World Meteorological Organization

Working together in weather, climate and water

Space Weather Activities Coordination by WMO

Space Weather Societal Impacts Workshop

Jérôme Lafeuille
WMO Space Programme,
Geneva

Outline

- Why is WMO involved in Space Weather coordination ?
- Inter-Programme Coordination Team on Space Weather early achievements
  - Observation requirements and gap analysis
  - On-line Space Weather Product Portal
- Future prospects

World Meteorological Organization

The specialized UN agency for weather, climate, operational hydrology and related geophysical sciences.

High-level goal to support:

- Protection of life and property
- Economic and social welfare
- Environment and natural resources
- Capacity building in less advanced countries

Founded in 1950, WMO has 189 Members (States and territories)

- Fosters international cooperation and information exchange
- Coordinates global observation, telecom, analysis, forecasting, warning
- Defines international Standards (ISO) in its area of competence

Motivations for WMO Space Weather activities

Space Weather is important for WMO

- Impact on radio-communications
- Impact on meteorological satellites
- Space Weather-climate linkage

WMO is important for Space Weather

- Meteorological satellites are flying space weather instruments
- WMO's 60-year experience in global operational coordination
- Synergy with current services to global aviation and hazard warning

➢ WMO Members decided to engage in « International coordination of ***operational*** Space Weather observation, products and services, in particular to protect against global Space Weather hazards »

Outline

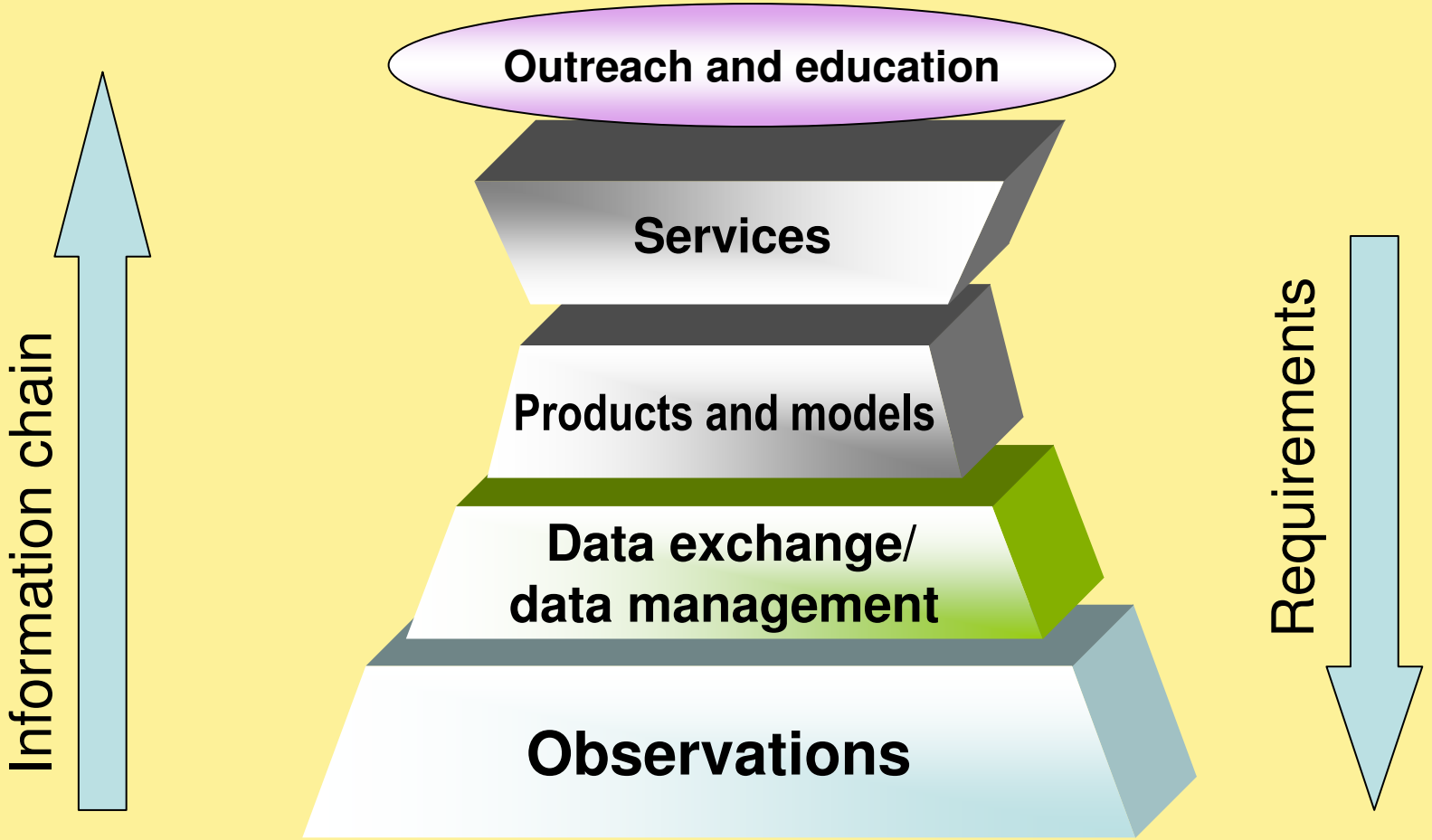
- Why is WMO involved in Space Weather coordination ?
- **Inter-Programme Coordination Team on Space Weather early achievements**
  - Observation requirements and gap analysis
  - On-line product portal
- Future prospects

Inter-Programme Coordination Team on Space Weather (ICTSW)

- Currently 15 countries
  - Australia, Belgium, Brazil, Canada, China, Colombia, Ethiopia, Finland, France, Japan, Pakistan, Rep. Korea, Russian Federation, United Kingdom, USA
- 6 international organizations
  - ESA, ISES
  - ICAO, ITU, OOSA, WMO
- Co-chairs
  - **Terrance Onsager** (USA)
  - **Xiaoxin Zhang** (China)
- Governance
  - WMO Commission for Basic Systems
  - WMO Commission for Aeronautical Meteorology

- Phil Wilkinson
- Ronald Van der Linden
- René Warnant
- Hisao Takahashi
- Larisa Trichtchenko
- Wang Jingsong
- Zhang Xiaoxin
- Alain Hilgers
- Kirsti Kauristie
- Nicole Vilmer
- Raoul Romero
- David Boteler
- Sergio Buonomo
- Ken Murata
- Hans Haubold
- Seok-Hee Bae
- Daeyun Shin
- Vyachesloav Burov
- David Jackson
- Joe Davila
- Jim Head
- Terry Onsager
- Jerome Lafeuille

ICTSW activity areas



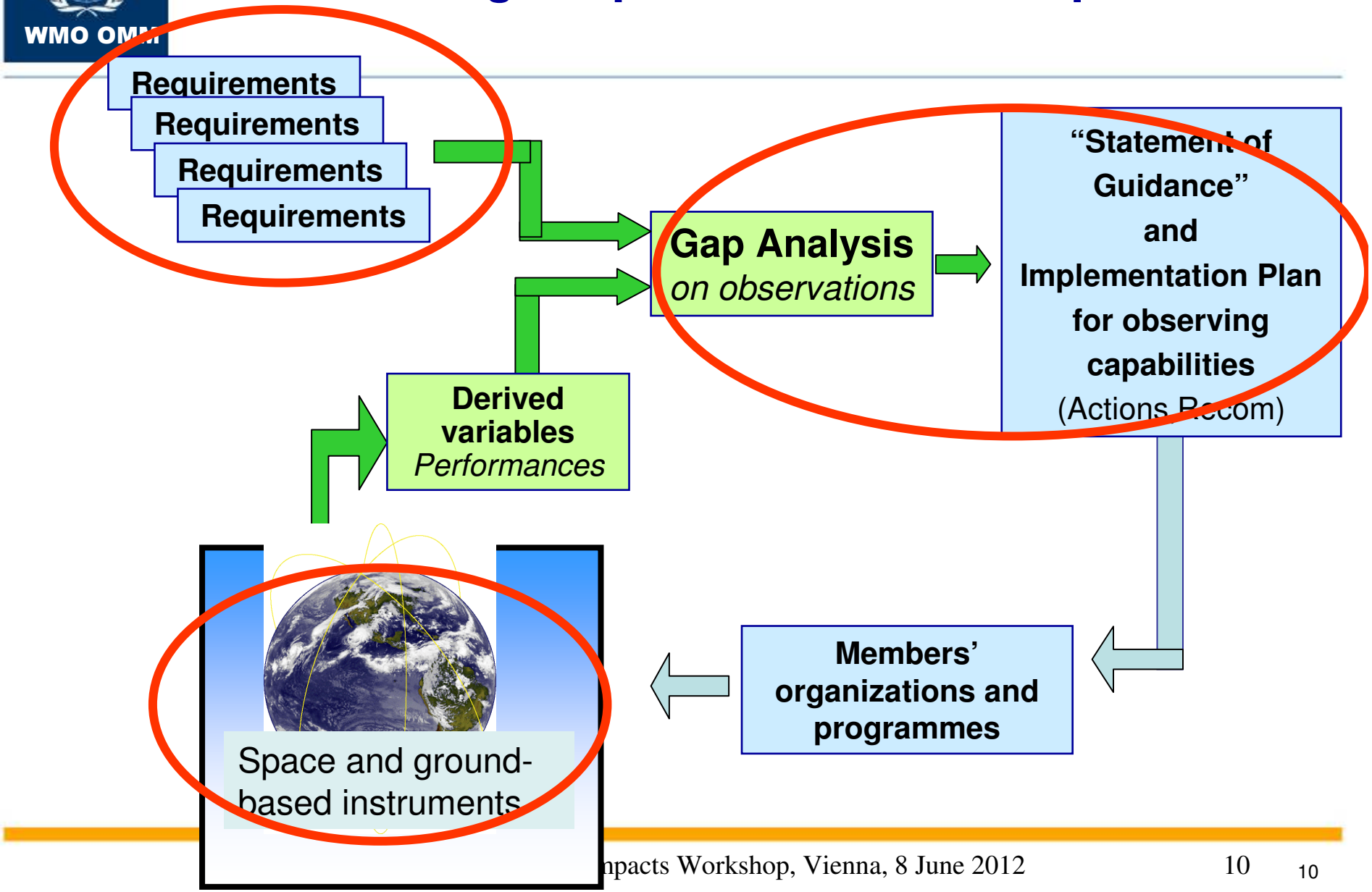
Current *and future* activities

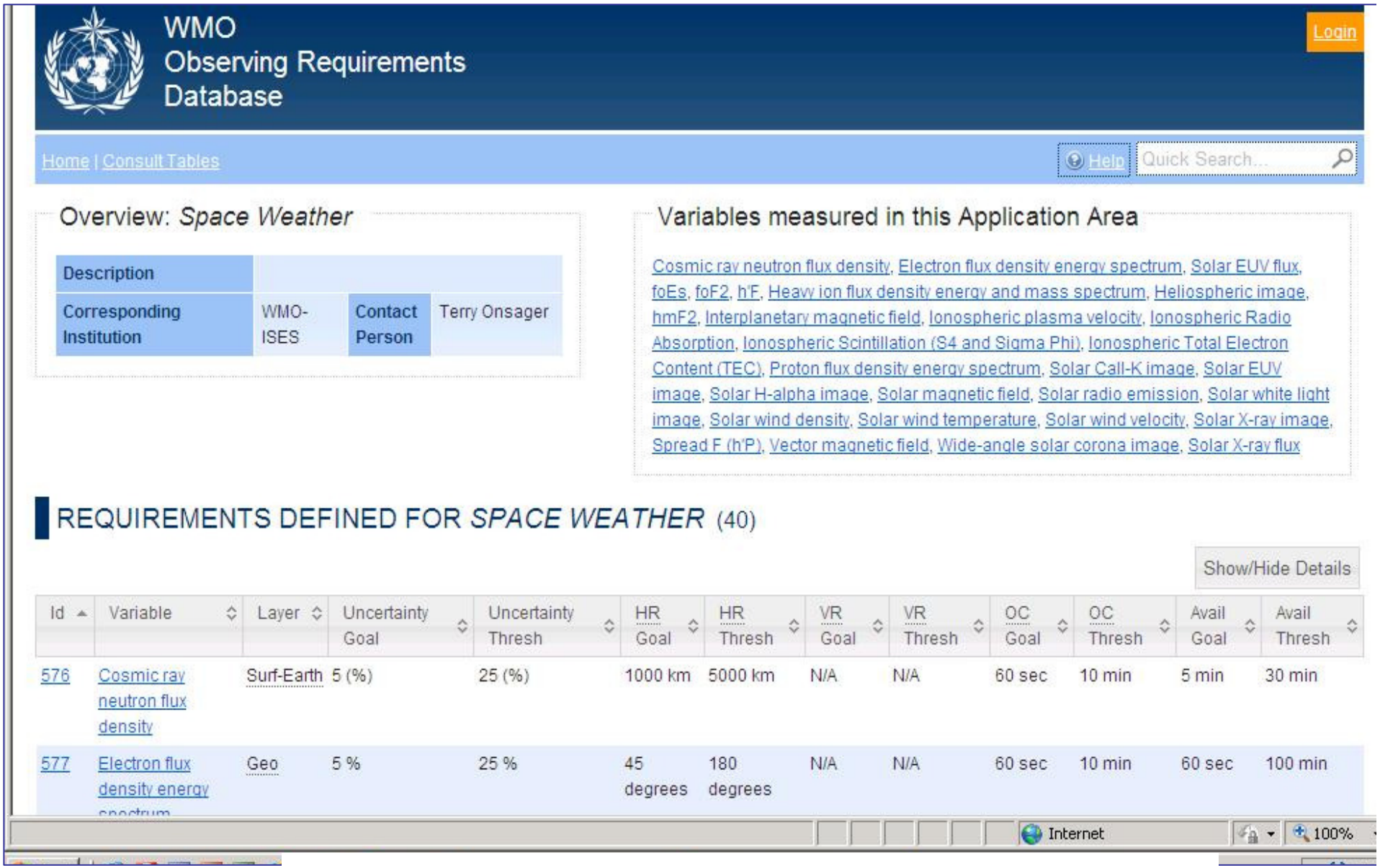
- **Space Weather training modules for users/providers**
- **Space Weather services to users**
  - **Specification of WMO Space Weather services to global aviation**
  - *Specification of services to other areas of activities*
  - *Organization and responsibility sharing for Space Weather warning*
- **Operational data and products**
  - **Product collections documented/accessible on online Product Portal**
  - *Harmonization of product specification*
  - *Data exchange, metadata, use of WMO Information System*
- **Observation requirements and capabilities**
  - **Requirements database, observation gaps and priorities**
  - *Harmonizing observation for greater interoperability*

Outline

- Why is WMO involved in Space Weather coordination ?
- Inter-Programme Coordination Team on Space Weather early achievements
  - **Observation requirements and gap analysis**
  - On-line product portal
- Future prospects

WMO Rolling Requirements Review process





http://www.wmo-sat.info/db/

Gap Analysis of Observing Capabilities

MISSION	SATELLITE	ECL/IN	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25?
SEM	FY-1D	03/30	X	X	X	X														
SEM/Z	NOAA-15	04/35	X	X	X	X														
SEM-N	DWSS-1	05/30											X	X	X	X	X	X		
SEM-N	DWSS-2	05/30															X	X	X	X
SEM+	DMSP-S19	05/30					X	X	X	X	X	X	X							
SEM+	DMSP-F17	05/35	X	X	X	X	X	X												
EIS	HINODE	06/00	X	X	X	X	X													
SOT	HINODE	06/00	X	X	X	X	X													
XRT	HINODE	06/00	X	X	X	X	X													
TRACE	TRACE	06/00	X	X	X															
PREMOS	PICARD	06/00			X	X	X	X	X	X										
SODISM	PICARD	06/00			X	X	X	X	X	X										
SOVAP	PICARD	06/00			X	X	X	X	X	X										
CORONAGR.	ADITYA-1	06/00					X	X		X	X									
AOPOD	KOMPSAT-5	06/00				X	X	X	X		X									
IGOR	PAZ (SEOSAR)	06/00						X												
IGOR	TERRASAR-X	06/00	X	X		X		X												
IGOR	TERRASAR-X2	06/00						X		X	X	X	X							
IGOR	TANDEM-X	06/1									X									
ROSA	SAC-D						X	X	X	X	X									
SEM+	DMSP-F16	06/	X	X	X															
SEM/Z	NOAA-16	07/30	X	X	X	X														
SEM+	DMSP-S20	07/30							X	X	X	X	X	X	X					
SEM+	DMSP-F18	08/10		X	X	X	X	X	X											
SEM/Z	NOAA-17	08/15	X	X	X	X														
GMSC	METEOR-M N1	09/10		X	X	X	X	X	X											
GMSC	METEOR-M N2	09/30					X	X	X	X	X	X								
RADIOMET.	METEOR-M N3	TBD							X	X	X	X	X	X						
RADIOMET	METEOR-MP N1	09/30										X	X	X	X	X	X	X		
GGAK-M	METEOR-MP N2	09/30										X	X	X	X	X	X			
GRAS	METOP-A	09/30	X	X	X	X	X													
SEM/Z	METOP-A	09/30	X	X	X	X	X													
GRAS	METOP-B	09/30					X	X	X	X	X	X								
SEM/Z	METOP-B	09/30					X	X	X	X	X	X								
GRAS	METOP-C	09/30									X	X	X	X	X	X				
EU	EPS-SG-A1	10/30													X	X	X	X	X	X

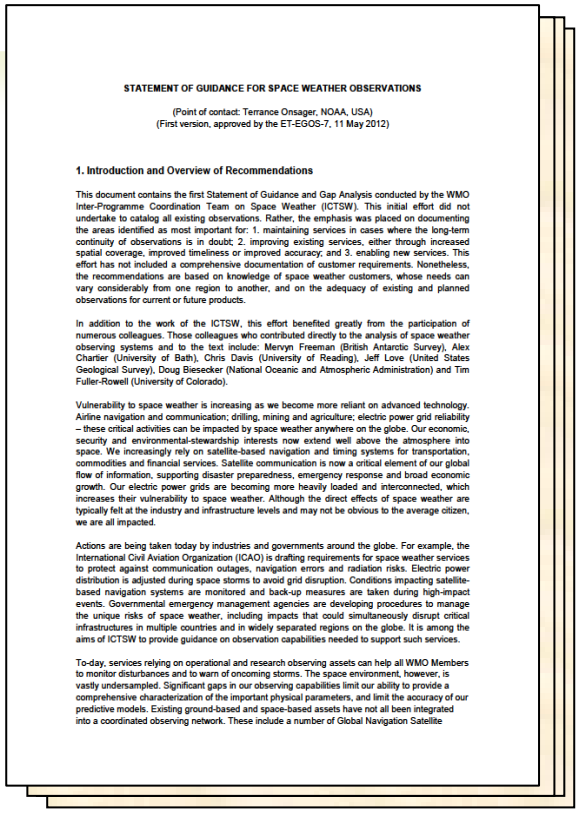
Satellite capabilities database (now under validation)

Statement of Guidance for Space Weather Observation (1)

- **Version 1, May 2012 (22 pages) is on line**

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

- **Observations required to**
  - Establish a Space Weather « climatology »
  - Detect hazardous events
  - Forecast disturbances
  - Validate models
  - Support research
- **Four observation domains**
  - Ionospheric
  - Geomagnetic
  - Energetic particles
  - Solar
  - Solar wind/interplanetary



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 Chartier (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.

To-day, 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

Statement of Guidance for Space Weather Observation (2)

- **Ionospheric observations**
  - *Required variables:* TEC, Radio absorption, (h'P, hmF2,h'F,fof2, foEs), plasma velocity and scintillation
  - *Measurement methods:* GNSS, Radio absorption, ionosonde, ISR, coherent radar, scintillation receivers and 2-frequency altimeters
  - *Assessment of availability and performance*
  - *Recommendations* : GNSS ground netwoks and data exchange, timeliness of GNSS-RO, coordinated use of 2-frequency altimeters
- **Geomagnetic observations**
  - *Required variables:* vector magnetic field at surface and in space
  - *Measurement methods:* magnetometer arrays at surface, on GEO and LEO
  - *Assessment of availability and performance*
  - *Recommendations:* ground magnetometer networks and data availability

Statement of Guidance for Space Weather Observation (3)

- **Energetic particles**
  - *Required variables:* Low- & high-energy flux of trapped, solar, galactic particles.
  - *Measurement methods:* satellites in LEO, MEO, GEO, HEO, L1
  - *Issues*: intercalibration and interoperability, contonuity
  - *Recommendations:* Continue satellite measurements at all levels, add HEO, data sharing, intercalibration, assimilation
- **Solar monitoring**
  - *Required variables:* sun images (H-alpha,EUV, X-ray, white, Ca-II-K, Magnetic field), flux (EUV, X-ray, radio emissions), Corona, heliosphere
  - *Measurement approach:* ground- and space-based
  - *Issues:* lsustainability of research missions, coordination, standardization
- **Solar wind**
  - *Required variables:* Velocity, density, temperature and magnetic field
  - *Measurement* approach: Observatory at L1, L5
  - *Recommendations:* coordinated plans to ensure continuity at L1, L5

Outline

- Why is WMO involved in Space Weather coordination ?
- Inter-Programme Coordination Team on Space Weather early achievements
  - Observation requirements and gap analysis
  - **On-line product portal**
- Future prospects

Space Weather Product Portal

- go to: http://www.wmo.int/sat
- in the right-hand menu select Space Weather

  and then select: → Space Weather Product Portal
- or just google: wmo space weather portal

World Meteorological Organization
Working together in weather, climate and water

www.wmo.int/sat

About us
- WMO in brief
- Vision & mission
- Strategic planning
- Structure of the Organization
- The Secretariat
- Office of the Secretary-General
- Milestones
- Awards & prizes

Governance
Members
Media centre
Programmes
Meetings
Publications
Library
Learning
Publishing tools
Partnership
Themes
Vacancies
Visitors' info
Youth corner

Search ...

WMO Space Programme

WMO Space Programme

The Space Programme`s objective is to promote availability and utilization of satellite data and products for weather, climate, water and related applications to WMO Members.

It coordinates environmental satellite matters and activities throughout all WMO Programmes and gives guidance on the potential of remote-sensing techniques in meteorology, hydrology and related disciplines.

Quick Access

- Observing Requirements Database
- Satellite Status
- Working Documents for Meetings
- Dossier on the space-based Global Observing System (GOS)
- Virtual Laboratory for Education and Training in Satellite Meteorology (VLAB)

Latest News and Announcements

07/12/2011	GOES-15 becomes new GOES-West satellite
30/11/2011	Announcement for a Post-doctoral Research Fellowship, Environment Canada
25/11/2011	First VIIRS images from NPP satellite

» Read News

Upcoming Meetings and Events

22/01/12 to 26/01/12	92nd AMS and 18th Conference on Satellite Meteorology, Oceanography and Climatology
23/01/12 to 17/02/12	World Radiocommunication Conference 2012 (WRC-12)
06/02/12 to 17/02/12	49th COPUOS Scientific and Technical Subcommittee (STSC-49)

» See all Events

The WMO Space Programme has 4 main components:

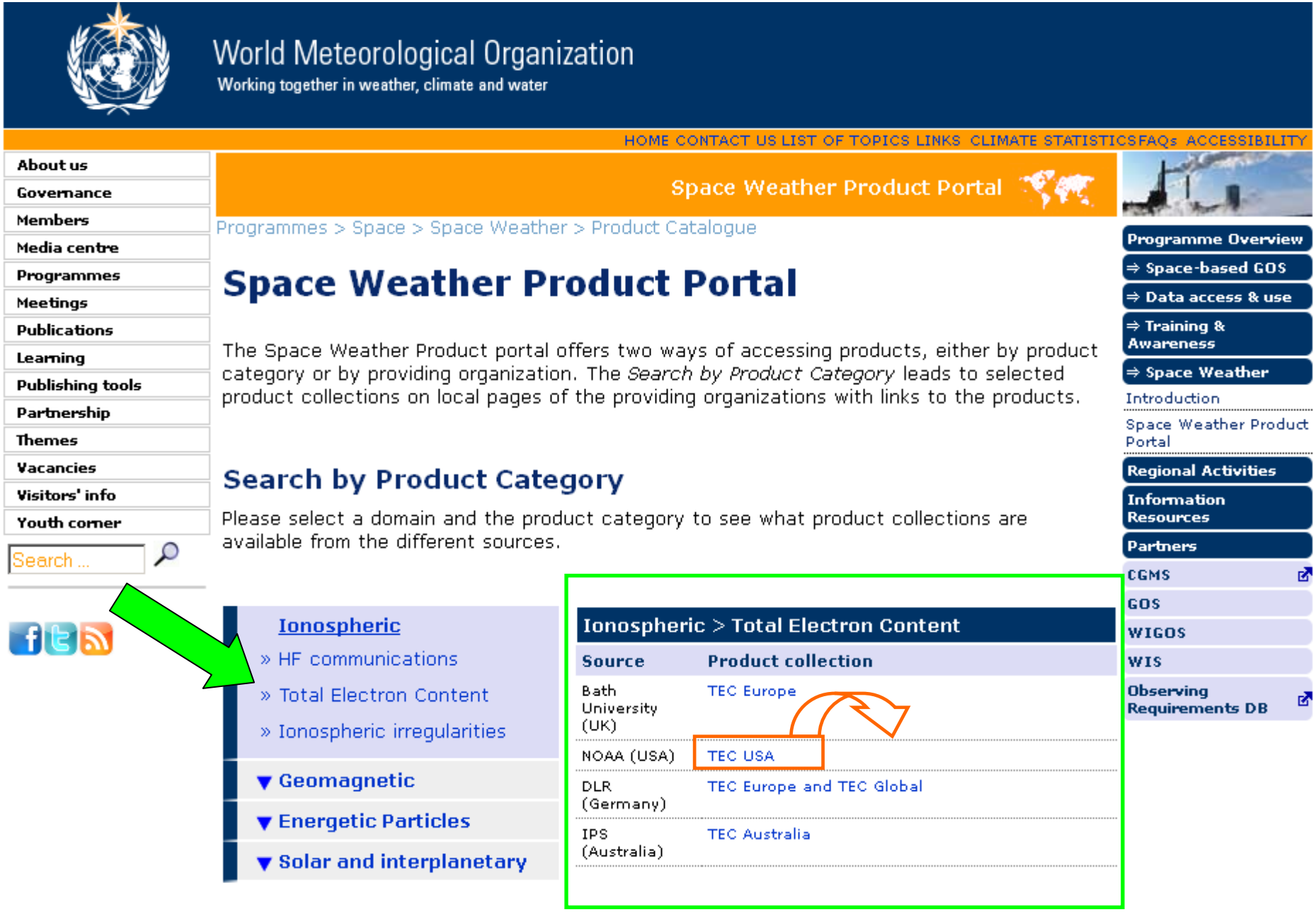
The space-based Observing System

Access to Satellite Data and Products

Awareness and Training

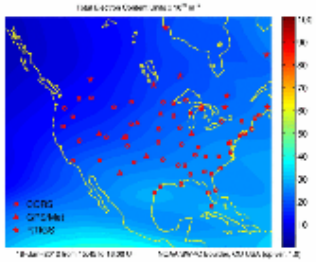
Space Weather Coordination

Programme Overview
⇒ Space-based GOS
⇒ Data access & use
⇒ Training & Awareness
⇒ Space Weather
Introduction
Space Weather Product Portal
Regional Activities
Information Resources
Partners
CGMS
GOS
WIGOS
WIS
Observing Requirements DB


World Meteorological Organization
Working together in weather, climate and water
HOME CONTACT US LIST OF TOPICS LINKS CLIMATE STATISTICS FAQs ACCESSIBILITY
About us
Governance
Members
Media centre
Programmes
Meetings
Publications
Learning
Publishing tools
Partnership
Themes
Vacancies
Visitors' info
Youth corner
Search ...
Space Weather Product Portal
Programmes > Space > Space Weather > Product Catalogue
Space Weather Product Portal
The Space Weather Product portal offers two ways of accessing products, either by product category or by providing organization. The Search by Product Category leads to selected product collections on local pages of the providing organizations with links to the products.
Search by Product Category
Please select a domain and the product category to see what product collections are available from the different sources.
Ionospheric
» HF communications
» Total Electron Content
» Ionospheric irregularities
▼ Geomagnetic
▼ Energetic Particles
▼ Solar and interplanetary
Ionospheric > Total Electron Content
Source
Product collection
Bath University (UK)
TEC Europe
NOAA (USA)
TEC USA
DLR (Germany)
TEC Europe and TEC Global
IPS (Australia)
TEC Australia
Programme Overview
⇒ Space-based GOS
⇒ Data access & use
⇒ Training & Awareness
⇒ Space Weather
Introduction
Space Weather Product Portal
Regional Activities
Information Resources
Partners
CGMS
GOS
WIGOS
WIS
Observing Requirements DB
Search by Organization

Total Electron Content

US Total Electron Content	**Product Description:** 2-D product showing the recent conditions of ionospheric Total Electron Content that impact GNSS-derived position accuracy. Vertical TEC and slant-path values of the line-of-sight electron content to the GPS satellites in view are given. This ionospheric product is designed to estimate the signal delay for single and dual frequency GNSS applications. **Target Users:** Product users include industries relying on high-accuracy GNSS positioning, such as airlines, agriculture, surveying, construction, and drilling. US Total Electron Content
Cadence: 15 min	**Data Source:** Ground-based GPS receivers



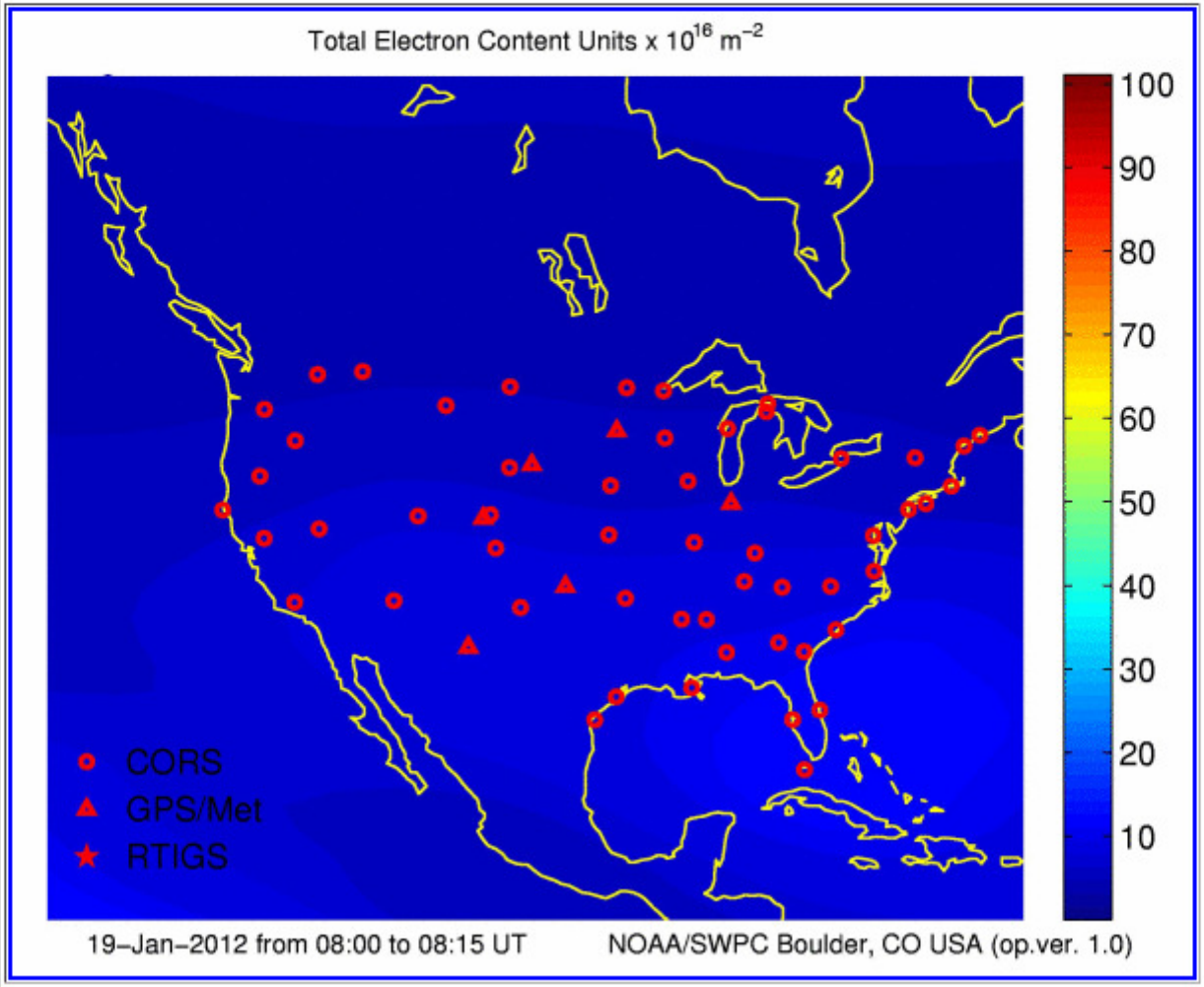
Real-time US-Total Electron Content: Vertical and Slant

Presented by the NOAA/Space Weather Prediction Center

Vertical TEC	TEC uncertainty	Recent trend	All Plots

Vertical Total Electron Content

2012 Jan 19 0800 - 0815 UTC



Today	Data files	Animation	Latest Updates (2008 Aug 22)

World Meteorological Organization
Working together in weather, climate and water

HOME CONTACT US LIST OF TOPICS LINKS CLIMATE STATISTICS FAQs ACCESSIBILITY

- About us
- Governance
- Members
- Media centre
- Programmes
- Meetings
- Publications
- Learning
- Publishing tools
- Partnership
- Themes
- Vacancies
- Visitors' info
- Youth corner

Search ...

Space Weather Product Portal

Programmes > Space > Space Weather > Product Catalogue

Space Weather Product Portal

The Space Weather Product portal offers two ways of accessing products, either by product category or by providing organization. The *Search by Product Category* leads to selected product collections on local pages of the providing organizations with links to the products.

Search by Product Category

Please select a domain and the product category to see what product collections are available from the different sources.

- △ Ionospheric
  - » HF communications
  - » Total Electron Content
  - » Ionospheric irregularities
- △ Geomagnetic
  - » Auroral activity
  - » Geomagnetic activity
- ▼ Energetic Particles
- ▼ Solar and interplanetary

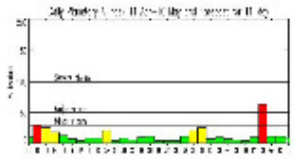
Geomagnetic > Geomagnetic activity

Source	Product collection
NOAA (USA)	Geomagnetic Activity
IPS (Australia)	Geomagnetic Activity Australia

Search by Organization

- Programme Overview
- Home
- Activities and objectives
- Structure and Governance
- News and External Announcements
- Calendar of Events
- Contact Information
- ⇒ Space-based GOS
- ⇒ Data access & use
- ⇒ Training & Awareness
- ⇒ Space Weather
- Regional Activities
- Information Resources
- Partners
- CGMS
- GOS
- WIGOS
- WIS
- Observing Requirements DB

Geomagnetic Activity

Daily Planetary A-Index 	**Product Description:** A-index plot displays a time series of the last 28 days of estimated daily planetary A-index. **Target Users:** Customers (exploration geophysicists, aeromagnetic survey, researchers) interested in the development of geomagnetic activity over the past month. Product Link
Cadence: Daily	**Data Source:** Global magnetometer data

GEOSTAT Alert 	**Product Description:** This is the latest GEOSTAT alert information. The GEOSTAT (GEOmagnetic STorm Alert Tracking) system has been developed to monitor the progress of a geomagnetic storm from its origin on the sun (Level5), to its impact on the Earth's magnetic field and subsequent geomagnetic storm (Level 0). The alert sequence is from 5 down to 0 to simulate a "countdown" style to the alert levels. When alert levels have been reached the green "No Alert" icon will change to one of the six GEOSTAT alert level icons. If GEOSTAT alert level 0 has not occurred within four days of GEOSTAT alert level 5 being issued, the GEOSTAT icon changes to the "Alert Fail" icon and a message indicating the geomagnetic storm failed to eventuate is issued. **Target Users:** Any customer likely to be affected by a geomagnetic storm. Product Link
Cadence: on demand	**Data Source:** Composite of key data streams

Latest Conditions
- Magnetograms
- Indices
- Maps
- Cosmic Ray

Alerts and Warnings
- Geomagnetic Warning
- Geomagnetic Alert
- GEOSTAT Alert
- Aurora Alert

Summary and Forecasts
- Daily Report
- Weekly Report

Prediction Tools
- Auroral Oval

Historical Data
- Magnetograms
- Indices
- Data Files

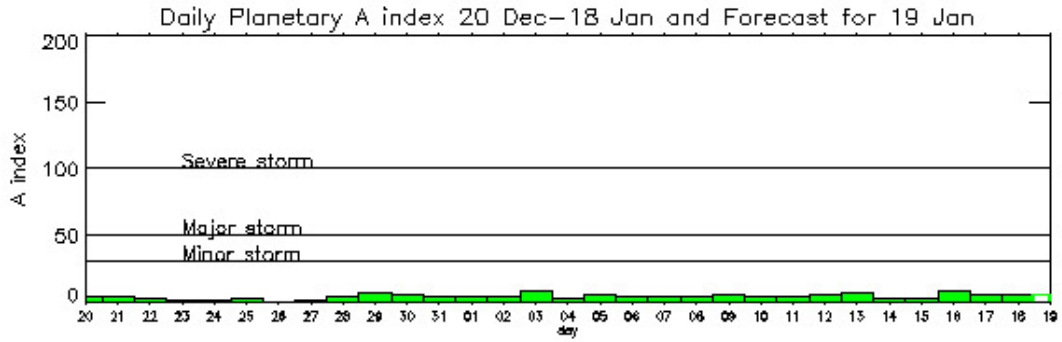
Related Sites
- Geophysical Links

Section Information
- Geophysical Help Page
- Latest News

Latest Conditions

Daily Planetary A-Index

Updates: Every 24 hours



▲ Top


Search ...
△ Ionospheric
» HF communications
» Total Electron Content
» Ionospheric irregularities
▼ Geomagnetic
▼ Energetic Particles
▼ Solar and interplanetary
Ionospheric > Total Electron Content
Source
Product collection
Bath University (UK)
TEC Europe
NOAA (USA)
TEC USA
DLR (Germany)
TEC Europe and TEC Global
IPS (Australia)
TEC Australia
CGMS
GOS
WIGOS
WIS
Observing Requirements DB
Search by Organization
ISES
CMA (China)
IPS (Australia)
INPE (Brazil)
Canada Space Weather
FMI (Finland)
ESA (Europe)
NICT (Japan)
Institute of Applied Geophysics (Russia)
Solar Influences Data Analysis Center, ROB (Belgium)
DLR (Germany)
NOAA (USA)

Space Weather
- Home
- Current Space Weather
- Data
- Effects on Technology

External Links
- Geomagnetism
- NRCan
- CSA
- ISES
- CARISMA

Proactive disclosure

Space Weather Canada

December 1st, 2011 : Our website is changing to conform to the standard on web accessibility. Some web pages and applications have changed address and look, please update your bookmarks accordingly. If you have questions, please contact us at webmaster@geolab.nrcan.gc.ca.

ISES Regional Warning Centre for Canada

Time remaining until content refreshes: 04:55

Current Geomagnetic Field Conditions at Date : 2012-01-19 Time : 08:30 UT

Zones	Activity	Storm Watch
Polar	Quiet	No Storm Watch
Auroral	Quiet	No Storm Watch
Sub-Auroral	Quiet	No Storm Watch

The Canadian Space Weather Forecast Centre in Ottawa is operated by Natural Resources Canada (NRCan), with support from the Canadian Space Agency (CSA). It is a Regional Warning Centre (RWC) of the International Space Environment Service (ISES, formerly IUWDS). The ISES global network monitors a variety of parameters that help to characterize the conditions on the Sun, in space between the Sun and Earth, and on the Earth. The data are used by Regional Warning Centres and others to develop Space Weather warnings and alerts.

Information
- What is Space Weather?
- Space Weather Research in Canada
- Space Weather Links
- RSS Feeds

Regional Warning Centres
- More Information
- Beijing
- Boulder
- Brussels
- Delhi
- Hermanus
- Lund
- Moscow
- Ottawa
- Prague
- São José dos Campos
- Sydney
- Tokyo
- Warsaw

Outline

- Why is WMO involved in Space Weather coordination ?
- Inter-Programme Coordination Team on Space Weather early achievements
  - Observation requirements and gap analysis
  - On-line product portal
- **Future prospects**

Expected benefits from WMO support

- WMO's experience and procedures (observation, information, warning systems) enable leveraging the technical coordination effort initiated by ISES
- WMO framework will facilitate international commitments by Members for long-term provision of services to the community
- Integration/synergy will develop with meteorological services delivered to various key users

➢ Sustainable, quality-controlled global space weather services to users

Challenges

Global operational coordination is emerging under WMO auspices, though there are a number of challenges e.g.:

- To raise awareness of decision makers and general public
- To involve more Members and organizations
- To organize responsibilities for efficient alert chain
  - (e.g. WMO hurricane centres or Volcanic Ash Advisory Centres)
- To improve data/product accessibility
- To enhance interoperability through standardization when relevant

WMO OMM

Thank you !