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# Technical Guidelines for Regional WIGOS Centres on the WIGOS Data Quality Monitoring System

**SECTION: TitlePage**

# Technical Guidelines for Regional WIGOS Centres on the WIGOS Data Quality Monitoring System

**SECTION: ISBN-Guides**
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## INTRODUCTION

This publication provides detailed technical guidance in addition to the contents of ~~is an Annex to~~ Chapters ~~9~~ 7 and 8 of the *Guide to the WMO Integrated Global Observing System* (WMO-No. 1165~~, 2018~~). ~~It provides detailed technical guidance~~ for Regional WMO Integrated Global Observing System (WIGOS) Centres (RWCs) to run the operational activities related to the WIGOS Data Quality Monitoring System (WDQMS)~~, specifically for the surface stations of the Global Observing System (GOS) located on land (on the territories of WMO Regional Association (RA) Members)~~. Although it is envisaged to address multiple components of WIGOS and observing networks of the Global Observing System (GOS), the current scope covered in this edition addresses specifically the surface-based stations of the GOS, including Global Basic Observing Network (GBON) stations, located on land.

~~These guidelines describe the three main functions of~~ It contains guidelines to perform the mandatory functions of an RWC described in chapter 8 (WMO-No. 1165), i.e. WIGOS metadata management and WDQMS (monitoring, evaluation and incident management), as well as the requirements (such as the resources needed) and the recommended practices and procedures to perform those functions ~~for the surface land stations of GOS~~. ~~They include the daily~~ These guidelines describe the tasks for RWC staff and of the relevant National Focal Points (NFP)[1] in charge of the (sub)regional monitoring, evaluation and incident management activities for identifying, assessing and tracking issues related to stations metadata in OSCAR/Surface[2] as well as data availability, timeliness and quality (accuracy)[3] from surface and upper-air stations, and also some recommended performance targets for both types of observations.

These guidelines are bounded by the current scope of the WIGOS operational tools (OSCAR/Surface webtool, WDQMS webtool and Incident Management System webtool), in terms of observing stations they cover, in particular by the observations that are integrated into the WDQMS Webtool. It is envisaged that in the future there will be semi-automated ~~WIGOS Monitoring Centres providing routine reports and making available regional and thematic specific information to be used by RWCs~~. procedures for additional observing

[1] National Focal Points on WDQMS are the most relevant contacts from WMO Members to perform these functions
[2] Observing Systems Capabilities, Analysis and Review tool for surface-based observations
[3] See Annex 3 for a description of quality performance characteristics of a measurement or a set of measurements: accuracy, trueness and precision. For a better understanding the term 'quality' is used throughout the document

networks of the GOS such as Regional Basic Observing Networks (RBON)[4], or networks comprising of other than land stations, to be integrated into the WIGOS tools, as well as for other WIGOS components, such as cryosphere and hydrologic observations providing routine reports and making available specific monitoring information to be used by RWCs, for which further guidance will have to be developed.

## 1. FUNCTIONS

~~Two workshops on quality monitoring and incident management reviewed the monitoring of conventional components of GOS, such as surface land stations, based on numerical weather prediction (NWP) processes, towards modernization within the WIGOS framework. These WIGOS workshops were held in December 2014 and December 2015, where participants developed a design for~~ According to the Manual on WIGOS (WMO-No. 1160, Attachment 2.4) the WDQMS ~~to~~ consists of three basic functional components, which define the scope of WDQMS:

- WIGOS monitoring function
- WIGOS evaluation function
- WIGOS incident management function

~~These three components define the scope of WDQMS.~~ WIGOS Monitoring Centres will provide quality monitoring information on a daily basis in the form of quality monitoring reports. These reports are the basis of the WIGOS monitoring function and provide input to the WIGOS evaluation function. The evaluation function ~~should~~ extracts the relevant information from the quality monitoring reports together with metadata about the observing stations, from the Observing Systems Capability Analysis and Review (OSCAR)/Surface tool, ~~for the surface land stations of GOS,~~ and from the WMO Information System (WIS), and generates routine performance reports. Then, the WIGOS incident management function ~~will~~ takes up the issues that the evaluation function raised as incidents, and follows up the necessary action with the data supplier to resolve the issue. Figure 1 shows the interoperability of WDQMS.

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**Figure 1. Interoperability of WDQMS**

The WMO Technical Regulations and their Annexes, including the Rolling Review of Requirements (RRR) process, provide the governance of WDQMS ~~(WMO, 2011*a*, 2015*a*, 2015*b*, 2015*c*, 2015*d*, 2015*e*, 2015*f*)~~. The ~~surface land~~ observing stations that are distributing observations via WIS provide the input to the WIGOS monitoring function. To run the incident management function, RWCs ~~will~~ need to ~~be in~~ closely collaborat~~ion~~e with Members, which, in most cases, are responsible for incident rectification.

The WDQMS currently covers the surface-based stations of the GOS and GBON with plans to include the stations of RBON for variables which are common to GBON. In future, the WDQMS may be further extended to cover other WIGOS sub-component observing stations (e.g., weather radar and wind profilers).

The key official WIGOS tools used in the WDQMS include:

[4] RBON, which now includes stations affiliated to the former RBSN, RBCN and ANTON, will be added in the future when the regional requirements and criteria for network design and implementation are clear.

- OSCAR/Surface webtool (https://oscar.wmo.int/surface)

- WDQMS webtool (https://wdqms.wmo.int)

- Incident Management System webtool (https://jira.wmo.int/)

Other/Supplementary monitoring tools may be used when performing monitoring and evaluation functions.

The inputs, tasks and outputs of the three main functions of WDQMS are further described below.

### *1.1 WIGOS monitoring function*

For practical implementation of WDQMS to GOS, the monitoring function is undertaken by WIGOS Monitoring Centres (for example, Global NWP Centres).

The WDQMS webtool[5] monitors the performance of some of the WIGOS observing components, namely the GOS land-based surface and upper-air (radiosonde) stations, the GBON surface and upper-air land-based stations, and the GCOS surface and upper-air land stations. The GOS and GBON monitoring is based on Numerical Weather Prediction (NWP) monitoring information provided by four global NWP centres at present and GCOS monitoring is based on data collected from the GCOS monitoring centres and includes the monitoring of the GCOS Surface Network (GSN) and of the GCOS Upper-Air Network (GUAN).

-Quality monitoring reports (for example, as a by-product of NWP data assimilation systems) for each station ~~of GOS should be~~ are generated and made available by the WIGOS Monitoring Centres on a daily basis for further use in quality monitoring and for the evaluation ~~processes~~function.

### *1.2 WIGOS evaluation function*

The evaluation function ensures that a universally applicable model can be applied to WDQMS. It takes the quality monitoring outputs from all the contributing WIGOS Monitoring Centres, extracts the relevant information from ~~WMO (2012)~~ OSCAR/Surface regarding the ~~distribution~~ expected international exchange of data on WIS/GTS according to the functions of WIS, ~~and from the OSCAR/Surface metadata database,~~ and generates routine daily performance reports based on at least two performance indicators:

- Comparison with the status of the availability of observations exchanged internationally according to the ~~expected~~ planned number of observations as described in ~~WIS and~~ OSCAR/Surface and in the WMO Technical Regulations,

- Trends in network performance over a suitable period (for observations of GOS, monthly rolling averages are proposed).

Additionally, the evaluation function uses the quality monitoring reports, which include issues identified with the observations from ~~surface land~~ stations, OSCAR/Surface status information, WIGOS Monitoring Centre features and other contextual information (such as geo-political, environmental, expectation of typical performance and exceptional circumstances), to determine if the observational issues identified should be formally raised as incidents with observational data providers. These observational data providers are usually, but not exclusively, National Meteorological and Hydrological Services (NMHSs).

[5] See also Guide to WMO Integrated Global Observing System (WMO-No. 1165, chapter 9)

~~During implementation of WDQMS and after the operational launch of RWCs,~~ The development of an automated alert system that issues alarms on the basis of the results of the WDQMS webtool ~~might~~will be considered in future. These alarms could be in the form of emails to RWCs and the corresponding ~~national focal points (~~NFPs~~)~~, if a target was missed over a certain period of time. If possible, linking into national alerting systems might be beneficial for reducing duplication in alerting at national and regional levels.

### ***1.3 WIGOS incident management function***

If the issues considered by the evaluation function merit being raised as incidents, then the incident management function will undertake this. Clear communication of incidents with the suppliers of observational data, and also with users of the data to ensure they take suitable precautions with the source, is key to the success of the incident management function. The evaluation function monitors the status and successfulness of incident rectification. In most cases, the tasks to rectify incidents will be the responsibility of observational data providers ~~suppliers~~/Members. A more suitable method of communication with data users might be considered as a future responsibility of an RWC, possibly automated through enhancements of the Incident Management System (IMS) webtool.

Figure 2 shows the Functions of Regional WIGOS Centres ~~WDQMS processes~~.

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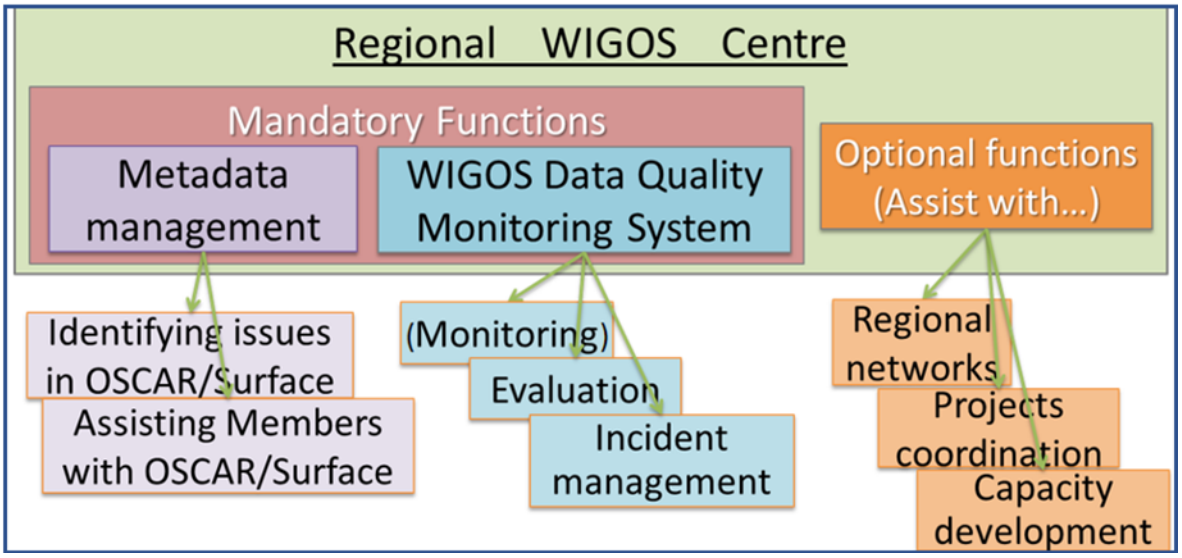


**Figure 2. Functions of Regional WIGOS Centres~~WDQMS processes~~**

## ~~2. QUALITY MONITORING PRACTICES~~

Data quality monitoring practices ~~should~~ focus ~~initially~~ on the assessment of the performance of the ~~surface land~~ observing stations of GOS[6] and GBON[7] against a set of targets~~, defined in Annexes 1–4~~:

[6] See WDQMS Users Guide: https://confluence.ecmwf.int/display/WIGOSWT/3.2+Data+quality
[7] See GBON requirements in the Guide to WIGOS (WMO-No. 1165, chapter 11)

1. Performance figures in terms of quantities (for example, number of observations provided on a daily basis, compared to the required and expected number of observations to be ~~ingested to~~ exchanged internationally via WIS/GTS according to the schedule outlined by WMO Members for routine dissemination from stations listed in OSCAR/Surface);

2. Performance figures in terms of timeliness indicating the delay of data during data transmission between the observation time at the site of a Member and the reception of the data by the users via the Global Telecommunication System (GTS)/WIS (in the NMHS database);

3. Quality indicators of the observed variables, which provide a measure of accuracy (for example, measurement uncertainty, usually in the form of bias (calculated as a measure of trueness and thereby being an estimate of systematic error), standard deviation (calculated as a measure of precision and thereby being an estimate of random error) and number (or percentage) of incidental gross errors);

4. Quality indicators for metadata, which are essential for interpretation and use of the data (timestamp, station positions and station elevation) and other information, and which are necessary for appropriate data management and usage;

5. Results of data quality control processes, including error and consistency checking ~~of~~ across various meteorological bulletins~~ in Traditional Alphanumerical Code (TAC) or Table-Driven Code Form/Binary Universal Form for the Representation of meteorological data (TDCF/BUFR) and the detection and elimination of discrepancies in TAC and BUFR bulletins~~.

## 2. METADATA MANAGEMENT

### 2.1 Links between OSCAR/Surface and WDQMS webtool

The WDQMS webtool retrieves metadata information from OSCAR/Surface on a daily basis. For example, the availability maps are generated in near-real time by comparing the observations received by the NWP Centres against the schedules retrieved from OSCAR/Surface. Therefore, if the metadata has been updated today, tomorrow's maps should reflect that change. If a new station is added to OSCAR/Surface, it should appear on the WDQMS availability map on the next day. If that does not happen, it means that some fields may have not been correctly populated in OSCAR/Surface and this needs to be reported to the RWCs.

In the case of Global Observing System (GOS) surface and upper-air stations on land, the monitoring results of the actual performance of each station, produced by the WDQMS webtool, are provided to OSCAR/Surface and displayed as "Assessed reporting status".

### 2.2 Evaluation of WIGOS Metadata

Station metadata: the received observations are more than the required number of bulletins as determined by the observing schedule for international exchange according to OSCAR/Surface for GOS stations and GBON requirements; or the station is not expected to report during the period according to OSCAR/Surface schedule, yet data was received. A station may also report data but is not registered in OSCAR/Surface. Such stations can only be identified by their Traditional Station Identifier (TSI), WIGOS Station Identifier (WSI) or location in the WDQMS webtool.

It is important to note that RWCs are not responsible for correcting station metadata.

## 3. QUALITY MONITORING PRACTICES

### ~~2~~3.1 Quality monitoring categories

To run ~~GOS~~ WIGOS observing networks effectively and to ensure the ~~system~~ observational data is delivered according to the require~~d~~ments ~~level of common user needs~~, the following three main categories have been identified to be most important for measuring the performance of ~~the system~~an observing network against a set of targets:

- **Data availability**: total number of meteorological bulletins ~~(TAC/BUFR)~~ received during a defined period (for example, 24 hours) compared to the required number of bulletins as determined ~~by the observing schedule to be ingested to GTS~~for international exchange according to ~~WIS for stations/platforms that are listed in~~ OSCAR/Surface for ~~and affiliated to~~ GOS stations and according to requirements for GBON stations.

- **Timeliness**: delay between the nominal observation time of a particular observation message issued at an observing station ~~Member~~ (site) and the reception time at the user database of this message received via GTS/WIS. The nominal observation time of a SYNOP message is typically HH+00. Hence, the timeliness of a SYNOP message is calculated by computing the delay between the reception time of the observations' database time stamp of the WIGOS Monitoring Centres and HH+00.

- ~~Accuracy~~**Quality**: combining trueness and precision as outlined in the International Organization for Standardization (ISO) standard ISO 5725 (see Annex ~~4~~3), mainly derived from "observation minus background" (O-B) NWP results from Global NWP Centres for parameters such as atmospheric~~ir~~ pressure, air temperature, wind and relative humidity observations. For some parameters such as precipitation, Global NWP Centre forecast skills might not be good enough to allow usage of forecasts as reference in the procedure for determining observation accuracy. Hence, different approaches to determine accuracy may have to be considered for particular parameters of GOS networks. For example, large errors in pressure observations derived from O-B NWP results might be caused by incorrectly reported station metadata (station position, station or barometer height) that are either edited in OSCAR/Surface or encoded in BUFR bulletins. In this case, the RWC will contact the WDQMS NFP of the Member operating the station and issuing bulletins via GTS/WIS to check and update station metadata information in OSCAR/Surface or in BUFR bulletins. ~~Note that RWCs are not responsible for checking and correcting station metadata.~~

Further issues and incidents might be identified during the quality monitoring and evaluation process. This should result in the initiation of the incident management procedure (IMP) in the same way as for the three main categories. Issues may include:

- Suspicious values of particular variables (consistency check) according to the daily monitoring reports provided by the WIGOS Monitoring Centres.

- Discrepancies in the total number of TAC and BUFR bulletins compared to the number of bulletins expected to be ~~ingested~~ exchanged internationally through WIS/GTS according to ~~WIS~~ OSCAR/Surface (for GOS stations) or as indicated in the Manual on WIGOS (WMO-No. 1160) for GBON stations.

- Encoding issues mainly in BUFR messages (due to wrong use of descriptors, missing descriptors, incorrect TAC to BUFR conversions, etc.), although, in many cases, encoding issues cannot be explicitly identified and highlighted by the WIGOS Monitoring Centres during the automated quality monitoring process. Hence, RWCs have to consider that low

performances in availability might be caused by encoding errors and thus must be able to access an observations database to check bulletins distributed via GTS/WIS.

### ~~2~~3.2 Performance targets

To identify underperforming stations, targets for the three main categories described above have to be agreed. Station performances will be compared to these targets. Whenever a station shows non-compliance with one of the three categories, an IMP should be initiated as described in Chapter ~~4~~5.

The WDQMS performance targets take into account the following:

- WMO guidance, especially from the ~~Commission for Basic Systems Open Programme Area Group on Integrated Observing Systems – Inter Programme Expert Team on Observing System Design and Evolution~~Guide to WIGOS (WMO-No. 1165)
- WMO global NWP application area requirements as indicated in the OSCAR/Requirements database
- OSCAR/Surface, which is the WMO official repository of metadata on surface-based WIGOS observations
- WIS, which is the single coordinated global infrastructure responsible for telecommunications and data management functions
- Other national and regional requirements
- Constraints of Members, in particular NWP centre data assimilation cut-off times and remote data communications issues leading to time delays in data submission (for example, due to the use of satellite transmission windows)

All targets regarding data availability refer to the ~~percentage~~ number of observations received from the different GOS observing system/networks in relation to the number of observations expected to be ~~ingested~~ exchanged internationally to WIS/GTS according to the observation schedules defined in WIS. As OSCAR/Surface is the WMO official repository of metadata on surface-based WIGOS observations, a direct link to WIS should be established, to ensure that OSCAR/Surface provides information on the general capability of measuring a particular parameter at a site and Member commitment to ingest corresponding bulletins to WIS/GTS. For example, it might be the case that a station measures air pressure hourly but is committed to WIS to ingest SYNOP message to GTS every 3 hours. If the information on international exchange via WIS/GTS commitment is not captured in OSCAR/Surface, the data availability monitoring would not show appropriate results.

All targets regarding timeliness refer to the time delay between the nominal observation time and its reception time at user databases. Targets relate to the percentage of data received, not expected. This means that if, for a particular station, no bulletins were ingested to WIS/GTS, the data availability performance will drop for this station~~, but this data outage should not affect the timeliness performance statistics for the station~~. Currently, the WDQMS webtool offers no functionality to monitor timeliness. Hence, RWCs may use other means to monitor this category.

All ~~measurement uncertainty~~ quality targets are stated as targets for standard deviation (estimate of random errors) as a measure of observation precision. ~~Biases should be avoided; that is, related targets are close to zero. Observations should be made in such a way that any biases (estimates of systematic errors) of measurement systems form only a small part of the measurement uncertainty.~~ It is important to note that all observations are considered in the

monitoring and evaluation functions, including outliers or apparently wrong encodings. The goal of WDQMS is to ensure ~~GOS is~~ the observing networks are operating and delivering data to the required standards; it thus needs to identify all types of issues and incidents. If continuously occurring large outliers were neglected in the monitoring and evaluation functions, RWCs would never initiate an incident rectification process within the incident management function and thus the situation would not improve over time. As a consequence, outliers (caused by gross errors) should not be filtered out prior to calculation of bias and standard deviation if no separate statistic about number of gross errors is provided. Hence, the WDQMS webtool shows if an NWP Centre rejected the data or blacklisted the station.

Targets within these guidelines mainly use "threshold" requirements. However, in the evolution of WDQMS and the tasks for RWCs, "breakthrough" requirements and "goals" might be introduced as descriptors. The general definitions of these terms according to WMO RRR are described in the Manual on WIGOS (WMO-No. 1160) and published in OSCAR/Requirements database[8]:

~~– "Threshold" is the minimum requirement to be met to ensure that data are useful~~

~~– "Goal" is an ideal requirement above which further improvements are not necessary~~

~~– "Breakthrough" is an intermediate level between "threshold" and "goal", which, if achieved, would result in a significant improvement for the targeted application; the breakthrough level may be considered as optimal, from a cost–benefit point of view, when planning or designing observing systems~~

Whenever the WDQMS performance targets are revised, the targets defined in WMO RRR for the global NWP application area are taken into account. The WDQMS performance targets ~~for surface land stations and upper-air land stations~~ used by the WDQMS webtool are described in ~~Annex 1~~WDQMS User Guide~~,~~; for GBON stations the performance targets are described in the *Guide to WIGOS* (WMO-No. 1165)~~which also contains links to the relevant IDs in the requirements for the global NWP application area~~.

### ~~2~~3.3 Web tools and automated daily quality monitoring reports

WIGOS Monitoring Centres should produce and make available automated data availability and quality monitoring reports on a daily basis. The format for monitoring reporting of observations, such as surface land stations and upper-air land stations provided by Global NWP Centres for the WDQMS webtool is described in ~~Annexes 5 and 6 of this document~~ the WDQMS User Guide[9]. These reports might be provided on a 3 or 6 hours basis or on a daily accumulated/averaged basis. The reports ~~should be~~are made available and maintained on the Internet in ~~appropriate~~ WDQMS web-tool~~s (for example, the WIGOS quality monitoring web tool, currently a prototype (http://128.65.196.37/wdqms/) or the WMO Quality Monitoring Portal operated by EUMETNET (https://eucos.dwd.de/ravi))~~or other monitoring webtools to display the data availability, timeliness of data and ~~accuracy~~quality~~/measurement uncertainty~~ of observations (for example, derived from observation minus first guess/background fields (O-B results) of Global NWP Centres for surface ~~land stations~~ and upper-air (radiosonde) ~~land~~ stations on land, over a period of time).

The key/official webtool used by RWCs is the WDQMS webtool, which is a resource developed by WMO to monitor the performance of WIGOS observing components. The current operational version of the webtool monitors the availability and/or quality of observational data based on near-real-time NWP monitoring information for surface and upper-air land observations of the

[8] https://space.oscar.wmo.int/observingrequirements
[9] For Land-based surface observations: https://confluence.ecmwf.int/display/WIGOSWT/6.1+Land-based+surface+observations, for upper-air land observations: https://confluence.ecmwf.int/display/WIGOSWT/6.2+Upper-air+land+observations

GOS/GBON and monthly monitoring information of GCOS, based on data from the WIGOS Monitoring Centres. More WIGOS components are expected to be added to the webtool in the future. The WDQMS webtool undergoes continuous review and development to better support the performance monitoring process. The WDQMS webtool provides daily and monthly aggregations of the monitoring information.

RWCs should use these web tools to fulfil their task of daily quality monitoring and evaluation, and to be in a position to identify issues and raise them as incidents if the issues persist. The webtools ~~o further assist RWCs in their daily quality monitoring, the web tools should compile and~~ provide daily~~/~~ and monthly summaries, based on the files produced by the WIGOS Monitoring Centres (for example, the quantity or volume of land-based observations reported on WIS/GTS compared to the required (and thus expected), the ~~number of reports according to WIS, the~~ average daily timeliness of the data and daily averaged ~~measurement uncertainty~~ quality results from the different WIGOS Monitoring Centres). The web tools should ~~allow~~ continue to evolve to provide RWCs and NFPs with useful functions based on their needs, such as various statistics ~~to be~~ and a filter~~ed~~ function, to display, for example stations by ~~country~~ Member [*Japan*], or ~~to display~~ only those stations that exceed targets on data availability, timeliness or ~~measurement uncertainty (bias, standard deviation, mean vector difference (MVD) and root mean square vector difference (RMSVD))~~quality and by station metadata.

RWCs should be able to access the entries in the OSCAR/Surface metadata database (https://oscar.wmo.int/surface). Although it is not the task of RWCs to check and correct station metadata in OSCAR/Surface, during the quality monitoring and evaluation process, it might turn out that amendments in the entries of OSCAR/Surface metadata database will be required. This is particularly the case regarding barometer or station heights and station positions recorded in OSCAR/Surface or encoded in the BUFR messages, if large ~~measurement uncertainty (bias)~~ quality errors in pressure observations occur. If this happens, RWCs will need to ask the WDQMS NFP of the corresponding Member to review the entries in OSCAR/Surface or in BUFR encoding and to monitor the successful incident rectification. A detailed background and understanding of the defined observing schedule of the monitored stations are essential to operate an effective WDQMS.

## ~~3~~4. DATA QUALITY MONITORING AND EVALUATION

### ~~3~~4.1 Resources

Details on required staff competences and technical resources to establish and operate a Regional WIGOS Centre are described in chapter 8 of the Guide to WIGOS (WMO-No. 1165).

#### ~~*3.1.1 Staff competences*~~

~~To effectively run the evaluation function, RWCs should be staffed by suitable technical/scientific officers that have:~~

~~1. Detailed understanding of the surface-based system of GOS and its operation (to be expanded in future to other WIGOS observing components, although the functions might be split among multiple RWCs);~~
~~2. Sound knowledge of meteorological observations and WMO codes, as well as skills in data analysis;~~
~~3. Skills and knowledge in quality management systems (in general), and incident management processes (in particular);~~
~~4. Skills and knowledge in communication and report writing.~~

~~The more challenging the requirements and thus the tasks, the more the skills and knowledge levels of the staff might have to be increased or potentially other experts have to be consulted.~~

~~***3.1.2 Technical resources***~~

~~RWCs should have access to information, data and tools that support quality evaluation processes. As a minimum, these include:~~

~~1. Observation bulletins in TAC and BUFR received via GTS and stored in an operational observations database;~~
~~2. OSCAR/Surface;~~
~~3. Relevant automated monitoring statistics provided via the web tools described in section 2.3 and other global, regional and national monitoring reports that might be of use for the quality evaluation process;~~
~~4. Quality monitoring results and statistics in a form that allows flexible and rapid rendering of the data for analysis, comparison, plotting, etc.;~~
~~5. Data analysis applications and tools.~~

~~***3.1.3 Duties***~~

~~RWCs should have the resources to run the incident management function, through an appropriate incident management system (IMS) for the registration and follow-up of issues identified in the quality evaluation process.~~

~~RWCs should utilize the results of quality evaluation and incident management practices to identify systemic issues that might be addressed to improve the performance of stations through proposed modification or changes to processes and procedures.~~

~~Results of quality evaluation analyses and resulting changes to the observing system should be notified, recorded and documented in line with national, regional and WMO quality management standards and recommended procedures.~~

### ~~3~~4.2 Daily tasks

RWCs should evaluate the performance of GOS stations ~~(for example, Regional Basic Synoptic Network surface and upper-air land stations and stations)~~ and of GBON stations of ~~countries~~ Members under their responsibility. This should be done on a daily basis at least on working days, by reviewing the automated quality monitoring reports received from the WIGOS Monitoring Centres on the WDQMS webtool and other monitoring portals for supplementary information. RWCs should evaluate the performance of the stations within their scope ~~every day in the morning hours~~ daily as follows:

~~2~~1. ~~Be aware~~Take into account that the results from various WIGOS Monitoring Centres might differ and hence initiate an incident management process only if most WIGOS Monitoring Centres show similar results (for example, data from the same station is missing in most Global NWP Centres). The following differences might be recognizable when using quality monitoring reports of different Global NWP Centres (see also WDQMS user guide, 5. NWP Centre aggregation (Monitoring Centre)):

(a) When a station reports in format types TAC and BUFR, some Global NWP Centres consider only one of those types, while other Global NWP Centres consider both types;

(b) Monitoring reports of a Global NWP Centre contain only the data that passed the quality control prior to data assimilation, and therefore part of the available data that was deemed poor quality was filtered out and not available for data assimilation, whereas monitoring files of another Global NWP Centre may contain the data deemed as poor quality and that were rejected and/or blacklisted;

(c) Monitoring reports of a Global NWP Centre might not contain any information about a particular station if the variable in question (for example, pressure observation) was not reported, whereas monitoring reports of other Global NWP Centres might contain a result for this station if a message in general was available but the particular variable was missing;

(d) A Global NWP Centre assimilates geopotential height from high-altitude stations, whereas another Global NWP Centre does not assimilate geopotential height;

(e) Due to technical problems at a Global NWP Centre, subsidiary data availability, timeliness or quality results provided to the RWC are not comparable to data available on WIS/GTS.

~~3~~2. In the case of any non-compliance of a particular station, consider raising an incident ticket according to the procedure described in section 45.2 and to item 6 below. When several stations of a Member show the same non-compliance, one incident ticket might be raised for a group of stations.

~~4~~3. Check the web-tools for whether the station started reporting, if the station did not report any data the previous day. This is especially important in the case of non-compliance according to 1(a) above.

~~5~~4. Check the performance of the corresponding station and follow the same quality evaluation processes if an issue has been reported to the RWC by a user (for example, a WIGOS Monitoring Centre, a Global NWP Centre or a Member of an RA).

~~6~~5. Check the status of issues identified in previous days, in addition to checking station performances the previous day. Stations with identified issues should be checked again as to whether the performance improved (for example, the station started reporting again, ~~did~~ the station reported as many reports as required according to OSCAR/Surface observing schedule again, the data started arriving without delays again or quality results of observations have improved, again and therefore remained within the agreed targets on a daily average):

(a) If an issue continued for 5 (or more) days in a row, an incident management process (IMP) as described in Chapter 45 should be initiated by raising a ticket in the Incident Management System (IMS) webtool which is assigned to the WDQMS NFP of the Member operating the station ( section45.2);

(b) If an issue "disappeared" within these 5 days because the performance of the station improved again, no formal incident process has to be initiated and the issue will be closed ( section45.2).

~~7~~6. Monitor the status of raised incident tickets on a daily basis, and ensure that the Member to which an incident has been reported:

(a) Confirmed the reception of a new incident ticket;

(b) Provided an appropriate action proposal containing details of the cause of the incident, proposed actions and a timeline to resolve the incident;

(c) Provided regular updates whenever possible, at least once every month;

(d) Reported on incident rectification.

~~8~~7. After the WDQMS NFP of the Member has reported incident rectification, check the improvement in performance of the station in question, confirm successful rectification of the incident, and incident ticket.

~~9~~8. Ask the WDQMS NFP of the Member operating the station to investigate and, if needed, to update the entries in OSCAR/Surface accordingly, in cases where it is suspected that an issue or incident was caused by incorrect metadata in OSCAR/Surface.

9. "Won't fix" and Escalation: The RWC may update the status of a ticket to "Won't fix" when the WDQMS NFP finds that incident cannot be rectified because no immediate action can be taken. The ticket with "Won't fix" status can be returned to status "In progress" when the WDQMS NFP has indicated that corrective actions can be taken to rectify the incident. If there is no confirmation from WDQMS NFPs, the RWC may escalate the incident via the WMO Secretariat, by changing the ticket status to "Escalated". WMO Secretariat may escalate the issue to a higher level, e.g. bring it to the attention of the PR of the Member if there is no feedback from WDQMS NFP. It is recommended that the RWCs make various efforts to contact the WDQMS NFPs before deciding to escalate a ticket.

### *4.2.1 Near real-time NWP monitoring of the Global Observing Systems networks*

*4.2.1.1 Surface land observations (global NWP) – Availability, Timeliness, Quality and Station metadata*

1. Review the available WDQMS web~~-~~tool outputs (maps and graphics) and other quality monitoring reports to identify stations that show any non-compliance concerning data availability, timeliness, ~~and measurement uncertainty (bias, standard deviation, MVD and RMSVD)~~ quality and station metadata regarding the WDQMS performance targets ~~(Annex 1)~~. Reasons for non-compliance might be:

   (a) The station did not report any data ~~yesterday~~ since the previous day (category: data availability) – black dot in WDQMS webtool;

   (b) The total number of reports is significantly lower than the expected number of observations as defined in the observing schedule in WIS and OSCAR/Surface (category: data availability) – orange/red dot in WDQMS webtool;

   (c) The total number of reports is higher than the expected number of observations defined in the observing schedule for international dissemination in OSCAR/Surface (category: metadata) – pink dot in WDQMS webtool;

   (d) The station is not expected to send reports during the period according to OSCAR/Surface schedule (category: metadata) – grey dot in WDQMS webtool;

   (e) The station send reports but there is no corresponding station ID (not registered) in OSCAR/Surface – yellow dot in WDQMS webtool.

   (~~e~~f) The data ~~arrived~~ received with a significant delay, which may lead to a situation where data could not be used in near-real-time applications, for example, for nowcasting purposes (category: timeliness) – not quantified in WDQMS webtool currently;

   (~~d~~g) The daily averaged ~~measurement uncertainty statistics (bias, standard deviation, MVD and RMSVD)~~ quality results received from WIGOS Monitoring Centres (for example, derived from O-B results from Global NWP Centres) exceed the WMO threshold requirements concerning a particular variable or variables (category: ~~accuracy~~quality) - yellow/orange/red dot in WDQMS webtool.

~~2. Be aware that the results from various WIGOS Monitoring Centres might differ and hence initiate an incident management process only if most WIGOS Monitoring Centres show similar results (for example, data are missing in most Global NWP Centres). The following differences might be recognizable when using quality monitoring reports of different Global NWP Centres:~~

~~(a) When a station reports in format types TAC and BUFR, some Global NWP Centres consider only one of those types, while other Global NWP Centres consider both types;~~

~~(b) Monitoring reports of a Global NWP Centre contain only the data that passed the quality control prior to data assimilation, and therefore part of the data available that was deemed poor quality was filtered out and not available for data assimilation, whereas monitoring files of another Global NWP Centre contain even the data deemed as poor quality and that were rejected and/or blacklisted;~~

~~(c) Monitoring reports of a Global NWP Centre might not contain any information about a particular station if the parameter in question (for example, pressure observation) was not reported, whereas monitoring reports of other Global NWP Centres might contain a result for this station if a message in general was available but the particular parameter was missing;~~

~~(d) A Global NWP Centre assimilates geopotential height from high-altitude stations, whereas another Global NWP Centre does not assimilate geopotential height;~~

~~(e) Due to technical problems at a Global NWP Centre, subsidiary data availability, timeliness or measurement uncertainty results provided to the RWC are not comparable to data available on GTS.~~

~~3. In the case of any non-compliance of a particular station, raising an incident ticket according to the procedure described in section 4.2. When several stations of a country show the same non-compliance, one incident ticket might be raised for a group of stations.~~

~~4. Check the web tools for whether the station started reporting, if the station did not report any data yesterday. This is especially important in the case of non-compliance according to 1(a) above.~~

~~5. Check the performance of the corresponding station and follow the same quality evaluation processes if an issue has been reported to the RWC by a user (for example, a WIGOS Monitoring Centre, a Global NWP Centre or a Member of an RA).~~

~~6. Check the status of issues identified in previous days, in addition to checking yesterday's station performances. Stations with identified issues should be checked again as to whether the performance improved (for example, did the station start reporting again, did the station report as many reports as required according to Volume C1 and according to the WIS and OSCAR/Surface observing schedule again, did the data start arriving without delays again or did the measurement uncertainty of observations decrease, that is improve, again and therefore remained within the agreed targets on a daily average):~~

~~(a) If an issue continued for 5 (or more) d for surface land stations or radiosonde stations, an IMP as described in Chapter 4 should be initiated by defining a unique incident ticket number and by informing the national contact of the country (section 4.2 and Annex 7);~~

~~(b) If an issue "disappeared" within these 5 d because the performance of the station improved again, no formal incident process has to be initiated and the issue will be closed (section 4.2 and Annex 7); in this case, the issue reporter should be informed about the improved performance and the closure of the issue.~~

~~7. Monitor the status of raised incident tickets on a daily basis, and ensure that the country to which an incident has been reported:~~

~~(a) Confirmed the reception of a new incident ticket;~~

~~(b) Provided an appropriate action proposal containing details of the cause of the incident, proposed actions and a timeline to resolve the incident;~~

~~(c) Provided weekly updates and even "no change" reports;~~

~~(d) Reported on incident rectification.~~

~~8. Close an incident ticket after the national contact of the country has reported incident rectification, check the improvement in performance of the station in question, confirm~~

~~successful rectification of the incident, and inform issue reporters about successful incident rectification and closure of the report.~~

~~9. Ask the national contacts of the country operating the station to investigate and, if needed, to update the entries in OSCAR/Surface accordingly, in cases where it is suspected that an issue or incident was caused by incorrect metadata in OSCAR/Surface.~~

*4.2.1.2 Upper-air land observations (global NWP) – Availability, Quality and Station metadata*

1. Review the available webtool outputs and quality other monitoring reports to identify stations that show any non-compliance concerning the received upper-air (soundings) observations and quality results regarding the WDQMS performance targets. Reasons for non-compliance might be:

   (a) The station did not report any data the previous day (category: data availability) – black dot in WDQMS webtool;

   (b) The total number of daily reports is significantly lower than the expected number of soundings as defined in the observing schedule for international dissemination in OSCAR/Surface (category: data availability) – red dot in WDQMS webtool;

   (c) The total number of daily reports is higher than the expected number of soundings as defined in the observing schedule for international dissemination in OSCAR/Surface (category: metadata) – pink dot in WDQMS webtool;

   (d) The station reported data but has completeness issues (category: availability) – orange dot in WDQMS webtool;

   (e) The station is not expected to report during the period according to OSCAR/Surface schedule (category: metadata) – grey dot in WDQMS

   (f) The station reported data but there is no corresponding station ID (station not registered) in OSCAR/Surface (category: metadata) – yellow dot in WDQMS webtool;

   (g) The data received with a significant delay, which may lead to a situation where data could not be used in near real time applications, for example, for nowcasting purposes (category: timeliness) – not quantified in WDQMS webtool currently;

   (h) The daily averaged quality results received from WIGOS Monitoring Centres (for example, derived from O-B results from Global NWP Centres) exceed the WMO threshold requirements concerning a particular variable or variables (category: quality) – yellow/orange/red dot in WDQMS webtool.

### *4.2.2 Global Basic Observing Network (GBON)*

*4.2.2.1 Surface land observations – Station compliance (Availability of surface land observations (GBON))*

1. Review the available webtool outputs and other quality monitoring reports to identify stations that show any non-compliance concerning data availability.

Reasons for non-compliance might be:

   (a) The station did not report any data the previous day (category: data availability) – black dot in WDQMS webtool;

(b) The total number of reports is significantly lower than the expected number of observations as defined in the observing schedule for international dissemination in OSCAR/Surface (category: data availability) – orange/red dot in WDQMS webtool.

2. If a station did not meet the GBON compliance criteria for surface land observations for ~~1~~2 [*Japan*] or more days, an IMP as described in Chapter 5 should be initiated by raising a ticket in the Incident Management System which is assigned to the WDQMS NFP of the Member operating the station (section 5.2);

*4.2.2.2 Upper-air land observations – Station compliance (Availability of upper-air land observations (GBON))*

1. Review the available webtool outputs and other quality monitoring reports to identify stations that show any non-compliance concerning data availability.

Reasons for non-compliance might be:

(a) The station did not report any complete sounding the previous day (category: data availability) – black dot in WDQMS webtool;

(b) The station reported only one complete sounding the previous day (category: data availability) – orange dot in WDQMS webtool;

2. If a station did not meet the GBON compliance criteria for surface land observations for ~~1~~2 [*Japan*] or more days, an IMP as described in Chapter 5 should be initiated by raising a ticket in the Incident Management System which is assigned to the WDQMS NFP of the Member operating the station (section 5.2);

**4.3 Monthly tasks**

***4.3.1 Global Basic Observing Network (GBON)***

*4.3.1.1 Surface land observations – Station compliance (Availability of surface land observations (GBON))*

1. Review the available webtool outputs and quality monitoring reports to identify stations that show any non-compliance concerning data availability. Reasons for non-compliance might be:

(a) The station reported less than 10 days for the month (category: data availability) – white dot in WDQMS webtool;

(b) The station did not report any data for the month (category: data availability) – black dot in WDQMS webtool;

(c) The total number of reports is significantly lower than the expected number of observations for the month (category: data availability) – orange/red dot in WDQMS webtool.

2. If a station did not meet the GBON compliance criteria for surface land observations, an IMP as described in Chapter 5 should be initiated by raising a ticket in the Incident Management System which is assigned to the WDQMS NFP of the Member operating the station (section 5.2);

*4.3.1.2 Upper-air land observations – Station compliance (Availability of upper-air land observations (GBON))*

1. Review the available webtool outputs and quality monitoring reports to identify stations that show any non-compliance concerning data availability. Reasons for non-compliance might be:

   (a) The station did not report any complete soundings for the month (category: data availability) – black dot in WDQMS webtool;

   (b) The total number of complete soundings is significantly lower than the expected number of soundings for the month (category: data availability) – orange/red dot in WDQMS webtool;

2. If a station did not meet the GBON compliance criteria for surface land observations, an IMP as described in Chapter 5 should be initiated by raising a ticket in the Incident Management System which is assigned to the WDQMS NFP of the Member operating the station (section 5.2).

## ~~4~~5. INCIDENT MANAGEMENT PROCEDURE

Figure 3 illustrates the Incident Management Process (IMP) to formally record issues, report incidents, follow up on actions and correct problems.

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**Figure 3. Incident Management Process (IMP)**

### ~~4~~5.1 Responsibilities

The success of an IMP depends on clear identification of roles and responsibilities. These are defined below for each of the six IMP steps illustrated in Figure 3.

It is essential to have clearly defined contacts for each ~~country monitored by the RWC of those~~ WDQMS NFP who is responsible for ensuring a corrective action is taken once requested by the RWC. These ~~contacts could be the~~ nominations and updates to NFP for WDQMS, as well as the NFP for OSCAR/Surface or the NFP for WIGOS ~~listed~~ are made in the WMO ~~Country Profile~~ Contacts Database~~.~~: https://contacts.wmo.int/.

~~It would be beneficial to have generic email addresses available for each country, which are accessible by national contact points, to ensure that~~ Newly created/updated tickets should be distributed to several persons inside the concerned Member ~~can~~ to be informed about any incident/progress simultaneously. Responsibility for solving the incident raised by the RWC, by issuing an incident ticket, lies entirely with ~~the country or data provider operating the station~~ the supervising organization of the concerned station within the Member (data provider). The responsibility of the RWC is to supervise the status of the incident and its rectification, and to escalate the incident to a higher level if necessary. Communicating issues to ~~data users~~ WDQMS NFPs, i.e. initiating an IMP (B) is not necessary unless they remain for some time or significantly affect users. ~~An~~ The IMS is designed for routine operations, not for catastrophic events.

### ~~4~~5.2 Steps

~~To ensure efficient operation of an IMS, an~~ RWCs should ~~utilize a standard ticket template~~ use the IMS webtool for raising, tracking and assisting in resolving an incident according to the

~~different~~ various IMP steps shown in Figure 3. ~~An example of such an incident ticket is provided in Annex 7.~~

The incident tickets and all correspondence between the RWC and the WDQMS NFP of the ~~countries~~ Members under its responsibility will be ~~uploaded and~~ maintained on ~~an appropriate website or ticket system tool that can be easily accessed by all organizations involved~~ the IMS webtool. ~~The RWC should create and keep updated an~~ The IMS allows the RWC to extract incident~~s~~ ticket~~s~~ summar~~y~~ies~~, preferably automatically~~ for their affiliated Members. ~~The ticket summary will aid communication during all stages of the IMP, to ensure that all the necessary information is made available for monitoring and documenting the status of the raised incident~~ RWCs and WDQMS NFPs may refer to any user manuals on the Incident Management System that WMO Secretariat make available.

~~Most~~ Members ~~might~~ may operate their national ~~IMSs and~~ incident management systems with software of their own but need to respond to issues raised by RWC in the IMS webtool. RWCs will generally use ~~only their own~~ the IMS ~~software~~ webtool to initiate and supervise tickets for incidents identified ~~in~~ when performing the evaluation function. ~~If a Member intends to maintain and supervise the incident ticket within their national IMS, the RWC should be informed about the national ticket number~~.

### ~~4~~5.2.1 *Issue identification (A)*

Issue identification is part of the evaluation function because it is a result of the daily monitoring activity of ~~a~~ station~~'~~s performance~~s~~. Generally, RWCs will be responsible for monitoring network performances on a daily basis and for identifying issues, although relevant participating organizations, such as NMHSs and Global NWP Centres, are themselves encouraged to use the IMS webtool to report non-compliances to RWCs if they become aware of an issue.

When an NMHS, a WIGOS Monitoring Centre or a Global NWP Centre identifies an issue on data availability or timeliness of a particular station/several stations or on ~~measurement uncertainty~~ quality by showing high O-B results, the RWC should be informed. ~~Once a~~An issue ~~has~~ can be~~en~~ reported to the RWC ~~or has been identified by~~ directly, e.g. via email, in which case the RWC~~,~~ ~~the issue~~ will ~~be~~ document~~ed~~ the issue by creating a new ticket.

Each ticket should have a unique ~~number~~ description-ID ("Summary" field in IMS webtool) that consists of ~~five parts [ccc-ID-nnnnn-i-yyyymmdd]:~~

~~ccc: a three-character country code, for example "KEN"~~

~~ID (for example, WMO ID or WIGOS identifier in the future)~~

~~nnnnn: a sequential number (for every new ticket opened), for example "01204"~~

~~i: a figure indicating if the issue has been raised as an incident (using "1") or not ("0")~~

~~yyyymmdd: the year (yyyy), month (mm) and day (dd) when the ticket was created~~

~~Example: KEN-63688-005-0-20160712~~

a set of alphanumeric characters with the following format:

**ddmmyyyy-Member-WIGOS module-period-station/location-network type-monitoring category- issue**, where:

- "ddmmyyyy" it the day, month and year when ticket is created
- Member: Member operating the station
- WDQMS webtool module: NWP or GBON
- Period: daily or monthly
- Station/location: station name
- Network type: Surface or Upper-air, GBON
- Monitoring category: availability, quality, metadata
- Issue: keyword of the issue

Example: "04032020-Chile-NWP-daily-Tamuco-Surface-Quality-suspicious pressure values" means that on March 4, 2020, a ticket related to NWP daily for surface land station, air pressure data quality in Tamuco Station in Chile was created.

If more than one station of a Member show the same non-compliance, the station/location text could be used to describe such cases, e.g. by inserting "three stations" or just "stations".

~~RWCs should insert the following information in part A of the ticket:~~

~~- Date and time when the ticket describing an issue was created~~
~~- Station details, in particular WIGOS station identifiers and network type, station name and WMO Member~~
~~- Name of the person and organization that raised the issue, including contact details (email address)~~
~~- Full description of the issue, including the dates the issue was first identified, characteristics of the issue, category of incident type (for example, availability and timeliness of data or quality (accuracy/measurement uncertainty) of data), instrumentation identified as the source of the issue and, if possible, application areas affected by the issue~~

~~RWCs should add the issue to the ticket summary by setting "i" in the incident ticket number to "0" at this stage, and set the ticket status to open.~~

RWCs should also monitor each issue ~~at surface land stations and upper-air (radiosonde) land~~ from observing stations over 5 working days in a row for near real time (NRT) monitoring and 2 days for GBON monitoring before raising the issue into an incident and initiating the incident management process (part B of the ticket).

### ~~4~~5.2.2 *Issue raised as incident (incident process initiation) (B)*

RWCs will be responsible for initiating the incident management process. Once an issue (part A) has been deemed serious enough to be raised as an incident (for example, if the identified issue lasted longer than 5 working days for NRT NWP monitoring), a notification to the WDQMS NFP of the ~~country~~Member is required by converting the ticket stats from "Open" to "Incident" on the IMS webtool. ~~This will involve the following tasks and additions to the ticket in part B:~~

~~- Convert the issue ticket number into an incident ticket number (which will be used in all future correspondence)~~

~~- Add date and time of incident raising (process initiation)~~

~~- - - - - - Add details of the evaluation results to document why the RWC raised an incident (for example, reported data outage of a particular station was monitored via the web tools and the outage was still ongoing)~~

~~- - - - - - Prioritize the level assigned to the incident (low, medium, high and very high; see details in Annex 2)~~

~~- - - - - - Bring the problem to the attention of the country in question, making the ticket available to them via the NFP and requesting the relevant NFP to take corrective action as rapidly as possible~~

~~- - - - - - Add the new incident ticket number ("Incident ID") to the ticket summary and update the date, status and other relevant parts accordingly~~

If the identified issue has been monitored over the defined periods and the issue has been resolved (or has disappeared) without further action taken by the RWC, ~~this shall be highlighted by adding "No incident process required" to the ticket. The issue ticket shall either be closed in part F, or the performance of the station will be further monitored over the next 2 d before deciding to finally close the issue or to raise an incident~~, the ticket should be closed. RWCs may choose to further monitor the performance of the station for another 2 days before closing the issue. If there is a significant incident (for example, SYNOP data of all stations of a particular ~~country~~Member ~~are~~ missing on WIS/GTS), ~~data users should be informed about the incident and informed again after successful incident rectification (see part F)~~ the issue can be converted to an incident immediately so that the WDQMS NFP can follow-up accordingly. Annex 1 shows priority levels for some frequent issues.

### ~~4~~5.2.3 *Receipt confirmation (C)*

As soon as the WDQMS NFP of the ~~country~~Member has received the incident ticket, ~~with the unique incident number from the RWC, actions shall be~~ will taken actions to investigate the cause of the incident and to find a solution. Annex ~~3~~2 shows some ~~incident~~ frequent issues, potential sources and corresponding actions to be taken. To make the RWC aware that the ~~country~~Member has taken over the task of following up the incident, ~~a receipt confirmation (part C) including date/time, name of recipient and potential comments should be added to the IMS ticket by the NFP. Part C of the incident ticket should be updated by the NFP, and the RWC should be informed about the update immediately. The RWC will then update the date, ticket status and part of IMS in the ticket summary of the country in question. Once a confirmation is received at the RWC, the ticket status should be set as "in progress"~~ the WDQMS NFP should confirm receipt of the ticket through the "Comment" section of the ticket, in the IMS webtool. RWCs should reply to the acknowledgement received from the WDQMS NFP by updating the ticket status to "Under Investigation".

### ~~4~~5.2.4 *Action proposal (D)*

As soon as the WDQMS NFP of the ~~country~~Member has identified the cause of the incident and found a solution, the WDQMS NFP should ~~alert~~ update the RWC of the proposed actions by ~~adding the following information to the incident ticket in part D~~ providing input under the "Comment" section of the concerned ticket~~:~~.

~~- - - Date/time, name of NFP and details of proposed action including timeline to solve the incident and additional relevant comments~~

~~The incident ticket should be updated by the NFP, and the RWC should be informed about the update as soon as possible.~~ The RWC will then ~~update the date, ticket status and other relevant parts of the ticket summary of the country in question, preferably automatically~~

validate the actions proposed by the WDQMS NFP and decide on whether to update the ticket status to "In Progress".

### ~~4~~5.2.5 *Incident status (E)*

The WDQMS NFP will regularly provide the RWC with summarized updates on the status of the incident (part E)~~, as follows~~ at least once every month, through the "Comments" section of the ticket, with the following information:

– Any significant action that has been taken and which should be recorded (for example, "incident ticket passed on to another department" or" cause of problem identified")

~~– – Routinely on a weekly basis (including "no change" reports)~~

~~– – At the moment when the incident has been rectified~~

~~NFPs should document the updates in the incident ticket by adding the following information in part E of the ticket:~~

– Activities undertaken to resolve the incident, by whom and when – essentially a work log of the actions undertaken during the lifetime of the ticket by adding date/time, organization and name of who is taking action, as well as the resulting status after each action

~~The IMS ticket should be updated at least once a week. The RWC will update the date, ticket status and other relevant parts of the ticket summary.~~

During part E of the IMP, it might be found that an incident cannot be rectified because no (immediate) action can be taken. In this case, the RWC should ~~close the ticket and put the incident into the log of~~ update the ticket to "Known problems" ("Won't fix" in the IMS webtool). One of the most likely known problems that might be identified at the beginning of RWC operations is that stations do not provide any data to WIS/GTS although they are listed as being operational and affiliated to GOS in OSCAR/Surface (so-called "silent stations").

It also might be the case that actions taken so far have been unsuccessful because the incident has ~~been caused by~~ a different ~~activator~~cause. In this case, the RWC ~~should~~may also close the former incident ticket and initiate a new incident process (part B) with a different incident description-ID.

### ~~4~~5.2.6 *Incident rectification (F)*

If the incident has been rectified ~~by the country and~~ the WDQMS NFP should inform the RWC ~~has been informed (part E)~~ through the "Comments" section of the concerned ticket~~.~~. ~~t~~The RWC will check whether the incident ticket can be closed or has to be kept open due to ongoing non-compliance and underperformance compared to the WDQMS performance targets. In the case of ongoing non-compliance, the RWC will ask the WDQMS NFP to take further actions, ~~to be recorded in part E~~ through the "Comments" section of the same ticket. If the RWC ~~decides~~ considers that the incident ticket has been rectified, the RWC will update the ticket status to "Resolved".

~~can be closed, the RWC will add to the ticket a closing date/time and the name of the RWC staff closing the ticket (part F), inform the NFP point and the issue reporter, and archive the ticket as a "resolved incident" in the ticket summary (that is, update the date and other relevant parts of the IMP, and set the ticket status to closed). Data users should be informed about successful incident rectification if required.~~

RWCs may choose to further monitor the performance of the station for another 2 days before closing the incident by updating the ticket status to "Closed".

The RWC can update the incident status with comments received from the WDQMS NFP via email or any other verifiable means of communication, including e.g. social media platforms. The RWC can also update the incident status should there be no comment from the Member, but the data availability, quality and metadata challenges have been resolved. The IMP will be completed once the last step has been carried out, that is, the ~~issue identification procedure~~ incident ticket shows evidence that the station performs correctly again.

### ~~4~~5.2.7 *Incident escalation procedure*

~~In the unlikely event of non-response to the RWC incident reporting by a national contact of the country and the incident is sufficiently severe, the incident escalation procedure will state who should be contacted at a higher level. In the most severe cases, this may involve asking the WIGOS NFP and the WMO Country Profile Database NFP if needed to approach the Permanent Representative with WMO of the corresponding country asking for support.~~

~~The incident escalation procedure might also be initiated if long-lasting incidents are identified as "known problems" (problems that are ongoing and cannot be solved within the responsibility of the RWC and the NFP).~~

The WDQMS NFP should take all actions to resolve issues identified and to report the follow-up to the RWCs. There could be instances where the resolution of the issue requires coordination with other functions within the NMHS, such as:

- For metadata issues (e.g., in relation to barometer, station heights), the WDQMS NFPs may need to work with the OSCAR/Surface NFP to update the station metadata.
- For cases where the observation reports are sent but are not received by the WIGOS Monitoring Centres, the WDQMS NFP may need to work with the WIS Focal Point to engage with the respective GISC on possible transmission issues.
- For non-NMHS data the WDQMS NFP may need to work with the contact of the respective observational data provider.

If the issue still continues to be unresolved, the WDQMS NFP should escalate the issue internally within the NMHS for support in resolution. Such cases should be properly described in the comments section of the concerned ticket, in the IMS webtool.

There could also be situations when the issues identified by the RWCs cannot be resolved as the RWC is unable to contact with the WDQMS NFP (e.g., no WDQMS NFP is nominated or the NFP is not reachable). In cases where there is no response to the incident ticket by the WDQMS NFP of the Member and the incident is sufficiently severe the incident should be escalated to the WMO Secretariat who will reach out to the Permanent Representative (PR) with WMO of the respective Member via the WMO Regional Office of the respective RA.

In some cases where the RWC host Member and the concerned Member keep strong bilateral cooperation relationships, the RWC may consider contacting directly the PR of the Member, aiming at nominating or updating the contacts of the NFP for WDQMS. In such cases, the RWC should keep the WMO Regional Office informed.

The Incident escalation procedure to the PR might also be initiated if long lasting incidents are identified as "known problems" (problems that are ongoing and cannot be solved within the responsibility of the RWC and the WDQMS NFP).

## ~~5~~6. QUALITY PERFORMANCE REPORTS

### 6.1 Monthly Reports

The WDQMS webtool provides monthly aggregations of the monitoring results (currently only for GBON) which can be downloaded.

RWCs should ~~provide monthly quality performance reports to NFPs of the corresponding RA or subregion by email and should also make them available online~~ make use of the WDQMS webtool ~~. Future~~ to generate WDQMS ~~monthly~~ performance reports ~~will supersede the current lead centre reports. Monthly reports should be generated and distributed automatically. Semester reports could include more detailed results than monthly reports.~~

~~Quality performance reports should describe the station and~~ which contains network monthly performances compared to WDQMS performance targets. ~~(see Annex 1) and~~ The WDQMS reports ~~should~~ will contain, if possible:

~~1. Total number of raised incident tickets within the evaluated period (for example, per month) and per country.~~

~~2~~1. Total number of observations per station received in the month compared to the total number required, according to the observing schedule outlined in OSCAR/Surface. ~~Furthermore, the overall network performance for data availability should be provided on a monthly basis.~~

~~3~~2. Monthly average timeliness (delay between nominal observation time and reception time at a WIGOS Monitoring Centre's database) per station as well as the number of reports that have been received with a significant delay according to the targets. Furthermore, the overall network performance for timeliness will be provided on a monthly basis. The monthly average timeliness is not quantified in WDQMS webtool currently.

~~43. Monthly arithmetic averages of daily pressure, temperature, wind and relative humidity, root mean squares of differences from O-B NWP comparison results and monthly percentages of gross errors compared to the total number of all single observations for each variable and station. Furthermore, the overall network performance for data quality should be provided on a monthly basis.~~

~~5. Sorted station performances by listing station, with suspect records first, followed by stations with non-suspect records, grouped by country and network.~~

3. Monthly station metadata reports showing stations with OSCAR schedule issues, or other WIGOS metadata challenges outlined in OSCAR/Surface and stations not registered in OSCAR/Surface.

### 6.2 Quarterly reports

In addition to the monthly reports, the RWCs should prepare quarterly reports, to the WDQMS NFPs of their affiliated Members and should also make them available online on the RWC website, containing the following information, as much as possible:

1. List of raised incident tickets within the evaluated period per Member

2. List of outstanding incident tickets from previous evaluated period

3. List of activities in relation to correcting/improving the WIGOS metadata of Members

4. Quarterly availability results for the evaluated period per monitoring network per Member

5. Quarterly quality results for the evaluated period per monitoring network per Member

6. Quarterly station metadata results per Member

7. Optional functions conducted by RWC (if any)

The RWCs should provide regular (at least quarterly) quality performance reports to the WDQMS NFPs of their affiliated Members and should also make them available online on the RWC website.

Furthermore, the overall network performance for data availability as well as for data quality should be provided with sorted station performances by listing station, with suspect records first, followed by stations with non-suspect records, grouped by ~~country~~ Member[*Japan*] and network.

The IMS webtool is able to generate the required lists of incident tickets for the RWCs to include in the quarterly reports.

The content of the quality performance reports might evolve after feedback from Members using the reports.

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# ~~ANNEX 1. PERFORMANCE TARGETS~~

## ~~1. Surface synoptic land stations~~

~~The Observing Systems Capability Analysis and Review (OSCAR)/Surface tool and the *Manual on the Global Observing System, Volume II – Regional Aspects* (WMO, 2011*b*) define requirements for observation cycles. According to the Manual, a minimum of three observations at main hours in Universal Time Coordinated (UTC) and five observations at main and intermediate hours (3 h) are required (MRQ). The target is four observations at main hours in UTC and eight observations at main and intermediate hours (3 h) required (TRQ).~~

~~Table 1 provides values used as performance targets. They are examples for the WMO Integrated Global Observing System (WIGOS) Data Quality Monitoring System (WDQMS) of Regional Association (RA) VI. It is up to individual RAs to define their own performance targets.~~

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## Table 1. Performance targets for surface synoptic land stations

TABLE: Table shaded header with lines

| *Parameter* | *Target* | | | *Comment* |
|---|---|---|---|---|
| Data availability: percentage of observations received from the network | 95%<br>*Manual on the Global Observing System* (WMO, 2011*b*)<br>MRQ: 50%<br>TRQ: 95–100% (depending on the RA) | | | Percentage of monthly data available from the surface land station network according to the schedule outlined in OSCAR/Surface (number of observations received per month compared to number of observations expected per month) |
| Timeliness: percentage received by<br>HH+100<br>HH+50 | <br>95%<br>90% | | | Percentage of data received by target times (HH+100 or HH+50) calculated on a monthly basis<br>Targets relate to percentage of data received, not expected<br>Threshold requirement<br>Breakthrough requirement |
| *Parameter* | *Trueness – target for bias* | *Precision – target for standard deviation* | *Threshold for gross errors* | *Comment* |
| Pressure (hPa) | 0.5 hPa | 1.5 hPa | 10 hPa<br><15% of all single observations | Bias as a measure of trueness: on average (several days), the absolute value of the daily calculated bias of pressure observations (P BIAS) should not exceed the given target<br>Standard deviation as a measure of precision: on average (several days), the daily calculated standard deviation of pressure (P STDDEV) should not exceed the given target<br>Gross errors: the number of gross errors during 1 month should not exceed a percentage of all single observations of that particular station<br>Threshold requirement |

TABLE: Table shaded header with lines

| Parameter | Trueness – target for bias/mean vector difference (MVD) | Precision – target for standard deviation/root mean square vector difference (RMSVD) | Threshold for gross errors | Comment |
|---|---|---|---|---|
| Geopotential height (m) | 30 m | 40 m | 100 m<br><15% of all single observations | For surface land stations in mountainous areas only where no pressure observations are provided but geopotential heights (gpm) are<br>Bias as a measure of trueness: on average (5 d), the absolute value of the daily calculated bias of gpm observations (gpm BIAS) should not exceed the given target<br>Standard deviation as a measure of precision: on average (several days), the daily calculated standard deviation of gpm (gpm STDDEV) should not exceed the given target<br>Gross errors: the number of gross errors during 1 month should not exceed a percentage of all single observations of that particular station<br>Threshold requirement |
| Temperature (K) | 0.5 K | Not currently specified: numerical weather prediction (NWP) 2 m temperature forecasts are not yet reliable to serve as reference | 10 K<br><15% of all single observations | Bias as a measure of trueness: on average (5 d), the absolute value of the daily calculated bias of temperature observations (T BIAS) should not exceed the given target<br>Standard deviation as a measure of precision: on average (several days), the daily calculated standard deviation of temperature (T STDDEV) should not exceed the given target<br>Gross errors: the number of gross errors during 1 month should not exceed a |

| | | | | |
|---|---|---|---|---|
| | | | | ~~percentage of all single observations of that particular station~~<br>~~Threshold requirement~~ |
| ~~Wind vector (m s$^{-1}$)~~ | ~~3.0 m s$^{-1}$~~ | ~~5.0 m s$^{-1}$~~ | ~~15 m s$^{-1}$~~<br>~~≤15% of all single observations~~ | ~~MVD as a measure of trueness: on average (several days), the absolute value of the daily calculated MVD of wind observations (WIND MVD) should not exceed the given target~~<br>~~RMSVD as a measure of precision: on average (several days), the daily calculated RMSVD of wind should not exceed the given target~~<br>~~Gross errors: the number of gross errors during 1 month should not exceed a percentage of all single observations of that particular station~~<br>~~Threshold requirement~~ |
| ~~Relative humidity (%)~~ | ~~10%~~ | | ~~30%~~<br>~~≤15% of all single observations~~ | ~~Bias as a measure of trueness: on average (several days), the absolute value of the daily calculated bias of relative humidity observations (RH BIAS) should not exceed the given target~~<br>~~Standard deviation as a measure of precision: on average (several days), the daily calculated standard deviation of relative humidity (RH STDDEV) should not exceed the given target~~<br>~~Gross errors: the number of gross errors during 1 month should not exceed a percentage of all single observations of that particular station~~<br>~~Threshold requirement~~ |

~~Table 2 shows the links to the sets of requirements from global NWP, for surface variables, available at the OSCAR/Requirements database.~~

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**Table 2. Links to requirements for global NWP, for surface variables, in OSCAR/Requirements**

TABLE: Table horizontal lines

| *Air pressure (at surface)* | *Air temperature (at surface)* | *Wind vector over the surface (horizontal)* | *Specific humidity* |
|---|---|---|---|
| ID 250 | ID 253 | ID 320 | ID LT 303 |
| http://www.wmo-sat.info/oscar/variables/view/10 | http://www.wmo-sat.info/oscar/variables/view/12 | http://www.wmo-sat.info/oscar/variables/view/183 | http://www.wmo-sat.info/oscar/variables/view/161 |

## 2. Land upper-air (radiosonde) stations

The OSCAR/Surface tool and the *Manual on the Global Observing System, Volume II – Regional Aspects* (WMO, 2011*b*) define requirements for observation cycles. According to the Manual, a minimum of one sounding at 12 UTC up to 100 hPa is required (MRQ). The target is two soundings at 00 and 12 UTC up to 10 hPa required (TRQ).

The provision of time and coordinates in Binary Universal Form for the Representation of meteorological data (BUFR) data as well as the provision of high-resolution BUFR data of all radiosonde stations is recommended (2 s).

Table 3 provides values used as performance targets. They are examples for RA VI WDQMS. It is up to individual RAs to define their own performance targets.

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## Table 3. Performance targets for upper-air (radiosonde) land stations

TABLE: Table shaded header with lines

| *Parameter* | *Target* | *Comment* |
|---|---|---|
| Data availability: percentage of observations received from the network | 95%<br>*Manual on the Global Observing System* (WMO, 2011*b*)<br>MRQ: 25–50% (depending on RA)<br>TRQ: 95–100% (depending on RA) | Percentage of monthly data availability of the upper-air (radiosonde) land network according to the schedule as outlined in OSCAR/Surface (number of soundings received per month compared to number of soundings expected per month) |
| Timeliness: percentage data received by<br>HH+100 – the entire sounding (BUFR) or TEMP parts CD (Traditional Alphanumeric Code (TAC))<br>HH+50 – up to 100 hPa (BUFR) or TEMP parts AB (TAC) | 95%<br><br>90% | Percentage of data received by target times (HH+100 or HH+50) to be calculated on a monthly basis<br>Targets relate to percentage of data received, not expected<br>Threshold requirements |
| Geopotential height: percentage achieving<br>100 hPa<br>50 hPa | 97%<br>95% | Targets relate to percentage of data received, not expected<br>Threshold requirements |

| *Parameter* | *Trueness – target for bias* | *Precision – target for standard deviation* | *Threshold for gross errors* | *Comment* |
|---|---|---|---|---|
| Temperature (K) | 0.5 K | 1.5 K | 10 K<br><15% of all single observations | Bias as a measure of trueness: on average (several days), the absolute value of the daily calculated bias of temperature observations (T BIAS) over all levels should not exceed the given target<br>Standard deviation as a measure of precision: on average (several days), the daily calculated standard deviation of temperature |

| | | | | |
|---|---|---|---|---|
| | | | | ~~(T STDDEV) over all levels should not exceed the given target~~<br>~~Gross errors: the number of gross errors during 1 month should not exceed a percentage of all single observations of that particular station~~<br>~~Threshold requirement~~ |

~~TABLE: Table shaded header with lines~~

| ~~*Parameter*~~ | ~~*Trueness – target for bias/MVD*~~ | ~~*Precision – target for standard deviation/RMSVD*~~ | ~~*Threshold for gross errors*~~ | ~~*Comment*~~ |
|---|---|---|---|---|
| ~~Wind vector (m s$^{-1}$)~~ | ~~3.0 m s$^{-1}$~~ | ~~5.0 m s$^{-1}$~~ | ~~15 m s$^{-1}$ <15% of all single observations~~ | ~~MVD as a measure of trueness: on average (several days), the absolute value of the daily calculated MVD of wind observations (WIND MVD) over all levels should not exceed the given target~~<br>~~RMSVD as a measure of precision: on average (several days), the daily calculated RMSVD of wind over all levels should not exceed the given target~~<br>~~Gross errors: the number of gross errors during 1 month should not exceed a percentage of all single observations of that particular station~~<br>~~Threshold requirement~~ |
| ~~Relative humidity (%)~~ | ~~10%~~ | | ~~30% <15% of all single observations~~ | ~~Bias as a measure of trueness: on average (several days), the absolute value of the daily calculated bias of relative humidity observations (RH BIAS) over all levels should not exceed the given target~~<br>~~Standard deviation as a measure of precision: on average (several days), the daily calculated standard deviation of relative humidity (RH STDDEV) over all levels (from the surface to the tropopause) should not exceed the given target~~ |

| | | | | |
|---|---|---|---|---|
| | | | | ~~Gross errors: the number of gross errors during 1 month should not exceed a percentage of all single observations of that particular station~~<br>~~Threshold requirement~~ |
| ~~Observation minus background 100 hPa geopotential height difference (m)~~ | ~~65 m~~ | | | ~~Equates to 1 hPa error at 100 hPa~~ |

~~Table 4 shows the links to the sets of requirements for global NWP, for upper-air variables, available at the OSCAR/Requirements database.~~

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~~**Table 4. Links to requirements for global NWP, for upper-air variables, in OSCAR/Requirements**~~

~~TABLE: Table horizontal lines~~

| ~~*Atmospheric temperature*~~ | ~~*Wind (horizontal)*~~ | ~~*Specific humidity*~~ |
|---|---|---|
| ~~ID LT: 257~~<br>~~ID HT: 255~~ | ~~ID LT: 313~~<br>~~ID HT: 311~~ | ~~ID LT: 303~~<br>~~ID HT: 302~~ |
| ~~http://www.wmo-sat.info/oscar/variables/view/13~~ | ~~https://www.wmo-sat.info/oscar/variables/view/179~~ | ~~http://www.wmo-sat.info/oscar/variables/view/161~~ |

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# ANNEX ~~2~~1. PRIORITY LEVELS OF ISSUES

## 1. Surface land stations

The issues described in Table 1 shall be identified in most daily monitoring reports of the different WMO Integrated Global Observing System (WIGOS) Monitoring Centres, not in the daily monitoring reports of one particular WIGOS Monitoring Centre only.

Note: The timeline for issuing an incident ticket for NRT NWP monitoring is over [*Japan*] 5 days and 2 days for GBON monitoring.

**Table 1. Issues with surface land stations**

TABLE: Table shaded header with lines

| *Category* | *Description* | *Level of priority* |
|---|---|---|
| Data availability (issues/incidents might be identified in Traditional Alphanumeric Code (TAC) and/or Binary Universal Form for the Representation of meteorological data (BUFR) data) | One station showed data outages occasionally | Low |
| | Several/all stations of one ~~National Meteorological and Hydrological Service (NMHS)/country~~ Member [*Japan*] showed data outages occasionally ~~since 5 d ago~~ | Medium |
| | One station reported <80% data availability | Medium |
| | Several/all stations of one ~~NMHS/country~~Member reported <80% data availability | High |
| | One station did not provide any data ~~since 5 d ago~~ | High |
| | Several/all stations of one ~~NMHS/country~~Member did not provide any data ~~since 5 d ago~~ | **Very high** |
| Timeliness (SYNOP data should be available for users within 50 min after the nominal observation time) | Data of one station seemed to arrive delayed (later than **100** min) occasionally ~~since 5 d ago~~ | Low |
| | Data of several/all stations of one ~~NMHS/country~~Member seemed to arrive delayed (later than **100** min) occasionally ~~since 5 d ago~~ | Medium |
| | All data of one station seemed to arrive delayed (later than **100** min) ~~since 5 d ago~~ | High |
| | All data of several/all stations of one ~~NMHS/country~~Member seemed to arrive delayed (later than **100** min) ~~since 5 d ago~~ | **Very high** |
| ~~Accuracy/measurement uncertainty~~ Quality | Daily averages of quantitative measures of performance characteristics (based on observation minus background (O-B) results | Low |

| | | |
|---|---|---|
| (issues/incidents might be identified for several parameters, for example pressure, temperature, wind and humidity) | from numerical weather prediction (NWP)) of one station exceeded the target occasionally ~~since 5 d ago~~ (regarding bias [trueness], standard deviation [precision] or number of gross errors) | |
| | Daily averages of quantitative measures of performance characteristics (based on NWP O-B results) of several/all stations of one ~~NMHS/country~~Member exceeded the target occasionally ~~since 5 d ago~~ (regarding bias [trueness], standard deviation [precision] or number of gross errors) | Medium |
| | All daily averages of quantitative measures of performance characteristics (based on NWP O-B results) of one station exceeded the target ~~since 5 d ago~~ (regarding bias [trueness], standard deviation [precision] or number of gross errors) | High |
| | All daily averages of quantitative measures of performance characteristics (based on NWP O-B results) of several/all stations of one ~~NMHS/country~~Member exceeded the target ~~since 5 d ago~~ (regarding bias [trueness], standard deviation [precision] or number of gross errors) | **Very high** |
| Quality (issues/incidents might be identified concerning suspicious values in reports, for example negative temperatures or snow during the summer) | One station showed suspicious values in reports occasionally ~~in the last 5 d~~ | Low |
| | Several/all stations of one ~~NMHS/country~~Member showed suspicious values in reports occasionally ~~in the last 5 d~~ | Medium |
| | All data of one station showed suspicious values in reports over several days ~~(in the last 5 d)~~ | High |
| | All data of several/all stations of one ~~NMHS/country~~Member showed suspicious values in reports over several days ~~(in the last 5 d)~~ | **Very high** |
| Station Metadata | One station reported >100% data availability | Low |
| | Several/all stations of one Member reported >100% data availability | Medium |
| | One station reported data but is not expected to send reports during the period according to OSCAR/Surface schedule | Medium |
| | Several/All stations of one Member stations reported data but are not expected to send reports during the period according to OSCAR/Surface schedule | High |
| | One station reported data but there is no corresponding station ID (not registered) in OSCAR/Surface | High |
| | Several/All stations of one Member reported data but there are no corresponding station IDs (not registered) in OSCAR/Surface | Very High |

## 2. Upper-air (radiosonde) land stations

The issues described in Table 2 shall be identified in most daily monitoring reports of the different WIGOS Monitoring Centres, not in daily monitoring reports of one particular WIGOS Monitoring Centre only.

Note: The timeline for issuing an incident ticket for NRT NWP monitoring is over [*Japan*] 5 days and 2 days for GBON monitoring.

**Table 2. Issues with upper-air (radiosonde) land stations**

**TABLE: Table shaded header with lines**

| *Category* | *Description* | *Level of priority* |
|---|---|---|
| Data availability (issues/incidents might be identified in TAC and/or BUFR data) | One station showed data outages occasionally ~~in the last 5 d~~ [*Japan*] | Low |
| | Several/all stations of one ~~NMHS/country~~Member showed data outages occasionally ~~in the last 5 d~~ | Medium |
| | One station reported a sounding with a completeness issue | Low |
| | Several/all stations of one Member reported a sounding with a completeness issue | Medium |

| | | |
|---|---|---|
| | The total number of reports of one station is significantly lower than the expected number of soundings as defined in OSCAR/Surface | High |
| | The total number of reports of several/all stations of one Member are significantly lower than the expected number of soundings as defined in OSCAR/Surface | Very high |
| | One station did not provide any data ~~since 5 d ago~~ | High |
| | Several/all stations of one ~~NMHS/country~~Member did not provide any data ~~since 5 d ago~~ | **Very high** |
| Timeliness (data of an entire sounding should be available to users within 100 min after the nominal observation time) | Data of the entire sounding of one station seemed to arrive delayed (later than **100** min) occasionally ~~in the last 5 d~~ | Low |
| | Data of the entire soundings of several/all stations of one ~~NMHS/country~~Member seemed to arrive delayed (later than **100** min) occasionally ~~in the last 5 d~~ | Medium |
| | All data of the entire sounding of one station seemed to arrive delayed (later than **100** min) ~~in the last 5 d~~ | High |
| | All data of the entire soundings of several/all stations of one ~~NMHS/country~~Member seemed to arrive delayed (later than **100** min) ~~in the last 5 d~~ | **Very high** |
| ~~Accuracy/measurement uncertainty~~ Quality (issues/incidents might be identified for several parameters, for example pressure, temperature, wind and humidity) | Daily averages of quantitative measures of performance characteristics (based on O-B results from NWP) of one station exceeded the target occasionally ~~since 5 d ago~~ (regarding bias [trueness], standard deviation [precision] or number of gross errors) | Low |
| | Daily averages of quantitative measures of performance characteristics (based on NWP O-B results) of several/all stations of one ~~NMHS/country~~Member exceeded the target occasionally ~~since 5 d ago~~ (regarding bias [trueness], standard deviation [precision] or number of gross errors) | Medium |
| | All daily averages of quantitative measures of performance characteristics (based on NWP O-B results) of one station exceeded the target ~~since 5 d ago~~ (regarding bias [trueness], standard deviation [precision] or number of gross errors) | High |
| | All daily averages of quantitative measures of performance characteristics (based on NWP O-B results) of several/all stations of one ~~NMHS/country~~Member exceeded the target ~~since 5 d ago~~ (regarding bias [trueness], standard deviation [precision] or number of gross errors) | **Very high** |
| Quality (issues/incidents might be identified concerning suspicious values in the reports, for example negative temperatures or snow during the summer) | One station showed suspicious values in the soundings occasionally ~~in the last 5 d~~ | Low |
| | Several/all stations of one ~~NMHS/country~~Member showed suspicious values in soundings occasionally ~~in the last 5 d~~ | Medium |
| | All data of one station showed suspicious values in soundings ~~since 5 d ago~~ | High |
| | All data of several/all stations of one ~~NMHS/country~~Member showed suspicious values in soundings ~~since 5 d ago~~ | **Very high** |
| Station Metadata | The total number of reports of one station is higher than the expected number of soundings as defined in OSCAR/Surface | Low |
| | The total number of reports of several/all station of one Member are higher than the expected number of soundings as defined in OSCAR/Surface | Medium |
| | One station reported data but is not expected to send reports during the period according to OSCAR/Surface schedule | Medium |
| | Several/All stations of one Member reported data but is not expected to send reports during the period according to OSCAR/Surface schedule | High |
| | One station reported data but there is no corresponding station ID (station not registered) in OSCAR/Surface | High |
| | Several/All stations of one Member reported data but there is no corresponding station ID (station not registered) in OSCAR/Surface | Very High |

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# ANNEX ~~3~~2. FREQUENT ISSUES, POTENTIAL CAUSES OF INCIDENTS AND CORRESPONDING ACTIONS TO BE TAKEN

The figure below shows frequent issues arising in the WMO Integrated Global Observing System Data Quality Monitoring System (WDQMS), their potential sources and corresponding actions to be taken by data providers (usually National Meteorological and Hydrological Services/operators).

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**WDQMS frequent issues, potential sources and corresponding actions to be taken (BUFR = Binary Universal Form for the Representation of meteorological data; GOS = Global Observing System; WIS/GTS = WMO Information System/Global Telecommunication System; NWP = numerical weather prediction; O-B = observation minus background; OSCAR = Observing Systems Capability Analysis and Review Tool; TAC = Traditional Alphanumeric Code)**

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# ANNEX ~~4~~3. ACCURACY, TRUENESS AND PRECISION

## 1. Introduction

It is important to base underlying guidance material on accepted scientific knowledge and related general principles and definitions to establish community-wide accepted standards and best practices for observation monitoring. It is of particular importance here to use well-established mathematical, especially statistical, concepts and related terminology. The terms "accuracy", "measurement uncertainty", "trueness", "precision" and a few more are often used when describing the quality of observations or measurements. Thus, it is important to precisely define the meaning and usage of these terms. A commonly shared understanding of the underlying terminology allows effective and efficient WMO-wide collaboration on quality monitoring, evaluation and incident management. General principles and definitions are described in this annex, and some terminology is brought into the specific context of monitoring routine meteorological observations with the help of numerical weather prediction (NWP) forecasts.

## 2. Definitions and interrelationships among types of errors

International Organization for Standardization (ISO) standard ISO 5725-1:1994 describes the meaning, usage and interrelation of terms such as accuracy and trueness.

According to ISO 5725-1:1994 , "accuracy" means "the closeness of agreement between a test result and the accepted reference value". In the context of meteorological observations, a "test result" means a measurement or observation. Furthermore, according to ISO 5725-1:1994 , "accuracy" refers to "trueness" and "precision". Thereby the following hold: "trueness" refers to the closeness of agreement between the arithmetic mean of a large number of test results

and the true or accepted reference value and "precision" refers to the closeness of agreement between test results.

While the terms "accuracy", "trueness" and "precision" describe performance characteristics of a measurement or a set of measurements, the terms "total error", "systematic error" and "random error" describe the underlying related types of error in mathematical/statistical language. Finally, the terms "measurement uncertainty", "bias" and "standard deviation" are the related quantitative expressions of performance characteristics.

Measurements and observations are usually not free of errors. Measurements can be considered an estimate of the true state of a parameter. However, truth is usually unknown. And when measuring or observing, measurement or observational errors occur. The difference between the measured or observed value and the true but unknown value is often called the total error. This total error consists of two parts: the systematic error and the random error. The systematic error is an offset, and remains constant in magnitude and sign when repeating measurements. The random error varies when measurements are repeated, that is, the magnitude and sign of the random error fluctuates. Systematic error and random error usually cannot be determined precisely because truth and total error are usually unknown. Therefore, the errors have to be estimated in practice. The error estimates are generally referred to as performance characteristics. Trueness is an estimate of systematic error and precision estimates the random error.

Quantitative expressions of the performance characteristics are defined as follows.

"Bias" is the quantitative measure of trueness. To calculate the bias, for a repeated measurements of the same parameter, the difference between measured value and a reference value is initially determined. In a second step, the bias is calculated as the average of these differences. The reference value can be another independent very precise measurement or another estimate of truth. In operational meteorology, short-term numerical weather forecasts can serve as independent estimates of the true atmospheric state.

"Standard deviation" is the quantitative expression of precision. Both bias and standard deviation contribute to the overall measurement uncertainty, which is a quantitative expression of accuracy.

Note: The aforementioned description of interrelationships among types of errors, performance characteristics and quantitative expressions of performance characteristics is based on a related text available at https://sisu.ut.ee/measurement/7-precision-trueness-accuracy, which is an online course on Estimation of Measurement Uncertainty in Chemical Analysis, by Mr Ivo Leito from University of Tartu, Estonia.

## 3. Numerical weather prediction short-term forecasts as reference in the procedure for measuring accuracy, trueness and precision

To assess the quality (accuracy) of observations, a comparison of the observation "to be assessed" and a "reference" has to be made. Ideally, the truth would be used as reference. However, truth is unknown and it is therefore necessary to search for very good estimates of the truth. This can be other observations or modelling results. At special observatories (that is, only in a few places), it is affordable to compare observations against other independent observations from different observing systems. This can be achieved by using two sensors that are the same or by using slightly different sensors for the same physical parameter.

However, for large and widespread operational observing networks, a cheaper reference is needed. Currently, the only omnipresent references are NWP model forecasts of the physical parameters of interest. Therefore, instead of comparing observations against other observations, using other references should be considered (for example, comparing observations against forecasted fields of the observed variables). This was demonstrated in an article by Hollingsworth et al. (1985). That article describes how the predictive skill of NWP

models improved from 1975 to 1985, and it concludes that "it is therefore reasonable to suppose that in areas with even moderate data coverage the accuracy of the analysis should be comparable with the accuracy of the observations". More specifically, it states that "the 6-hour prediction error is comparable with the observation error". Based on this finding, it is reasonable to use short-term numerical forecasts as reference for observation quality (accuracy) monitoring. Such short-term forecasts are used as background information in assimilation procedures and then often referred to as "first guesses". The article by Hollingsworth et al. (1985) explains that the "observation minus first guess" or "observation minus background" differences have a simple statistical structure. It argues that "large variations of the statistics from station to station, or large biases, are indicative of problems in the data or in the assimilation system". The effect of weather/synoptic variations that would generally prevent a direct comparison of the data quality of different observing sites can now be removed by subtracting the "forecasted weather".

Other global modelling centres have also implemented similar observation data and assimilation system monitoring tools. An article by Baker (1992) describes quality control for the Navy Operational Atmospheric Database; that by DiMiego (1988) outlines the National Meteorological Center Regional Analysis System in the United States of America; and that by Ingleby (1992) explains The New Meteorological Office Quality Control System of the Met Office in the United Kingdom of Great Britain and Northern Ireland.

The following should be taken into account for day to day monitoring of observation accuracy by means of comparison against NWP forecasts:

- Modelled temperature and wind fields in the free atmosphere taken from very short-range forecasts are accurate enough and can be used as reference for observations. Routine ongoing (such as daily) monitoring of, for example, radiosonde temperature and wind data against the corresponding model data taken from short-term forecasts (called "first guess" in data assimilation terminology) can at least help to spot drifts or jumps in the quality of observations.

- Representativeness of model forecasts for other parameters (such as humidity and precipitation) or for certain parameters near the surface (at the border between the atmosphere and ground/sea/ice) is limited. For such parameters, monitoring against NWP model results has to be conducted with care. Nevertheless, it is possible to identify sensor drifts or sudden jumps in "observation minus first guess/background fields" (identification of systematic errors).

- Quality figures from models have to be considered with care, especially for observations from mountainous and partly maritime regions. The representativeness of model forecasts is much smaller in such places.

The advantage of the above approach of using NWP outputs as a reference for quality (accuracy) monitoring of observations is that it allows relatively cheap detection of long-lasting drifts or sudden and significant jumps in sensor readings (poor data quality).

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# ANNEX 5. FILE FORMAT FOR EXCHANGING INFORMATION ON LAND SURFACE OBSERVATIONS

The data file for exchanging information on land-surface observations from Global Numerical Weather Prediction (NWP) Centres (as of 8 December 2017) contains information about the status of the global land-surface observational system in ASCII format. The first six lines (header) are identified by "#" and contain general information about the data that follow (see example below). The data are organized by line, where each line (data record) corresponds to an observation of a particular variable; the values on each line are separated by commas (.csv).

Each record has the following format:

Station_id,yyyymmdd,HHMMSS,latitude,Longitude,StatusFlag,Centre_id,var_id,Bg_dep

where

- Station_id (string) is the WMO station identifier;
- yyyymmdd (integer) is the observation date (yyyy is year, mm is month, dd is day);
- HHMMSS (integer) is the observation time (HH is hour, MM is minutes, SS is seconds);
- Latitude (float) is the geographical latitude of the station in decimal format;
- Longitude (float) is the geographical longitude of the station in decimal format;
- StatusFlag (integer) is the computed flag with information about the usage of the observation parameter within the NWP data assimilation system (see table below);
- Centre_id (string) is the name of the originating centre;
- var_id (integer) is the identifier of the observation parameter;
- Bg_dep (float) is the observation-minus-background residuals (also known as background departures).

The table below provides a summary of the quality flags used. A comprehensive description of the flagging system is given on the Wiki page under the WMO Integrated Global Observing System Data Quality Monitoring Flagging System for registered users (https://software.ecmwf.int/wiki/display/WIGOS).

## Quality flags

TABLE: Table horizontal lines

| *StatusFlag* | *Meaning* |
|---|---|
| 0 | Used |
| 1 | Not used |
| 2 | Rejected by data assimilation process |
| 3 | Never used by data assimilation process |
| 4 | Data thinned |
| 5 | Rejected before data assimilation process |
| 6 | Alternative used |
| 7 | Quality issue |
| 8 | Other reason |
| 9 | No content |

Note that the observed variables included in the files are the following: surface pressure (var_id = 110), 2 m temperature (var_id = 39), 2 m relative humidity (var_id = 58), and zonal and meridional components of surface wind at 10 m (var_id = 41 and var_id = 42, respectively). The units of observation-minus-background residuals (Bg_dep) are K, hPa, m $s^{-1}$ and hundredths of percentage for temperature, pressure, wind and relative humidity, respectively.

**Example**

```
   # TYPE=SYNOP
   #An_date= 20161204
   #An_time= 18
   #An_range=] 15 to 21 ]
   #StatusFlag: 0(Used);1(Not Used);2(Rejected by DA);3(Never Used by DA);4(Data
    Thinned);5(Rejected before DA);6(Alternative Used);7(Quality Issue);8(Other
    Reason);9(No content)
   #Station_id,yyyymmdd,HHMMSS,latitude,Longitude,StatusFlag,Centre_id,var_id,Bg_dep
   16469,20161204,210000,37.93000,16.06000,5,ECMF,110,-1.4
   31913,20161204,210000,45.22000,131.98000,2,ECMF,110,-0.1
```

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# ANNEX 6. FILE FORMAT FOR EXCHANGING INFORMATION ON UPPER-AIR LAND OBSERVATIONS

The data file for exchanging information on upper-air land observations from Global Numerical Weather Prediction (NWP) Centres (as of 13 February 2018) contains information about the status of the global upper-air land observational system in ASCII format. The first six lines (header) are identified by "#" and contain general information about the data that follow (see example below). The data are organized by line, where each line (data record) corresponds to a (predefined) vertical layer summary per observed/assimilated variable; the values on each line are separated by commas (.csv).

Each record has the following format:

   Station_id,yyyymmdd,HHMMSS,latitude,Longitude,StatusFlag,Centre_id,var_id,Mean_Bg_dep,Std_Bg_dep,Levels,LastRepLevel,CodeType

where

- Station_id (string) is the WMO station identifier;
- yyyymmdd (integer) is the observation date (yyyy is year, mm is month, dd is day);
- HHMMSS (integer) is the observation time (HH is hour, MM is minutes, SS is seconds);
- Latitude (float) is the geographical latitude of the station in decimal format;
- Longitude (float) is the geographical longitude of the station in decimal format;
- StatusFlag (integer) is the computed flag with information about the usage of the observation parameter within the NWP data assimilation system (see the table above in Annex 5);
- Centre_id (string) is the name of the originating centre;
- var_id (integer) is the identifier of the observation parameter (see the table below in this annex);
- Mean_Bg_dep (float) is the layer-average observation-minus-background residuals (also known as background departures);
- Std_Bg_dep (float) is the layer-standard deviation observation-minus-background residuals (also known as background departures);
- Levels (string) is a four-character string indenting the layer used to compute the statistics: "Surf" is for the surface, "Trop" is for the first level up 100 hPa inclusive and "Stra" is for the 100 hPa level up to the top level reported;
- LastRepLevel (float) is the last reported pressure level in the radiosonde;

- CodeType (integer) is the identifier of the observation type (for example, 35 and 109 refer to land upper-air observations formatted using the Traditional Alphanumeric Code and the Table-driven Code Form/Binary Universal Form for the Representation of meteorological data, respectively).

**Example**

```
# TYPE=TEMP
#An_date=_20171115
#An_time=_18
#An_range=]_15_to_21_[
#StatusFlag:_0(Used);1(Not_Used);2(Rejected_by_DA);3(Never_Used_by_DA);4(Data_Thinned);5(Rejected_before_DA);6(Alternative_Used);7(Quality_Issue);8(Other_Reason);9(No_content)
#Station_id,yyyymmdd,HHMMSS,latitude,Longitude,StatusFlag,Centre_id,var_id,Mean_Bg_dep,Std_Bg_dep,Levels,LastRepLevel,CodeType
01001,20171115,173435,70.93970,-8.66791,0,ECMF,2,-0.1276,0.6259,Trop,100.0,109
01001,20171115,173435,70.93970,-8.66791,0,ECMF,29,0.0171,0.0915,Trop,100.0,109
01001,20171115,173435,70.93970,-8.66791,0,ECMF,3,0.5818,1.6464,Trop,100.0,109
01001,20171115,173435,70.93970,-8.66791,0,ECMF,4,-0.2153,1.7774,Trop,100.0,109
47122,20171115,180000,37.08000,127.03000,0,ECMF,2,0.3631,1.0317,Trop,166.0,35
47122,20171115,180000,37.08000,127.03000,0,ECMF,29,0.0426,0.0757,Trop,166.0,35
47122,20171115,180000,37.08000,127.03000,0,ECMF,3,1.4831,3.0970,Trop,166.0,35
47122,20171115,180000,37.08000,127.03000,0,ECMF,4,-0.2008,1.7213,Trop,166.0,35
47158,20171115,180000,35.12000,126.80000,0,ECMF,2,0.2755,0.9581,Trop,7.2,35
47158,20171115,180000,35.12000,126.80000,0,ECMF,2,-0.0509,2.1681,Stra,7.2,35
47158,20171115,180000,35.12000,126.80000,0,ECMF,29,0.0354,0.1027,Trop,7.2,35
47158,20171115,180000,35.12000,126.80000,5,ECMF,29,0.0035,0.0074,Stra,7.2,35
47158,20171115,180000,35.12000,126.80000,0,ECMF,3,0.8701,1.8287,Trop,7.2,35
47158,20171115,180000,35.12000,126.80000,0,ECMF,3,0.4957,3.8780,Stra,7.2,35
47158,20171115,180000,35.12000,126.80000,0,ECMF,4,-0.1994,1.7315,Trop,7.2,35
47158,20171115,180000,35.12000,126.80000,0,ECMF,4,0.4891,3.3831,Stra,7.2,35
```

The table below gives a description of the var_id codes.

**var_id codes**

TABLE: Table horizontal lines

| *var_id* | *Name* | *Abbreviation* | *Units* |
|---|---|---|---|
| 2 | Upper-air temperature | t | K |
| 3 | Upper-air zonal wind component | u | $m\ s^{-1}$ |
| 4 | Upper-air meridional wind component | v | $m\ s^{-1}$ |
| 29 | Upper-air relative humidity | rh | Hundredths of % |
| 110 | Surface pressure | ps | hPa |

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# ANNEX 7. EXAMPLE INCIDENT MANAGEMENT SYSTEM TICKET

The figure below provides an example of an incident management system ticket.

ELEMENT: Picture inline fix size

Element Image: Figure_5.eps

~~END ELEMENT~~

~~Example incident management system ticket (DA = data assimilation; ECMWF = European Centre for Medium-range Weather Forecasts; GTS = Global Telecommunication System; JMA = Japan Meteorological Agency; NCEP = National Centers for Environmental Prediction; NWP = numerical weather prediction; RTH = Regional Telecommunication Hub; UTC = Universal Time Coordinated)~~

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