



UK Research
and Innovation



Global Realtime Early Assessment of Tsunami GREAT

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ICG/IOTWMS Working Group 2 Meeting (online)

25 August 2025



Intergovernmental
Oceanographic
Commission



2021
2030 United Nations Decade
of Ocean Science
for Sustainable Development

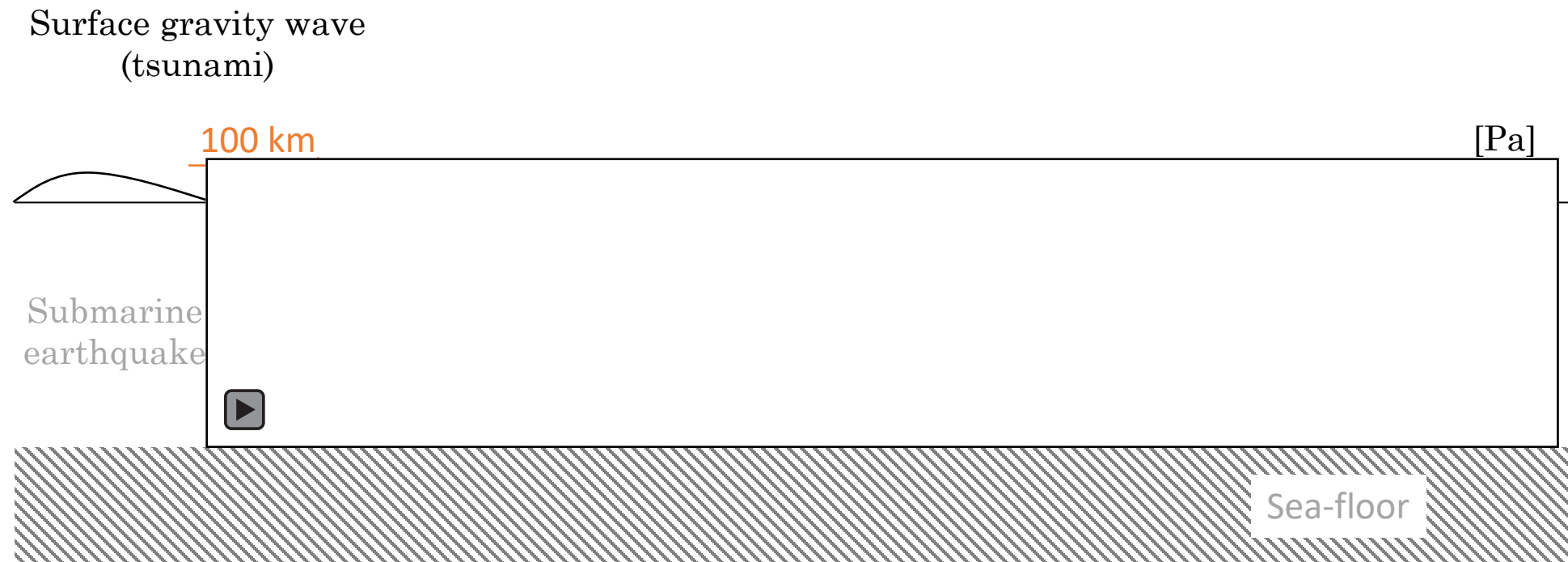
Content

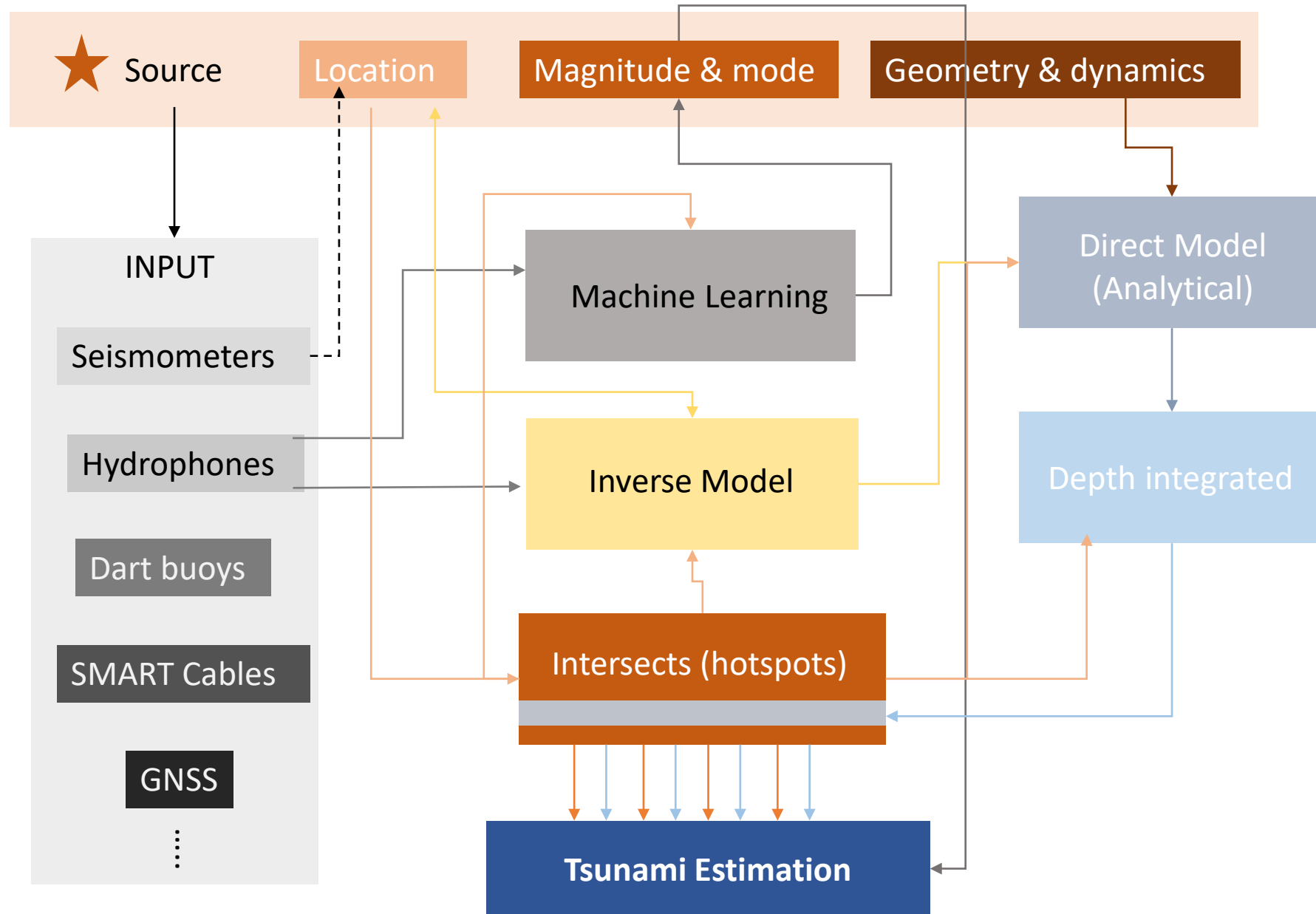
- A very brief background
- Focus on recent events (highlighting challenges & opportunities)
- Recommendation for actions



Real-time Tsunami Detection by **Acoustic-Gravity Waves**

Background





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

Detection → Warning → Dissemination

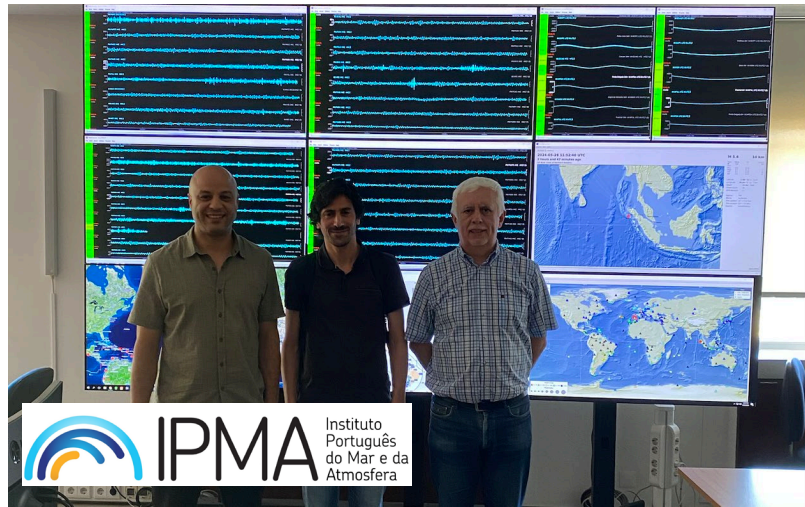
- Provides **initial assessment** based on EQ epicentre, sensors' locations, and required evacuation time.
- Detects signals; **categorises** earthquakes / events; **analyses** hydroacoustic data; calculates **tsunami size**
- Operates **automatically**, and **manually** (after training)
- Hydrophones & 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)

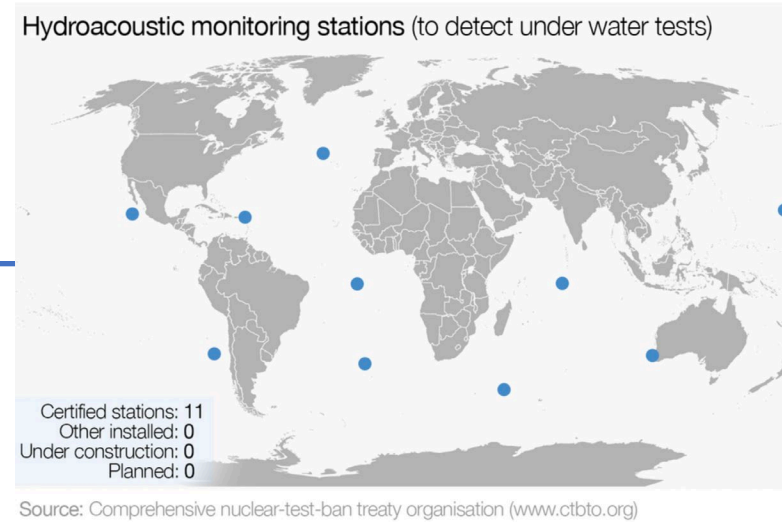


Access to IMS/CTBTO Real-Time Hydroacoustic Data

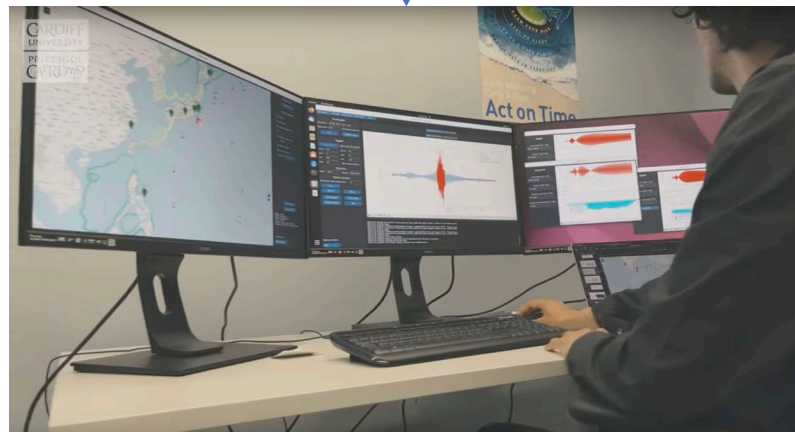
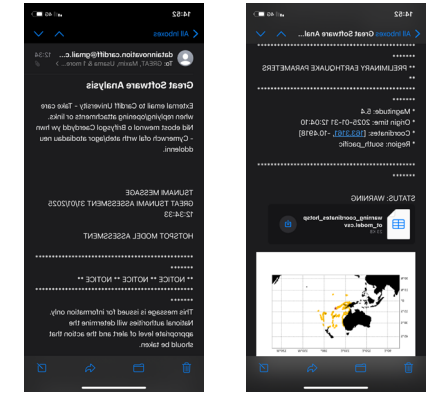
Software deployed at IPMA June 2024



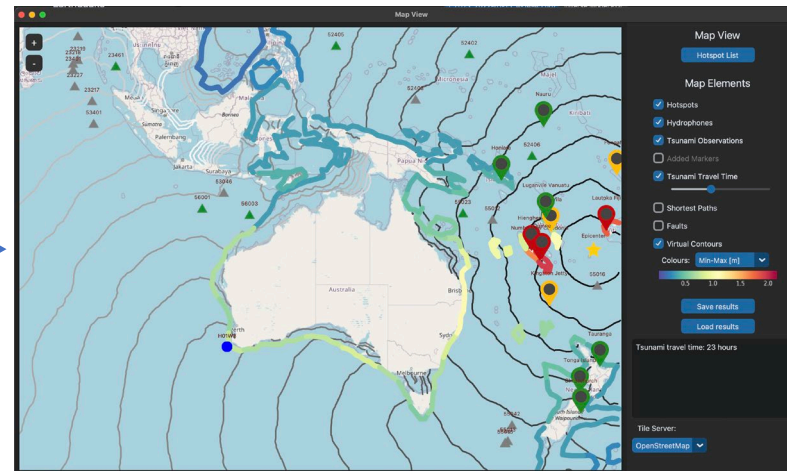
Real-time access



e-mail Alerts



Live streaming



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

Lack of hydroacoustic stations

CTBTO hydroacoustic stations map

- We need **access to ALL stations via CTBTO** (11 is better than 4)
- Current access is unstable → we require **direct access, either via NDC's/TWCs or IDC**

→ UNESCO-IOC can liaise with CTBTO and NDC's

Probabilistic offline model

Exploiting historical data

Settings

Mesh

```
data/mesh/global60_50km_unstr.msh
```

Hotspots

Conservation law:

Greens

Direct model type:

Mixed

Theta type:

faults_map

Maximum T (s):

50

Surface elevation factor:

1

Tsunami travel time step (hr):

1.0

Inverse model regression:

blaser_subsurface

- ✓ Precalculated inverse results

Magnitude delta:

0.2

Bathymetry contours

Depth (m):

1000

Minimum distance (km):

75

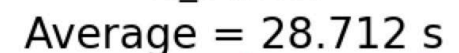
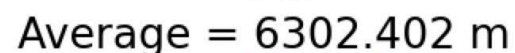
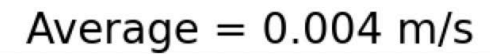
Maximum tsunami travel time (hr):

12

Min-Max power:

0.5

Apply



Execution time: 0.03589 seconds

Advantages: (1) Quick (seconds); (2) Can be used for pre-calculations (risk assessment or building a results library)

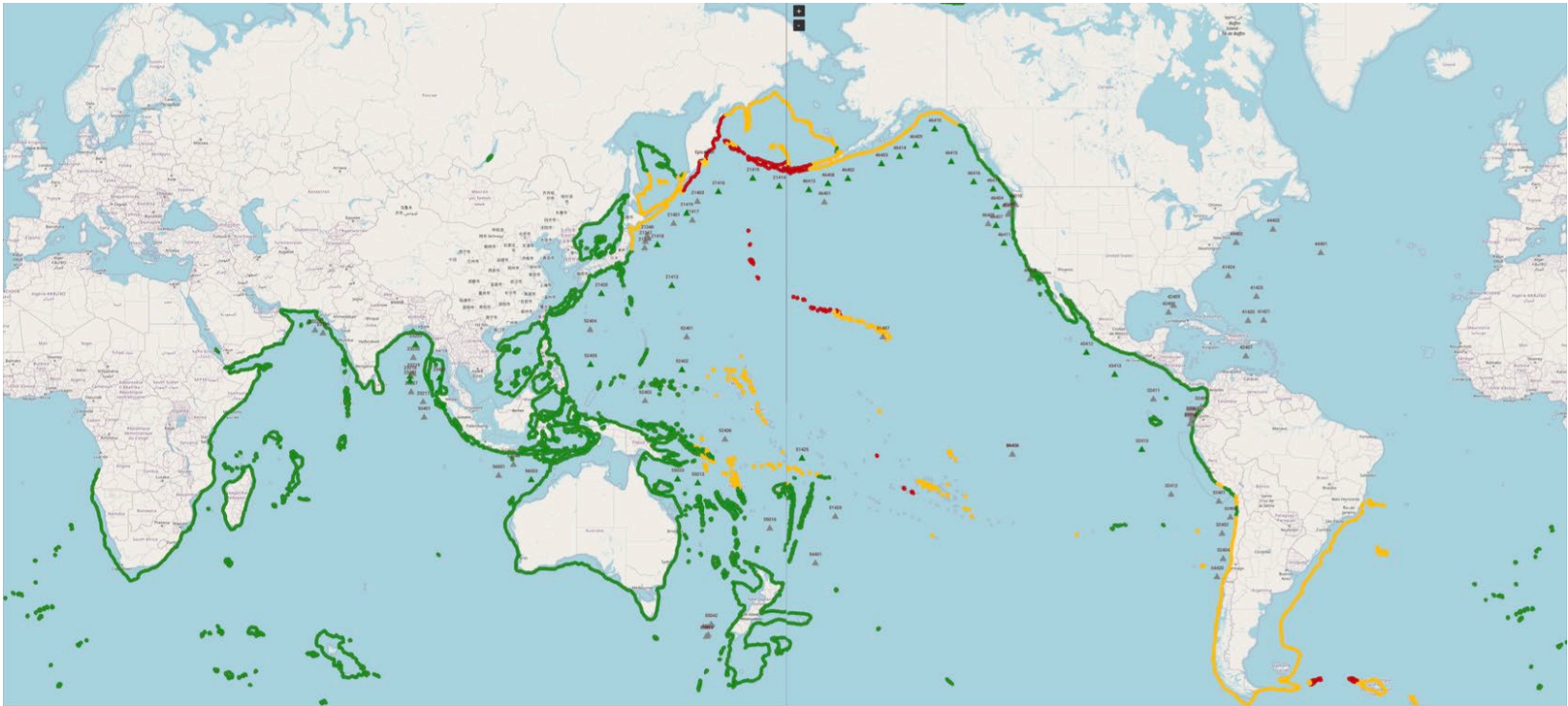
Disadvantages: (1) Does not analyse the actual signal; (2) Only good in case of EQs
→ subject to re-evaluation of magnitude

Challenges

- 1) Re-evaluation of EQ magnitude
- 2) Delays in uploading data (USGS)

M 8.8 – 2025 Kamchatka Peninsula, Russia Earthquake

2025-07-29 23:24:52 (UTC) | 52.498°N 160.264°E | 35.0 km depth



DART Station	Lat	Lon	Time of measure (UTC, min)	Period (min)	Observed height (m)	GREAT height (m)
21415	50.2N	171.9E	117	8	0.20	0.590
21414	49.0N	178.2E	103	32	0.28	0.260
46413	48.0N	174.2W	144	40	0.19	0.180
52402	11.9N	153.9E	507	44	0.06	0.076
52403	1.1N	154.2E	551	52	0.05	0.075

TSUNAMI MESSAGE NUMBER 1
NWS PACIFIC TSUNAMI WARNING CENTER HONOLULU HI
2334 UTC TUE JUL 29 2025

....PTWC TSUNAMI THREAT MESSAGE...

**** NOTICE **** NOTICE **** NOTICE **** NOTI

THIS MESSAGE IS ISSUED FOR INFORMATION
UNESCO/IOC PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM
MEANT FOR NATIONAL AUTHORITIES IN EACH COUNTRY OF THAT SYSTEM.

NATIONAL AUTHORITIES WILL DETERMINE THE APPROPRIATE LEVEL OF
ALERT FOR EACH COUNTRY AND MAY ISSUE ADDITIONAL OR MORE REFINED
INFORMATION.

**** NOTICE **** NOTICE **** NOTICE **** NOTI

PRELIMINARY EARTHQUAKE PARAMETERS

- * MAGNITUDE 8.0
- * ORIGIN TIME 2325 UTC JUL 29 2025
- * COORDINATES 52.2 NORTH 160.0 EAST
- * DEPTH 74 KM / 46 MILES
- * LOCATION OFF THE EAST COAST OF KAMCHATKA RUSSIA

EVALUATION

* AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 8.0 OCCURRED
OFF THE EAST COAST OF KAMCHATKA, RUSSIA AT 2325 UTC ON
TUESDAY JULY 29 2025.

* BASED ON THE PRELIMINARY EARTHQUAKE DATA... HAZARDOUS TSUNAMI WAVES ARE POSSIBLE
ALONG SOME COASTS.

TSUNAMI THREAT FORECAST

* HAZARDOUS TSUNAMI WAVES FROM THIS EARTHQUAKE ARE FORECAST
WITHIN THE NEXT THREE HOURS ALONG SOME COASTS OF

RUSSIA AND JAPAN

TSUNAMI MESSAGE NUMBER 2
NWS PACIFIC TSUNAMI WARNING CENTER HONOLULU HI
0016 UTC WED JUL 30 2025

After 42 minutes

....PTWC TSUNAMI THREAT MESSAGE...

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE ****

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INFORMATION.

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE ****

THE TSUNAMI FORECAST IS UPDATED IN THIS MESSAGE.

PRELIMINARY EARTHQUAKE PARAMETERS

- * MAGNITUDE 8.7
- * ORIGIN TIME 2325 UTC JUL 29 2025
- * COORDINATES 52.2 NORTH 160.0 EAST
- * DEPTH 74 KM / 46 MILES
- * LOCATION OFF THE EAST COAST OF KAMCHATKA RUSSIA

EVALUATION

* AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 8.7 OCCURRED
OFF THE EAST COAST OF KAMCHATKA, RUSSIA AT 2325 UTC ON
TUESDAY JULY 29 2025.

* BASED ON ALL AVAILABLE DATA... HAZARDOUS TSUNAMI WAVES ARE
FORECAST FOR SOME COASTS.

TSUNAMI THREAT FORECAST...UPDATED

* TSUNAMI WAVES REACHING MORE THAN 3 METERS ABOVE THE TIDE
LEVEL ARE POSSIBLE ALONG SOME COASTS OF

TSUNAMI MESSAGE NUMBER 7
NWS PACIFIC TSUNAMI WARNING CENTER HONOLULU HI
0623 UTC WED JUL 30 2025

> 6 hours

....PTWC TSUNAMI THREAT MESSAGE...

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INFORMATION.

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE ****

THE TSUNAMI FORECAST IS UNCHANGED IN THIS MESSAGE.

PRELIMINARY EARTHQUAKE PARAMETERS

Final

- * MAGNITUDE 8.8
- * ORIGIN TIME 2325 UTC JUL 29 2025
- * COORDINATES 52.2 NORTH 160.0 EAST
- * DEPTH 74 KM / 46 MILES
- * LOCATION OFF THE EAST COAST OF KAMCHATKA RUSSIA

EVALUATION

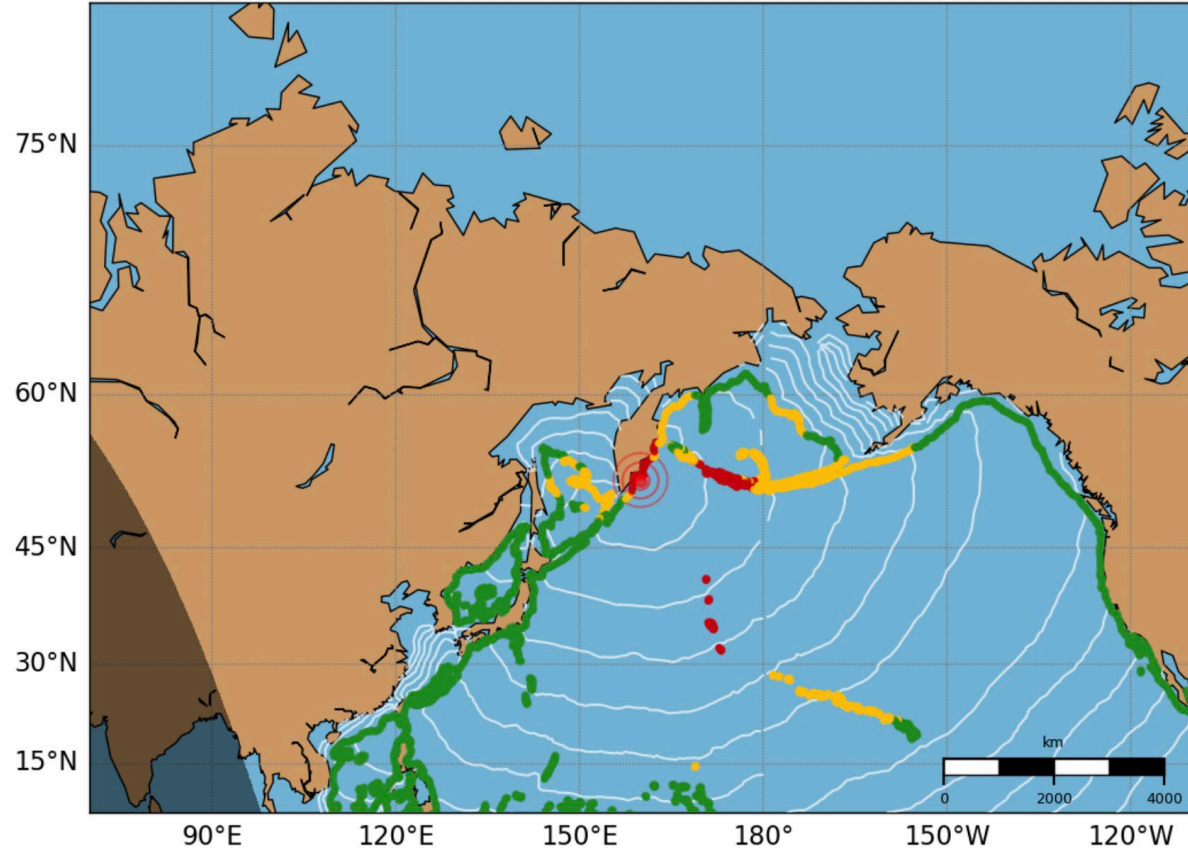
* AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 8.8 OCCURRED
OFF THE EAST COAST OF KAMCHATKA, RUSSIA AT 2325 UTC ON
TUESDAY JULY 29 2025.

* TSUNAMI WAVES HAVE BEEN OBSERVED.

* BASED ON ALL AVAILABLE DATA... HAZARDOUS TSUNAMI WAVES ARE
FORECAST FOR SOME COASTS.

Mw 8.0

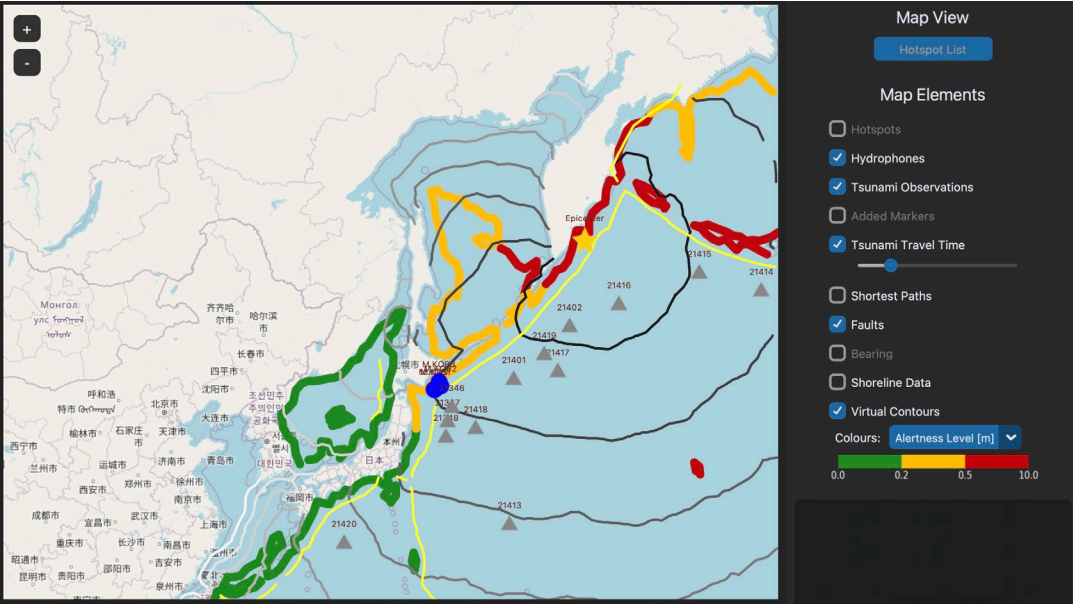
Direct Model Results



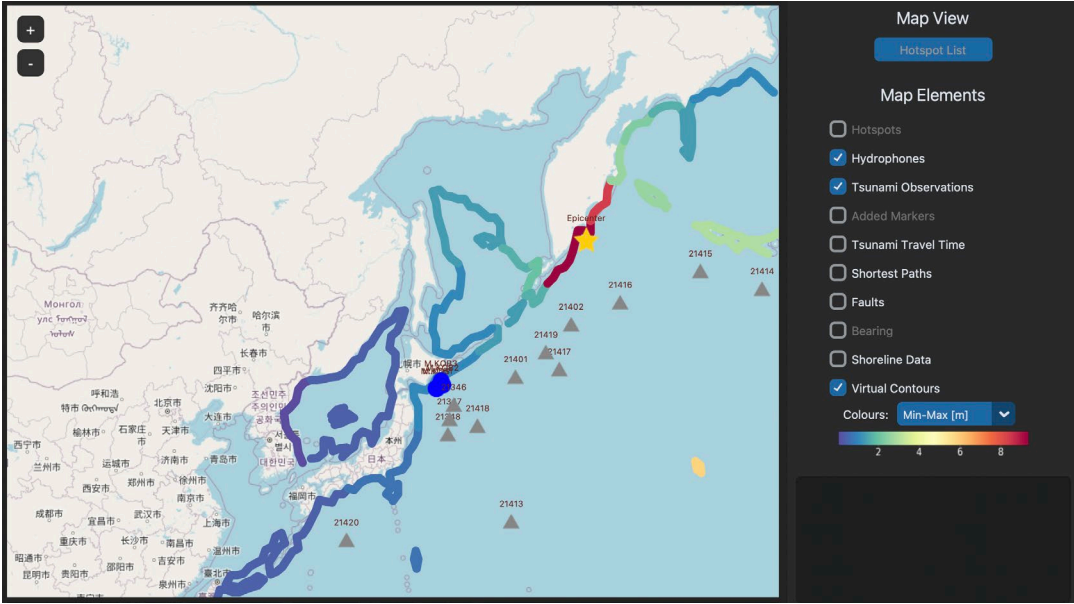
Mw 8.8

- If a hydroacoustic station was within 1,000 km
- 1) Analysis is done **once** (magnitude is not relevant)
 - 2) End-to-end analysis **< 7.5 min**

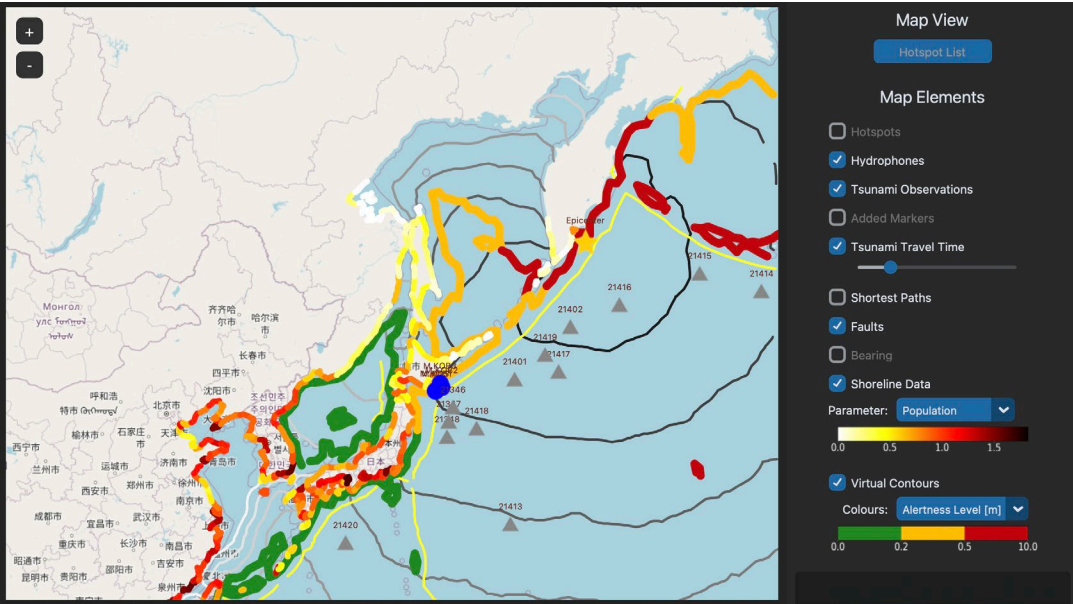
Alertness level



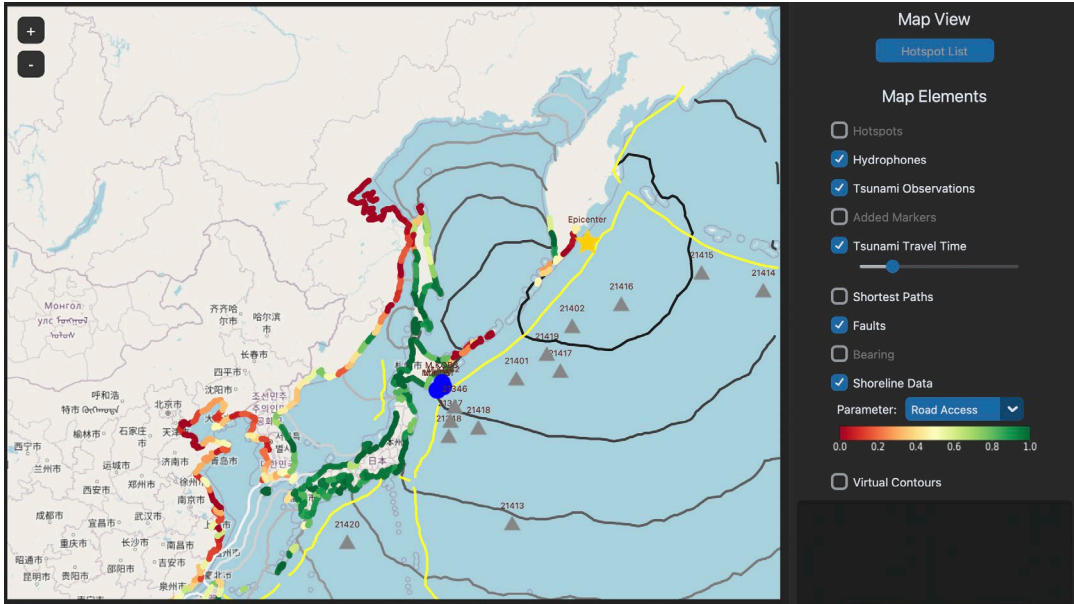
Tsunami height



Population

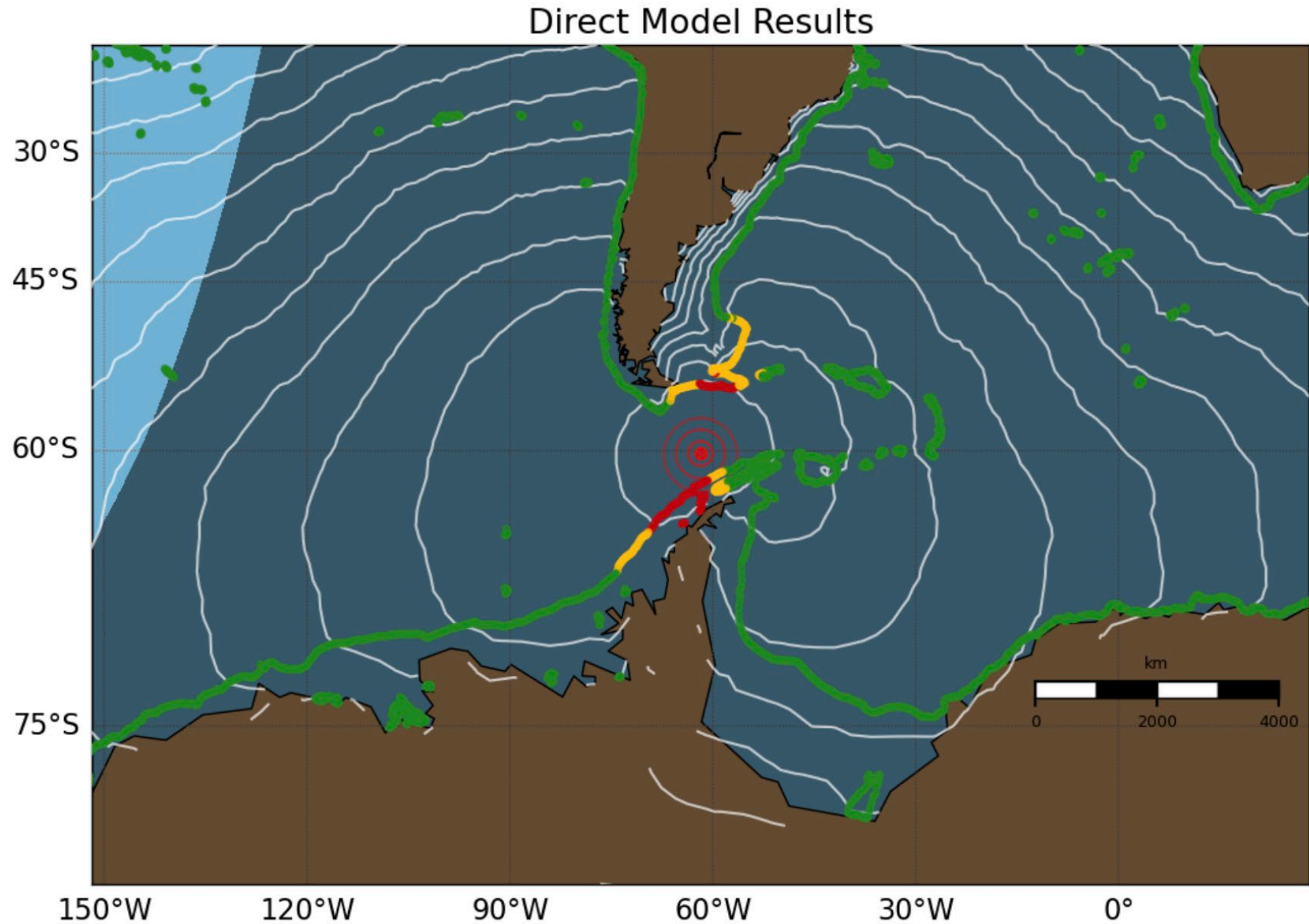


Road access



M 7.5 - 2025 Southern Drake Passage Earthquake

2025-08-22 02:16:19 (UTC) | 60.186°S 61.821°W | 10.8 km depth



M 7.5 – 2025 Southern Drake Passage Earthquake

2025-08-22 02:16:19 (UTC) | 60.186°S 61.821°W | 10.8 km depth

TSUNAMI INFORMATION STATEMENT NUMBER 1
NWS PACIFIC TSUNAMI WARNING CENTER HONOLULU HI
0224 UTC FRI AUG 22 2025

....TSUNAMI INFORMATION STATEMENT...

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE ****

THIS STATEMENT IS ISSUED FOR INFORMATION ONLY IN SUPPORT OF THE UNESCO/IOC TSUNAMI AND OTHER COASTAL HAZARDS WARNING SYSTEM FOR THE CARIBBEAN AND ADJACENT REGIONS AND IS MEANT FOR NATIONAL AUTHORITIES IN EACH COUNTRY OF THAT SYSTEM.

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**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE ****

PRELIMINARY EARTHQUAKE PARAMETERS

- * MAGNITUDE 8.0
- * ORIGIN TIME 0216 UTC AUG 22 2025
- * COORDINATES 60.4 SOUTH 62.0 WEST
- * DEPTH 10 KM / 6 MILES
- * LOCATION DRAKE PASSAGE

TSUNAMI INFORMATION STATEMENT NUMBER 2
NWS PACIFIC TSUNAMI WARNING CENTER HONOLULU HI
0304 UTC FRI AUG 22 2025

After 42 minutes

....TSUNAMI SUPPLEMENT STATEMENT...

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**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE ****

* REVISED MAGNITUDE

PRELIMINARY EARTHQUAKE PARAMETERS

- * MAGNITUDE 7.5
- * ORIGIN TIME 0216 UTC AUG 22 2025
- * COORDINATES 60.4 SOUTH 62.0 WEST
- * DEPTH 10 KM / 6 MILES
- * LOCATION DRAKE PASSAGE

GREAT sends requests (API) to USGS website to check for a new EQ, every 5 minutes

```
2025-08-22 03:14:59: Sending an API call for min mag 5.5 and times: 2025-08-22 01:24:58.632380+00:00 - 2025-08-22 02:14:59.192100+00:00
2025-08-22 03:19:59: Sending an API call for min mag 5.5 and times: 2025-08-22 01:29:59.192100+00:00 - 2025-08-22 02:19:59.620400+00:00
2025-08-22 03:25:00: Sending an API call for min mag 5.5 and times: 2025-08-22 01:34:59.620400+00:00 - 2025-08-22 02:25:00.122925+00:00
2025-08-22 03:30:00: Sending an API call for min mag 5.5 and times: 2025-08-22 01:40:00.122925+00:00 - 2025-08-22 02:30:00.525301+00:00
2025-08-22 03:35:01: Sending an API call for min mag 5.5 and times: 2025-08-22 01:45:00.525301+00:00 - 2025-08-22 02:35:01.329467+00:00
2025-08-22 03:40:01: Sending an API call for min mag 5.5 and times: 2025-08-22 01:50:01.329467+00:00 - 2025-08-22 02:40:01.802584+00:00
2025-08-22 03:45:03: Sending an API call for min mag 5.5 and times: 2025-08-22 01:55:01.802584+00:00 - 2025-08-22 02:45:03.602327+00:00
2025-08-22 03:50:04: Sending an API call for min mag 5.5 and times: 2025-08-22 02:00:03.602327+00:00 - 2025-08-22 02:50:04.023346+00:00
2025-08-22 03:55:10: Sending an API call for min mag 5.5 and times: 2025-08-22 02:05:04.023346+00:00 - 2025-08-22 02:55:10.485077+00:00
2025-08-22 04:00:10: Sending an API call for min mag 5.5 and times: 2025-08-22 02:10:10.485077+00:00 - 2025-08-22 03:00:10.947292+00:00
2025-08-22 04:05:11: Sending an API call for min mag 5.5 and times: 2025-08-22 02:15:10.947292+00:00 - 2025-08-22 03:05:11.355627+00:00
2025-08-22 04:05:11: An earthquake detected. Magnitude: 7.5, location (lat, lon): -60.1859,-61.8206, datetime: 2025-08-22 02:16:19.202000+00:00
2025-08-22 04:05:11: Earthquake epicenter basin: southern. Hydrophones: H01W H08S
2025-08-22 04:05:11: Performing preliminary analysis for earthquake with magnitude: 7.5, location (lat, lon): -60.1859,-61.8206, datetime: 2025-08-22 02:16:19.202000+00:00...
```

```
2025-08-22 04:05:11: Sending an API call for min mag 5.5 and times: 2025-08-22 02:15:10.947292+00:00 - 2025-08-22 03:05:11.355627+00:00
2025-08-22 04:05:11: An earthquake detected. Magnitude: 7.5, location (lat, lon): -60.1859,-61.8206, datetime: 2025-08-22 02:16:19.202000+00:00
2025-08-22 04:05:11: Earthquake epicenter basin: southern. Hydrophones: H01W H08S
2025-08-22 04:05:11: Performing preliminary analysis for earthquake with magnitude: 7.5, location (lat, lon): -60.1859,-61.8206, datetime: 2025-08-22 02:16:19.202000+00:00...
```

EQ updated at 04:05:11 (UTC+1) i.e., after 71 minutes !!!

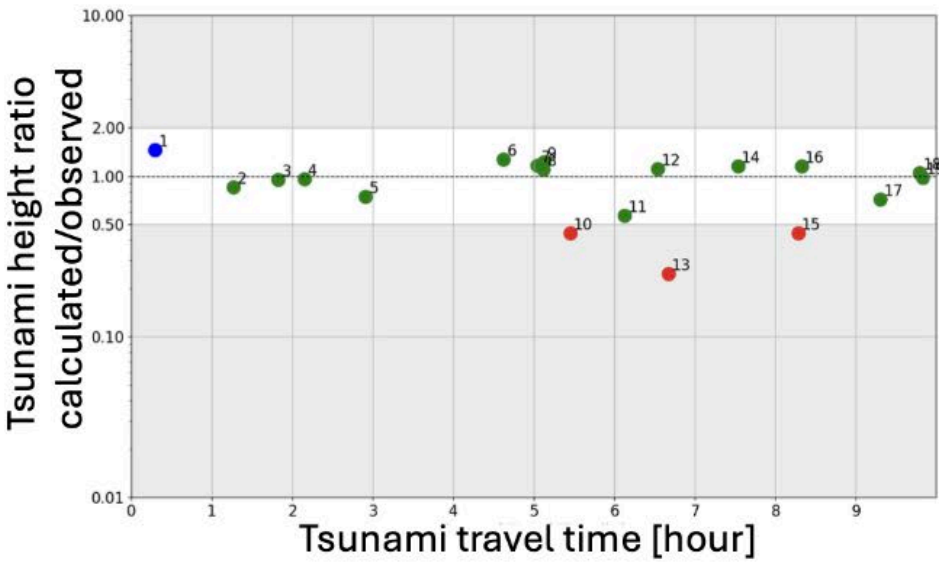
➔ There is a need for a more direct connection

Cost-effective hydrophones

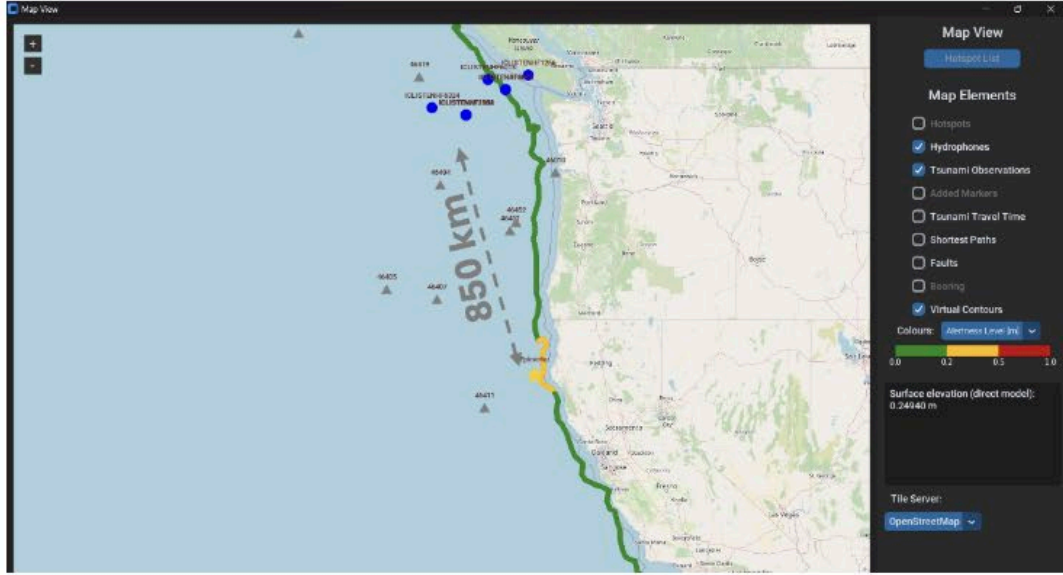
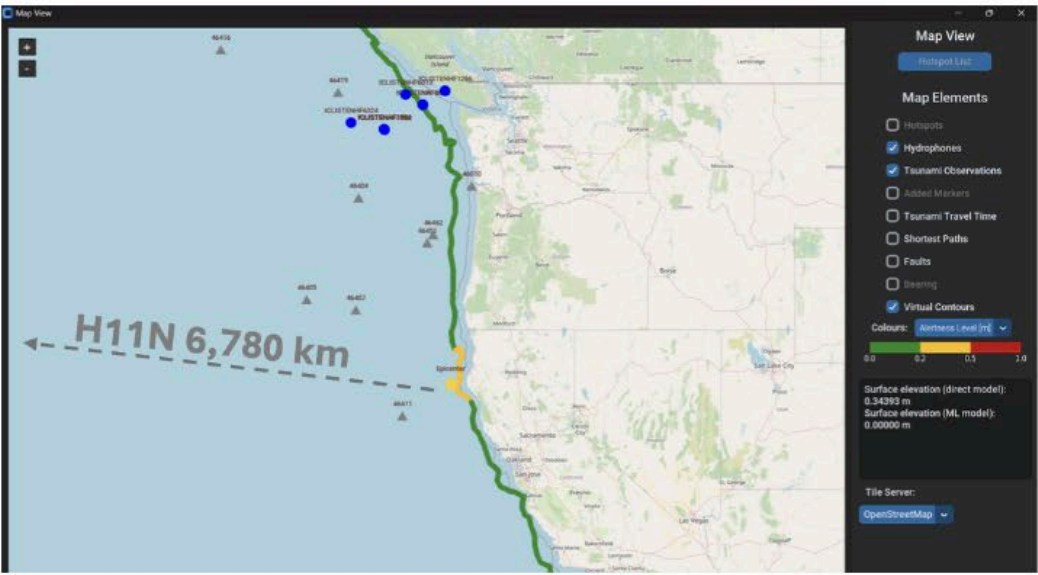
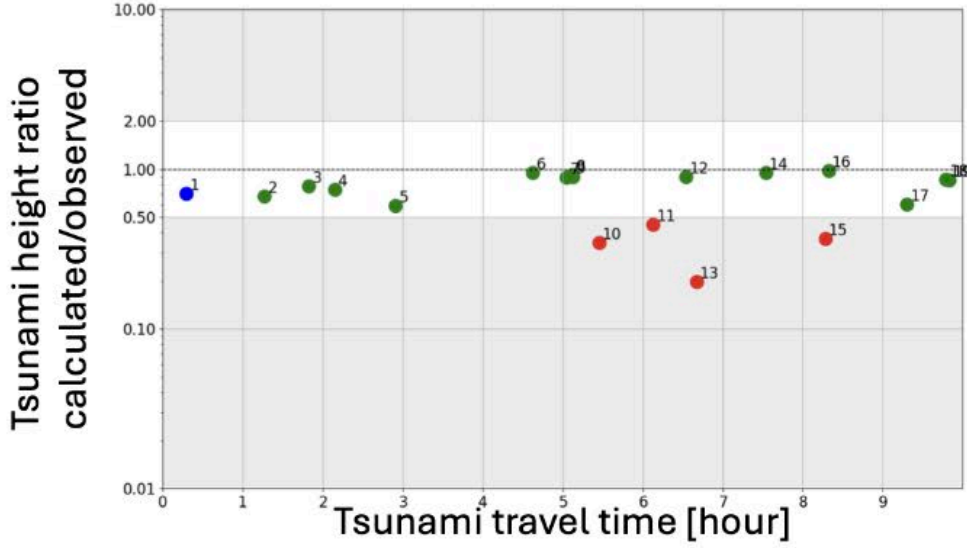
Potential exploitation of technology

M 7.0 - 2024 Offshore Cape Mendocino, California Earthquake 2024-12-05 18:44:21 (UTC)

CTBTO (hydroacoustic station H11N)

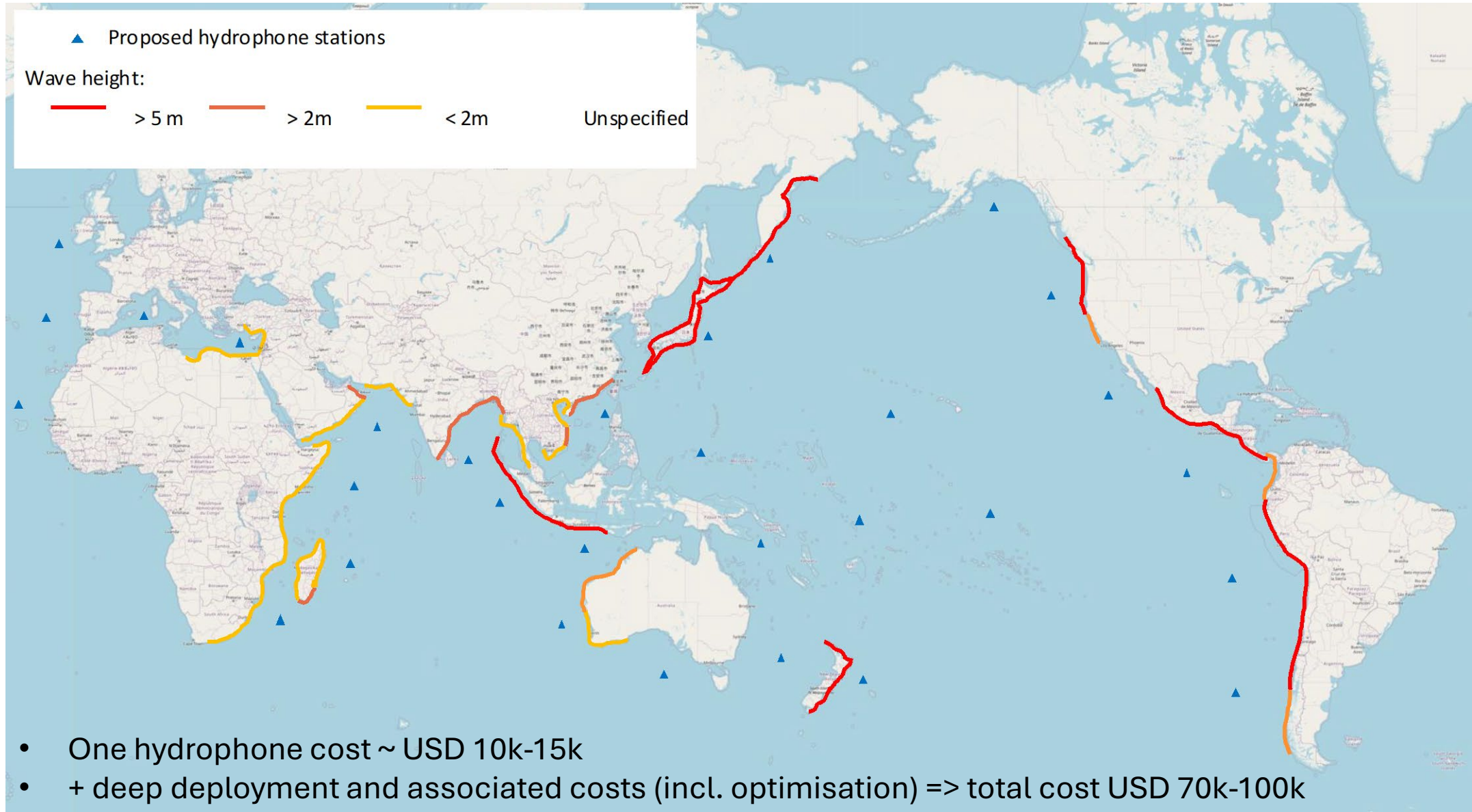


Ocean Networks Canada (icListen AF 2534)



Future plan - deploy hydrophones designed for Tsunami warning

~30 stations are needed for global coverage (End-to-end analysis < 7.5 min)



Conclusions



Join GREAT mailing list

- Our **operational software** (GREAT) has been running in **real-time** since June 2024.
- Assessment of real-time analysis are in good agreement with observations.
- If a hydroacoustic station was within 1,000 km
 - 1) Analysis is done **once** (magnitude is not relevant)
 - 2) End-to-end analysis **< 7.5 min**
- Acoustic technology can be used for seismic and non-seismic sources.
 - Small project (EPSRC, ongoing) – focuses on non-seismic volcanic (landslide, meteotsunami)
- With the absence of real-time acoustic data, we developed a probabilistic model for EQs (historic data)

Advantages:

- (1) Quick (seconds)
- (2) Can be used for pre-calculations (risk assessment or building a results library)

Disadvantages:

- (1) Does not analyse the actual signal
- (2) Only good in case of EQs → subject to re-evaluation of magnitude

Thank you

Recommendation for Actions



Join GREAT mailing list

Current stage - improve working with what is available

1. Direct access to existing data, such as seismometers.
2. Reliable access to CTBTO hydroacoustic data (3 stations in Indian Ocean, H04, H08, H01)
3. Access to national stations – e.g., ONC

Future plan - deploy hydrophones designed for Tsunami warning

~30 stations are needed for global coverage (End-to-end analysis < 7.5 min)

- Small project funded (EPSRC, Sept 2025 – March 2026)
Advancing real-time tsunami warning through hydroacoustic deployment and regional policy integration
(in collaboration with UPM Malaysia)

Applying for a large grant (5 years)



European Research Council
Established by the European Commission

Details call: [ERC-2025-ADG](#) 

Deadline date: 28 August 2025 - 17:00:00
Brussels time

Tsunamis are rare but devastating hazards, capable of causing massive loss of life and economic damage within minutes of generation. Existing early warning systems, relying mainly on seismic data and ocean surface measurements, often issue late or false alerts and cannot reliably detect non-seismic sources such as landslides, volcanic eruptions, meteotsunamis, or impacts.

This project will revolutionise tsunami early warning by exploiting low-frequency hydroacoustic signals, known as acoustic-gravity waves (AGWs), that travel through the ocean at the speed of sound, carrying detailed information about the tsunami source and arriving well before the destructive waves.

Building on pioneering analytical models, machine-learning algorithms, and the operational Global Real-time Early Assessment of Tsunamis (GREAT) platform, the research will: (1) develop new analytical solutions for seismic and non-seismic tsunami sources; (2) deploy hydrophone networks in the Indian Ocean and the North Atlantic for real-time AGW detection; (3) integrate hydroacoustic, geodetic, and environmental data for robust multi-hazard assessment; and (4) extend the framework to include solid Earth elastic wave propagation for faster warnings.

The outcome will be a validated, low-cost, globally deployable system that improves tsunami detection speed by minutes to tens of minutes, reduces false alarms, and strengthens resilience for coastal communities worldwide, delivering both scientific breakthroughs and operational impact.

- External partners should consent if interested