

2nd ICAO/UNOOSA Symposium, 15
– 17 March 2016, Abu Dhabi, UAE

Space Weather

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Science, Capacity Building and Outreach

- **2004:** Session of the Committee on the Peaceful Uses of Outer Space (COPUOS) called for addressing solar-terrestrial interaction: global climate, **space weather**, Sun-Earth-heliosphere-system
 - **2005 - 2009:** Workshops and Follow-up projects: low-cost, ground-based world-wide instrument arrays, GNSS on board of instrument arrays
- TRIPOD:** BSS, 1991-2004 (Telescope, Observing, Teaching) – IHY, 2005 -2007 (Instrument Array, Data, Teaching)
- **2010 - 2012:** STSC agenda item “International Space Weather Initiative” & ISWI Workshops (Egypt, Nigeria, Ecuador)
GNSS for Space Weather Applications - Instrument Network – Capacity Building (Space Science Schools)
 - **2013:** STSC agenda item “Space Weather”
 - **2014:** Establishment of the “Expert Group on Space Weather” to stock of relevant technology, information and observation systems around the world and propose recommendations, including areas for future study (A/RES/69/20, para. 146)
 - **2015:** United Nations/Japan Workshop on Space Weather: Science and Data Products from ISWI Instruments, 2 – 6 March 2015, Fukuoka, Japan (A/AC.105/1096)



ISWI Instrument Network: Recommendations

- a) Recalled that the **focus of ISWI** was on science, capacity-building and outreach activities;
- b) Recalled in that regard the **progress achieved by ISWI** in different regions of the world and the cooperation with SCOSTEP;
- c) Welcomed the **addition of three new ISWI instrument arrays**, bringing the total number of instrument arrays to 17;
- d) Appreciated that the **ISWI secretariat had been expanded** to include a workshop coordinator and that the **United States had committed additional resources to make ISWI data available to all scientists**;
- e) Agreed on the **need to review the status of ISWI instruments** (see A/AC.105/2013/CRP.11 and the ISWI secretariat website) and the **status of ISWI national points of contact** by the ISWI secretariat;
- f) Agreed on the **need for action to help bridge the gap between ISWI science and potential operational use of ISWI data** (from data collection to data analysis and modelling), based on a step-by-step approach;
- g) Recommended that **the ISWI steering committee should solicit annual reports from member countries and instrument principal investigators**, and should publish such reports in the ISWI newsletter.



Science, Capacity Building and Outreach

▪ ISWI and ISWI Steering Committee

- A programme of international cooperation to advance the space weather science by a combination of instrument deployment, analysis and interpretation of space weather data
- About 80 National Coordinators from Member countries

▪ **Website** (Bulgarian Academy of Sciences): <http://www.iswi-secretariat.org/>

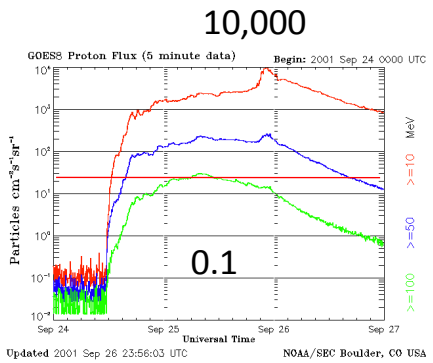
▪ **Newsletter** (International Centre for Space Weather Science and Education (ICSWSE) of Kyushu University)

▪ **BSSI** (Office for Outer Space Affairs): <http://www.unoosa.org/oosa/en/ourwork/psa/bssi/index.html>

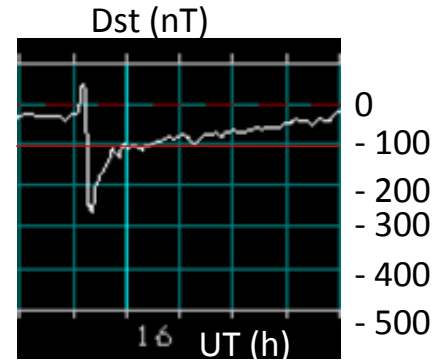
▪ **Space Weather and GNSS** (ICG Information Portal): <http://www.unoosa.org/oosa/en/ourwork/icg/space-weather-and-gnss.html>

ISWI Instruments Measure Source and Impact of Space Weather

Also solar flare effects



CMEs
CIRs
from the Sun



Radio telescope network
H-alpha Telescope network
Particle detector networks

SEPs

Space systems
Airplanes
atmosphere

Combine with remote-sensing
space- and ground-based
measurements

Magnetic storms

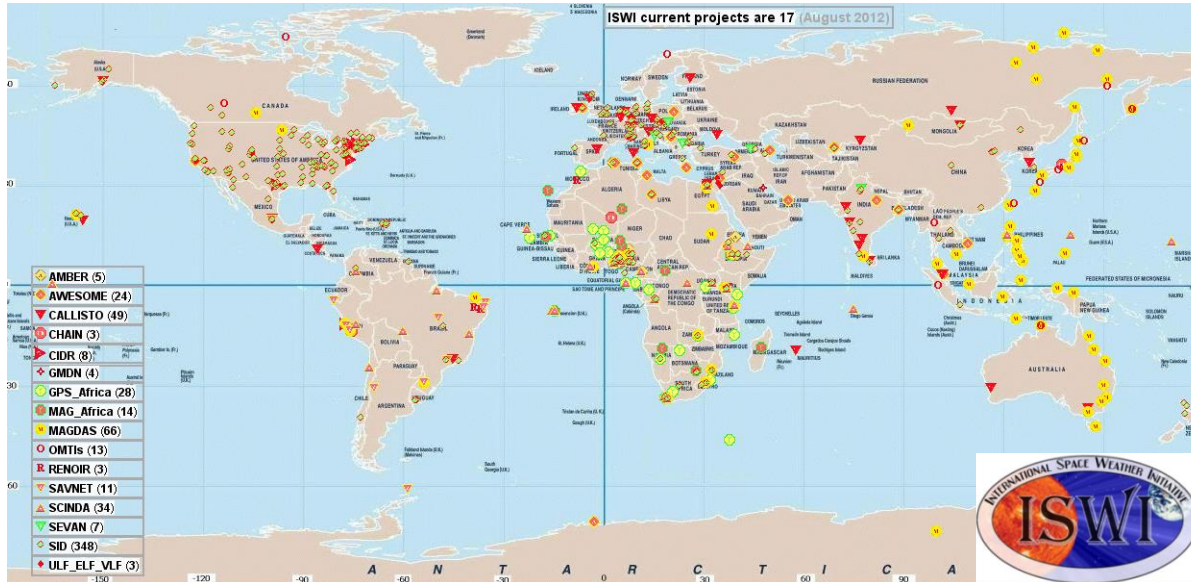
Space systems
Magnetosphere
Ionosphere
Atmosphere
Ground

Combine in-situ and
space measurements

magnetometer networks
GPS receiver networks
VLF receiver network
Atmospheric instruments



ISWI Instrument Sites

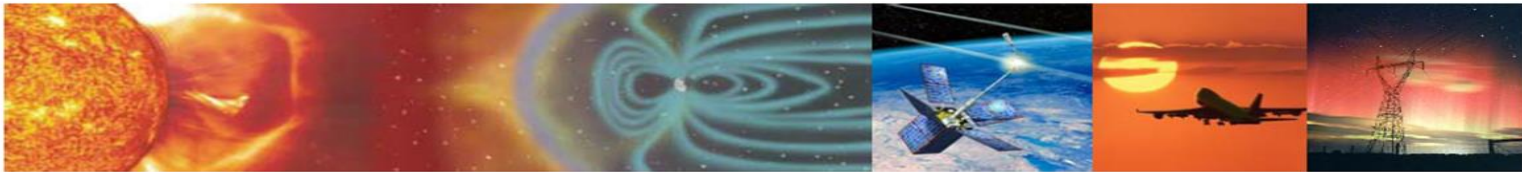


- Scientists from developing/developed nations work together in deploying and operating SW instruments: > 1000 deployments in >100 countries;
- Students and faculty participate at all levels of the instrument project and science;
- 17 instrument networks from 8 countries (USA, Germany, Japan, Brazil, France, Israel, Armenia, Switzerland)



Data Utilization and Operational Use

- ISWI data are currently used for SW science
- ISWI SC has adopted an open data policy and rules of the road data use (SC meeting, 19 February 2016, Vienna)
- All ISWI data will be made accessible, available and independently usable
- **This means data can be used by any SW service that needs data on any aspect of the Sun-Earth space**





Space Weather and Global Navigation Satellite Systems

- **International Committee on Global Navigation Satellite Systems (ICG)**
- Working Group on Capacity Building and Information Dissemination: Action C4
 - Build upon the success of ISWI and support the establishment of ground-based world-wide instrument arrays for exploring atmospheric phenomena related to SW and climate change. The initiative is to address all aspects of the response of the mid- and low-latitude ionosphere to magnetic storms and SW effects of such storms, including in-situ & ground-based observations as well as modeling & theoretical studies.
- Continue to support existing infrastructure
- Provide SW education: focus on the use of SW instruments for scientific research and for SW effects – hands-on
- Develop on-line training
- Develop a website: links to SW websites for up-to-date activity; links to reference papers; links to training opportunities; SW forums/meetings

Ionospheric Effects on GNSS

✦ Range Error

- ✦ Due to a change in the speed of the signal
 - ✦ Group Delay of the signal modulation (absolute range error)
 - ✦ Carrier Phase advance (relative range error)
- ✦ Proportional to Total Electron Content
 - ✦ Range Error = $\pm \frac{40.3 \text{ TEC}}{f^2}$

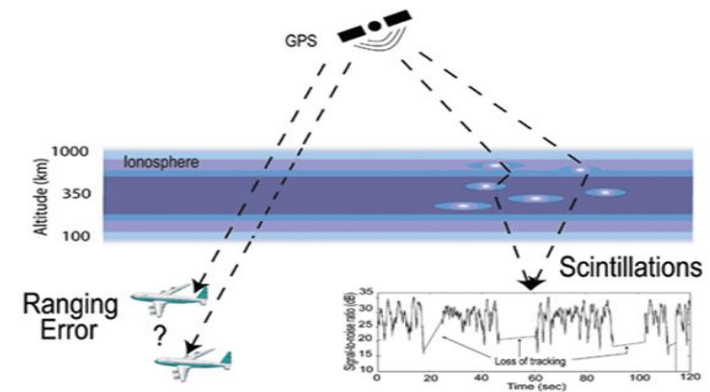
✦ Varies from 1 to ~100m

✦ Scintillation

- ✦ Due to rapid fluctuations in the amplitude and phase of the signal
- ✦ May induce loss of lock
- ✦ Rare at mid-latitudes
- ✦ Can be severe after local sunset in the equatorial regions, especially near the peak of solar cycle

✦ Other Effects

- ✦ Faraday Rotation, Absorption, Doppler Shift, Waveform Distortion and Refraction, Diffraction

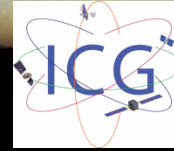


Varies with location, local time, season, geomagnetic and solar activity.

▪ Promoting International Cooperation

- Space weather is a global phenomena
- Advancing Space Weather Enterprise on an International Scale is Vital
- UK released a Space Weather Preparedness Strategy in 2014 (updated 2015)
- US released a National Space Weather Strategy in October 2015

Source: P. Doherty, Institute for Scientific Research, Boston College, USA



ICG: Programme on GNSS Applications

- ICG, ICTP and Boston College
 - Use of Ionospheric GNSS Satellite Derived Total Electron Content Data for Navigation, Ionospheric and SW Research, 20 – 24 June 2016, Trieste, Italy
 - International Beacon Satellite Symposium, 27 June – 1 July 2016, Trieste, Italy
- [Interim Meeting of the Working Group \(ICG WG Enhancement of GNSS Performance, New Services and Capabilities\), 8 June 2016, Vienna, Austria](#)
 - Space Service Volume, Space Weather (Examine the performance of atmospheric models to correct single frequency measurements; To identify how GNSS can better support the advancement of Space Weather/RS products and vice versa)
- [United Nations/Nepal Workshop, 5 – 9 December 2016, Kathmandu](#)
 - **ICG Seminar: Space Weather and its effects on GNSS**
 - Part I: General space weather phenomena
 - Part II: Ionospheric physics and how the ionosphere affects GNSS signals under quiet and disturbed conditions
 - Part III: Illustrate the effects that space weather has shown on GNSS systems and applications



Towards UNISPACE+50 in 2018

- **2018** marks the 50th anniversary of the first UN Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE), held in Vienna in 1968
- **UNISPACE+50 will articulate a long-term vision for Space:** from a domain of States towards a domain of a commonly shared human experience

High Level Forum on Space as a driver for socio-economic sustainable development, 20 – 24 November 2016, Dubai, United Arab Emirates

- The Forum aims to become a platform for providing updates and recommendations on the potential of space innovations to address new and emerging sustainable development challenges
- The Forum seeks to address the cross-sectoral benefits of integrating economic, environmental, social, policy and regulatory dimensions of space in pursuance of global sustainable development

Thank you

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