

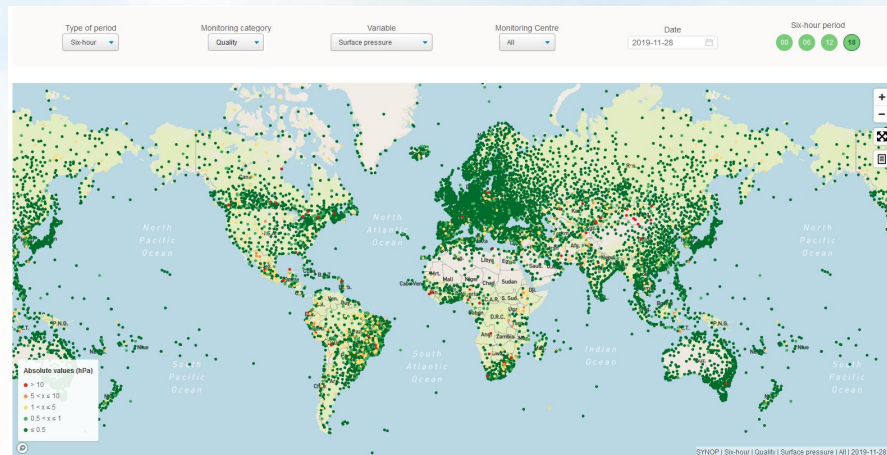
WIGOS Data Quality Monitoring System (WDQMS)

How to evaluate the data accuracy performance of surface land stations



WMO OMM

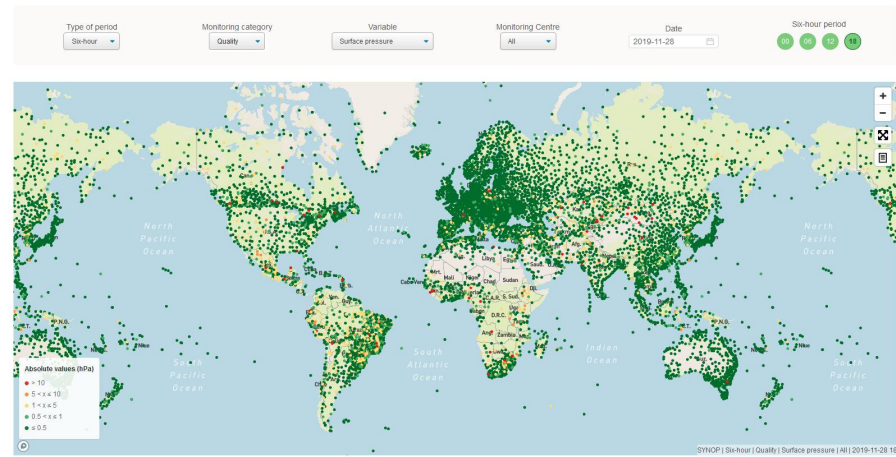
World Meteorological Organization
Organisation météorologique mondiale



Category 'Accuracy' in comparison to WIGOS MC outputs

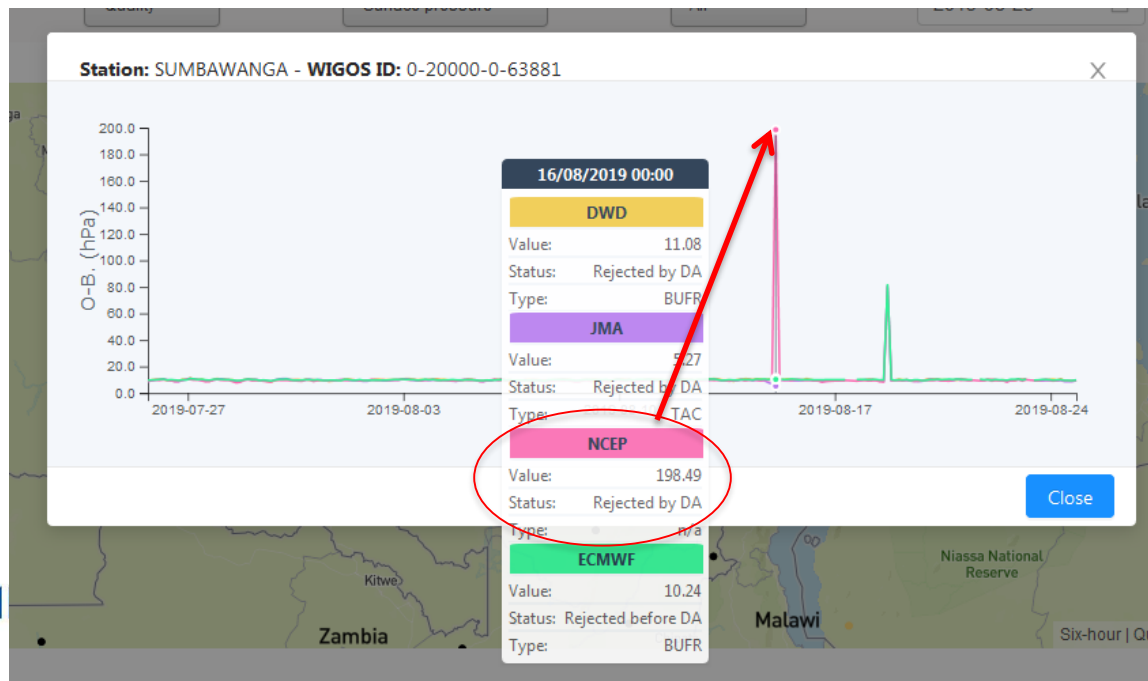
- One important aspect of monitoring the health of the GOS is to assess the accuracy of each individual observation, so that one can assess the average accuracy of a station for example.
- All data assimilation systems perform an accuracy check on the observations (Kalnay 2003, section 5.8) before assimilation and observations may not be used because they are blacklisted (e.g. due to known poor accuracy) or rejected.
- The WDAQMS web tool offers information on '**Accuracy**' by displaying averages of **Observation against Background (O-B)** values over the selected period (e.g. 6-hourly or daily)

→ *Select 'Quality' in the web tool*



Different WIGOS MCs → different results

- If at least one WIGOS MC shows low (good) O-B results (**green dots**) most likely the issue is related to the corresponding WIGOS MC which shows larger O-B results
- Example - 63881 SUMBAWANGA: NCEP showed large O-B results for pressure observations of **198 hPa** on 16th August 2019
 - O-B results of the other WIGOS MC were much lower (5-11 hPa)



Different WIGOS MCs → different results

- The station distributed **two SYNOP messages for 00 UTC**, one containing a suspicious pressure value of **228 hPa**, the other SYNOP message **823 hPa** (see screenshot from a database query) (→ 228 hPa considered by NCEP but not by the other WIGOS MCs?)

BUFR
Length: 247 octets
Data subset #1

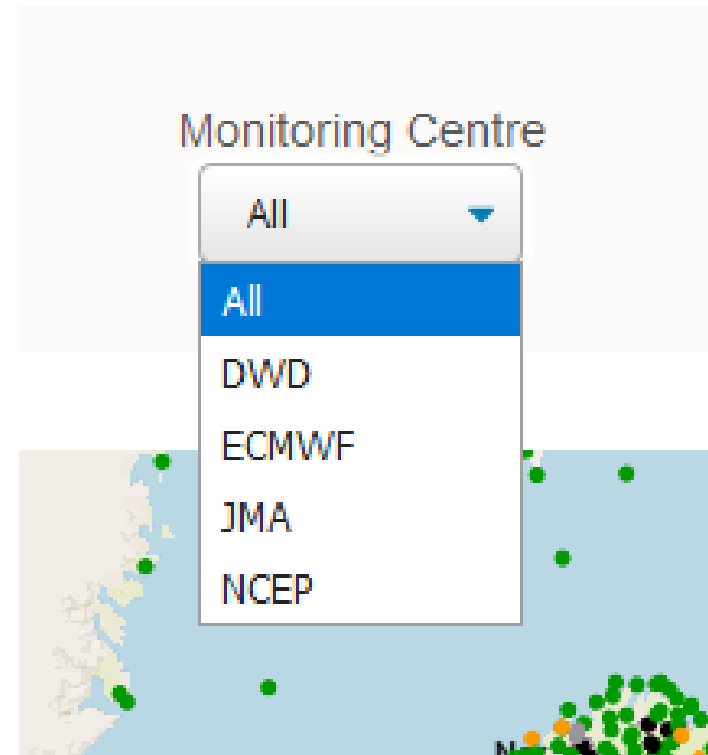
Field ID	Field Name	Value
(1)	Short station or site name	Missing value
(2)	Surface station identification; time, horizontal and vertical coordinates	
(3)	Surface station identification	
(4)	WMO block number	63.000
(5)	WMO station number	881.000
(6)	Station or site name	SUMBAWANGA
(7)	Type of station	1.000
(8)	Year, month, day	
(9)	Year	2019.000
(10)	Month	8.000
(11)	Day	16.000
(12)	Hour, minute	
(13)	Hour	0.000
(14)	Minute	0.000
(15)	Latitude/longitude (high accuracy)	
(16)	Latitude (high accuracy)	-7.96667
(17)	Longitude (high accuracy)	31.63333
(18)	Height of station ground above mean sea...	1921.000
(19)	Height of barometer above mean sea level	1923.000
(20)	Pressure information	
(21)	Pressure and 3-hour pressure change	
(22)	Pressure	82300.000
(23)	Pressure reduced to mean sea level	Missing value
(24)	3-hour pressure change	Missing value
(25)	Characteristic of pressure tendency	Missing value

BUFR
Length: 301 octets
Data subset #1

Field ID	Field Name	Value
(1)	Short station or site name	Missing value
(2)	Surface station identification; time, horizontal and vertical coordinates	
(3)	Surface station identification	
(4)	WMO block number	63.000
(5)	WMO station number	881.000
(6)	Station or site name	SUMBAWANGA
(7)	Type of station	1.000
(8)	Year, month, day	
(9)	Year	2019.000
(10)	Month	8.000
(11)	Day	16.000
(12)	Hour, minute	
(13)	Hour	0.000
(14)	Minute	0.000
(15)	Latitude/longitude (high accuracy)	
(16)	Latitude (high accuracy)	-7.96667
(17)	Longitude (high accuracy)	31.63333
(18)	Height of station ground above mean sea...	1921.000
(19)	Height of barometer above mean sea level	1923.000
(20)	Pressure information	
(21)	Pressure and 3-hour pressure change	
(22)	Pressure	22800.000
(23)	Pressure reduced to mean sea level	Missing value
(24)	3-hour pressure change	Missing value
(25)	Characteristic of pressure tendency	Missing value

Display of 'All' centers

- The WDAQMS web tool allows selecting results of a **particular WIGOS Monitoring Centre** or the aggregation of all centres.
- If 'All' is selected the results of all WIGOS MCs are combined into **one figure** concerning 'Accuracy'.
- The WIGOS MC results might differ due to various reasons
See [Potential differences in results of WIGOS Monitoring Centres](#) for more details
- For **accuracy** the NWP model **whose background field is closest to the observed value** will be displayed in the performance maps as it exhibits the best performance result.



O-B results caused by model biases

- Large O-B results for the various variables sometimes are caused by model biases.
- Especially O-B results of the variables 2m temperature and 2m relative humidity might be influenced by the model bias. Large O-B results concerning temperature for instance are often due to model temperature biases. Especially in winter times and in areas with steep orography models cannot always resolve strong temperature inversions and thereby might lead to wrong 2m temperature forecasts.
- Hence, for the different variables different [thresholds in the performance targets](#) are defined in the *'Technical Guidelines for Regional WIGOS Centres on the WIGOS Data Accuracy Monitoring System'* (WMO-No. 1224) or as [GBON requirements](#).



Bias, trueness and precision

- The **bias** is used as a measure of trueness and is calculated as the average of O-B results over a certain period.
- The targets regarding **trueness** are stated such that the bias should be close to zero for all measured variables.
- The standard deviation is the quantitative measure of **precision**. The targets for precision are applied to the standard deviation of O-B results over a certain period for each of the observed variables.
- All three measures – bias, trueness and precision - are assessed daily and monthly. Also, the 5-day moving average of daily calculated standard deviation of O-B will be calculated for all variables and compared to the respective prescribed threshold.



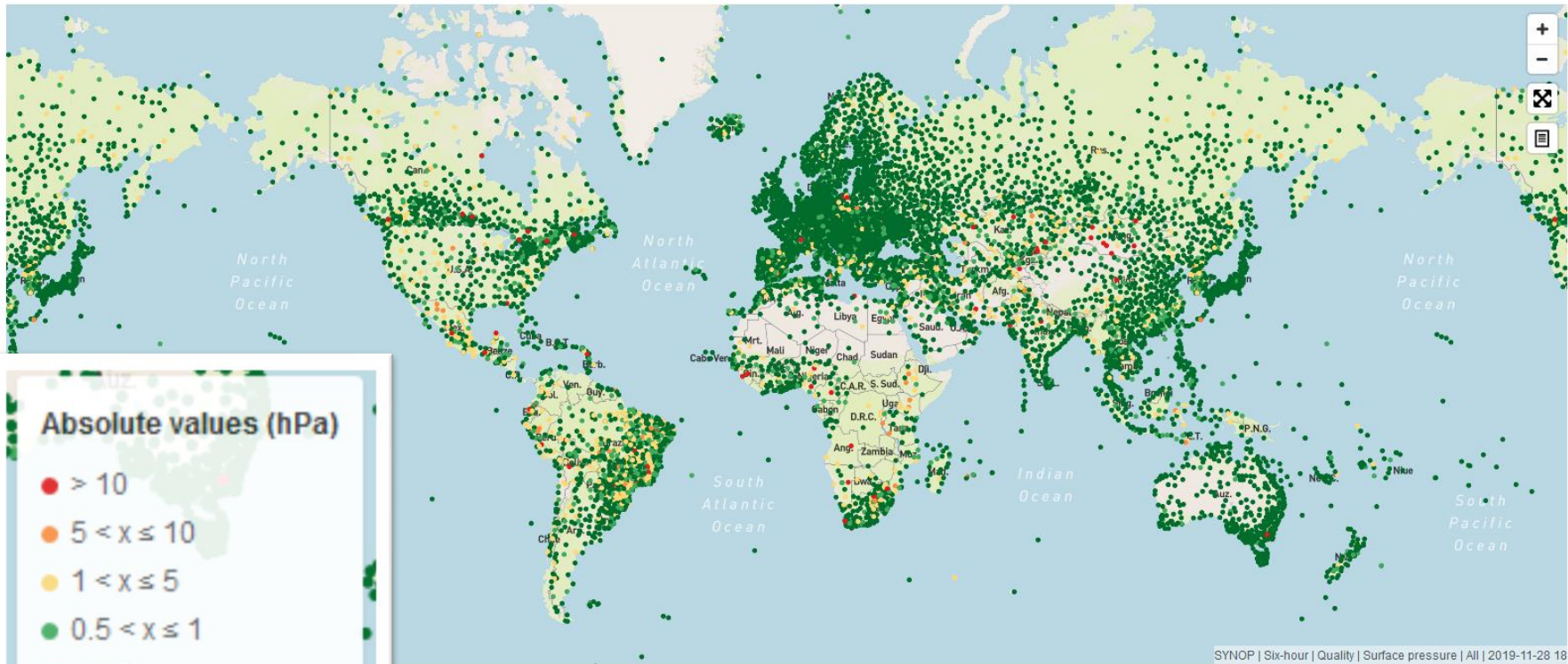
Gross errors

- The number of gross errors in a month (number of single observations whose O-B results exceed the prescribed threshold) will be computed for each variable at each station.
- The station will be flagged as an issue when the percentage of gross error per variable is larger than 15% of the total observations of that variable in the month.
- For different variables different thresholds are defined. The [thresholds](#) proposed for land surface observations as outlined in *WMO-No. 1224* are:
 - 10hPa for surface pressure or 100 m for geopotential height
 - 10 K for 2-metre temperature
 - 15 m/s for wind vector
 - 0.30% for relative humidity.



Display of surface pressure O-B results

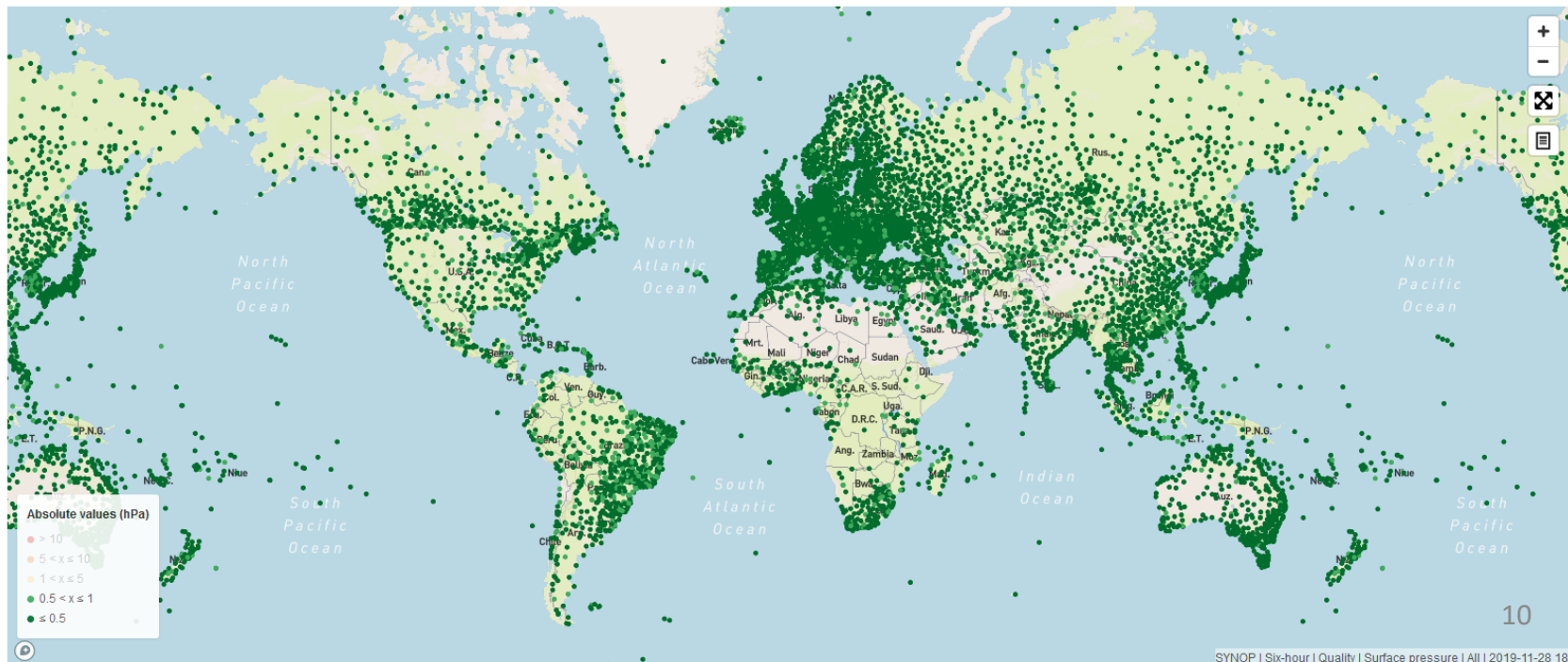
Type of period: Six-hour
Monitoring category: Quality
Variable: Surface pressure
Monitoring Centre: All
Date: 2019-11-28
Six-hour period: 00, 06, 12, 18



●● Absolute pressure obs values ≤ 1 hPa

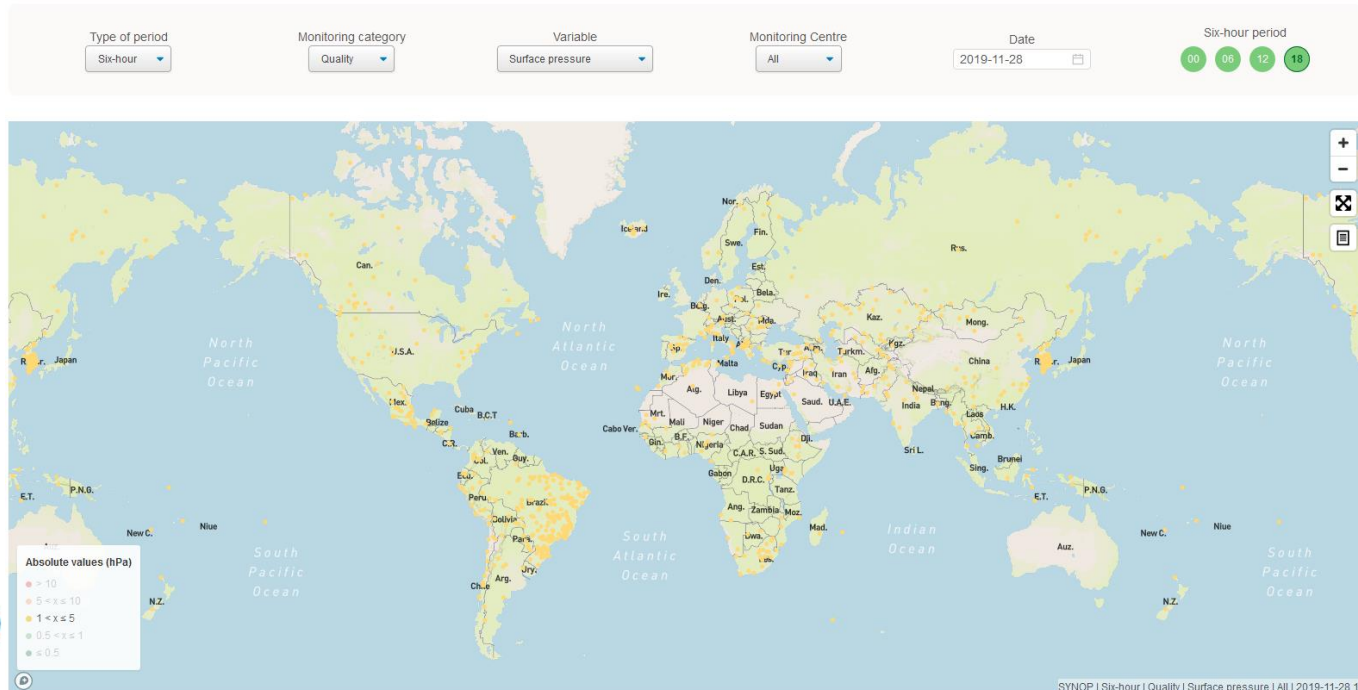
- Stations shown as green dots
- The accuracy of pressure observations is good, the station is performing well
➔ no action required 😊

Type of period: Six-hour
Monitoring category: Quality
Variable: Surface pressure
Monitoring Centre: All
Date: 2019-11-28
Six-hour period: 00 06 12 18



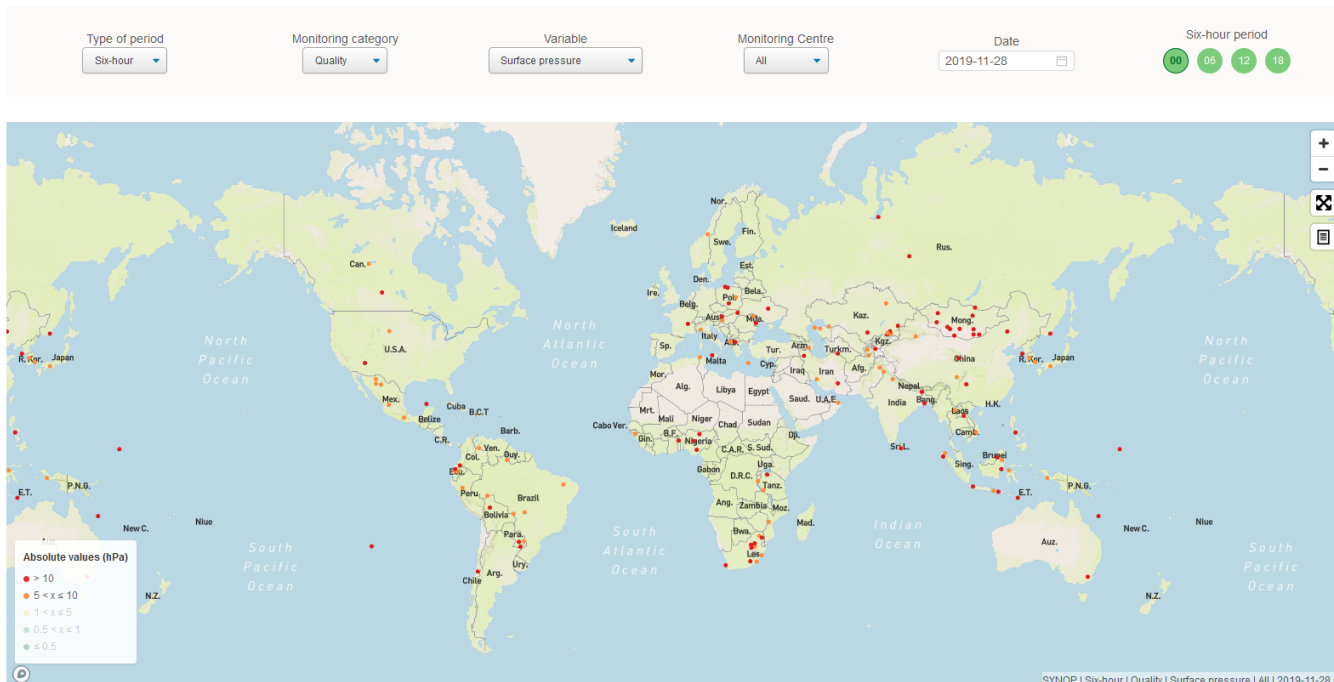
● Absolute pressure obs values 1 - 5 hPa

- Stations showing yellow dots have accuracy issues
- If they continue to appear having accuracy issues especially when selecting **'All' Centers** and the **'Daily'** or **'Alert'** display
➔ **action:** RWC to initiate an IMP with medium priority (●) asking WDQMS NFP to take actions to investigate the cause of the incident and to find a solution



●● Absolute pressure obs values > 5 hPa

- Stations showing orange dots have accuracy issues
- If they continue to appear having accuracy issues especially when selecting **'All' Centers** and the **'Daily'** or **'Alert'** display
→ **action:** RWC to initiate an IMP with **high** (●) or **very high priority** (●) asking WDAQMS NFP to take actions to investigate the cause of the incident and to find a solution



Reasons for accuracy issues in pressure obs

Large O-B results in surface pressure observations are in most cases related to the following causes:

1. Sporadic incorrect measurements or readings at site
action → if the issue is reoccurring RWC should initiate incident management process (IMP) on accuracy by contacting WDQMS NFP asking to take appropriate actions to avoid such issues in future
See issue No. 1
2. Incorrect metadata being used as background for data assimilation by WIGOS MCs (either from OSCAR/Surface or BUFR messages)
action → RWC should initiate IMP by contacting WDQMS NFP to work with OSCAR/Surface NFP to check the barometer height and station height in OSCAR/Surface and/or BUFR metadata
See issue No. 2

Reasons for accuracy issues in pressure obs

Large O-B results in surface pressure observations are in most cases related to the following causes (cont.):

3. Apparent sensor drift leading to increasing wrong measurements at site

action → if the RWC identifies continuously increasing O-B results in all WIGOS MC outputs the RWC should initiate an IMP by contacting WDAQMS NFP asking to take appropriate actions to solve the issue.

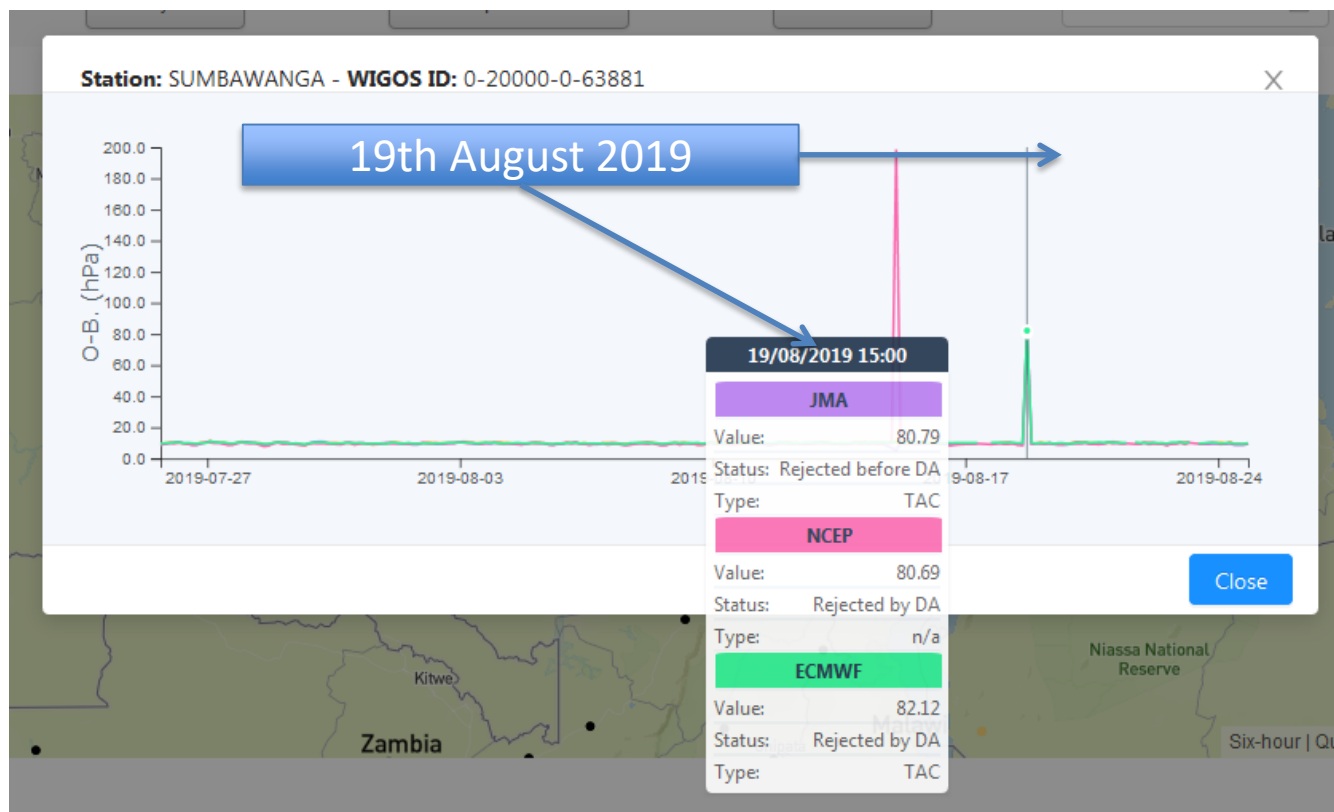
Example of issues in data accuracy

63881 SUMBAWANGA (Tanzania)

Issue No. 1 (occasionally occurring large errors):

Issue No. 1

- Station 63881 SUMBAWANGA showed large pressure O-B results of approximately **80 hPa** on 19th August 2019 in all WIGOS MC outputs



Example of issues in data accuracy

63881 SUMBAWANGA (Tanzania)

Issue No. 1 (cont.):

- Looking into the SYNOP messages of 63881 for 20th Aug 2019 it turns out that the pressure report for the particular synoptic hour at 15 UTC seemed to be suspicious compared to the other pressure reports of the day.
 - During the day the reported surface pressure at station level was **820-822 hPa**
 - Reported pressure at station level at 15 UTC: **891.6 hPa**
 - Most likely an instrument reading error or typing error!
- **RWC to initiate IMP if this reoccurs more frequently!**

Example of issues in data accuracy

63881 SUMBAWANGA (Tanzania)

Issue No. 1 (cont.):

19th August 2019

Corresponding SYNOP messages
in Traditional Alphanumeric
Codes (TAC) format

SYNOPS from 63881, Sumbawanga (Tanzania)

SI	19/08/2019 21:00->	AAXX 19214	63881 32980 01510 10145 20058 38219 48/// 333 58000=
SM	19/08/2019 18:00->	AAXX 19184	63881 02980 00000 10170 20081 38212 60002 333 10260 58001 60007==
SI	19/08/2019 15:00->	AAXX 19154	63881 32680 20905 10228 20076 38916 48/// 82400 333 58001 82631=
SM	19/08/2019 12:00->	AAXX 19124	63881 02980 03604 10246 20054 38200 60001 333 60007==
SI	19/08/2019 09:00->	AAXX 19094	63881 32980 00505 10210 20064 38224 48/// 333 5////=
SM	19/08/2019 06:00->	AAXX 19064	63881 32980 00607 10134 20069 38227 48/// 333 20101 51001 55107 59002=
SI	19/08/2019 03:00->	AAXX 19034	63881 32982 01506 10110 20058 38209 48/// 333 59001=
SM	19/08/2019 00:00->	AAXX 19004	63881 32980 01214 10133 20054 38205 48/// 333 59009=

During the day pressure
at station level of appr.

820-
822 hPa reported

At **15 UTC** pressure at
station level of **891.6 hPa**
reported



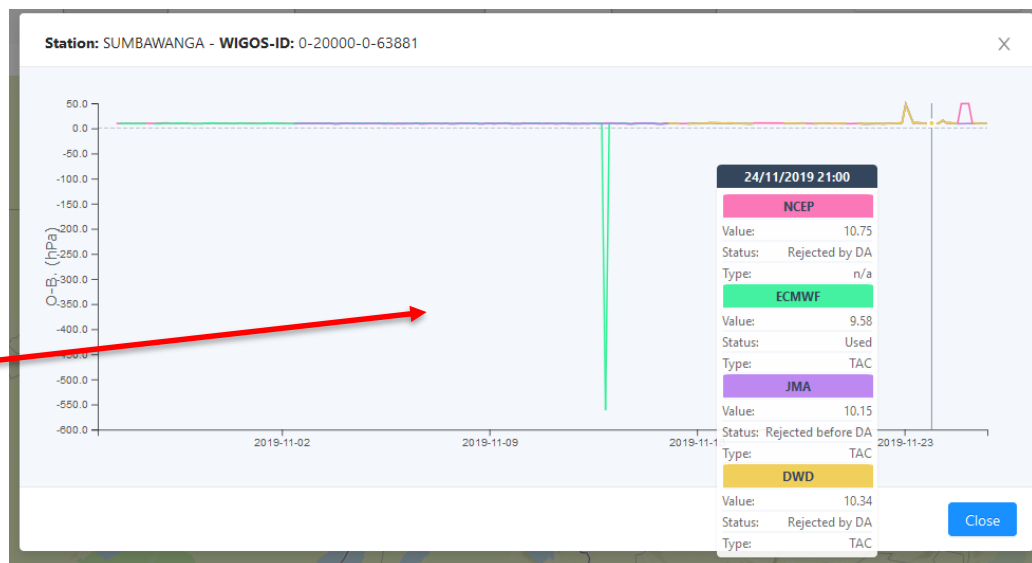
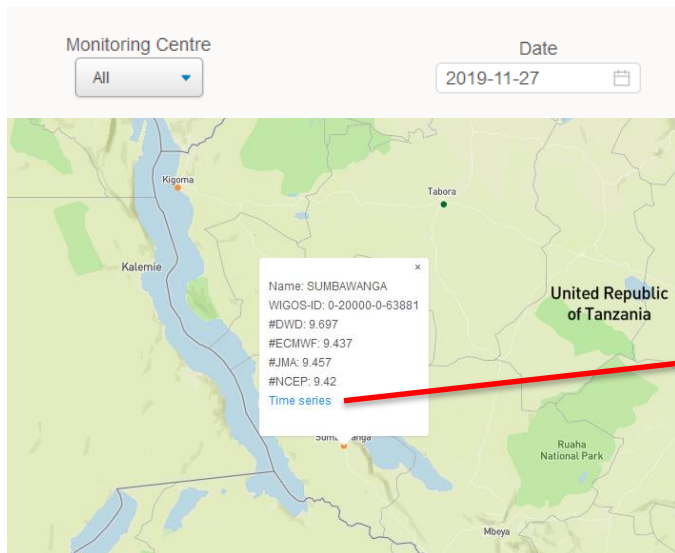
Example of issues in data accuracy

63881 SUMBAWANGA (Tanzania)

Issue No. 2

Issue No. 2 (ongoing and constant large errors):

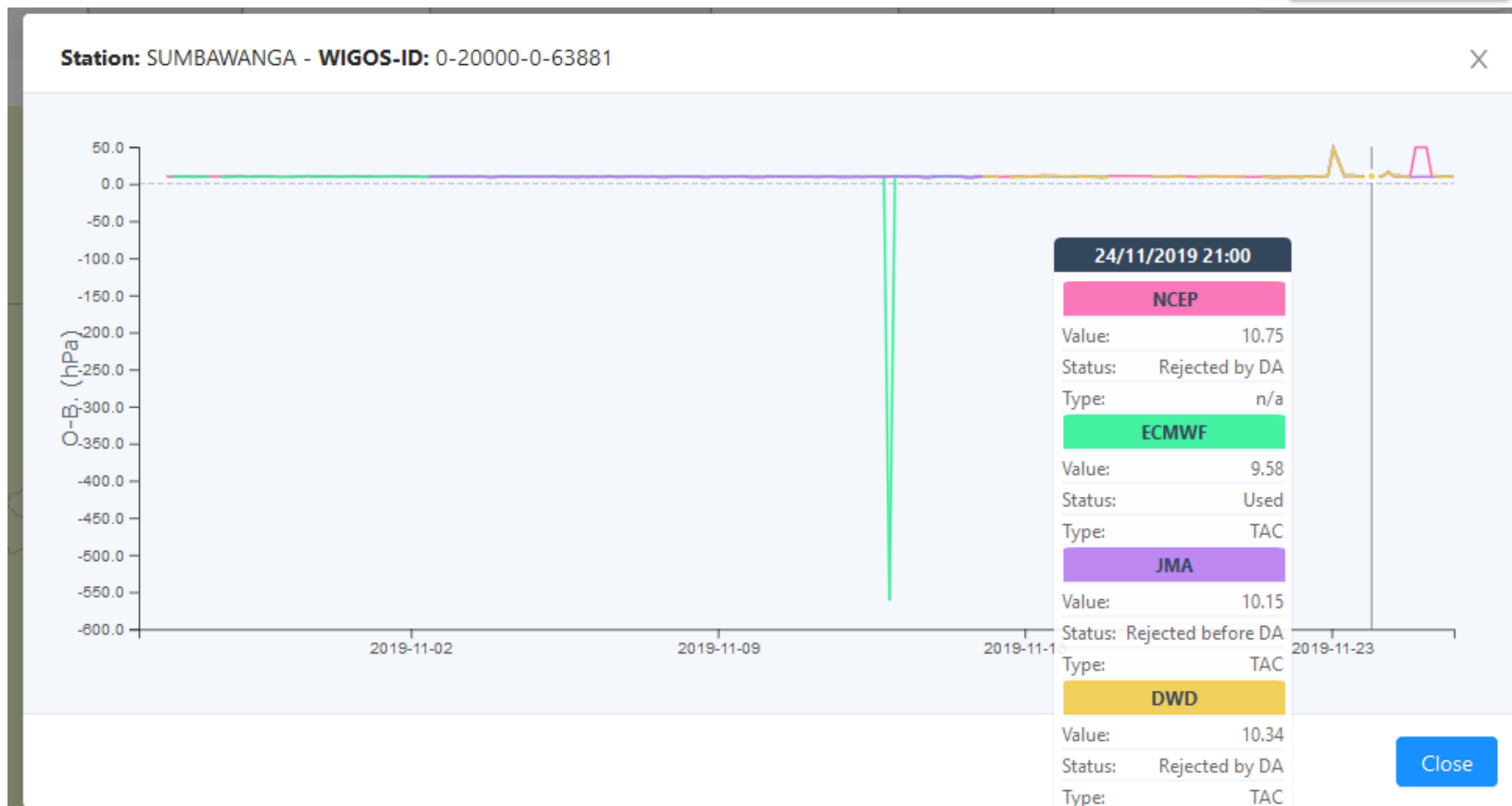
- Station 63881 SUMBAWANGA shows constant large pressure O-B departures of **appr. 10 hPa** since the Demonstration Project in RA I in all WIGOS MC outputs
- This is most likely related to incorrect entries of the barometer height in OSCAR/Surface and in BUFR messages issued by TMA



Example of issues in data accuracy

63881 SUMBAWANGA (Tanzania)

Issue No. 2



Example of issues in data accuracy

63881 SUMBAWANGA (Tanzania)

Issue No. 2 (ongoing and constant large errors):

- OSCAR/Surface metadata repository refers to an elevation of the barometer in **1923 m**

▼ Atmosphere > Pressure

▼ Atmospheric pressure - [Geometry: Point]

Variable: Atmospheric pressure

Geometry: Point

Programs / network affiliations: GOS

Last updated: On 2016-05-31

▼ Deployments

▼ From 2016-04-29

Near Real Time: No

▼ Instrument characteristics

Manufacturer: (unknown)

Model: unknown

Observing method: (unknown)

Coordinates:

Latitude	Longitude	Elevation	Geopositioning method	From
7.966666666 7°S	31.63333333 33°E	1923m		

See also <https://oscar.wmo.int/surface/#/search/station/stationReportDetails/8636>



Example of issues in data accuracy

63881 SUMBAWANGA (Tanzania)

Issue No. 2 (ongoing and constant large errors):

- According to other tools such as Google related websites displaying altitude or 'Gladstone Family' the elevation of the station is in **1856 m**
See also <https://weather.gladstonefamily.net/site/HTSU> and next slide
- **RWC to initiate IMP asking WDQMS NFP to work with OSCAR/Surface NFP to take appropriate actions to rectify the incident**

Example of issues in data accuracy

63881 SUMBAWANGA (Tanzania)

METAR/Synop Information for HTSU (63881) in Sumbawanga Airport, Tanzania

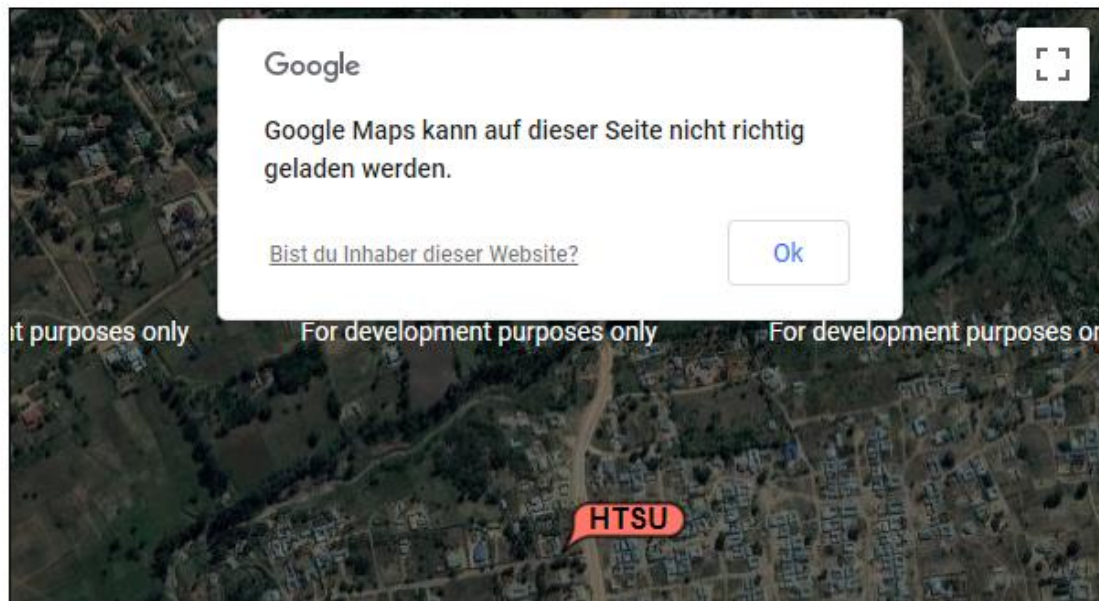
The following information is known about HTSU. If you think that any information is incorrect, then please follow the instructions for correcting that data item.

It is *possible* that this page will report a problem where no problem exists. If you believe that this has happened, then please contact me (address at the bottom of this page) and explain *clearly* why you think this page is in error. Note that any changes that you make may take a few days to show up here, so please give it a week before commenting.

Registered Location

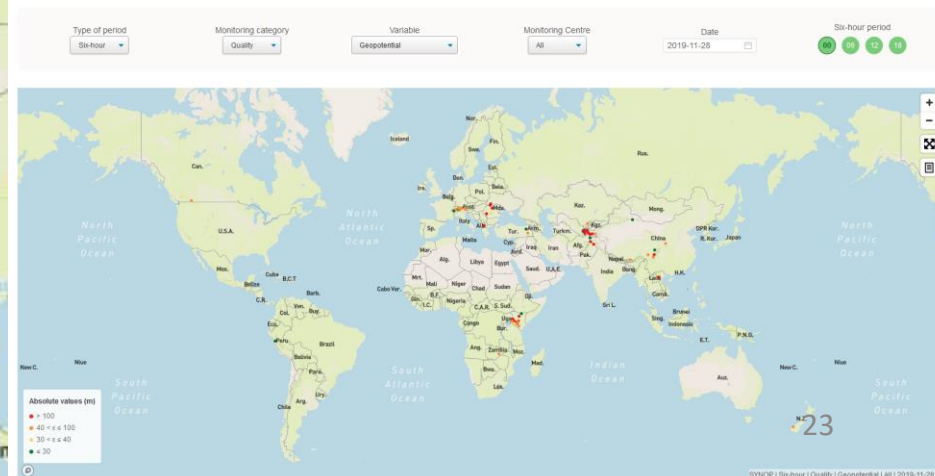
Latitude: 7° 58' 0" S (deg min sec), -7.9667° (decimal), 0758.00S (LORAN)
Longitude: 31° 38' 0" E (deg min sec), 31.6333° (decimal), 03138.00E (LORAN)
Elevation: 1923 metres (6309 feet)
WMO Id: 63881
Location: Sumbawanga Airport, Tanzania

The elevation does not correspond with the estimated elevation (1856 metres (6088 feet)) -- source Google) at that point. Either the location or the elevation (or both) are almost certain to be incorrect. Please use the 'send the updated information' link below to update the location or elevation.



●● Geopotential height O-B results

- O-B results for land stations in mountainous areas which report geopotential height instead of surface pressure
- Same procedure as for pressure observations: stations showing orange dots have accuracy issues
- If they continue to appear having large accuracy issues
→ **action:** RWC to initiate an IMP with **high** (●) or **very high priority** (●) asking WDQMS NFP to take actions to investigate the cause of the incident and to find a solution



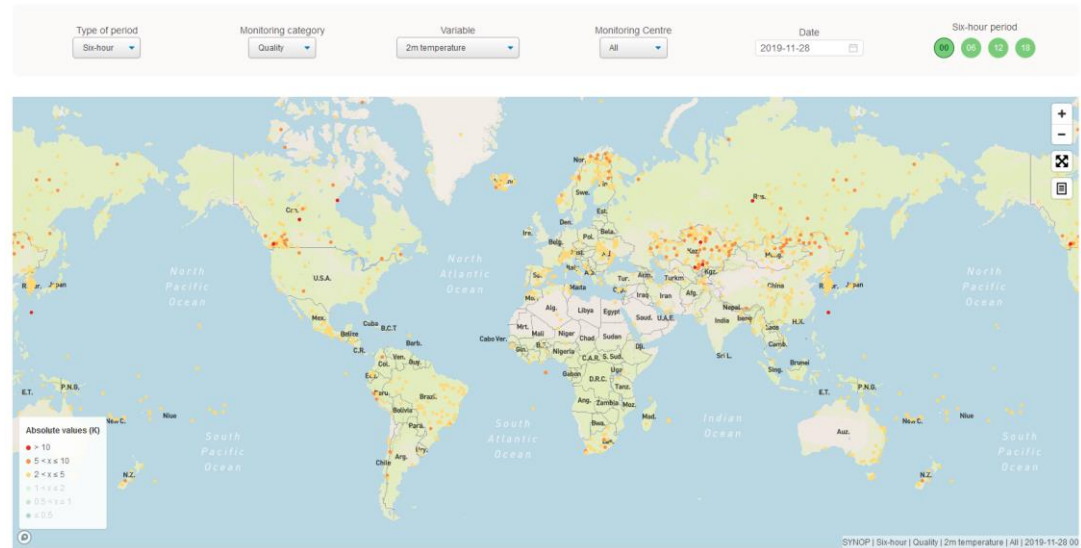
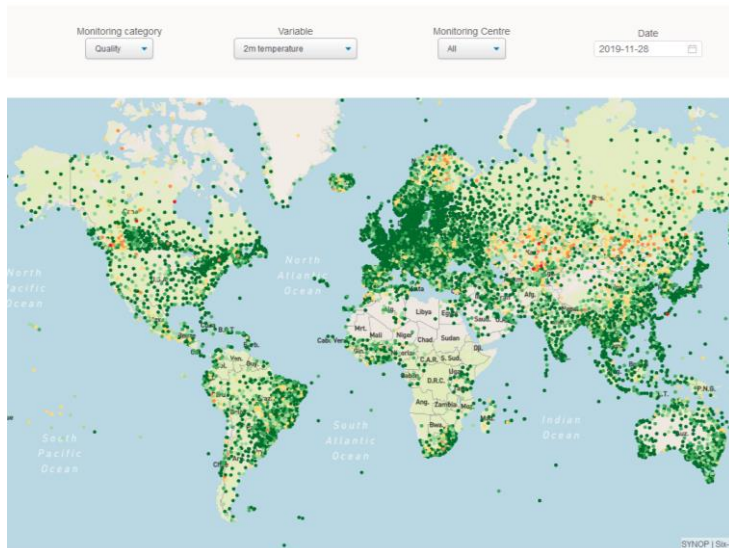
Other O-B results

- NWP models base on observations from the respective regions
 - The observations are interpolated to the model layers
 - O-B results of pressure observations are quite reliable because the pressure can be interpolated to the relevant levels quite well
 - However, large O-B results of temperature and relative humidity are often caused by model biases. Especially in winter times and in areas with steep orography models cannot always resolve strong temperature inversions and thereby might lead to wrong 2m temperature forecasts.
 - Therefore O-B results of the variables 2m temperature and 2m relative humidity have to be considered with care
- **Hence, raise IMP in case of ongoing large errors in O-B results especially with an increasing trend only**



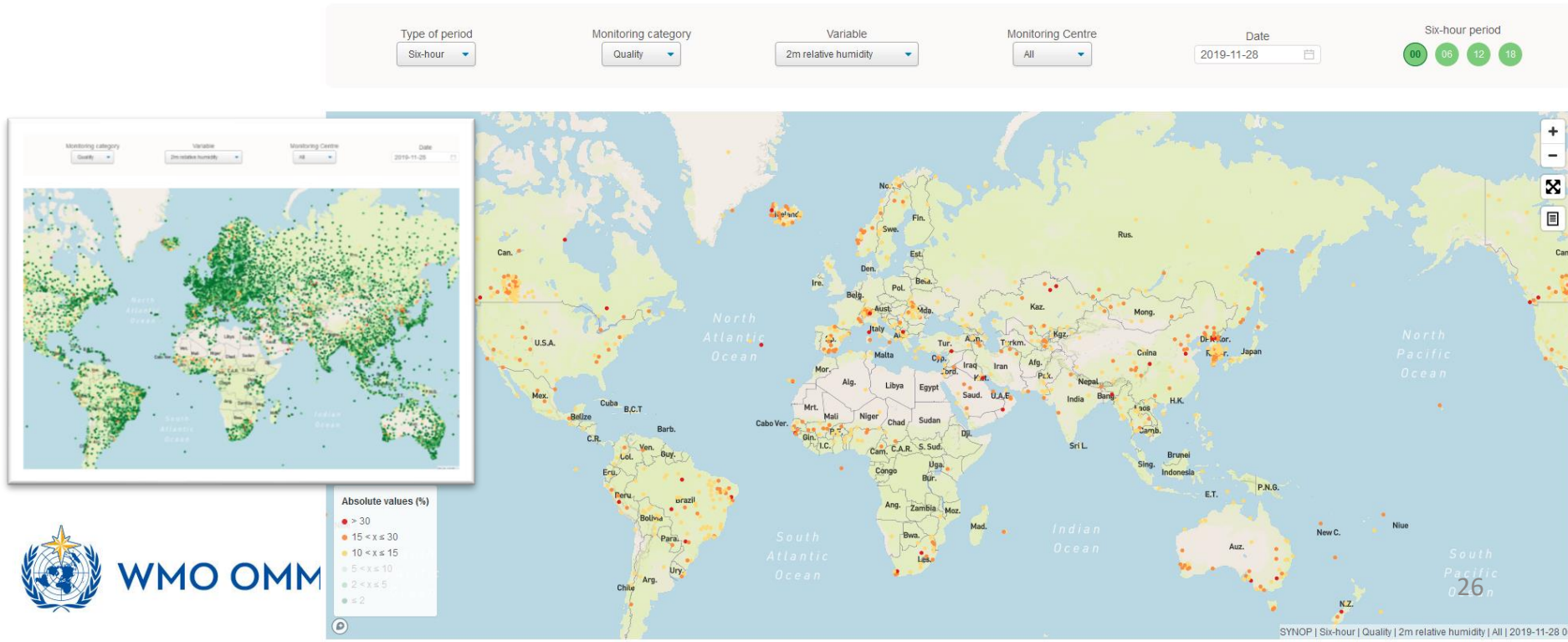
●● 2m temperature O-B results

- Stations showing orange dots have accuracy issues
- If they continue to appear having large accuracy issues
➔ **action:** RWC to initiate an IMP with **high** (●) or **very high priority** (●) asking WDAQMS NFP to take actions to investigate the cause of the incident and to find a solution



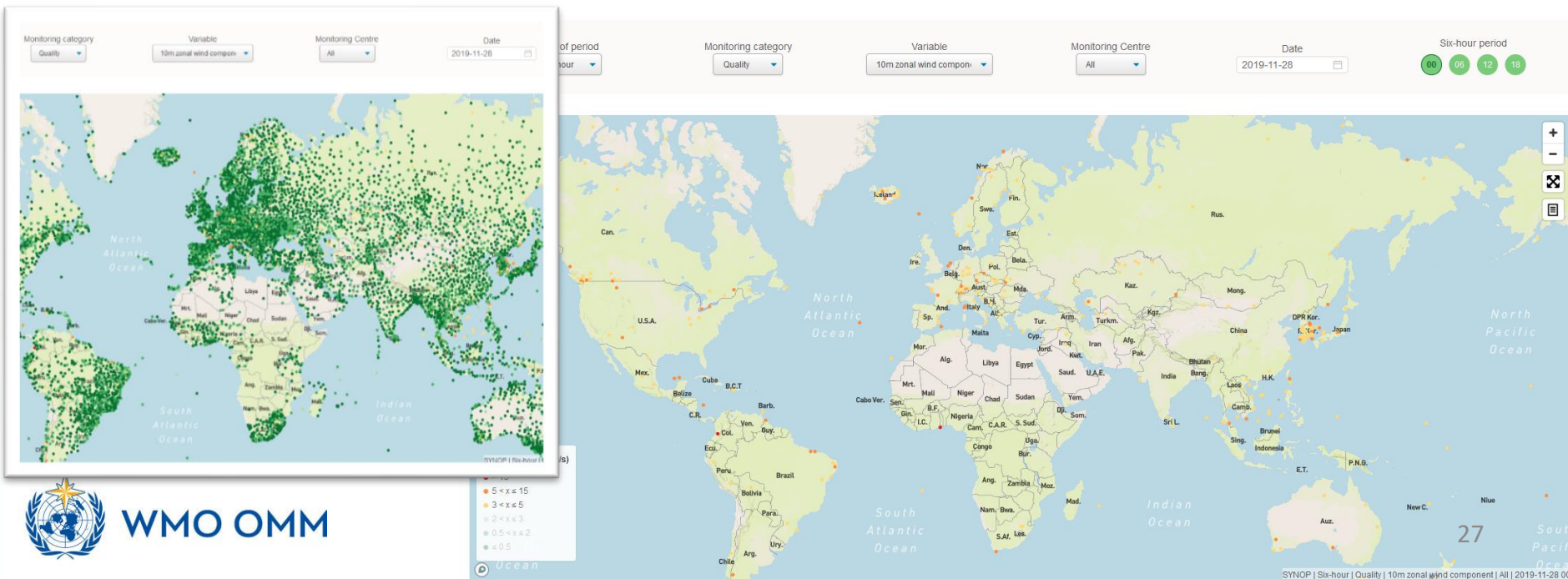
●● 2m relative humidity O-B results

- Stations showing orange dots have accuracy issues
- If they continue to appear having large accuracy issues
→ **action:** RWC to initiate an IMP with **high** (●) or **very high priority** (●) asking WDAQMS NFP to take actions to investigate the cause of the incident and to find a solution



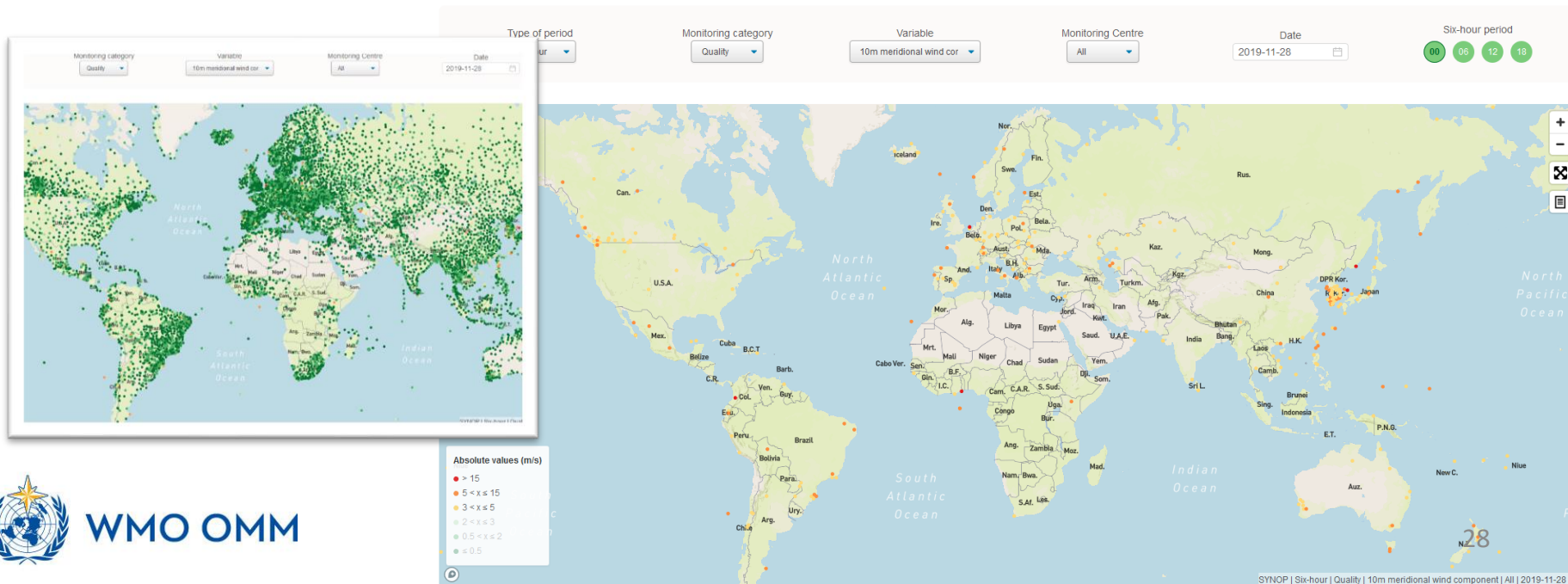
●● 10m zonal wind O-B results

- Stations showing orange dots have accuracy issues (very few!)
- If they continue to appear having large accuracy issues
→ **action:** RWC to initiate an IMP with **high** (●) or **very high priority** (●) asking WDAQMS NFP to take actions to investigate the cause of the incident and to find a solution



●● 10m meridional wind O-B results

- Stations showing orange dots have accuracy issues (very few!)
- If they continue to appear having large accuracy issues
→ **action:** RWC to initiate an IMP with **high** (●) or **very high priority** (●) asking WDAQMS NFP to take actions to investigate the cause of the incident and to find a solution



RWC starting to operationalize...

- When a RWC is starting its WDQMS operations they should initiate incident management processes for long-term ongoing issues in surface pressure O-B results first before getting into detail with special incidents of particular stations or other variables:
 - Ongoing and constant large O-B results which are most likely related to incorrect OSCAR/Surface metadata on barometer or station height of the station in question

Thank you

Tanja.Kleinert@dwd.de

<https://community.wmo.int/activity-areas/wigos>



WMO OMM

World Meteorological Organization

Organisation météorologique mondiale