Scientific workshop ICG/PTWS XXX Meeting - 11/09/2023

A back projection of the deep-ocean tsunami waves observation after the HTHH eruption.

Anthony Jamelot
Laboratoire de Géophysique de Tahiti
Centre Polynésien de Prévention des Tsunamis

Bill Fry
GNS science Te Pu Ao
R-CET

Preliminary understanding of the event

CEA — DE LA RECHERCHE À L'INDUSTRIE

LABORATOIRE DE GEOPHYSIQUE — LDG Tahiti

GNS SCIENCE TE PŪ AO

Summary

- **Introduction**
- Quick Feedback of French Polynesia
- An Early analysis of the event using the DART network (January 2022)
- Further analysis and studies
- Conclusions

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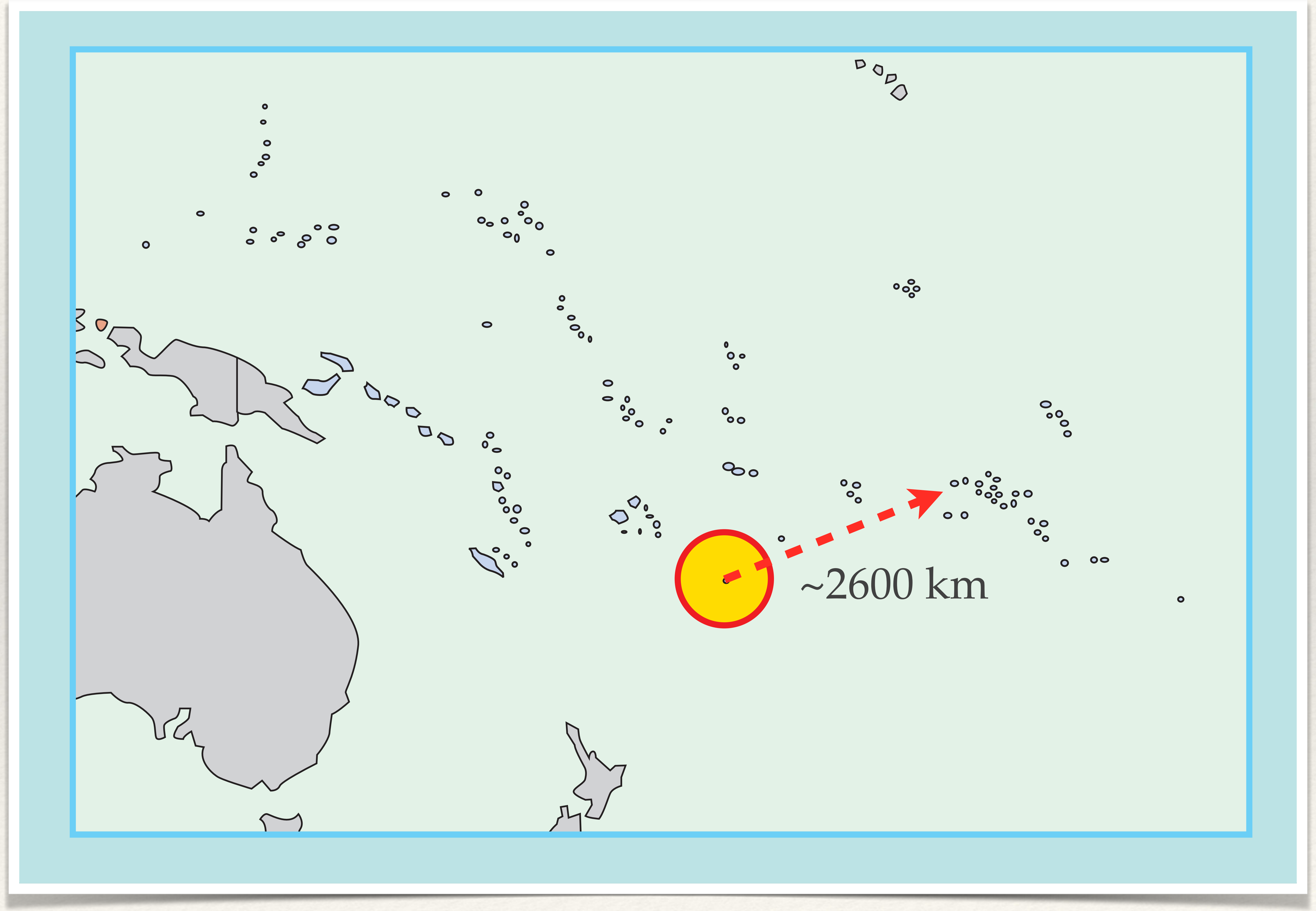
- **No automatic tsunami alert triggered at the NTWC CPPT because no P-waves**
- TREMORS detection of the event Mm 6.0 under the threshold
- A tsunami time travel equal to 3 hours => Rapid scenario
- Our TSP backup (PTWC) did not send any tsunami bulletin to French Polynesia.



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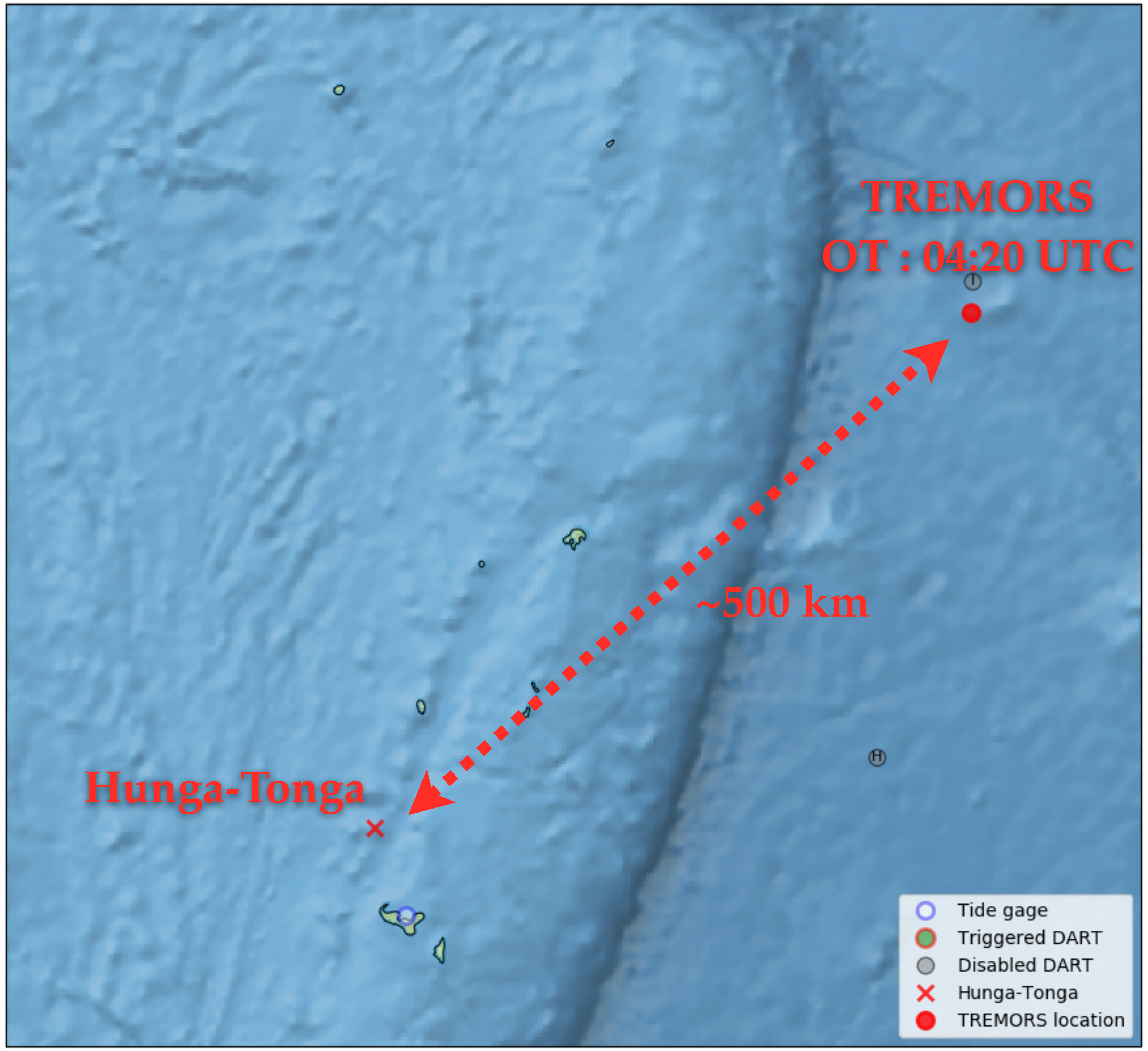

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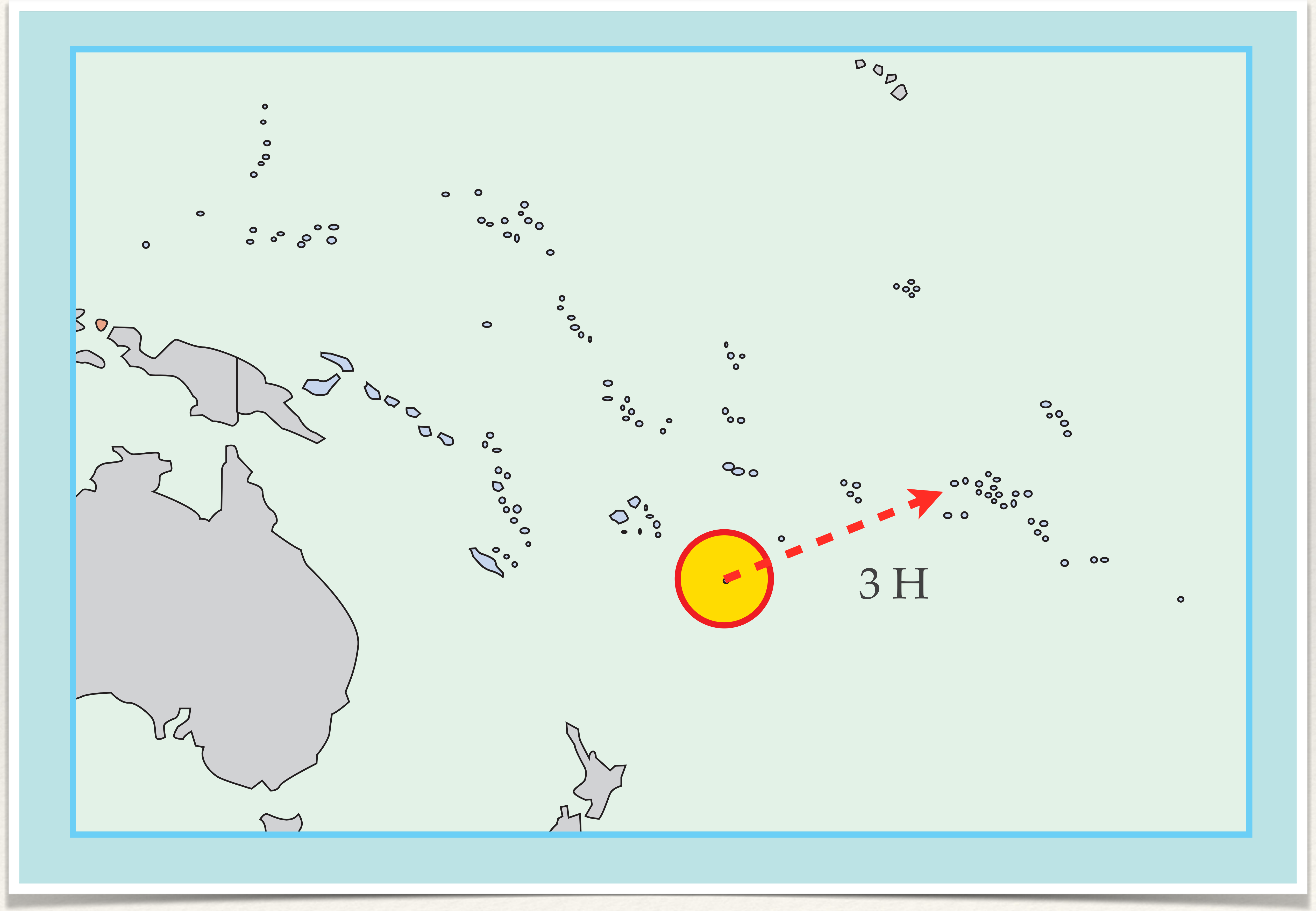

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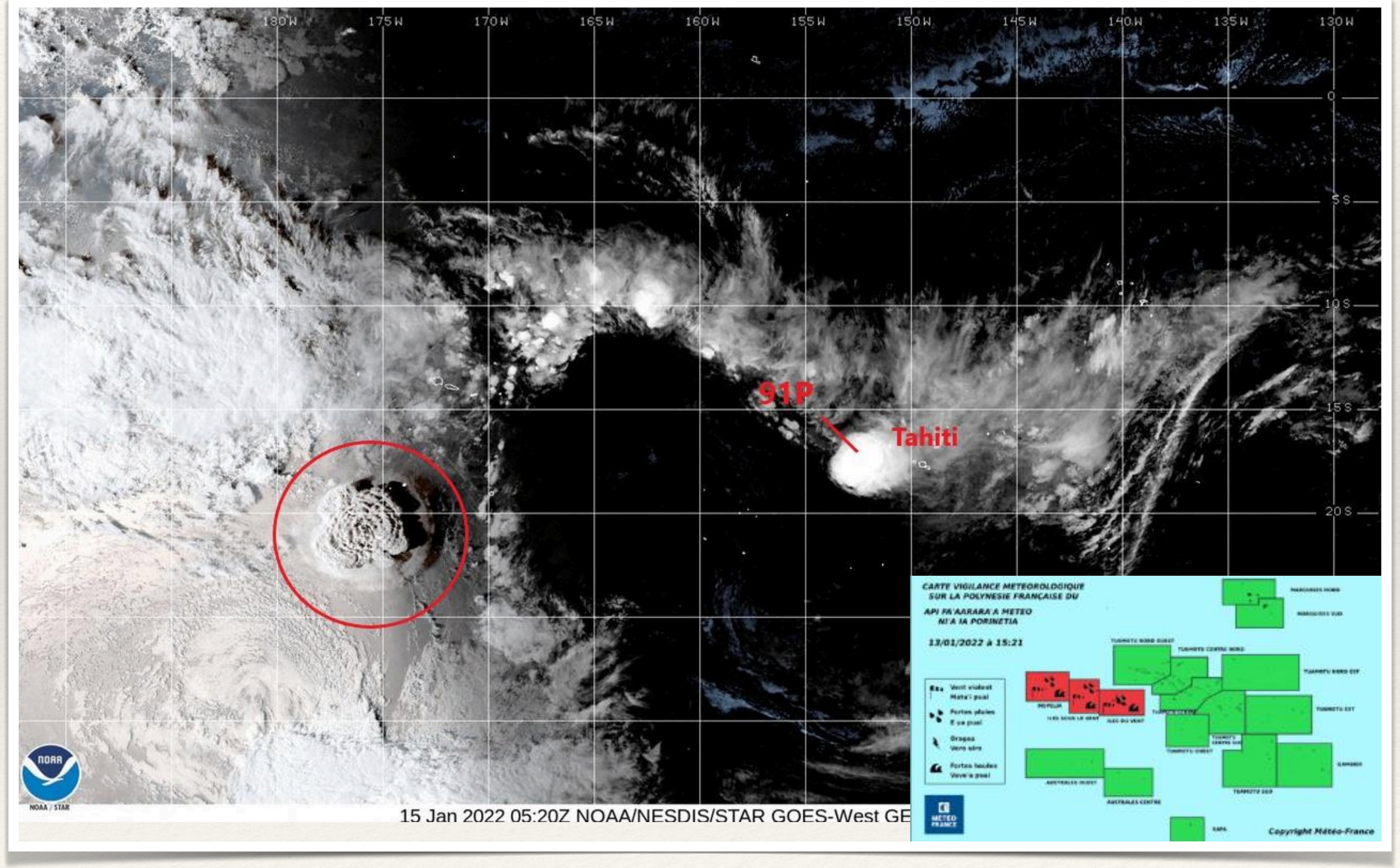
- **A situation even worst but for the best …**
- Society islands were in meteorological warning due to high precipitation following a tropical depression
- Crisis cells at City level were all in place
- Recommendation was stay home, avoid unnecessary displacement. People were in bed when tsunami arrived at night around 10pm (local time).



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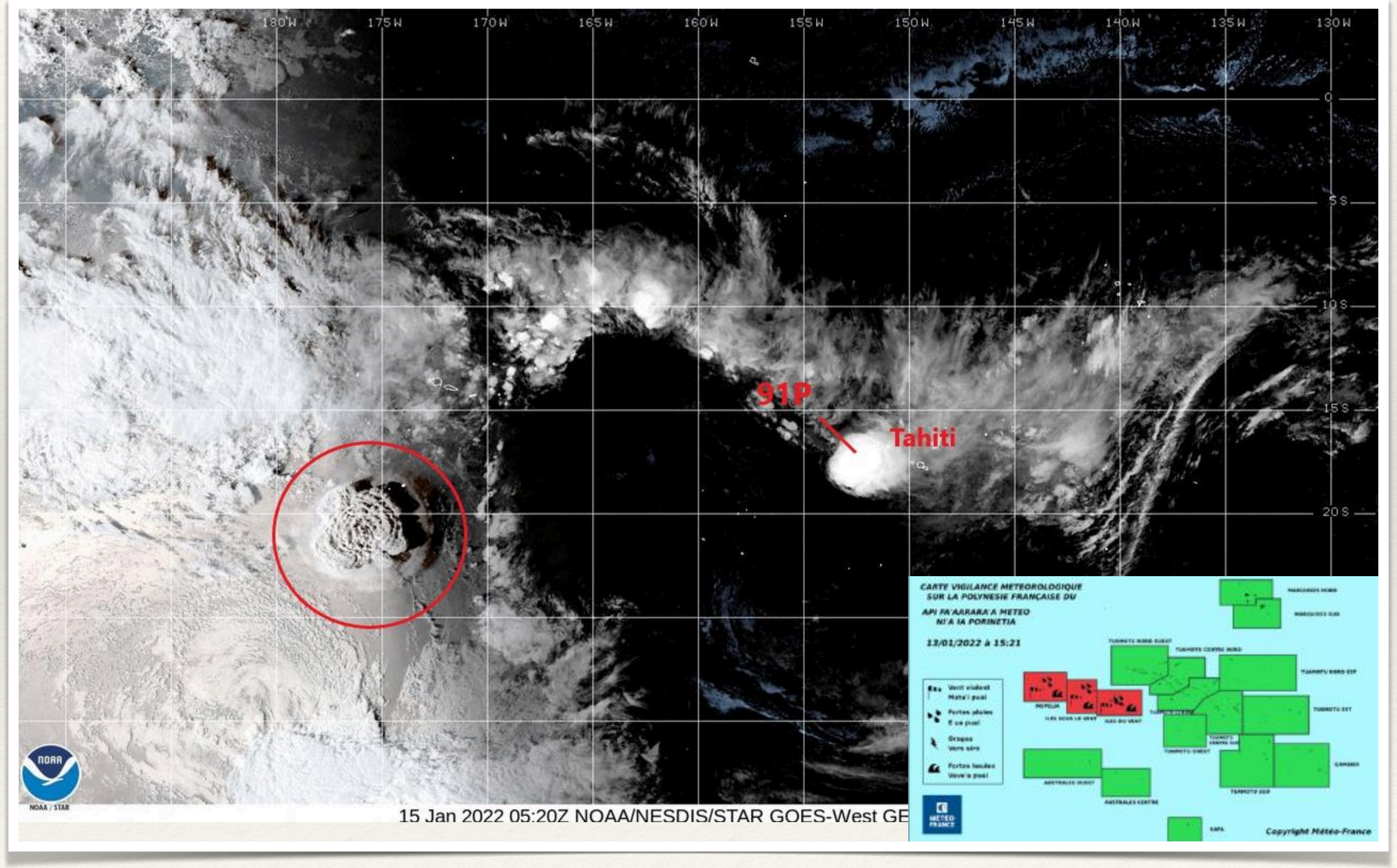

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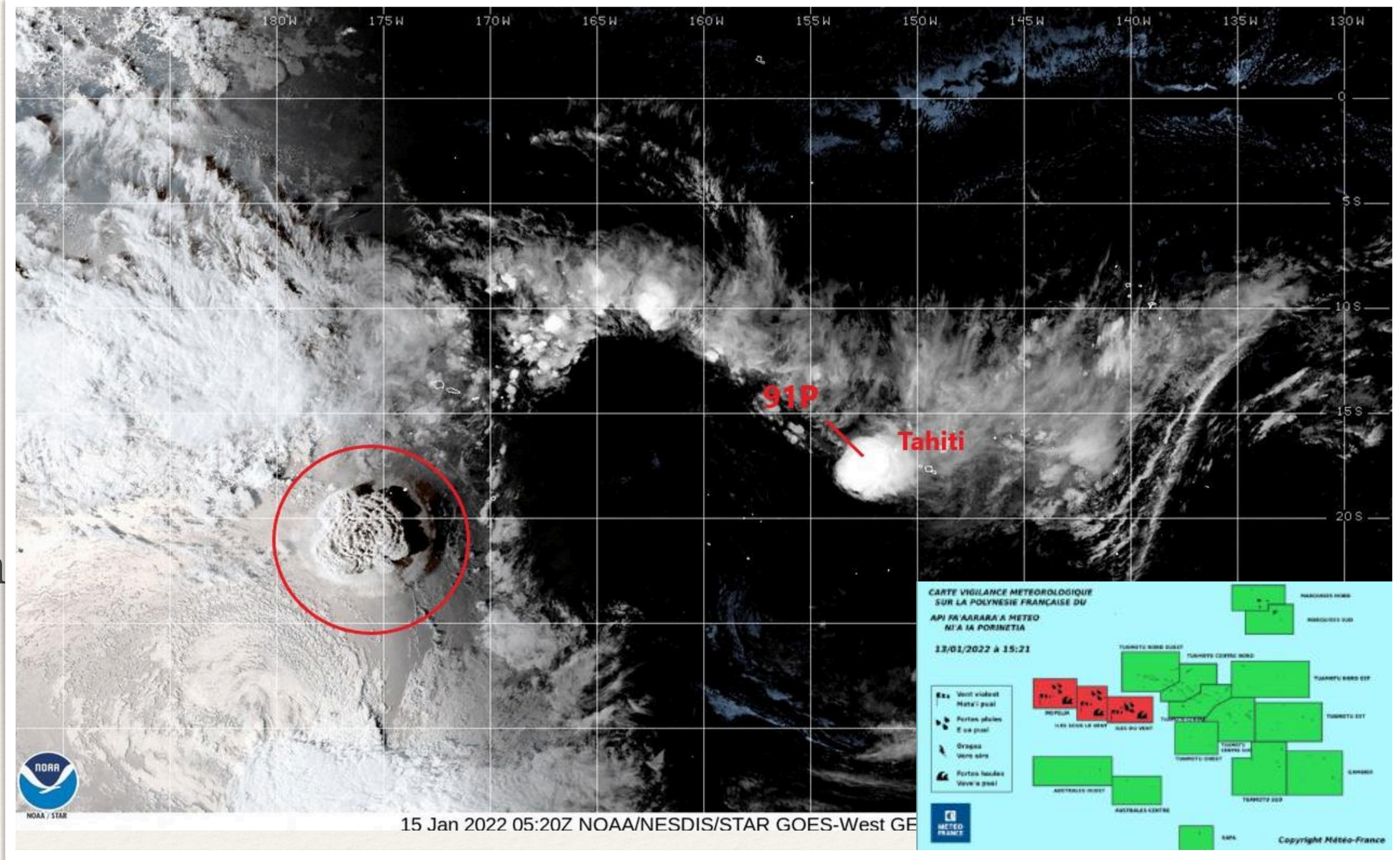
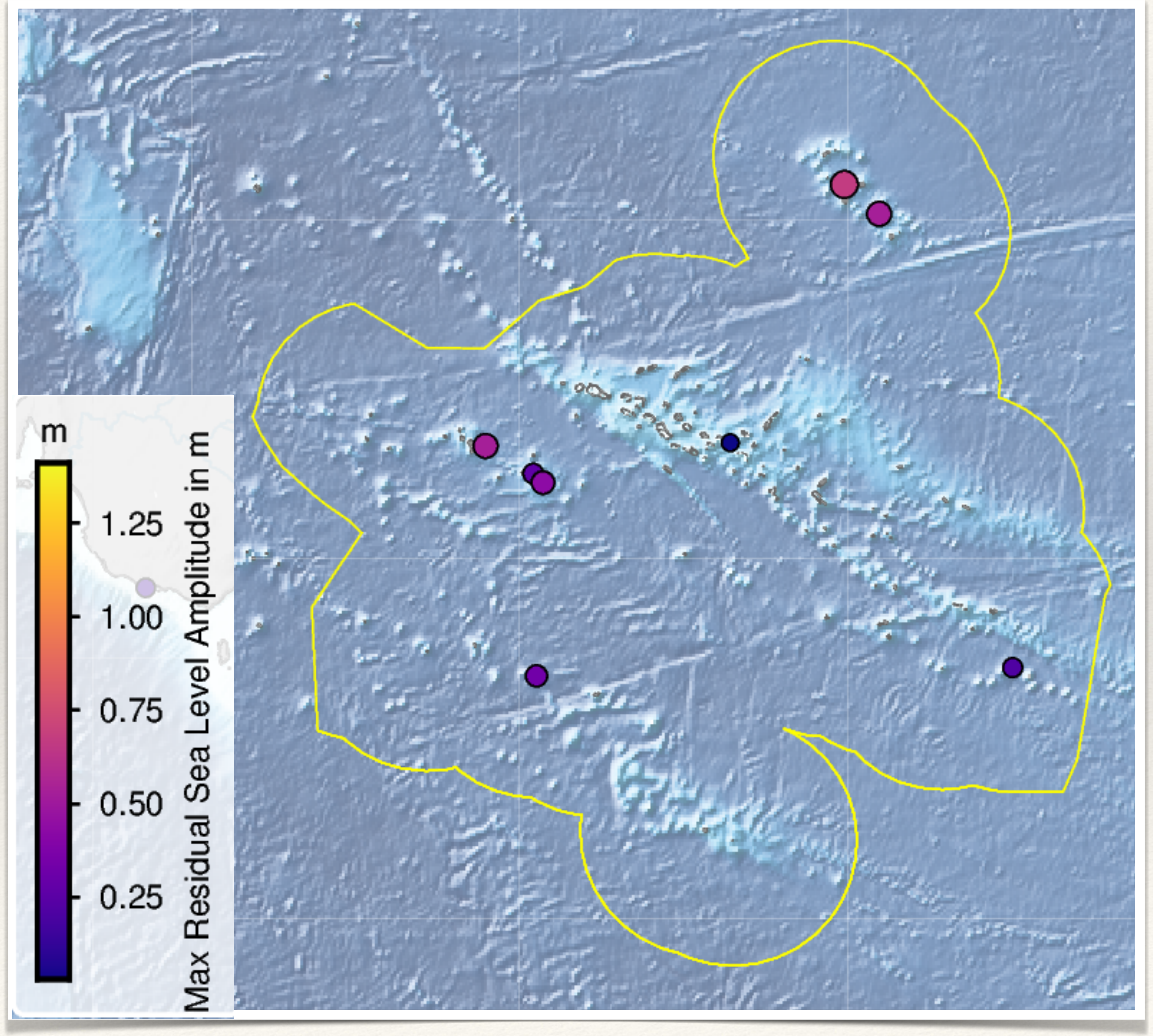
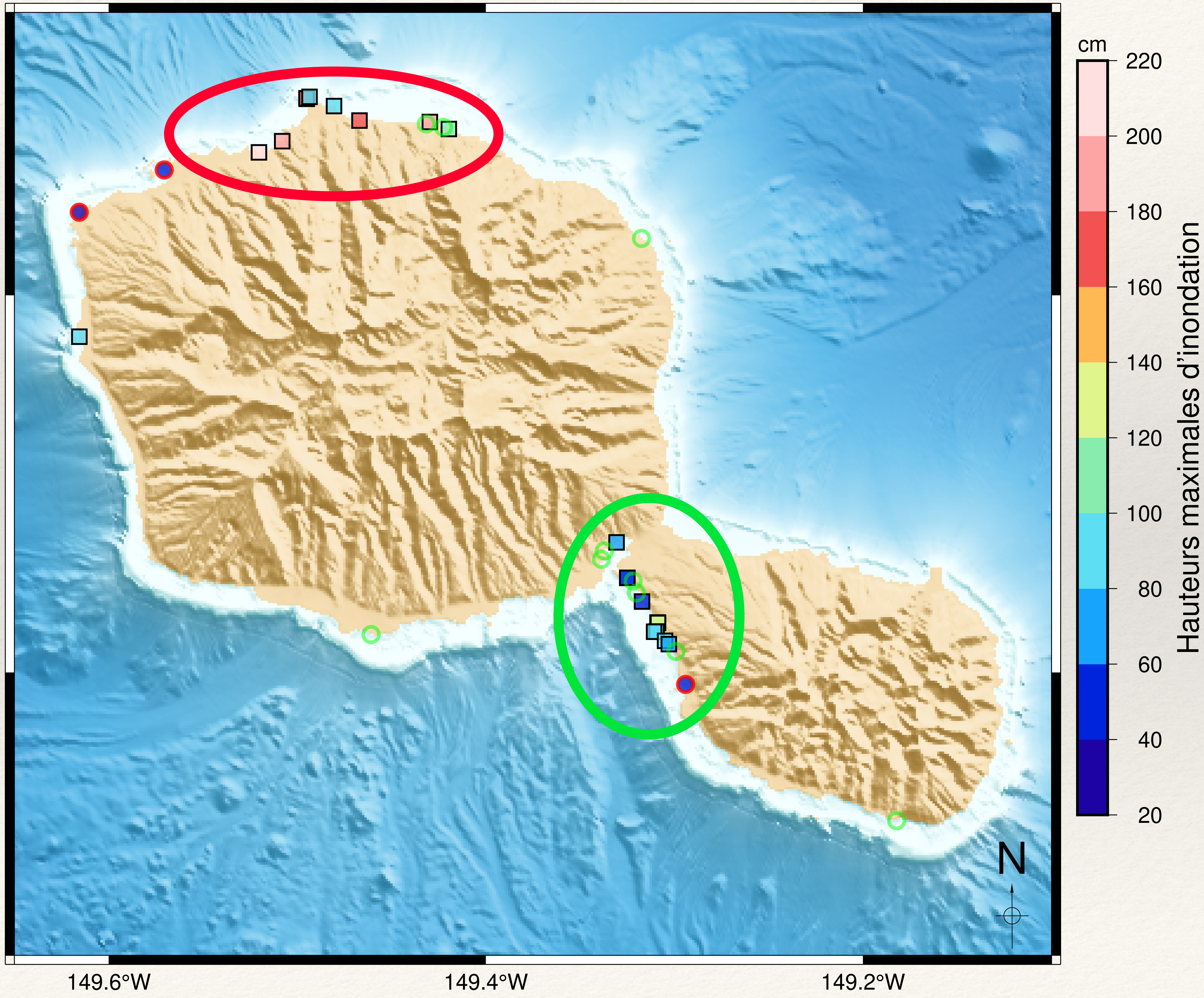


French Polynesian observations

- The tsunami was record on all tide gages. Some of them recorded also the shockwave earlier.
- ~ 60 cm observed at Society islands and Marquesas
- ≤ 30 cm for Austral, Tuamotu and Gambiers islands.

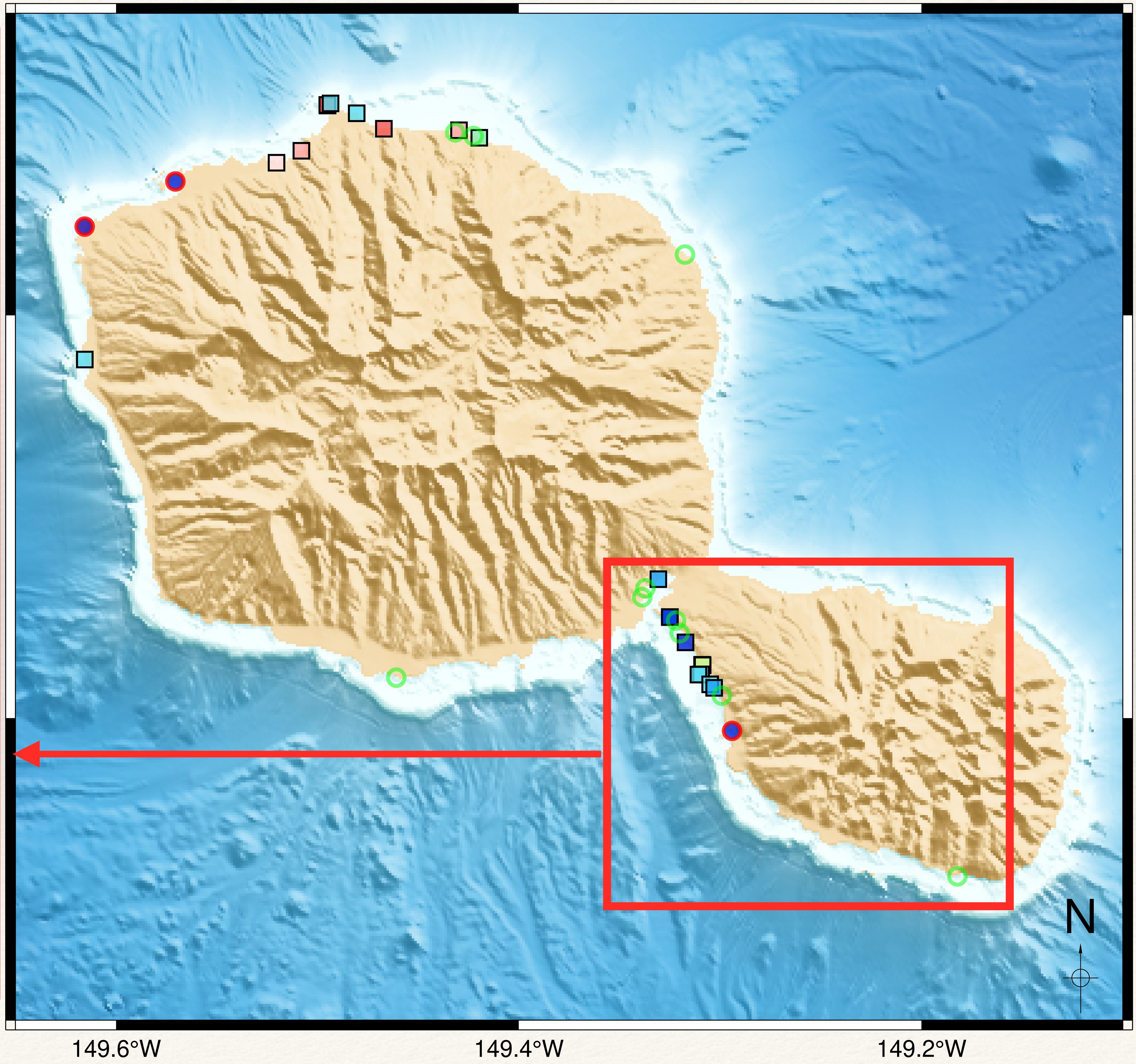


Observations - Tahiti



- Maximum run-up was 2m on Northern coast but there was an important swell from North-east at this time.
- A mean run-up of 80 cm on the southern coast of Tahiti.
- On the other coasts of Tahiti no significant observation and testimonies, no observation also from people on the East coast because of the big swell coming at this time.

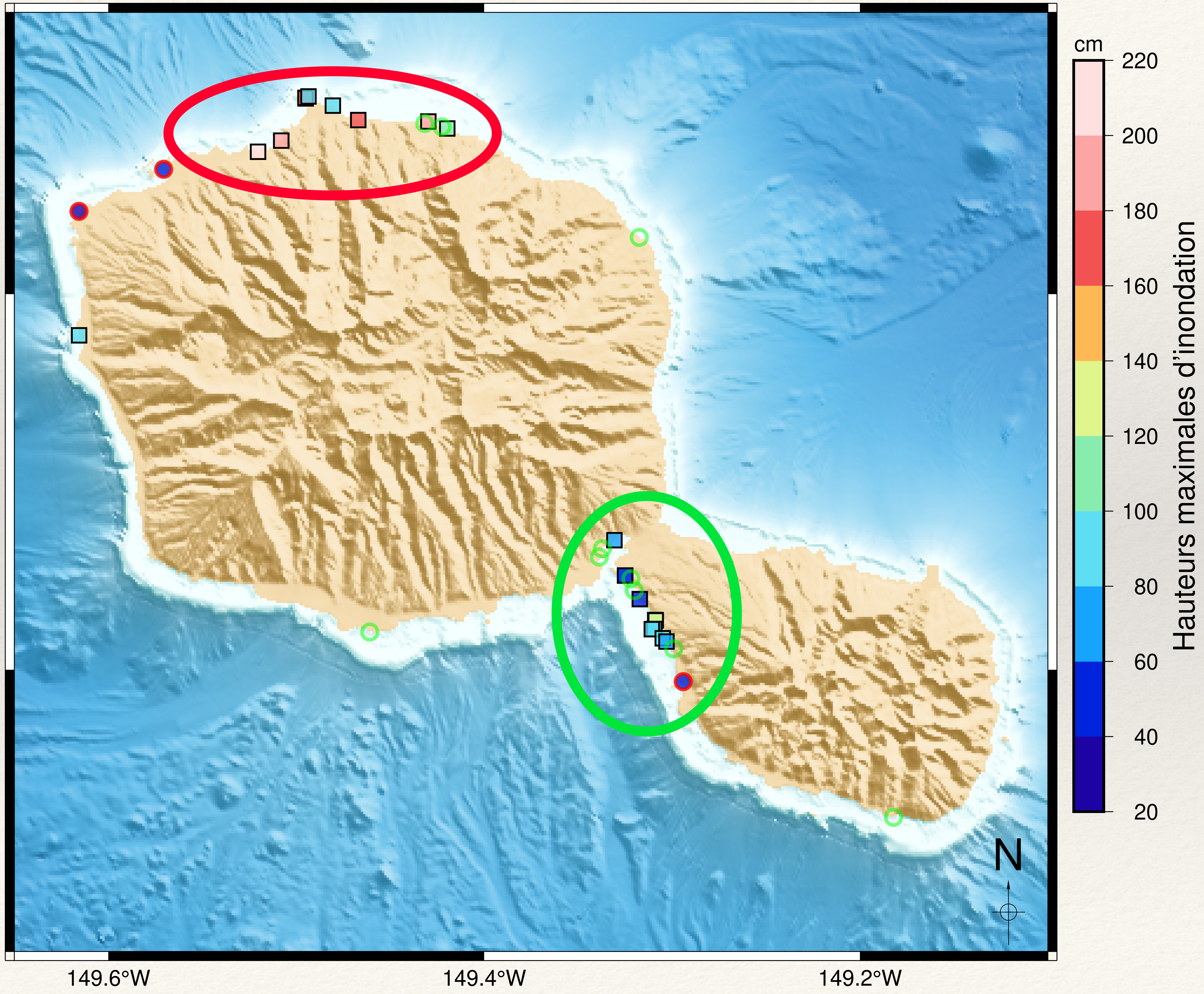
Observations - Tahiti



Observations - Tahiti

- Most important impact occured on 4 houses completely inundated. Lost of all electronics and 1 vehicule broke.
- **Impacted houses are located less than 6 meters away from coastline and with an altitude ≤ 1.5 m**
- This is a first observation of an impact on coast with a fringing reef.
- People told they have been wake up by the noise then stand up from bed with feet in seawater.
- All testimonies Only one wave up was observed followed by a strong back current that brought everything away to the sea.

Observations - Tahiti



- An significant impact similar to 2010 Chile tsunami event on North coast, and more than ever observed on southern coast protected by fringing reef
- All houses impacted are located in the red zone of oceanic natural hazard, but for all (over last 30 years) nothing like this happened before. (Today those houses could not be build).
- Probably an underestimated impact since the field survey received low feedback from Cities town halls.
- Also strong rain was erasing pretty quickly traces.

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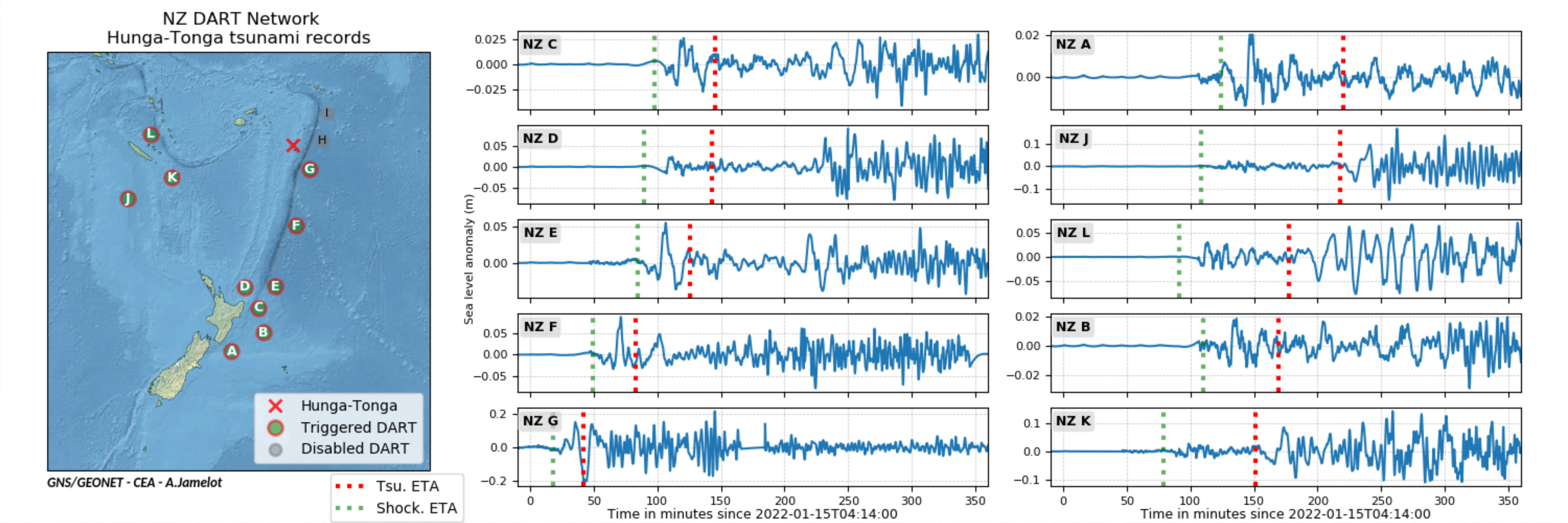
- Using the New-Zealand and NOAA DART buoys , something wrong on arrival time.
- Several waves with no coherence with a classic tsunami arrival time



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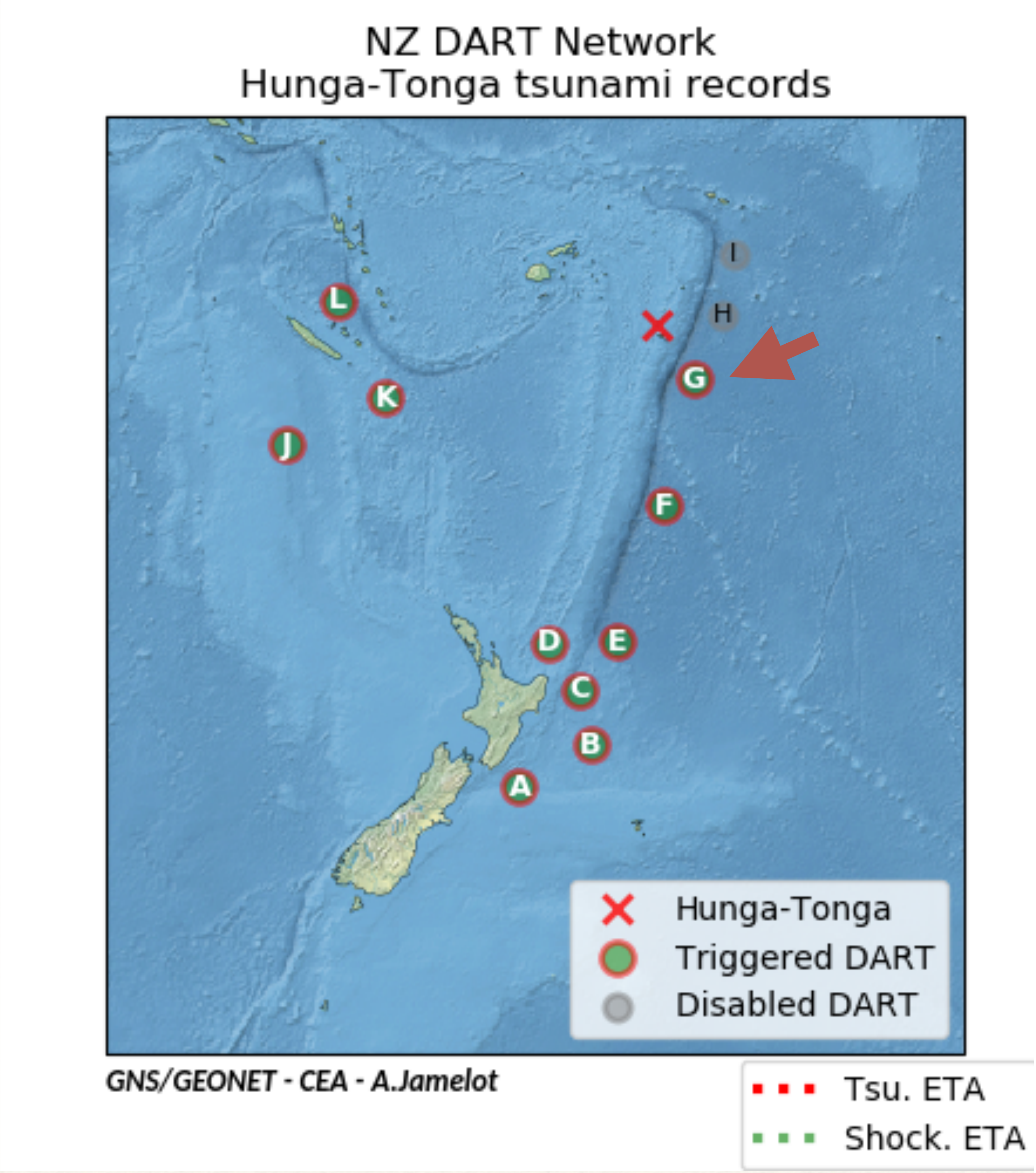

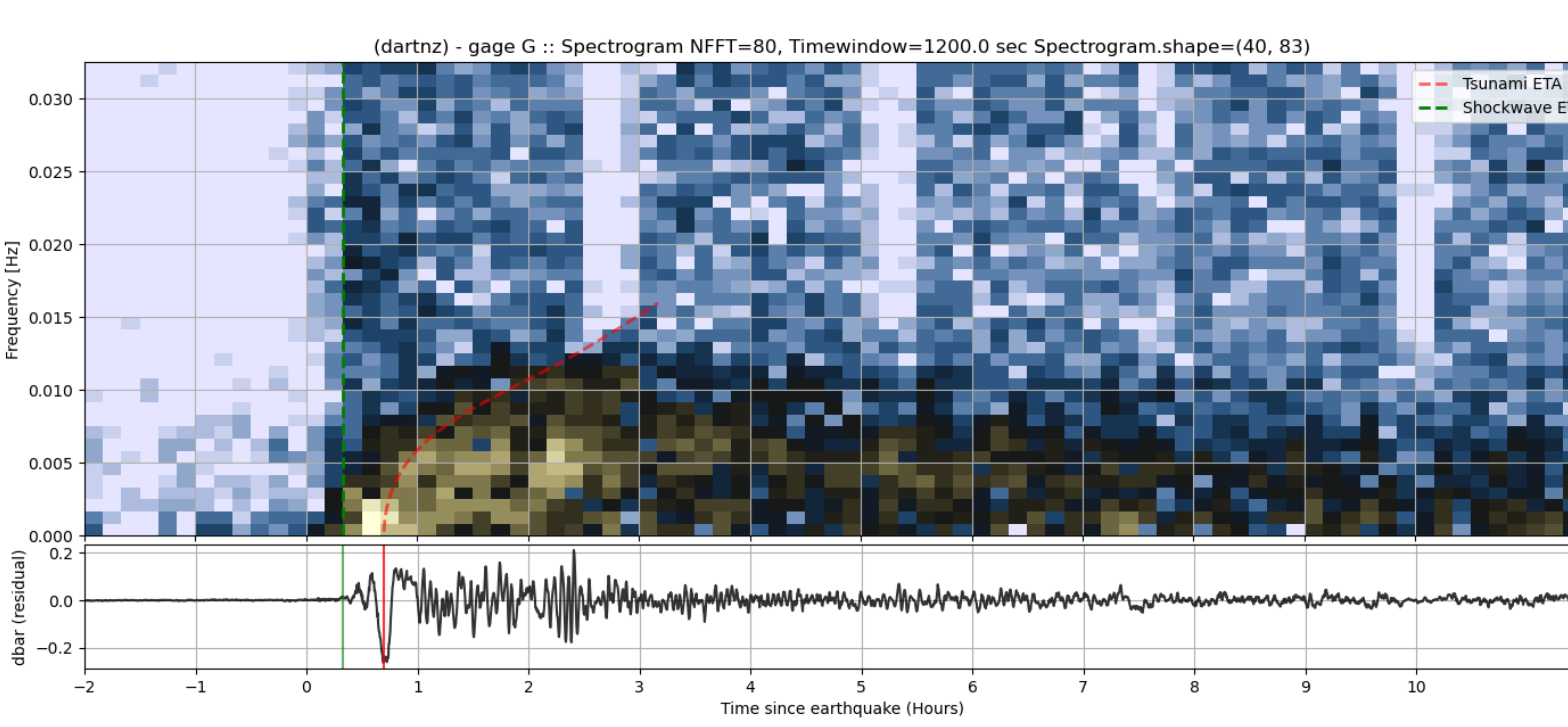

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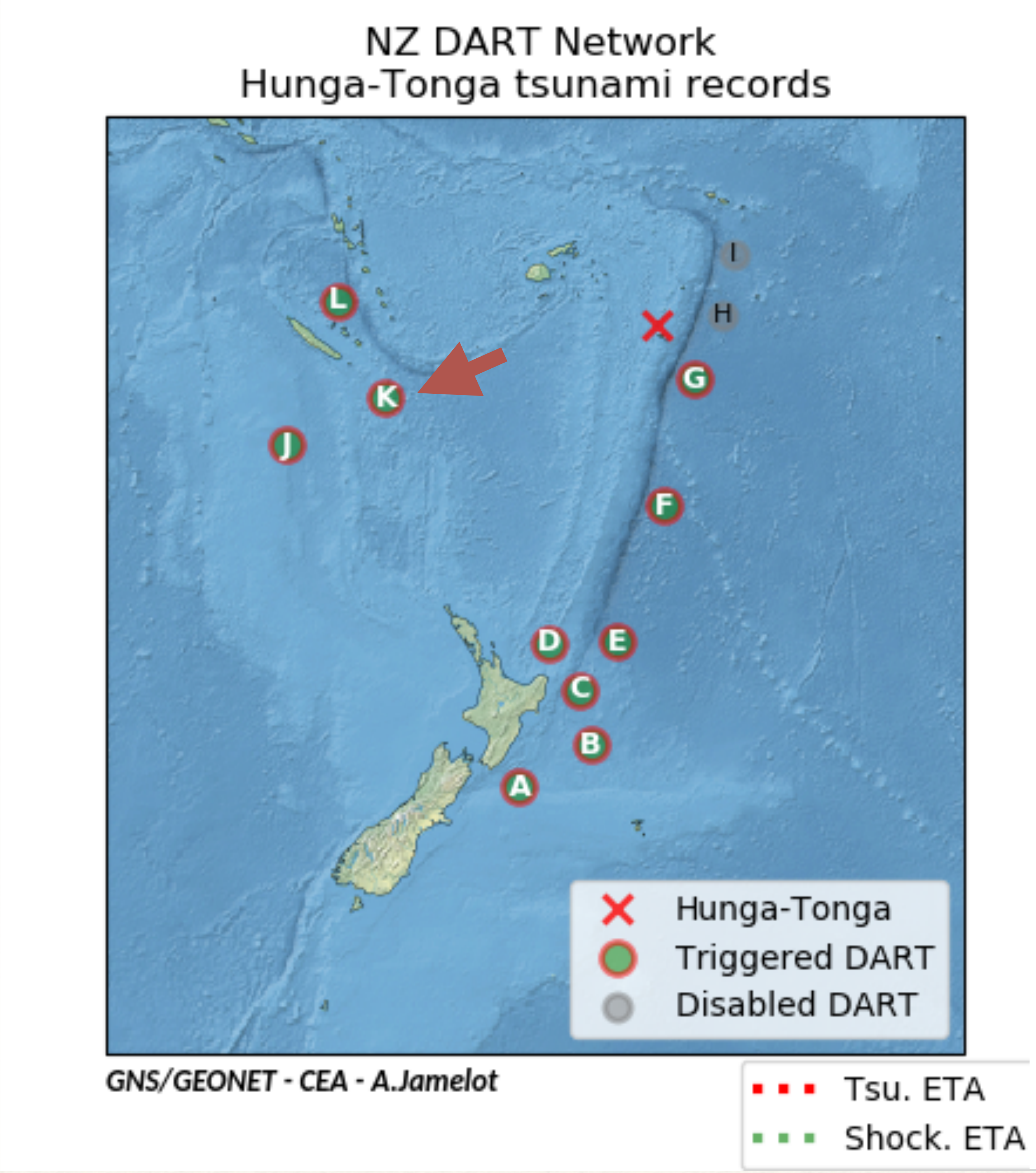

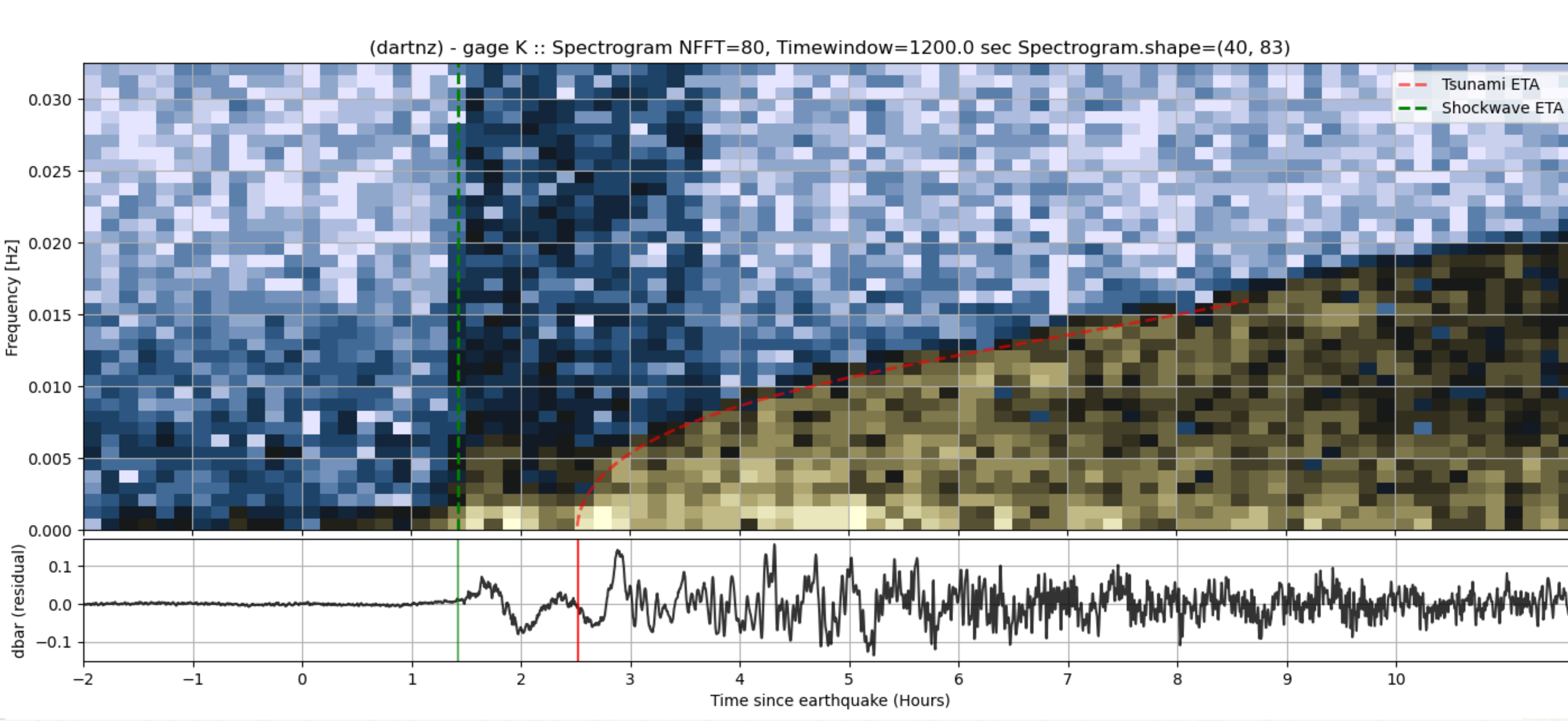

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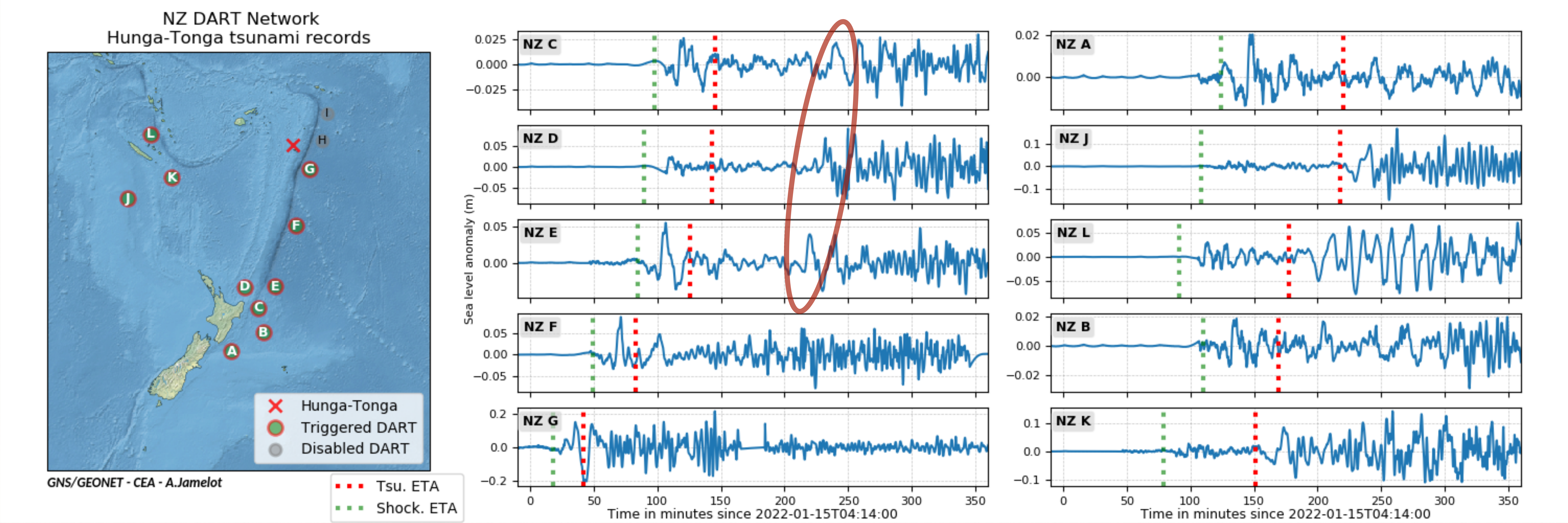

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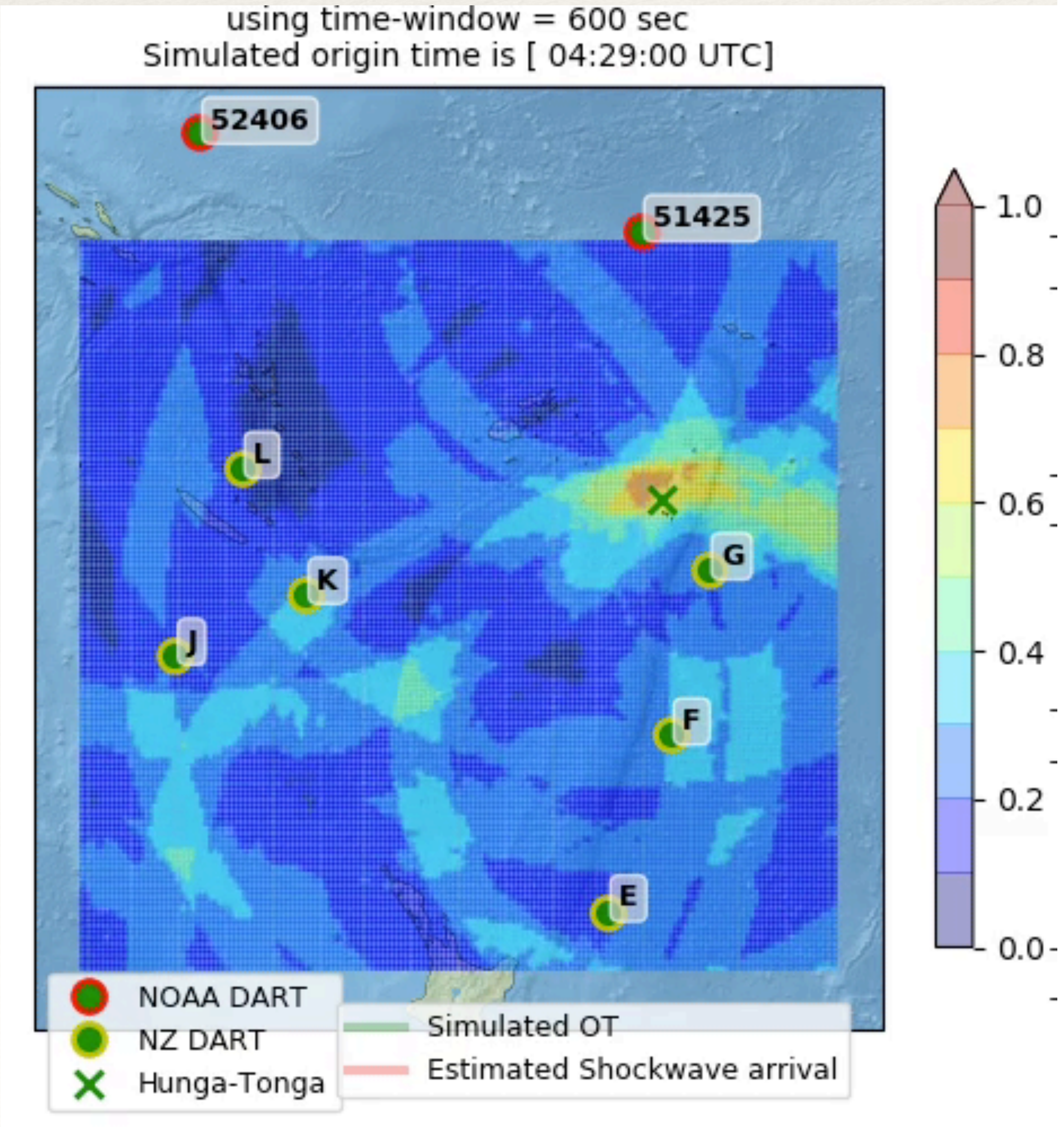

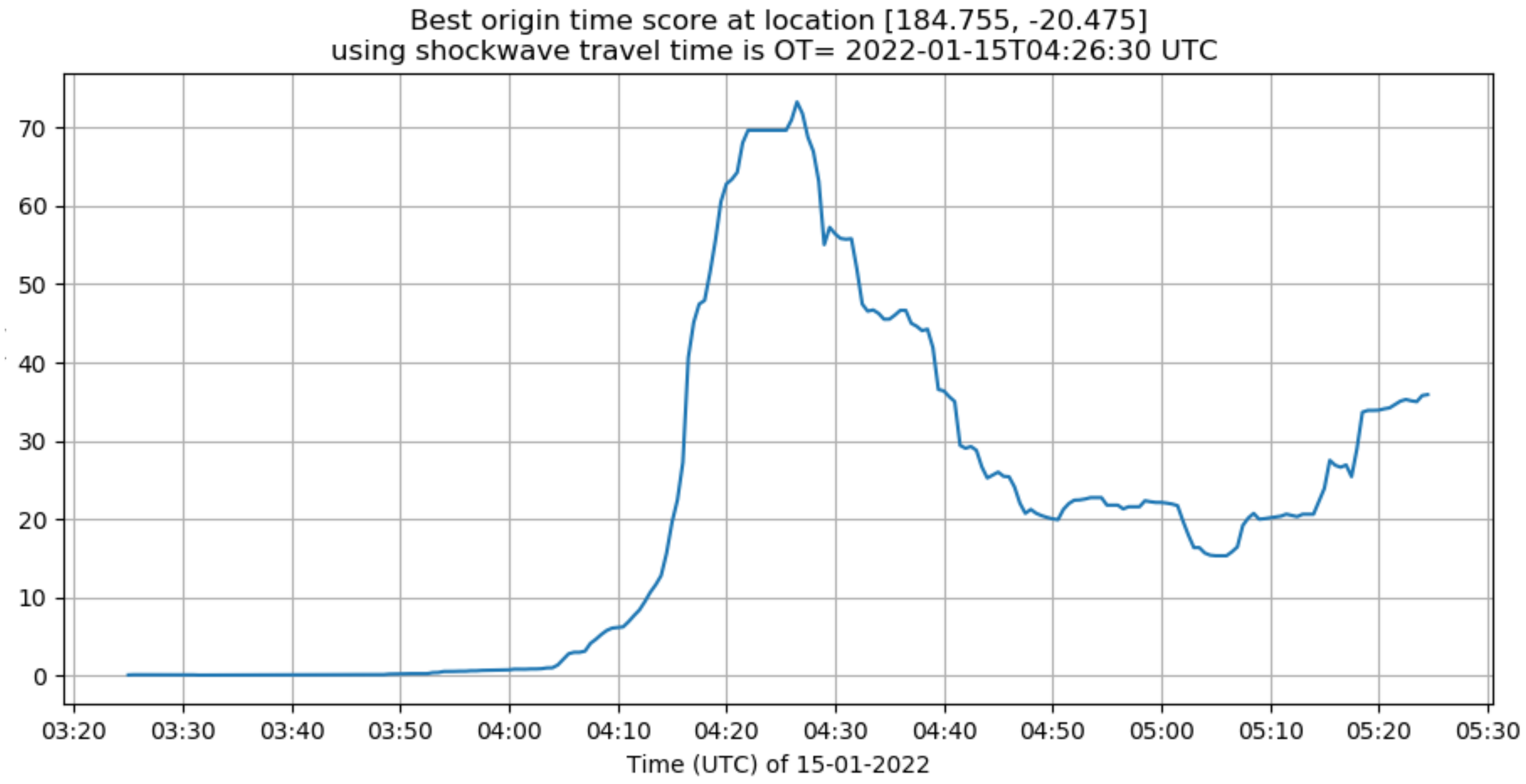

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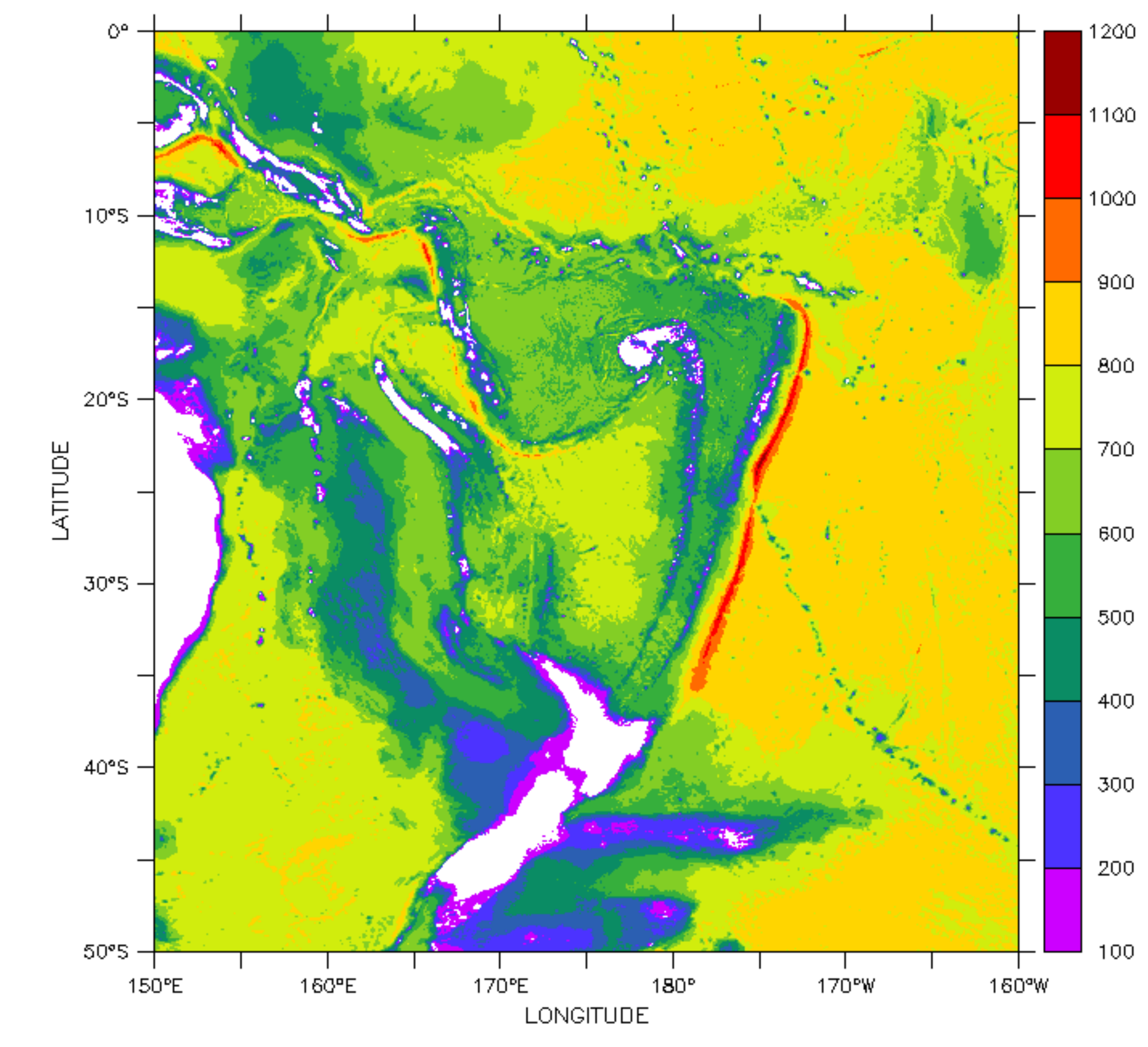
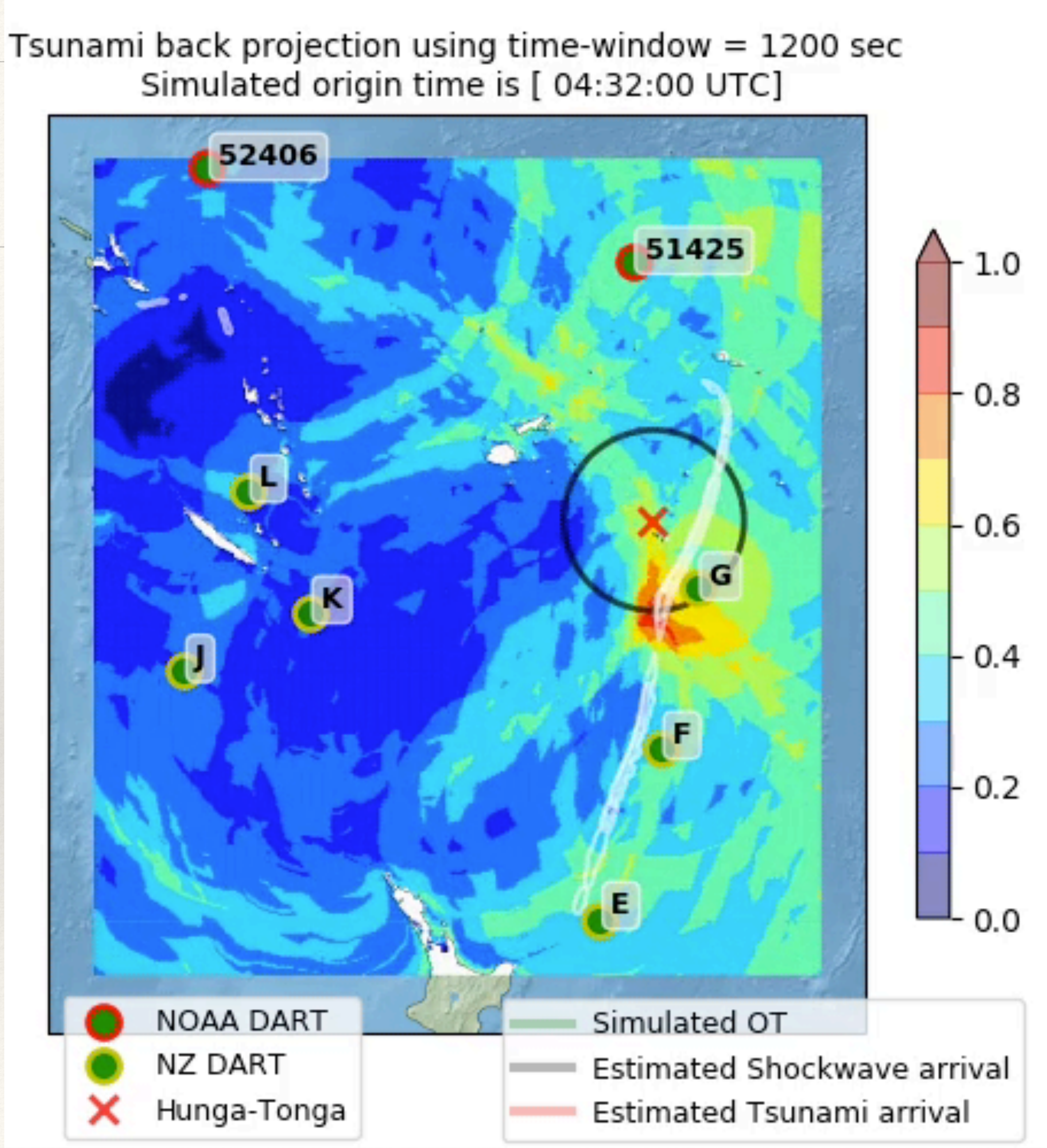
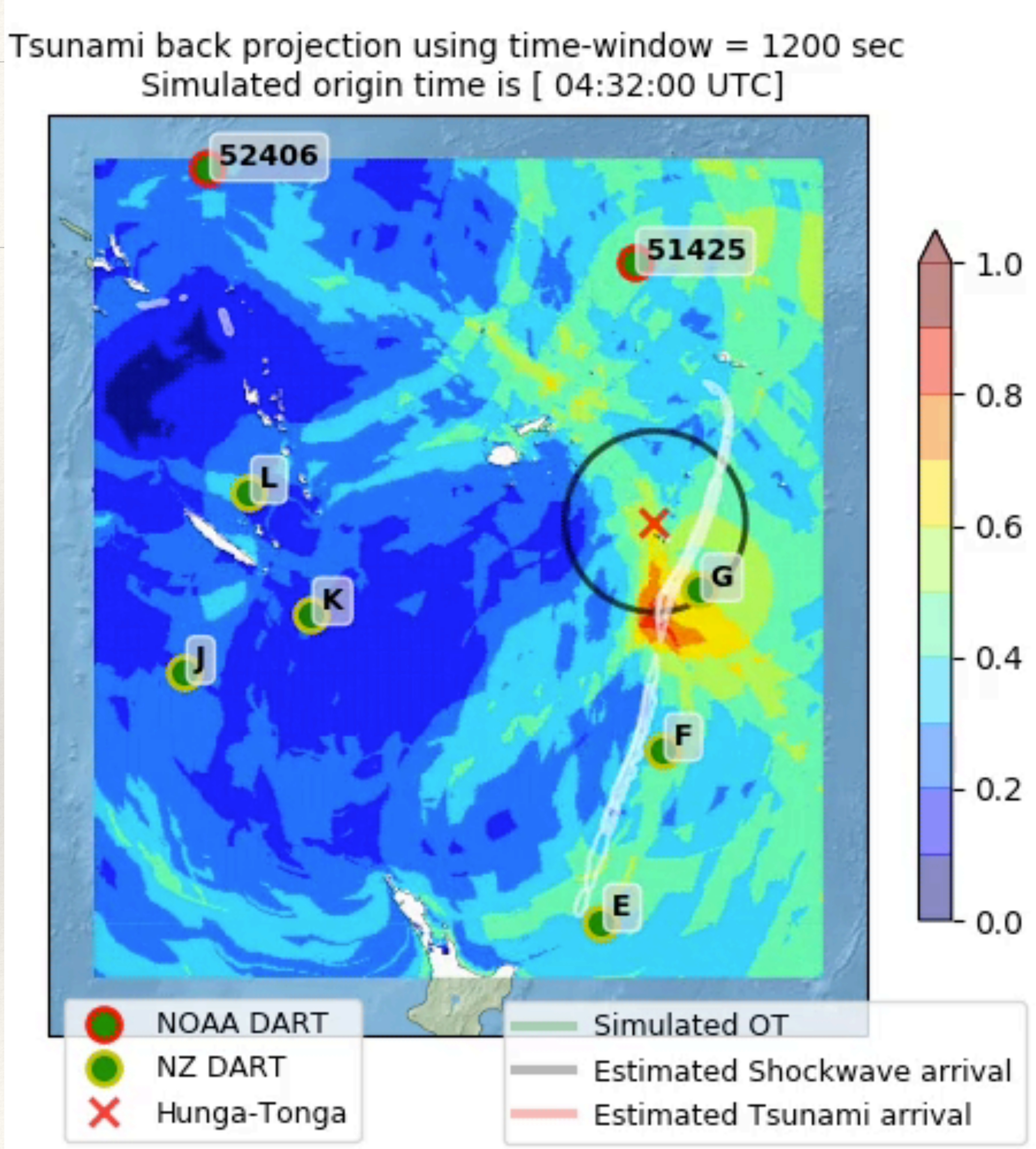


Maximum tsunami wave speed (km/h)



Preliminary analysis

- Back Projection results with highest correlation are geographic zone with a Froude coefficient near 1.
- The amplitudes of this tsunami all across the Pacific was unexpected for such event and location, the coupling Air-Waves across deep oceanic trench can explain as alternative tsunami source neither than resonance along the shockwave path itself.



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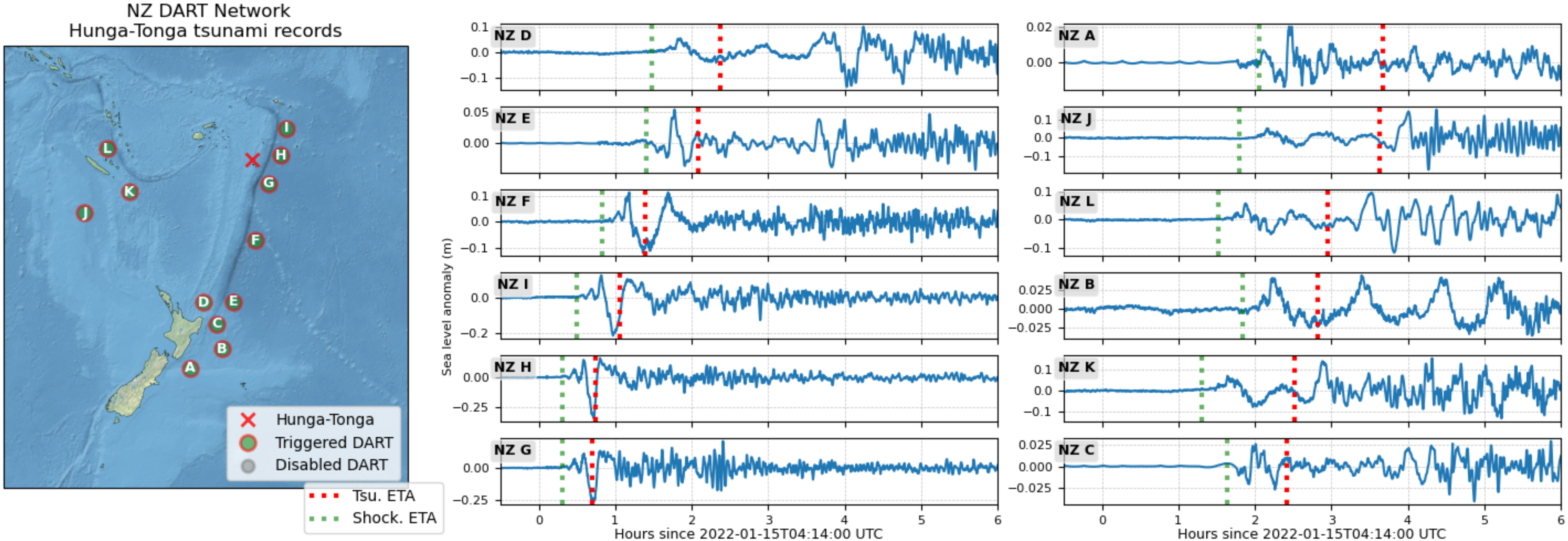
Further analysis / Post event



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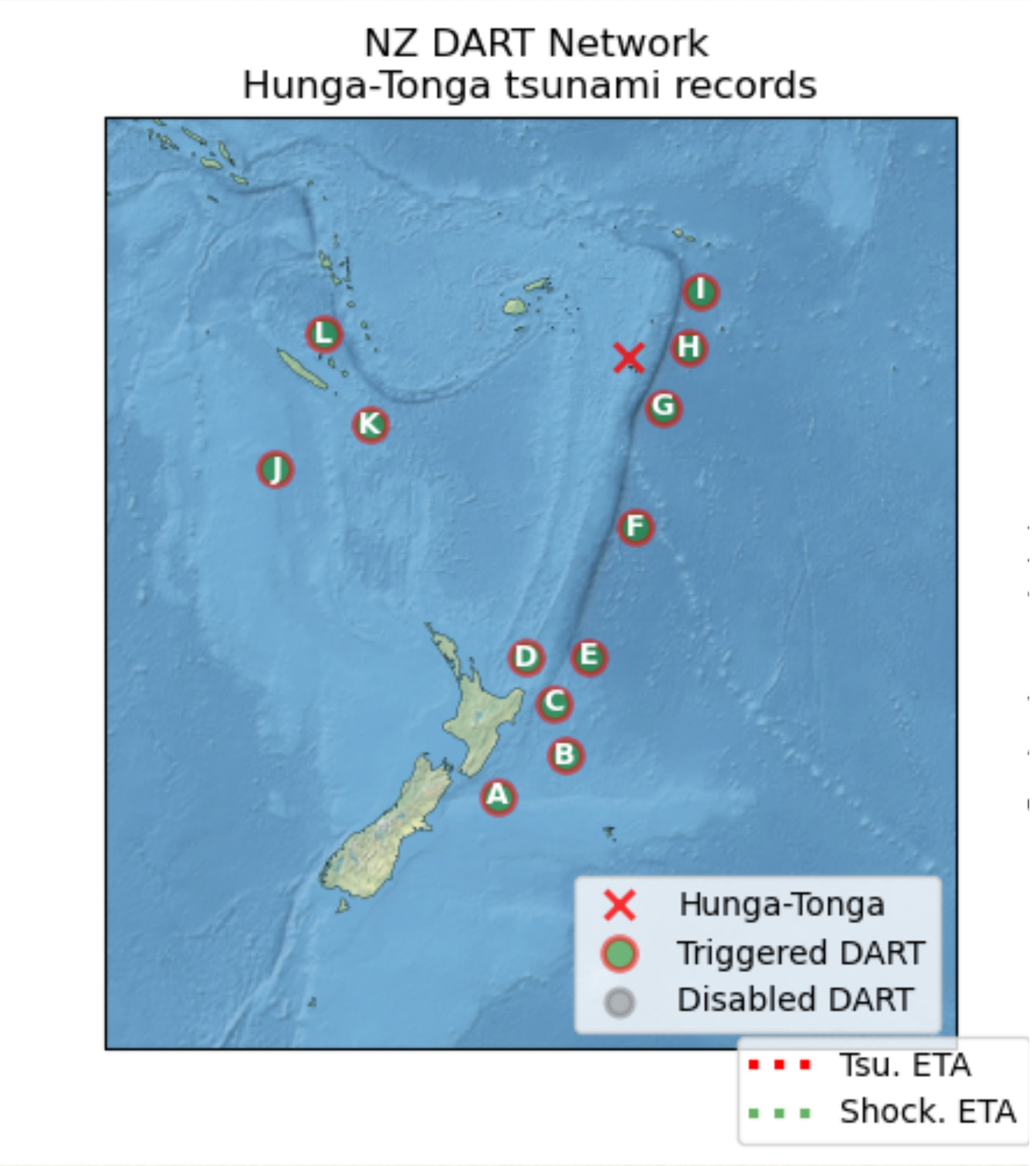
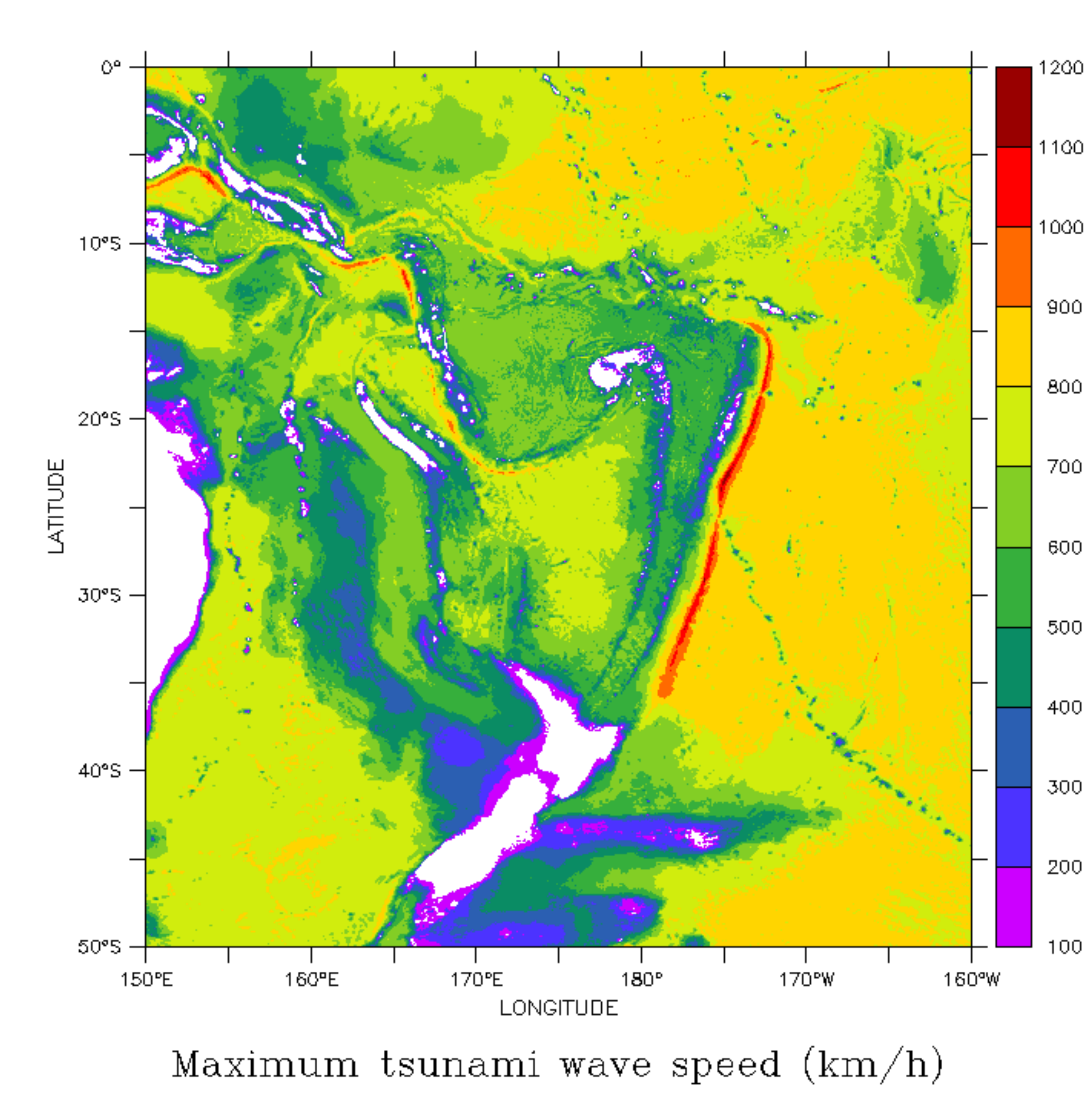
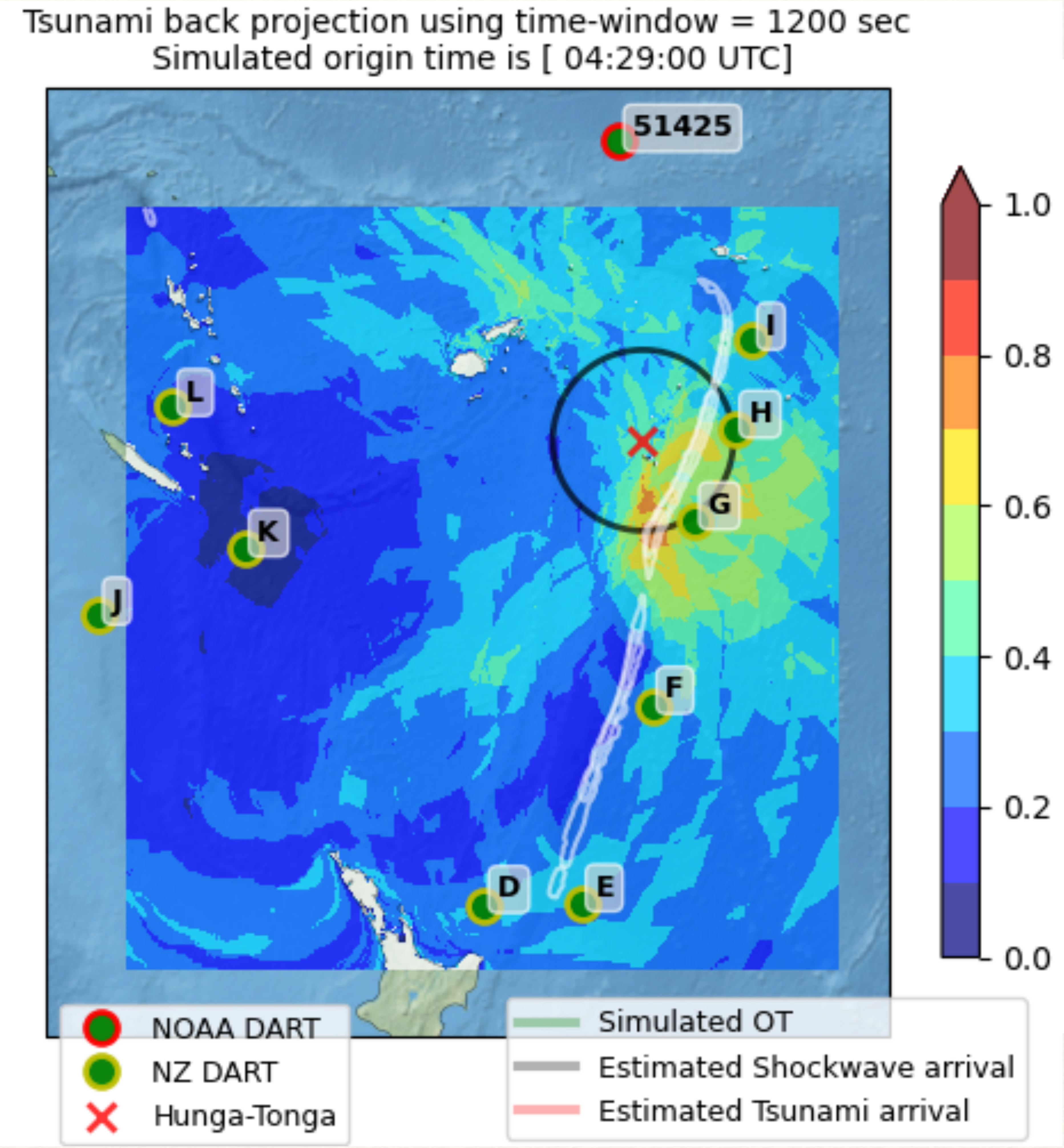






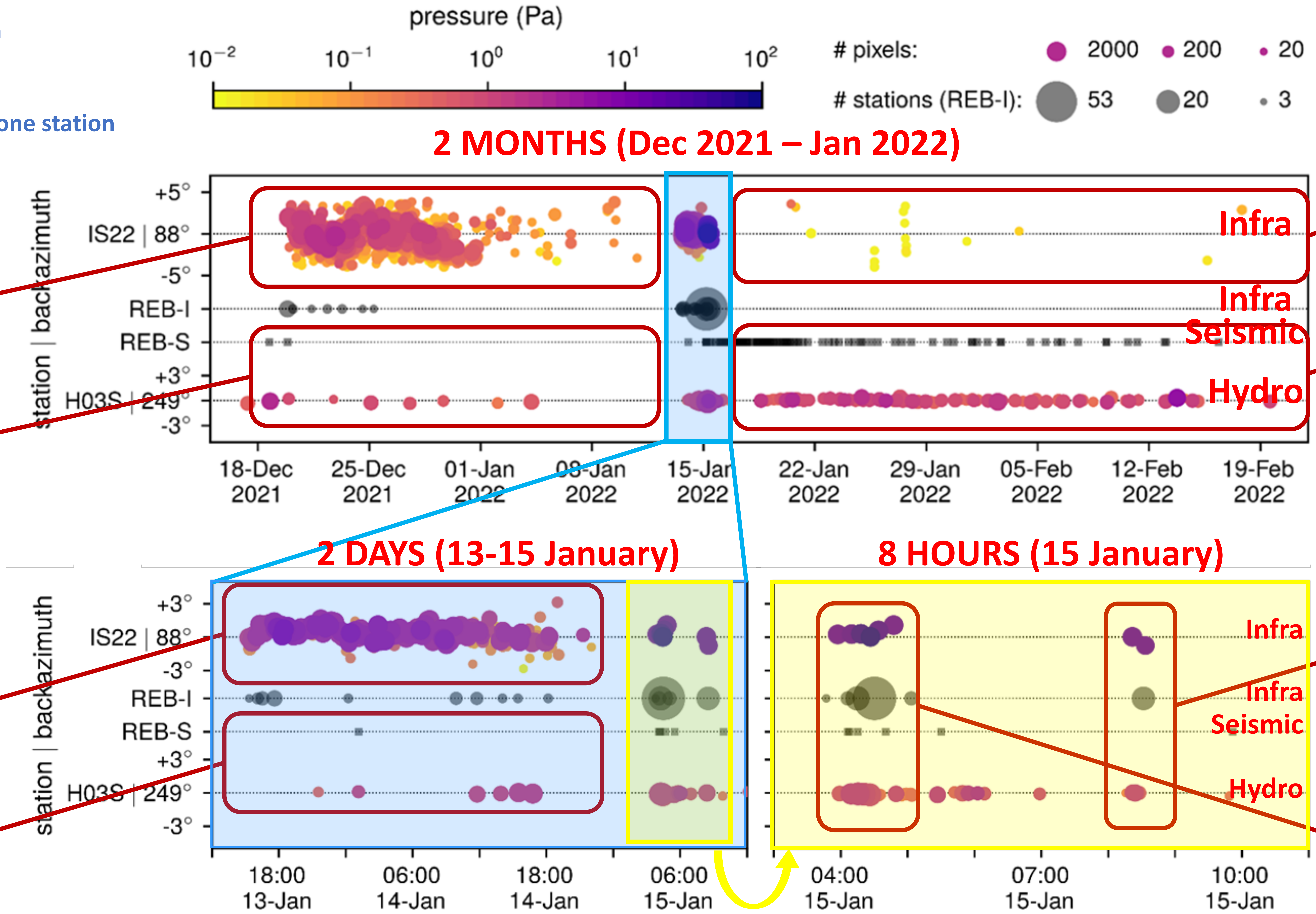
Multi-scale picture of the 2021-2022 eruptive sequence

Atmospheric, underground and underwater activity as seen by the IMS network

Vergoz, Hupe, Listowski et al. (2022)

IS22: Closest infrasound station (1 850 km, New Caledonia)

H03S: Juan Fernandez hydrophone station (9 335km, Chile)



Continuous infrasound, 2-4 weeks before, then decreasing activity

No seismic and almost no hydroacoustic activity

No follow-up infrasound activity

Strong seismic and hydroacoustic activity for 1 month
→ *Post caldera forming event aftershock sequence ?*

Stronger infrasound, 6-36 hours before, then silence again

No seismic and almost no hydroacoustic activity

4:15 h later, another strong eruption

Most explosive events, strong infrasound, moderate seismic and hydroacoustic activity

- A valuable **IMS-only data**
  - **Excellent capability of the IMS network to globally and operationally characterize** Hunga's eruptive episodes
  - First event detected by **all 53 IMS infrasound arrays** (the 2013 Chelyabinsk fireball was the largest before)
- **Infrasound sensors of the IMS network captured a broad range of atmospheric waves (0.1 mHz – 10 Hz) which allow to characterize strong atmospheric events from microbarometer instruments only (required instrument correction)**
- Most explosive event produced a **Lamb wave and infrasonic waves** that encircled the globe several times
- Opportunity to **investigate poorly understood volcanological aspects** like the phreato-magmatic interaction of large-scale eruptions or caldera forming events

17 Jan 2022 vs Apr 2021

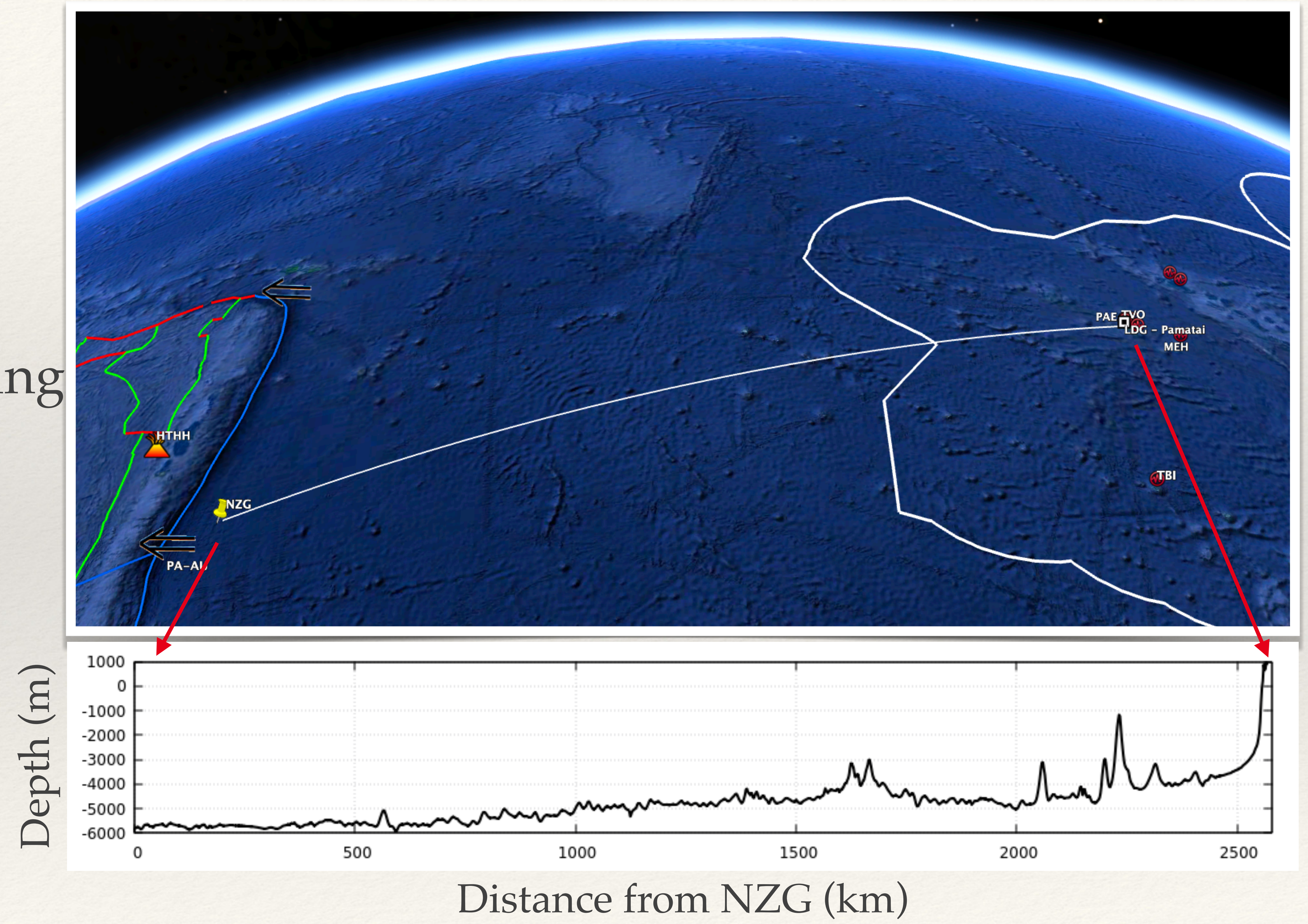
(7) CTBTO SnT2023, Forum : Day 3 Wednesday 6/21/2023 14:20 CEST, Oral session (O1.4) - YouTube.

Vergoz, Hupe, Listowski et al. (2022)

Earth and Planetary Science Lett.
doi:10.1016/j.epsl.2022.117639

Exploring ...

- How to deal with unknown tsunami source process and location ? How to forecast tsunami heights ?
- We tried here a numerical experiment by using the first available record on NZG as the left wave inlet on a 1D simulation time :
  - + Low computation time
  - +/- Conservative



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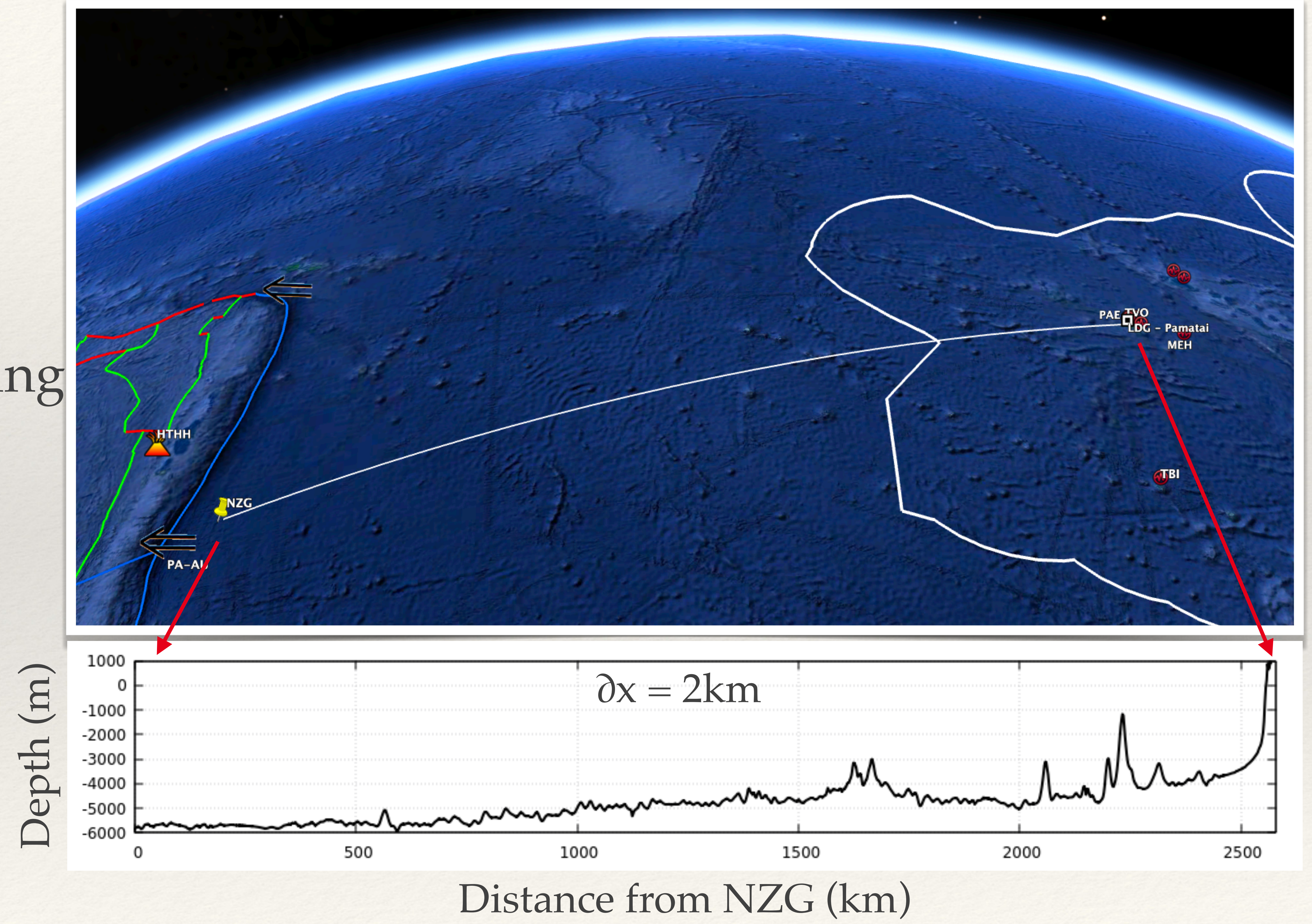

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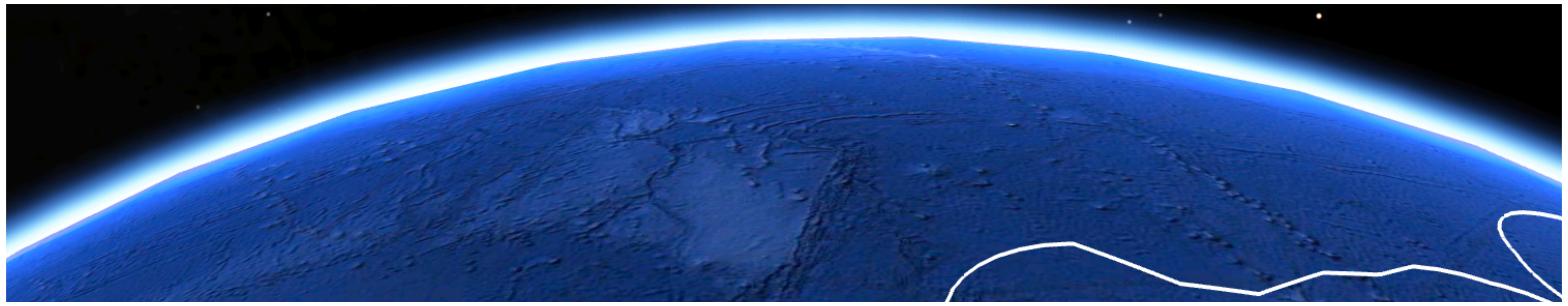

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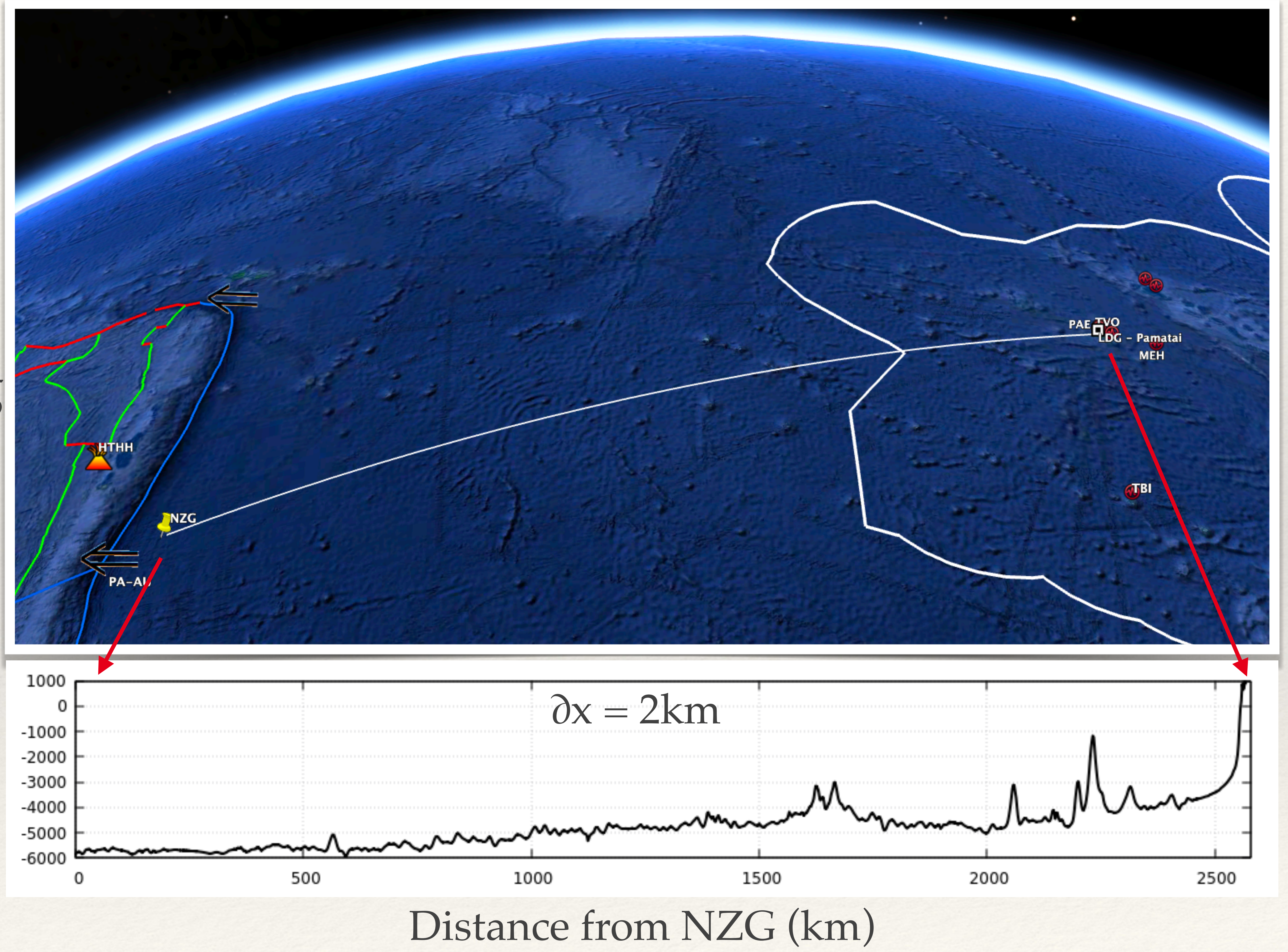

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- Again many events remains how it is crucial to keep alive sea-level networks (tide gages, bottom pressure sensors , …) but also develop and support new technologies that are asked by scientist since many years (SMART Cable) especially in the South Pacific Region.

Mauruuru | Malo ‘Aupito

- ***Contacts :***
- A.Jamelot : jamelot@labogeo.pf
- Bill Fry: b.fry@gns.cri.nz