Content

I. WMO Space Programme Office

II. Space-based Observing System

III. Observing System Capability analysis

IV. Vision for WIGOS in 2040

V. WMO governance Reform

VI. Conclusion
I. WMO Space Programme Office
World Meteorological Organization

- UN Specialized Agency on weather, climate & water
- 193 Members, HQ in Geneva
- 2\textsuperscript{nd} oldest UN Agency, 1873-
- Coordinates work of ~3000 national experts serving on WMO technical committees from meteorological and hydrological services, academia and private sector
  - Secretariat with ~290 staff (~80 technical and scientific) in Geneva, Switzerland
  - Space Programme Office: 3 staff

- Co-Founder and host agency of IPCC (1\textsuperscript{st} World Climate Conference)
- Co-Founder of UNFCCC (2\textsuperscript{nd} World Climate Conference)
WMO Space Programme

• WMO started implementation of World Weather Watch in 1967
  • Combines observing systems, telecommunication facilities as well as data-processing and forecasting centres
• Since that there was growing importance of space-based observing system component
• WMO Space Programme established by the 14th WMO Congress in 2003
• Tasked to promote availability and utilization of satellite data and products for weather, climate, water and related applications and to coordinate environmental satellite matters and activities throughout all WMO Programmes.
• 16th WMO Congress in 2011 confirmed four main components of the Programme:

  - The space-based Observing System
    - Global Planning
    - Satellite Status
    - Frequency Coordination
  - Access to Satellite Data and Products
  - Awareness and Training
  - Space Weather Coordination
WMO Space Programme value Chain

Satellite Operators → Calibrated data sets → Quality-controlled products → Data collection, Dissemination & Access → Awareness & training → Users

- Satellite Operators: Initiative to improve quality of observations
- Calibrated data sets: Initiative to ensure sustained and continuous provision of Satellite Data
- Quality-controlled products: DBNet
- Data collection, Dissemination & Access: To ensure efficient delivery of data and products to a global user community
- Awareness & training: Global network of specialised training centres and meteorological satellite operators

20 September 2019
II. Space-based Observing System
WMO Integrated Global Observing System

- World Weather Watch (WWW), established in 1963.

- Later needs for the observation system supporting weather, water, climate and environmental issues:
  - WMO Integrated Global Observing System (WIGOS)
  - WMO Information System (WIS)
WMO Integrated Global Observing System

World Weather Watch

GOS

GDPFS

GTS

WMO Information System - WIS

GAW

GCW

Hydro OS

GCOS

Partners

Co-sponsors

20 September 2019

2019 RO SAF and IROWG
III. Observing system capability analysis
Welcome to OSCAR

OSCAR is a resource developed by WMO in support of Earth Observation applications, studies and global coordination.

It contains quantitative user-defined requirements for observation of physical variables in application areas of WMO (i.e. related to weather, water and climate). OSCAR also provides detailed information on all earth observation satellites and instruments, and expert analyses of space-based capabilities.

The tool constitutes a building block of WIGOS and more specifically, the so-called Rolling Requirements Review process. OSCAR targets all users interested in the status and the planning of global observing systems as well as data users looking for instrument specifications at platform level. To continue, please select one of the following modules:

- Observation Requirements
- Satellite Capabilities
- Surface based Capabilities

Each of the modules can be consulted individually, however, the tool is also designed with the goal to integrate user requirements with actual capabilities. This facilitates the Rolling Requirements Review process, comparing "what is required" with "what is, or will be available", in order to identify gaps and support the planning of integrated global observing systems.

The tool is being further developed, and additional functionality and features will be introduced as appropriate. Please visit http://oscar.wmo.int for more information.
# Gap Analysis - Measurement timeline for Radio Occultation Sounding missions

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IV. Vision for WIGOS in 2040
Why a Vision for WIGOS in 2040?

- To serve as reference for WMO Members and other observing system operators
  - providing context and expected boundary conditions relevant for observing system developments

- To inform long-term planning of satellite agencies about expected evolution of WMO user requirements
  - This drives the 2040 timeline

- To inform planning efforts of users (NHMSs, NWP centers, ...) regarding systems development and required computing and communication capabilities

See: https://www.cgms-info.org/Agendas/WP/CGMS-47-WMO-WP-02
Space-based Component - Four Groups

- Backbone system with specified orbital configuration and measurement approaches (Group 1).
  - MetOp, ...

- Backbone system with open orbit configuration and flexibility to optimize the implementation (Group 2).
  - Cosmiq, ...

- Operational pathfinders, and technology and science demonstrators (Group 3).
  - Future needs

- Additional capabilities (Group 4).
  - Commercial data providers, ...
V. WMO Governance Reform
Reform Objectives

Effectiveness and efficiency

Seamless and integrated approach

Increase value for society

Engagement of Members and Partners

Agile and responsive to new challenges

Earth System approach

WMO acting as one
Cg-18 Adopted New WMO Structure

- Global development agenda

See https://public.wmo.int/en/governance-reform
WMO Strategic Plan 2020-2030

**VISION 2030**

A world where all nations, especially the most vulnerable, are more resilient to the socio-economic impact of extreme weather, climate, water and other environmental events, and empowered to boost their sustainable development through the best possible weather, climate and water services.

**OVERARCHING PRIORITIES**

<table>
<thead>
<tr>
<th>Services</th>
<th>Infrastructures</th>
<th>Science &amp; Innovations</th>
<th>Member Services</th>
<th>Smart Organization</th>
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</thead>
<tbody>
<tr>
<td>Preparedness for, and reducing losses from hydrometeorological extremes</td>
<td>Climate-smart decision-making to build resilience and adaptation to climate risk</td>
<td>Socioeconomic value of weather, climate, hydrological and related environmental services</td>
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</tbody>
</table>

**CORE VALUES**

- Accountability for Results and Transparency
- Collaboration and Partnership
- Inclusiveness and Diversity

**LONG-TERM GOALS**

1. **Services**
   - Better serve societal needs
   - Strengthen national multi-hazard early warning/alert systems
   - Broaden provision of policy- and decision-supporting climate, water and weather services

2. **Infrastructures**
   - Enhance Earth system observations and predictions
   - Optimize observation data acquisition
   - Improve access to, exchange and management of Earth system observation data and products

3. **Science & Innovations**
   - Advance scientific knowledge of the Earth system
   - Enhance science-for-service value chain to improve predictive capabilities
   - Advance policy-relevant science

4. **Member Services**
   - Enable developing countries to provide and utilize essential weather, climate, hydrological and related environmental services
   - Develop and sustain core competencies and expertise
   - Scale up partnerships

5. **Smart Organization**
   - Optimize WMO constituent body structure
   - Streamline WMO programmes
   - Advance equal, effective and inclusive participation

20 September 2019 2019 RO SAF and IROWG
VI. Conclusion

- **WMO Space Programme promotes:**
  - Availability and utilization of satellite data and products for weather, climate, water and related applications
  - Coordinate environmental satellite matters and activities

- **Vision for WIGOS 2040 serves as reference for WMO Members and other observing system operators including space-based component**

- **WMO reform goal:**
  - Increase efficiency and improve partnerships through holistic Earth system approach
Coordination is needed!

ESA weather satellite's near miss warns of dangers to come

BY PAUL WILLIS ON SEPTEMBER 17, 2019

A weather satellite belonging to the European Space Agency (ESA) was forced into a last-minute maneuver to avoid colliding with another satellite in a large constellation, in a first for the agency.

The ESA performed what it called a “collision avoidance maneuver”, firing the thrusters of its Aeolus observation satellite to move it off a course from a potential direct hit with a SpaceX satellite in the Starlink constellation.

For the first time ever, ESA has performed a 'collision avoidance manoeuvre' to protect one of its satellites from colliding with a 'mega constellation'

#SpaceTraffic
Thank you

http://www.wmo.int/sat
Back up slides
### WMO Application Areas – Earth System Approach

<table>
<thead>
<tr>
<th></th>
<th>Application Area</th>
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<tbody>
<tr>
<td>1</td>
<td>Global numerical weather prediction</td>
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<tr>
<td>2</td>
<td>High-resolution numerical weather prediction</td>
</tr>
<tr>
<td>3</td>
<td>Nowcasting and very short range forecasting</td>
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<tr>
<td>4</td>
<td>Sub-seasonal to longer predictions</td>
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<tr>
<td>5</td>
<td>Aeronautical meteorology</td>
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<tr>
<td>6</td>
<td>Forecasting atmospheric composition</td>
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<td>7</td>
<td>Monitoring atmospheric composition</td>
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<td>8</td>
<td>Atmospheric composition for urban applications</td>
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<td>9</td>
<td>Ocean applications</td>
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<td>10</td>
<td>Agricultural meteorology</td>
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<td>11</td>
<td>Hydrology</td>
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<tr>
<td>12</td>
<td>Climate monitoring (GCOS)</td>
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<tr>
<td>13</td>
<td>Space weather</td>
</tr>
<tr>
<td>14</td>
<td>Climate science</td>
</tr>
</tbody>
</table>

WMO Space Programme Expert Teams

- **ET-SAT**
  - Expert Team on Satellite Systems

- **IPET-SUP**
  - Inter-Programme Expert Team on Satellite Utilization and Products

- **IPT-SWeISS**
  - Inter-Programme Team on Space Weather Information, Systems and Services

- Established under the Open Programme Area Group on Integrated Observing Systems (OPAG-IOS) of the Commission for Basic Systems (CBS)
- The OPAG-IOS makes recommendations to CBS biennially.
  - CBS reports annually to the WMO Executive Council through the report of the president of CBS.
- Members nominated by Permanent Representatives
Rolling Review of Requirements

OSCAR/Requirements

User requirements for observations

Gap Analyses
(Statements of Guidance)

Implementation Plan

Long-term Vision for global observing systems

Programmes of Members and Agencies

OSCAR/Space

Observing capabilities

OSCAR/Surface

WIGOS Vision 2040
Sorting criteria – OSCAR/Space Gap Analysis

Relevant instruments and their contribution

The sorting column describes how the instruments, by design, have the potential to contribute to certain pre-determined capabilities, assuming ground segments. For this particular capability, instrument performance is considered to be driven by:

- the number of occultations per day, determined by:
  - how many GNSS systems are exploited (GPS, GLONASS, Galileo, Beidou)
  - whether occultations are exploited with the GNSS satellite rising and/or setting (viewing fore- and/or aft-);
  - whether the instrument is launched and operated as a constellation or an individual system;
- the capability to scan the ionosphere (this requires GNSS signal sampling for altitudes above 100 km).

Sorting criteria and colour code:

1. Receivers flown on dedicated satellite clusters to track >=3 GNSS systems by 2 directional antennas for both fore- and aft- occultations. Altitude ionosphere OR not.
2. Receivers flown on dedicated satellite clusters to track >=1 GNSS systems by 2 directional antennas for both fore- and aft- occultations. Altitude ionosphere OR not.
3. Receiver hosted on single satellites, to track >=3 OR >=2 GNSS systems by 2 directional antennas for both fore- and aft- occultations. Altitude ionosphere OR not.
4. Receiver hosted on single satellites to track 1 GNSS system by 2 directional antennas for both fore- and aft- occultations. Altitude scanned not.
5. Receiver hosted on single satellites to track 1 GNSS system by 1 directional antenna for either fore- or aft- occultation. OR receiver equipped directional antenna. Altitude scanned up to the ionosphere OR not.
Other Key Cg-18 Outcomes (Relevant to Observations)
<table>
<thead>
<tr>
<th></th>
<th>Selected Cg-18 Outcomes</th>
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</thead>
<tbody>
<tr>
<td>34</td>
<td>Global Basic Observing Network (GBON)</td>
</tr>
<tr>
<td>35</td>
<td>WMO Integrated Global Observing System station identifiers</td>
</tr>
<tr>
<td>37</td>
<td>The WMO Integrated Global Observing System transition to operational status commencing in 2020</td>
</tr>
<tr>
<td>38</td>
<td>Vision for the WMO Integrated Global Observing System in 2040</td>
</tr>
<tr>
<td>40</td>
<td>Members’ contribution to the actions specified in the Implementation Plan for the Evolution of Global Observing Systems, in the context of the future WMO Integrated Global Observing System Implementation Plan</td>
</tr>
<tr>
<td>42</td>
<td>Radio frequencies for meteorological and related environmental activities</td>
</tr>
<tr>
<td>46</td>
<td>Future collaboration between WMO and the Intergovernmental Oceanographic Commission on facilitating oceanographic observations in coastal regions in support of Earth system prediction and climate services</td>
</tr>
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## Selected Cg-18 Outcomes

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<thead>
<tr>
<th></th>
<th>Description</th>
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<tbody>
<tr>
<td>47</td>
<td>Ocean observations in support of Earth system prediction, and WMO support to the Global Ocean Observing System Strategy 2030 (including Tropical Pacific Observing System 2020)</td>
</tr>
<tr>
<td>49</td>
<td>Antarctic Observing Network</td>
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<tr>
<td>50</td>
<td>Pre-operational phase of the Global Cryosphere Watch</td>
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<tr>
<td>51</td>
<td>Implementation of the architecture for climate monitoring from space</td>
</tr>
<tr>
<td>52</td>
<td>Strategy for the Virtual Laboratory for Education and Training in Satellite Meteorology 2020–2024</td>
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<tr>
<td>53</td>
<td>Four-year plan for WMO activities related to space weather 2020–2023</td>
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<tr>
<td>54</td>
<td>Implementation plan of the regional operational subproject for space-based monitoring of weather and climate extremes in East Asia and the Western Pacific</td>
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<tr>
<td>55</td>
<td>Emerging data issues</td>
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<tr>
<td>56</td>
<td>Data policies and practices</td>
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</tbody>
</table>

1. National WIGOS implementation:
2. Implementation of the Global Basic Observing Network and the Regional Basic Observing Networks;
3. Operational deployment of the WIGOS Data Quality Monitoring System;
4. Operational deployment of Regional WIGOS Centres;
5. Further development of the OSCAR databases and integration with other system elements;
6. Fostering a culture of compliance with the WIGOS technical regulations;