



World Meteorological Organization

Working together in weather, climate and water

Four-Year Plan for WMO Coordination of Space Weather Activities

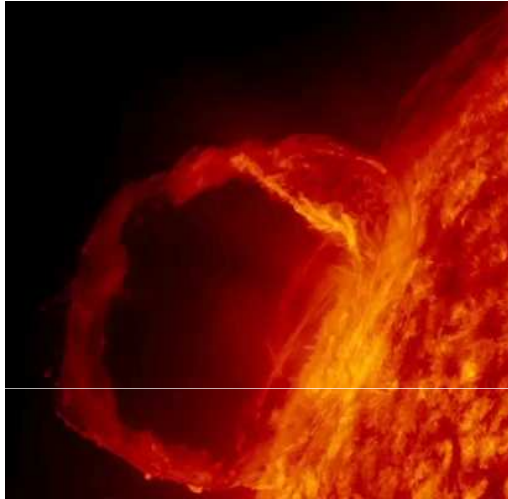
WMO-WP-11, Plenary Item D.6

Jérôme Lafeuille (WMO Space Programme)

Terry Onsager (NOAA, Co-Chair WMO/ICTSW)



Main Topics



- Space Weather and the WMO mandate
- Initial WMO achievements in Space Weather
- Plans for the next four years and beyond



Space Weather in the WMO mandate

WMO is the specialized United Nations agency for meteorology (weather and climate), operational hydrology and *related geophysical sciences*.

Space weather is “related” to meteorology not only by the atmosphere/ionosphere coupling but also in the area of observations and services.

WMO Space Programme components (Cg-16):

Space-based
Observing System



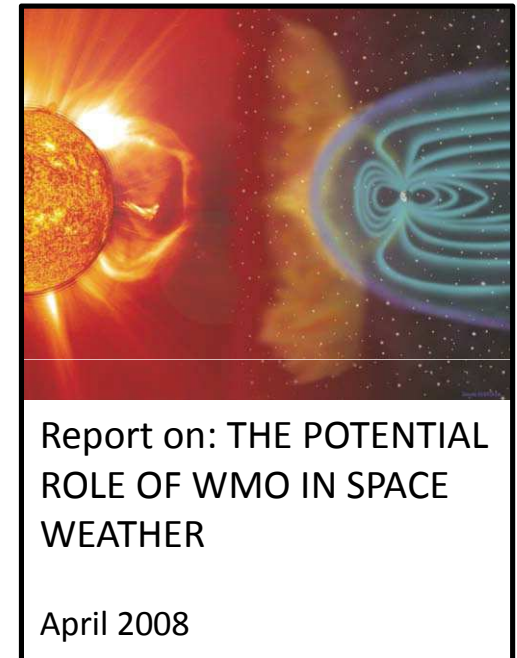
Access to Satellite
Data and Products



Awareness and
Training



Space Weather
Coordination





WMO Inter-Programme Coordination Team on Space Weather (ICTSW)

Established in May, 2010

Joint leadership: Commission for Basic Systems & Commission for Aeronautical Meteorology



26 out of 185 WMO Member States and
7 International Organizations



International Space Weather Observing Requirements

- Observing requirements are documented
- Updated on two-year basis
- Addressing operational, research, and climatology needs
- Form the basis for gap analysis and advocacy

WMO Observing Requirements Database

Home | Consult Tables

Overview: Space Weather

Variables measured in this Application

REQUIREMENTS DEFINED FOR SPACE WEATHER (40) [Export to Excel](#)

Id	Variable	Layer	Uncertainty Goal	Uncertainty Thresh	HR Goal	HR Thresh	VR Goal
576	Cosmic ray neutron flux density	Surf-Earth	5 (%)	25 (%)	1000 km	5000 km	N/A
577	Electron flux density energy spectrum	Geo	5 %	25 %	45 degrees	180 degrees	N/A
578	Electron flux density energy spectrum	Leo	5 %	25 %	45 degrees	180 degrees	N/A
579	Electron flux density energy spectrum	Meo	5 %	25 %	45 degrees	180 degrees	N/A
580	Electron flux density energy spectrum	L1	5 %	25 %	degrees	degrees	N/A
581	foEs	Ionos	0.05 MHz	0.2 MHz	100 km	500 km	N/A
582	foF2	Ionos	0.05 MHz	0.2 MHz	100 km	500 km	N/A
583	h'F	Ionos	1 km	10 km	100 km	500 km	N/A
584	Heavy ion flux density energy and mass spectrum	Geo	0.05 (cm ² s sr MeV ^{muc}) ⁻¹	0.25 (cm ² s sr MeV ^{muc}) ⁻¹	45 degrees	180 degrees	N/A
585	Heavy ion flux density energy and mass spectrum	Leo	0.05 (cm ² s sr MeV ^{muc}) ⁻¹	0.25 (cm ² s sr MeV ^{muc}) ⁻¹	45 degrees	180 degrees	N/A
586	Heavy ion flux density energy and mass spectrum	Meo	0.05 (cm ² s sr MeV ^{muc}) ⁻¹	0.25 (cm ² s sr MeV ^{muc}) ⁻¹	45 degrees	180 degrees	N/A
587	Heavy ion flux density energy and mass spectrum	Helio	0.05 (cm ² s sr MeV ^{muc}) ⁻¹	0.25 (cm ² s sr MeV ^{muc}) ⁻¹	360	360 degrees	N/A

<http://www.wmo-sat.info/oscar/applicationareas/view/25>



WMO Space Weather Observations Gap Analysis (Statement of Guidance)

- Address observing needs for:
 - Long lead-time forecasts
 - Alerts of hazardous conditions
 - Event climatology
 - Model validation
 - Scientific research
- Observing domains:
 - Ionosphere
 - Thermosphere
 - Geomagnetic
 - Energetic Particles
 - Solar and Interplanetary

Statement of Guidance for Space Weather Observations

STATEMENT OF GUIDANCE FOR SPACE WEATHER OBSERVATIONS

(Point of contact: Terrance Onsager, NOAA, USA)
(First version, approved by the ET-EGOS-7, 11 May 2012)

1. Introduction and Overview of Recommendations

This document contains the first Statement of Guidance and Gap Analysis conducted by the WMO Inter-Programme Coordination Team on Space Weather (ICTSW). This initial effort did not undertake to catalog all existing observations. Rather, the emphasis was placed on documenting the areas identified as most important for: 1. maintaining services in cases where the long-term continuity of observations is in doubt; 2. improving existing services, either through increased spatial coverage, improved timeliness or improved accuracy; and 3. enabling new services. This effort has not included a comprehensive documentation of customer requirements. Nonetheless, the recommendations are based on knowledge of space weather customers, whose needs can vary considerably from one region to another, and on the adequacy of existing and planned observations for current or future products.

In addition to the work of the ICTSW, this effort benefited greatly from the participation of numerous colleagues. Those colleagues who contributed directly to the analysis of space weather observing systems and to the text include: Mervyn Freeman (British Antarctic Survey), Alex Charner (University of Bath), Chris Davis (University of Reading), Jeff Love (United States Geological Survey), Doug Biesecker (National Oceanic and Atmospheric Administration) and Tim Fuller-Rowell (University of Colorado).

Vulnerability to space weather is increasing as we become more reliant on advanced technology. Airline navigation and communication; drilling, mining and agriculture; electric power grid reliability – these critical activities can be impacted by space weather anywhere on the globe. Our economic, security and environmental-stewardship interests now extend well above the atmosphere into space. We increasingly rely on satellite-based navigation and timing systems for transportation, commodities and financial services. Satellite communication is now a critical element of our global flow of information, supporting disaster preparedness, emergency response and broad economic growth. Our electric power grids are becoming more heavily loaded and interconnected, which increases their vulnerability to space weather. Although the direct effects of space weather are typically felt at the industry and infrastructure levels and may not be obvious to the average citizen, we are all impacted.

Actions are being taken today by industries and governments around the globe. For example, the International Civil Aviation Organization (ICAO) is drafting requirements for space weather services to protect against communication outages, navigation errors and radiation risks. Electric power distribution is adjusted during space storms to avoid grid disruption. Conditions impacting satellite-based navigation systems are monitored and back-up measures are taken during high-impact events. Governmental emergency management agencies are developing procedures to manage the unique risks of space weather, including impacts that could simultaneously disrupt critical infrastructures in multiple countries and in widely separated regions on the globe. It is among the aims of ICTSW to provide guidance on observation capabilities needed to support such services.

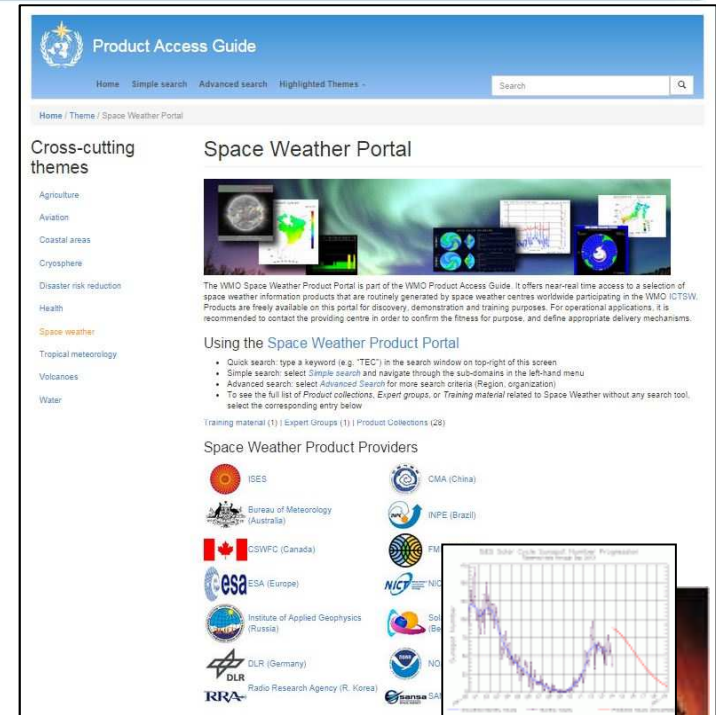
Today, services relying on operational and research observing assets can help all WMO Members to monitor disturbances and to warn of oncoming storms. The space environment, however, is vastly undersampled. Significant gaps in our observing capabilities limit our ability to provide a comprehensive characterization of the important physical parameters, and limit the accuracy of our predictive models. Existing ground-based and space-based assets have not all been integrated into a coordinated observing network. These include a number of Global Navigation Satellite

<http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-SW.doc>

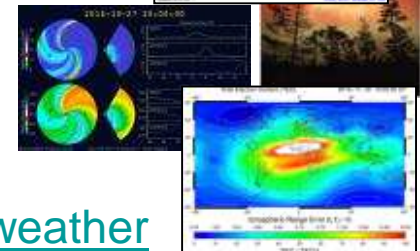
WMO Space Weather Product Portal

Ten countries now contribute space weather products on the portal

- Enhance awareness of available products
- Near real-time use at no cost enabling demonstration in operational context
- Increase global participation in space weather services
- Facilitate comparison and harmonization of products
- Training module under development



The screenshot shows the 'Product Access Guide' for the 'Space Weather Portal'. It features a navigation menu with options like 'Home', 'Simple search', 'Advanced search', and 'Highlighted Themes'. A search bar is located in the top right. The main content area is titled 'Space Weather Portal' and includes a banner image of space weather data. Below the banner, there is a section titled 'Using the Space Weather Product Portal' with instructions for quick, simple, and advanced searches. A list of 'Space Weather Product Providers' is displayed, including logos for ISES, CMA (China), Bureau of Meteorology (Australia), INPE (Brazil), COWFC (Canada), ESA (Europe), NICT (Japan), Institute of Applied Geophysics (Russia), DLR (Germany), and RRA (Radio Research Agency (R. Korea)). To the right of the providers, there is a graph titled 'ISES Solar Cycle Forecast: Monthly Progression' showing a line graph of solar activity over time.



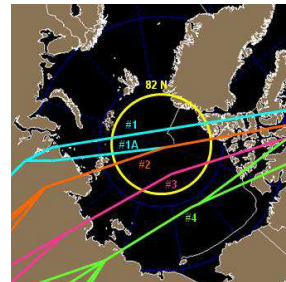
<http://www.wmo-sat.info/product-access-guide/theme/space-weather>



Coordination of Major Application Areas: Aeronautical Meteorology

ICAO recognizes the ICTSW (as a technical body supporting the WMO CAeM) to provide advice on space weather matters

- Reviewed the ICAO Concept of Operation for International Space Weather Information
- Reviewed draft Standards and Recommended Practices on space weather
- Provided guidance on future organization of operational space weather service delivery





Draft Four-Year Plan for WMO Coordination of Space Weather Activities

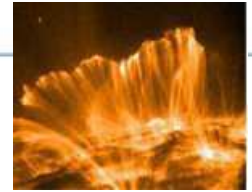
- Elaborated by ICTSW and finalized in consultation with CBS and CAeM Presidents
- Encouraged by the UN COPUOS /STSC
- Submitted to 17th WMO Congress (May- June 2015)
- Aims to provide clear framework, to enhance internal/external visibility, formalize interactions with other WMO programmes, mobilize more effort ... for more and quicker benefits



WMO Space Weather Goals

- Promote the sustained availability and interoperability of essential observations
- Improve the exchange and delivery of space weather information
- Facilitate transfer of scientific advances to operational services
- Identify user requirements for services, develop best practices to support such services, focusing on areas where international coordination is required, such as aviation
- Improve emergency warning procedures and global preparedness
- Support training and capacity building
- Promote synergy between the space weather, meteorology, and climate communities

Space Weather
Coordination



Space-based
Observing System



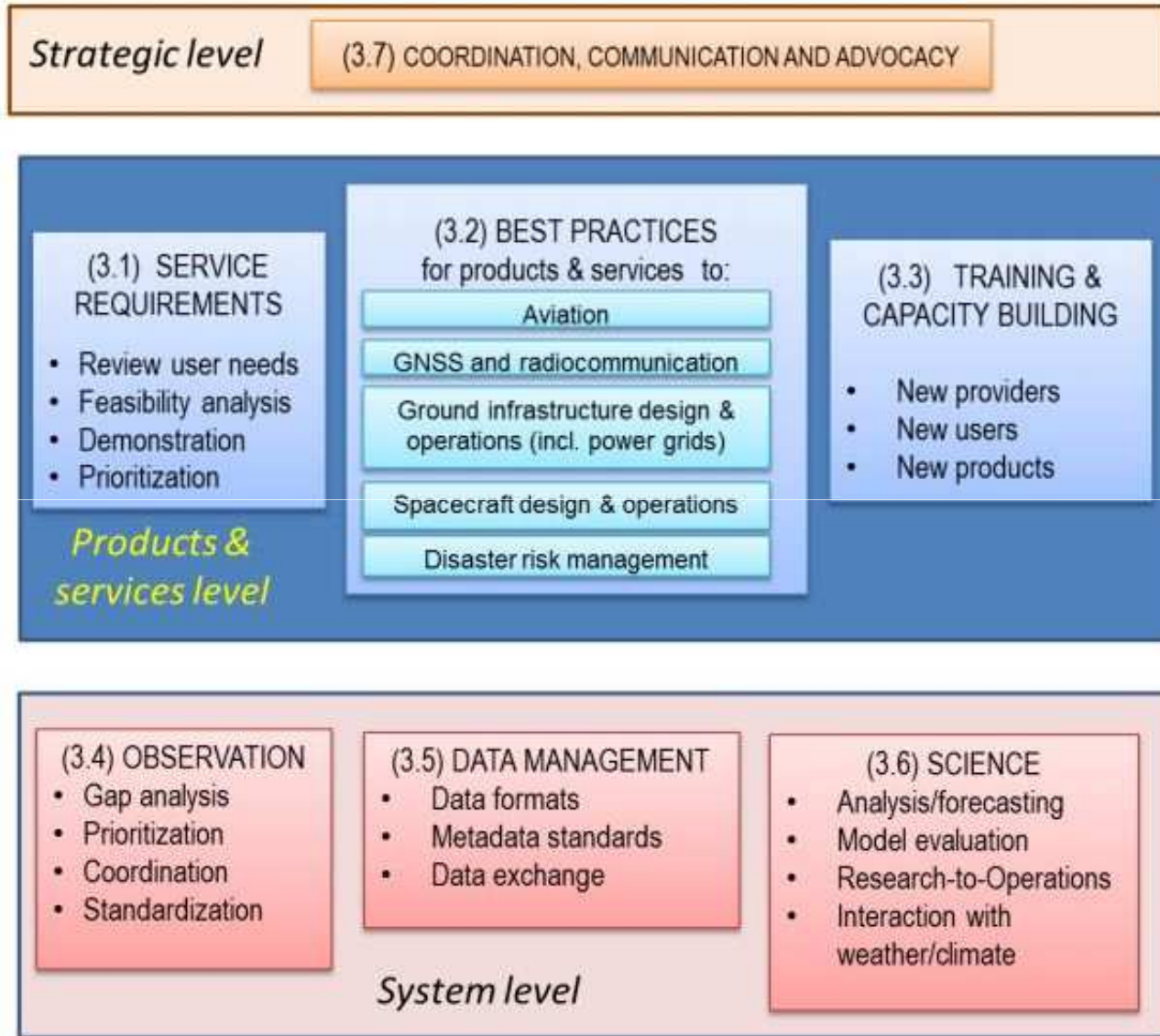
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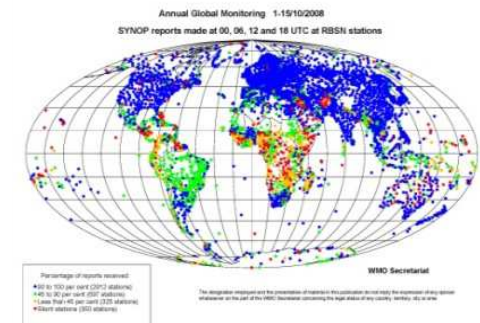
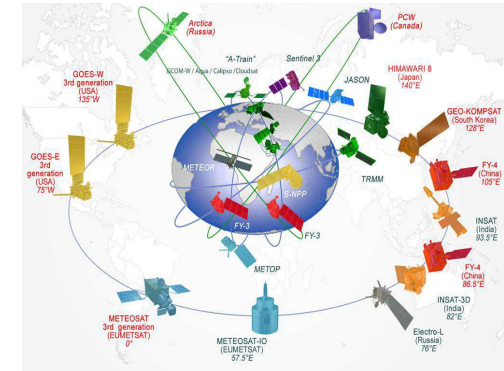


WMO Four-Year Plan for Space Weather Activities



Systems Level Activities

- Coordinate observational assets and plans to ensure interoperability and continuity of space weather observations
- Take advantage of integration of meteorological and space weather observations where relevant
- Support information exchange through the WMO Information System (WIS) framework, standards, practices, policies
- Dialogue with meteorological/climate community on modeling and verification



Service Level Activities

- Organize WMO Members to deliver coordinated services responding to ICAO requirements
- Prepare for extreme events in a multi-hazard Disaster Risk Reduction approach
- Analyze requirements for applications including ionospheric disturbances (radio propagation and GNSS), satellites, and ground infrastructure (power grids)
- Provide training on delivery and use of services



Strategic Level Activities

- Build on partnership with:
 - Service providers (ISES)
 - Observations providers (e.g., INTERMAGNET, CGMS)
 - Scientific organizations (e.g., COSPAR)
 - User organizations (e.g., ICAO and ITU)
 - Capacity building initiatives (e.g., ISWI)
 - Overall UN space policy framework (COPUOS)
- Emphasize synergy with core WMO activities
- Support involvement of additional WMO Members
- Focus on achievable priority objectives for 2016-2019
- Pave the way for long-term sustained activity



Examples of First Priority Actions

- Support ICAO working groups on requirements for aviation services
- Establish real-time coordination for extreme events
- Survey applications where coordination of services is required
- Identify WMO Members / organizations that wish to establish space weather service delivery and define training objectives
- Conduct training sessions and provide tutorial tools
- Update space weather observing requirements and gaps
- Identify essential data and products for exchange on the WMO Information System

Space Weather
Coordination



Space-based
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Access to Satellite
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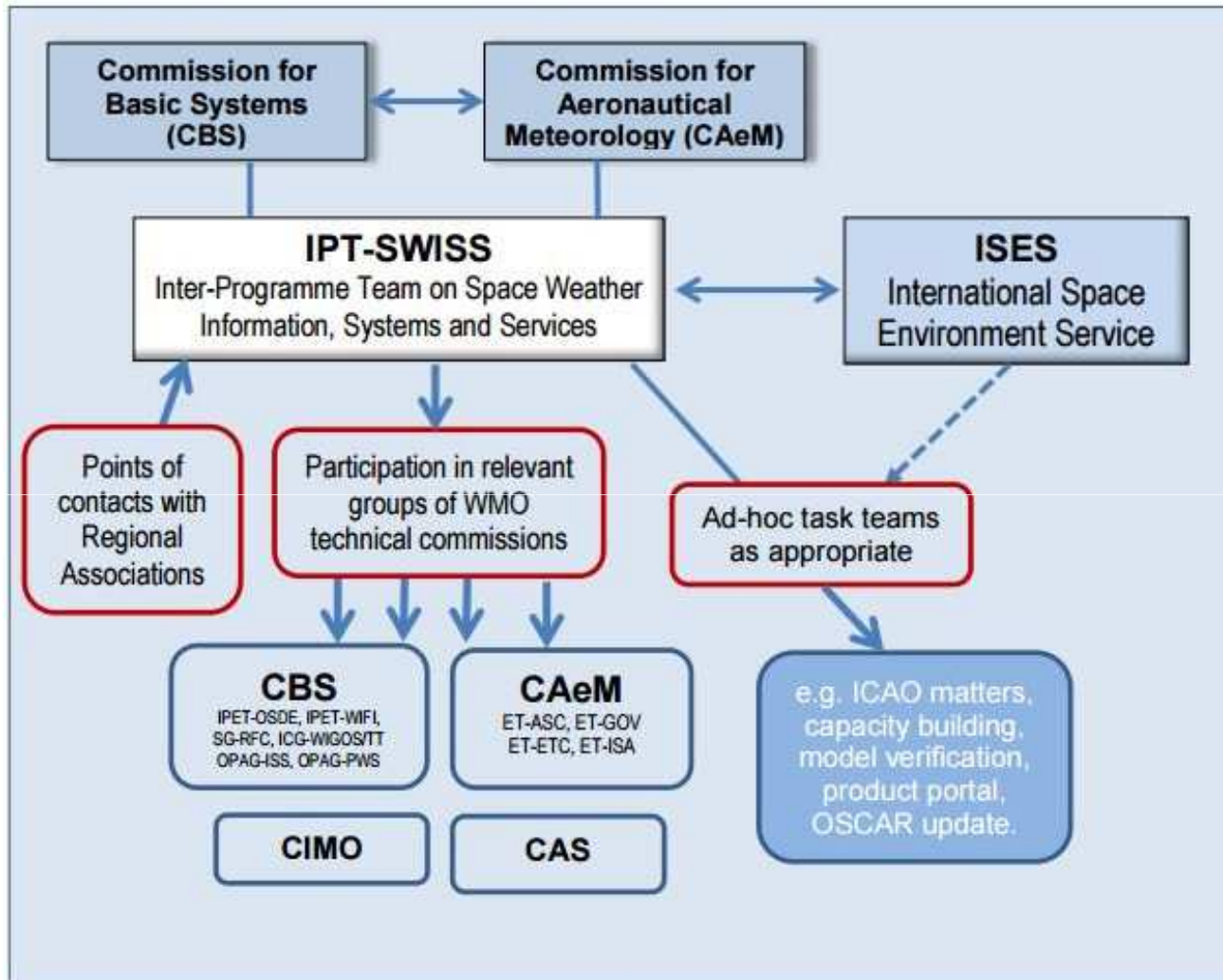


Specific actions on space-based observations

- Update space weather space-based capabilities assessment in OSCAR/Space database as support to gap analysis
 - ~ 260 sensors currently recorded in OSCAR/Space
- Update statement of guidance for priority observations for space weather (including space-based obs)
- **Dialogue with space agencies (including CGMS) and relevant authorities, on actions needed to fill the gaps in space-based observations** (e.g. long-term sun and solar wind observation at L1)
- Harmonize sensor specifications for energetic particle measurements and best practices for intercalibration and intercomparison of measurements
- Collaborate with CGMS to review procedure for recording spacecraft anomalies attributed to space environment, including archiving and use of these data



Proposed Organization of WMO Space Weather Activities



Summary

- Growing, global need for improved services and for consistent, coordinated observations and operational information
- WMO is now actively engaged in defining observing requirements, observation gaps, service needs and in coordinating efforts
- The four-year plan for space weather:
 - Builds on prior accomplishments and current efforts
 - Promotes synergy with WMO core programmes in meteorology/climate
 - Fosters coordination with service, research, and policy organizations
 - Identifies specific actions to achieve the identified goals
- Seeks to foster collaboration among space agencies, including CGMS, to best fill the gaps in space weather observation from space



Thank you for
your attention !

The draft Four-year plan is available as Cg-17 Doc. 4.2.4(2):

<https://docs.google.com/a/wmo.int/file/d/0B8DhC1GSWSmxVU80M3JZY2lwZ1U/edit?usp=drivesdk>

