IGS Constellations

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Updates on the Applications of GNSS for Disaster Risk Reduction

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Figure 1: Subset of the group photo during the Tour de l'IGS Fifth Stop.

Innovations in geodesy continue to push the boundaries of current applications, especially as advances in GNSS reveals its important role in remote sensing and Earth observations for disaster risk reduction. In the last year, the International GNSS Service (IGS) has worked extensively with partner groups in the United Nations International Committee on GNSS (ICG), Group on Earth Observations (GEO) Geodesy4Sendai Pilot Initiative, International Association of Geodesy (IAG) Global Geodetic Observing System (GGOS) Geohazards Focus Area, and International Union for Geodesy and Geophysics (IUGG) Georisk Commission to support three major events coordinating international collaborations for the applications of GNSS for Disaster Risk Reduction (DRR).

The IGS' "Tour de l'IGS" mini-workshop series, a collection of community-based capacity development seminars on a wide variety of GNSS-related topics, recently collaborated with the GEO Geodesy4Sendai Pilot Initiative to hold a virtual event on applications of GNSS for understanding and monitoring natural hazards in the South Pacific. This workshop commemorated the catastrophic 2022 volcanic eruption in Tonga, with speakers from the region reflecting on recent efforts to use geodetic data and geodesy-enabled information to inform disaster risk reduction policies in the South Pacific. As with all Tour de l'IGS iterations, the presentations and resources are available on the IGS.org website as well as our YouTube channel[1]

During the workshop, all speakers noted that the sharing of real-time/near-real-time data, practical knowledge, and software are paramount in developing disaster risk reduction techniques. In particular, John LaBrecque further insisted that Pacific GNSS-based Tsunami Early Warning Systems require improved, persistent, and maintainable GNSS infrastructures. Pragmatically speaking, Sobolev et al. [2017] inform that 1200 receivers are needed around the Pacific Ring of Fire in order to accurately monitor crustal displacements. LaBrecque added that only 500 receivers would be needed for monitoring the ionosphere; they do not require geodetic bracing, but they would need to track multi-GNSS signals.

In terms of tsunamis, Shunichi Koshimura underlined the importance of real-time modelling capabilities, which provide the most reliable and up-to-date forecasts, especially since the configuration of the coastal infrastructures change with time. Koshimura highlighted GSI's REGARD[2], which can rapidly provide the heterogeneous fault model for megathrust earthquakes. He also reported that Japan's high-performance computing capabilities can provide a 6-hour inundation forecast within 3 minutes, especially

[1] The recording and presentations are available at https://igs.org/tour-de-ligs/presentations#5th-stop-presentations.
[2] Geospatial Information Authority of Japan Real-time GEONET Analysis system for Rapid Deformation monitoring

Figure 2: Tsunami Evacuation Route Sign in Fiji. (Credit: Allison Craddock)

leveraging their "disaster mode" (which suspends other jobs in favour of disaster-related operations). Finally, he remarked that mapping products (e.g., inundation depth, exposed population, etc.), are extremely useful to the communities, but are not sufficiently well deployed by tsunami forecast services.

Viliami Folau and Andrick Lal reported key concerns affecting especially Pacific island nations. Indeed, those countries are among the most vulnerable regions when it comes to natural disasters: Folau reports that Tonga has experienced 115 tsunamis since 1900, and Simon McClusky added that the Pacific region accounts for almost 70% of all tsunamis around the world. In addition, Folau and Lal pointed out that the impact of disasters is particularly severe because islands remain rather unprepared and lack tsunami early warning systems. Furthermore, this is worsened by sea level rise, and the steady sinking of Tongan lands (7 mm/yr). Finally, Folau reported that the Pacific island nations are lacking in GNSS experts, and that the Tongan king, Tupou VI, encouraged the use of satellite-based technologies to improve the safety of the kingdom. Lal reminded the audience that the advantages of adding GNSS stations is two-fold: it enhances geodetic efforts, but also supports other areas of research critical for Pacific communities (sea level rise, oceanography, maritime boundaries, tide calendars, etc.).

McClusky reported that the accuracy of TEWS currently hinges on the accuracy of earthquake source determination, which is subject to assumptions and is only a proxy of the tsunami itself. He added that direct observations of tsunamis are generally very sparse, and argued in favour of acquiring those. He also presented cubesat-based radio occultation measurements taken after the 2022 Tonga eruption, highlighting further the global effect of such a disaster.

Finally, Elisabetta d'Anastasio underlined that the rapid source estimation for a given earthquake is possible using GNSS-based real-time products (e.g., peak ground displacement, PGD). She reported that New Zealand's GeoNet, a multi-domain geophysical network, already makes a broad variety of geodetic data publicly available, which is in line with the government's long-established open data policy. In terms of innovative monitoring capabilities, d'Anastasio pointed to Fournier et al. [2014], who argue that the signal-to-noise ratio of ground-based GNSS signals, given a line of sight passing over a volcano, can give near-real-time information about the contents of a volcanic plume.

It is important to note that, under the aegis of the United Nations Office for Outer Space Affairs (UN OOSA), the International Committee on GNSS (ICG) recommended in October 2022 the creation of a Task Force on "Applications of GNSS for Disaster Risk Reduction"[3]. Currently co-chaired by IGS, China, and Japan, the Task Force's main goals[4] are to (1) develop recommendations and (2) develop and catalogue existing operational tools for natural hazards monitoring. Its scope remains very broad, covering many GNSS techniques and several types of natural disasters. Relying on monthly meetings, it will work toward enhancing existing GNSS-based augmentations to early warning systems; in particular by leveraging real-time capabilities, improving processing for precise point positioning, and developing ionospheric monitoring techniques.

Likewise, John LaBrecque[5] assembled "GTEWS for Oceania" (GNSS-based Tsunami Early Warning Systems), an ad-hoc working group. Its focus is on tsunamis, the most threatening hazard for Oceania and in particular the geographically-vulnerable island nations of the South Pacific. This group advocates for the significant improvements to TEWSs that GNSS can provide. Initial efforts of this group also formed the foundation for geodetic contributions to the International Telecommunications Union (ITU), the World Meteorological Organization (WMO), and the United Nations Environment Programme (UNEP) focus Group on Artificial intelligence for Natural Disaster Management (FG_AI4NDM)[6], which examined how AI can be used in geodesy to detect tsunamis and avoid issues around sensitive data crossing national borders.

As efforts to enhance tsunami early warning systems with the unique powerful capabilities of GNSS-based monitoring continue to grow in the IGS as well as in its partner organisations, new contributions and active members to the groups introduced above are always welcome. In support of these efforts, IGS will be hosting the consolidated "GNSS4DRR" mailing list for these topic groups. To join any of these groups, or subscribe to updates on this topic, please visit https://forms.gle/nAQb7oGAuMGirGxv6.

[3]See paragraph #38 in ICG-16's Joint Statement (https://www.unoosa.org/documents/pdf/icg/2022/ICG16/ICG-16_JointStatement.pdf) and ICG WG-D's recommendation #26 (https://www.unoosa.org/documents/pdf/icg/2022/ICG16/ICG-16_WG-D_Recommendation.pdf).
[4]See the ICG DRR TF terms of reference (https://drive.google.com/file/d/17LBLn_hagK0dQy1G1qDkx2ZNluk6Ss2r).
[5]Chair of the GEO Geodesy4Sendai Pilot Initiative, GGOS Geohazards Focus Area, and IUGG Georisk Commission
[6]"Artificial Intelligence for Disaster Risk Reduction: Opportunities, challenges, and prospects" World Meteorological Organization Bulletin Vol 71(1)-2022 https://public.wmo.int/en/resources/bulletin/artificial-intelligence-disaster-risk-reduction-opportunities-challenges-and

Regional Network Spotlight: IGS Collaboration with SIRGAS

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SIRGAS (Geodetic Reference System for the Americas) provides the continental geodetic infrastructure necessary for the administration, generation, management, and all exchange of geospatial information in member states of the Americas. SIRGAS disposes of nearly 500 continuously operating GNSS (Global Navigation Satellite System) geodetic stations distributed throughout the continent, which define SIRGAS-CON (Continuously Operating Network) geodetic network. Its solutions are aligned with ITRF (International Terrestrial Reference Frame) through the current IGS (International GNSS Service) frame, thus beginning the densification of ITRF. It currently consists of 493 GNSS stations installed from the North to the South, from Alaska to Antarctica, and from the East to the West, from Africa to Polynesia, being the largest regional RF in the world. The network processing follows the IERS standards and IGS standards.

The relationship between IGS and SIRGAS is essential for both organizations. On the one hand, SIRGAS provides the necessary geodetic infrastructure so that the IGS can generate its products. On the other hand, IGS calculates orbits, clock parameters, ERP, and reference frames, which are essential to developing SIRGAS products: geometry data, vertical datum, and atmospheric studies. The above allows us to democratize geodesy in the continent, where the countries' effort places the region at an excellent level.

The SIRGAS network currently has 493 stations, of which 109 are part of the IGS Network (see figure 3).

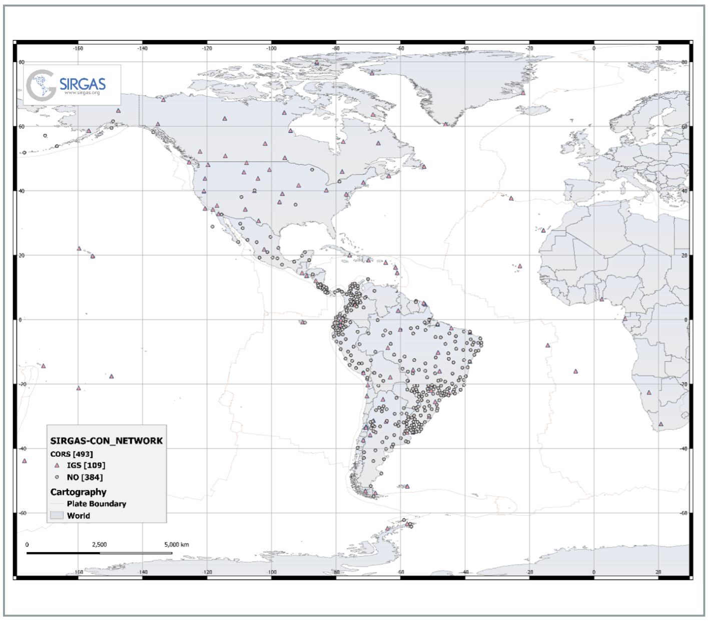
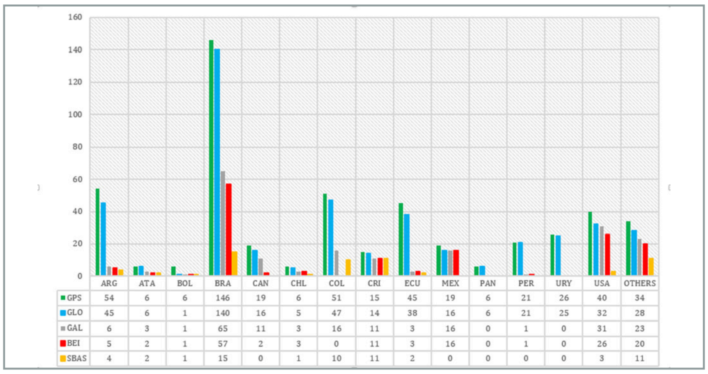


Figure 3: Stations in the IGS and SIRGAS networks.



	ARG	ATA	BOL	BRA	CAN	CHL	COL	CRI	ECU	MEX	PAN	PER	URY	USA	OTHERS
GPS	54	6	6	146	19	6	51	15	45	19	6	21	26	40	34
GLO	45	6	1	140	16	5	47	14	38	16	6	21	25	32	28
GAL	6	3	1	65	11	3	16	11	3	16	0	1	0	31	23
BEI	5	2	1	57	2	3	0	11	3	16	0	1	0	26	20
SBAS	4	2	1	15	0	1	10	11	2	0	0	0	0	3	11

Figure 4: Constellations tracked by SIRGAS-CON, per country.

Of the 493 stations that conform to SIRGAS-CON, 100% track GPS, 89% track GLONASS, 83% track BDS, 42% track Galileo, and 25% track the Australian SBAS (see figure 4).

SIRGAS-CON is processed weekly to obtain the following products related to the geodetic RF:

1. "loosely constrained weekly solutions" generated by the IGS-RNAAC-SIR to be combined with the "IGS (International GNSS Service) global solutions."
2. "weekly station solutions": The alignment of loosely constrained weekly solutions to the current IGS frame, IGb20, generates weekly solutions for the SIRGAS-CON stations.
3. Multiannual solutions: This product has been developed by the IGS-RNAAC-SIR approximately every two years, generating a cumulative solution from the loosely constrained weekly solutions. It allows for evaluating and analyzing the kinematics of the RF SIRGAS through constant positions and speeds of the stations. Multi-year solutions have made it possible to calculate several VEMOS (Velocity Model for SIRGAS) versions of the deformation model.
4. Tropospheric delay.

Our current goal is to have at least one IGS station in each country, that is at least, since the size of SIRGAS is almost half the world, so we aspire to strengthen the collaboration with IGS (infrastructure, solutions, real-time, and others), always with the idea of bringing geodesy closer to people.

Figure 5: TEJA00CHL station, in process to include in IGS.

Welcome the new IGS Central Bureau Deputy Director Dr. Léo Martire!

CB Deputy Director, IGS
Research Technologist, JPL
Pasadena, CA, USA

I am a scientist by trade, originally trained in applied mathematics and with experience in planetary atmospheric sciences. After working on seismoacoustics and infrasound, I moved up in the atmosphere to ionospheric remote sensing, which served as my introduction to GNSS and geodesy.

Joining the Central Bureau (CB) allowed me to develop administrative and outreach skills I always sought to explore. My parallel role, as a Research Technologist at the Jet Propulsion Laboratory (Pasadena, USA) enables an additional and constant scientific input feed to the CB. This synergy adequately reinforces my role as one of the IGS representative to the United Nations' International Committee on GNSS, where I have the chance to co-chair a Task Force on disaster risk reduction.

It is truly an honour to be able to make a contribution to the geodesic community through serving on the IGS Central Bureau. I am very much looking forward to working with as many of our international collaborators as possible, on even more exciting prospects in the coming years.

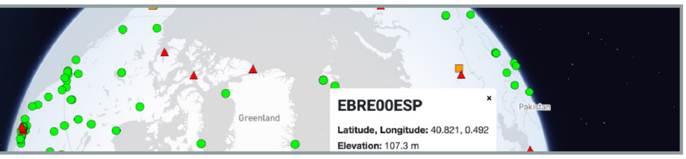
Welcome to our new Governing Board Members!

- **Sylvain Loyer, CNES** - Analysis Center Representative
- **Axel Rülke, BKG** - Real-Time Working Group Chair
- **Ryan Keenan, Positioning Insights** - FIG Representative
- **Patrizia, Tavella, BIPM** - BIPM representative

Thank you to our outgoing Governing Board Members!

- **Felix Perosanz, CNES** - Governing Board Chair
- **Suelynn Choy, RMIT** - FIG Representative
- **André Hauschild, DLR** - Real-Time Working Group Chair
- **Ignacio Romero, CSC** - RINEX Working Group Chair
- **Tim Springer, PosiTim** - GNSS Monitoring and Satellite Vehicle Orbit Dynamics Working Group Chair
- **ZHAO Qile, Wuhan University** - Appointed Member

IGS SLM and Network Upgrades Now Available!



On the 3rd of April 2023, the IGS Central Bureau launched a new and improved IGS Site Log Manager (SLM 2.0) and IGS Network visualization system (Network 2.0)!

The Network 2.0 can be accessed at a NEW URL https://network.igs.org and features the latest technology, a new and improved single-page layout, a new state saving feature, and improved interactive map, customizable station list/table, access to additional station information, and station filtering options.

IGS station operators can access the SLM 2.0 at https://slm.igs.org. Key new features include a new and improved user interface, use of the latest technology, an improved editing and validation, a new alerts feature, and a new list/map view.

To learn more about the upgrades, visit the news page: https://igs.org/news/slm-network-upgrades-available/

Upcoming Events

23-28 April 2023
EGU General Assembly 2023

24-26 May 2023
EUREF 2023 Symposium

27 May - 1 June 2023
FIG Working Week 2023
FIG Reference Frames in Practice Seminar

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