



World Meteorological Organization

Weather • Climate • Water

WMO's Involvement in Space Weather

Promoting Inter-Programme Team on Space Weather
Information, Systems and Services (IPT-SWISS)

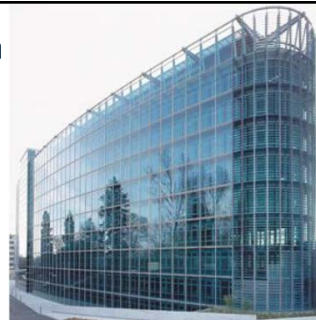
13th European Space Weather Week
14-18 November 2016, Oostende, Belgium

Toshiyuki KURINO
WMO Space Programme Office

Weather • Climate • Water

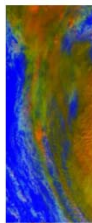
World Meteorological Organization

- Specialized agency of the United Nations for meteorology (weather and climate), operational hydrology and related geophysical sciences.
- 191 Members (States and Territories)
- Based in Geneva, Switzerland



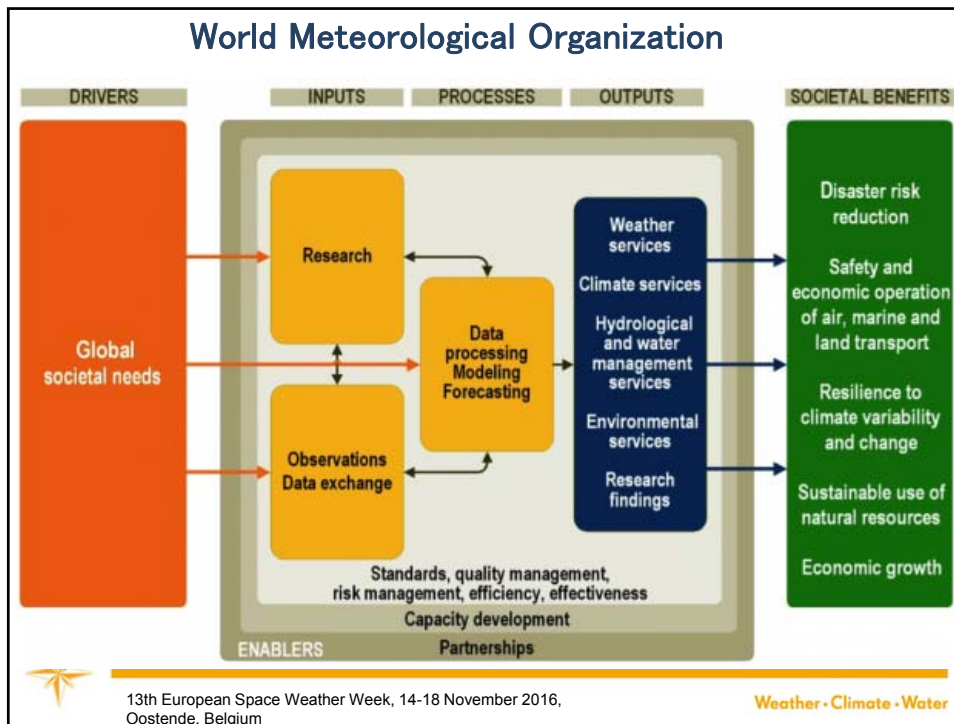
Vision and mission

WMO provides world leadership and expertise in **international cooperation** in the delivery and use of high-quality, authoritative weather, climate, hydrological and related environmental services **by its Members**, for the improvement of the well-being of societies of all nations.



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water



WMO Space Programme

The WMO Space Programme has 4 main components

<p>The space-based Observing System</p>	<p>Access to Satellite Data and Products</p>	<p>Awareness and Training</p>	<p>Space Weather Coordination</p>
--	---	--------------------------------------	--

http://www.wmo.int/pages/prog/sat/index_en.php

- [OSCAR/Requirements \(Observing Requirements Database\)](#)
- [OSCAR/Space \(Satellite & Instrument Database\)](#)
- [Satellite Status list](#)
- [Satellite User Readiness Navigator \(SATURN\)](#)
- [Product Access Guide \(PAG\)](#)
- [Virtual Laboratory for Education and Training in Satellite Meteorology \(VLAB\)](#)
- [Working Documents for Meetings](#)

13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

Coordination Group for Meteorological Satellites (CGMS)

- WMO Space Programme's objectives are to be achieved through strong partnership with **CGMS** and co-sponsoring **international science groups**: ITWG, IWWG, IPWG, **IROWG** and ICWG
- CGMS is a **technical** coordination body of satellite operators including space agencies focusing primarily on weather and climate satellite programmes in response to WMO requirements.



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

The baseline for holding a CGMS Membership covers: (http://www.cgms-info.org/index_.php/cgms/members_observers)

- Current and prospective developers and operators of meteorological satellites;
- WMO, because of its unique role as representative of the world meteorological data user community, and other programmes jointly supported by WMO and other international agencies;
- Space agencies operating R&D satellites contributing to WMO programmes.

Organisation	Website	Accession
Centre National d'Etudes Spatiales	CNES	2004
China Meteorological Administration	CMA	1989
China National Space Administration	CNSA	2006
EUMETSAT	EUMETSAT	1987
India Meteorological Department	IMD	1979
Indian Space Research Organisation	ISRO	2015
Intergovernmental Oceanographic Commission / UNESCO	IOC/Unesco	2001
Japan Aerospace Exploration Agency	JAXA	2003
Japan Meteorological Agency	JMA	1972
Korea Meteorological Administration	KMA	2005
National Aeronautics and Space Administration	NASA	2003
National Oceanic and Atmospheric Administration	NOAA	1972
Russian Federal Service for Hydrometeorology and Environmental Monitoring	ROSHYDROMET	1973
Russian Federal Space Agency	ROSCOSMOS	2003
The European Space Agency	ESA	2003
World Meteorological Organization	WMO	1973



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

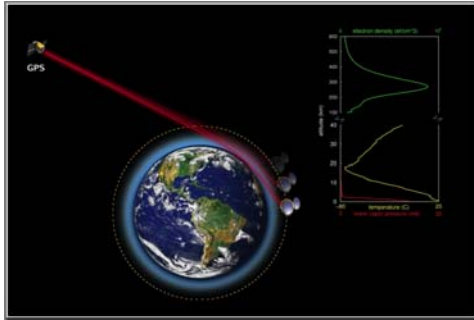
Weather • Climate • Water

International Radio Occultation Working Group (IROWG)

IROWG was established as a permanent Working Group of CGMS in 2009, co-sponsored by CGMS and WMO. The IROWG serves as a forum for operational and research users of radio occultation data. IROWG has in particular been set up to further exploit radio occultation data.

IROWG Co-chairs: Ulrich Foelsche (University of Graz) and Sean Healy (ECMWF)

IROWG Rapporteur: Anthony Mannucci (NASA JPL)



<http://irowg.org/>



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

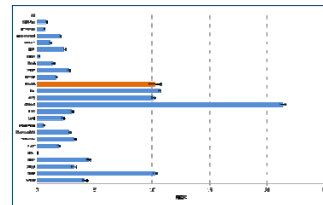
Weather • Climate • Water

Importance of GNSS-RO

■ **NWP: NRT Temperature/Humidity information**

- Bending angles or refractivity profiles
- Vertically resolved
- High impact per observation
- No significant instrumental bias

FSO : ECMWF, June 2011



■ **Climate : Climate Data Records**

- Benchmark observations that can supplement the GCOS Reference Upper-Air Network (*GCOS Implementation Plan*) as a consequence of its calibration free nature

■ **Space Weather : Total Electron Content for Ionosphere Monitoring**

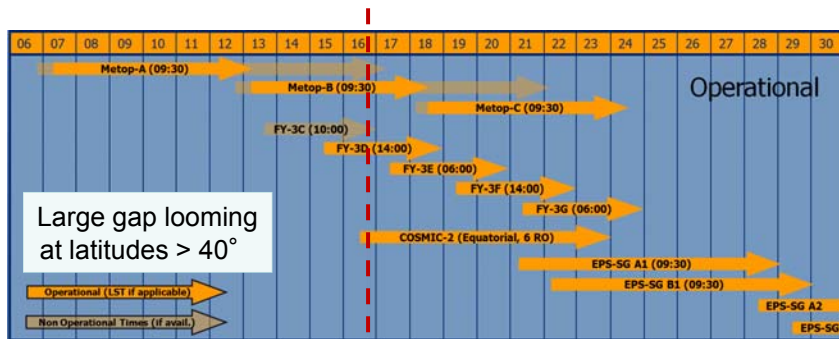
- Stringent timeliness constraint
- Need to scan up to > 100 km



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

Operational RO Satellites



- FY-series is a new GNSS RO instrument
- COSMIC-2/FORMOSAT-7 covers up to 40 degrees latitude
- **COSMIC-2 Polar provides 6 satellites with global coverage**

Coordination Group for
Meteorological Satellites



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

-Contribution of WMO to Space Weather

-WMO's Integrated Global Observation System (WIGOS) Vision/Space 2040

-Oscar/Space Version 2



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

-Contribution of WMO to Space Weather

-WMO's Integrated Global Observation System (WIGOS) Vision 2040

-Oscar/Space Version 2



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

WMO Space Weather

There is an increasing societal demand for space weather services as a result of growing dependence on technologies impacted by space weather:



- air navigation on polar routes exposed to space weather events
- fleet of satellites used operationally for telecommunication, broadcasting, observation or positioning
- use of satellite-based navigation and timing signals that are affected by ionospheric disturbances
- electric power grids that are exposed to geomagnetically induced currents



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

WMO Space Weather

- In 2014, **CGMS** decided to include objectives related to space weather monitoring into its multi-year High-Level Priority Plan (HLPP) and **agreed on Terms of Reference for CGMS Space Weather Activities**.
- It is anticipated that CGMS will soon extend the scope of its activity towards space-based observation of space weather variables.
- **Space Weather Task Team (SWTT)** was organized to define the methodology for the implementation of space weather into CGMS
- Chair: Suzanne Hilding (NOAA) / Rapporteur: Elsayed Talaat (NASA)



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

WMO's Contribution to Space Weather

SWTT

CGMS-44 ACTIONS - SWTT						
Actionee	AGN item	Action #	Description	Deadline	Status	HLPP ref
SWTT		A44.01	SWTT to conduct a workshop with leadership from the various space weather communities that will benefit from CGMS coordination of space-based space weather observing systems.	15 Dec 2016	OPEN	5.2.1
SWTT members		A44.02	Members of SWTT review the current WIGOS 2040 vision to ensure inclusion of necessary space weather observations.	15 Dec 2016	OPEN	1.1.7
SWTT		A44.03	(From WGIII): SWTT members wishing to participate in the SETT activities are invited to participate in the SETT activities, and should provide their contact information to the SETT accordingly (Charles.wooldridge@noaa.gov).	1 Jul 2016	OPEN	4.1.1



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

WMO Space Weather

Establishment of ICTSW

- In June 2008, the 60th WMO Executive Council (EC-60) acknowledged the potential synergy between meteorological and Space Weather services to operational users.
- EC-60 agreed that **WMO should support international coordination of Space Weather activities** and **urged WMO Members to provide corresponding resources through secondments and Trust Fund donations.**
- The establishment of the **Interprogramme Coordination Team on Space Weather (ICTSW)** was approved by EC-61 in 2010.



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

WMO Space Weather

- The ICTSW has two co-chairs nominated by WMO Commission for Basic Systems (CBS) and WMO Commission for Aeronautical Meteorology (CAeM) respectively.
- Co-chairs: Dr. T. Onsager (NOAA) and Dr. X. Zhang (CMA)
- The t
- or mc
- As of
- and s
- (EU),
- Intern
- Intern
- of Ou



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

ToR for ICTSW

- Standardization and enhancement of Space Weather data exchange and delivery through the **WMO Information System (WIS)**
- Harmonized definition of end-products and services, including e.g. quality assurance guidelines and emergency warning procedures, in interaction with aviation and other major application sectors
- Integration of Space Weather observations**, through review of space- and surface-based observation requirements, harmonization of sensor specifications, monitoring plans for Space Weather observation
- Encouraging the dialogue between the research and operational Space Weather communities.**



Initial Achievements of ICTSW

- formulation of the “**Observation Requirements**”,
- drafting the “**Statement of Guidance**” on space weather observation,
- establishment of a “**Space Weather Product Portal**”,
- supporting CAeM **to review the ICAO concept of future space weather services to aviation.**



Transition from ICTSW to IPT-SWISS

- The 17th World Meteorological Congress (Cg-17) in 2015 agreed that WMO should undertake **international coordination of operational space weather monitoring and forecasting**. In providing a global intergovernmental framework, WMO would facilitate international commitments and **enable the establishment of operational space weather services, in particular in the context of the support to the International Civil Aviation Organization (ICAO)**.



Transition from ICTSW to IPT-SWISS

- Cg-17 requested that **space weather observations be integrated into the WMO Integrated Global Observing System (WIGOS)**, and requested CAeM and CBS to consider existing responsibilities, working mechanisms, expert teams and integration within relevant WMO programmes in **finalizing a draft “Four-year Plan for WMO Coordination of Space Weather Activities (the Plan)”**.



WMO Space Weather

- The 68th Executive Council (EC-68) in 2016 **approved the Plan**, and requested CAeM and CBS to **establish IPT-SWISS** with the Terms of Reference defined in the Plan.
- EC-68 called for Members to support the implementation of the Plan with participation of experts, **“in-kind contributions”** and contributions to the **“Space Weather Trust Fund”**.



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

WMO Space Weather

- EC-68 requested the Secretary-General to take appropriate actions to support the activities identified in the Plan **in partnership with** relevant organizations such as **the International Space Environment Service (ISES)**, as well as national and international agencies, and to submit to the Cg-18 a report on the achieved results and a proposal for future actions in this domain.



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

ToR for IPT-SWISS

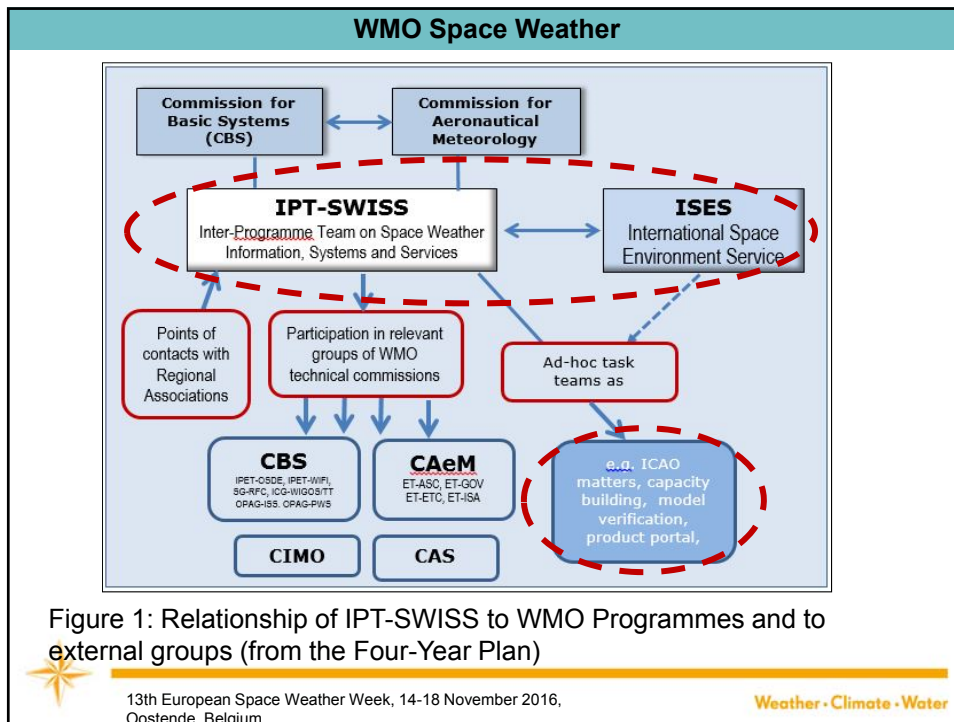
- Integration of Space Weather observations, through review of space- and surface-based observation requirements. harmonization of space-based
- Organization of **capacity building, training and outreach activities** towards WMO Members and space weather potential users;
- Provision of guidance to WMO Members and programmes on space weather matters, and conduct appropriate actions as requested by CBS and CAeM.



A working structure for IPT-SWISS

- **Space weather basic systems**, including issues related to observation techniques and networks, data managements and exchange, data centers, and space climatology
- **Space weather science**, including issues related to modelling, model evaluation and verification, interaction with climate, and transition from research to operations
- **Space weather application**, including requirements evaluation, the delivery of services, capacity building and user interaction





- Contribution of WMO to Space Weather
 - WMO's Integrated Global Observation System (WIGOS) Vision/Space 2040**
 - Oscar/Space Version 2
- 13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium Weather • Climate • Water

Vision/Space for The GOS in 2025

(Adopted by EC-61 in June 2009)

- to ensure that the future GOS serves the needs of climate monitoring and other WMO programmes in addition to the historical objective of supporting weather forecasting,
- to optimize the GOS taking into account updated user requirements and recently demonstrated **observing capabilities that could be operational by 2025**.

Additional operational missions in appropriate orbits (classical polar-orbiting, geostationary, others)

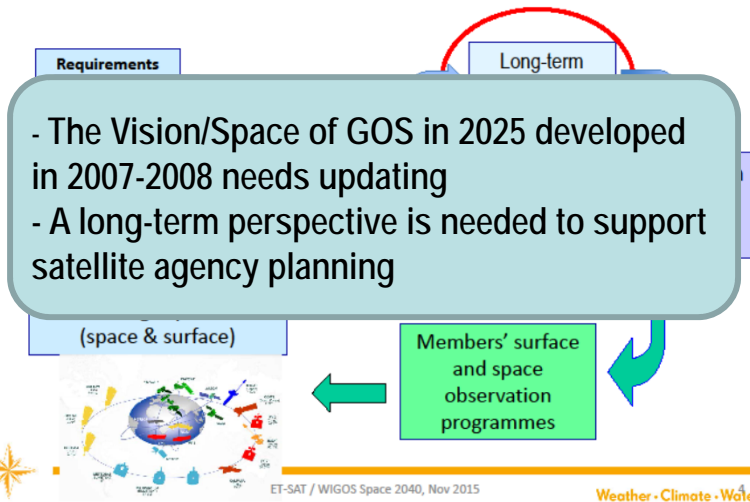
Radio occultation constellation – at least 8 receivers	Atmospheric temperature and humidity; ionospheric electron density
--	--

Polar and geo platforms / instruments for space weather

Solar imagery Particle detection Electron density	Solar radiation storms, high-energy particle rain, ionospheric and geomagnetic storms, radio black-out by X-ray photons
---	---



Vision of WIGOS in the Rolling Review of Requirements (RRR)



New Vision for Space-based Observation in 2040

Component I Operational fixed

- Solar coronagraph and radio-spectrograph, at L1
- In situ plasma, energetic particles, magnetic field (at L1 in solar wind, and GEO)
- In situ plasma, energetic particles at LEO
- GNSS radio-occultation for temperature, humidity and electron density

Component II Operational flexible

- Solar EUV/X-ray imager, magnetograph, EUV/X-ray irradiance, on the Earth-Sun line (e.g. L1, GEO) and off the Earth-Sun line (e.g. L5, L4)
- Solar coronagraph and heliospheric imager off the Earth-Sun line (e.g. L4, L5)
- Solar wind plasma, energetic particles & magnetic field off Earth-Sun line (e.g. L5)
- Magnetospheric energetic particles (e.g. GEO, HEO, MEO, LEO)

Component III Pathfinders or technology demonstration

- Solar coronal magnetic field imager, solar wind beyond L1
- Ionosphere/thermosphere spectral imager (e.g. GEO, HEO, MEO, LEO)
- Ionospheric electron and major ion density,
- Thermospheric neutral density and constituents
- Additional RO constellation for enhanced atmospheric/ionospheric soundings including use of optimized frequencies



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

WMO's Integrated Global Observation System (WIGOS) 2040

WMO will encourage users to raise issues to be discussed for Vision/Space with reference to the current system

A proposed description for the **radio-occultation** is as follows; “the radio-occultation technique can also be generalized, in using additional frequencies (beyond the current L1, L2 and L5 GPS frequencies) to maximize the sensitivity to atmospheric variables, and monitoring more systematically the ionosphere including ionospheric scintillation.”

- What should be added ?
- What is at risk and should be reinforced ?
- What should be improved (performance, coverage) ?
- What could be performed differently in the future ?
- What are the major challenges?

The Vision, to be developed and finalized by 2018 in WMO Secretariat by reflected comments



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

-Contribution of WMO to Space Weather

-WMO's Integrated Global Observation System (WIGOS) Vision 2040

-Oscar/Space Version 2



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

OSCAR/Space: oscar.wmo.int/space

Observing System Capability Analysis and Review tool (OSCAR) developed/maintained by WMO

3 components:

- OSCAR/Requirements (2012)
- OSCAR/Space (2012)
- OSCAR/Surface (2016)

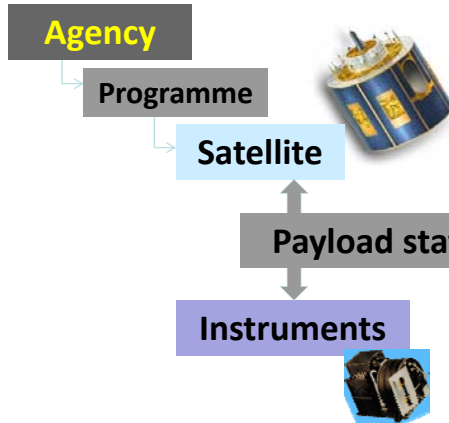
OSCAR/Space
>1100 page visited per day
Version 2 deployed in Sept 2016



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water

(1) Factual information content



- Name, purpose
- Mass, power
- Orbit (type, alt, ECT, longitude)
- Launch date, end date, status
- Data access, telecom frequencies

- Instrument status, dates
- Link to calibration events

- Name, purpose
- Mass, power
- Type, description, scan mode
- Resolution, FOV, coverage
- Status
- Spectral characteristics



13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Weather • Climate • Water

Satellite Programmes: ISRO, active programmes

List of all Satellite Programmes

This table shows all known past, current and future satellite programmes (also known as missions) for meteorological and earth observation purposes. It can be sorted by clicking on the column headers. The filter on the right allows to display only specific programmes. [Filter instructions](#)

Active Filter: Date range: Only currently operational | Space Agencies: ISRO

Id	Agency	Name	Satellites	Spaceagencies	First launch	Last EOL
200	Aditya	Aditya	Aditya-1	ISRO	≥2016	≥2019
18	CartoSat	Satellite for Cartography	CartoSat-2C CartoSat-2D	ISRO	≥2016	≥2021
83	INSAT-3	Indian National Satellite - 3	INSAT-3D INSAT-3DR	ISRO	2013	≥2024
259	NEMO-AM	Nanosatellite for Earth Monitoring and Observation-Aerosol Monitoring	NEMO-AM	ISRO	2016	≥2021
114	OceanSat	Satellite for the Ocean	ScatSat-1	ISRO	2016	≥2021
136	RISAT	Radar Imaging Satellite	RISAT-2	ISRO	2012	≥2017
139	SARAL	Satellite with ARGOS and ALTIKA	SARAL	CNES ISRO	2013	≥2018

Example Satellite ScatSat-1



13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Weather • Climate • Water

Satellite: ScatSat-1

Acronym	ScatSat-1		
Full name	ScatSat-1		
Satellite Description	<ul style="list-style-type: none"> Gap filler for the OSCAT instrument of OceanSat 2 Main mission: sea-surface wind 		
Mass at launch	Dry mass		
Power			
Data access link	no link provided		
Data access information	<ul style="list-style-type: none"> NRT product access under consideration by ISRO and EUMETSAT Off-line data are distributed by the National Remote Sensing Center (NRSC) in Hyderabad. Web site: www.nrsc.gov.in 		
Orbit	Sun-synchronous orbit	Altitude	723 km
ECT	08.45 desc		
Space agency	ISRO		
Status	Planned		
Details on Status (as available)	<ul style="list-style-type: none"> Launch scheduled for 26 September 2016. 		
Launch	Sep 2016	EOL	≥2021
Last update:	2016-09-08		

Note: red tag: no longer operational, green tag: operational, blue tag: future

- Satellite for the Ocean
 - OceanSat-1 (IRS-P4) (1999 - 2010)
 - OceanSat-2 (2009 - 2016)
 - OceanSat-3 (2018 - 2023)
 - ScatSat-1 (2016-09 - 2021)

Satellite Payload

All known Instruments flying on ScatSat-1

Acronym	Full name
OSCAT	OceanSat Scatterometer

[Show instrument status and calibration](#)



13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Weather • Climate • Water



OSCAR

Observing Systems Capability Analysis and Review Tool

GOES R satellite

Satellite payload

All known instruments flying on GOES-R

Instrument	Full name	Start date	EOL date	Status	NRT data	Calibration and events	Comments
ABI	Advanced Baseline Imager	Feb 2017 *	≥2027 *	N/A			
EXIS	Extreme Ultraviolet Sensor / X-Ray Sensor Irradiance Sensors	Feb 2017 *	≥2027 *	N/A			
GEOS&R	Geostationary Search and Rescue	Feb 2017 *	≥2027 *	N/A			
GLM	Geostationary Lightning Mapper	Feb 2017 *	≥2027 *	N/A			
SEM/MAG	SEM / Magnetometer	Feb 2017 *	≥2027 *	N/A			
SUVI	Solar Ultraviolet Imager	Feb 2017 *	≥2027 *	N/A			
DCIS	Data Collection and Interrogation Service	Feb 2017 *	≥2027 *	N/A			
		Feb 2017 *	≥2027 *	N/A			
		Feb 2017 *	≥2027 *	N/A			
		Feb 2017 *	≥2027 *	N/A			

* The information in this field is estimated or assumed

Details on Status (as available)	<ul style="list-style-type: none"> Launch scheduled for 16 November 2016. Extended commissioning planned at 18.5°W Operational longitude (137°W or 75°W) to be confirmed in due time. 		
Launch	Nov 2016	EOL	≥2027
Last update:	2016-10-20		

SEISSHS	SEISS / Energetic Heavy Ion Sensor
SEISSGPS	SEISS / Solar and Galactic Proton Sensor

[Show instrument status and calibration](#)

Satellite Field of View

Estimate of the satellite's footprint, assuming a zenith angle of 75°
You can drag the image around and zoom using the mousewheel



iter

Payload status, Calibration events Example: Metop-A

Satellite payload

All known instruments flying on Metop-A

Instrument	Full name	Start date	EOL date	Status	IBT date	Calibration and events	Comments
ADCS	Advanced Data Collection System (also called Argon 7)	15 May 2007	2016*	Active	Yes		
AMSU-A	Advanced Microwave Scanning Radiometer - A						
ASCAT	Advanced Scatterometer						
AIRS	Advanced Very High Resolution Radiometer - 1						
CDR2	Global Cloud Monitoring Experiment - 2						
CRIS	Cloud Resolving Instrument						
EPSR	High Resolution Infra-Red Sounder - 1						
IASI	Infrared Atmospheric Sounding Interferometer						
MHS	MicroWave Humidity Sounder						
SARSAT	Search & Rescue Satellite-Aided Tracking System						
SEMIRIS2	SEM / Medium energy proton detector						
SEMTEO	SEM / Total Energy Detector						

* The information in this field is estimated or assumed

METOP-A MHS

INSTRUMENT SPECIFICATIONS

- WMO OSCAR (Satellite Instrument Specifications)

INSTRUMENT EVENTS

- Metop-A MHS List of Instrument Events: User Notification Service

DATA OUTAGES

- Availability of data in the Data Centre

INSTRUMENT MONITORING

- This information is currently not available on-line

RELEVANT DOCUMENTS

TITLE	TYPE	REFERENCE	VER
MHS Level 1 Product Generation Specification	PGS	EUM.EPS.SYS.SPE.990006	6
MHS Level 1 Product Format Specification	PFS	EPS.MIS.SPE.97229	7E

> Top

Landing Pages maintained by the satellite operators

<http://www.eumetsat.int/website/home/Data/Products/Calibration/Instrumentsstatusandcalibration/index.html#metopamhs>



13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Weather · Climate · Water

Information for Frequency Management

List of all radio frequencies

This table shows all frequencies used for transmitting data to and from earth observation satellites or for microwave active or passive remote-sensing. Sorting is possible by clicking on the column headers. The filter on the right allows to display only specific satellites/frequencies. [Filter instructions](#)

ID	Satellite	Main Agency	Launch	EOL	Service	Direction or sensing mode	Frequency	Emission designator	Bandwidth
2350	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	23000 MHz	N/A	270000 kHz
2144	Aqua	NASA	2002-05-04	2016	SOUNDING	passive	51400 MHz	N/A	100000 kHz
2358	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	50200 MHz	N/A	100000 kHz
2282	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	52000 MHz	N/A	400000 kHz
2386	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	53481 - 53711 MHz	N/A	170000 kHz
2370	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	54400 MHz	N/A	400000 kHz
2374	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	54800 MHz	N/A	400000 kHz
2376	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	55500 MHz	N/A	330000 kHz
2382	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	57290.344 MHz	N/A	330000 kHz
2386	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	57073.344 - 57507.344 MHz	N/A	70000 kHz
2390	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	56920.144 - 57660.544 MHz	N/A	30000 kHz
2394	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	56948.344 - 57634.344 MHz	N/A	160000 kHz
2398	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	56958.344 - 57622.344 MHz	N/A	80000 kHz
2402	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	56963.644 - 57617.644 MHz	N/A	30000 kHz
2406	Aqua	NASA	2002-05-04	2016	SOUNDER	passive	89000 MHz	N/A	6000000 kHz
2410	Aqua	NASA	2004-07-15	2016	SOUNDER	passive	118000 MHz	N/A	TBD

Filter C band range

Filter by frequency range

4080 MHz - 8985 MHz

Filter by direction(s)

N-E E-S S-E active

passive

Filter by year of operation

Only currently operating

Filter by responsible agency

(Showing only agencies where data is available)

Filter by service

Refresh Table Close



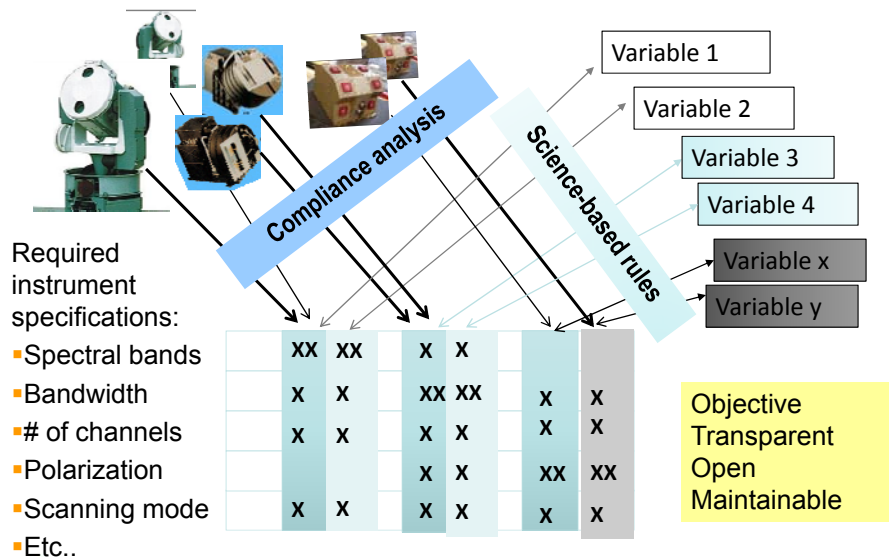
Weather · Climate · Water

(2) Assessments: mapping instruments to variables

- Which variables can be measured with a given instrument?
- Which instruments can measure a given variable?
...and during which period of time ?
=> Gap analysis



Instrument-variable mapping principle



Instrument: ASCAT

Instrument: ASCAT

Instrument details

Acronym	ASCAT
Full name	Advanced Scatterometer
Purpose	Sea surface wind vector. Also large-scale soil moisture
Short description	C-band (5.255 GHz), side looking both left and right. 3 antennas on each side
Background	Evolution of the AMI-SCAT flown on ERS-1 and ERS-2
Scanning Technique	Two 550-km swaths separated by a 700-km gap along-track. 3 looks each pixel (45, 90 and 135° azimuth)
Resolution	Best quality: 50 km - standard quality: 25 km - basic sampling: 12.5 km
Coverage / Cycle	Global coverage in 1.5 days
Mass	260 kg
Power	215 W
Data Rate	42 kbps

Detailed characteristics

Providing Agency	ESA
Instrument Maturity	Flown on operational programme
Utilization Period:	2007-05-15 to >2024
Last update:	2012-08-06

Tentative Evaluation of Measurements

The following list indicates which measurements can typically be retrieved from this category of instrument. To see a full Gap Analysis by Variable, click on the respective variable.

Note: table can be sorted by clicking on the column headers

Variable	Relevance for measuring this variable	Operational limitations	Explanation
Wind speed over the surface (horizontal)	1 - primary	Over sea only.	C-band scatterometer around 5.3 GHz
Soil moisture at surface	2 - very high	Coarse spatial resolution. Affected by vegetation.	Scatterometer in C-band (around 5.3 GHz)
Wind vector over the surface (horizontal)	2 - very high	Over sea only.	C-band scatterometer around 5.3 GHz
Leaf Area Index (LAI)	3 - high	Coarse spatial resolution.	C-band scatterometer sensitive to LAI
Biomass	4 - fair	Index only. Coarse spatial resolution.	C-band sensitive to total biomass
Sea-ice type	4 - fair	No specific limitation.	Scatterometer, C-band (around 5.3 GHz). Type interpreted as age/roughness
Snow cover	4 - fair	Coarse spatial resolution. Thick snow only.	Scatterometer in C-band (around 5.3 GHz)
Snow status (wet/dry)	4 - fair	Coarse spatial resolution. Thick snow only.	Scatterometer in C-band (around 5.3 GHz)
Soil moisture (in the roots region)	4 - fair	Coarse spatial resolution. Affected by vegetation.	Scatterometer in C-band (around 5.3 GHz). Assimilation process required



13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Weather - Climate - Water

Relevance

First step towards a Gap analysis

Measurement timeline: [Wind speed over the surface \(horizontal\)](#)

Definition: Module of the horizontal component of the 3D wind vector.

Hint: Move around in the timeline by clicking up, down, left or right.

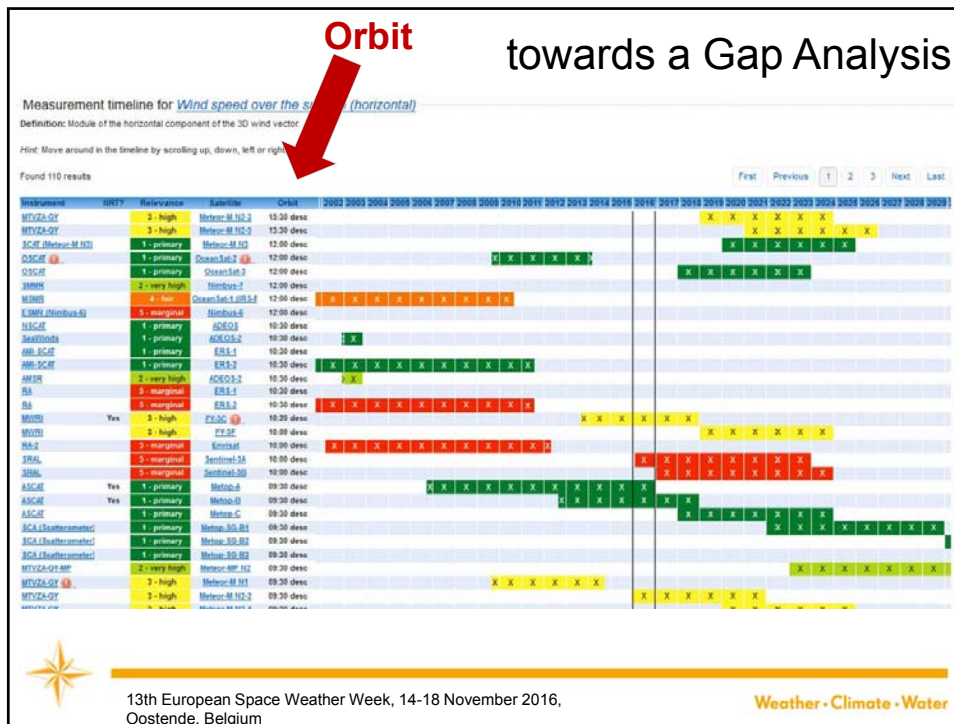
Found 110 results

Instrument	Relevance	Satellite	Orbit	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
ASCAT (Metop-A IMR)	1 - primary	Metop-A IMR	12:00 desc									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ASCAT	1 - primary	QuikSCAT	12:00 desc																			X	X	X	X	X	X	X	X	X	X	X	
ASCAT	1 - primary	ADEOS-2	10:30 desc																				X	X	X	X	X	X	X	X	X	X	
SeaWiFS	1 - primary	ADEOS-2	10:30 desc				X																										
AMR-ASCAT	1 - primary	ERS-1	10:30 desc																														
AMR-ASCAT	1 - primary	ERS-2	10:30 desc																														
ASCAT	Yes	Metop-B	09:30 desc							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ASCAT	Yes	Metop-C	09:30 desc																														
ASCAT	1 - primary	Metop-C	09:30 desc																														
SCA (Scatterometer)	1 - primary	Metop-SG-B1	09:30 desc																														
SCA (Scatterometer)	1 - primary	Metop-SG-D1	09:30 desc																														
SCA (Scatterometer)	1 - primary	Metop-SG-I1	09:30 desc																														
OSCAR	1 - primary	JaswiSat-3	06:45 desc																														
OSCAR (FCO-SAR)	1 - primary	CFOSAT	07:00 desc																														
WindSatQ	1 - primary	FY-3E	06:00 desc																														
WindSatQ	No	FY-3B	06:00 desc																														
ASCAT (HY-2A)	1 - primary	HY-2A	06:00 desc																														
ASCAT (HY-2A)	1 - primary	HY-2B	06:00 desc																														
ASCAT (HY-2A)	1 - primary	HY-2C	06:00 desc																														
ASCAT (HY-2A)	1 - primary	HY-2D	06:00 desc																														
WindSatQ	1 - primary	FY-3D	14:00 asc																														
SeaWiFS	1 - primary	QuikSCAT	06:00 asc																														
SeaWiFS	1 - primary	SeaWiFS	106 °																														
RapidScat	1 - primary	133 RapidScat	21.6 °																														
AMIS	2 - very high	SeaWiFS	12:00 desc																														
AMIS	2 - very high	ASCAT-2	10:30 desc																														
MYGAGE-MP	2 - very high	Metop-SP-N12	09:30 desc																														
WindSat	No	Conceits	06:00 desc																														



13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Weather - Climate - Water



Instrument : Rapid

Overview | Programmes | Satellites | **Instruments** | Frequencies | Agencies | Gap Analyses

Instrument: RAPID

Instrument details

Acronym	RAPID
Full name	Research with Adaptive Particle Imaging Detectors
Purpose	To study suprathermal plasma distributions of electrons and ions
Short description	Assemblage of two instruments: 1) an Imaging Ion Mass Spectrometer (IIMS) for ion distribution, energy range 2-1500 keV/n (Z from 1 to 8), and 2) Imaging Electron Spectrometer (IES) for measuring energetic electrons, range 20-400 keV
Background	Part of a package of instruments for the study of the Magnetosphere
Scanning Technique	Formation flight of 4 satellites in coordinated high-elliptical orbits cross the Magnetosphere for 3-D field reconstruction
Resolution	N/A
Coverage / Cycle	Magnetospheric volume
Mass	Power Data Rate

Providing Agency	ESA
Instrument Maturity	Flown on an R&D satellite
Utilization Period:	2000 to ≥2016
Last update:	2016-03-17

Satellites this instrument is flying on

Note: a red tag indicates satellites no longer operational, a green tag indicates a blue tag indicates future satellites

- Cluster (ESA)
 - CLUSTER A&B (see instrument status) Jul 2000 - 2016
 - CLUSTER C&D (see instrument status) Aug 2000 - 2016

Instrument classification

- Solar and space environment monitors
 - Energetic particle spectrometer

Mission objectives

- Primary mission objectives**
 - Electron differential directional flux
- Secondary mission objectives**
 - Alpha particles differential directional flux
 - Heavy ion flux energy and mass spectrum
 - Proton differential directional flux
- Opportunity objectives**
 - Electron flux energy spectrum

Show all

13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Instrument : Rapid (2)

Overview | Programmes | Satellites | Instruments | Frequencies | Agencies | Gap Analyses

Instrument: RAPID

Instrument details

Acronym	RAPID
Full name	Research with Adaptive and Intelligent Processing
Purpose	To study suprathermal plasma
Short description	Assemblage of two instruments: Spectrometer (IMS) for 0.1-10 keV/n (Z from 1 to 6), and for measuring energetic electrons
Background	Part of a package of instruments for the Magnetosphere
Scanning Technique	Formation flight of 4 satellites across the Magnetosphere
Resolution	N/A
Coverage / Cycle	Magnetospheric volume
Mass	Power
Providing Agency	ESA
Instrument Maturity	Flown
Utilization Period:	2000-2016-01
Last update:	2016-01

Instrument properties

It is flown in a satellite cluster	TRUE
It is an electron spectrometer	TRUE
It analyses low-energy electron spectrum (<50 keV)	TRUE
It analyses medium-energy electron spectrum (50-500 keV)	TRUE
It is a proton spectrometer	TRUE
It analyses low-energy proton spectrum (<50 keV)	TRUE
It analyses medium-energy proton spectrum (50-5000 keV)	TRUE
It is an alpha-particle spectrometer	TRUE
It analyses low-energy alpha particle spectrum (<200 keV)	TRUE
It analyses medium-energy alpha particle spectrum (50-20000 keV)	TRUE
It detects ions with Z>=3	TRUE
It is an ion spectrometer	TRUE
It analyses low-energy ion energy/mass spectrum (<50 keV/nuc)	TRUE
It analyses medium-energy ions energy/mass spectrum (50-5000 keV/nuc)	TRUE

13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Instrument : Rapid (3)

Overview | Programmes | Satellites | Instruments | Frequencies | Agencies | Gap Analyses

Instrument: RAPID

Instrument details

Acronym	RAPID
Full name	Research with Adaptive and Intelligent Processing
Purpose	To study suprathermal plasma
Short description	Assemblage of two instruments: Spectrometer (IMS) for 0.1-10 keV/n (Z from 1 to 6), and for measuring energetic electrons
Background	Part of a package of instruments for the Magnetosphere
Scanning Technique	Formation flight of 4 satellites across the Magnetosphere
Resolution	N/A
Coverage / Cycle	Magnetospheric volume
Mass	Power
Providing Agency	ESA
Instrument Maturity	Flown
Utilization Period:	2000-2016-01
Last update:	2016-01

Satellites this instrument is flying on

Tentative Evaluation of Measurements

The following list indicates which measurements can **typically** be retrieved from this category of instrument. To see a full Gap Analysis by Variable, click on the respective variable.

Note: table can be sorted by clicking on the column headers

Search:

Variable	Relevance for measuring this variable	Operational limitations	Explanation
Electron differential directional flux	1.1 - primary	No specific limitation.	Cross-magnetosphere satellite cluster low- and mid-energy
Proton differential directional flux	1.1 - primary	No specific limitation.	Cross-magnetosphere satellite cluster low- and mid-energy
Alpha particles differential directional flux	1.1 - primary	No specific limitation.	Cross-magnetosphere satellite cluster low- and mid-energy
Heavy ion flux energy and mass spectrum	1.1 - primary	No specific limitation.	Cluster in magnetosphere Low- and medium-energy

Showing 1 to 4 of 4 entries



13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Relevance



First step towards a Gap Analysis:
Alpha particles differential directional flux

Instrument	URL	Telescope	Scintillator	Orbit	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SIASO		1 - primary	CLUSTER.AAD											X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
HAPO		1 - primary	CLUSTER.CAD											X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
CS		1 - primary	CLUSTER.CAD											X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
CS		1 - primary	CLUSTER.CAD											X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
AST		1 - primary	THEMIS (2 sat)	6°																													
AST		1 - primary	AUTMIS (2 sat)	6°																													
LSA		1 - primary	THEMIS (2 sat)	6°																													
LSA		1 - primary	AUTMIS (2 sat)	6°																													
ECS-Madris		1 - primary	VAP (2 sat)	18°																													
BDSICE		1 - primary	VAP (2 sat)	18°																													
ECSHOPE		1 - primary	VAP (2 sat)	18°																													
EIS (M3)		1 - primary	MMS (4 sat)	28°																													
ELEZS		1 - primary	MMS (4 sat)	28°																													
EIS		1 - primary	MMS (4 sat)	28°																													
MICA		1 - primary	MMS (4 sat)	28°																													
HEP		2 - very high	GEOTAIL	29°	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ERIC		2 - very high	GEOTAIL	29°	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
CS		2 - very high	GEOTAIL	29°	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LEP		2 - very high	GEOTAIL	29°	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
WIM		2 - very high	CASSIOPEE	86°																													
CAMMICE		2 - very high	Eohat	86°																													
HYDRA		2 - very high	Eohat	86°																													
IDEPSI		2 - very high	Eohat	86°																													
IMAS		2 - very high	Eohat	86°																													
CEPSAD		2 - very high	Eohat	86°																													
VALIS		3 - high	ACE																														
CELLAS		3 - high	SOHO																														
COSEP		3 - high	SOHO																														
NEPCA		3 - high	ACE																														
IS		3 - high	ACE																														
WEPFAM		3 - high	ACE																														
WEPFAM		3 - high	Solar Probe Plus	3.4°																													
ISIS		3 - high	Solar Probe Plus	3.4°																													
Electron IM.PESCA		3 - high	CoronaeB.Floating	82.5°																													
NSL-particles		3 - high	CoronaeE	82.5°																													
NSL-particles		3 - high	CoronaeE	82.5°																													
EPACT		4 - low	WIND																														
LEMAN		4 - low	ACE																														
MMS		4 - low	WIND																														
EDM		4 - low	WIND																														

13th European Space Weather Week, 14-18 November 2016, Oostende, Belgium

Technical Configuration of OSCAR/Space

- MySQL database
- REST interface (for export to external sites)
- Machine-to-machine interface currently not activated
- CakePHP framework
- Drupal instance, hosted by external provider
- Metadata consistency with WIGOS/WIS core profile



User Engagement

- > 1100 page visits / day
- Community resource
- Many operational users
- Beta-testing of v2.0 in May-June 2016 with strong user participation
 - Not all suggestions yet implemented
- Feedback: sat-help-desk@wmo.int



Weather · Climate · Water

Maintenance and Support: Outlook

Two main tasks:

- (1) Updating facts
- (2) Keep under review assessments, functions, rules, interfaces

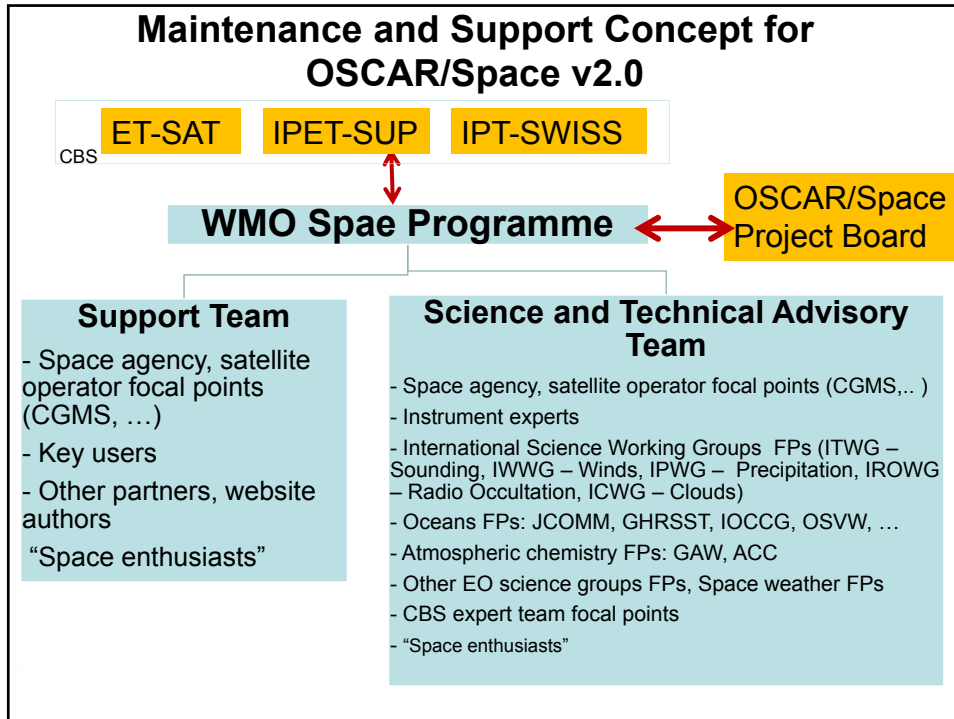
Under supervision of WMO CBS expert teams,
and consistent with overall OSCAR development,

WMO Space Programme Office plans to establish:

- OSCAR/Space Support Team (for task 1)
- OSCAR/Space Science and Technical Advisory Team (for task 2)



Weather · Climate · Water



- ### Concluision for OSCAR/Space v2.0
- OSCAR/Space is a reference community resource on satellite programmes, instruments, and the variables they can observe
 - New version 2.0 in now available online
 - Encompassing satellites for weather, climate, ocean, EO
 - Space weather part under development
 - Transparent gap analyses and assessments (rules to be kept under review)
 - WMO welcomes user feedback, for further improvements
 - The maintenance challenge:
WMO will need community engagement for supporting and advising on OSCAR/Space
 - Establishment of the maintenance and support structure underway
-
- v WE NEED YOU

Contact Details

- **OSCAR/Space** :
<http://oscar.wmo.int/space>
- **User feedback**
sat-help-desk@wmo.int
- For your engagement, please contact WMO:
Toshiyuki Kurino
Stephan Bojinski



Weather • Climate • Water

References

- OSCAR/Surface: <http://oscar.wmo.int/surface>
- OSCAR/Requirements: <https://www.wmo-sat.info/oscar/observingrequirements>
- WMO Space Programme: <http://www.wmo.int/sat>
- [WMO Vision for the Global Observing System in 2025](#)



Weather • Climate • Water

WEATHER CLIMATE WATER

Thank you



WORLD
METEOROLOGICAL
ORGANIZATION



7L30

Questions:
tkurino@wmo.int



13th European Space Weather Week, 14-18 November 2016,
Oostende, Belgium

Weather • Climate • Water