”. The 2023 additionality baseline will be publicly available on the SOFF website, thus ensuring complete transparency and open exchange of information on the status of all stations of SOFF beneficiary countries.

4.2. SOFF additionality exemption

To accommodate national circumstances and capabilities while pursuing avoiding perverse incentives, SOFF beneficiary countries can request an exemption to the additionality principle, provided that there is a strong justification that without SOFF support, the country will not be able to continue funding the operation and maintenance of the stations. For example, where

stations were funded by international climate and development funds and mechanisms through time-bound projects.

The GBON National Contribution Plan completed during the SOFF Readiness Phase includes a risk assessment that examines the likelihood that operating stations will cease internationally exchanging data if SOFF does not provide support to those stations and corresponding recommendations.

The SOFF Steering Committee considers and decides on the countries' request for exemption from the SOFF additionality principle as part of the Investment and Compliance phase funding requests.

5. Monitoring, Reporting and Verification

5.1. Monitoring and Reporting

WMO, as the SOFF Technical Authority, monitors the performance of each SOFF-supported station through the WDQMS web tool. The performance monitoring shows the status of each station based on the GBON compliance criteria (Tables 2 and 3).

5.1.1 WMO Technical Authority quarterly reports

WMO will provide SOFF-tailored quarterly GBON compliance reports showing the stations' performance and progress (according to station type and the WDQMS categories), including the total number of GBON-compliant stations for each SOFF beneficiary country. To assess progress or setbacks, the quarterly reports will include the performance status of each station for the current quarter, along with the results from the previous quarters for each SOFF operational year (1st of July to 30th June), as part of a representation of the full-time series of station compliance.

The WMO Technical Authority will provide the SOFF-tailored quarterly reports to the SOFF Secretariat, which will make these reports publicly available on the SOFF website as part of the implementation progress dashboard.

5.1.2 Troubleshooting monitoring and support

SOFF beneficiary countries are expected to be aware of their compliance status with the goal of evolving their observing networks towards full GBON compliance and notifying the SOFF Secretariat of any difficulties they may be facing. The Regional WIGOS Centres (RWCs)²¹ also assist countries by alerting them on non-compliance issues and discovered incidents.

²¹ The primary, mandatory functions of Regional WIGOS Centres are to support WMO Members with the management of metadata and to assist with following up on quality issues identified via the WIGOS Data Quality Monitoring System (WDQMS). Incidents with data availability are logged and the WIGOS focal point of the Member involved is contacted for resolution of the observational or data flow issue identified. Where an operational RWC does not exist to cover the Member, the WMO Secretariat can provide limited service upon consultation by the Member. RWCs may also contribute to the coordination of regional projects and support regional capacity development.

The SOFF Secretariat will transmit the WMO quarterly GBON compliance reports to the beneficiary country and its peer advisor and Implementing Entity. In case of underperforming stations, i.e., not meeting the GBON compliance criteria, peer advisors and, when applicable, Implementing Entities will support beneficiary countries in assessing the causes and provide technical troubleshooting support to ensure GBON compliance as soon as possible.

The WMO quarterly GBON compliance reports will also allow beneficiary countries and their peer advisors to provide feedback to WMO in case of contradictory information or disagreement with the reported status of the stations.

Through the WDQMS, real-time reporting is available to also allow beneficiary countries and their peer advisors to check the immediate GBON compliance of a station.

5.1.3 Annual reports

A SOFF-tailored annual WMO GBON compliance report for each SOFF operational year (1st of July to 30th June) will summarize the quarterly reports.

The WMO GBON compliance report will constitute an important part of the SOFF Annual Report and be publicly available on the SOFF website.

5.2. Verification

The SOFF-tailored annual WMO GBON compliance report serves as the verification means of GBON compliance, which trigger the completion of the Investment phase (see 3.2) and the SOFF annual results-based payments during the Compliance phase.