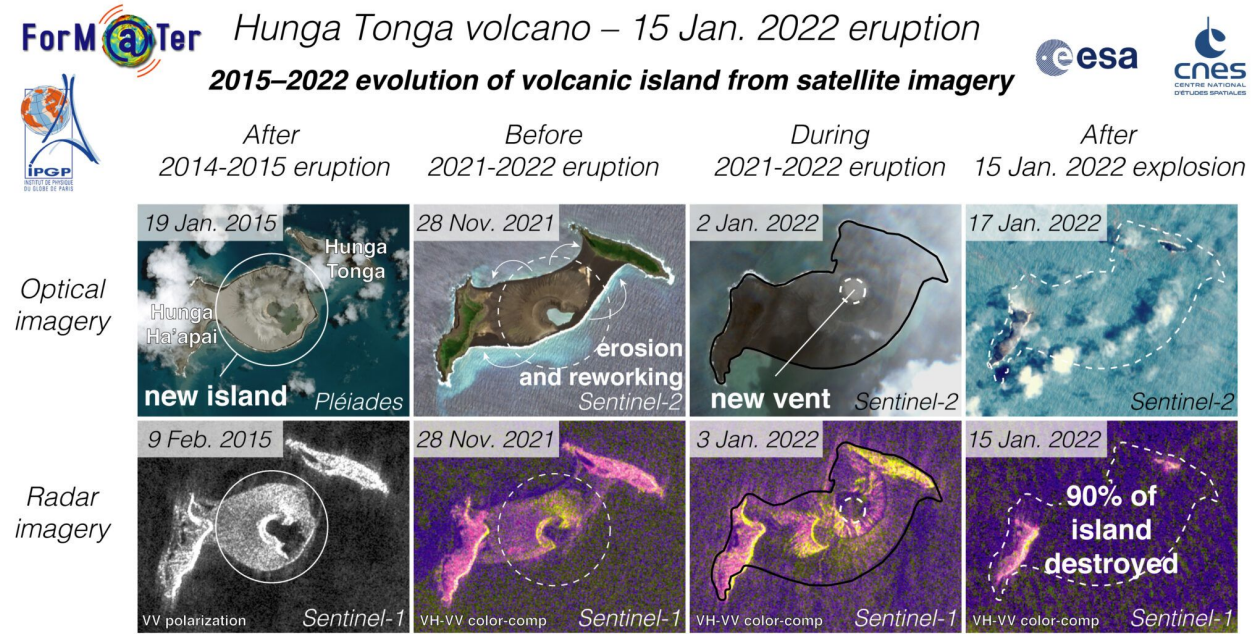
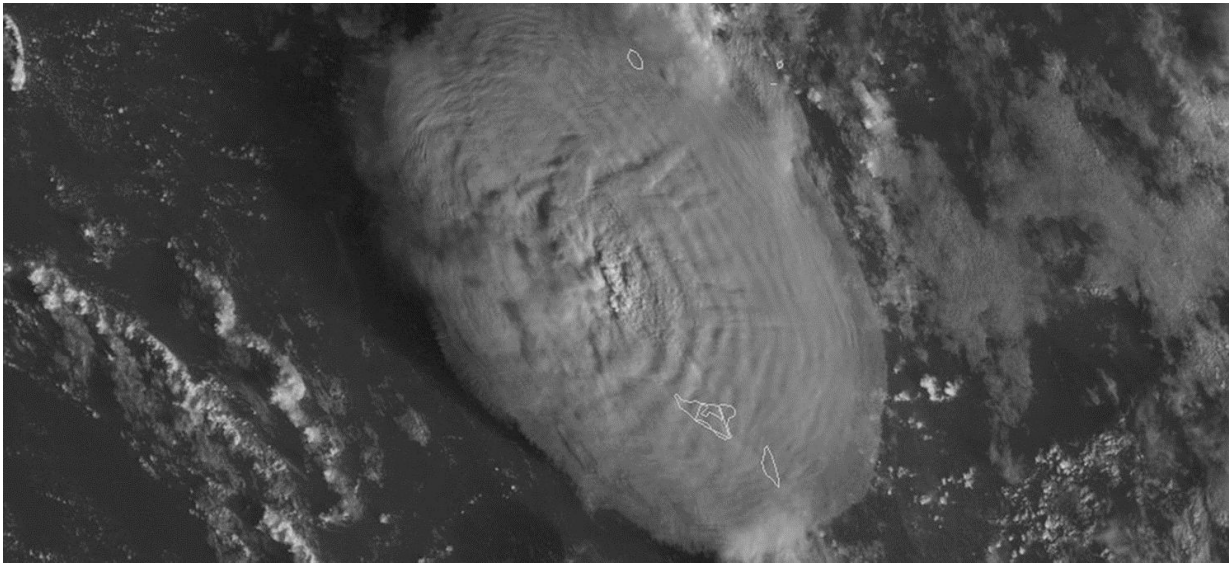


GNSS Infrastructure and Technologies to Support Tsunami Early Warning System

Experience after the Hunga Tonga Hunga Ha'apai
Eruption and Tsunami



Hunga Tonga Hunga Ha'apai

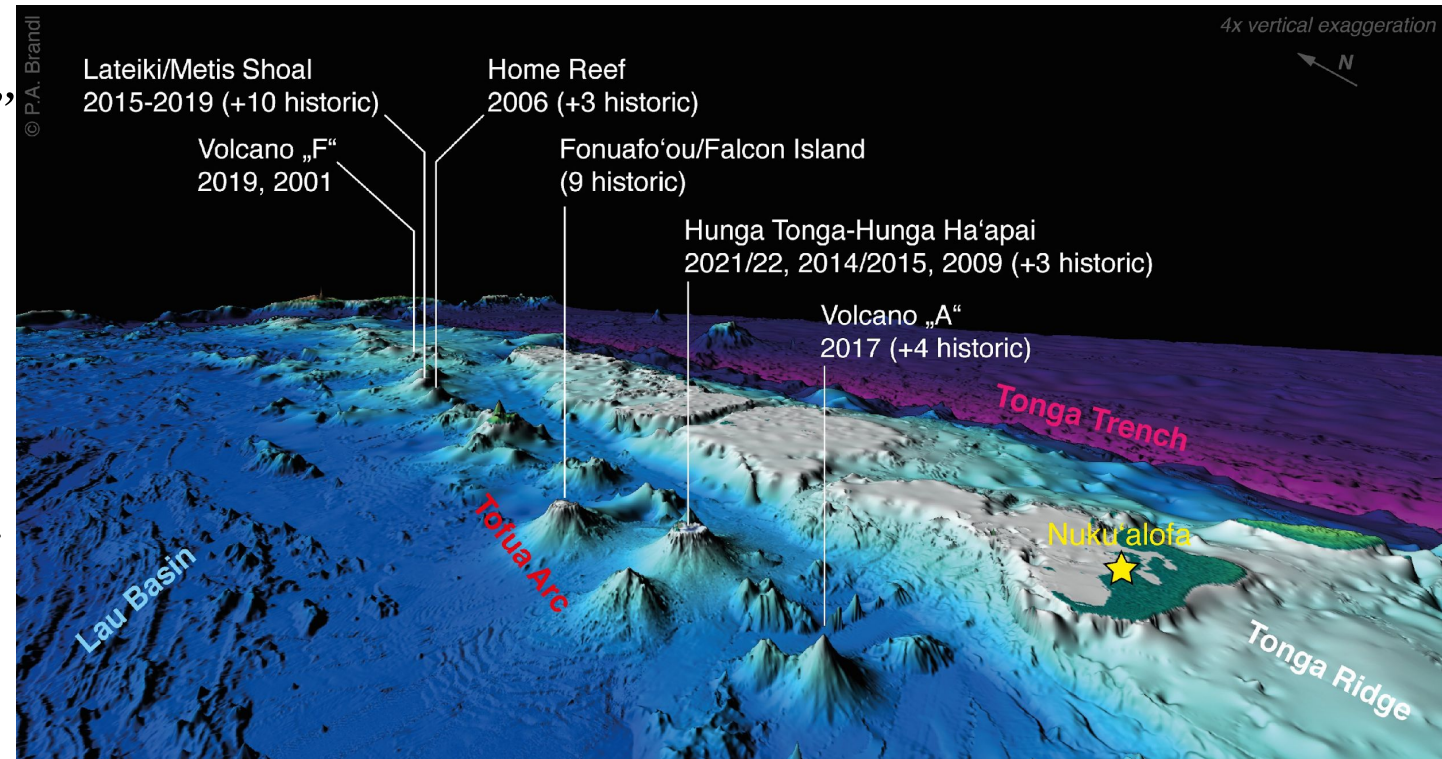


Tonga

- Tonga is one of the most vulnerable countries in the world
- Its islands are made up of volcanic and coral islands.
- Villages are located close to the sea



- Tonga's southwestern location bordering the Pacific "Ring of Fire" increases its risk to tsunamis. This area of high tectonic activity has had 115 tsunamis since 1900.
- Tonga's volcanic activity has been recorded since 1839, including submarine eruptions and emerging and disappearing islands.
- In terms of impact on human settlement, there is an active volcano on the island of Niuafo'ou.



GNSS Enhance Tsunami Early Warning System

- GNSS measures disturbance in the ionosphere by atmospheric waves
- It also measure land displacement
- The GTEWS 2017 workshop seeks to implement the vision articulated by IUGG 2015 Resolution #4 to encourage broader cooperation within the Indo-Pacific community of APEC economies for the adoption of GTEWS.



GTEWS

- Due to the Hunga volcano being so close to their territories, the sound of the eruption was unfortunately the earliest warning the people of Tonga could benefit from.
- However, for distant locations, monitoring the ionosphere remains a viable augmentation to natural hazard early-warning systems.
- It was the Japanese GEONET, the world's most advanced GNSS ground network of 1300 GPS receivers, that provided a convincing demonstration of the value of GTEWS for enhanced tsunami disaster warning.
- These measurements provide a clear example of the role that GNSS measurements can play in the providing rapid, accurate and cost-effective tsunami early warning.



GNSS Stations in Tonga

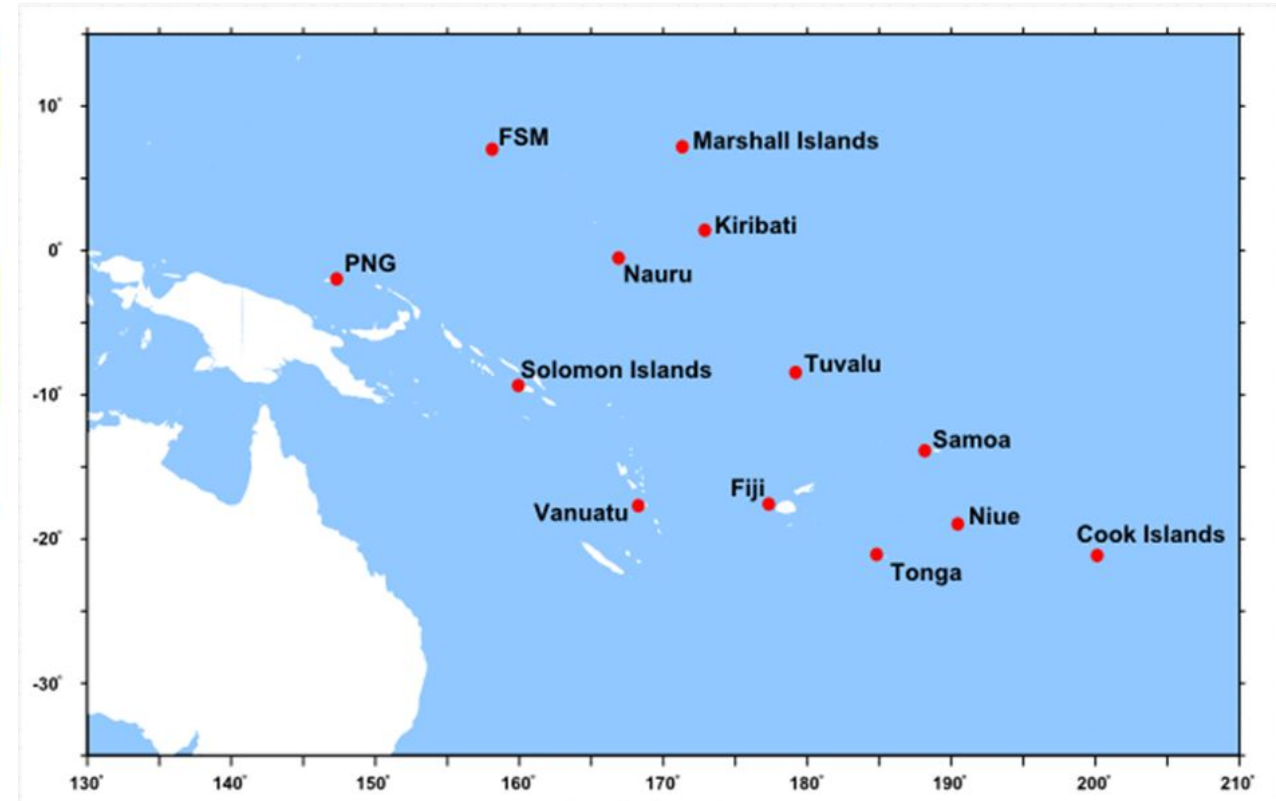
IGS Stations Highlight

by Ryan Ruddick

Geoscience Australia, with support from the local Land and Survey Ministries, coordinates a network of continuously operating reference stations across the Pacific. This network was established as part of the Australian Government's Climate and Oceans Support Program in the Pacific to support the generation of accurate sea level records in the Pacific. The benefits of the data from the network is now being realised for a number of other scientific and societal applications, including the modernisation and alignment of local geodetic datum's with the global geodetic reference frame.

Recently there has been a lot of interest in the data from stations in Nuku'alofa, Tonga (TONG00TON) and Apia, Samoa (SAM000WSM), which observed the Hunga Tonga-Hunga Ha'apai eruption in January this year.

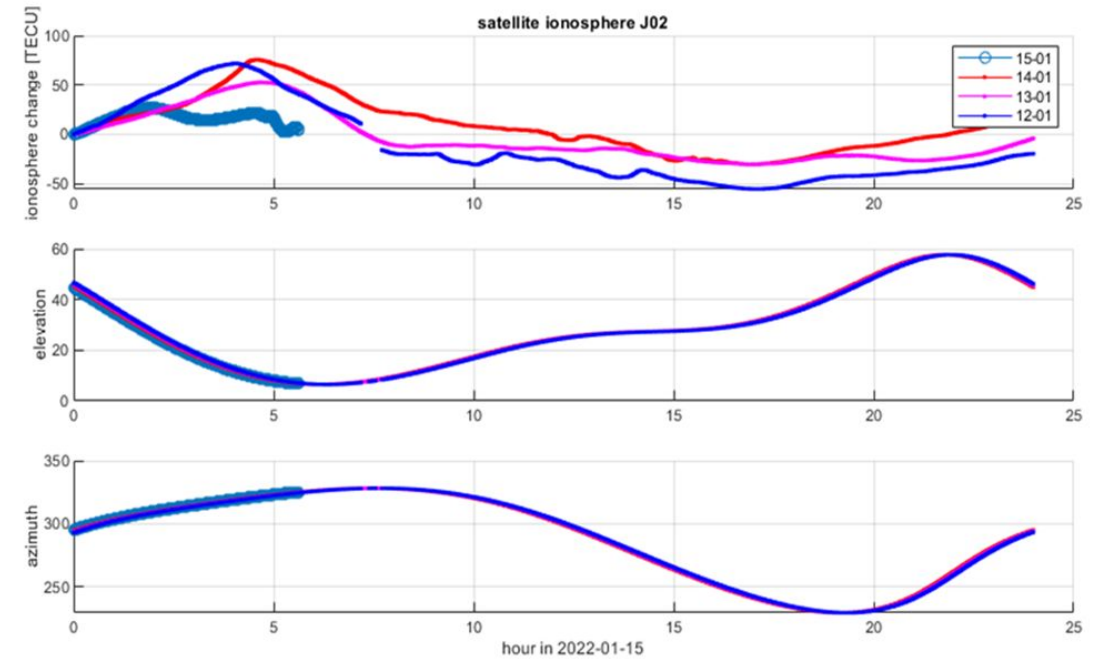
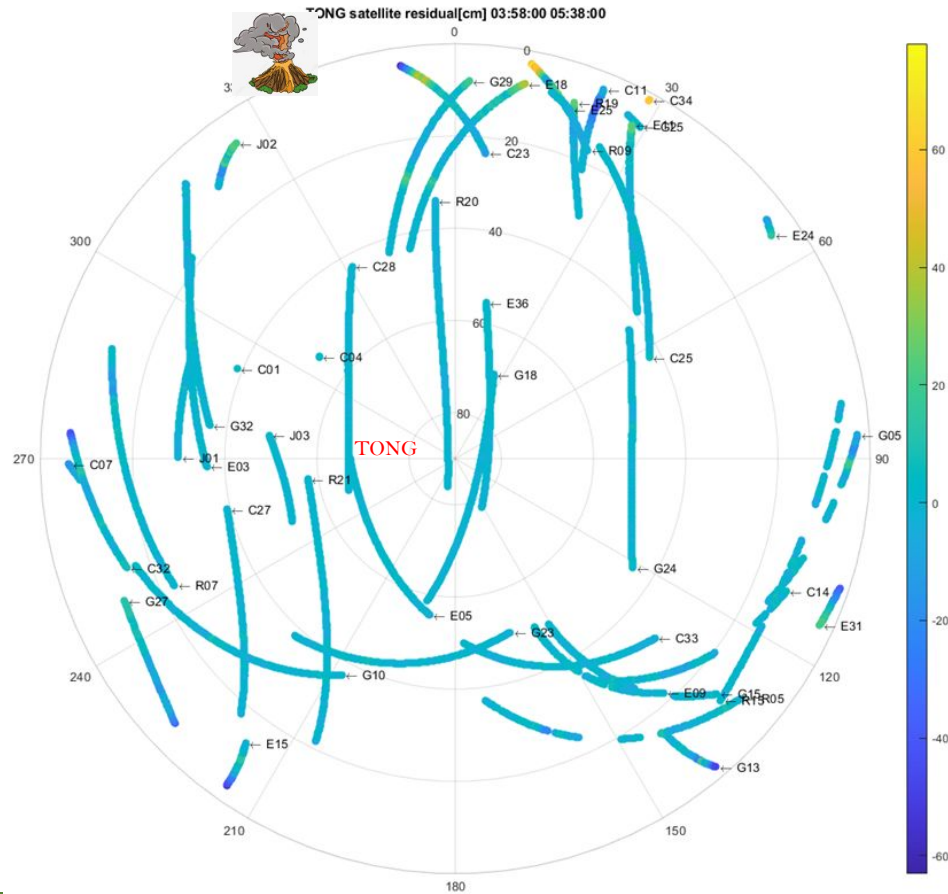
The stations, which have been part of the IGS network since 2015, will be upgraded this year to improve their resilience and ensure they are able to better support disaster risk reduction and recovery activities.



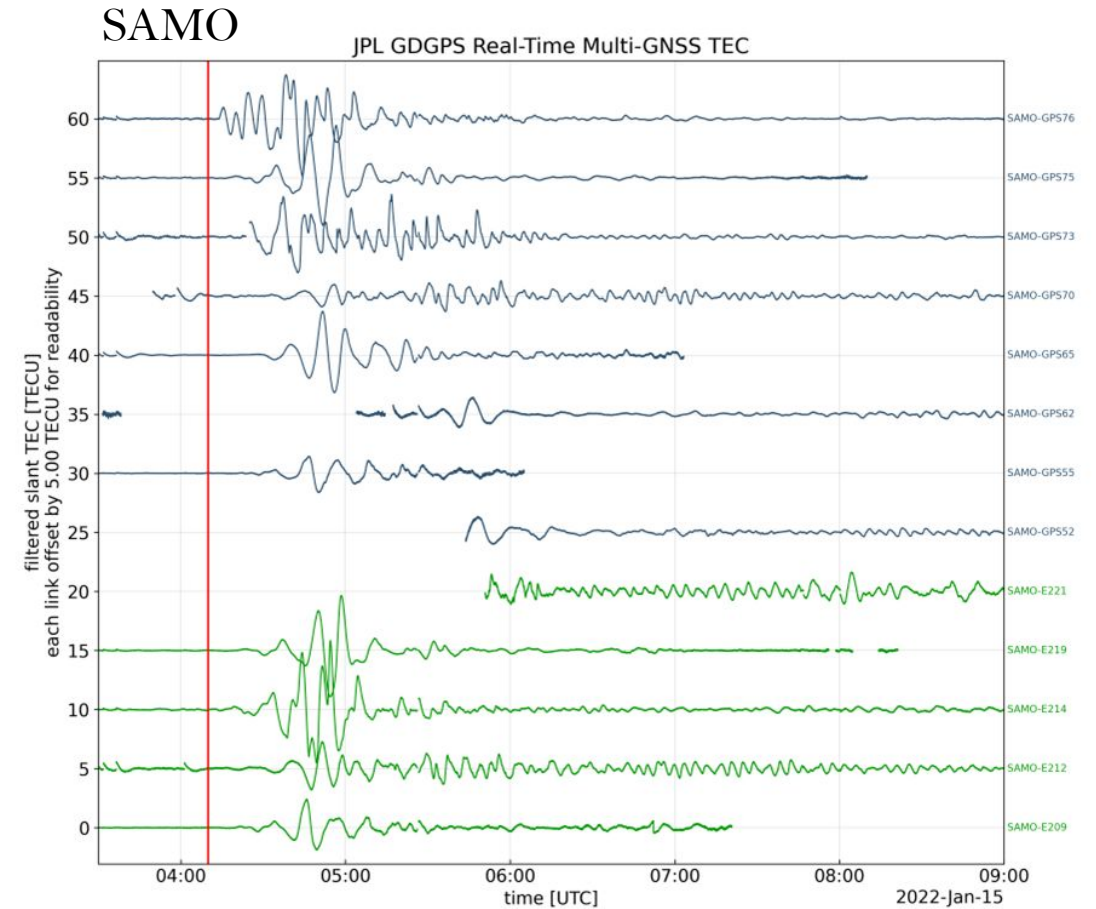
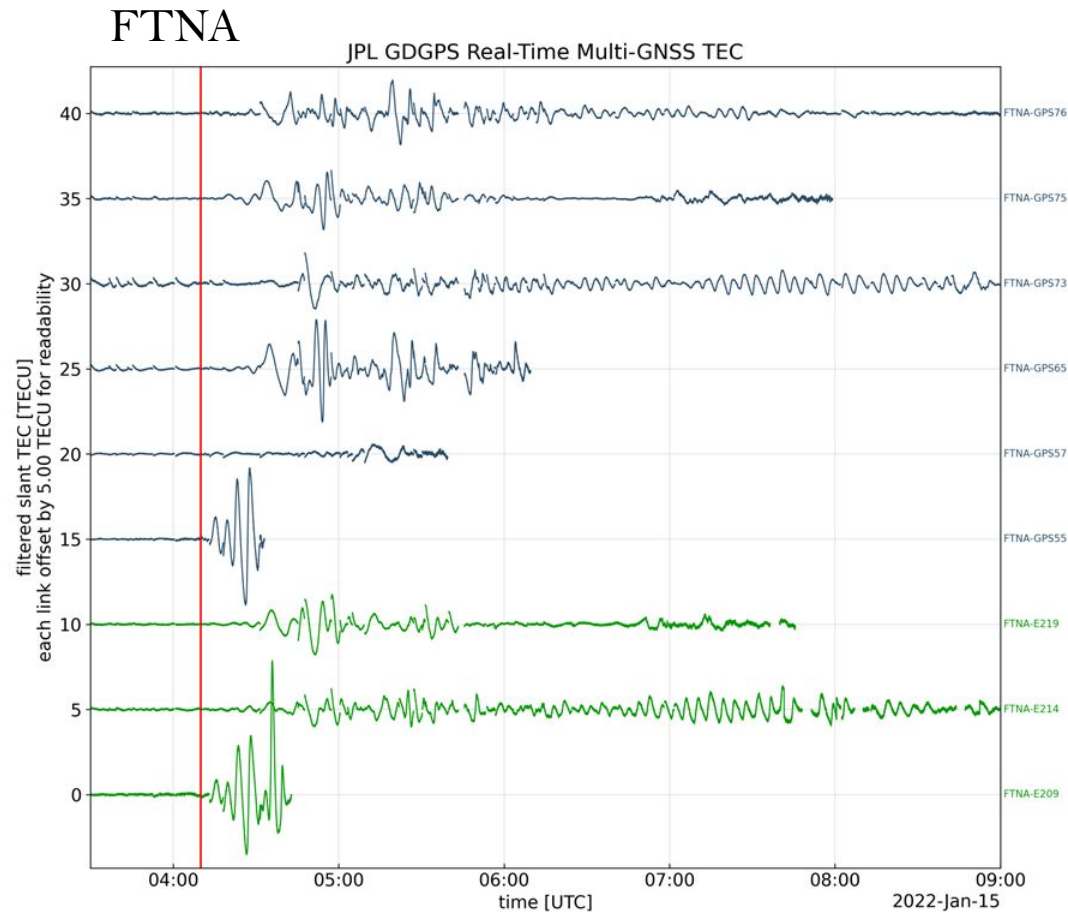
Ministry of Lands &
Natural Resources
GOVERNMENT OF TONGA

GNSS Measures Atmospheric Disturbance

Ionosphere Anomalies-Satellite J02

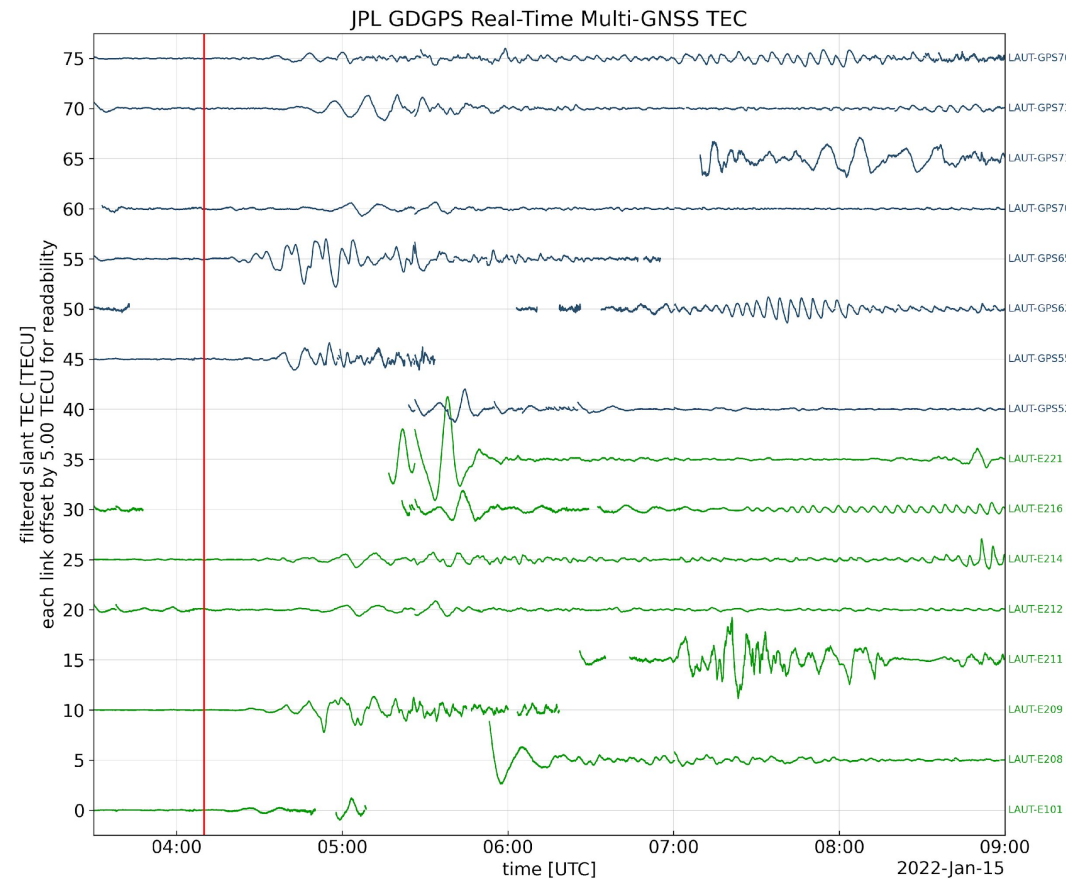


GNSS Measures Atmospheric Disturbance

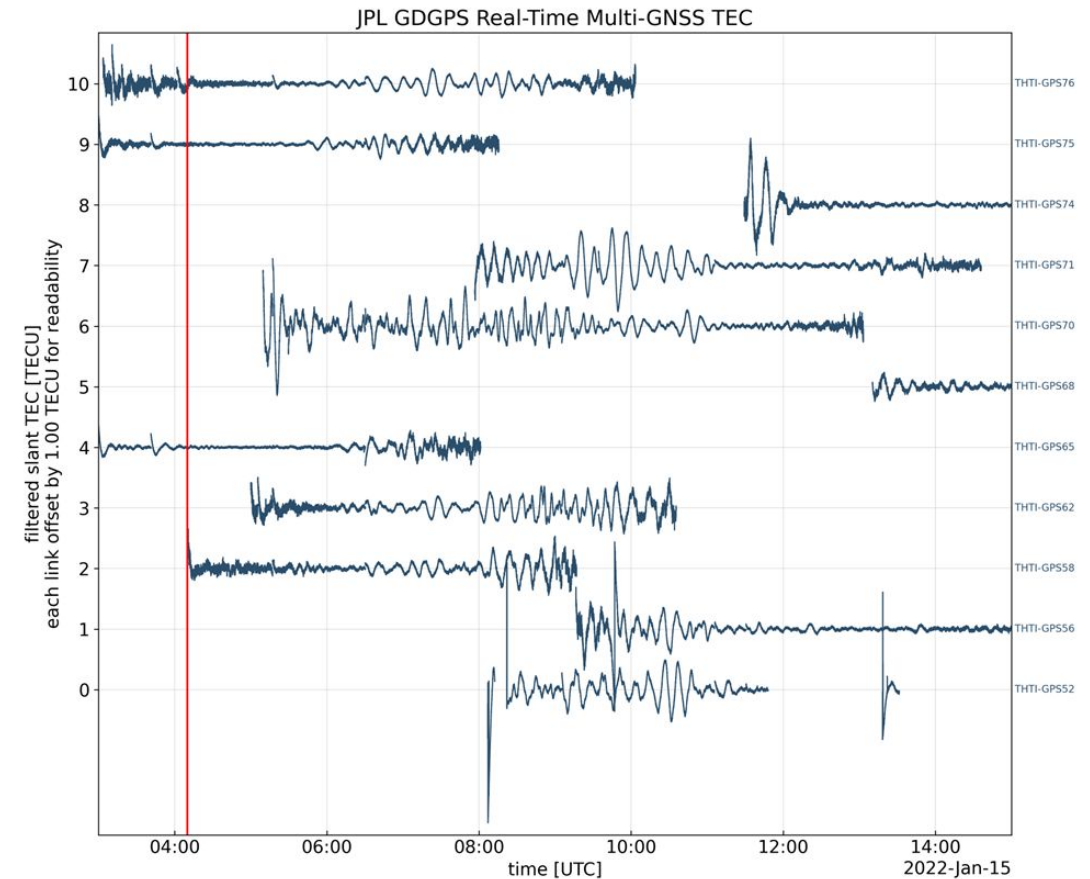


GNSS Measures Atmospheric Disturbance

LAUT

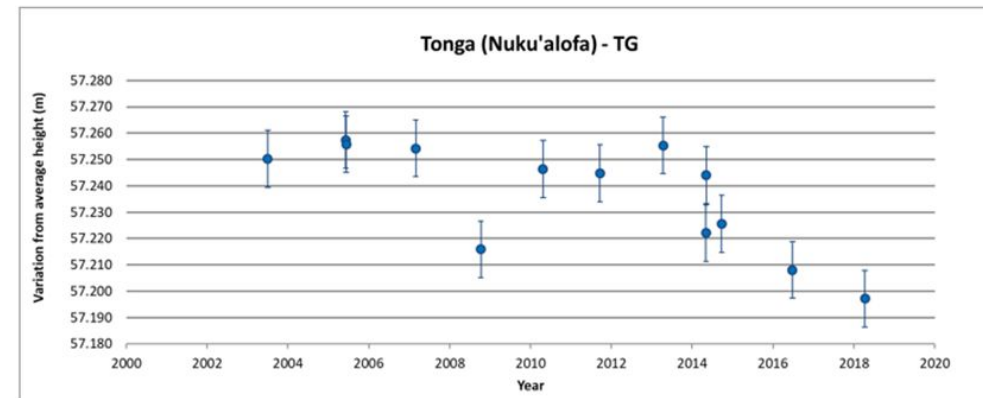
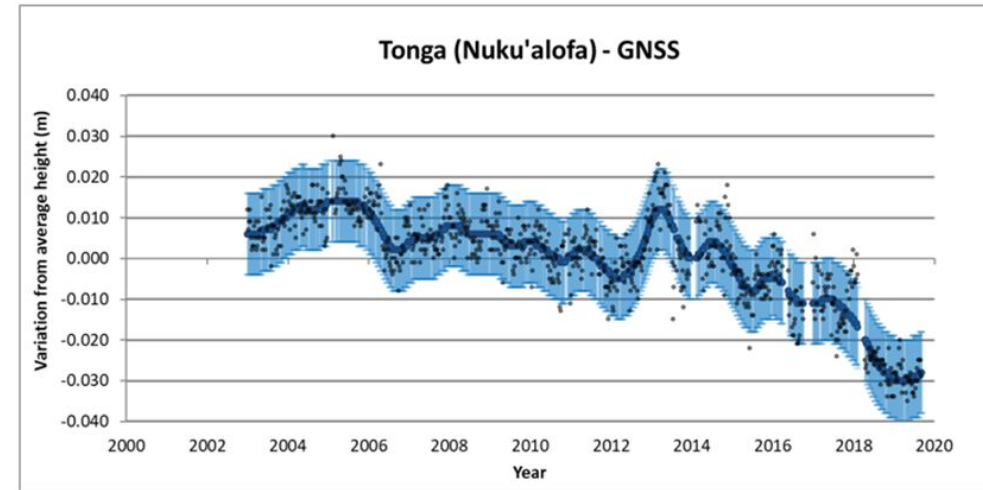


THTI



GNSS Measures Accurate Land Motions

- Vertical movement of the GNSS site (top) and tide gauge (bottom).
- The GNSS site is 1.1 km from the tide gauge.
- More stations needed to have an accurate representation of the whole of Tonga



Why?

Vulnerability

Unpreparedness

Lack of Early
Warning System

**Severe
Impact**

- Due to the Hunga volcano being so close to their territories, the sound of the eruption was unfortunately the earliest warning the people of Tonga could benefit from.



Why the Need to Enhance Warning System

- Tonga is made up of low-lying islands
- Villages are located close to the sea
- Sea level is rising PLUS Tonga is sinking by 7mm/yr makes the impact of tsunami more deadly in the near future.
- GNSS provides vital extra time for evacuation to safer grounds
- Not everyone has a vehicle to evacuate on



Way Forward

- Government needs to understand Tsunami Early Warning System can be enhanced by using GNSS. Need to convince government
- Co-location of GNSS Stations and Seismic Stations enhance the land displacement data.
- Must have local expertise in GNSS technologies and analysis
- More GNSS stations to cover the whole of Tonga





“Tonga needs to use latest satellite technologies to ensure the safety and security of Tonga”

HM King Tupou VI



Thank You Very Much

