UK Research and Innovation

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Global Realtime Early Assessment of Tsunami
GREAT

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(with Ali Abdolali & Maxim Filimonov)

Task Team on Tsunami Watch Operations (TTTWO) (online)

04-06 March 2026

unesco
Intergovernmental Oceanographic Commission

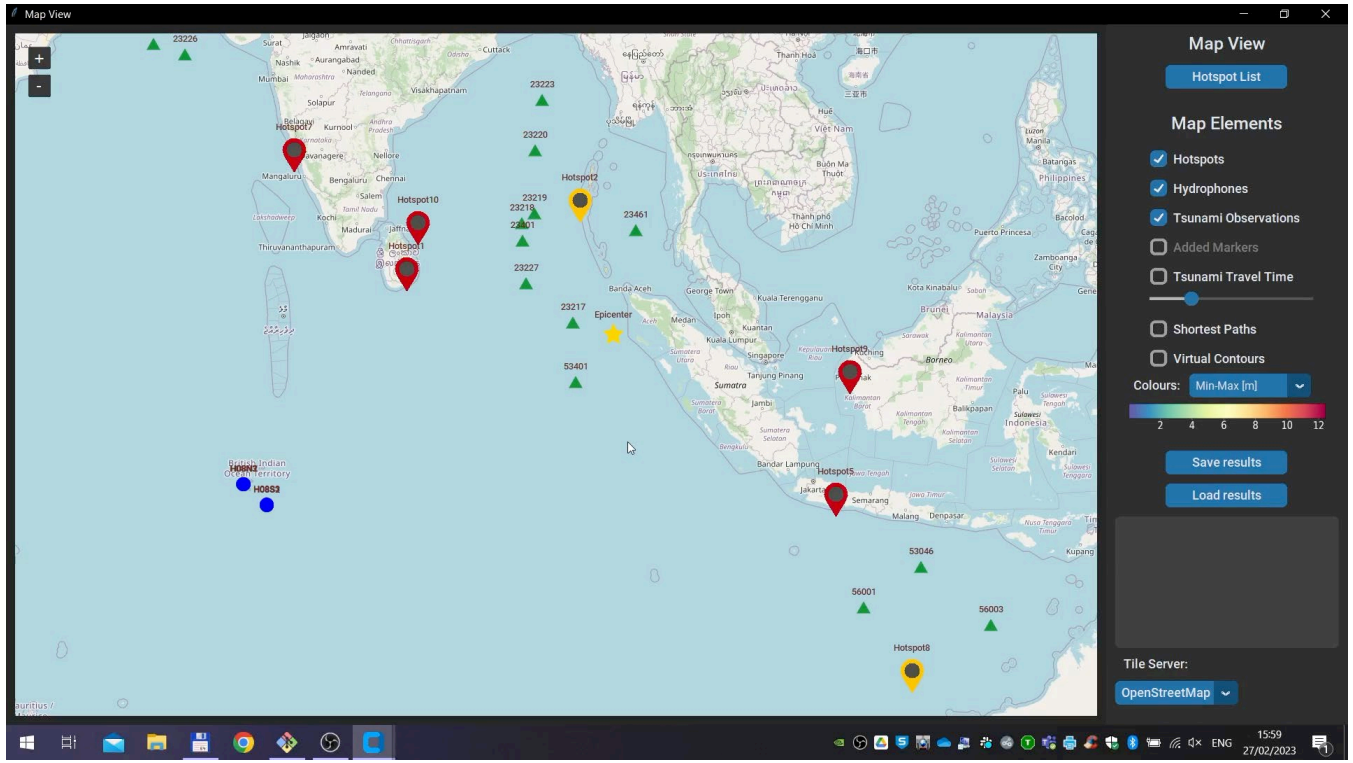
United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

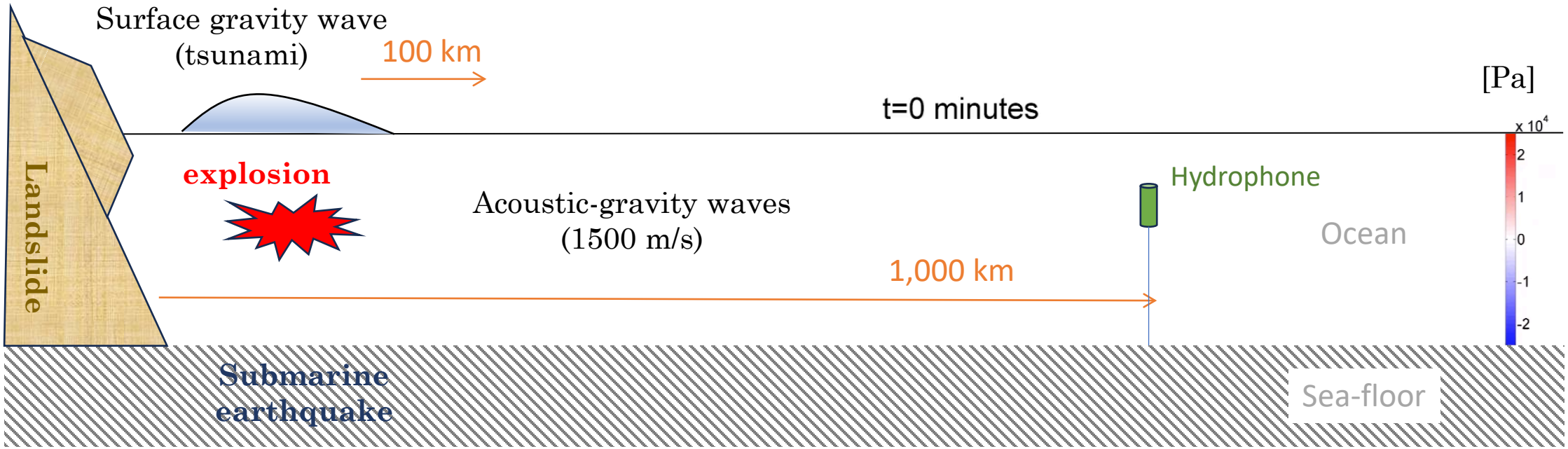
2021 2030 United Nations Decade of Ocean Science for Sustainable Development

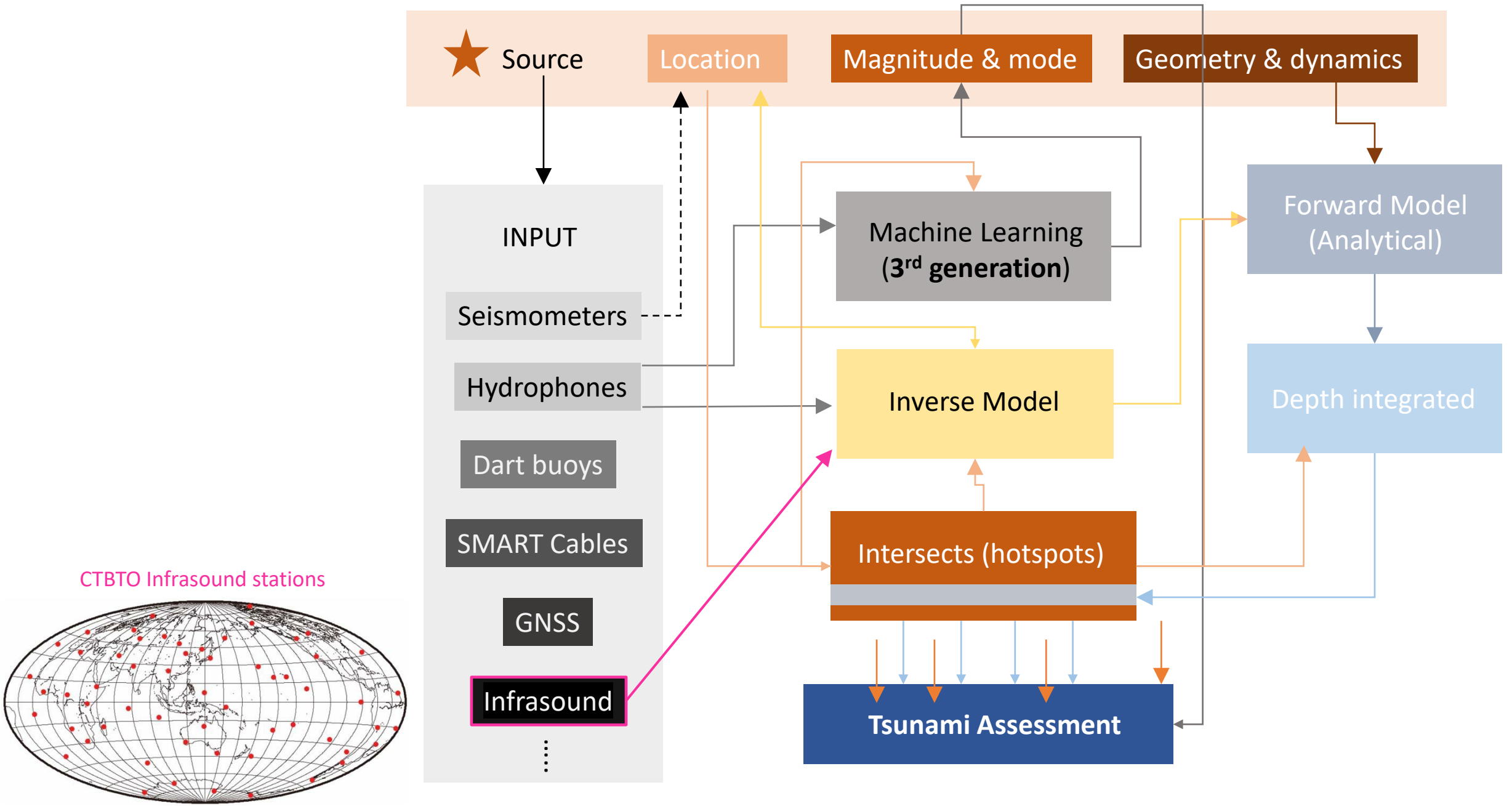
Content

- A very brief introduction (skipped)
- Selected activities & new collaborations
- Case studies – South China, Sulu, & Celebes sea
- Optimisation of hydrophone deployment in the Indian Ocean
- Landslides & Machine Learning
- Conclusions



Real-time Tsunami Detection by Acoustic-Gravity Waves





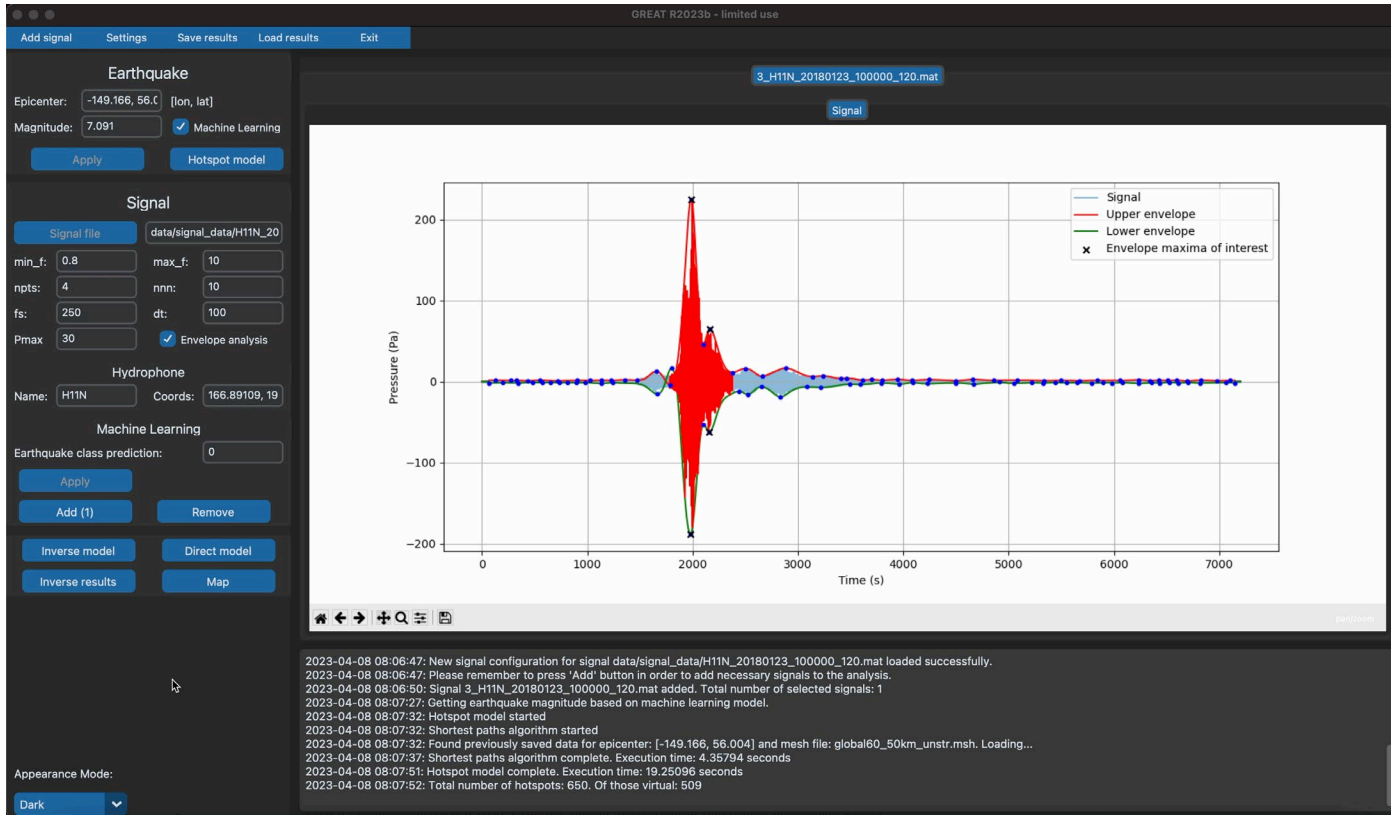
DOI: 10.4236/ijg.2013.44074

Operational Software: Global Real-time Early Assessment of Tsunami (GREAT)

Detect → Analyse → Disseminate

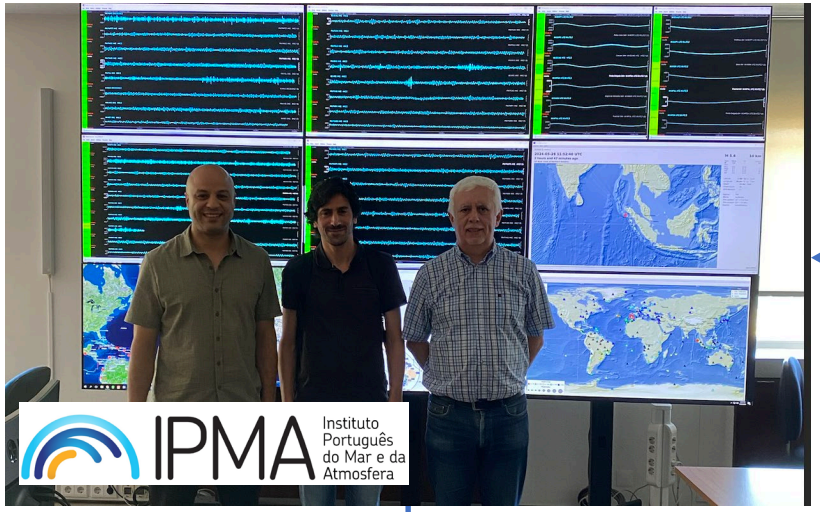
- Provides **initial assessment** based on EQ epicentre, sensors' locations, and required evacuation time.
- Detects signals; **categorises** earthquakes / events; **analyses** hydroacoustic data; calculates **tsunami size**
- End-to-end analysis is typically delivered within 8 min, if the hydrophone is within 1,000 km distance
- Operates **automatically**, and **manually** (after training)
- Hydrophones & Tide-gauges data are already integrated; other data sources can be integrated, e.g., seismic/GNSS, SMART cables, ...

M 7.9 - 2018 261 km SE of Chiniak, Alaska Earthquake 2018-01-23 09:31:40 (UTC)

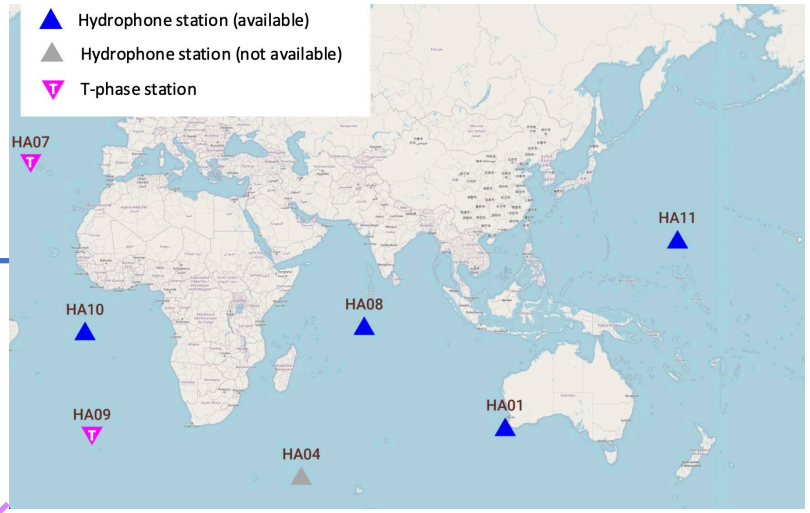


Access to IMS/CTBTO Real-Time Hydroacoustic Data

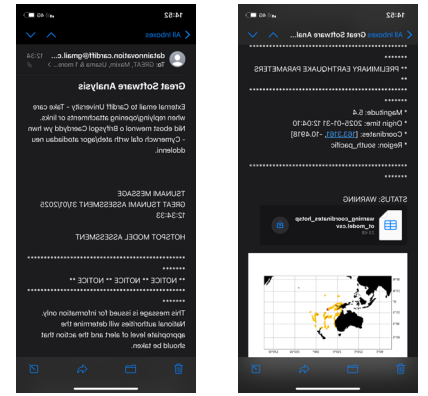
Software deployed at IPMA June 2024



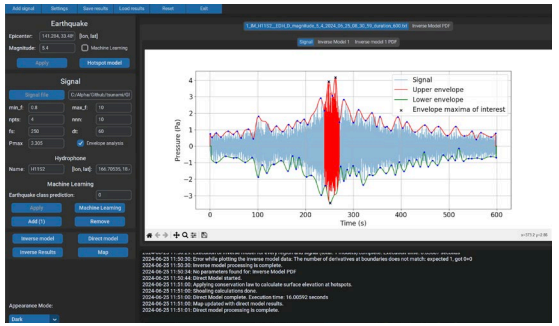
Real-time access

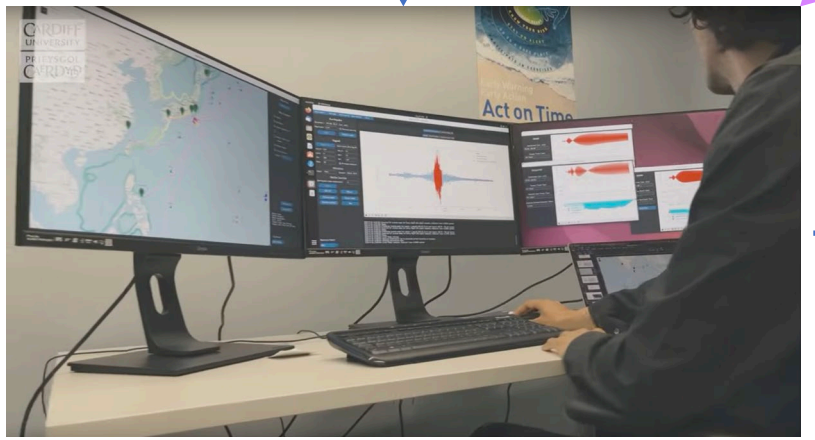


e-mail Alerts

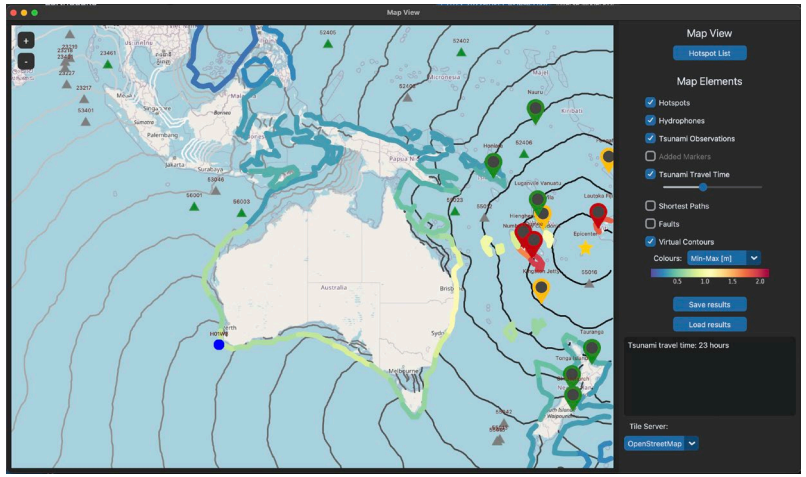


Live streaming





Cardiff University Tsunami Centre, UK



Assess Tsunami globally & benefits coastal communities, especially SIDS and LDCs

E-mail alert message

datainnovation.cardiff@gmail.com 00:22
MOLUKKA SEA - M6.7 - GREAT TSUNAMI ALERT
To: GREAT Email List

External email to Cardiff University - Take care when replying/opening attachments or links.
Nid ebost mewnol o Brifysgol Caerdydd yw hwn - Cymerwch ofal wrth ateb/agor atodiadau neu ddolenni.

GREAT TSUNAMI ALERT - MESSAGE 3
Global Real-time Early Assessment of Tsunami (GREAT) System
Issued by: GREAT Monitoring Center, Cardiff University, UK
Date and Time: 10/01/2026 16:22:13 UTC

IMPORTANT NOTICE
This alert is distributed solely for informational purposes to support the GREAT tsunami early assessment initiative. It is provided to assist national authorities in evaluating risk; each country should determine its own alert level and may supplement this message with additional local guidance.

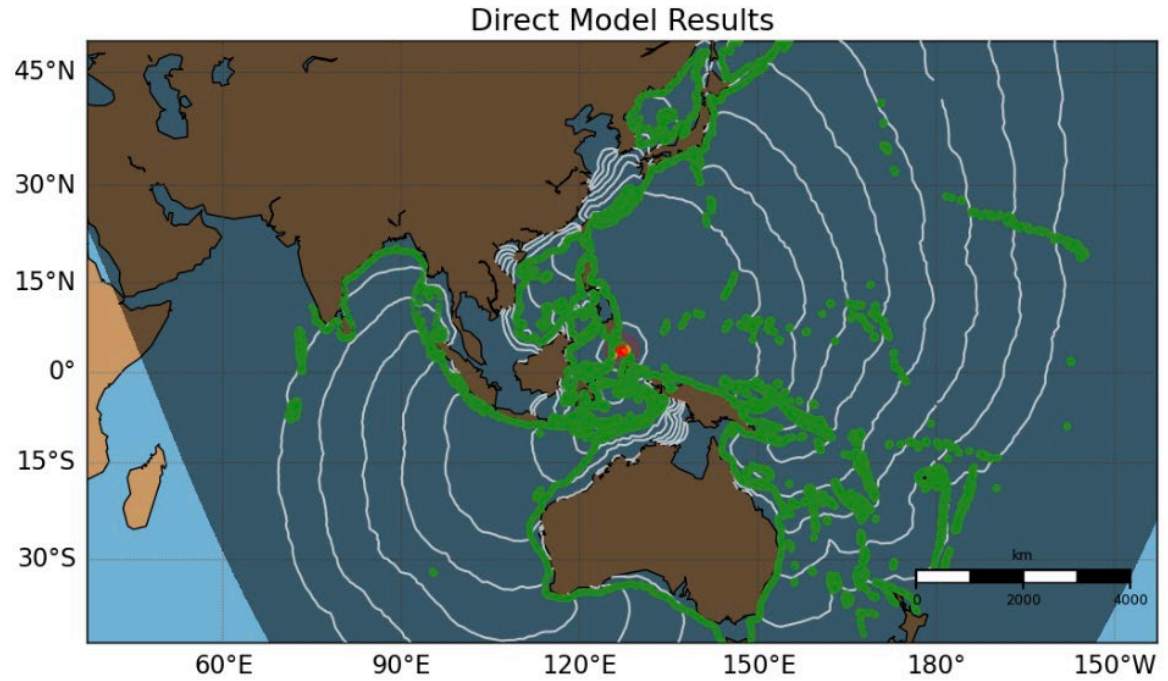
PRELIMINARY EARTHQUAKE DATA (Source: USGS)
* Magnitude: 6.7
* Event Date and Time: 2026-01-10 14:58:25 UTC
* Coordinates: 3.7° N, 127.1° E
* Location: Molukka Sea

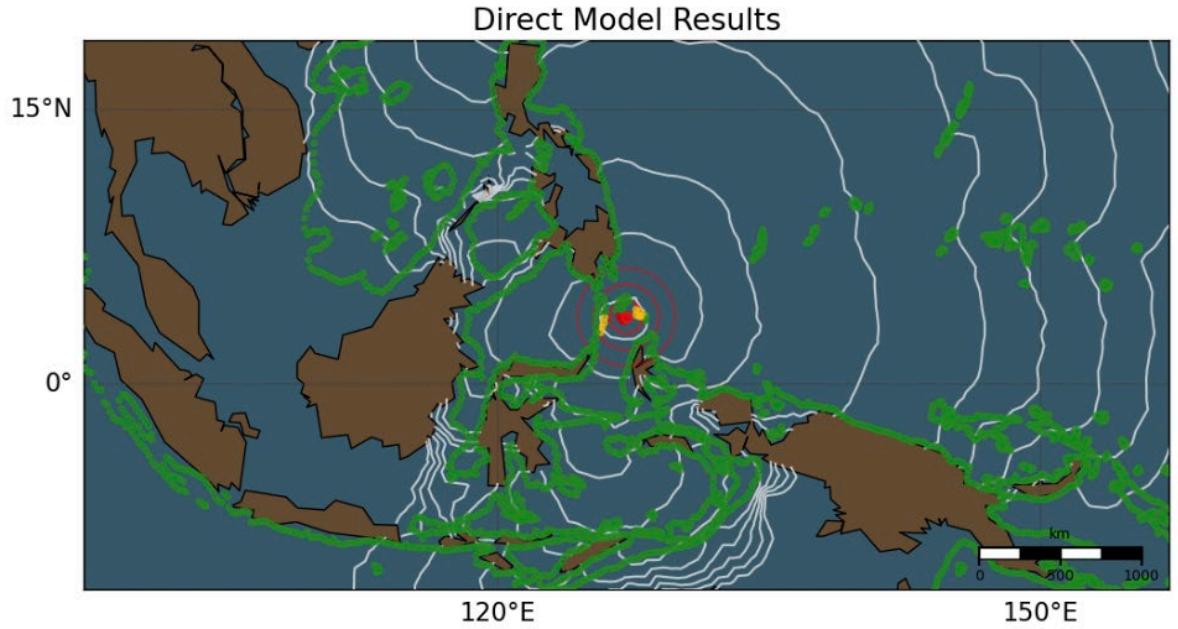
CURRENT EVALUATION
A seismic event registering a preliminary magnitude of 6.7 was recorded in Molukka Sea region on date and time: 2026-01-10 14:58:25 UTC. Hydroacoustic data recorded at station H11S1 on 10/01/2026 at 15:49:37 UTC was analysed using GREAT.
==> Our MACHINE LEARNING analysis does not indicate an imminent tsunami risk associated with this event.
==> Our ANALYTICAL analysis indicates an imminent tsunami risk associated with this event.

ADVICE TO AUTHORITIES
National authorities will determine the appropriate level of alert and the action that should be taken.

FUTURE UPDATES & ADDITIONAL INFORMATION
* This notice is intended as the only update for this event unless further data suggest a change in conditions.
* For authoritative earthquake details, please refer to the U.S. Geological Survey at earthquake.usgs.gov.
* Further tsunami-related updates are available at our GREAT website: [url pending].

DISCLAIMER
The information provided in this alert is compiled from multiple data sources and is meant for early situational awareness only. GREAT does not guarantee the timeliness, accuracy, or completeness of this information. It is the responsibility of local and national agencies to verify details and disseminate warnings appropriately.
To unsubscribe from these notifications, please send an email to KadriU@cardiff.ac.uk (Usama Kadri).





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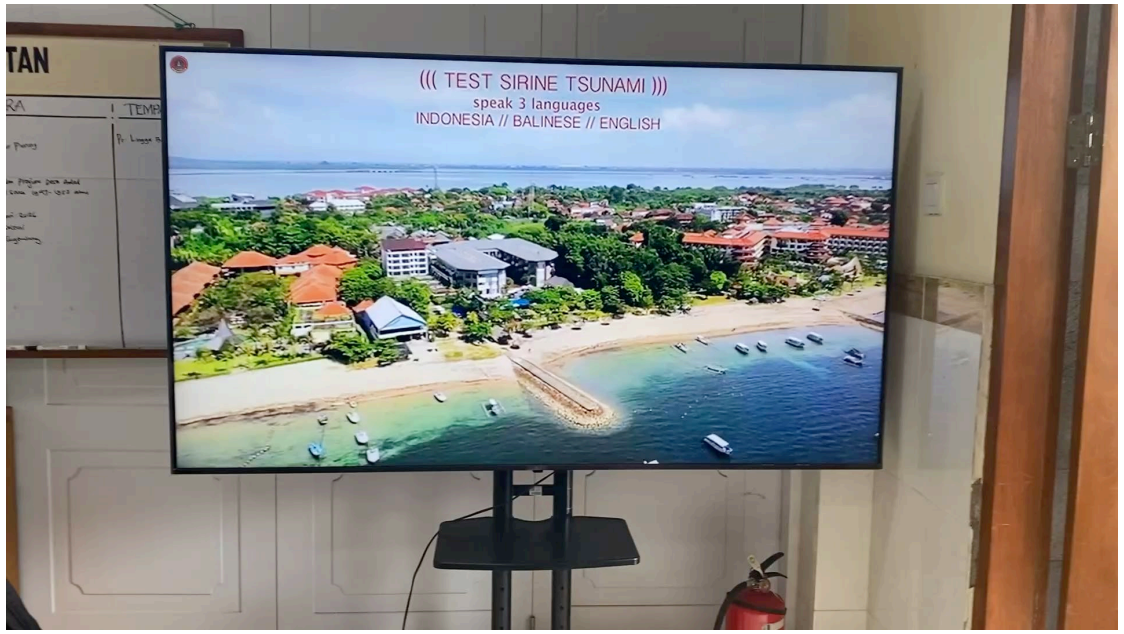
General Activities

Tsunami-Ready | New Collaborations

Meeting with local communities



Central Command (Tsunami Ready)

Badung, Bali, January 2026

Meeting with local communities

Central Command (Tsunami Ready)

Badung, Bali, January 2026

Universiti Putra Malaysia (Dec 2025 - Jan 2026) Short Sabbatical

IPMA Instituto Português do Mar e da Atmosfera

(Host: Prof. Aduwati Sali)

- Current IAA KEPS funding; collaboration includes:
  (a) optimisation; (b) ML; (c) flooding

National water research institute

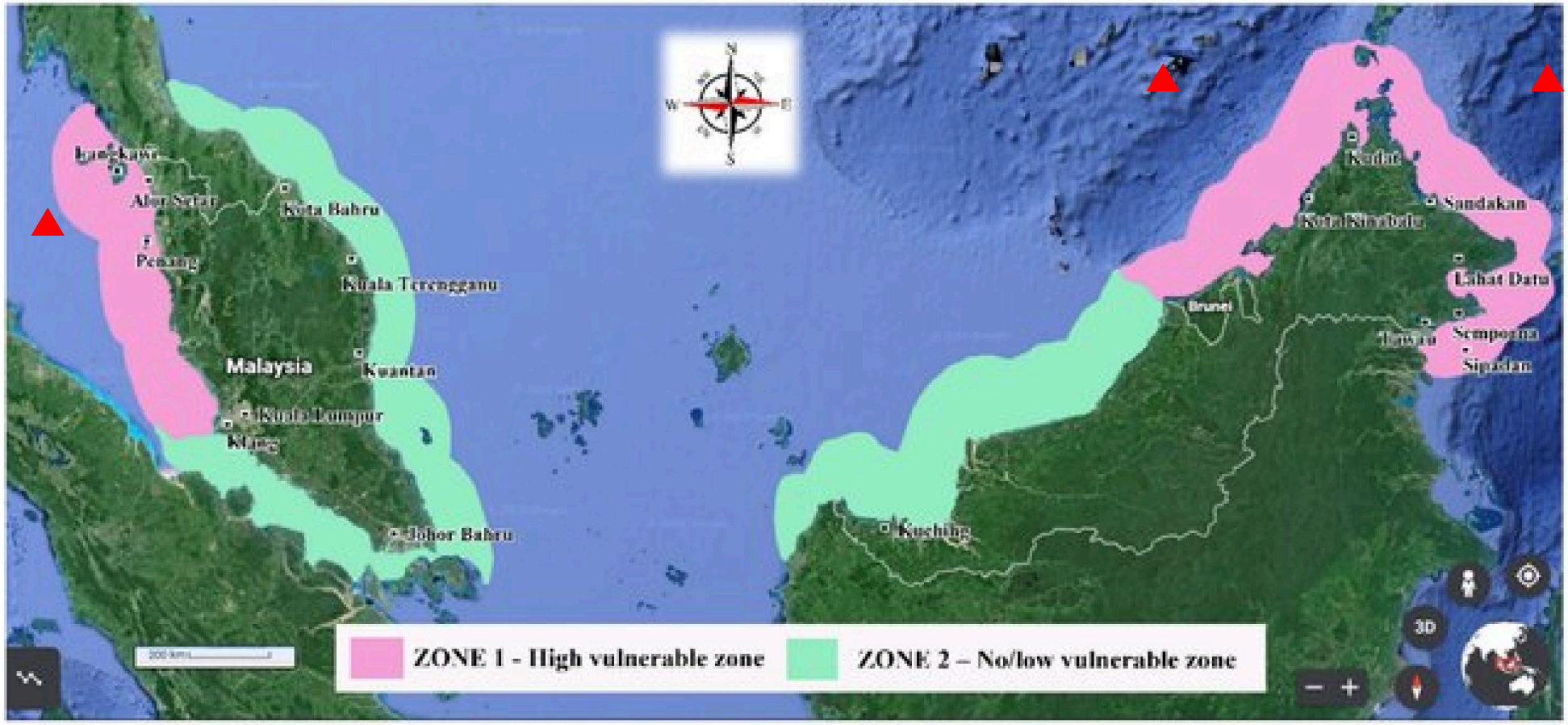
Hydraulic & instrumentation lab

- Potential collaborations

MET Malaysia January 2026)

- Optimisation of hydrophone locations

Towards hydrophone deployment – optimisation
(Tsunami, Hurricanes, Flooding)



Scientific considerations

- Target end-to-end analysis time
- Optimal signal to noise ratio
- Near-/Far-field warning

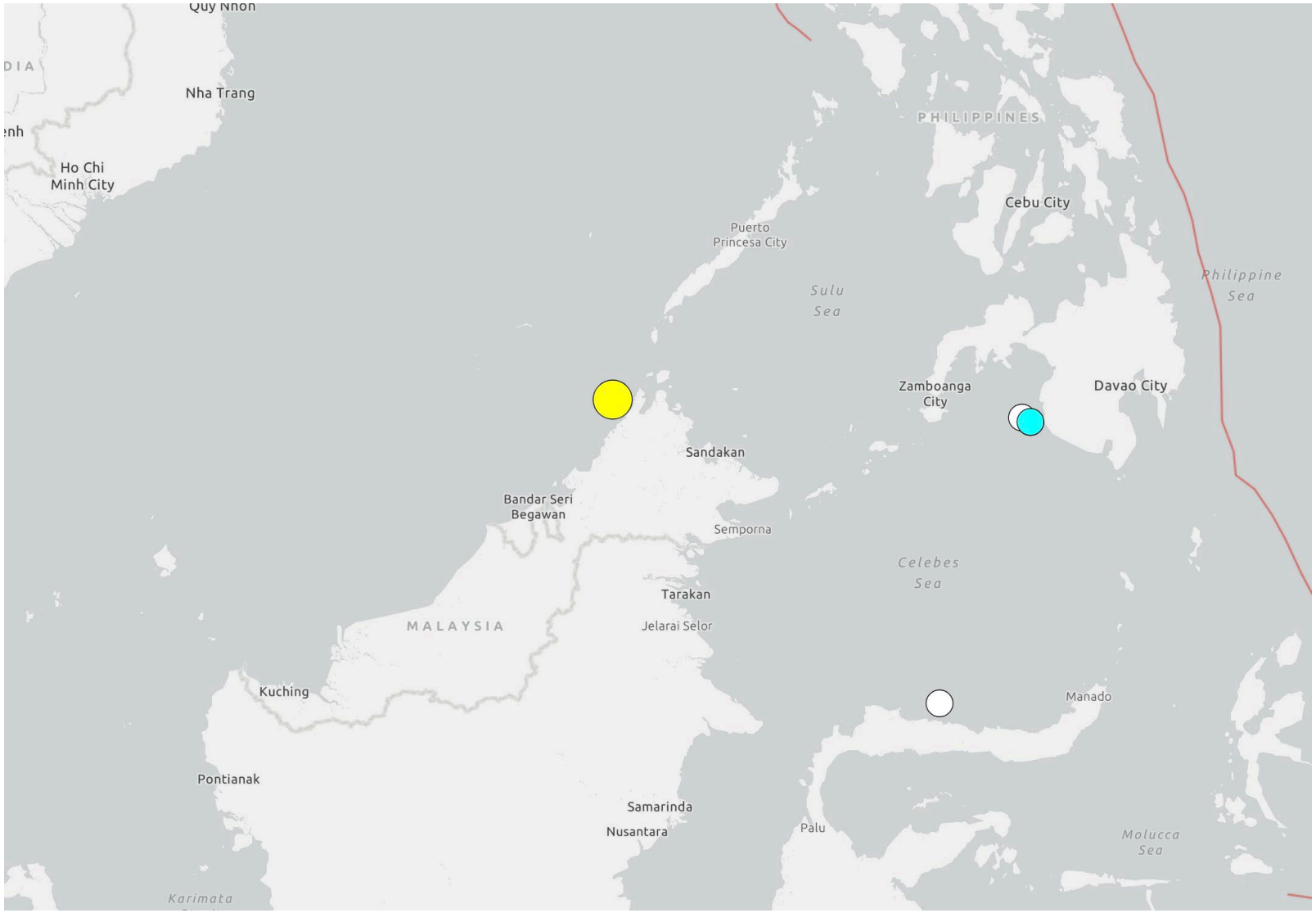
Constraints

- Deployment costs
- Logistics limitations
- Political limitations

Citation: Moon, W.C.; Sidek, L.M.; Lau, T.L.; Puay, H.T.; Majid, T.A.; Wahab, A.K.A.; Teo, F.Y. A Shared Vision on the 2004 Indian Ocean Tsunami in Malaysia: Hazard Assessments, Post-Disaster Measures and Research. J. Mar. Sci. Eng. 2022, 10, 1088. https://doi.org/10.3390/jmse10081088

M 5.9 – 27 km W of Sangay, Philippines

2026-01-28 06:47:00 (UTC) | 6.427°N 123.796°E | 10.0 km depth



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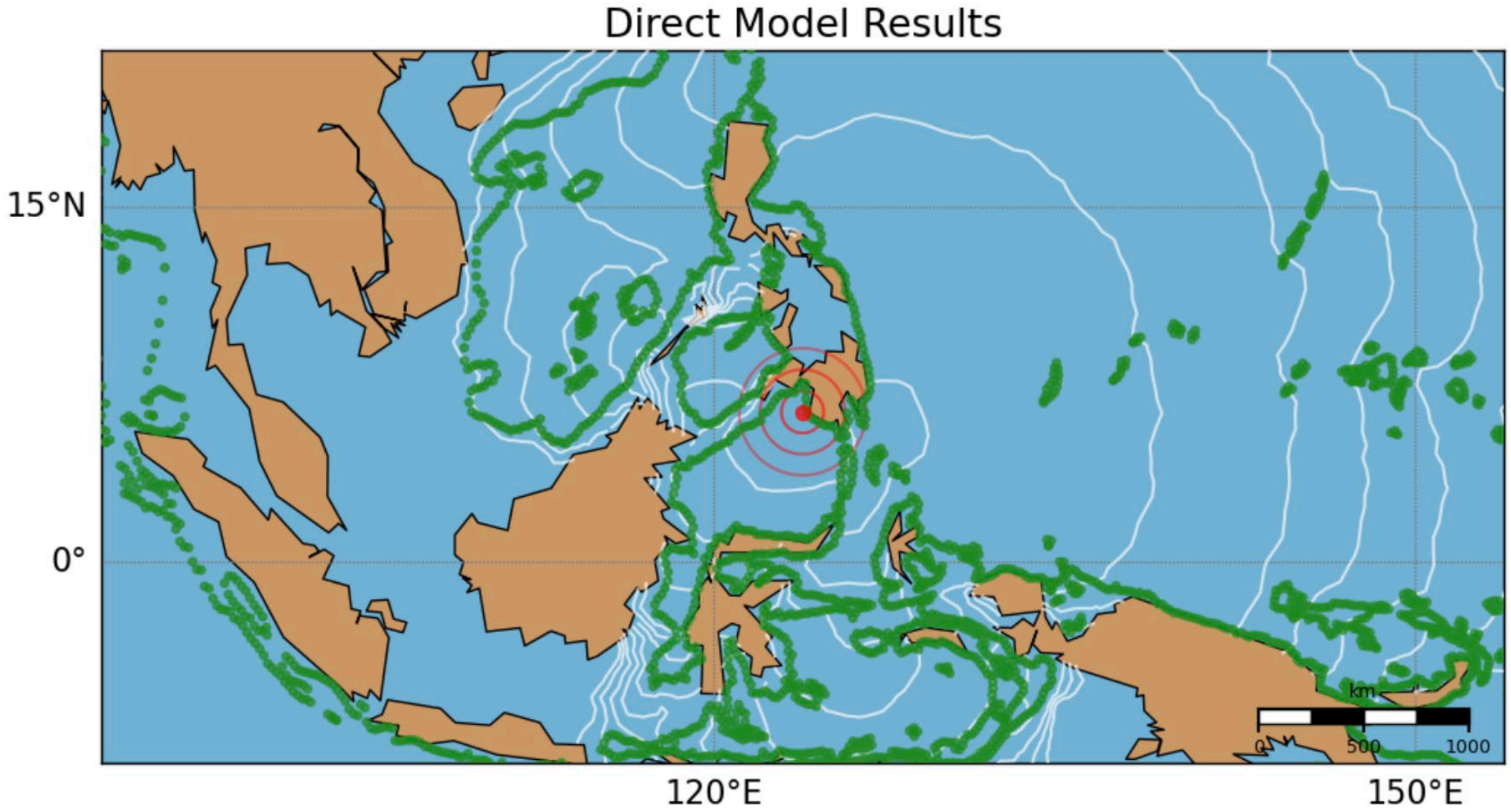

M 9.1

~~M 5.9~~ – 27 km W of Sangay, Philippines

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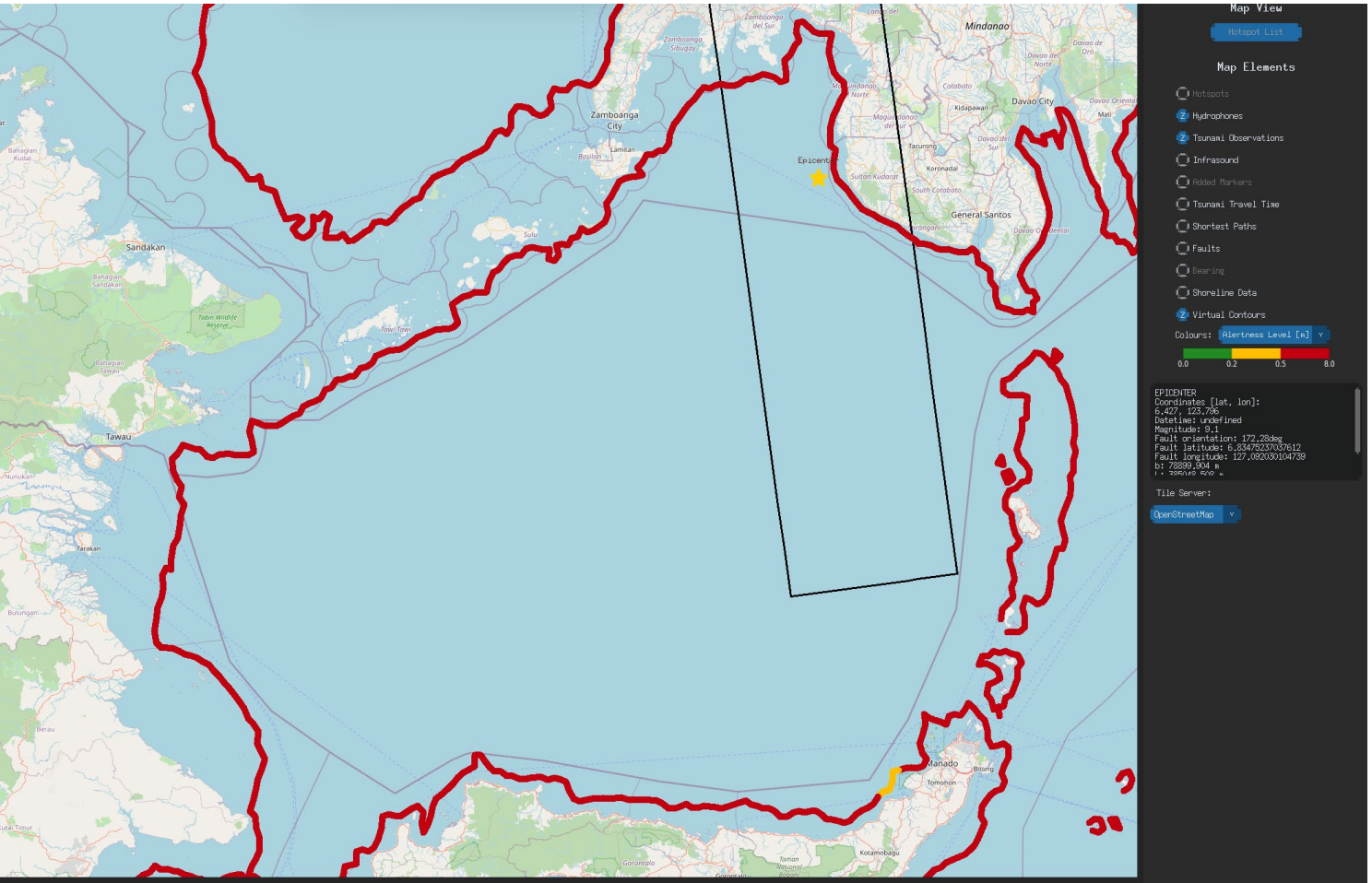
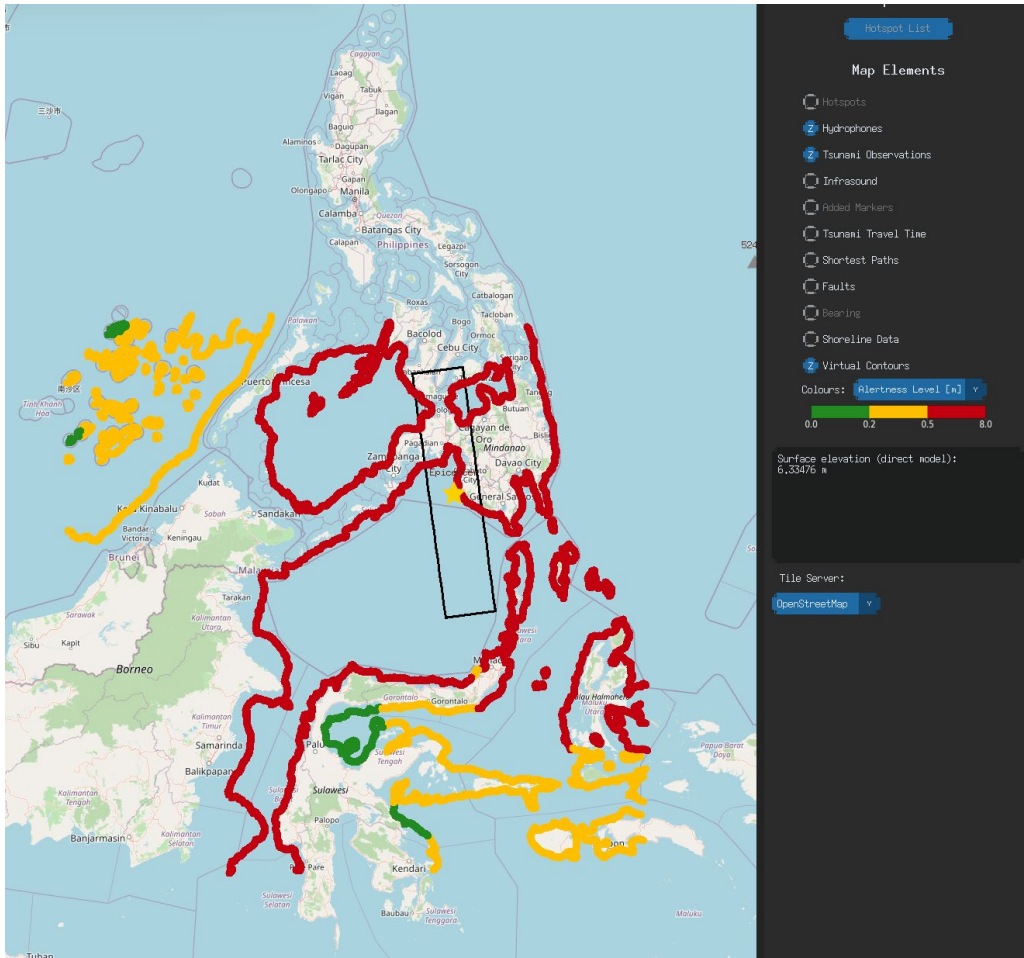
- Over confidence can be deadly!



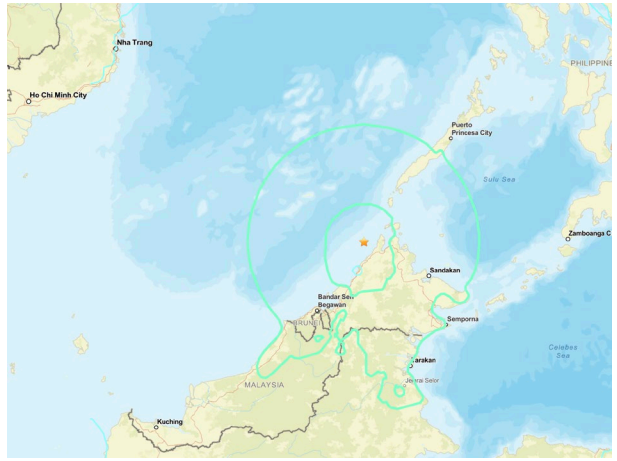


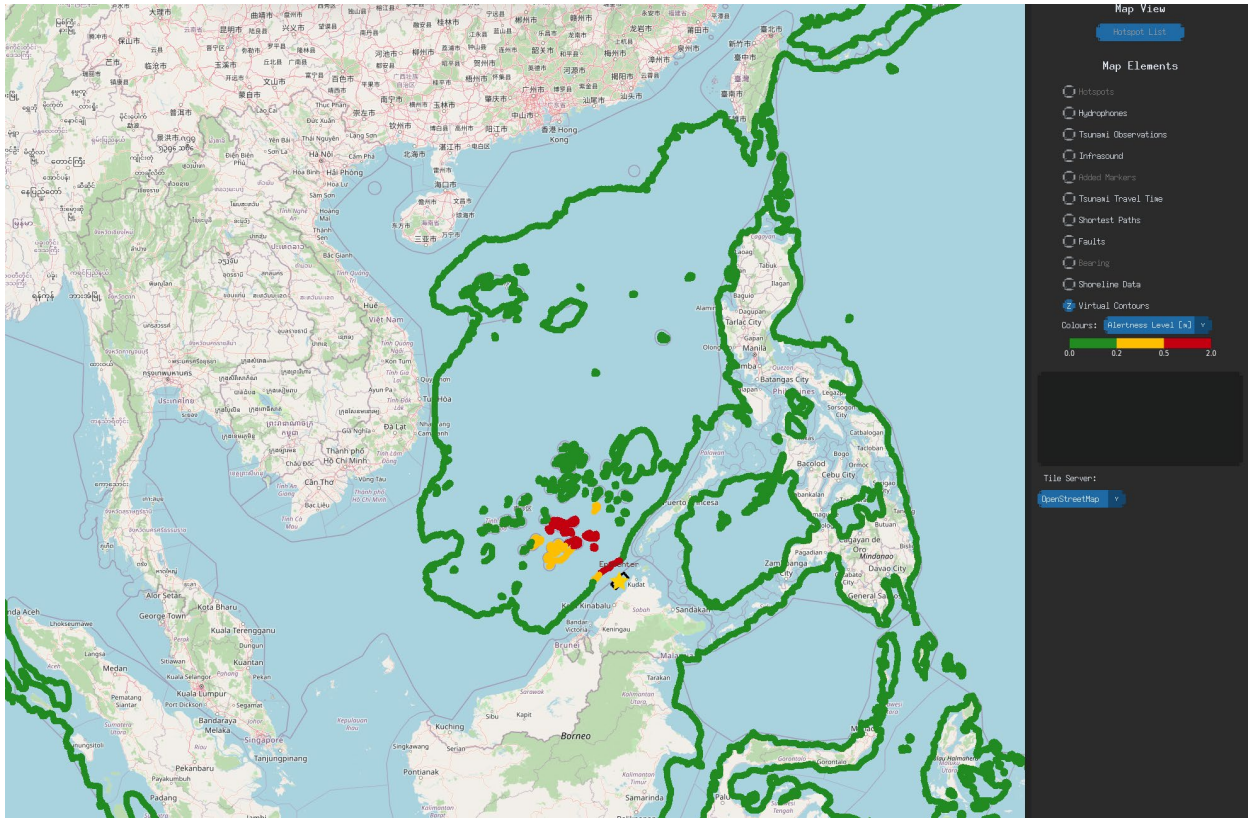
Event examples

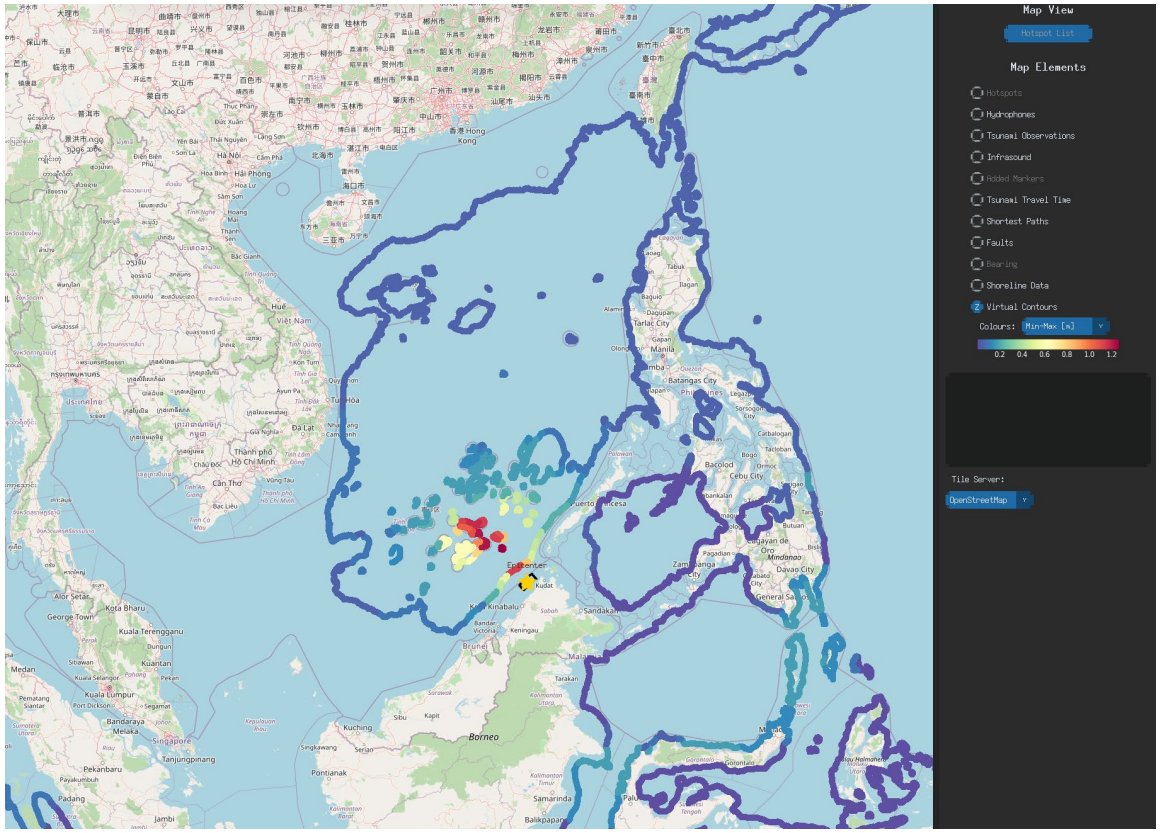
Kota Belud, Malaysia 2026

M 7.1 – 55 km NNW of Kota Belud, Malaysia

2026-02-22 16:57:46 (UTC) | 6.829°N 116.264°E | 619.8 km depth







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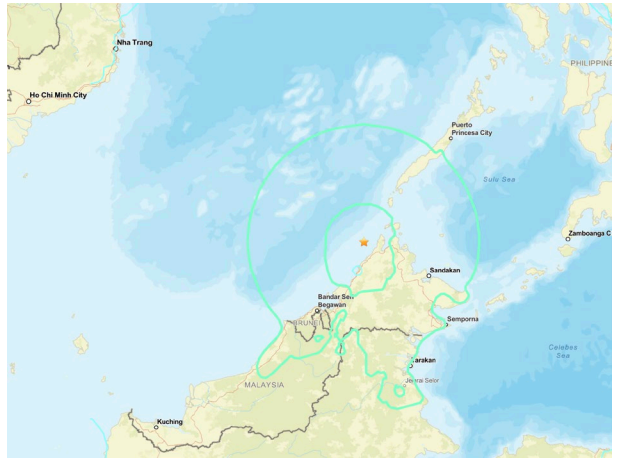
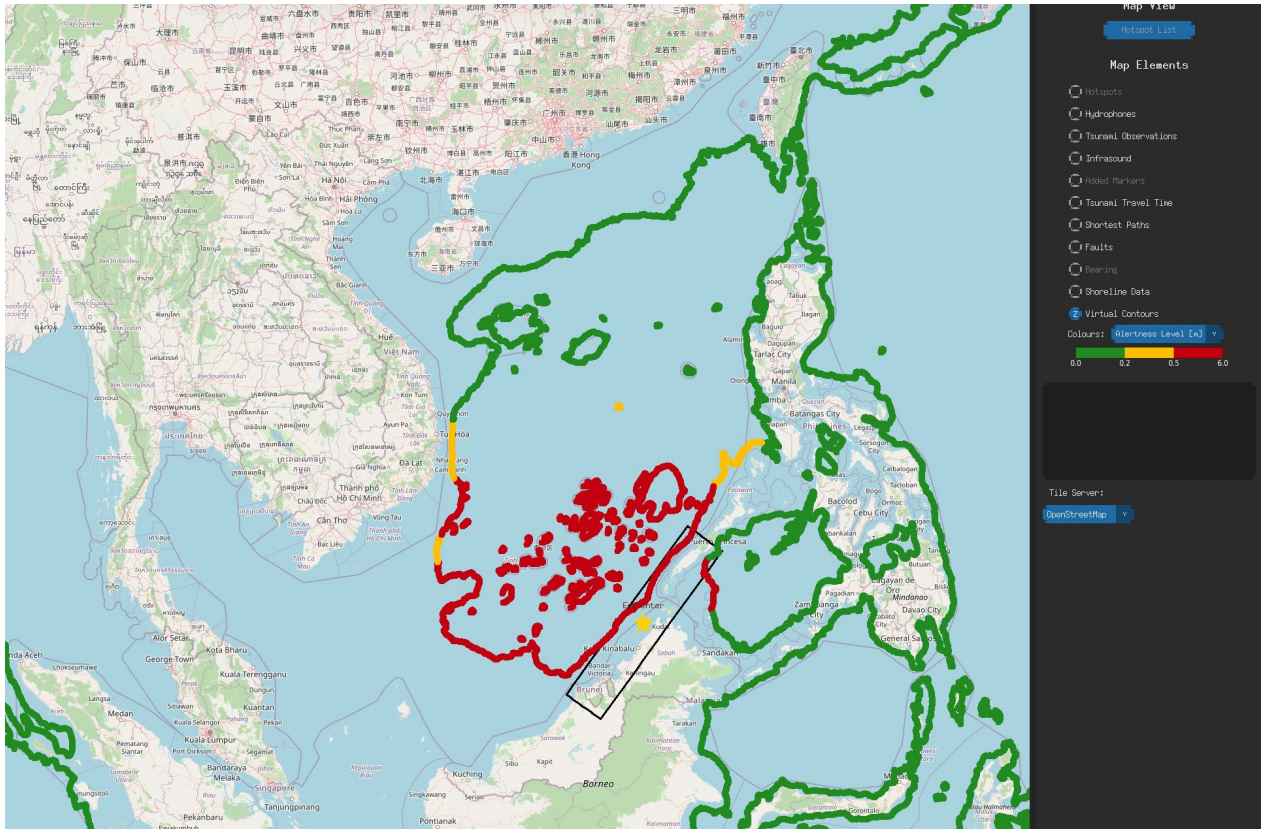
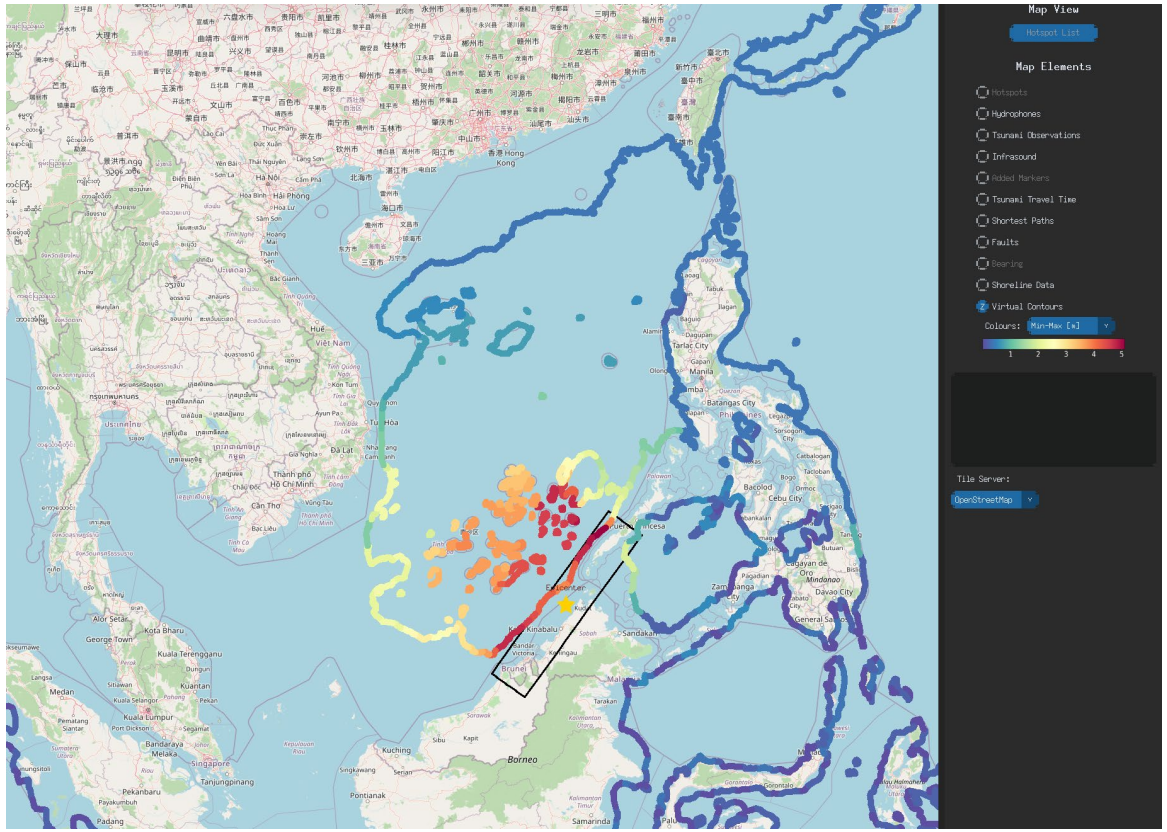




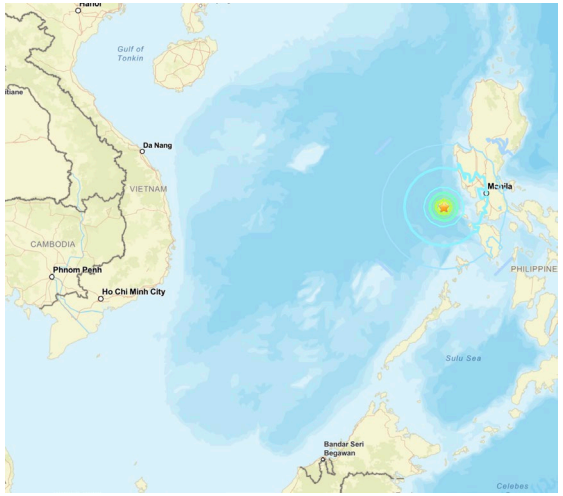


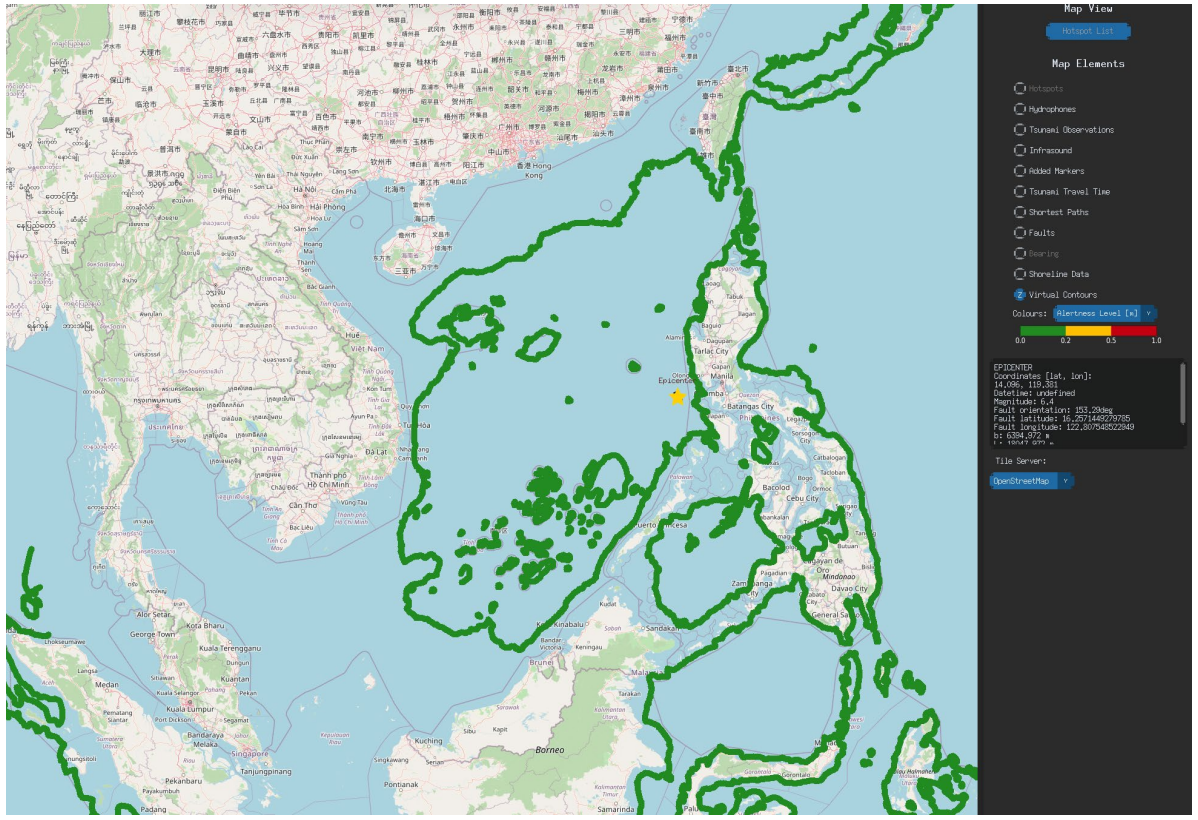
Event examples

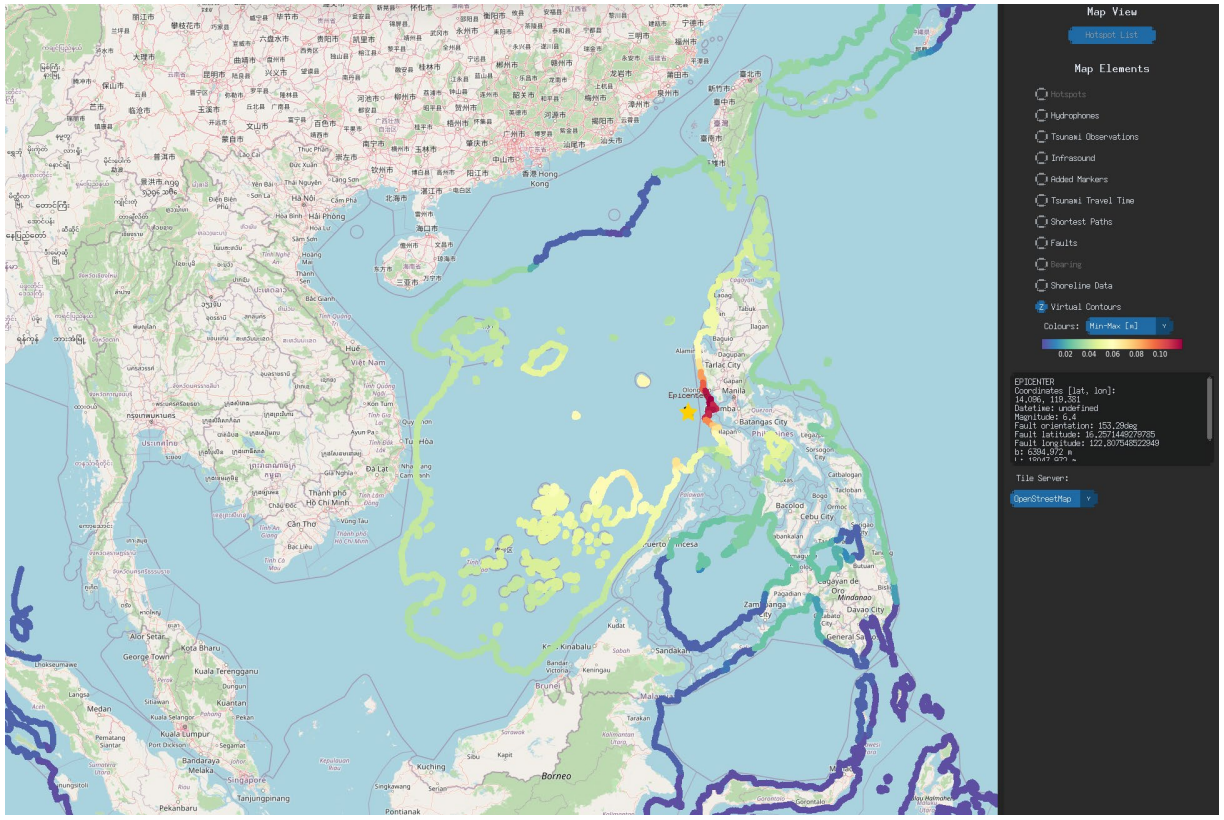
Cabra, Philippines 2022

M 6.4 – 75 km WNW of Cabra, Philippines

2022-03-13 21:05:49 (UTC) | 14.096°N 119.381°E | 11.0 km depth







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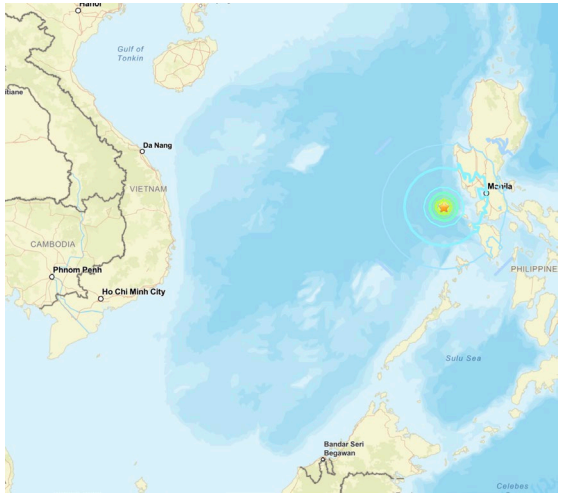
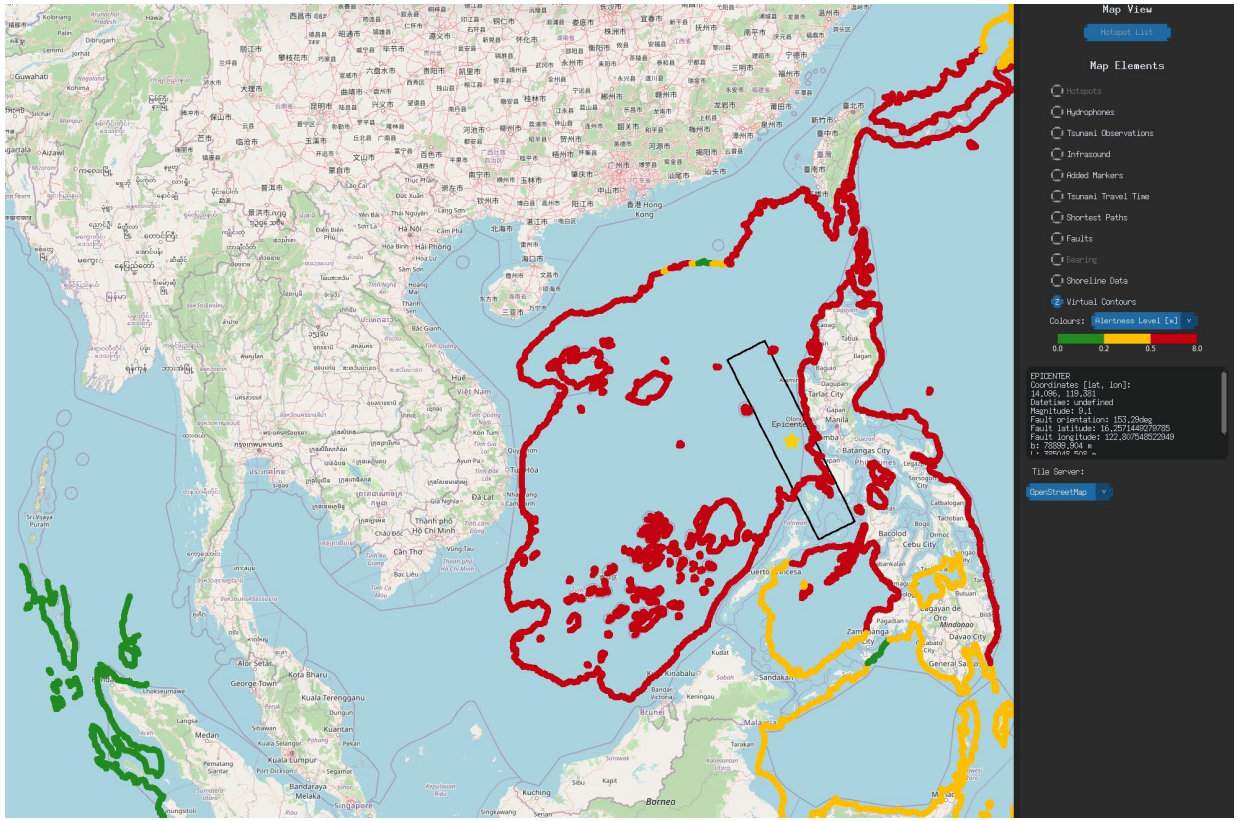
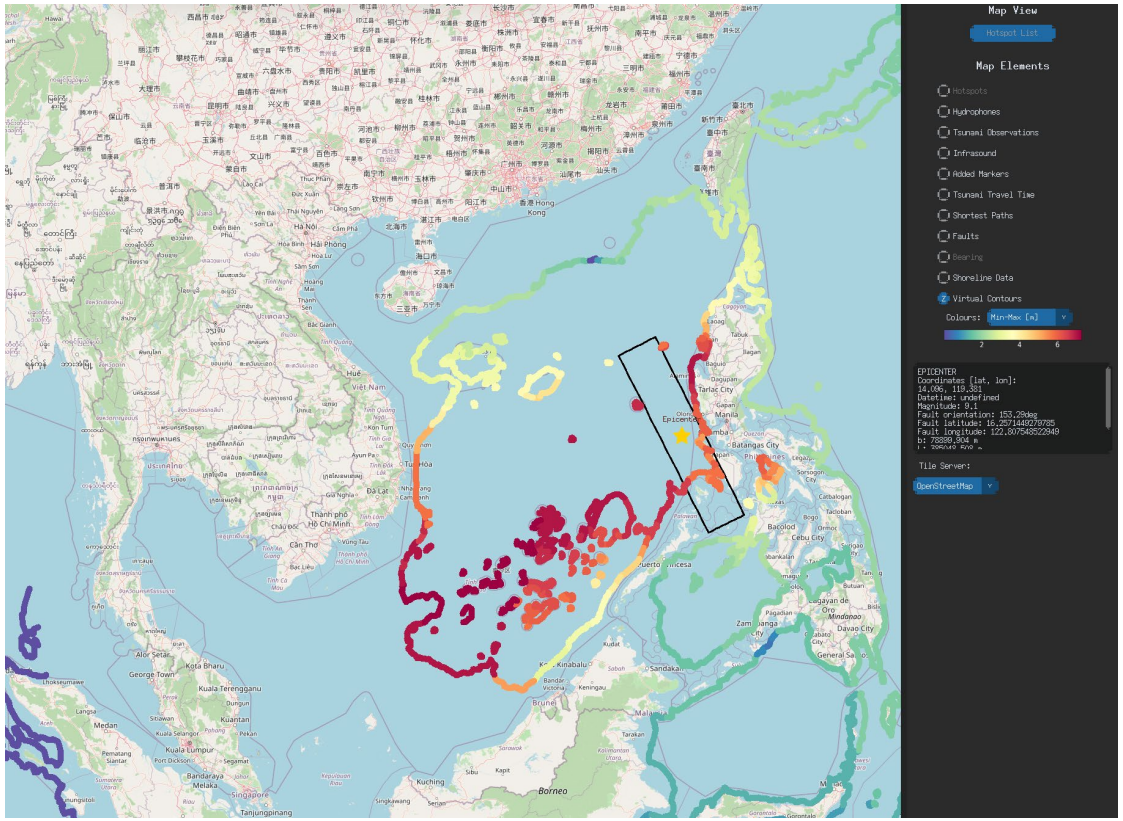
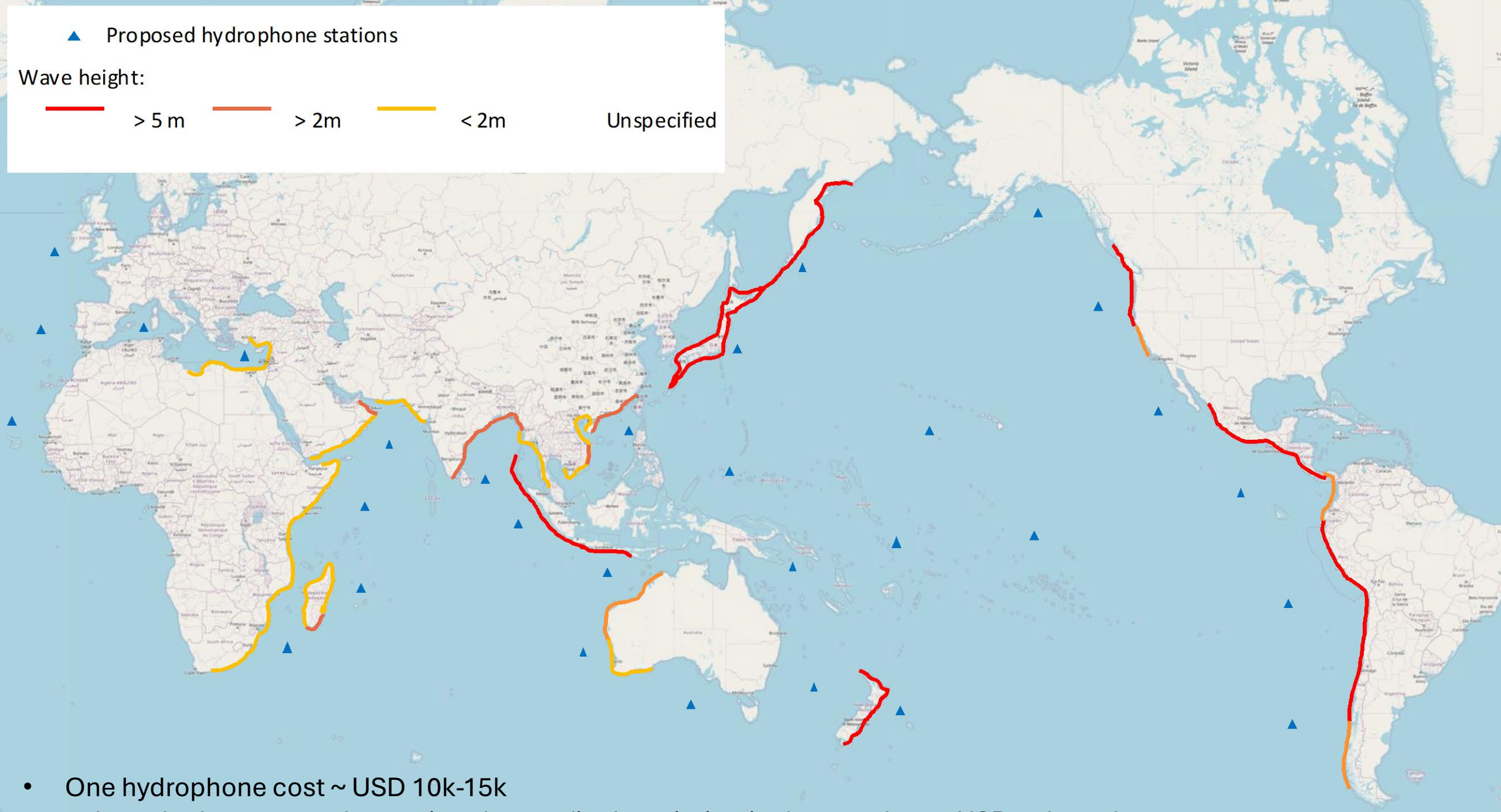






Global Real-time Early Assessment of Tsunami

Required Hydroacoustic Network

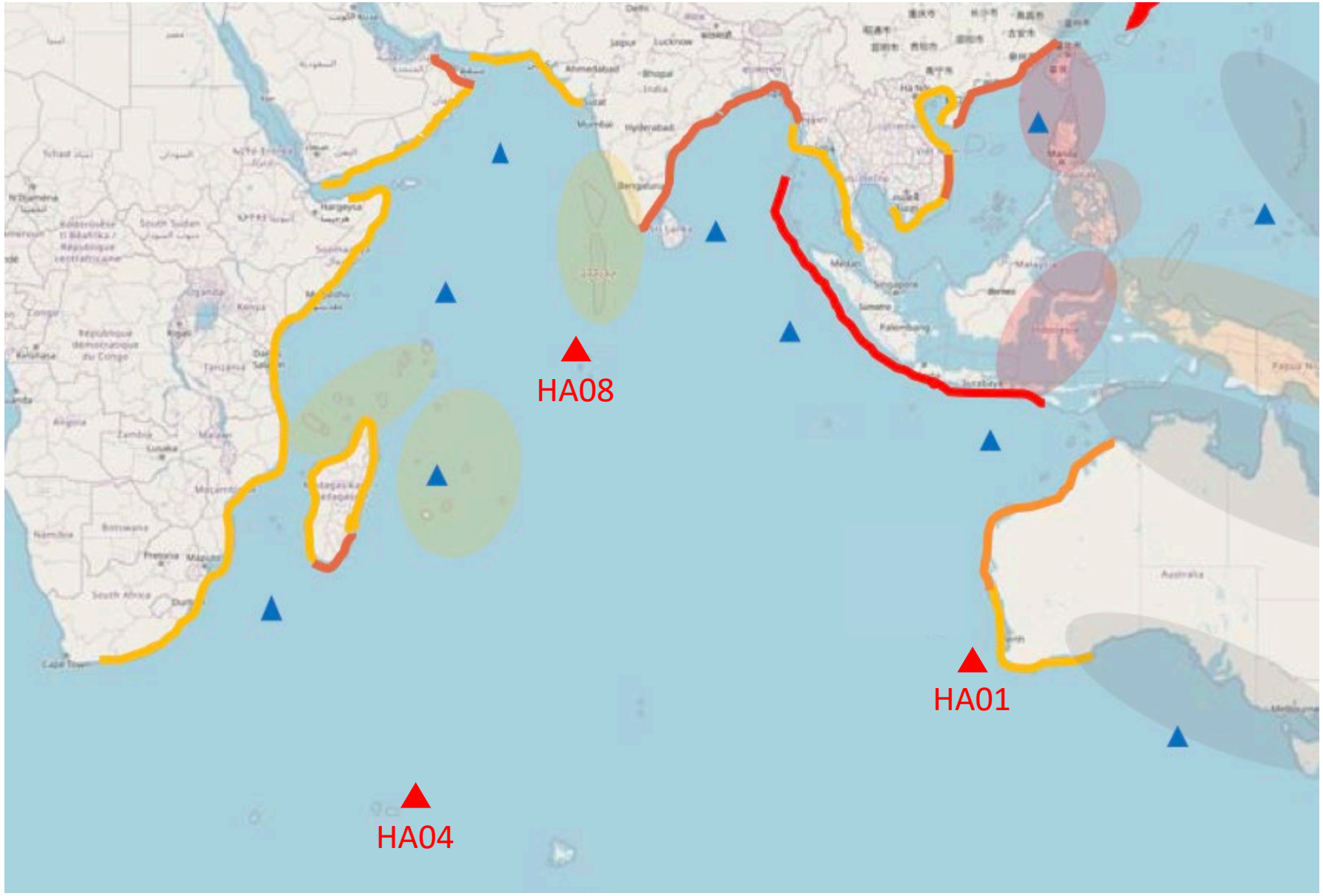


- One hydrophone cost ~ USD 10k-15k
- + deep deployment and associated costs (incl. optimisation) => total cost USD 70k-100k

First Ocean Decade Tsunami Programme Conference &
The International Tsunami Symposium, Hyderabad, India (November, 2025)

Towards Indian Ocean hydrophone deployment

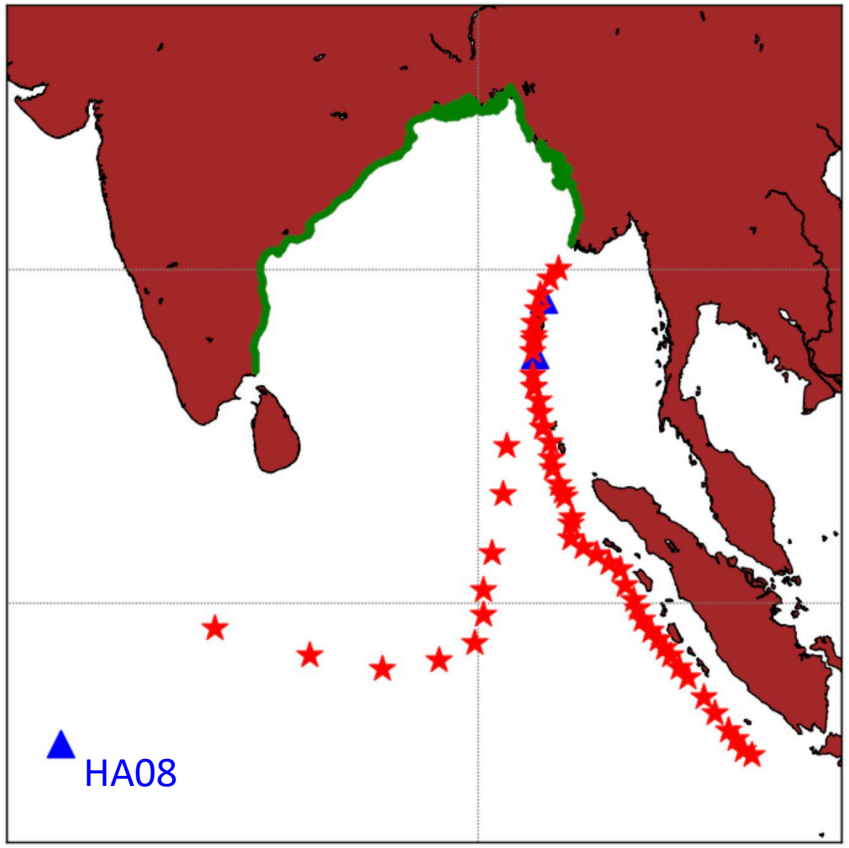
(in collaboration with INCOIS)

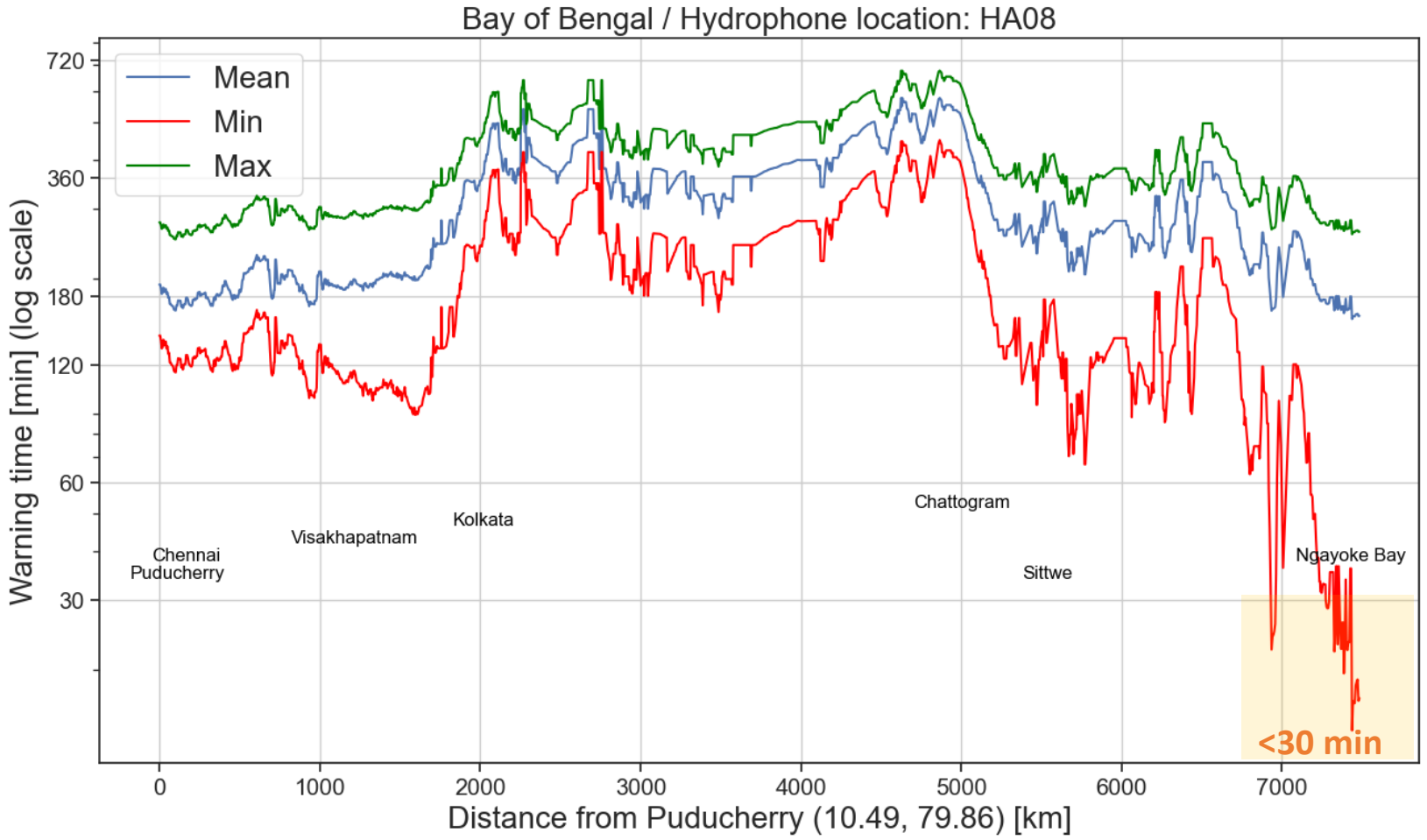


Hydrophone deployment optimisation location

Bay of Bengal
Hydrophone location: Diego Garcia (HA08)

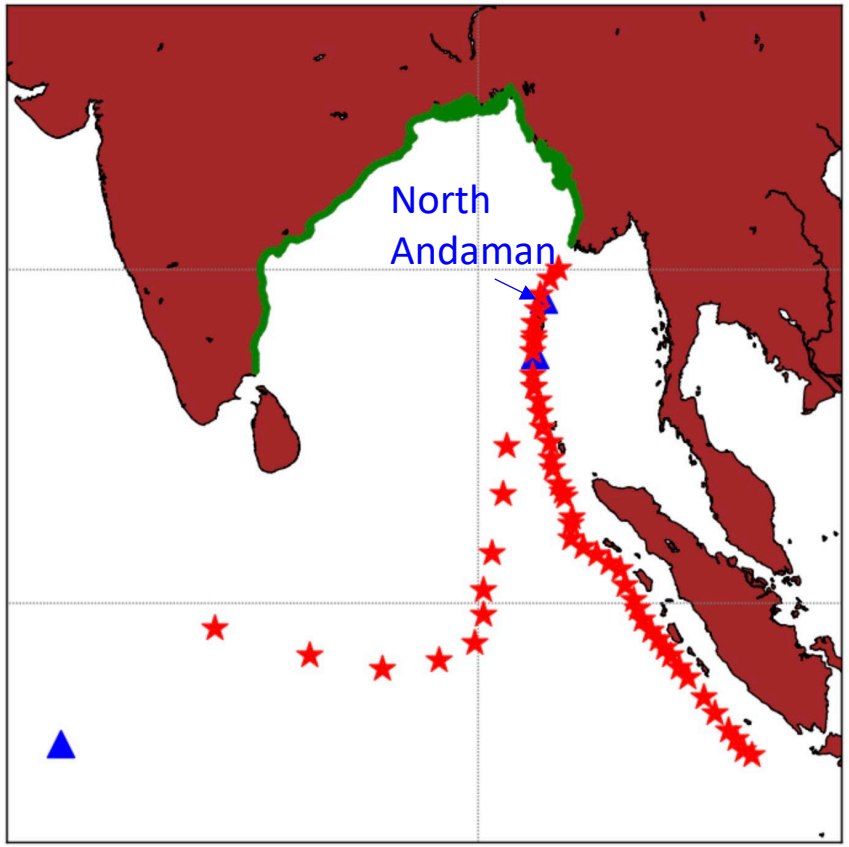
(Warning time = Tsunami travel time – Acoustic travel time)

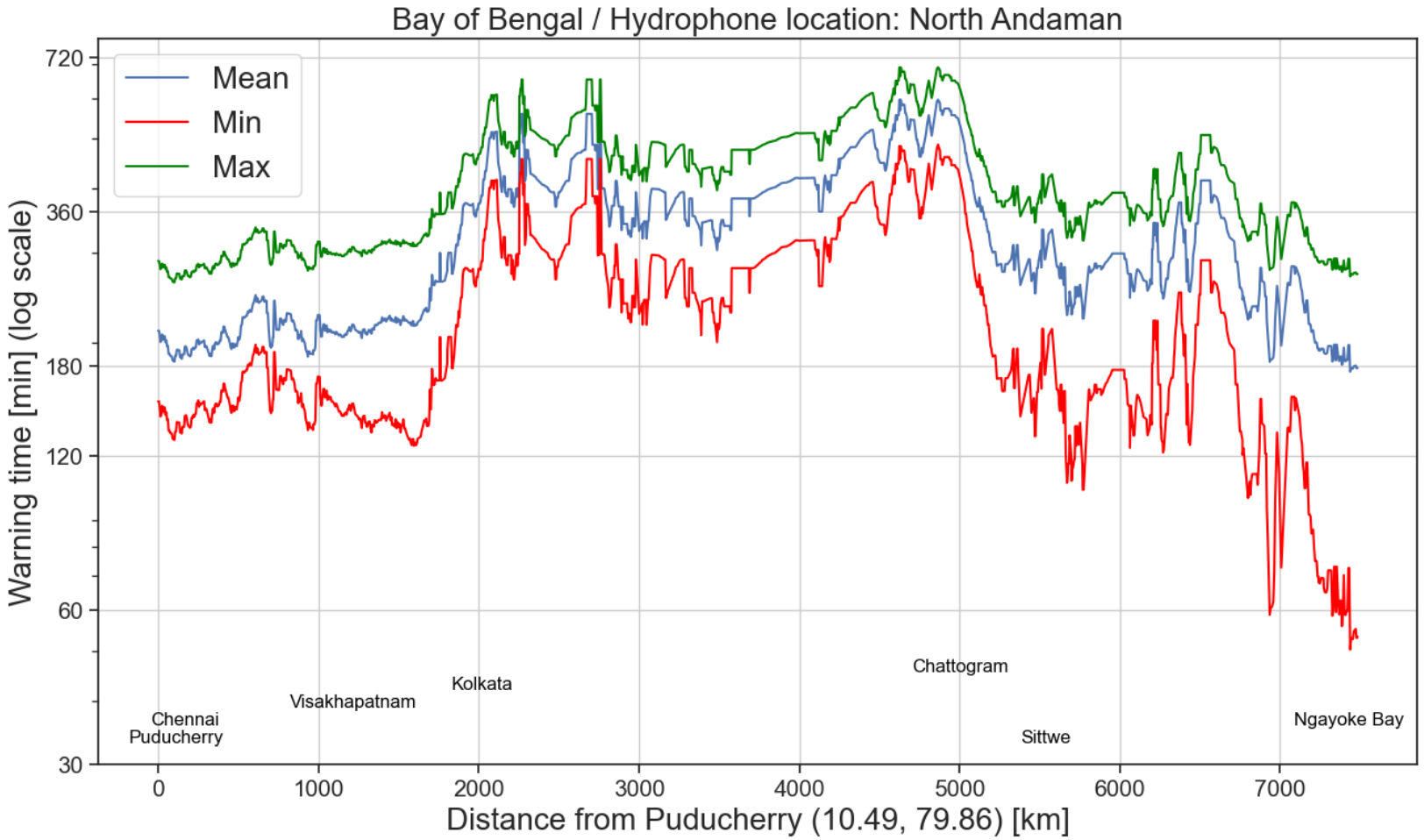




Bay of Bengal

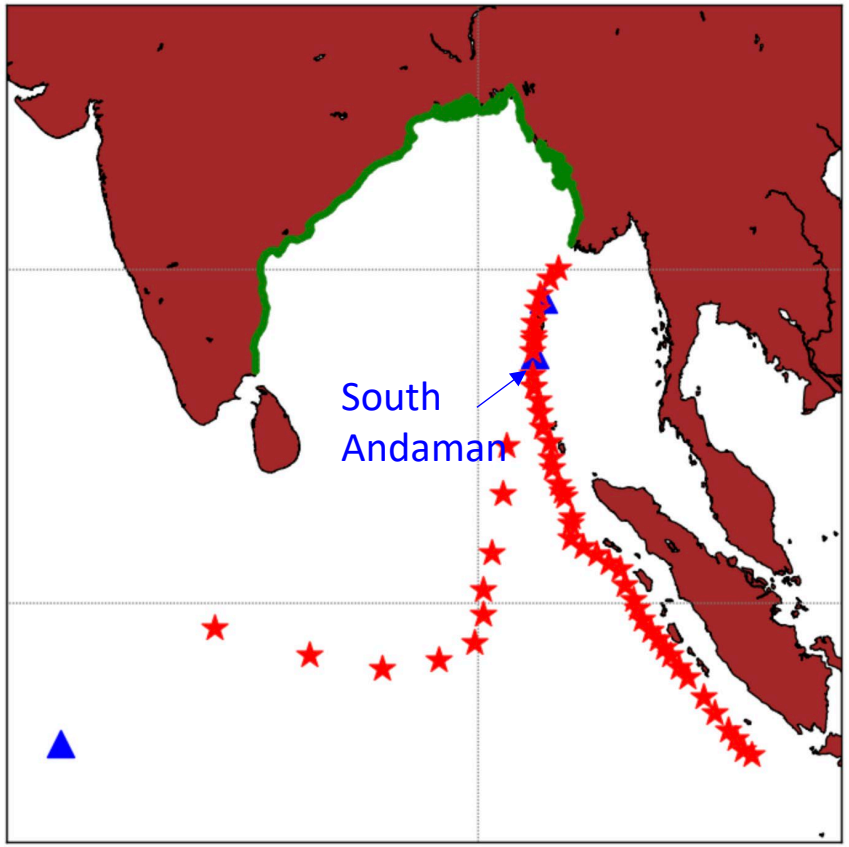
Virtual hydrophone location: North Andaman

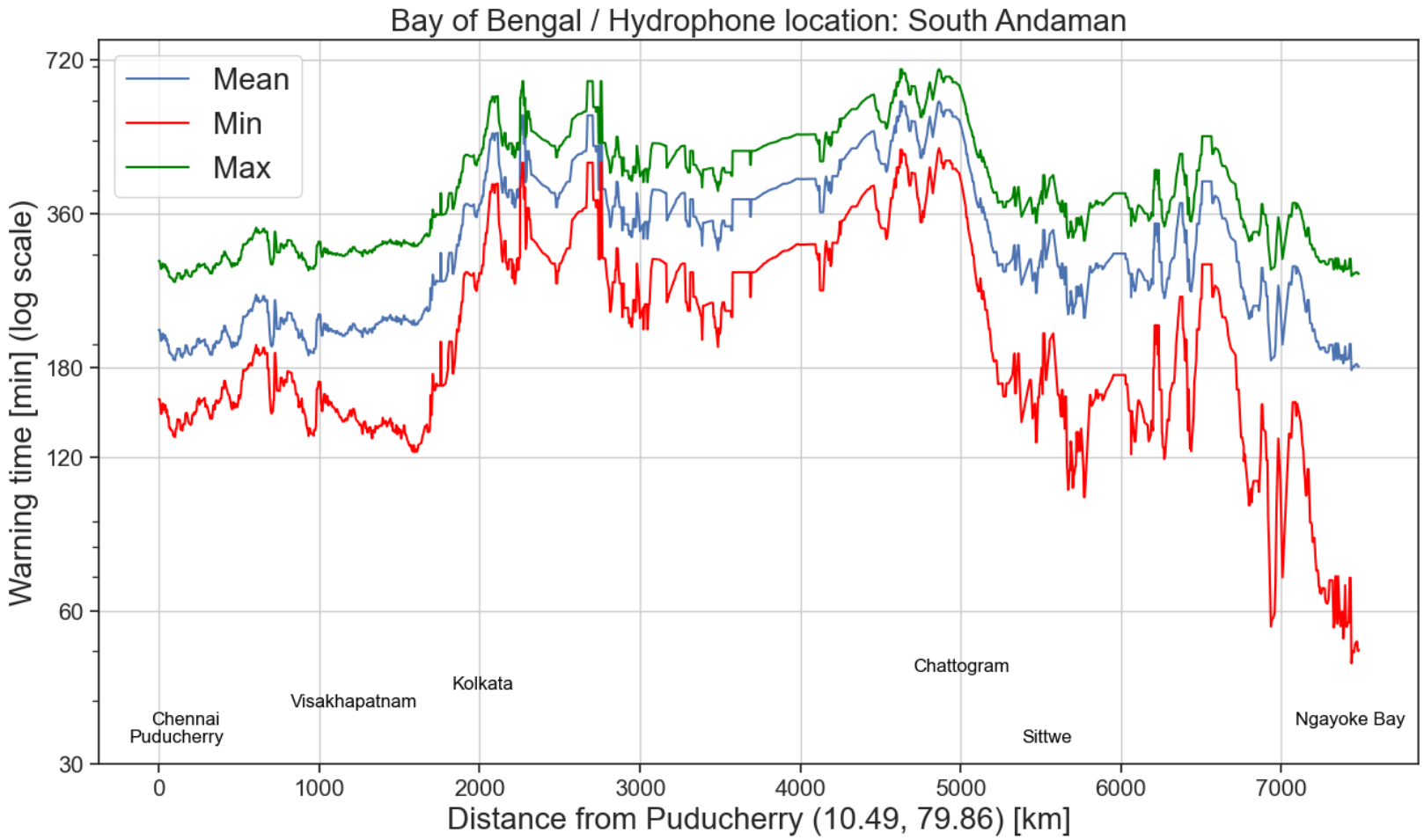




Bay of Bengal

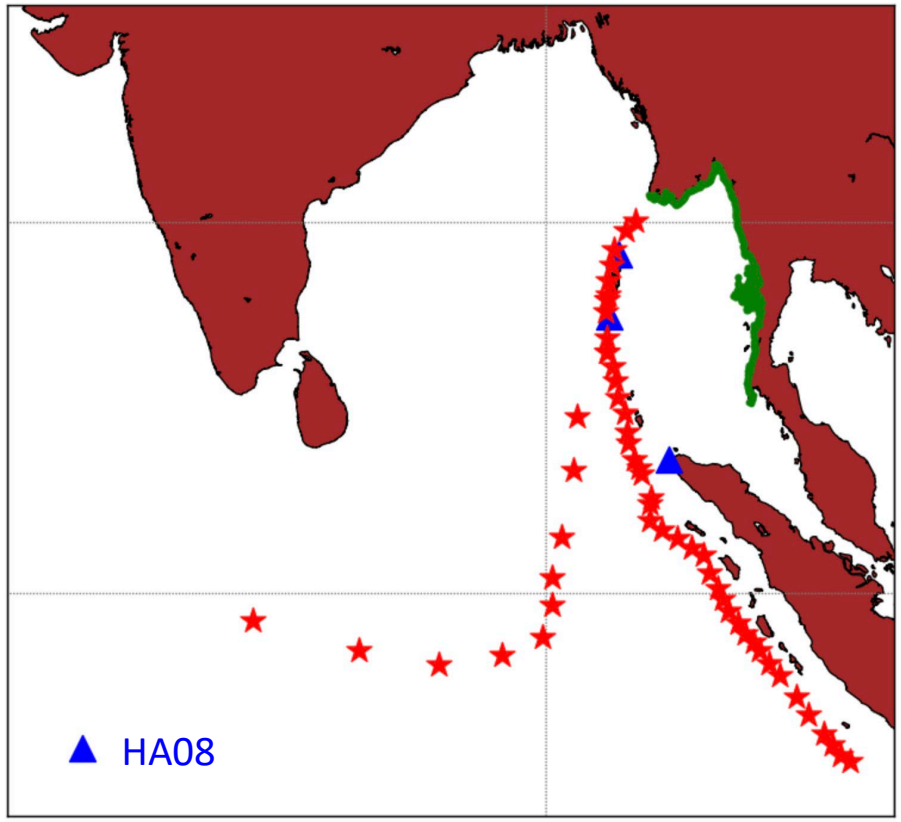
Virtual hydrophone location: South Andaman

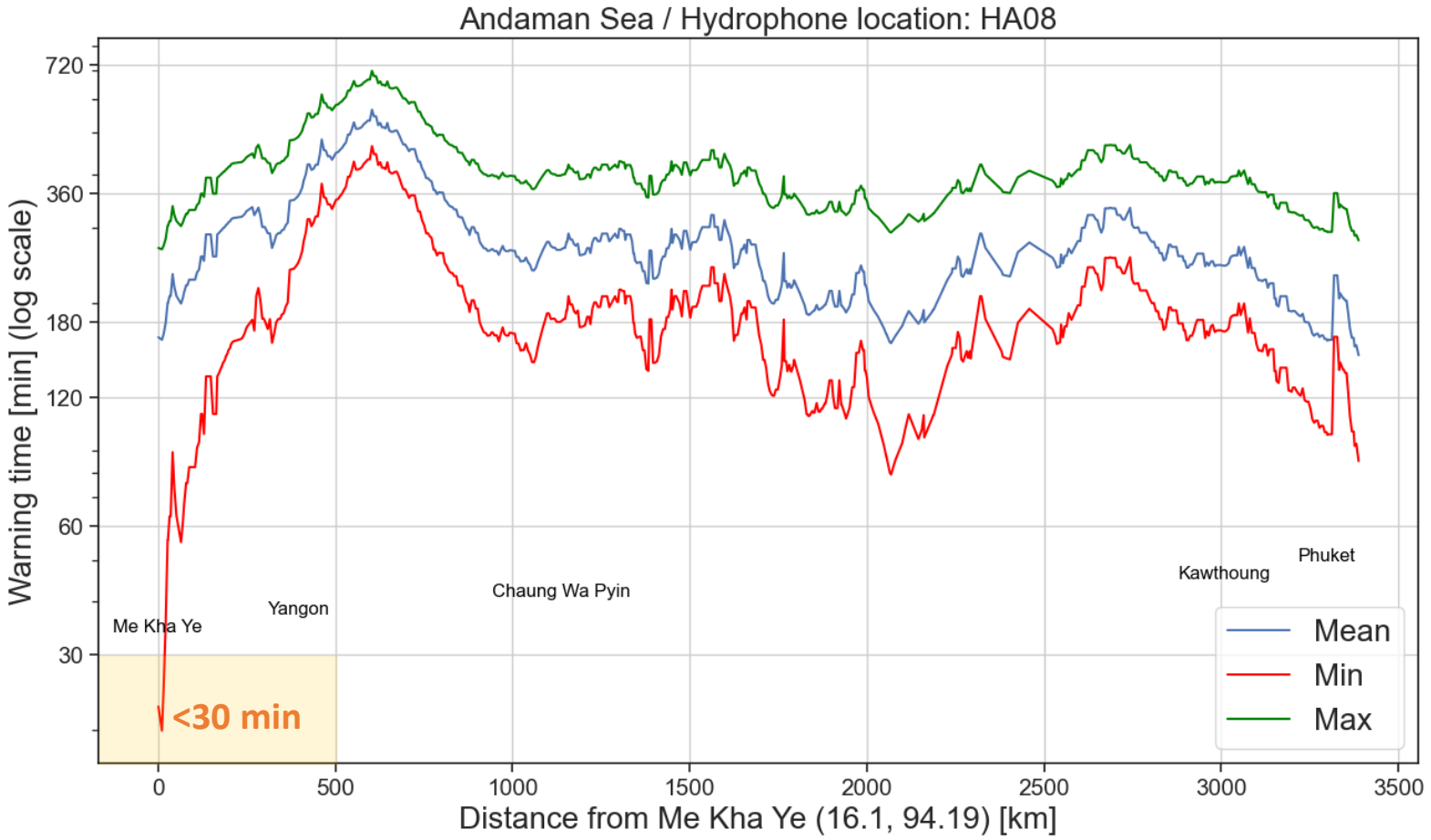




Andaman Sea

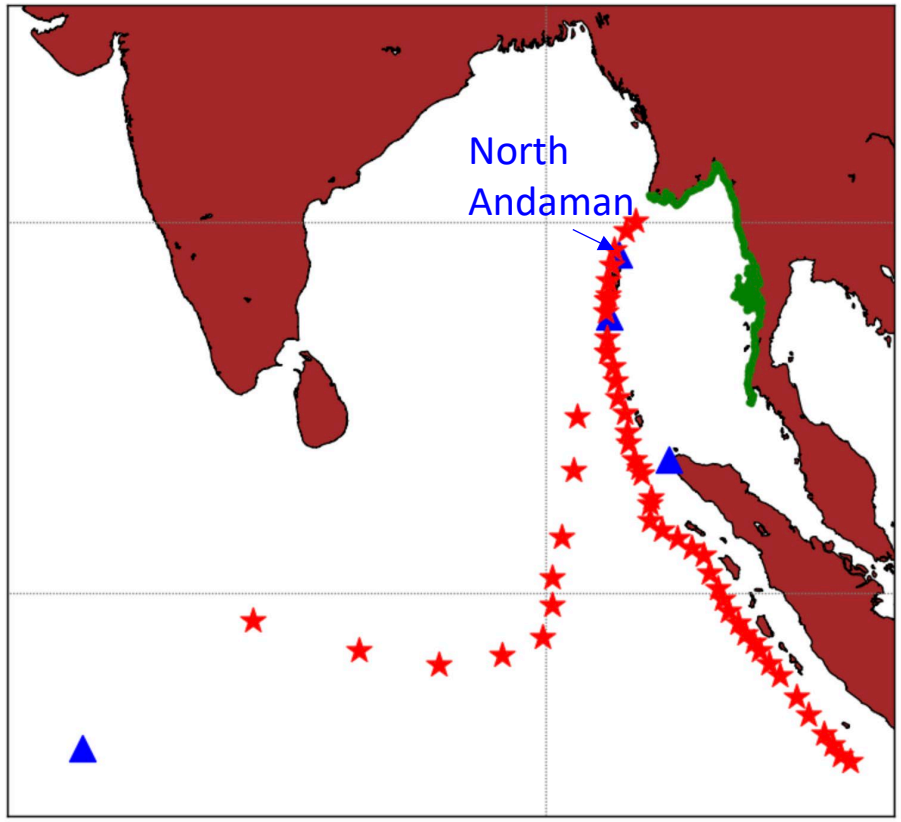
Hydrophone location: Diego Garcia (HA08)

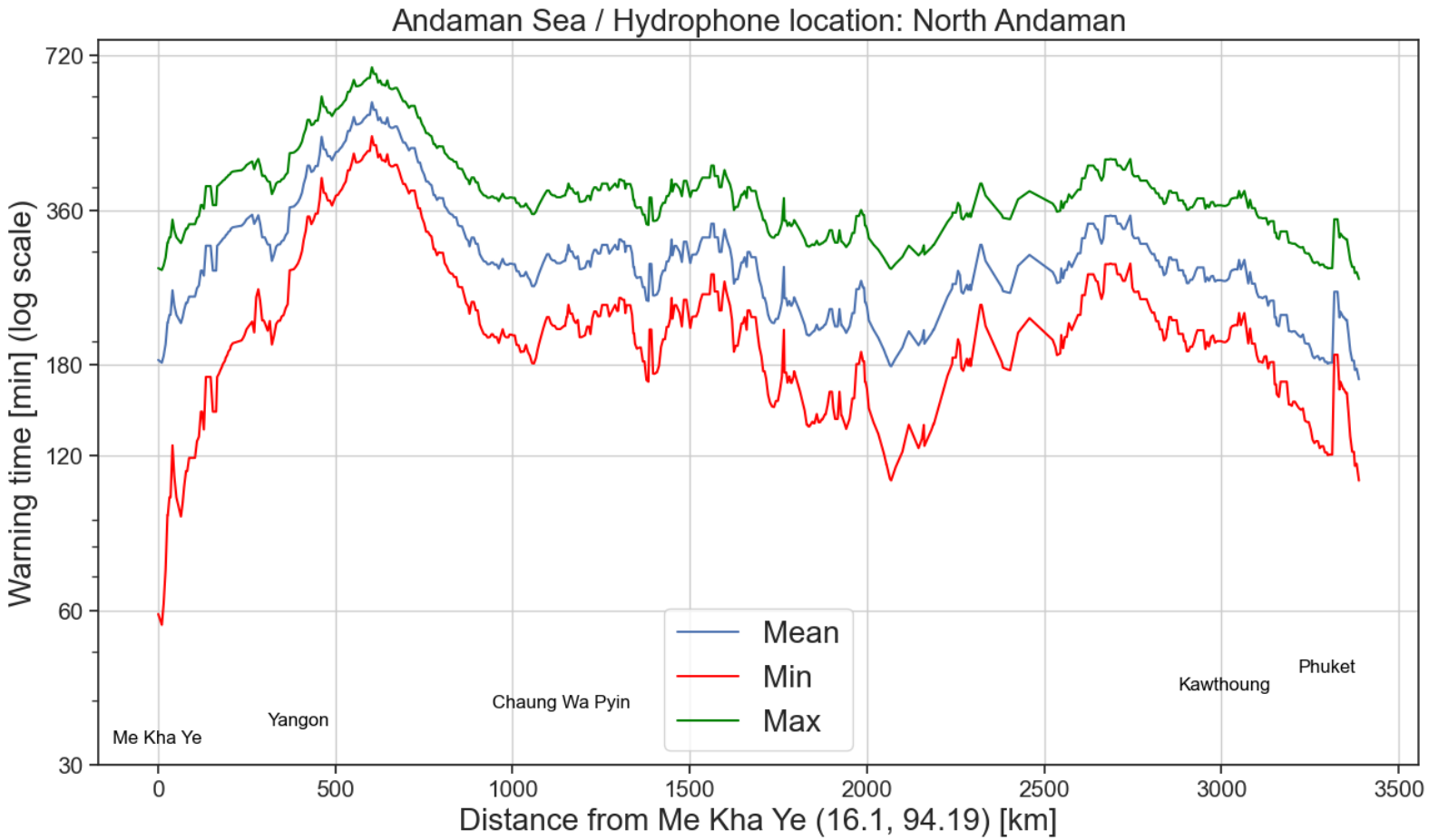




Andaman Sea

Virtual hydrophone location: North Andaman

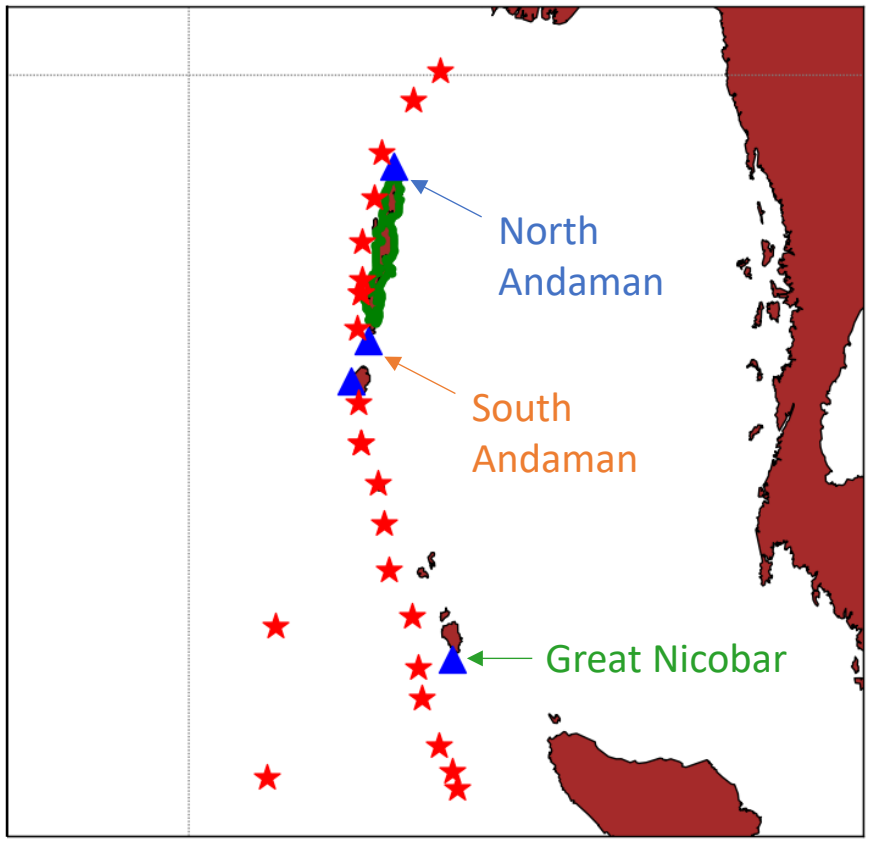


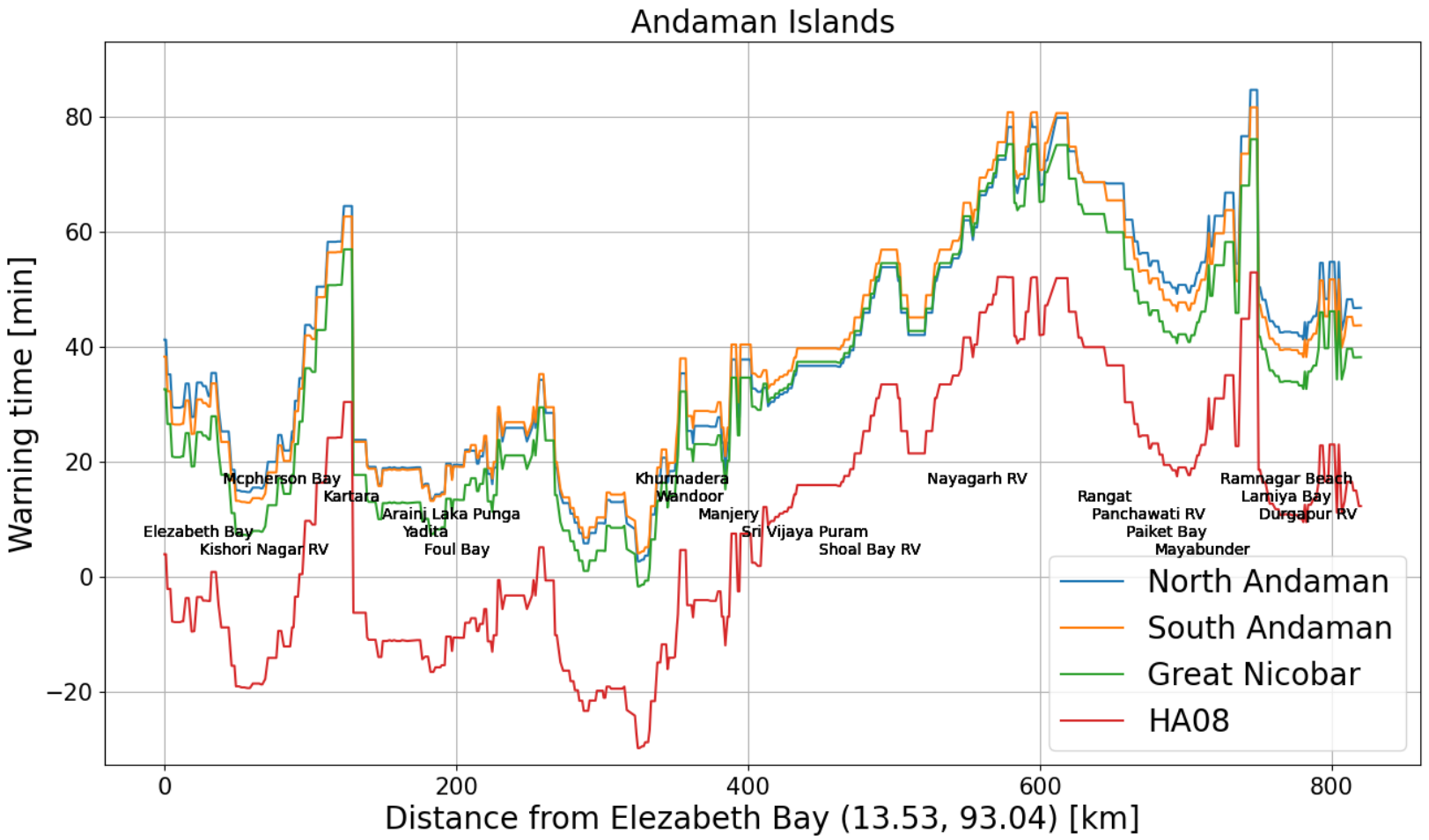


Andaman Islands

Hydrophone locations:

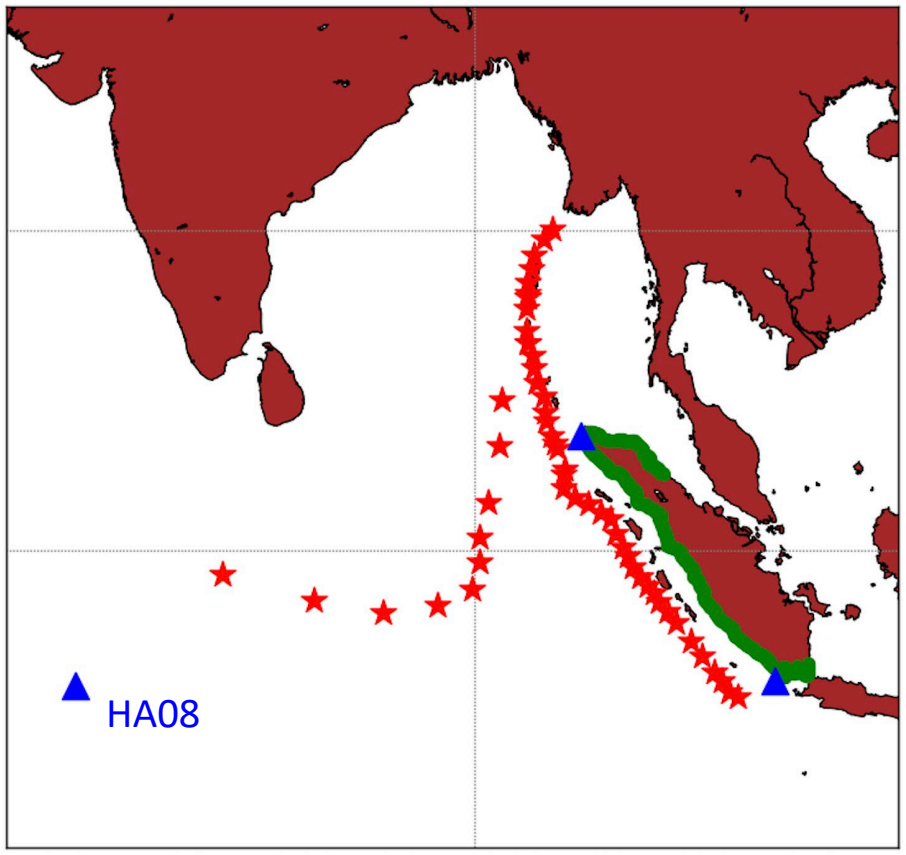
Deago Garcia (H08), North & South Andaman, Great Nicobar

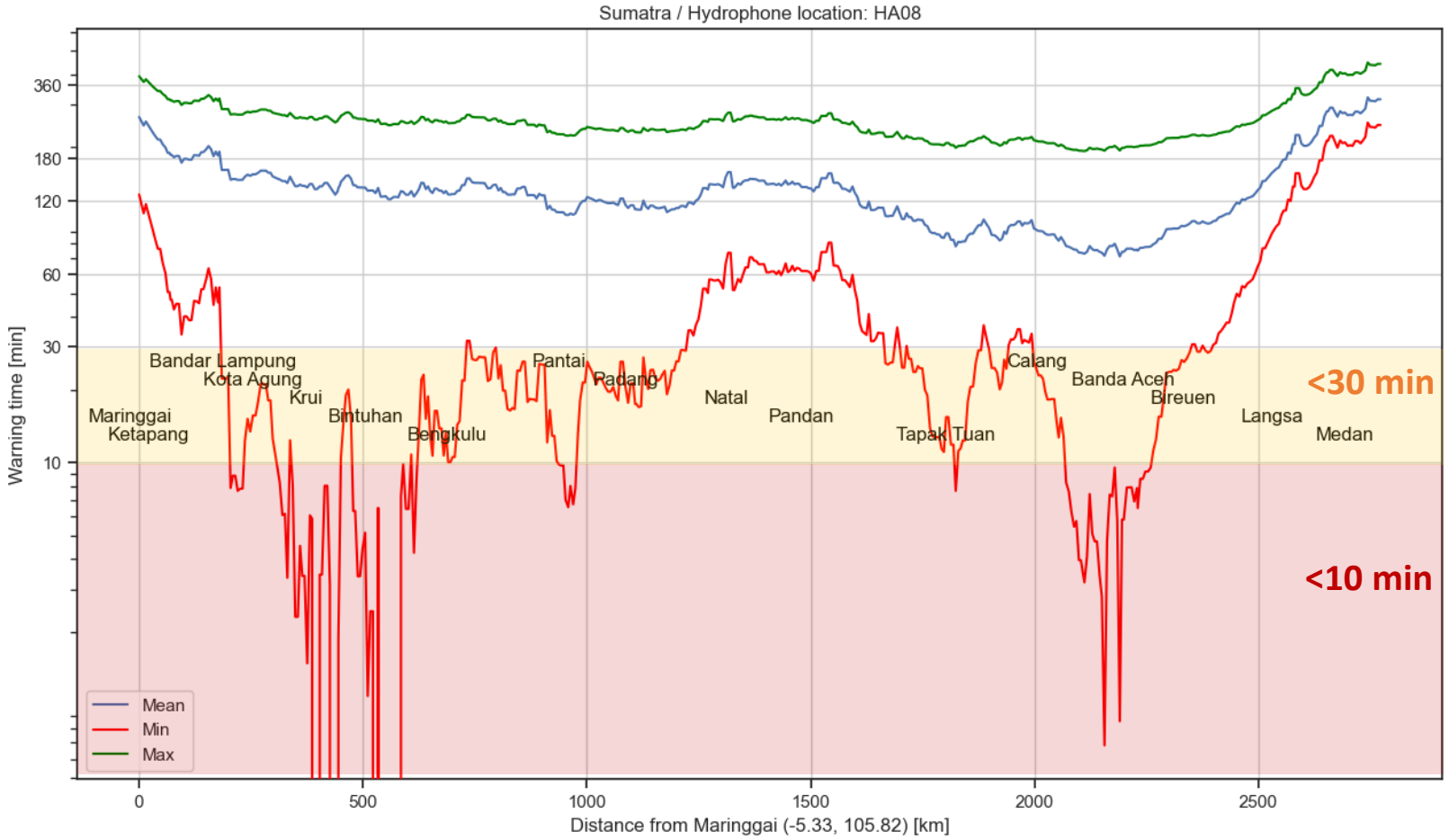




Indonesia, Sumatra Coastline

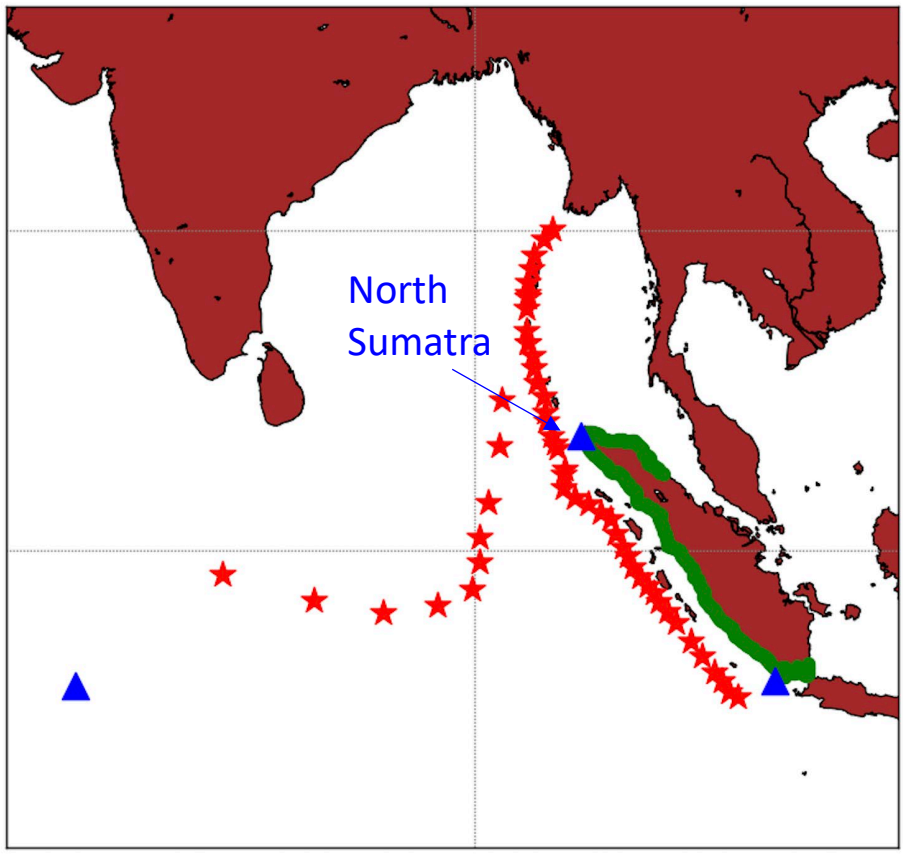
Hydrophone location: Diego Garcia (HA08)

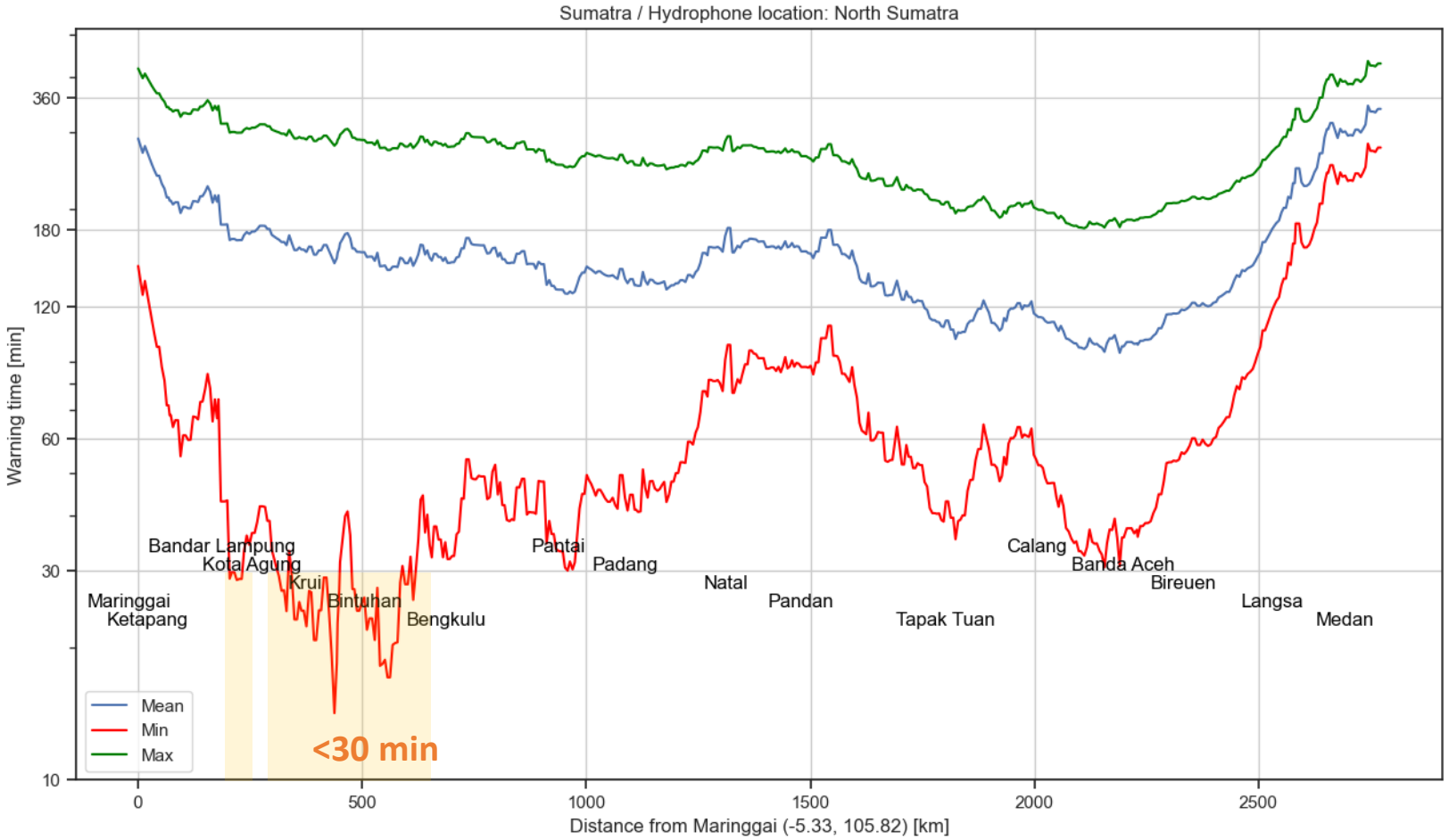




Indonesia, Sumatra Coastline

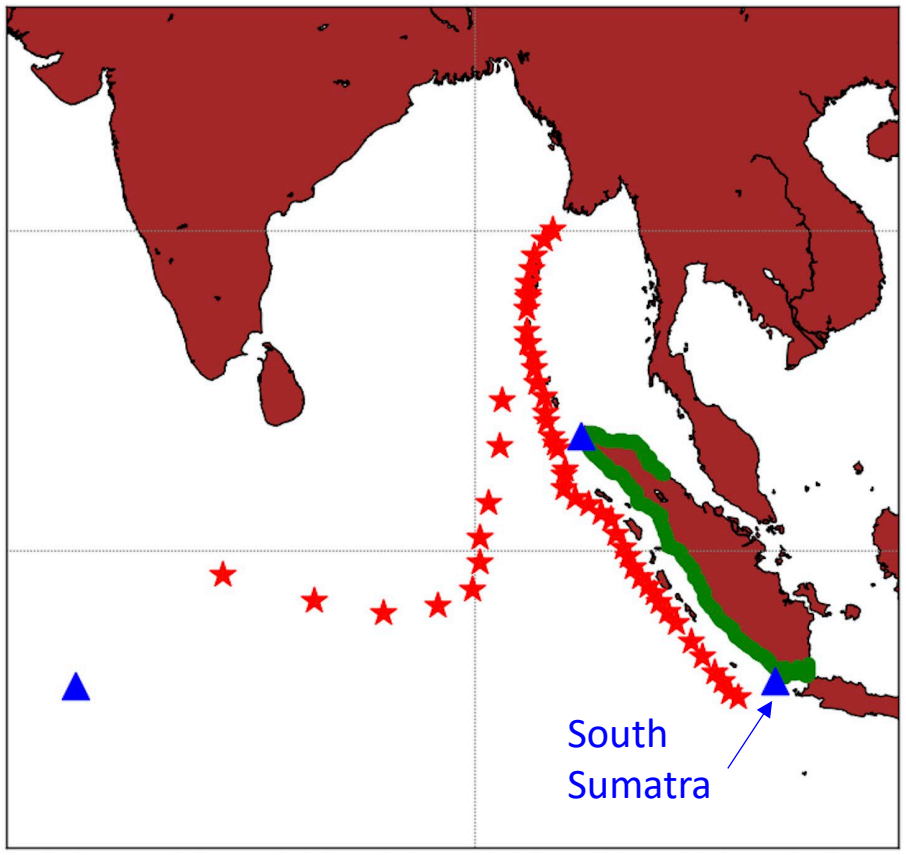
Virtual hydrophone location: North Sumatra

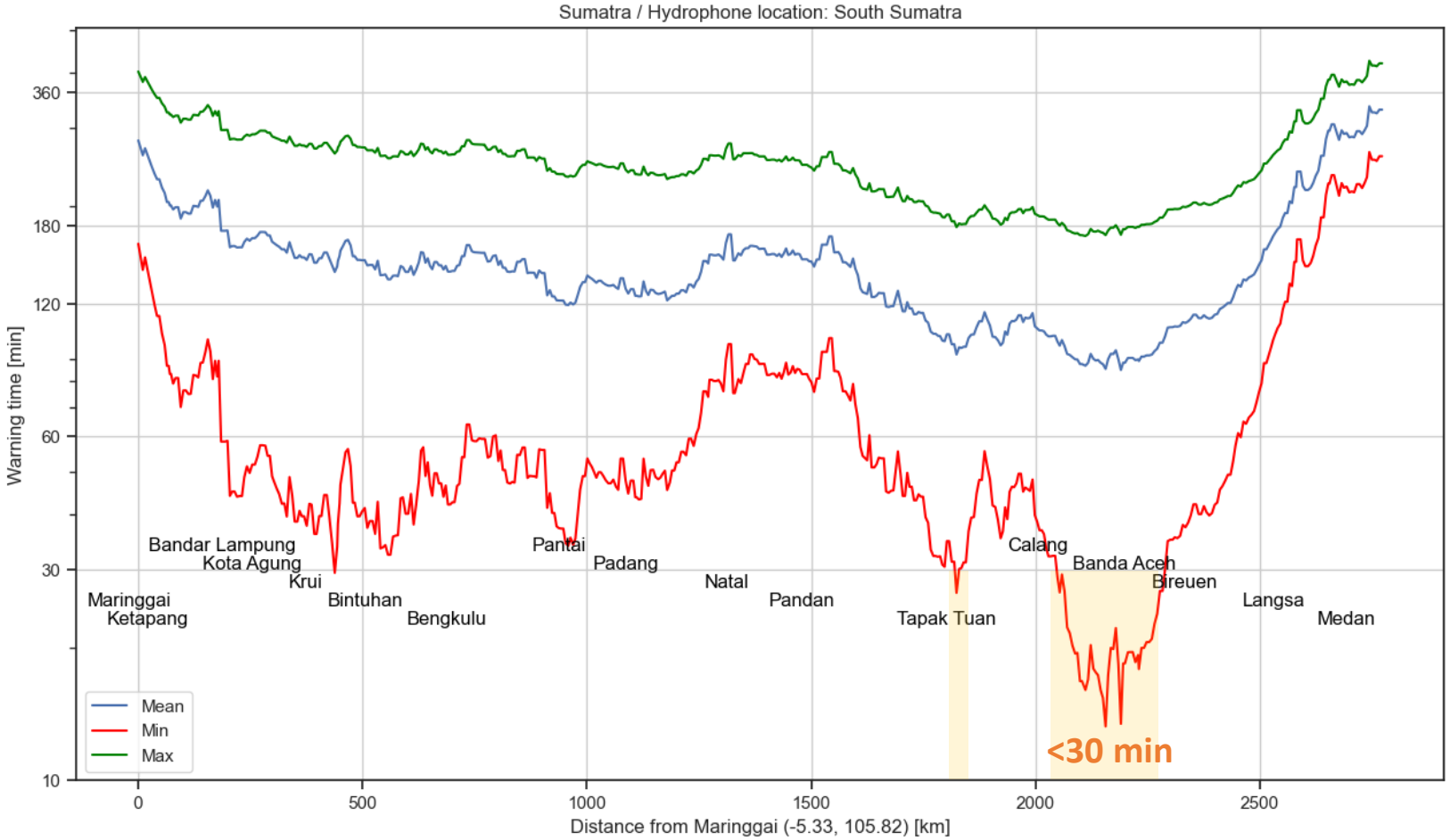




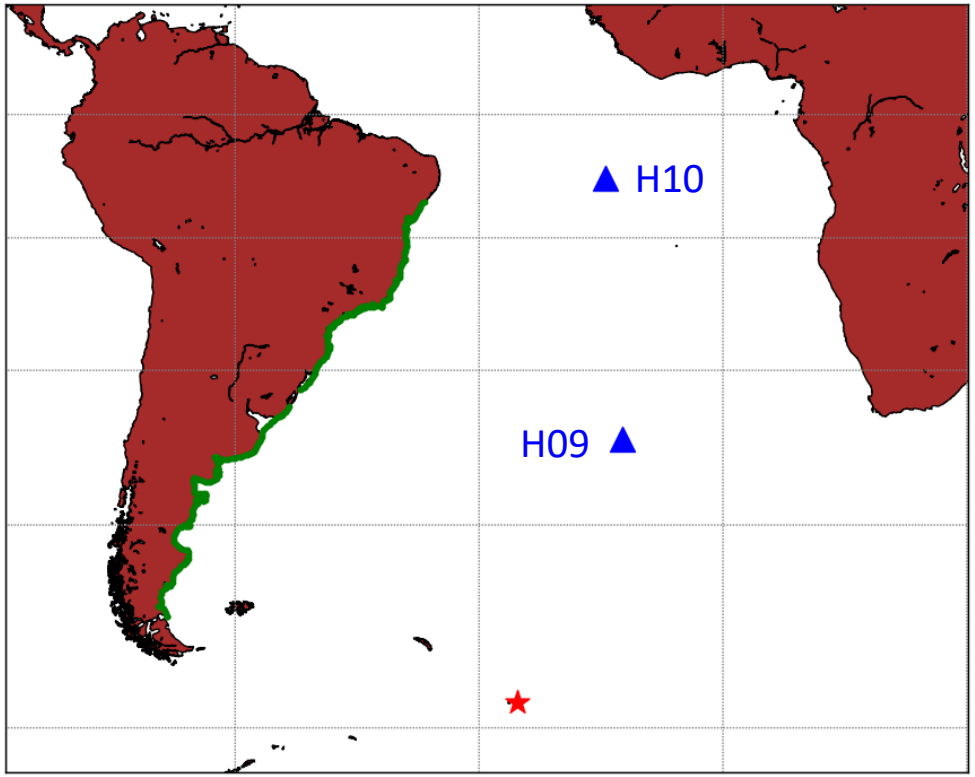
Indonesia, Sumatra Coastline

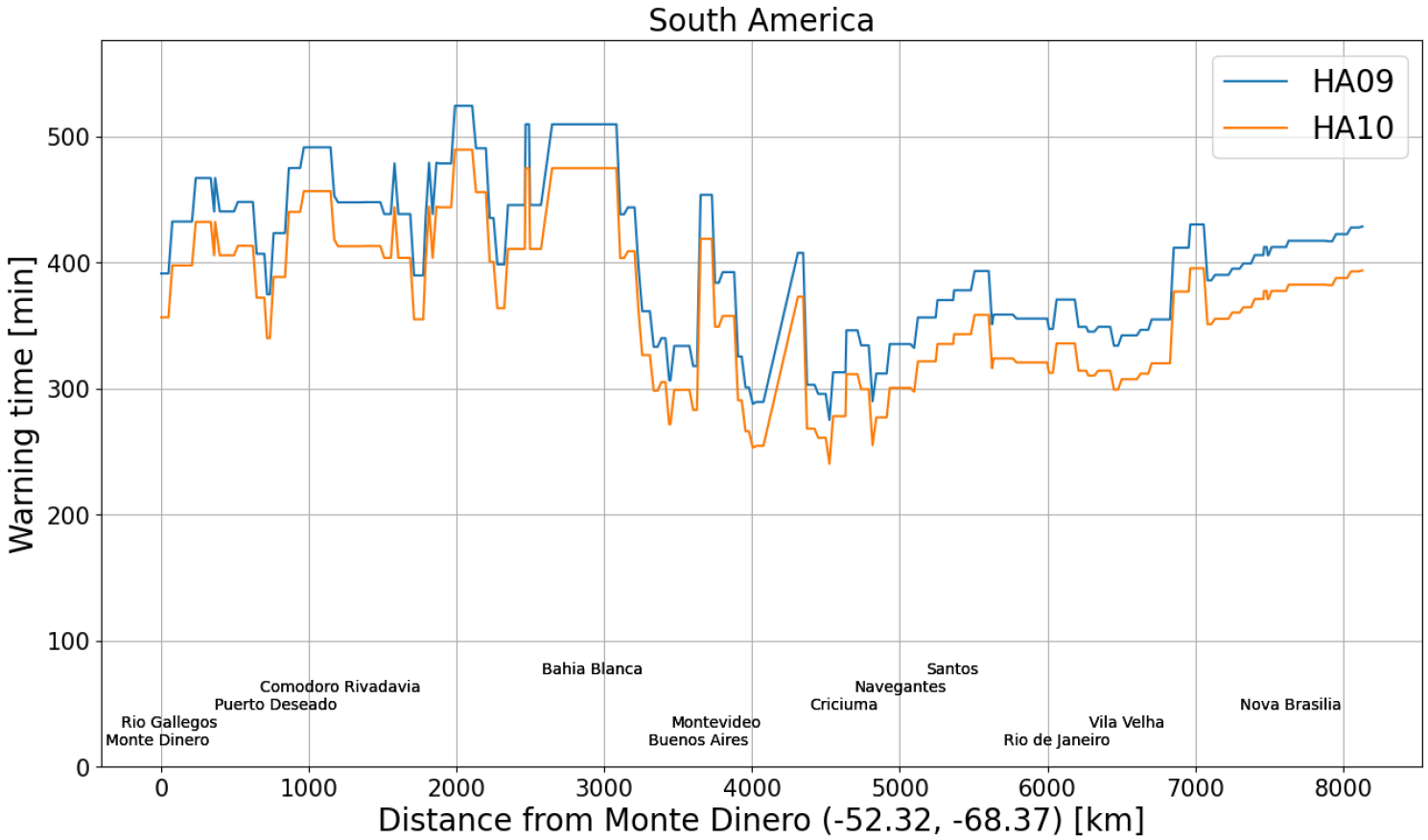
Virtual hydrophone location: South Sumatra



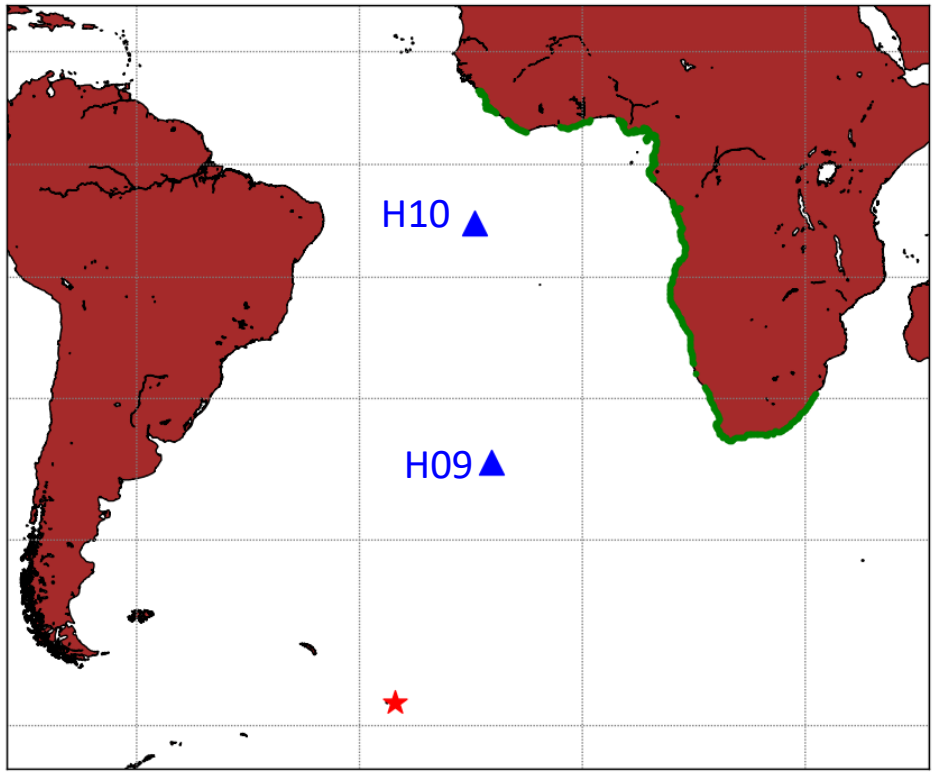


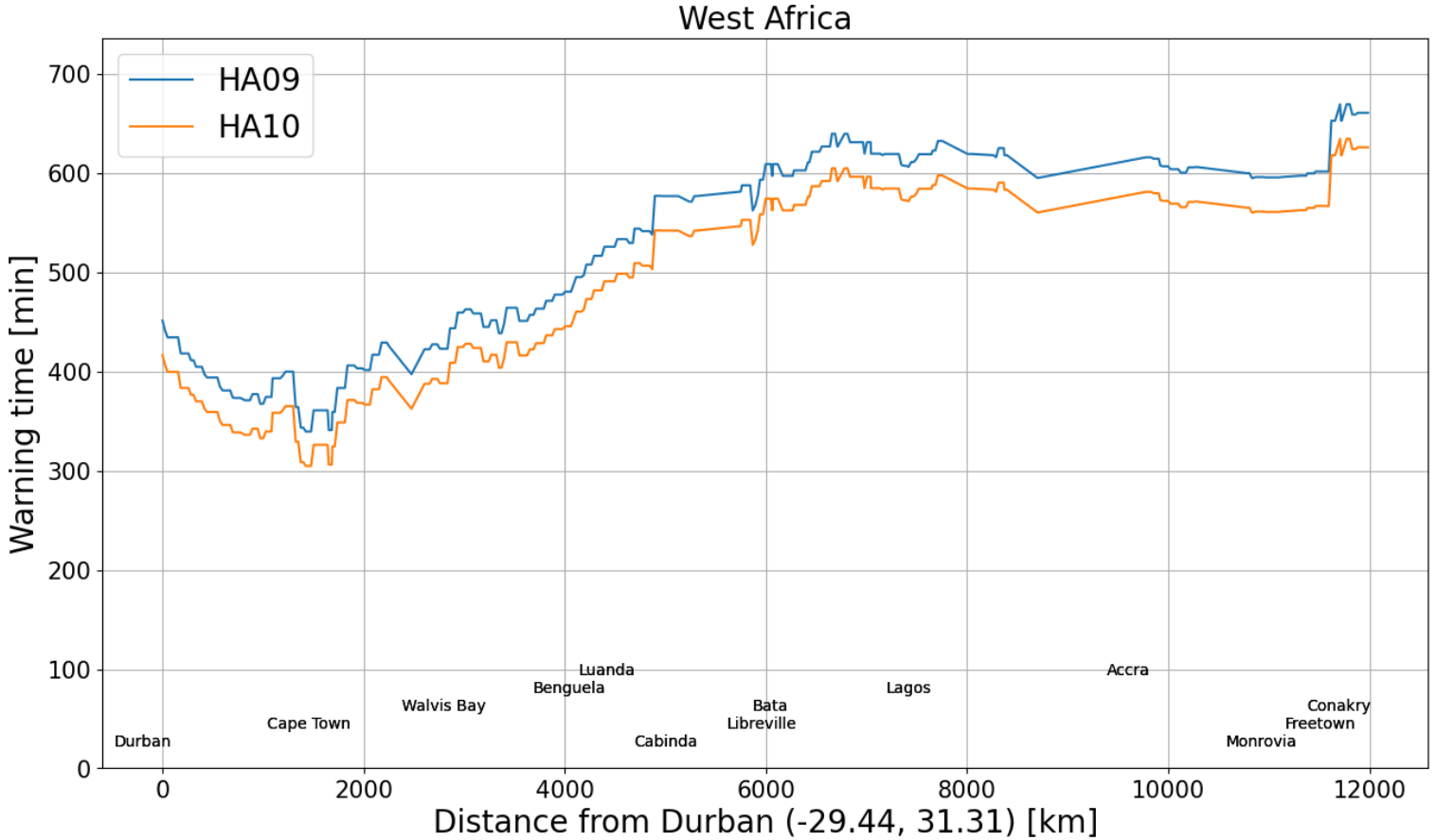
South Atlantic (South American coast)
CTBTO Hydrophones: H09 & H10





South Atlantic (West African coast)
CTBTO Hydrophones: H09 & H10



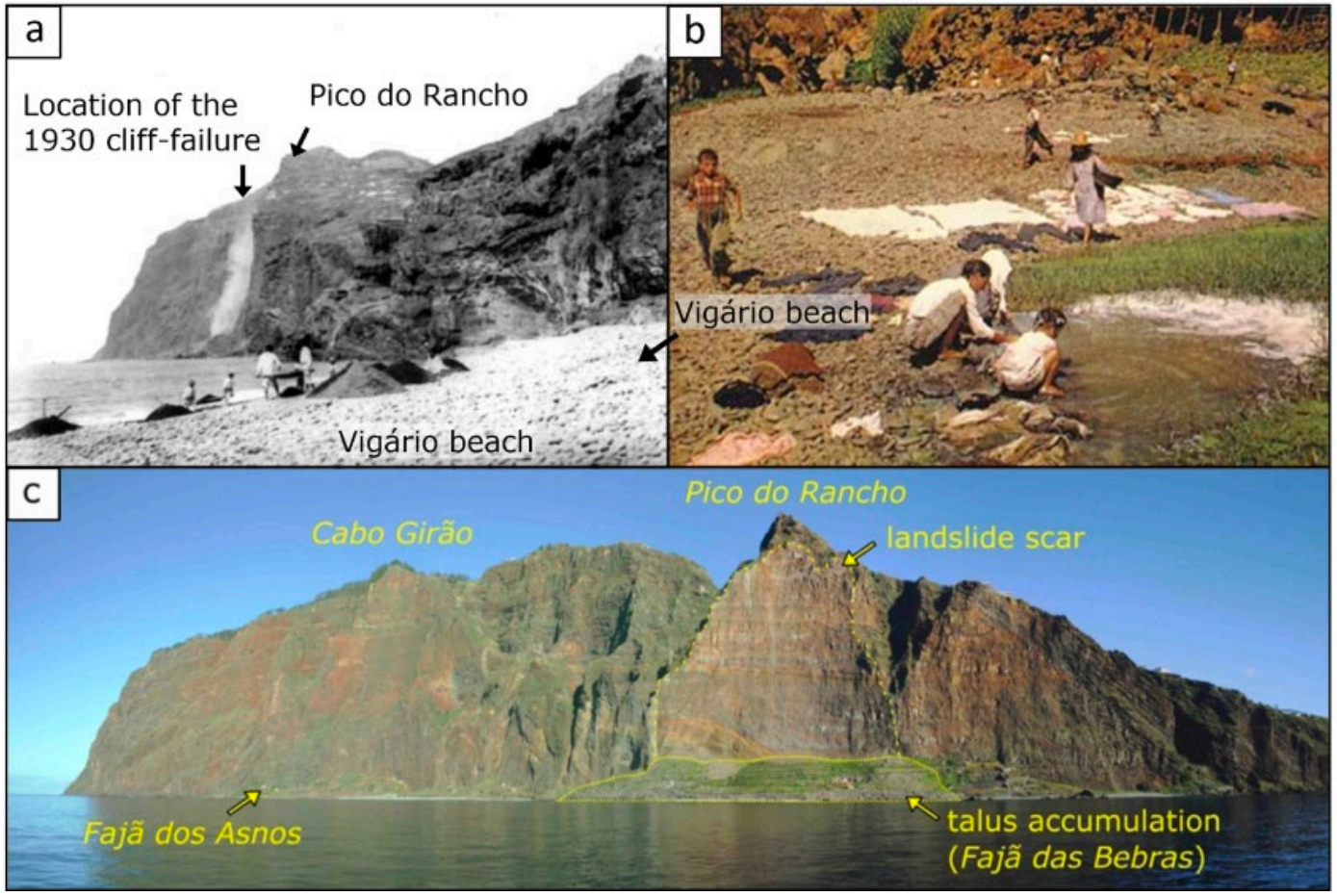


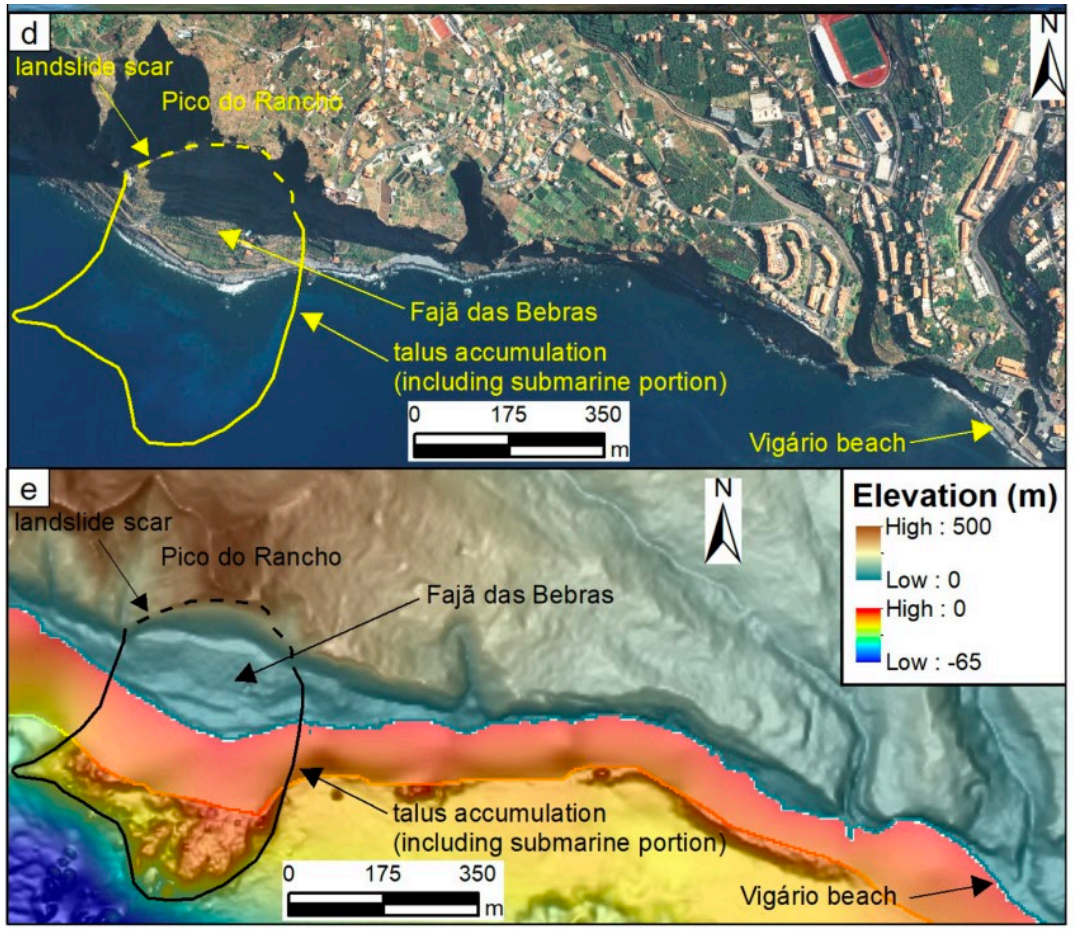
Landslides

R. Omira & J. Kim

(UKRA IAA project)

R.S. Ramalho



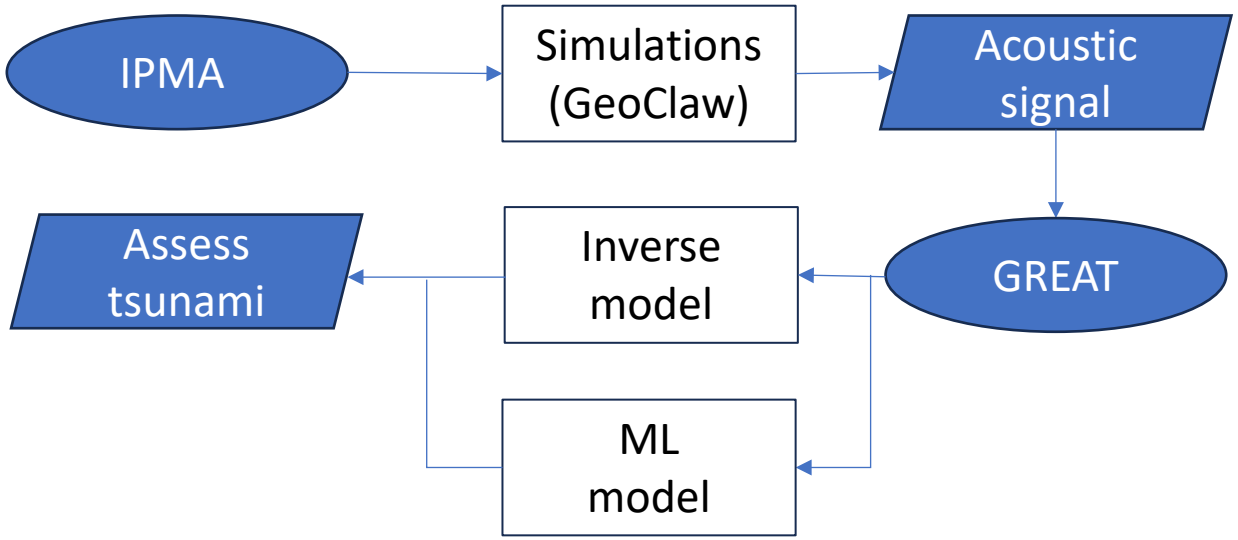


R. Omira, M.A. Baptista, R. Quartau et al. Earth and Planetary Science Letters 578 (2022) 117333

Landslides

- Lack of hydrophone data prevents reliable testing of GREAT with landslides

- The alternative: simulations (in collaboration with IPMA)

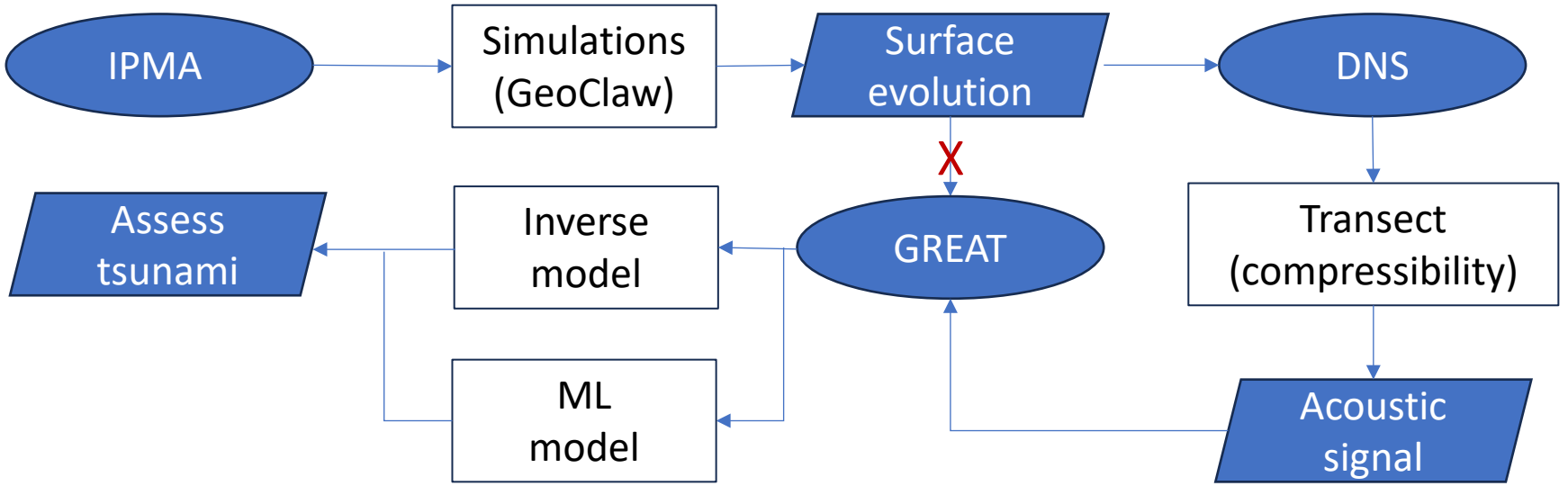


- GeoClaw uses an incompressible Boussinesq equation → **cannot** generate the acoustic signals ☹

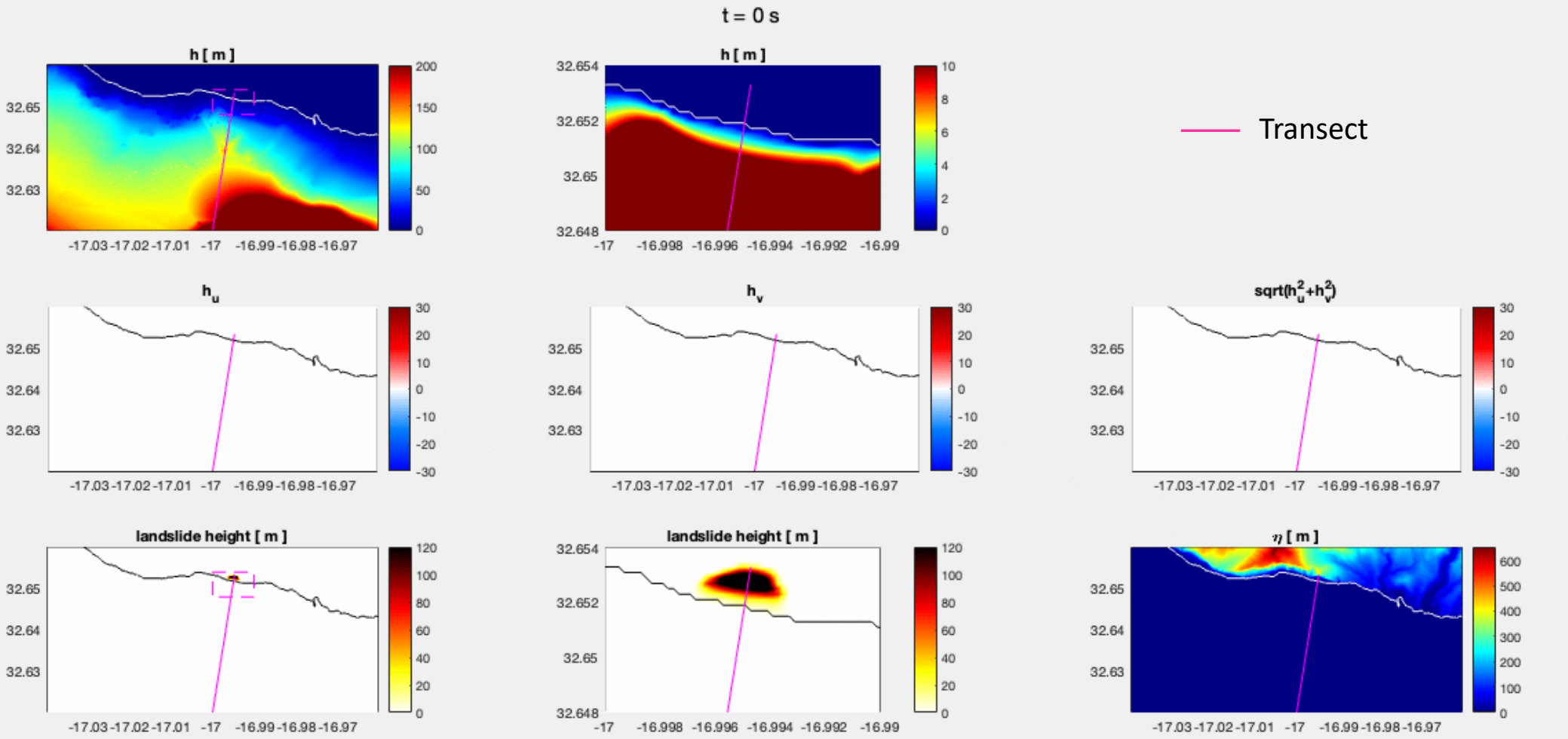
Landslides

- Lack of hydrophone data prevents reliable testing of GREAT with landslides

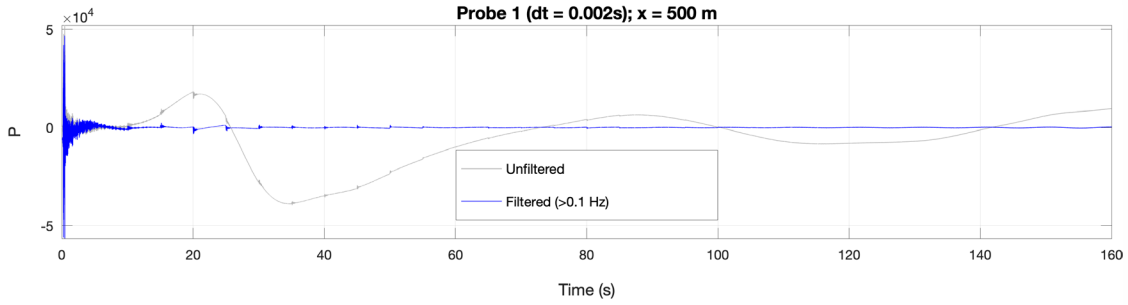
- The alternative: simulations (in collaboration with IPMA)

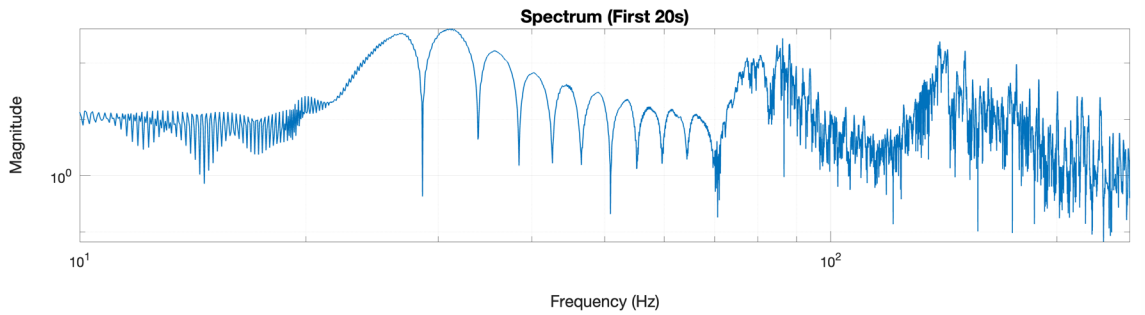


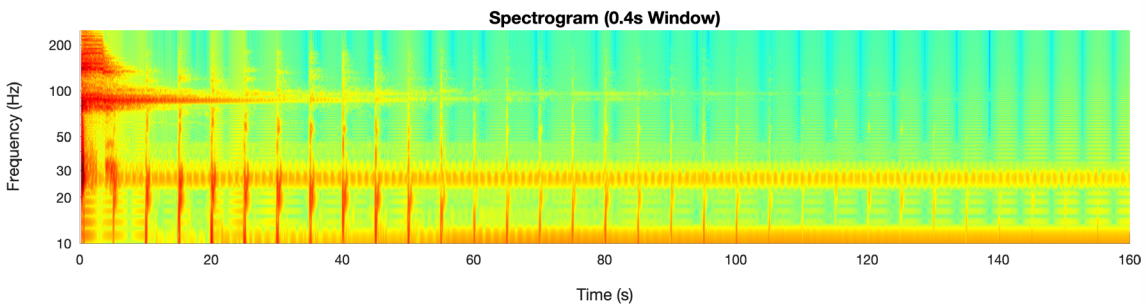
Landslide example

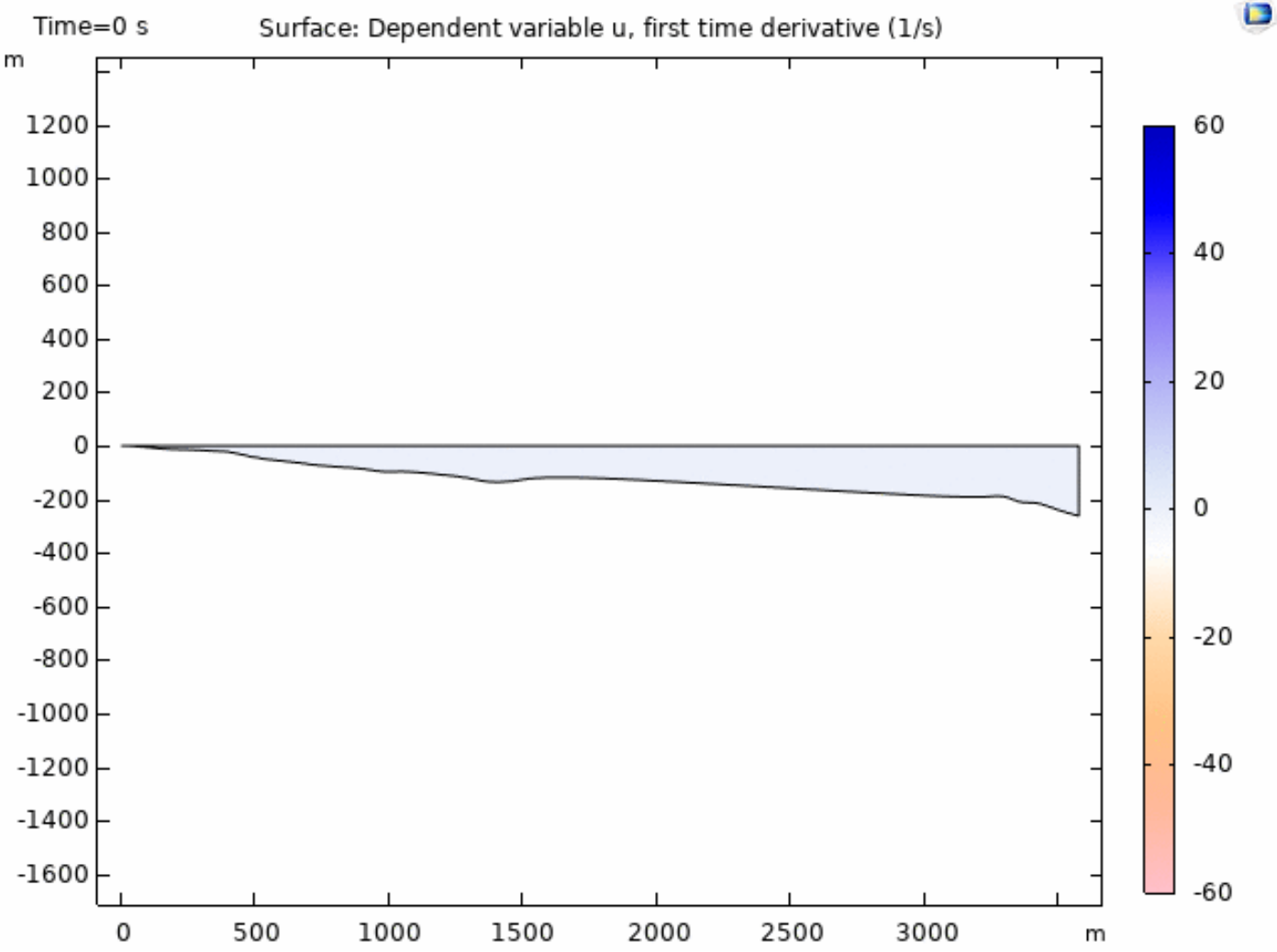


The acoustic modes appear as expected

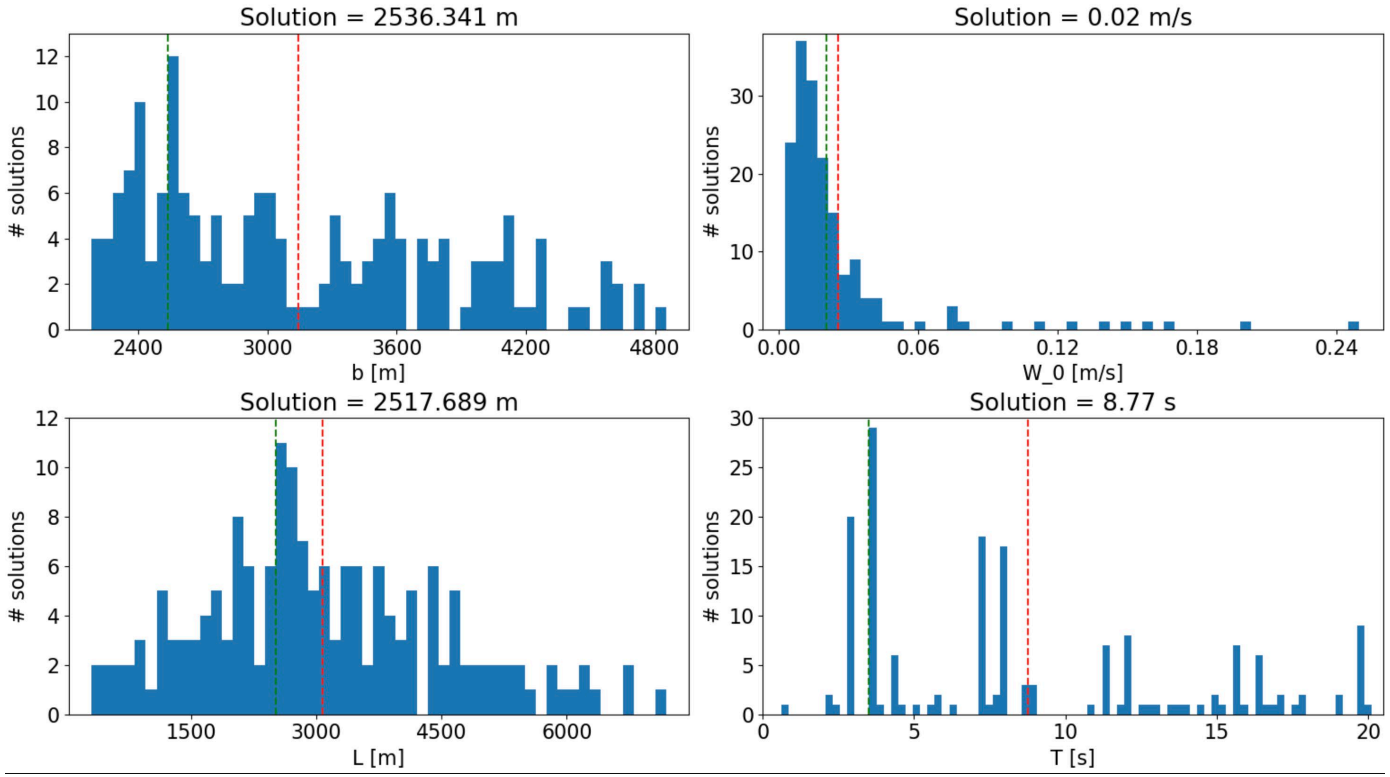








Inverse model results



- Preliminary results are promising → next generation of ML could include landslides

- A side note: we derived a compressible Boussinesq equation with the objective to help implementing it in GeoClaw & FunWave

Machine Learning

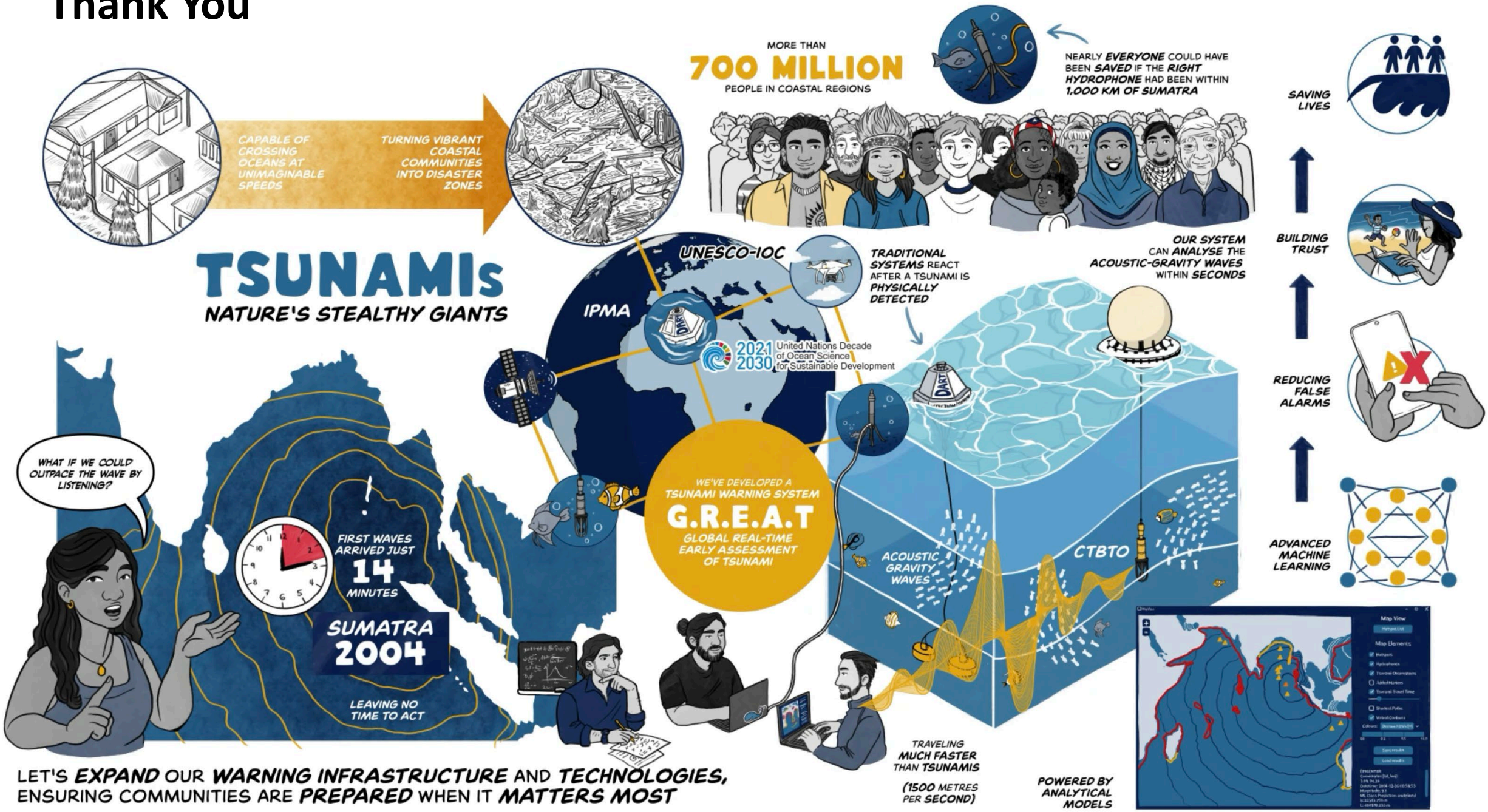
- Random forest classifier was demonstrated recently (independently) with accuracy of 95%
- Improvements by:
  (1) Feature extraction (physics-based)
  (2) Improving quality of data
- Looking to integrating Satellite data
- Next generation of ML could include landslides

Conclusions

- Our **operational software** (GREAT) has been running in real-time since June 2024.
- An end-to-end analysis can be made within 8 min on average if a hydroacoustic station was within 1,000 km.
- Acoustic technology can be used for seismic and non-seismic sources – preliminary results for Landslides are promising.
- Current ML is 95% accurate & next generation to include landslides.
- Tsunamis in South China, Sulu, and Celebes sea can be devastating.
- Optimisation of hydrophone deployments; new collaborations with UPM (with MET Malaysia) & INCOIS.
- North/South Andaman islands hydrophone deployment can increase evacuation time substantially.
- Future collaboration with BMKG; optimisation of hydrophone deployment along the Indonesian coast is crucial.

Join GREAT mailing list

Thank You


CAPABLE OF CROSSING OCEANS AT UNIMAGINABLE SPEEDS
TURNING VIBRANT COASTAL COMMUNITIES INTO DISASTER ZONES
MORE THAN
700 MILLION
PEOPLE IN COASTAL REGIONS
NEARLY EVERYONE COULD HAVE BEEN SAVED IF THE RIGHT HYDROPHONE HAD BEEN WITHIN 1,000 KM OF SUMATRA
TSUNAMIs
NATURE'S STEALTHY GIANTS
UNESCO-IOC
IPMA
2021 2030 United Nations Decade of Ocean Science for Sustainable Development
TRADITIONAL SYSTEMS REACT AFTER A TSUNAMI IS PHYSICALLY DETECTED
OUR SYSTEM CAN ANALYSE THE ACOUSTIC-GRAVITY WAVES WITHIN SECONDS
WE'VE DEVELOPED A TSUNAMI WARNING SYSTEM
G.R.E.A.T
GLOBAL REAL-TIME EARLY ASSESSMENT OF TSUNAMI
WHAT IF WE COULD OUTPACE THE WAVE BY LISTENING?
FIRST WAVES ARRIVED JUST 14 MINUTES
SUMATRA 2004
LEAVING NO TIME TO ACT
ACOUSTIC GRAVITY WAVES
CTBTO
TRAVELING MUCH FASTER THAN TSUNAMIS
(1500 METRES PER SECOND)
POWERED BY ANALYTICAL MODELS
SAVING LIVES
BUILDING TRUST
REDUCING FALSE ALARMS
ADVANCED MACHINE LEARNING
LET'S EXPAND OUR WARNING INFRASTRUCTURE AND TECHNOLOGIES, ENSURING COMMUNITIES ARE PREPARED WHEN IT MATTERS MOST