International Committee on GNSS: Space Weather

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Space weather monitoring using low-cost receiver system

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- Exploring low-cost GNSS receivers that satisfies space weather needs both in terms of scintillation and total electron content
  - *any receiver that is capable to output raw data*
  - *dual frequency receiver*
  - *cost (less than $1000, including antenna and data logging system)*

- *N.B.: No preferences of whatsoever on any brand/name. The examples are based on the selection criteria.*

	e.g., U-Blox F9P	e.g. Septentrio MOSAIC
GNSS	GPS, GLONASS, Galileo, BeiDou, QZSS, SBAS	
Frequency Bands	L1, L2, E5b	L1, L2, L5
Raw Data	Code Phase, Carrier Phase, Doppler, Signal quality related data	
Navigation Frame Data	Yes, including data bits	
Output Rate	Max 20Hz	Up to 100 Hz for Measurement 50Hz for RTK
RTK / PPP Capable	Yes	
TEC Computation	Yes	
S4 Computation	(is being currently studied)	
Price ($)	300	700

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- Exploring software that could be used to process data from low-cost GNSS receivers in order to compute TEC, scintillation and other space weather related parameters
  - FLEURY (*Matlab source files to compute TEC parameter provided by R. Fleury, France*): Tested with sample observation data files. STEC, VTEC and ROTI from GPS observation data in RINEX file format were computed
  - NeQuick (*free download* https://www.itu.int/rec/R-REC-P.531-14-201908-I/en)

- United Nations Workshop on ISWI, June 2023, Vienna
  - (ICTP) Performance in estimating TEC is *comparable to those of geodetic/scientific grade receivers and can therefore be used to monitor the ionosphere*
  - *(The University of Tokyo) Data formats and processing algorithms shall be standardized for uniform results*
  - *(Boston College) Space weather monitoring implies TEC and scintillation (both phase and intensity), and the preliminary results are promising. Full analysis of performance including tracking and other characteristics are in progress*

https://www.unoosa.org/oosa/en/ourwork/psa/schedule/2023/2023-iswi-workshop_presentations.html

Space weather monitoring using low-cost receiver system

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- Design a prototype low-cost GNSS receiver for space weather related applications
  - Design low-cost GNSS receiver system for unattended data logging

- Explore different types of configurations

- Requirements
  - The system shall be able to Log raw data when power is connected
  - Recover all setups including network information when the receiver is rest or power supply is turned off and on
  - Connect remote server automatically
  - Log raw data locally in a SD card

ICG Programme on GNSS applications

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- 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. ISWI 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.

- International Space Weather Initiative (ISWI)

  ISWI has proved to provide a framework for collaboration among teams of scientists, serving as an example of international work in instrument operation, data collection and analysis and the publication of scientific results.

- Cooperation ICG, ICTP and Boston College

  Provide training courses: focusing on the use of SW instruments for scientific research and for SW effects

International Space Weather Initiative

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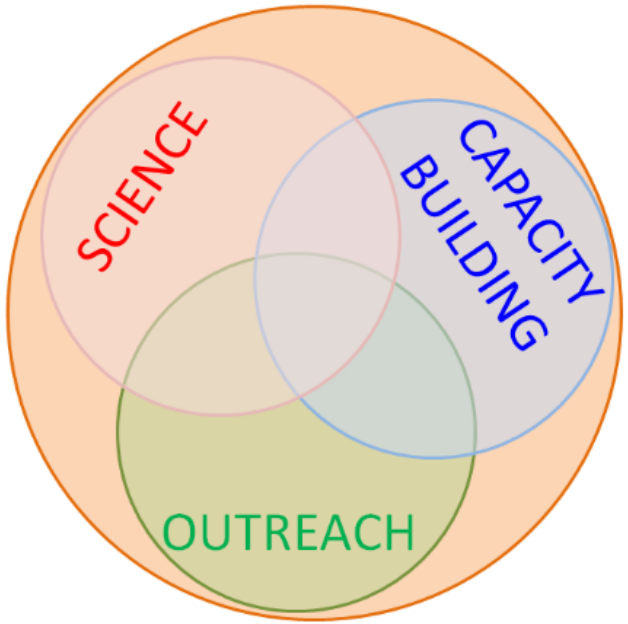
- Science: deploying space weather instruments, obtaining data, data analysis, and publishing results.
- Capacity building: training PhD students and young scientists to work on space weather data via workshops and advanced schools. ISWI runs monthly webinars given by international experts in space weather.
- Outreach: teaching teachers to take space weather material to school students; ISWI scientists giving public lectures in the vicinity of capacity building venues.



http://www.iswi-secretariat.org/

ISWI Instruments

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- ISWI helps deploying low-cost instrument networks in developing countries. These include networks of magnetometers, GNSS receiver, ionospheric instruments, atmospheric sensors, radio telescopes, and energetic particle detectors.

- Instrument leads from developing countries work with students and scientists of developing countries to establish long-lasting collaborations to advance space weather.

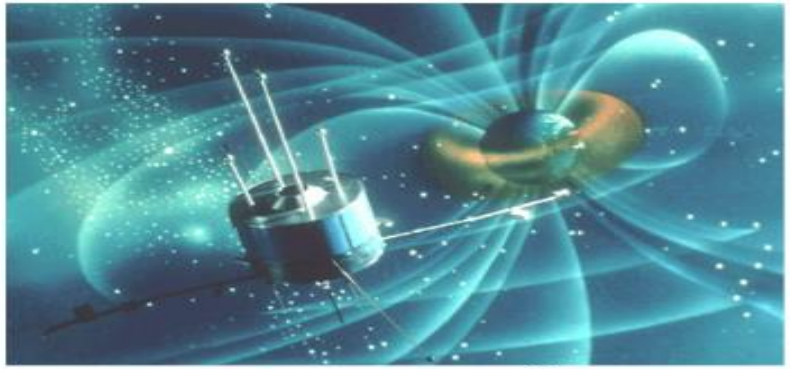
- ISWI has established open data policy and rules of the road in utilizing the data from ISWI instruments. ISWI data are combined with data from space missions to study space weather events.

Space Weather Effects on Society – The Big 3 !

- Damage to Electric Power Grids
  - Changes in the magnetic field can produce surges in power lines and transformers.
  - National Academies Report 2009 – estimated the impact of a space weather induced grid collapse to be ~$1trillion dollars

Damage to power grids.

- Damage to Satellites
  - Energetic ions can damage solar panels
  - Energized plasmas can cause electrical charges that can damage the electronics
  - Increase satellite drag
  - Economic value of satellite enterprise >$100Billion



Damage to satellites.

- Health Risks due to Radiation Hazards
  - Exposure at high altitudes
  - Astronauts
  - High flying jets
  - Crews/passengers flying over the poles
  - Redirecting these flights can cost $100,000+
  - What about space travel – mission to Mars???

Radiation exposure.

Thank you

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