International Committee on GNSS

Recent Developments

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Office for Outer Space Affairs

Committee on the Peaceful Uses of Outer Space

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Some of the key themes:

Space Debris	Long-term Sustainability	Small satellites / Constellations
Space Traffic Management	Space Resources	GNSS
Space weather	Near-Earth Objects	Global health

Meetings:

- **Scientific and Technical Subcommittee**
  - *ISWI Steering Committee, ICG WG meetings*
- **Legal Subcommittee**
- **Committee on the Peaceful Uses of Outer Space**
  - *ICG Providers' Forum Meeting*

Exec. Secretariat to Int'l Committee on GNSS

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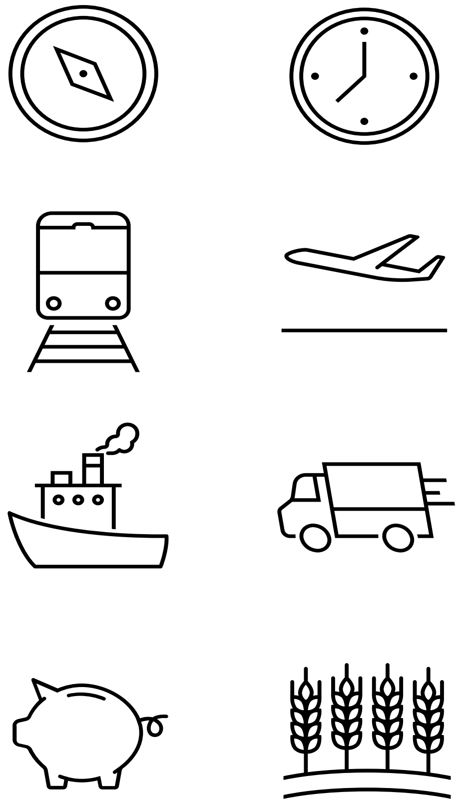
Key responsibilities:

Executive Secretariat
Int'l Committee on GNSS (ICG)
• ***Est. 2005***, annually
• Voluntary cooperation, coordination, promoting utilization ***of multiple GNSS signals***
4 Working Groups
• Systems, Signals, Services; Enhancement of GNSS Performance, New services and capabilities; ***Information & Capacity-building;*** Reference Frames, Timing and applications
Provider's Forum
• ***Compatibility & interoperability***

Capacity Development
GNSS
• ***Workshops***; 2001, annually
• Education Curriculum
Space Weather
• ***Workshops***; 2012, annually



International Committee on GNSS

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The ICG is an **important vehicle** in the multi-lateral arena, as satellite-based positioning, navigation and timing becomes more and more a **genuine multinational cooperative venture**.

- Encourages **coordination** among GNSS providers
- Promotes the introduction and **utilization** of GNSS services **in developing countries**
- **Assists GNSS users** with their development plans and applications
- **Assure** GNSS **interoperability and compatibility** among providers and users globally for enhanced services and applications

Open to all countries and entities that are either GNSS providers or users of GNSS services, and are interested and willing to actively be engaged in ICG work

ICG International Committee on Global Navigation Satellite Systems

ICG: Working Groups

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- **Systems, Signals and Services** (*United States & Russian Federation*): Compatibility and spectrum protection; interoperability and service standards; system-of-system operations

- **Enhancement of GNSS Performance, New Services and Capabilities** (*India, China & ESA*): Future & novel integrity solutions; implementation of interoperable GNSS Space Service Volume (SSV) examination of performance of atmospheric models, *establish dialogue with space weather*/RS communities and its evolution;

- **Information Dissemination and Capacity Building** (*UNOOSA*): Focused on education and training programmes, promoting GNSS for scientific exploration (incl., *space weather and its effects on GNSS*)

- **Reference Frames, Timing and Applications** (*IAG, IGS & FIG*): Focused on monitoring and reference station networks

ICG: Working Groups Recommendations

- The incorporation of resilience into GNSS interference detection and mitigation and consideration of the reinforcement of IDM policy based on a three-prong approach (*service, hardware and end-user*)
- The coordination of GNSS and lunar positioning, navigation and timing systems for lunar operations
- The inclusion and coordination of lunar search and rescue capabilities in lunar positioning, navigation and timing architecture
- (*recognized*) The potential impact that the rising solar activities of the 25th solar cycle could have on GNSS services and satellites. Further discussions among experts should be conducted through workshops to *understand the possible impact of space weather events and the need for alert systems*
- The creation of a task force on the applications of GNSS for disaster risk reduction

Incorporating Resilience Into GNSS Interference Detection and Mitigation (IDM)

To increase critical infrastructure resilience to GNSS disruptions and interference, the ICG recommends that Provider IDM Policy should reinforce the need for system resilience based on a three-prong approach

- (*Provider Aspect*): GNSS spectrum protection, enforcement and implementation of IDM capabilities
- (*Hardware Aspect*): PNT systems designed with resilient architectures and systems incorporating cybersecurity principles for holistic approach to threats; and operational resilience
- (*End User Aspect*): Operators plan for and know how to respond to, withstand, operate through and recover from PNT disruptions and interference, as well as understand and minimize the impact of PNT disruptions in downstream systems

GNSS Interference and Spectrum Protection

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Educational Seminars and Workshops (WG S)

- *Usage:* There are an almost unlimited number of different GNSS applications; and GNSS is extremely important and critical to national and global economies
- *Vulnerability:* GNSS signals are extremely weak in comparison to typical terrestrial radio services, and GNSS signal reception vulnerable to interference from those terrestrial services
- *Threats:* There are many potential interference sources that can degrade GNSS performance and prevent GNSS usage, and GNSS Jammers are currently the single biggest threat to GNSS reception
- *Spectrum Protection:* Starts with good foundations, the ITU; but it is crucial to protect GNSS spectrum at BOTH international and national levels
  - Compatibility analysis is essential before introducing new systems and/or changing regulations and allocations – especially near GNSS frequency bands
- *Interference Detection:* The ITU provides the regulatory framework (Radio Regulations), but it is national regulators that play the key role in finding interferers to GNSS

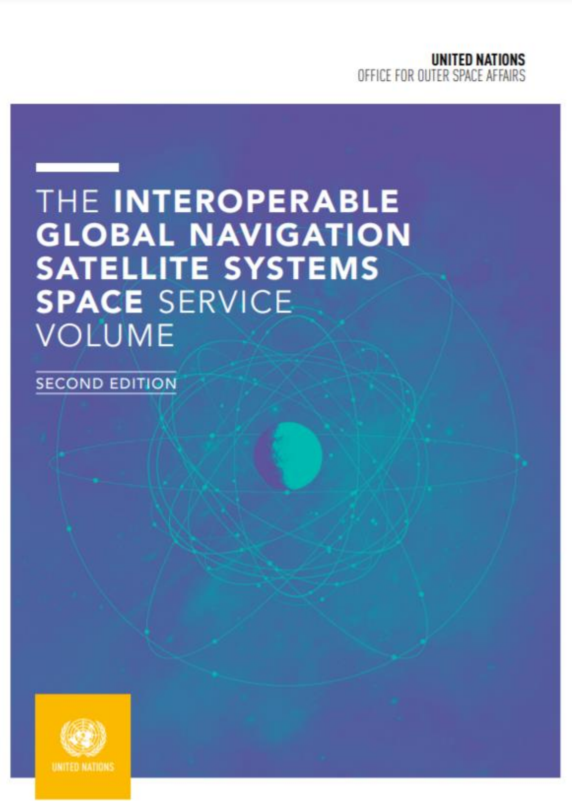
https://www.unoosa.org/oosa/en/ourwork/icg/working-groups/s/idm10.html

Enhancement of GNSS Performance, New Services and Capabilities (WG B)

Inclusion and Coordination of Lunar Search and Rescue in Lunar PNT Architecture

Encourages GNSS providers and lunar PNT developers to work together in order to

- Ensure the future attainment of an **interoperable, compatible and available** PNT system of systems that can support the worlds ever-expanding human and robotic space operations around and on the surface of the moon
- ICG will analyse planned lunar PNT systems and their interactions with GNSS and propose recommendations that may be taken up by GNSS providers and lunar PNT developers



The collaborative efforts of ICG, including the GNSS SSV initiative, serves as a model for this international exploration initiative

https://www.unoosa.org/res/oosadoc/data/documents/2021/stspace/stspace75rev_1_0_html/st_space_75rev01E.pdf

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

Space weather monitoring using low-cost receiver system

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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

The Applications of GNSS for Disaster Risk Reduction (WG D/WG B)

- Natural hazards *generate atmospheric waves.*
- These waves *propagate through the atmosphere* (up to the ionosphere), and *cause perturbations along the way*.
- These perturbations can be detected using *various GNSS-based remote sensing techniques*, at *next-to-no cost*, in *near-real-time*, and with a *worldwide coverage*.

technique	probing region	relevant to
GNSS Reflectometry	surface conditions (soil moisture)	earthquakes storms floods tsunamis wildfires volcanic eruptions ***solar storms*** ***CMEs***
GNSS Radio Occultation (RO)	surface to mid-stratosphere (temperature + moisture)	
GNSS Polarimetric RO	surface to mid-stratosphere (temp. + moist. + heavy precipitation)	
GNSS-Based Ionospheric TEC	***ionosphere (100-1500 km) (Total Electron Content - TEC)***	

Objective: use GNSS to **augment monitoring capabilities and early warning systems** for natural hazards.

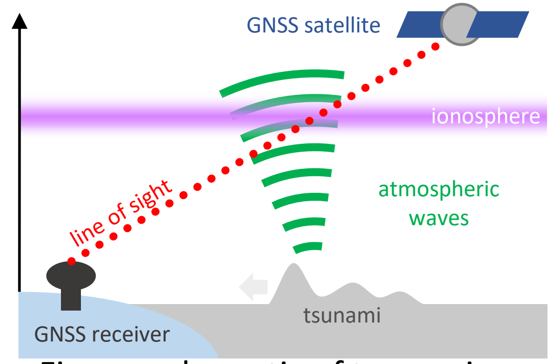


Figure: schematic of tsunami-induced atmospheric waves and ground-based GNSS measurements.

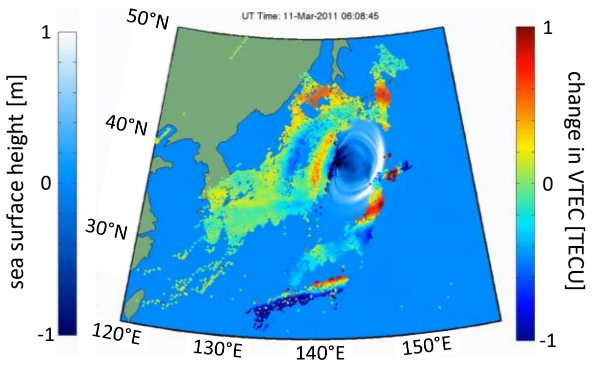


Figure: Ionospheric TEC and sea surface height map for the 2011 Tōhoku-Oki event (Galvan *et al.*, 2012).

jpl.nasa.gov

Publications

In 2022, humanity crossed a symbolic milestone as the world's population reached 8 billion. Science has been among the main drivers of this growth, gradually increasing the human lifespan thanks to advances in public health, water, sanitation and hygiene, and nutrition, among many others. There are 8 billion stories, minds, bright ideas and new perspectives, all waiting to leave their mark in improving life on our cosmic spaceship – planet Earth (UNOOSA-EUSPA).

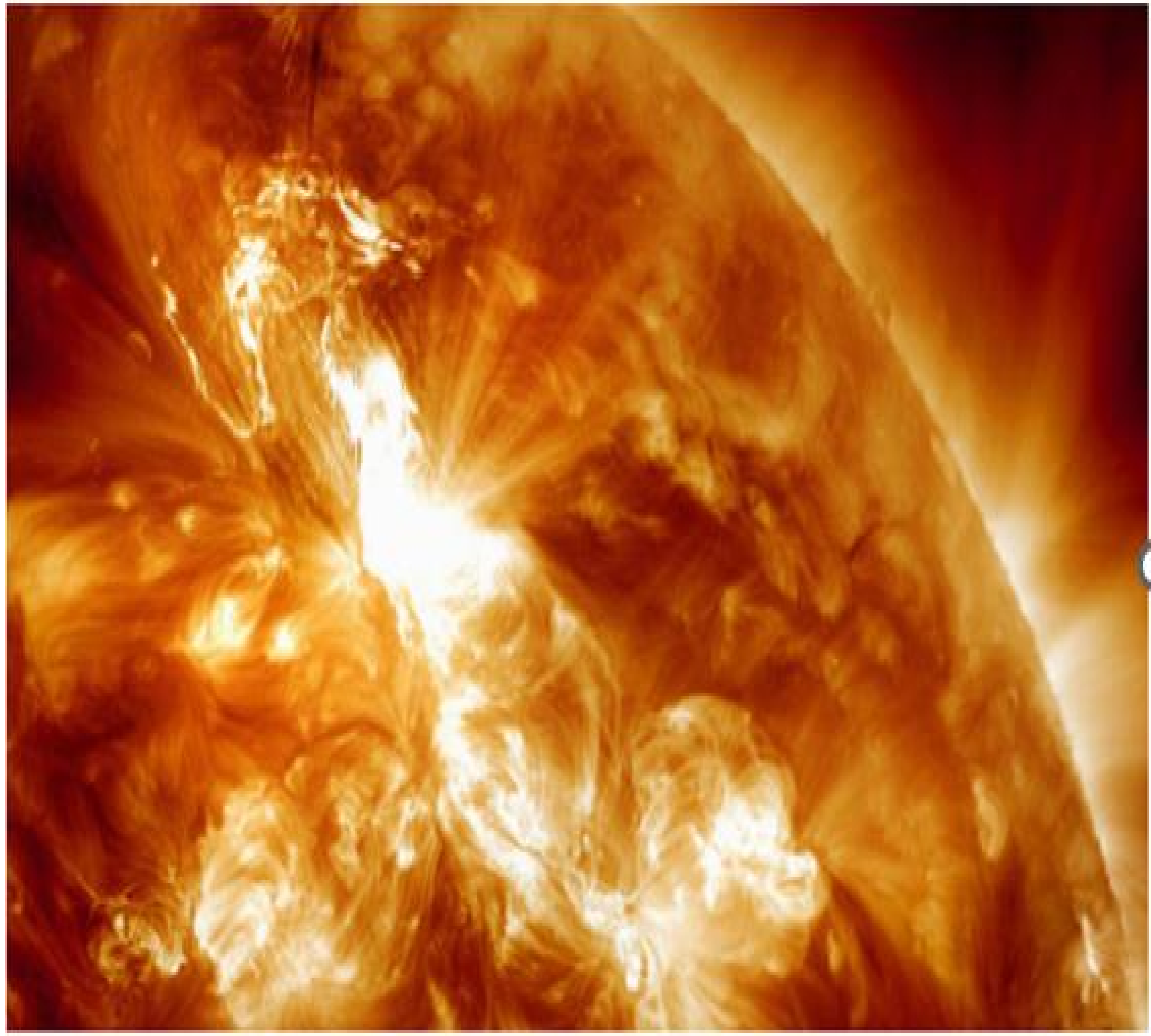
https://www.unoosa.org/res/oosadoc/data/documents/2023/stspace/stspace85_0_html/st_space_085E.pdf

Conclusion

- ***GNSS*** is a cost-effective and ubiquitous technology for discovering, characterizing, monitoring (and mitigating) key space weather impacts

- ***Space weather*** is so critical because we are more dependent on space-based technology than ever before

- ***The activities and opportunities provided through UNOOSA/ICG*** result in the development and growth of capacities that will enable each country to enhance its knowledge, understanding and practical experience in those aspects of GNSS technology that have the potential for a greater impact on its economic and social development, including the preservation of its environment



A solar flare erupting from the sun. Photo: AP Photo/NASA

17th meeting of ICG

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Hosted by the
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in collaboration with the
Spanish Presidency of the EU

15 – 20 October 2023, Madrid

Thank you

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