The WMO Integrated Global Observing System (WIGOS), status of observations in East Africa, and expectations for HIGHWAY

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WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

Outline

- Introduction to WIGOS
- The Rolling Review of Requirements (RRR), OSCAR and WDQMS
- Gap analysis for East Africa
- Suggested HIGHWAY project goals and priority activities
- Role of Regional WIGOS Centers
- Summary and conclusions

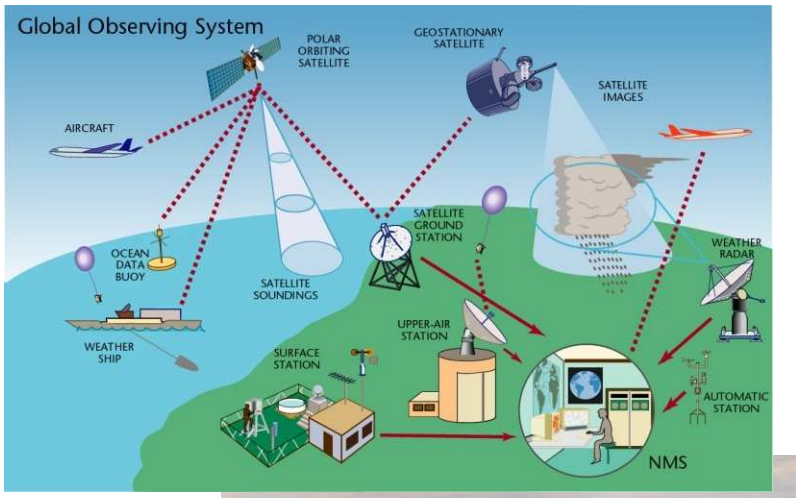
What is the WMO Integrated Global Observing System (WIGOS)?

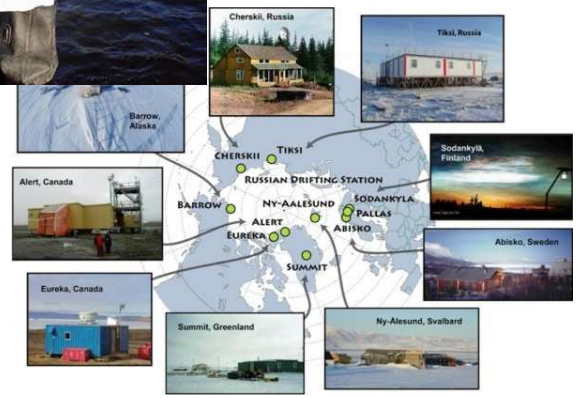
- WMO foundational activity addressing the observing needs of the weather, climate, water and environmental services of its Members
- A framework for integrating all WMO observing systems and WMO contributions to co-sponsored observing systems under a common regulatory and management framework
- WIGOS is not:
  - Replacing or taking over existing observing systems, which will continue to be owned and operated by a diverse array of organizations and programmes, national as well as international.

WIGOS homepage

WIGOS Component Systems

- Global Observing System (WWW/**GOS**)
- Observing component of Global Atmospheric Watch (**GAW**)
- WMO Hydrological Observations (including **WHYCOS**)
- Observing component of Global Cryosphere Watch (**GCW**)





The WIGOS Pre-Operational Phase (2016-2019)

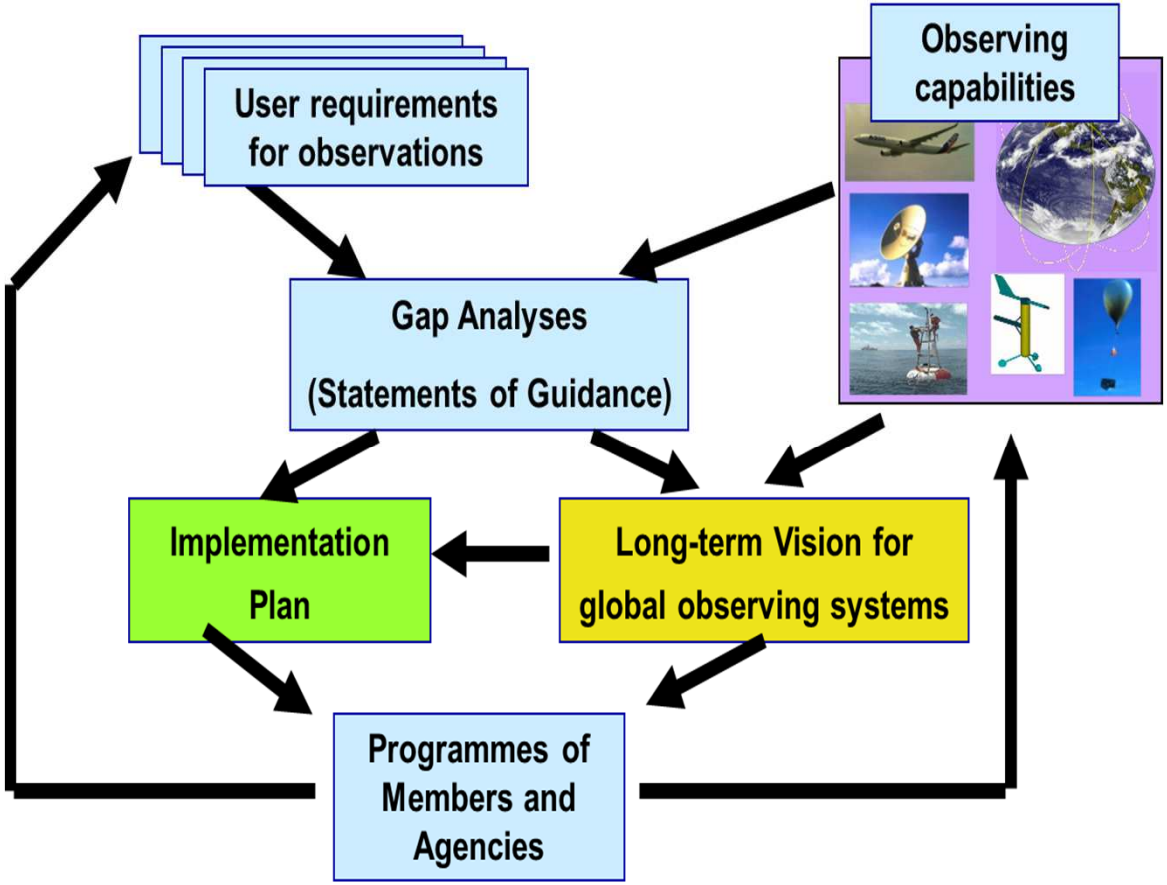
decided by Cg-17 in 2015

- Increased emphasis on regional and national activities
- Five main priority areas:
  I. WIGOS Regulatory Material, supplemented with necessary guidance material
  II. WIGOS Information Resource, including the Observing Systems Capabilities analysis and Review tool (OSCAR), especially OSCAR/Surface
  III. WIGOS Data Quality Monitoring System (WDQMS)
  IV. Regional Structure; *Regional WIGOS Centers*
  V. National WIGOS Implementation, coordination and governance mechanisms

Rolling Review of Requirements (RRR)

- WMO Congress: All WMO and WMO co-sponsored observing systems shall use the RRR to design networks, plan evolution and assess performance.

- The RRR is the process used by WMO to collect, vet and record user requirements for all WMO application areas and match them against observational capabilities



Rolling Review of Requirements

OSCAR

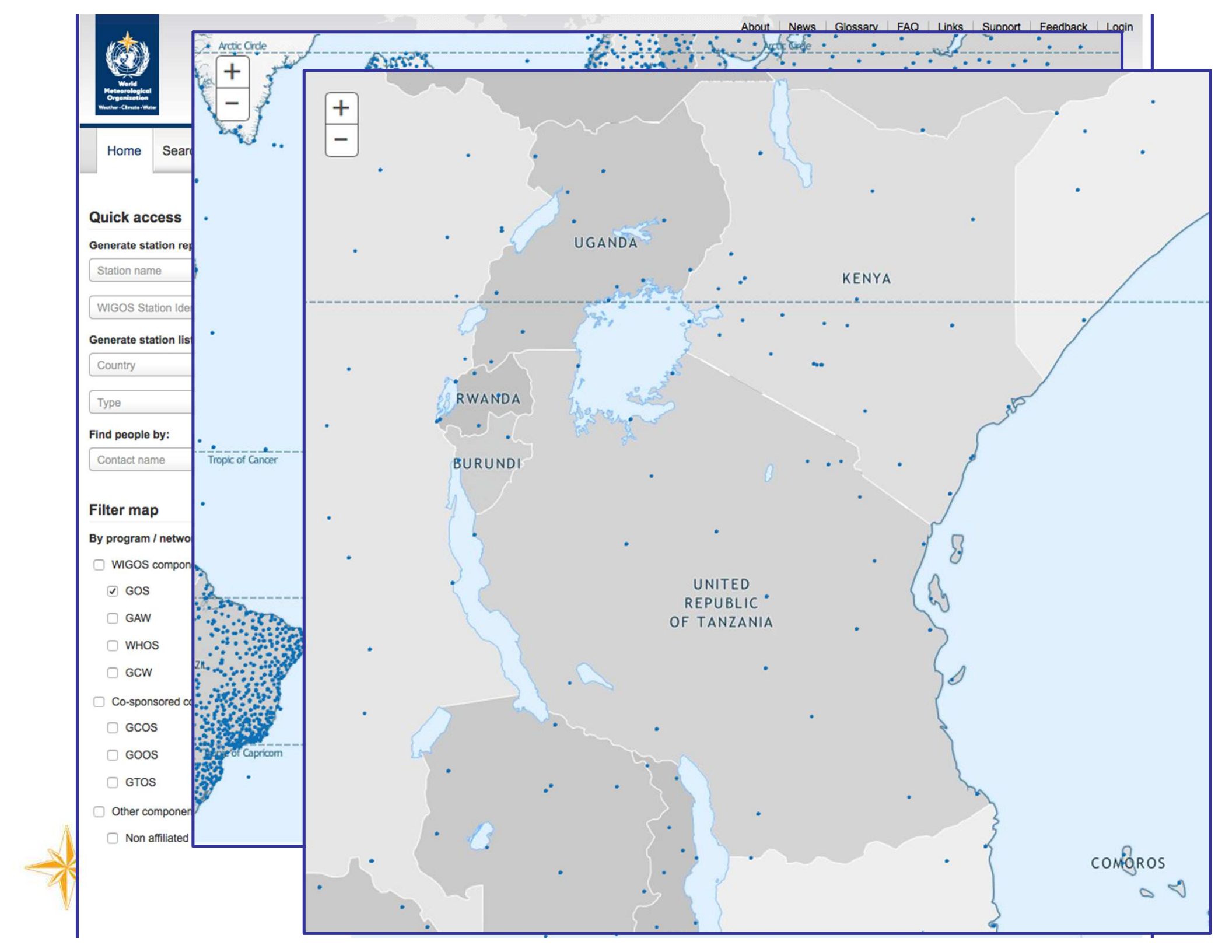
- The RRR is supported by three key databases of **OSCAR**, the *Observation Systems Capabilities and Review* tool :
  - **OSCAR/Requirements**, in which "technology free" requirements are provided for each application area, expressed in units of geophysical variables (260 in total currently);
  - **OSCAR/Space,** listing the capabilities of all satellite sensors, whether historical, operational or planned
  - **OSCAR/Surface,** list surface-based capabilities; developed by MeteoSwiss for WMO, operational since

OSCAR homepag

Gap analysis over East Africa (EAC), using information from these two databases

OSCAR/Surface
("What is WIGOS?")

- Implementation layer of the *WIGOS Metadata Standard*: **Modern, electronic, searchable inventory of metadata for all observing stations/platforms under WIGOS**
  - OSCAR/Surface has replaced *WMO Pub. 9, Volume A*, but in addition it includes information from similar inventories for other (non-GOS) components of WIGOS
  - Developed jointly by WMO and MeteoSwiss, with the Swiss government providing the major part of the funding
  - Operational since May 2016
  - Education and training Members in populating, editing and using OSCAR/Surface is a major priority for 2016-2019 financial period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OSCAR/Requirements

- The following requirements are listed for each of the (currently 14 application) areas and for all relevant geophysical variables (currently more than 200):
  - Spatial (horizontal and vertical) and temporal resolution, uncertainty, data latency, required coverage area, source, and level of confidence
- Each requirement is expressed in terms of three separate values:
  - Threshold (observations not useful unless this is met)
  - Break-through (optimum cost-benefit ratio)
  - Goal (exceeding this provides no additional benefit)
- OSCAR/Requirements information content is assembled by CBS and other WMO Inter-Program Expert Teams and Task Teams and is informed by the broader scientific community

WMO Application Areas listed in the RRR

(January 2017)

1. **Global numerical weather prediction**
2. High-resolution numerical weather prediction
3. Nowcasting and very short range forecasting
4. Seasonal and inter-annual forecasting
5. Aeronautical meteorology
6. Forecasting atmospheric composition
7. Monitoring atmospheric composition
8. Atmospheric composition for urban applications
9. Ocean applications
10. Agricultural meteorology
11. Hydrology
12. Climate monitoring *(currently under revision by GCOS and WCRP)*
13. Climate applications *(currently under revision by GCOS and WCRP)*
14. Space weather

Suggestion for HIGHWAY Priority for Output 2: Focus on Application area 1: Global NWP

- **Why?**
- Global Numerical Weather Prediction is a foundational activity for nearly all weather and climate applications
- All modern NWP systems include objective, quantitative metrics of quality and observational impact on skill;
- Global NWP is a pre-requisite for high resolution NWP and related methods used for nowcasting and short-range prediction
  - Global NWP shares many of its requirements with high resolution NWP, except the latter are even more stringent
- Most weather prediction products available to users world-wide (including in Africa) are based on global NWP output
  - Without local observations, this output will be of poor quality, especially in the tropics

Which of the many types of observations used for global NWP should we focus on?

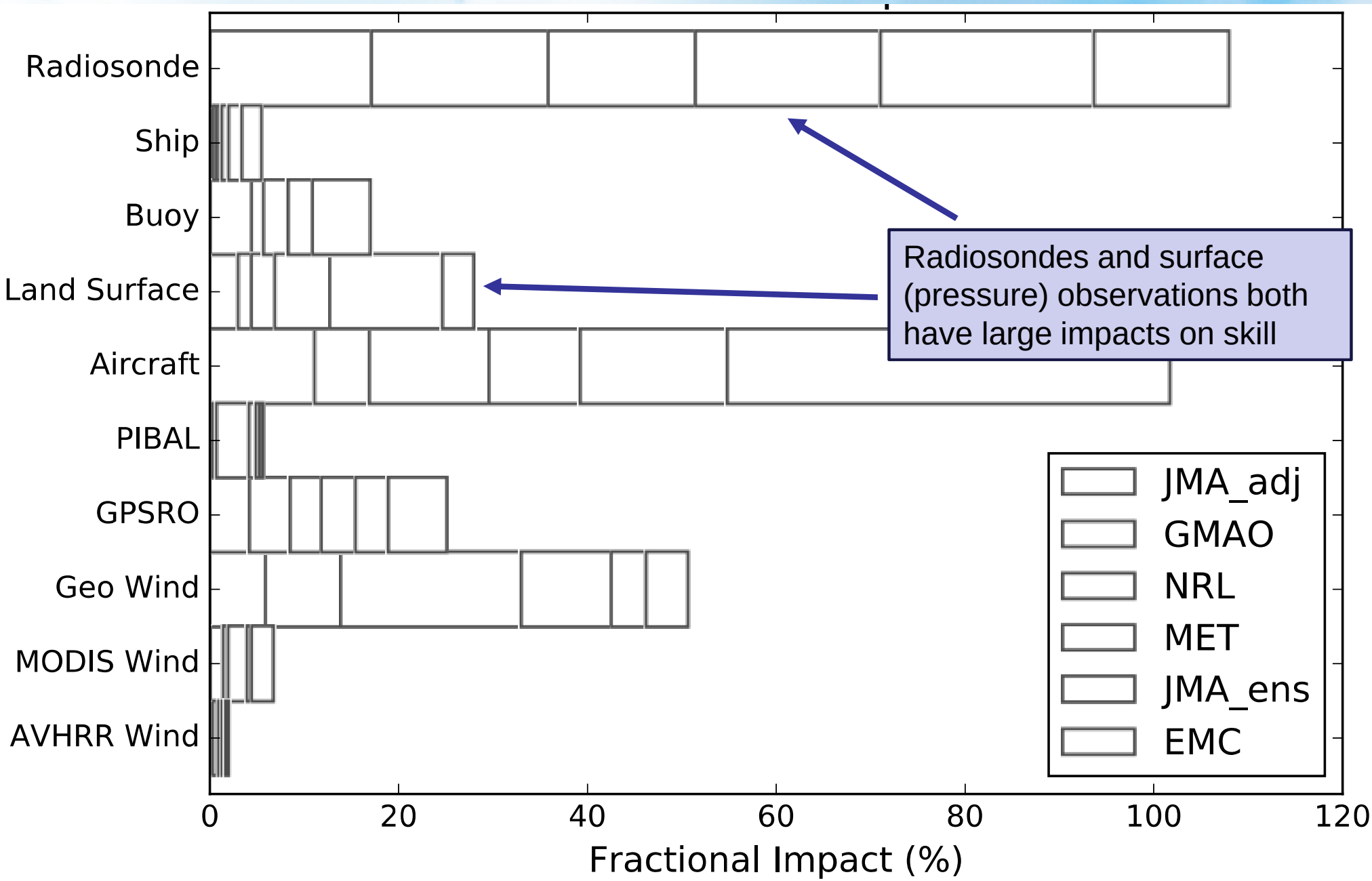
- **Surface pressure and upper air wind**
- Why?
  - Among the fundamental predicted variables for NWP (the other two are temperature and humidity)
  - Both provide driving requirements for surface-based observing systems, since – as opposed to temperature or humidity - neither is currently well measured from space

    Surface pressure is derived in experimental mode from total CO2 column measurements

    Satellite imagers provide horizontal wind components by feature tracking, but only for a single layer (no vertical resoultion) and limited height information

    Both theory and practice show that vertically resolved wind observations are particularly important in the tropics

Fractional Impact at 00UTC: **Other Observations**



Variable: Air pressure (at surface)

Definition

Full name	Air pressure (at surface)		
Definition	Pressure of the air column measured at 2 m above surface		
Measuring Units	hPa	**Uncertainty Units**	hPa
Horizontal Res Units	km	**Vertical Res Units**	
Stability Units	hPa (Stability /decade)		

Comment:	
Last modified:	2011-07-05

Classification

- **Domain:** Atmosphere
  - **Sub-domain:** Basic atmospheric
    - **Variable:** Air pressure (at surface)
      - **Measured in Layers:**
        - Near Surface
- **Cross-cutting themes:**
- **Used in Application Areas:**
  - Climate-AOPC (deprecated)
  - Global NWP
  - High Res NWP
  - Ocean Applications
  - Aeronautical Meteorology

Requirements defined for *Air pressure (at surface)* (8)

This tables shows all related requirements. For more operations/filtering, please consult the full list of Requirements

Note: In reading the values, goal is marked blue, breakthrough green and threshold orange

Id	Variable	Layer	App Area	Uncertainty	Stability / decade	Hor Res	Ver Res	Obs Cyc	Timeliness	Coverage	Conf Level	Val Date	Source
250	Air pressure (at surface)	Near Surface	Global NWP	0.5 hPa 1 hPa 1 hPa		15 km 100 km 500 km		60 min 6 h 12 h	6 min 30 min 6 h	Global land	firm	2009-02-10	John Eyre

Requirements for upper air winds

239	Wind (horizontal)	HS&M	Climate Modelling Research (deprecated)	3 m.s^{-1} 4 m.s^{-1} 5 m.s^{-1}		50 km 100 km 500 km	2 km 3 km 5 km	3 h 6 h 12 h	30 d 45 d 60 d	Global	reasonabl
240	Wind (horizontal)	LS HT LT	Climate Modelling Research (deprecated)	1 m.s^{-1} 2 m.s^{-1} 4 m.s^{-1}		10 km 50 km 250 km	0.2 km 1 km 3 km	60 min 3 h 6 h	30 d 45 d 60 d	Global	reasonabl
310	Wind (horizontal)	HS&M	Global NWP	1 m.s^{-1} 5 m.s^{-1} 10 m.s^{-1}		50 km 100 km 500 km	1 km 2 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
311	Wind (horizontal)	HT	Global NWP	1 m.s^{-1} 3 m.s^{-1} 8 m.s^{-1}		15 km 100 km 500 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
312	Wind (horizontal)	LS	Global NWP	1 m.s^{-1} 3 m.s^{-1}		15 km 100 km 500 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
313	Wind (horizontal)	LT				15 km 100 km 500 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
383	Wind (horizontal)	HT	High Res NWP	1 m.s^{-1} 3 m.s^{-1} 8 m.s^{-1}		2 km 10 km 20 km	0.5 km 0.7 km 1 km	15 min 60 min 12 h	15 min 30 min 2 h	Global	firm

"Threshold" global NWP requirement for upper air wind observations: **100 km** horizontal resolution; **12-hour** cycle

Observational data requirement for Global NWP (surface pressure)

Note: In reading the values, goal is marked blue, breakthrough green and threshold orange

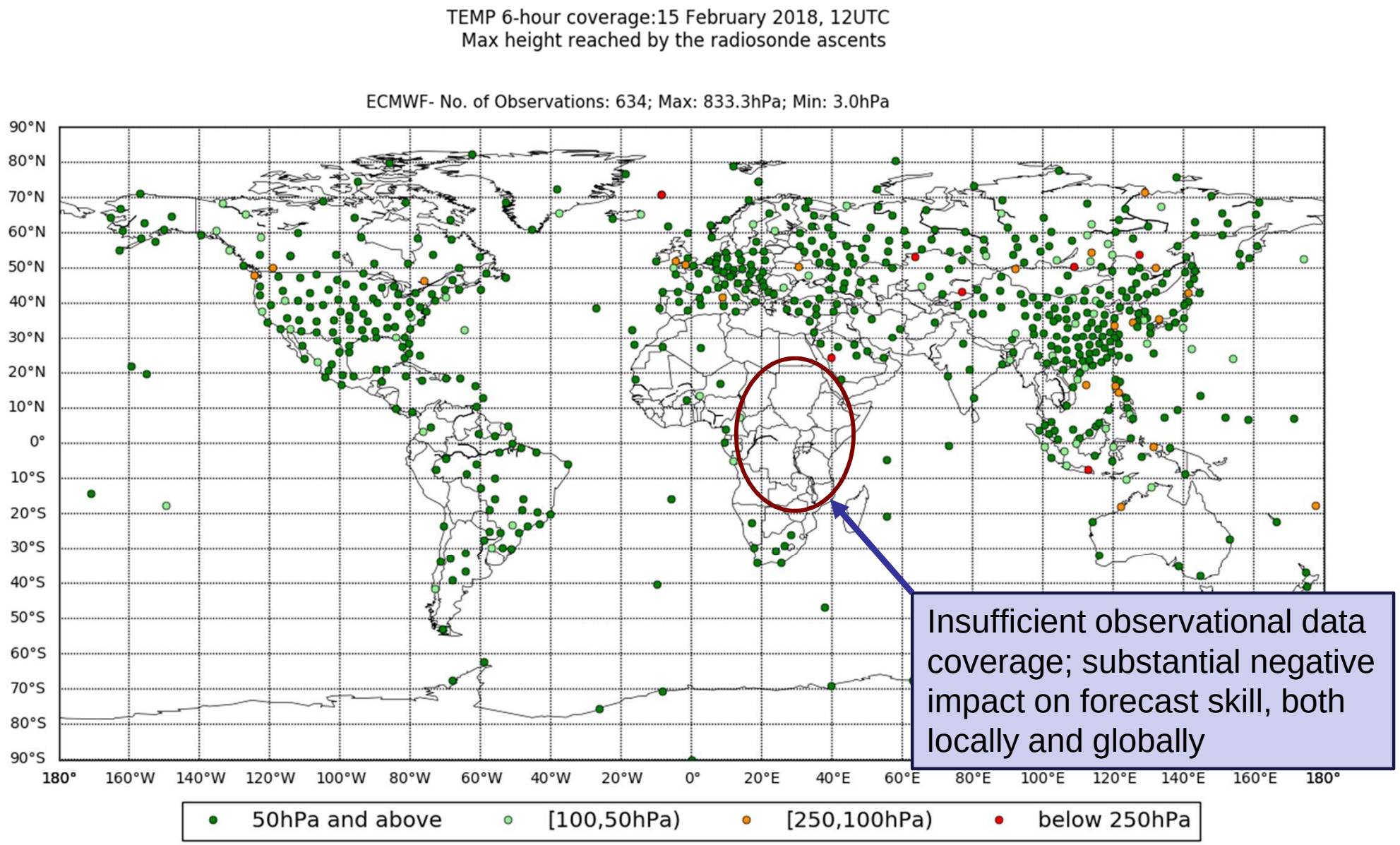
Id	Variable	Layer	App Area	Uncertainty	Stability / decade	Hor Res	Ver Res	Obs Cyc	Timeliness	Coverage	Conf Level
250	Air pressure (at surface)	Near Surface	Global NWP	0.5 hPa 1 hPa 1 hPa		15 km 100 km 500 km		60 min 6 h 12 h	6 min 30 min 6 h	Global land	firm
251	Air pressure (at surface)	Near Surface	Global NWP	0.5 hPa 1 hPa 1 hPa		15 km 100 km 500 km		60 min 6 h 12 h	6 min 30 min 6 h	Global ocean	firm
335	Air pressure (at surface)	Near	High Res NWP	0.5 hPa		2 km 10 km 40 km		30 min 60 min 3 h	15 min 30 min 2 h	Global	firm
487	Air pressure (at surface)					10 km 25 km 100 km		30 min 2 h 12 h	30 min 60 min 2 h	Global ocean	firm

"Break-through" global NWP requirement for surface pressure observations: **100 km** horizontal resolution

"Break-through" high-resolution NWP requirement for surface pressure observations: **60-minute** observation cycle

Gap analysis for wind profiles
(provided primarily by radiosondes)

- Threshold requirement for global NWP: **500 km**, i.e. every cell of 500 km x 500 km = 250,000 km2 should contain on average one radiosonde station, reporting twice daily
- In principle achievable for the continental landmasses; over Europe and North America the design separation is 200 to 250 km
  - A 500 km resolution would require 120+ radiosonde stations functioning over Africa (more than 30M Km2)
    - Today we typically have fewer than 20 reporting
  - **EAC countries (1.8M km2) would need 7 radisonde stations**
    - Today only one (Nairobi) is reporting, and not consistently


TEMP 6-hour coverage:15 February 2018, 12UTC
Max height reached by the radiosonde ascents
ECMWF- No. of Observations: 634; Max: 833.3hPa; Min: 3.0hPa
90°N
80°N
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
50°S
60°S
70°S
80°S
90°S
180°
160°W
140°W
120°W
100°W
80°W
60°W
40°W
20°W
0°
20°E
40°E
60°E
80°E
100°E
120°E
140°E
160°E
180°
Insufficient observational data coverage; substantial negative impact on forecast skill, both locally and globally
50hPa and above
[100,50hPa)
[250,100hPa)
below 250hPa

Gap analysis for surface pressure
(provided by manual and automated surface stations)

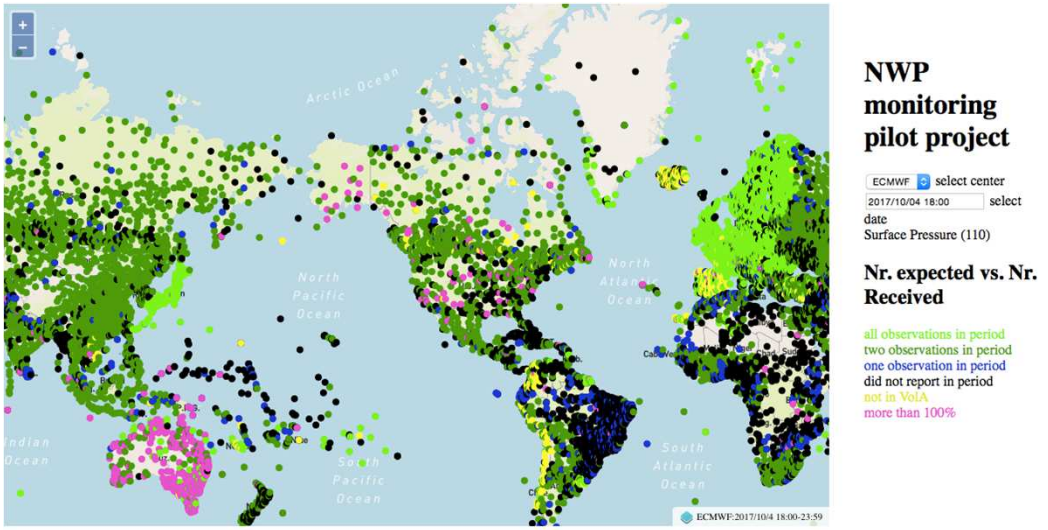
- Threshold requirement for global NWP is **500 km**
  - One station per 250,000 km2
- Breakthrough requirement for global NWP is **100 km**:
  - One station per 10,000 km2
- Threshold requirement for high resolution NWP is **40 km**,
  - One station per 1,600 km2

GOS Stations in EAC countries
(according to OSCAR/Surface)

- **Burundi**
  - 2 stations; 27,834 km2, effective resolution 110 km
- **Kenya**
  - 37 stations; 580,367 km2; effective resolution 125 km
- **Rwanda**
  - 5 stations; 26,338 km2; effective resolution 75 km
- **Tanzania**
  - 26 stations; 947,303 km2; effective resolution 190 km
- **Uganda**
  - 12 stations; 241,038 km2; effective resolution 140 km

Horizontal resolution not too bad; what about reporting status?

WIGOS Data Quality Monitoring System (WDQMS)



- Real-time monitoring of performance (data availability and data quality) of all WIGOS components, searchable by region, country, station type, period, etc.

Delayed mode monitoring of data quality as measured against reference sources of information will be included for non-real time observations

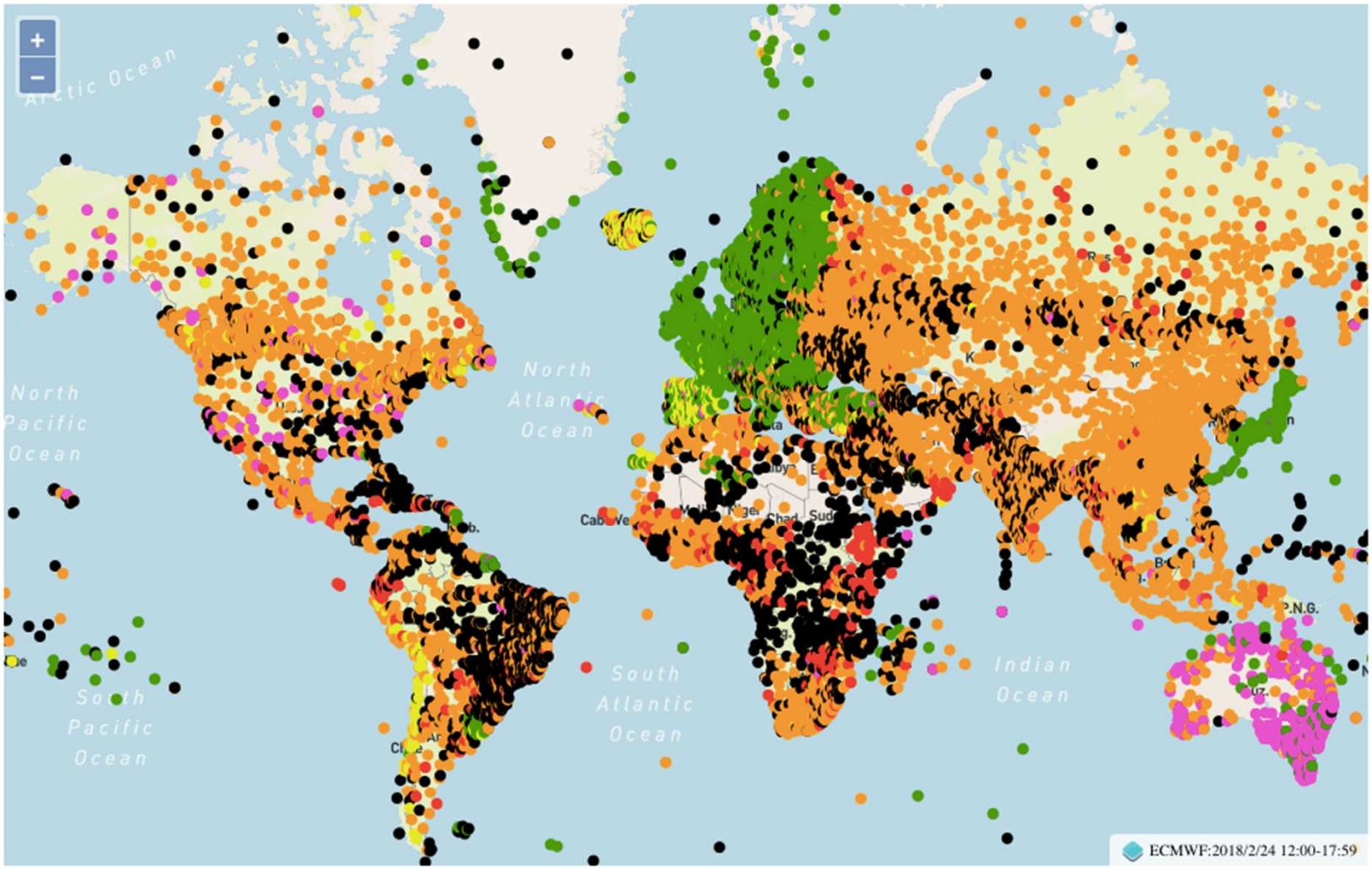
Incident management component for mitigation of performance issues

- **The WDQMS will provide a complete description of how well WIGOS is functioning**

Current activities

- **Pilot project on NWP-based monitoring; ECMWF, NCEP, DWD, JMA**
- **RA-I Demonstration Project of monitoring and incident management involving Kenya and Tanzania running through 2017**

WDQMS surface pressure observations seen by ECMWF 2018 02 24 12Z; (bright green means fully reporting)



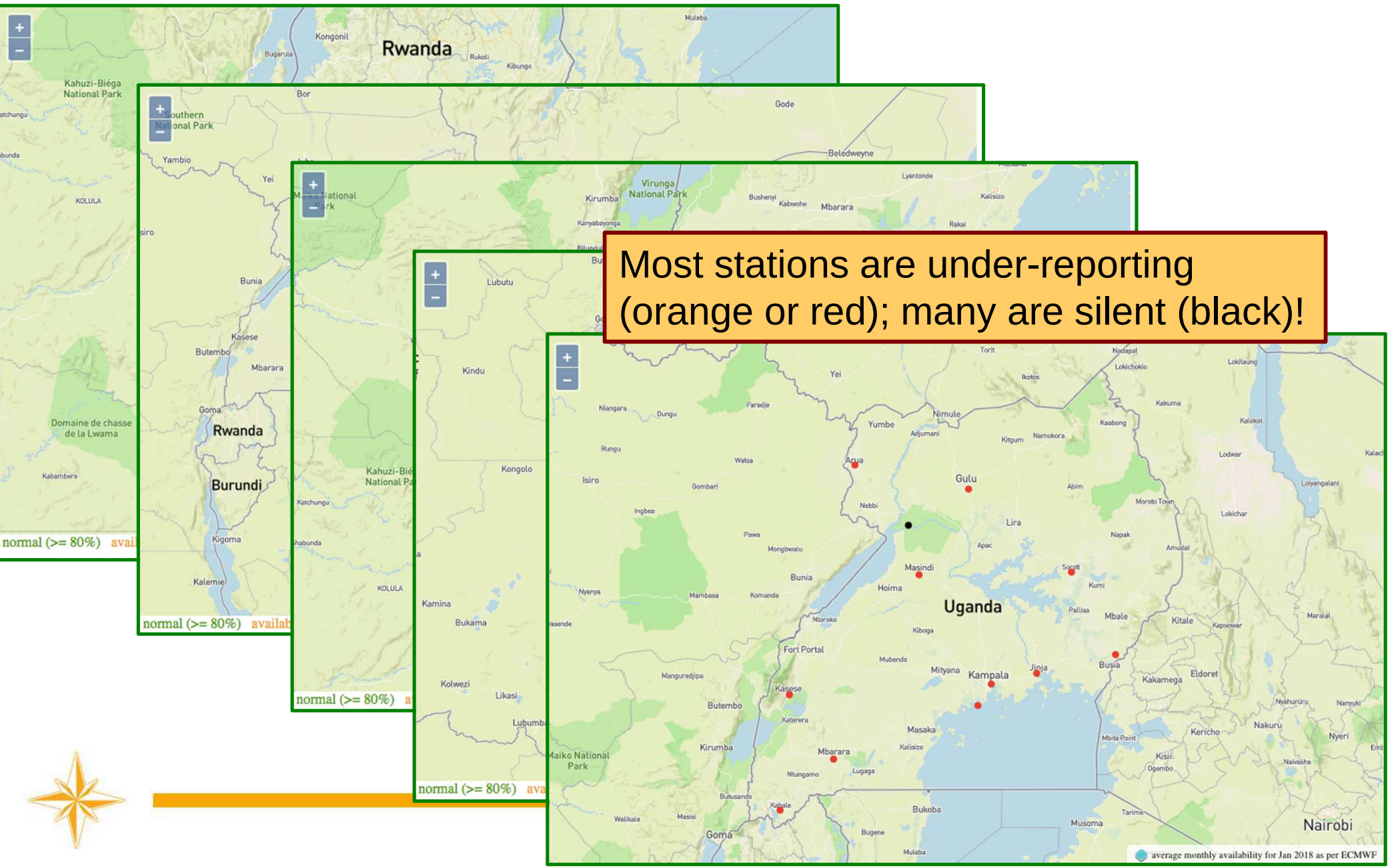
NWP monitoring pilot project

SYNOP (surface pressure)
ECMWF select center
2018/02/24 select date
0h 6h 12h 18h

Nr. expected vs. Nr. Received

normal (>= 80%)
availability isuses (>=30%)
availability isuses (<30%)
did not report in period
not in VolA
more than 100%

Monthly (Jan 2018) average reporting status for HIGHWAY project country stations in OSCAR/Surface



Suggested Project Goals for HIGHWAY
(Output 2)

- An **observing system that meets agreed requirements** for the project region
- An **observing systems that provides regular and timely reports** to national and international users on the WIS/GTS ("green dots on the WDQMS maps")
  - Minimum 3 (preferably 4) radiosonde stations reporting daily at 00Z and 12Z
  - Surface stations corresponding to a target resolution of 100-200 km, reporting hourly observations

Initial Project Steps
(Output 2)

- Ensure that all project countries have active national focal points for WIGOS and OSCAR
- Observing system inventory
  - What stations are available?
  - What is missing in order for existing stations to be able to report observations? (hardware, staff, communications capabilities, …)
- Implementation plan for gap mitigation
- Installation/upgrade of hardware according to implementation plan; training
- Monitoring and quality control of observational data

National Focal Points in EAC countries

(according to the WMO Country Profile Database)

- **Burundi**
  - WIGOS: **No**; OSCAR/Surface: **No**
- **Kenya**
  - WIGOS: Yes; OSCAR/Surface: Yes
- **Rwanda**
  - WIGOS: **No**; OSCAR/Surface: Yes
- **Tanzania**
  - WIGOS: **No**; OSCAR/Surface: Yes
- **Uganda**
  - WIGOS: Yes; OSCAR/Surface: Yes

WIGOS project support tools

- OSCAR/Surface
  - Critical inventory of observational capabilities; needs to be kept accurate and up to date
  - Serves as a basis for observing network redesign/rehabilitation efforts
- WIGOS Data Quality Monitoring System (WDQMS)
  - Measurement of data availability and data quality
  - ***WDQMS output will be provide the primary metrics for project success (output 2)***

Initial priority activities; rough timeline
(Output 2; output 1)

- Observing system assessment for all project countries
  - Throughout 2018; depending on availability of expertise
- Regional WIGOS Center Implementation Meeting
  - Ideally 2nd or 3rd Q 2018; depending on national commitments
- OSCAR/Surface training event
  - 2nd Q 2018
- Possibly broader WIGOS Workshop on AWS Networks (may or may not be tied to HIGHWAY; to be discussed)
  - 3rd Q 2018

Regional WIGOS Centers (RWC)

- Why?
  - Many WMO Members requesting support from Secretariat for national implementation efforts
  - Can be addressed more efficiently and effectively at regional level
- What?
  - Initial role or RWC will be to support national WIGOS Implementation efforts, in particular as concerns
    - **OSCAR/Surface; ensuring metadata input and QC**
    - **WDQMS; especially fault management component**
- How?
  - To be decided by individual WMO Regions - will likely take place primarily at the sub-Regional level, aligned with existing cultural, linguistic and/or political groupings of countries

Regional WIGOS Centers (II)

- **Region I**: Interest (e.g. Morocco, Tanzania); limited national resources, WMO seeking donor funds; sub-regional basis.
- **Region II**: Interest from China, Japan, Saudi Arabia; will be done on a sub-regional basis
- **Region III**: plans for Virtual RWC maturing, decision to be made at RA-III Session later this year; Region VI used as model
- **Region IV**: no clear path yet; to be discussed at RA-IV Hurricane Committee Meeting in April 2018
- **Region V**: To be discussed at RA-V MG during EC-70
- **Region VI**: successful RWC operating in pilot mode at DWD thanks to EUTMETNET engagement *(see subsequent presentation by Tanja Kleinert);* tentative plans for RWCs also in Belarus and Croatia

Regional WIGOS Center in HIGHWAY countries

- RWC for Burundi, Kenya, Rwanda, Tanzania and Uganda could be established in pilot mode for the project period, possibly as a virtual center, involving two (or more) Members
- HIGHWAY can contribute resources to this, but it will have to build on existing expertise in NMHS
- Total scope of the effort expected to be no more than 1-1.5 FTE per NMHS
- Main duties would be to

i. Ensure OSCAR/Surface station catalog kept accurate and up to date

i. Monitor data availability and data quality using WDQMS tools

ii. Take corrective action in case of availability of quality problems

Other elements to consider/ opportunities to pursue

- Engagement with regional and national users concerning observational data requirements is needed
- Leveraging efforts undertaken by other weather- and climate-related projects in the region
- Engagement with African countries outside the HIGHWAY project, e.g. using project resources to leverage efforts that would benefit the whole continent
- Broader engagement with non-NMHS observational data provider (or potential providers) from the private sector and non-profit organizations
- Strengthening of the regional AMDAR program would be very helpful to overall the project goals

Summary and Conclusions

- WIGOS is a global framework for integrating all WMO and co-sponsored observing systems under a common regulatory and management umbrella;
- Purpose is to help WMO Members provide and gain access to more observational data at reduced cost by taking an integrated approach;
- Technical tools are developed and implemented globally
  - Regional WIGOS Centers to be established to help implement WIGOS regionally and nationally;
- HIGHWAY provides a unique opportunity to strengthen the regional WIGOS infrastructure and the observing systems, with substantial benefits to both local and global users as a result;
  - A Regional WIGOS Center pilot involving all five project countries would greatly help facilitate this.