Welcome to the Tour de l’IGS 5th Stop

GNSS for Natural Hazards in the South Pacific

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Outline

• Disaster Risk Reduction
• GNSS Techniques
  • GNSS-TEC Examples
    • 2022 Tonga Volcanic Eruption
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# Disaster Risk Reduction

**UN Office for DRR:** “preventing new and reducing existing disaster risk and managing residual risk”.

<table>
<thead>
<tr>
<th>Disaster</th>
<th>Risk</th>
<th>Reduction</th>
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<tbody>
<tr>
<td>earthquakes</td>
<td>human casualties</td>
<td>prevention <em>(do not create risk)</em></td>
</tr>
<tr>
<td>storms</td>
<td>community health concerns</td>
<td>prediction capabilities</td>
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<tr>
<td>floods</td>
<td>infrastructure damage</td>
<td>early warning systems</td>
</tr>
<tr>
<td>tsunamis</td>
<td>power grid damage</td>
<td>rapid response techniques</td>
</tr>
<tr>
<td>wildfires</td>
<td>positioning systems disruptions</td>
<td></td>
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<tr>
<td>solar storms</td>
<td>economic losses</td>
<td></td>
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<tr>
<td>coronal mass ejections</td>
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GNSS Techniques

**GNSS-based techniques** enable the (remote) sensing of the whole surface-atmosphere system. **Objective:** use GNSS to augment early warning systems for natural hazards.

<table>
<thead>
<tr>
<th>technique</th>
<th>probing region</th>
<th>relevant to</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNSS Precise Point Positioning</td>
<td>ground displacements (3D position of the receiver)</td>
<td>earthquakes, storms, floods</td>
</tr>
<tr>
<td>(GNSS-PPP)</td>
<td></td>
<td>volcanic eruptions, CMEs</td>
</tr>
<tr>
<td>GNSS Reflectometry (GNSS-R)</td>
<td>surface conditions (e.g., soil moisture, ice thickness)</td>
<td>tsunamis</td>
</tr>
<tr>
<td>GNSS Radio Occultation (GNSS-RO)</td>
<td>surface to mid-stratosphere (40 km) (temperature + moisture)</td>
<td>wildfires</td>
</tr>
<tr>
<td>GNSS Polarimetric RO (GNSS-PRO)</td>
<td>surface to mid-stratosphere (40 km) (temperature + moisture + heavy precipitation)</td>
<td>solar storms</td>
</tr>
<tr>
<td>GNSS Ground-Based Ionospheric TEC (GNSS-TEC)</td>
<td>ionosphere (100-1500 km) (Total Electron Content - TEC)</td>
<td>CMEs</td>
</tr>
</tbody>
</table>

GNSS Precise Point Positioning (GNSS-PPP) allows for precise positioning, which can be used to monitor ground displacements. GNSS Reflectometry (GNSS-R) can measure surface conditions, such as soil moisture and ice thickness. GNSS Radio Occultation (GNSS-RO) provides information about the surface to mid-stratosphere, including temperature and moisture. GNSS Polarimetric RO (GNSS-PRO) can detect conditions relevant to GNSS Reflectometry (GNSS-R), such as soil moisture and ice thickness. GNSS Ground-Based Ionospheric TEC (GNSS-TEC) monitors the ionosphere, which is crucial for understanding solar storms and CMEs.
Example Cases - 2022 Tonga Volcanic Eruption

Ionospheric signals appear as soon as \(~15\) minutes after the onset of the event.

Background: Total Electron Content map (2-min. resolution, 1000 sites worldwide).

Foreground: Filtered TEC (individual links, periods < 60 min.).

Ionospheric signals:
A. strong depletion,
B. shock wave, and
C. enhanced ionospheric activity (depletion recovery + gravity waves).
Example Cases - 2023 Turkey Earthquakes

GNSS-based monitoring (TEC and Precise Point Positioning) captured signals in (near-)real-time.

Note that no technique can provide an early enough warning for epicentral effects. GNSS-based techniques are valuable for far-field hazards and applications.

Figure: Ionospheric TEC time series captured in near-real-time (< 10 min. latency) by JPL’s GUARDIAN system (Martire et al., 2023, 10.1007/s10291-022-01365-6).

Figure: Ground displacement time series captured in real-time by JPL’s GREAT Alert System (credit: GREAT Alert team), for event us6000jllz ($M_w = 7.8$). Delays (2 min, 2.5 min, 3.5 min) = seismic wave propagation.
ICG Task Force: Applications of GNSS for Disaster Risk Reduction

Created in October 2022 by the International Committee on GNSS, based on a lack of international coordination on topics at the intersection of GNSS applications and disaster risk reduction.

Chairs: IGS + China + Japan.

Goals: develop international collaborations, recommendations, and policies; establish science connections to the relevant strategic plans; and facilitate the development of GNSS-based operational tools for early warning systems.

Kick-Off Meeting: February 28th, 2300-0000 UTC.

If interested, please contact us at leo.martire@igs.org and/or craddock@igs.org.
Workshop Guidelines

Please make sure you are using a first and last name, turn off your camera and microphone, use the “Raise Hand” feature or the chat to ask questions, and follow the IGS Code of Conduct (see reminder email and next slide).

Note that this meeting is recorded and will be made available on the International GNSS Service’s YouTube Channel (https://www.youtube.com/user/igsorg).

An online “group picture” will be taken just before the break.
Code of Conduct

Expected Behavior

- All participants are treated with respect and consideration, valuing a diversity of views and opinions.
- Act demonstrably in the best interest of the whole of the IGS and its strategic objectives and values.
- All participants should consult the pre-meeting reading prior to joining the meeting.
- Be considerate, respectful, and collaborative. Do not speak over others, and avoid monopolizing the discussion.
- Communicate openly with respect for others, critiquing ideas rather than individuals, organizations or countries/regions.
- Participants should feel able to ask questions without being discouraged, as well as respectfully and constructively challenge discussion points.
- Avoid personal attacks directed toward other participants.
- Anyone requested to stop unacceptable behavior is expected to comply immediately. Staff may take any action deemed necessary and appropriate, including immediate removal from the meeting without warning or refund.

Unacceptable Behavior

- Harassment, intimidation, or discrimination in any form will not be tolerated.
- Abuse of any participant. Examples of unacceptable behavior include, but are not limited to, purposely disrupting discussions and/or talks, verbal comments related to gender, sexual orientation, disability, physical appearance, body size, race, religion, national origin, geopolitical ideals, inappropriate use of nudity and/or sexual images in public spaces or in presentations, or threatening or stalking any participant.
- Disruptive behavior and/or interruption of discussions, presentations, sessions, or events.
- Any retaliation for reporting harassment or reporting an incident in bad faith.

Reporting Unacceptable Behavior

- If you are the subject of unacceptable behavior or have witnessed any such behavior, please immediately notify the IGS Central Bureau and the workshop organizers.
- Notification should be done by contacting a staff person on site or by emailing your concern to cb@igs.org and workshop@igs.org.
Tour de l’IGS 5th Stop Agenda

All times are UTC.

2140-2200 John LaBrecque  
   GNSS Tsunami Early Warning for the South Pacific

2200-2220 Shunichi Koshimura  
   A nation-wide tsunami inundation and damage forecast system in Japan

2220-2240 Viliami Folau  
   GNSS Infrastructure and Technologies to Support Tsunami Early Warning System

2240-2250 Break  
   A “group picture” will be taken right before the break.

2250-2310 Simon McClusky et al.  
   Australian perspectives on the use of GNSS for Tsunami Warning

2310-2330 Andrick Lal  
   Pacific Sea Level and Geodetic Stations for Natural Hazards

2330-2350 Elisabetta d’Anastasio et al.  
   GNSS for Natural Hazards in Aotearoa New Zealand

2350-0000 Léo Martire  
   Concluding Remarks, Further Discussion
Workshop will resume at **2300 UTC**
IGS Goals

Serving the community with facilitation, coordination, incubation, and advocacy in three strategic goals:

1. Achieve Multi-GNSS Technical Excellence
2. Strengthen Outreach and Engagement
3. Build Sustainability and Resilience
Example Cases - 2023 Turkey Earthquakes

Event us6000jllz ($M_w = 7.8$)
Event us6000jlqa ($M_w = 7.5$)