No More Crying Wolf: Rethinking tsunami thresholds to reduce false alarms

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AGENCIA ESTATAL DE INVESTIGACIÓN

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Tsunamis in the 21st Century

2004 Indian Ocean Boxing Day

Cordon Press

227,000 DEATHS

9,9 B$ losses

2010 Chile

ElMundo

550 DEATHS

10% affected population

2011 Japan

National Geographic

20,000 DEATHS

309 B$ losses

2025 Russia

Reuters

2M PEOPLE EVACUATED

Minimal damage, but huge social impact

How are people warned?

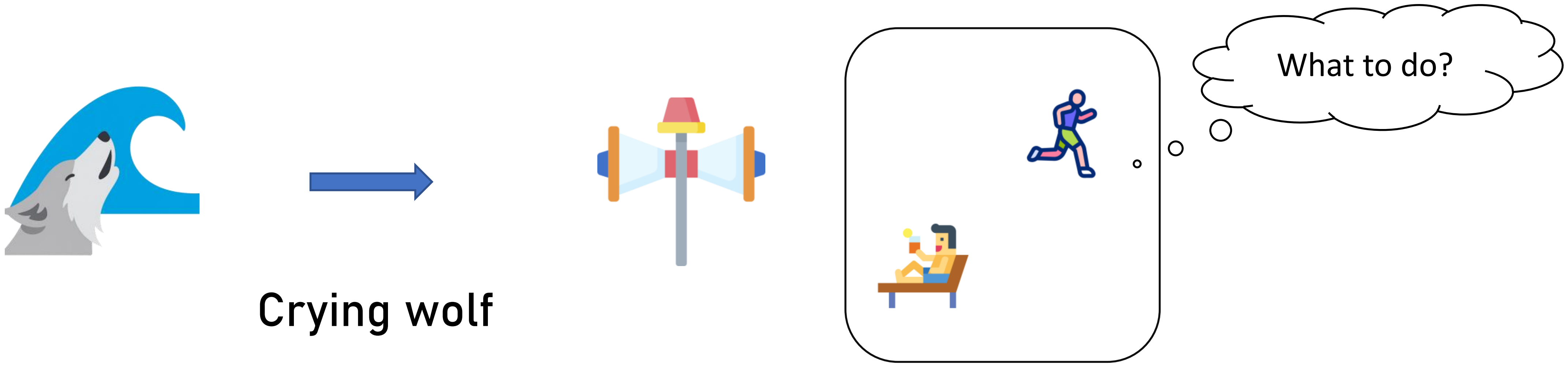
- Tsunami Service Providers
- Tsunami Warning Centers

Depth	M	Epicenter Location	Tsunami Potential	ALERT LEVEL *VS* DISTANCE: $\Delta eq \leq 100$ km	100 km $< \Delta eq \leq 400$ km	$\Delta eq > 400$ km
< 100 km	$5.5 \leq M \leq 6.0$	Offshore or Inland ≤ 100 km	Nil	Information Bulletin		
	$6.0 < M \leq 6.5$	Inland (40 km < Inland $\leq$ 100 km)	Nil	Information Bulletin		
		Offshore or near the coast (Inland $\leq$ 40 km)	Potential of weak local tsunami $\Delta eq < 100$ km	LOCAL Tsunami ADVISORY	Information	
	$6.5 < M \leq 7.0$	Offshore or Inland $\leq$ 100 km	Potential of destructive local tsunami $\Delta eq < 100$ km $\vert$ 400 km	LOCAL Tsunami WATCH	REGIONAL Tsunami ADVISORY	Information
	$7.0 < M \leq 7.5$		Potential of destructive regional tsunami $\Delta eq < 400$ km $\vert$ basin	REGIONAL Tsunami WATCH		BASIN-WIDE Tsunami ADVISORY
	$M > 7.5$		Potential of destructive tsunami in the whole basin any Δeq	BASIN-WIDE Tsunami WATCH		
$\geq$100 km	*$M \geq 5.5$*	*Offshore or Inland $\leq$ 100 km*	*Nil*	*Information Bulletin*		
any	*any*	***Inland > 100 km***	*Nil*	*Nil*		
				LOCAL	REGIONAL	BASIN-WIDE

Aim of the study

Use numerical simulations of historical events to identify tsunami vs. non-tsunami cases.

⚠️ False alarms (false positives) → loss of trust in the population
⏱️ Events not detected in time (false negatives) → high impact
❌ Binary decision (“yes/no tsunami”)



- False negative (FN): Events not detected in time

LATERCERA

HISTÓRICO

Caso Tsunami: juzgado reabre investigación luego de ac requerimiento de uno de los acusados

La defensa de Mariano Rojas, capitán (R) a cargo del Shoa la noche de la tragedia, pidió indagar en los antecedentes de la oceanógrafa Cecilia Zelaya, quien era la que habría tenido mayor capacitación durante la emergencia.

Por Constanza Cortés Miquel 23 JUNIO 2014

Tribunal chileno acoge salida extrajudicial para imputados en fallida alerta de tsunami en 2010

By Reuters

April 7, 2016 7:11 PM GMT+2 · Updated April 7, 2016

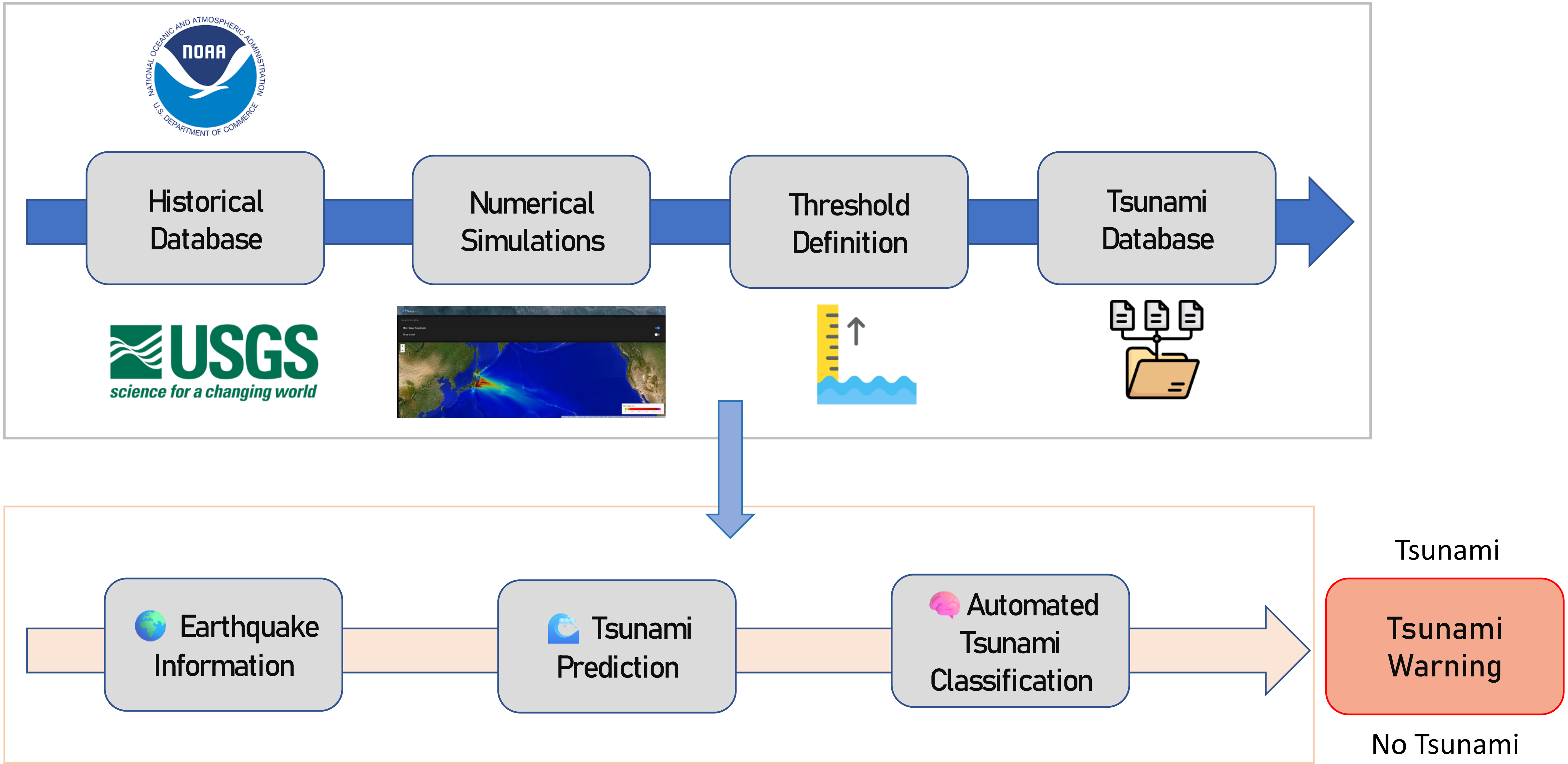
- False positive (FP): Alert without real danger

"Magnitude 7.8 earthquake in Kamchatka triggered a tsunami alert in Russia"

75% of Tsunami Warnings Were False Alarms

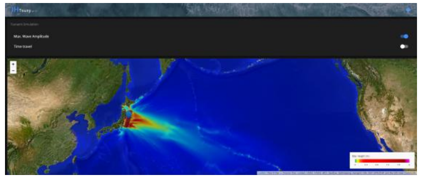
But in 2001, the DART System Changed the Game

Hydrau Follow 7 min read · Jan 18, 2025


Historical Database
Numerical Simulations
Threshold Definition
Tsunami Database
USGS
science for a changing world
Earthquake Information
Tsunami Prediction
Automated Tsunami Classification
Tsunami
Tsunami Warning
No Tsunami

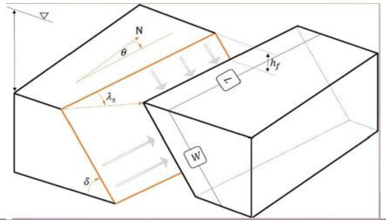
Historical Database

Numerical Simulations



Introduction | Methodology-Results | Output | Key Insights

Historical simulated global database

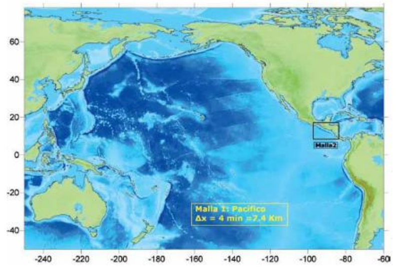


Characterisation of seismotectonic sources

USGS
science for a changing world

SOURCES

BATHYMETRY



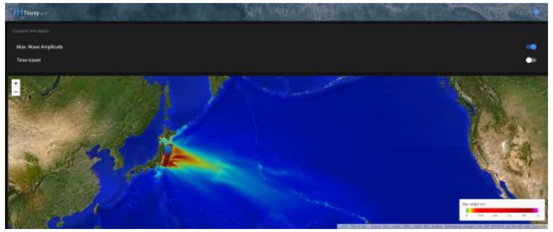
Construction of a high-resolution topobathymetry

NUMERICAL MODELLING

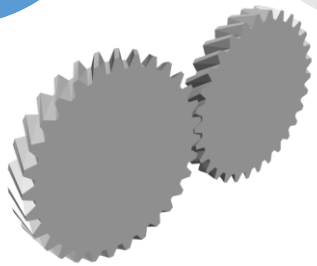
RESULTS

Tsunami-HySEA

Application of numerical model

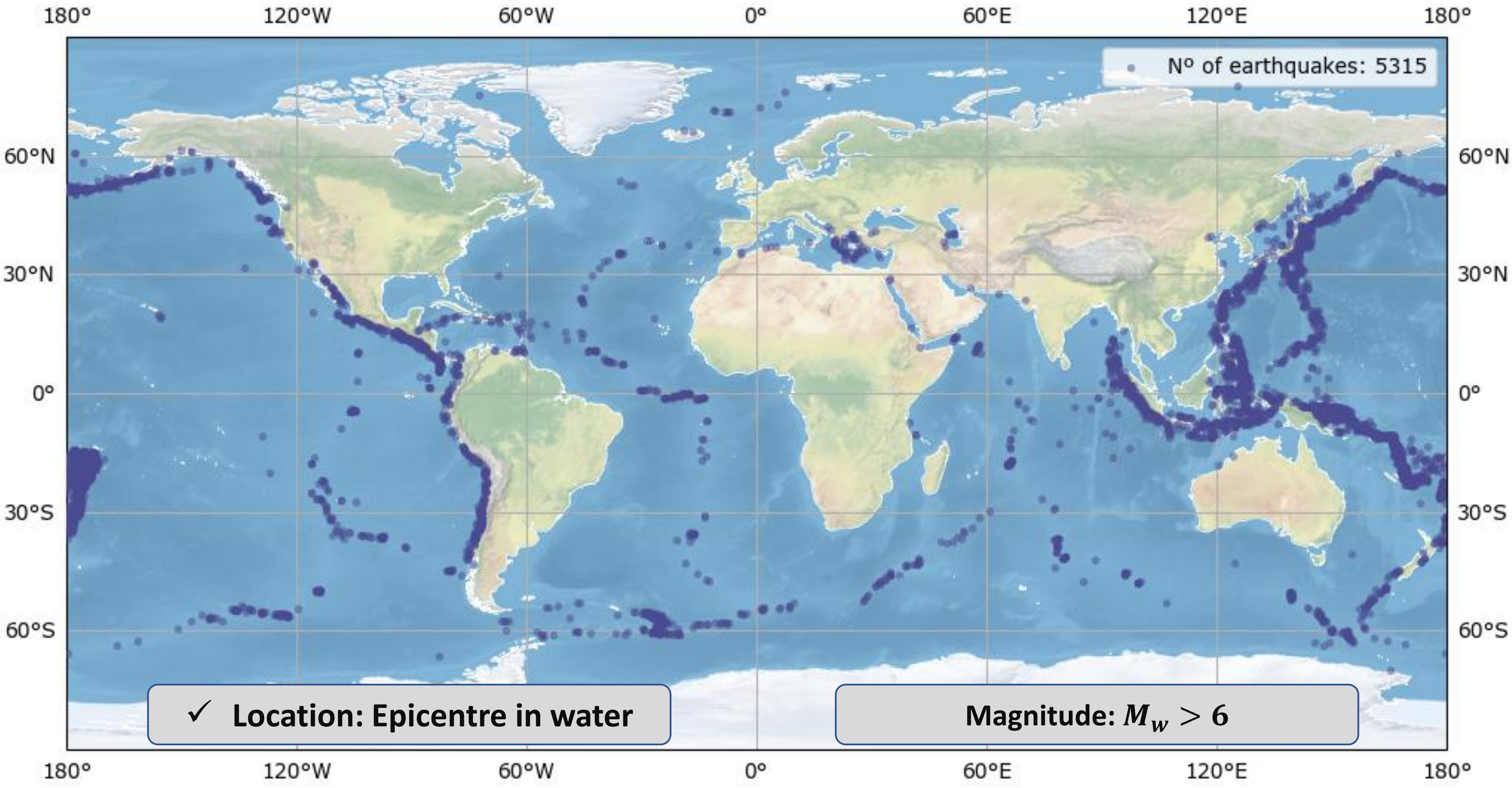


Map of heights and times



IHCantabria – Simplified method for tsunami hazard assessment, showing the main steps of the approach

Introduction | Methodology-Results | Output | Key Insights



✓ **Location: Epicentre in water**

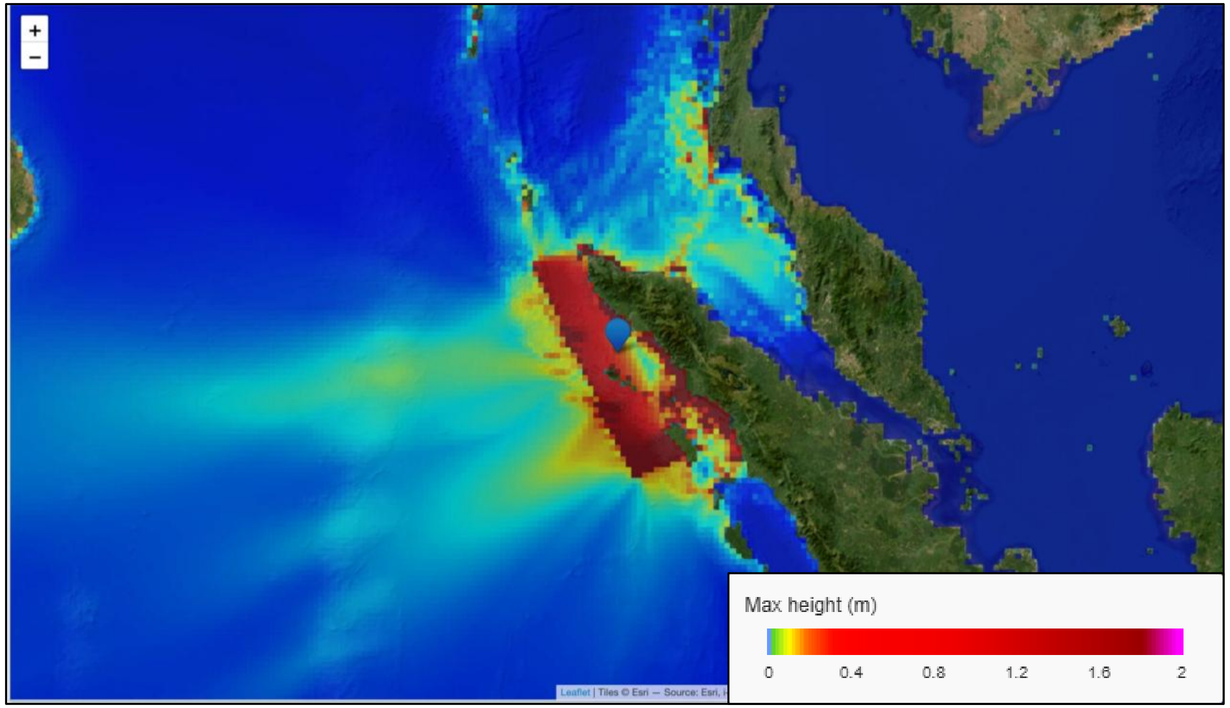
Magnitude: $M_w > 6$

2004 Sumatra - Andaman Islands Earthquake

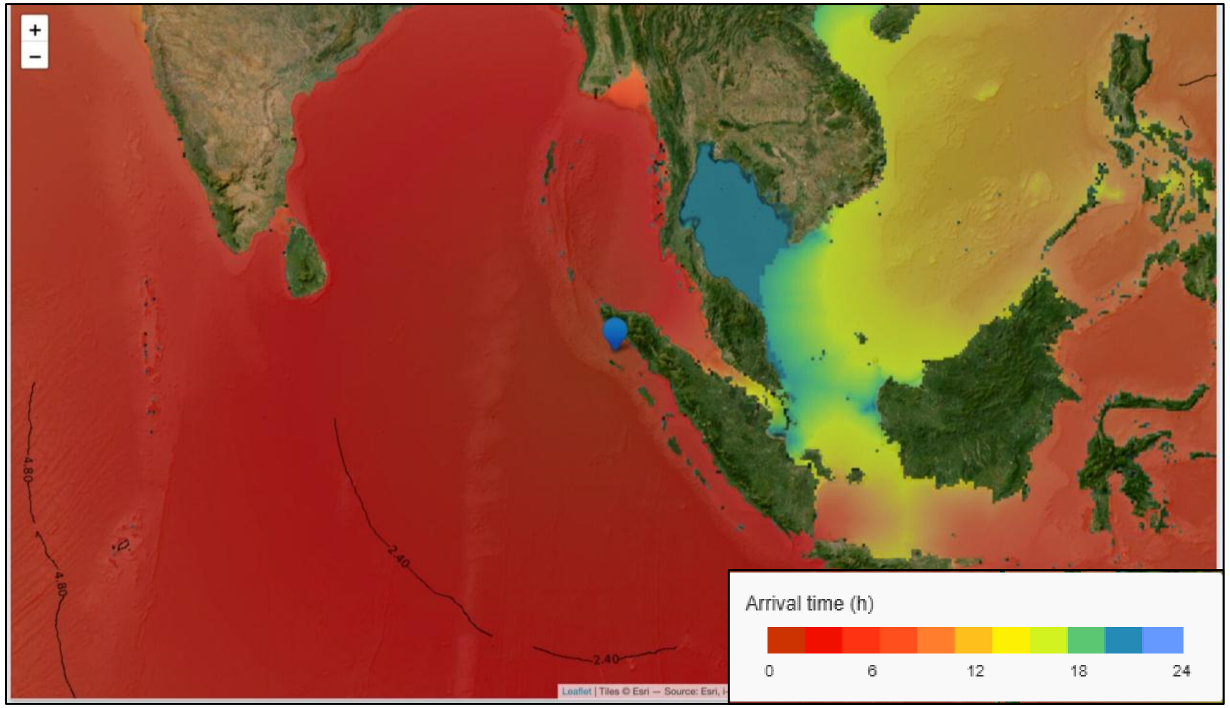
Lon 95.982° Lat 3.295°
Date 26-12-2004 01:58

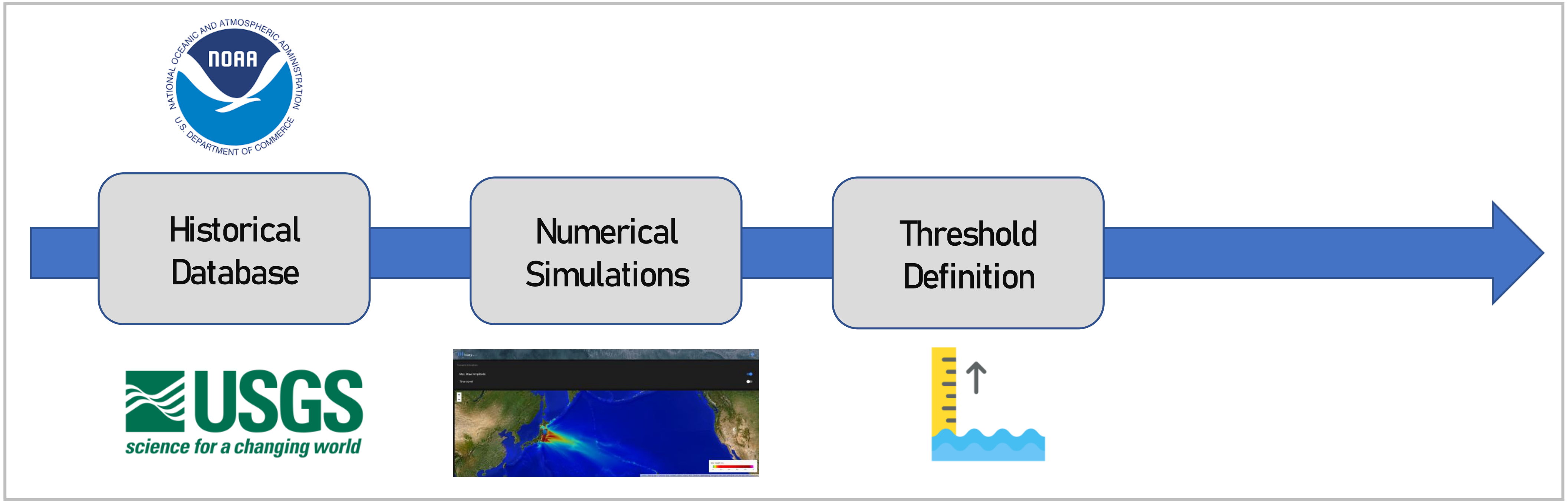
Magnitude (M_w): 9.1
Focal Depth: 30 km depth

Maximum Wave Height (m)



Arrival Time (h)

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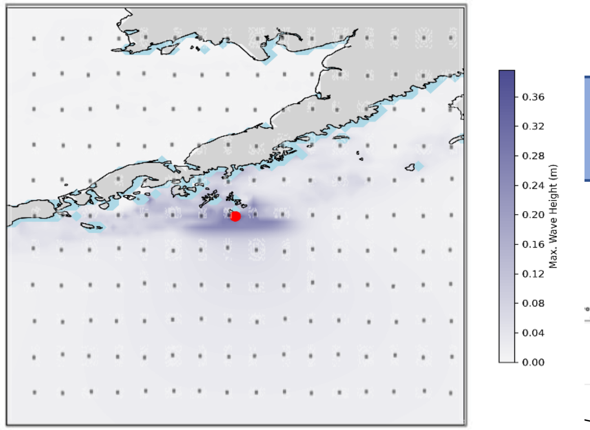
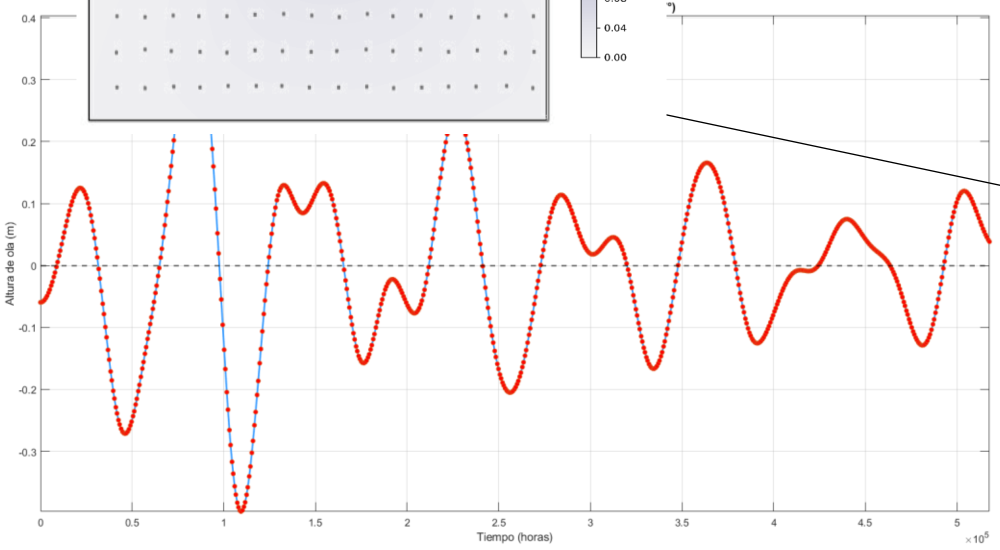
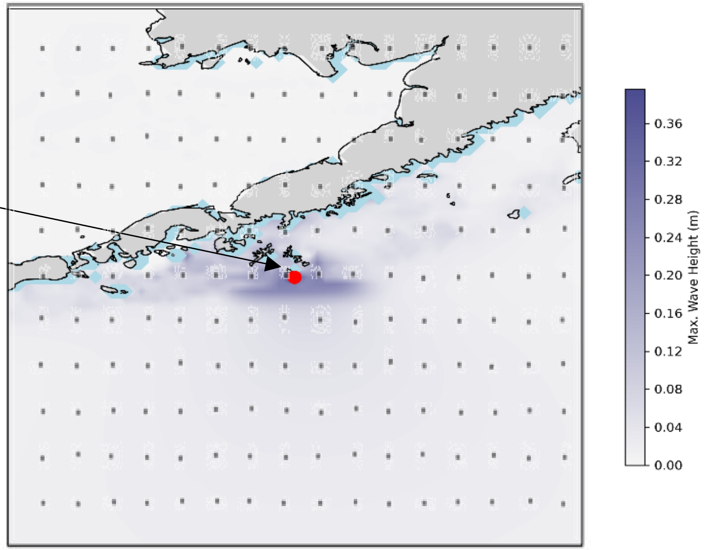
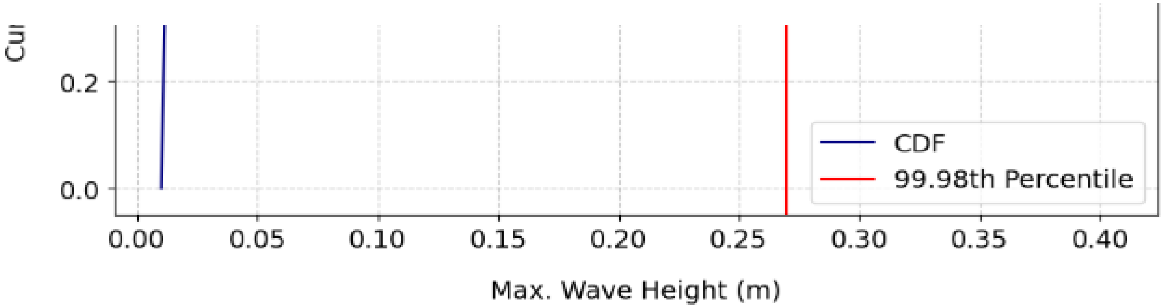






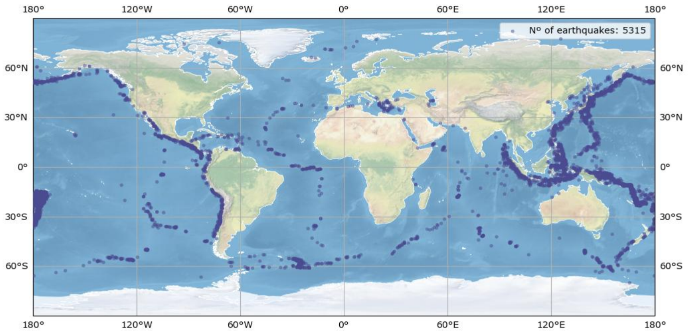


	lue (m)
	0.404
	0.344
	0.299
$H_{max(4)}$	0.274
$H_{max(5)}$	0.271
$H_{max(6)}$	0.270

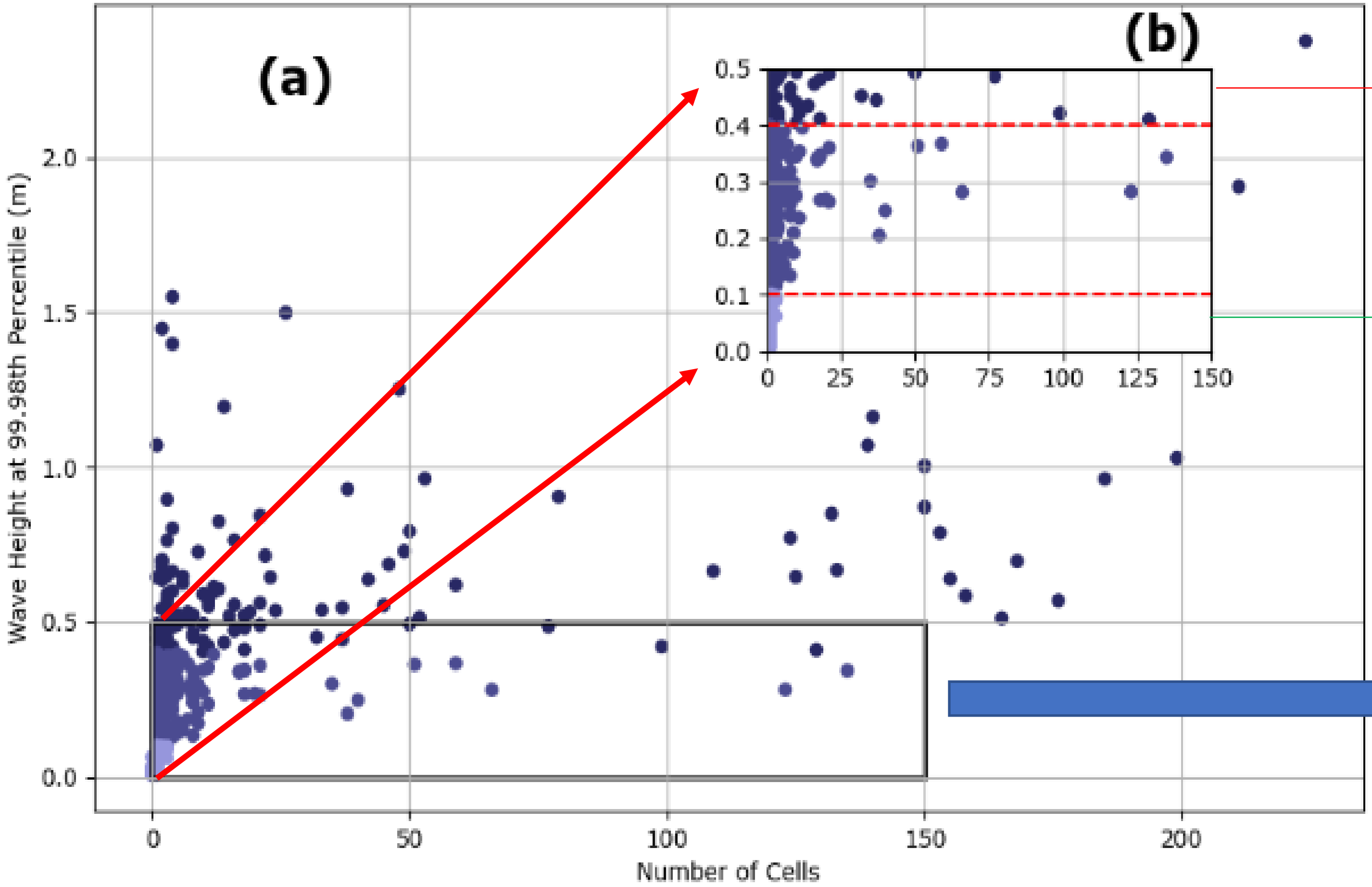
Maximum wave height (m)

Why?

Introduction | Methodology-Results | Output | Key Insights



Classification threshold



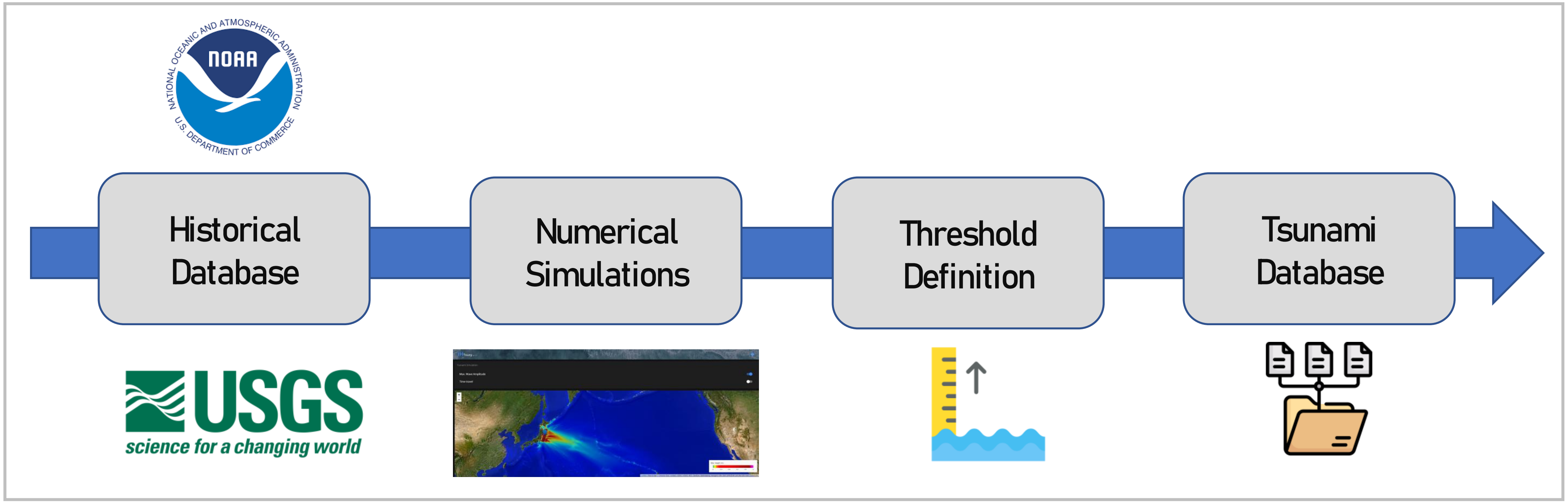
TSUNAMI

NO TSUNAMI

0.15 m

Median

Threshold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Tsunami Database

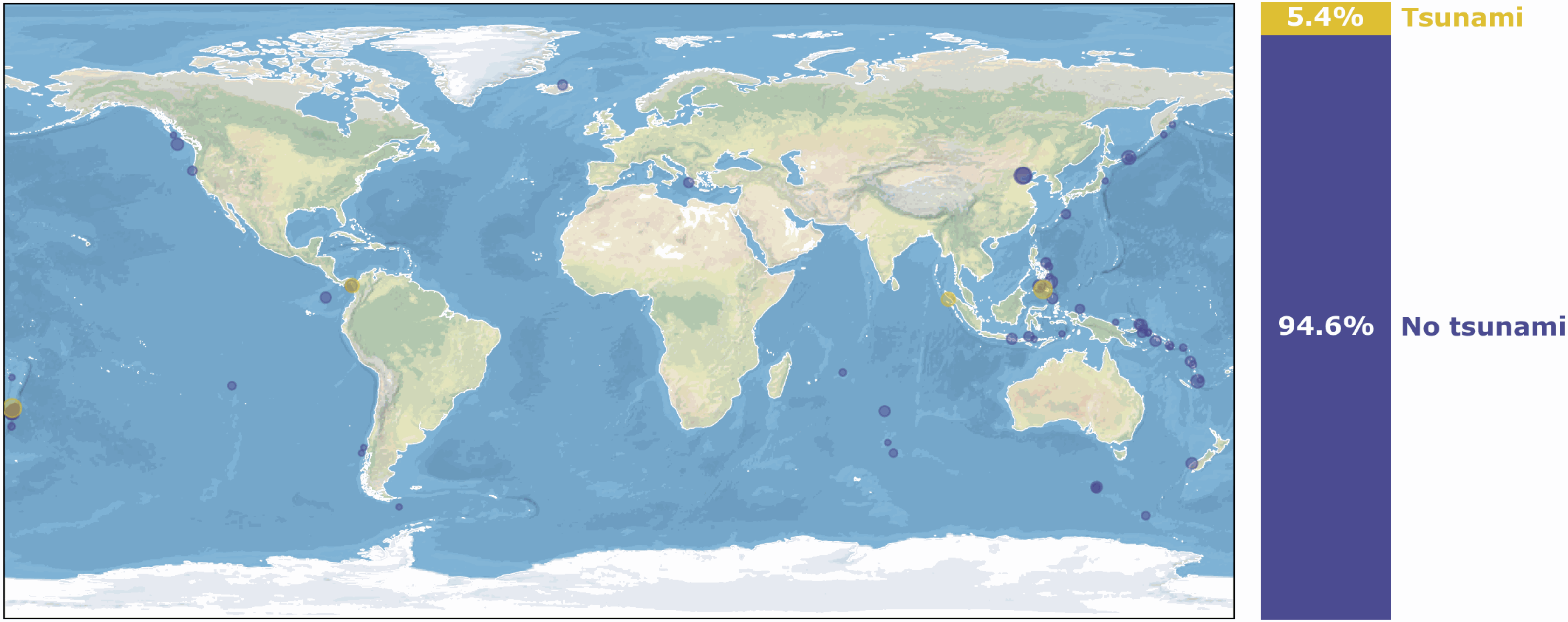
Introduction

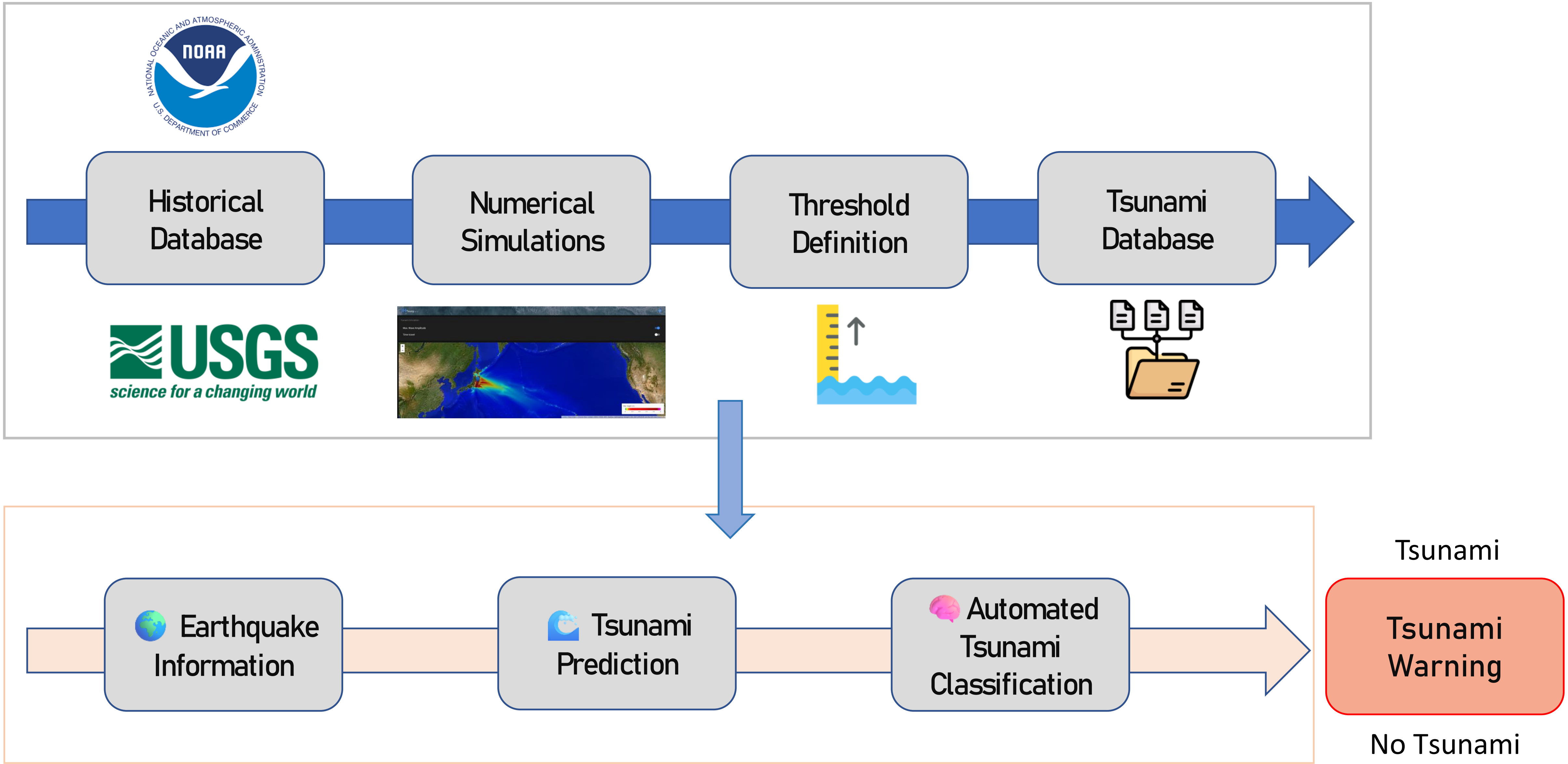
Methodology-Results

Output

Key Insights

Earthquakes up to Year 1976 (N=74)

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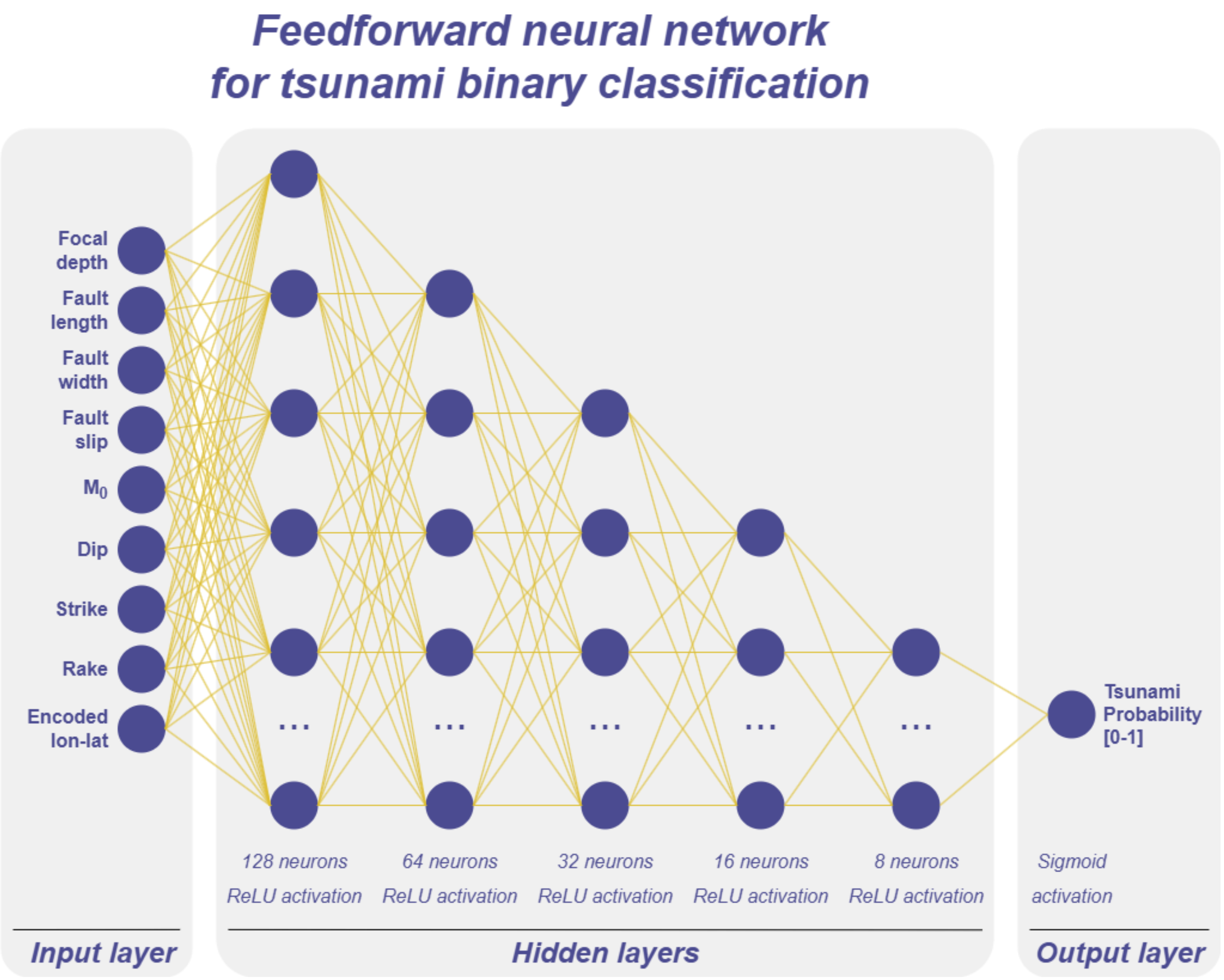
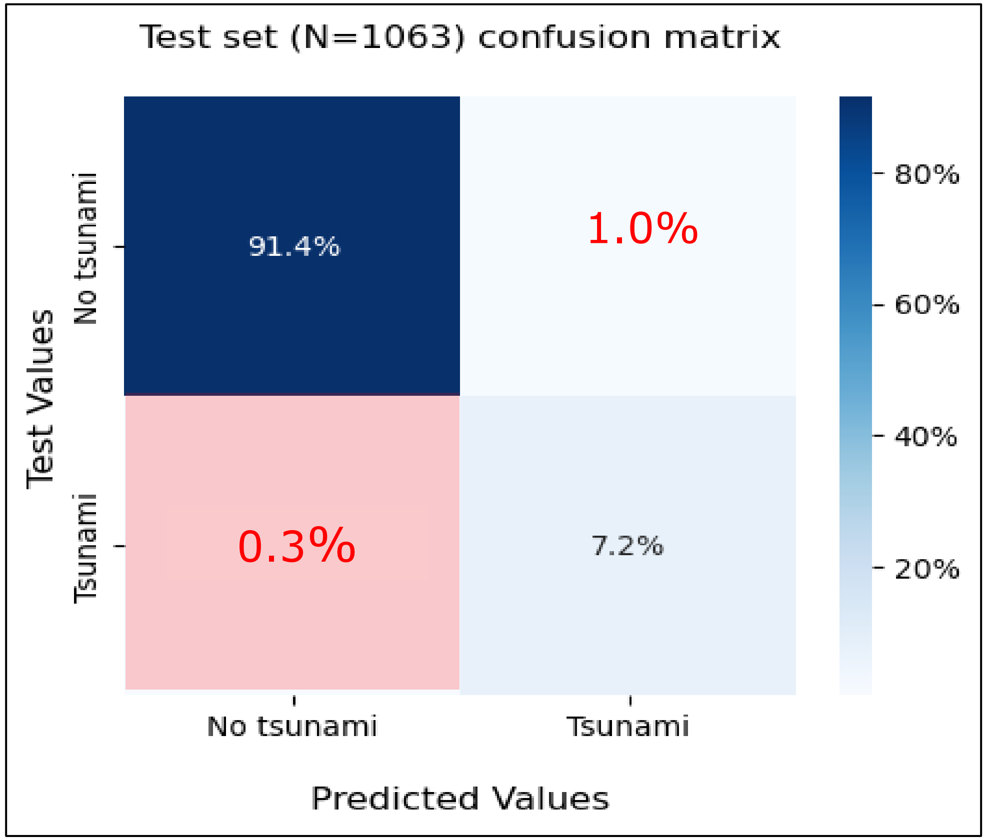
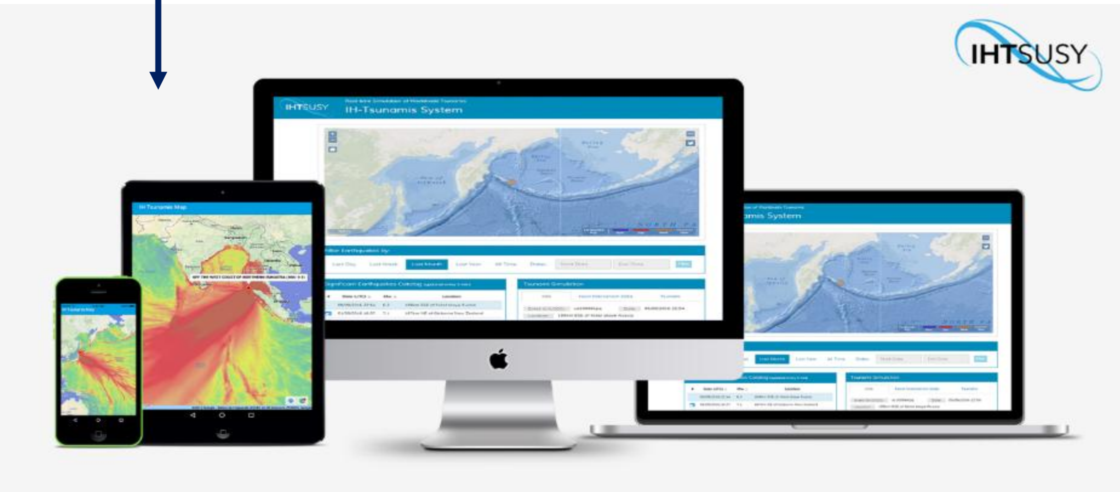
No Tsunami

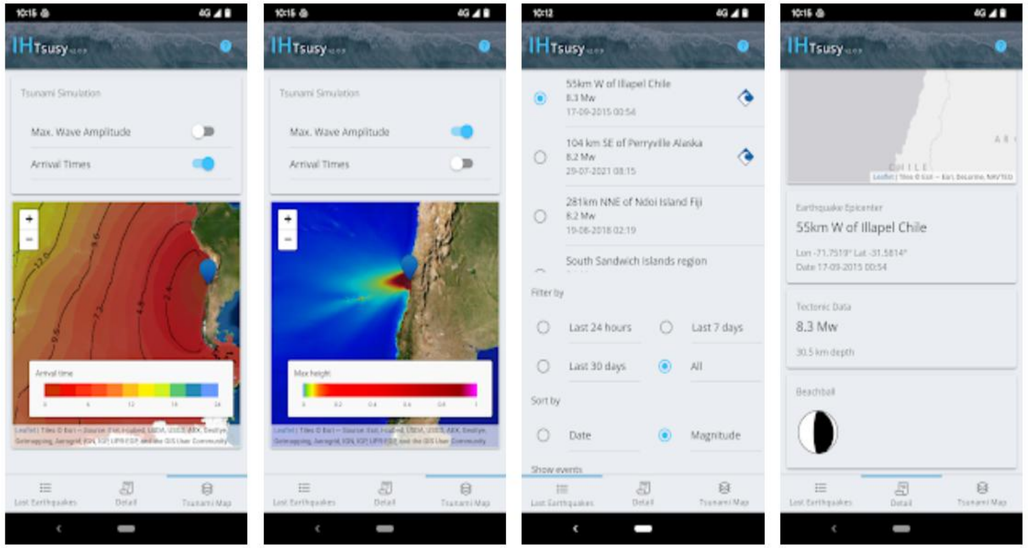
AI training model





IH-Tsunamis System (IH-Tsusy)





Tsunami Propagation Simulation (WEB)
Historical Simulation Database

EPOS
EUROPEAN PLATE OBSERVING SYSTEM

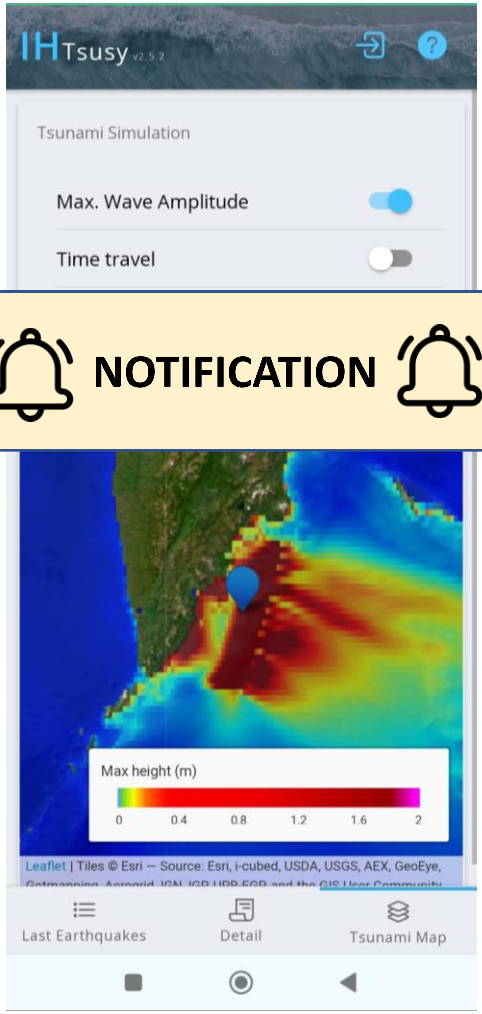
USGS science for a changing world

Earthquake information:
- 7:01
- Lon, lat
- 20 km
- $M_w = 7.6$

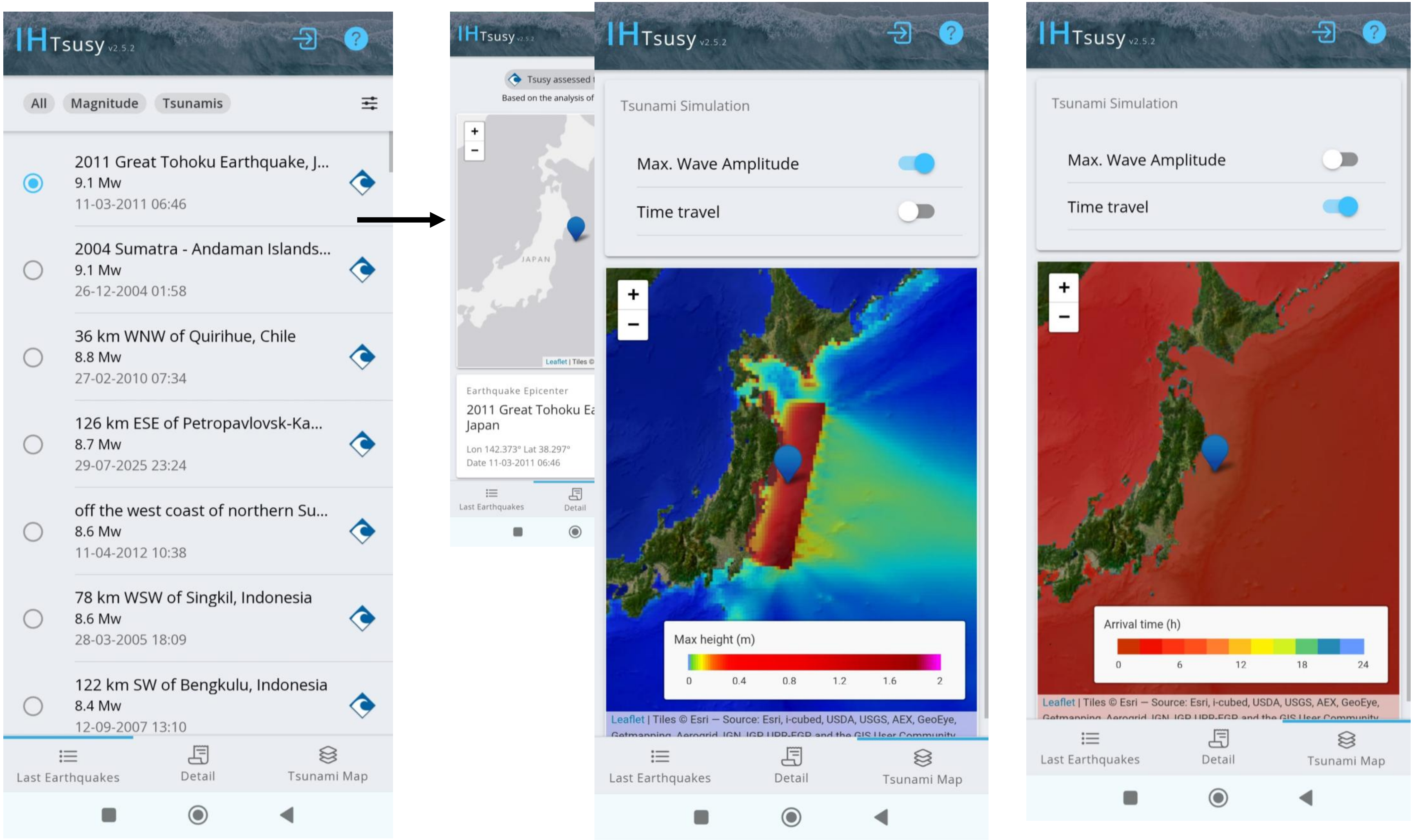
¿Will generate tsunami?

IHTSUSY

AI model trained with > 5000 events



NOTIFICATION


IHTsusy v2.5.2
All
Magnitude
Tsunamis
2011 Great Tohoku Earthquake, J...
9.1 Mw
11-03-2011 06:46
2004 Sumatra - Andaman Islands...
9.1 Mw
26-12-2004 01:58
36 km WNW of Quirihue, Chile
8.8 Mw
27-02-2010 07:34
126 km ESE of Petropavlovsk-Ka...
8.7 Mw
29-07-2025 23:24
off the west coast of northern Su...
8.6 Mw
11-04-2012 10:38
78 km WSW of Singkil, Indonesia
8.6 Mw
28-03-2005 18:09
122 km SW of Bengkulu, Indonesia
8.4 Mw
12-09-2007 13:10
Last Earthquakes
Detail
Tsunami Map
Earthquake Epicenter
2011 Great Tohoku Ea
Japan
Lon 142.373° Lat 38.297°
Date 11-03-2011 06:46
Tsunami Simulation
Max. Wave Amplitude
Time travel
Max height (m)
0
0.4
0.8
1.2
1.6
2
Arrival time (h)
0
6
12
18
24
Leaflet | Tiles © Esri — Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye,

A new tool has been developed based on historical events and numerical simulations that allows reducing FP and FN

- 🌍 TSUSY Database → >5,000 historical earthquake scenarios simulated with Tsunami-HySEA.
- 📊 Objective threshold → 0.15 m separates tsunamis from non-tsunamis.
- ⚖️ Reduces uncertainty → fewer false alarms (false positives) and missed events (false negatives).
- 🚀 Future application → labelled database ready to train AI models for automatic tsunami prediction at TWC.

THANK YOU FOR YOUR ATTENTION!

NTWC

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