Comparison of Modeling Approaches and Derived Warning Products in the Framework of the Indonesia Tsunami Early Warning System (InaTEWS)

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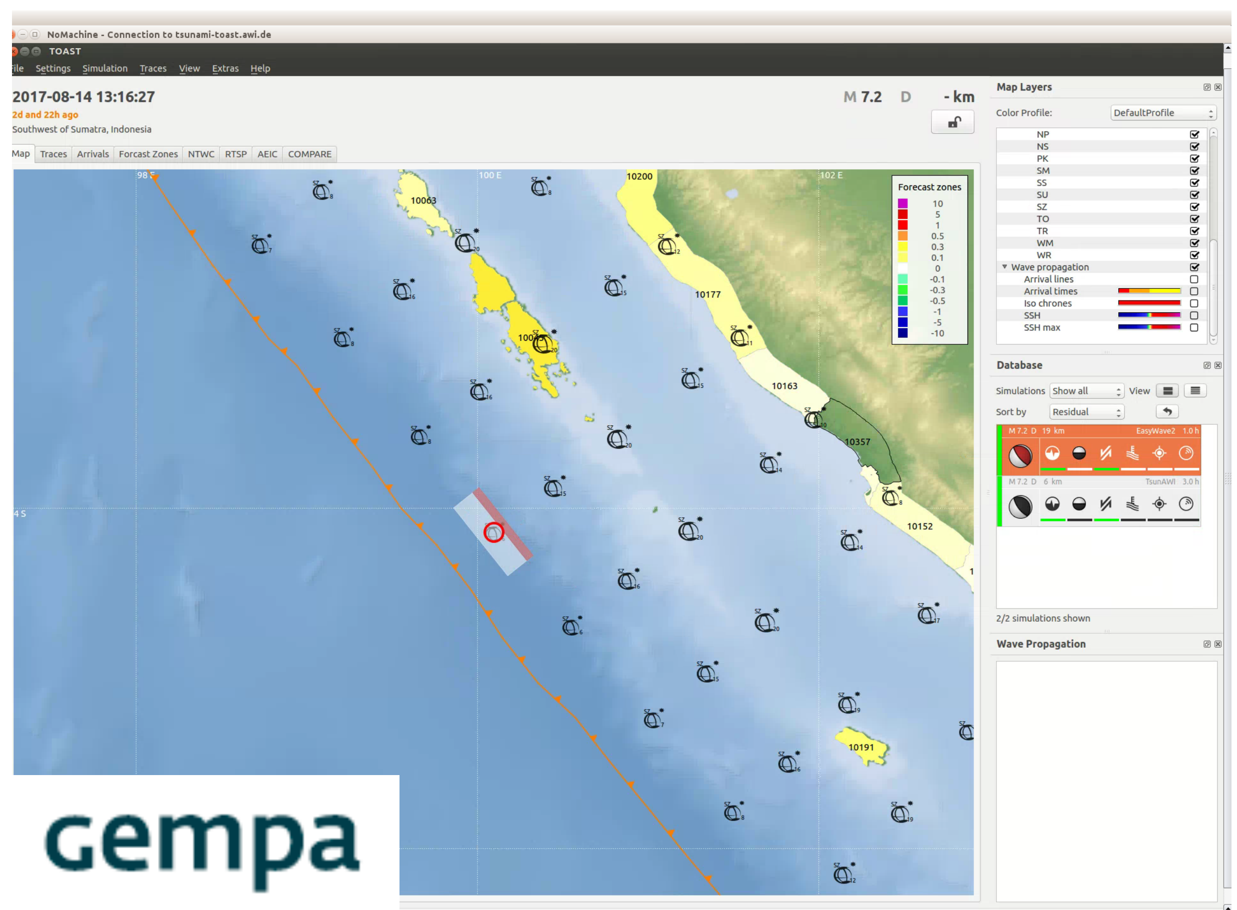
Motivation for the study

- Tsunami Early Warning Systems determine and disseminate **warning products** like
  - Estimated wave height (EWH)
  - Estimated arrival time (ETA)
- These informations are obtained by **numerical simulations** and may lead to severe implications like evacuations of the potentially affected population
- Thus the quality of these products is of crucial importance

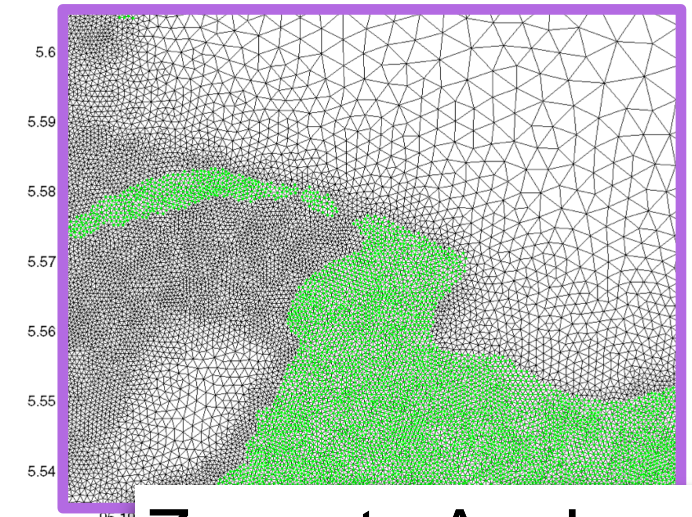
in coastal areas over a large range



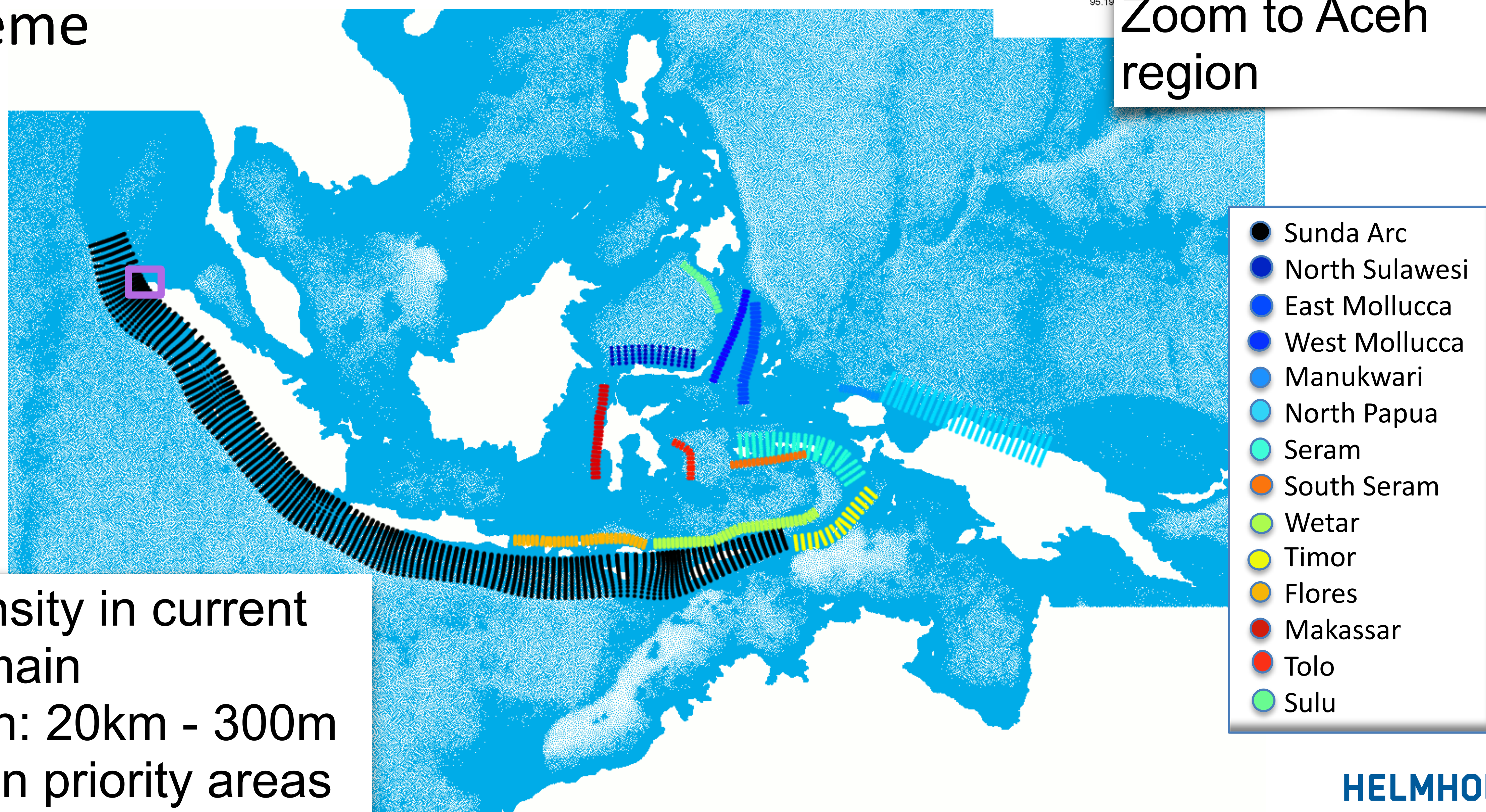
Modelling approaches in InaTEWS

InaTEWS contains

- Database of precomputed **high resolution** tsunami scenarios (**TsunAWI**) including an inundation scheme



Zoom to Aceh region



Nodal density in current mesh domain
Resolution: 20km - 300m and 50m in priority areas

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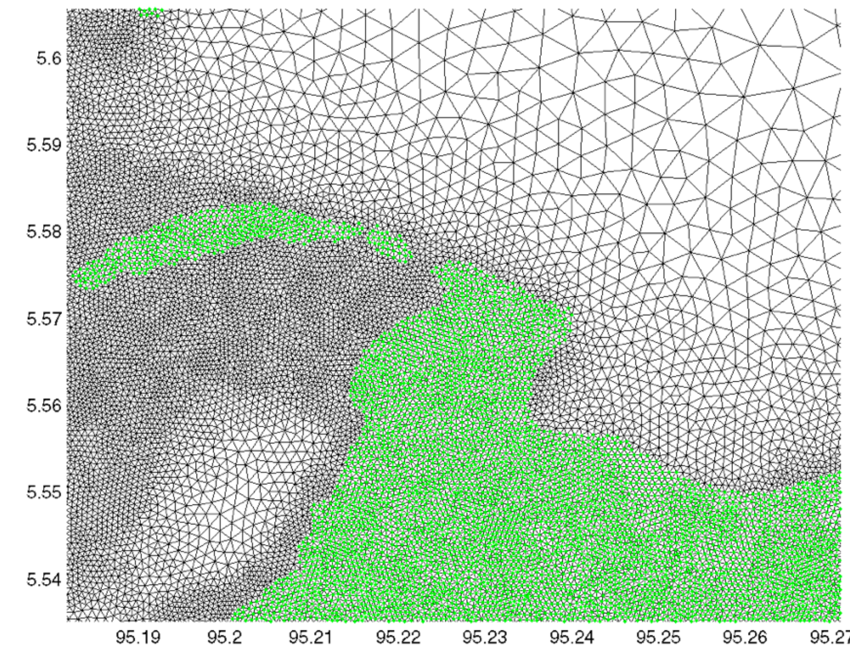
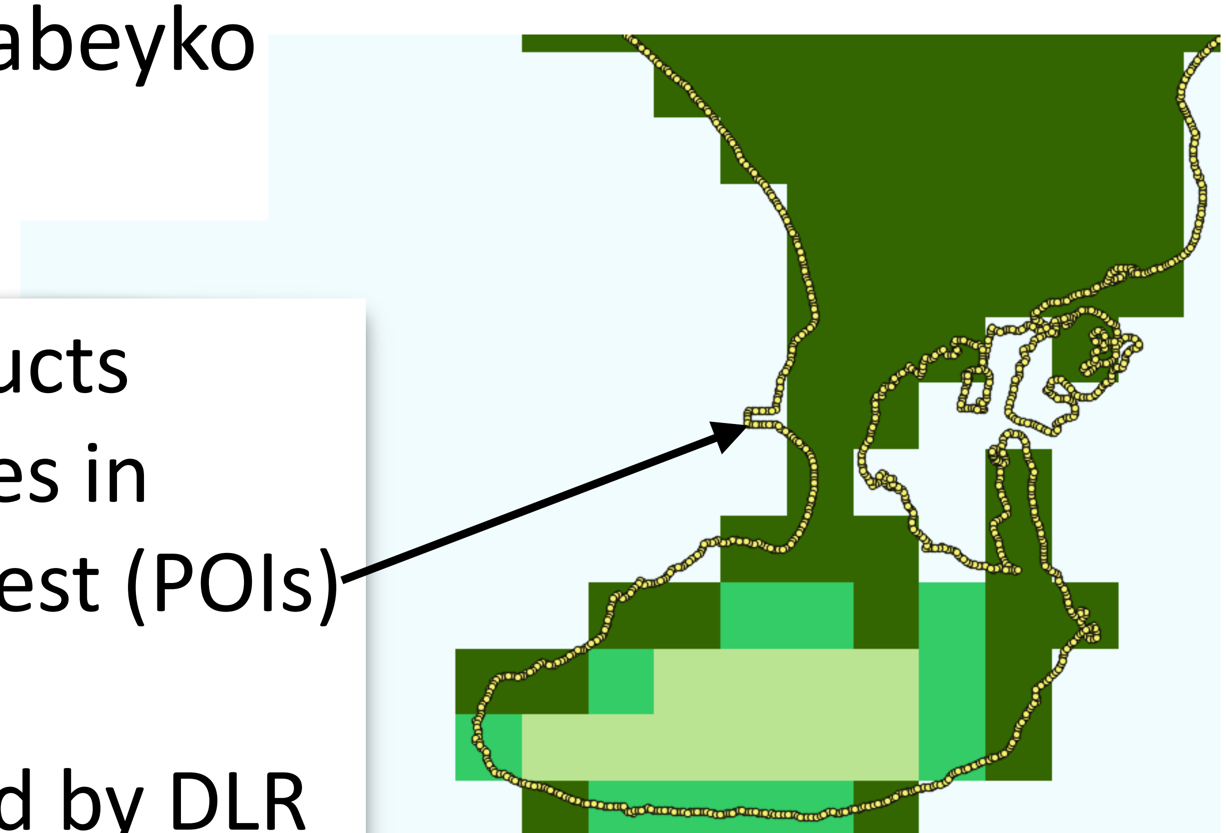
Modelling approaches in InaTEWS

InaTEWS contains

- Database of precomputed **high resolution** tsunami scenarios (**TsunAWI**) including an inundation scheme
- **On-the-fly** modelling component (**easyWave**) developed by A. Babeyko (GFZ) with coarser resolution

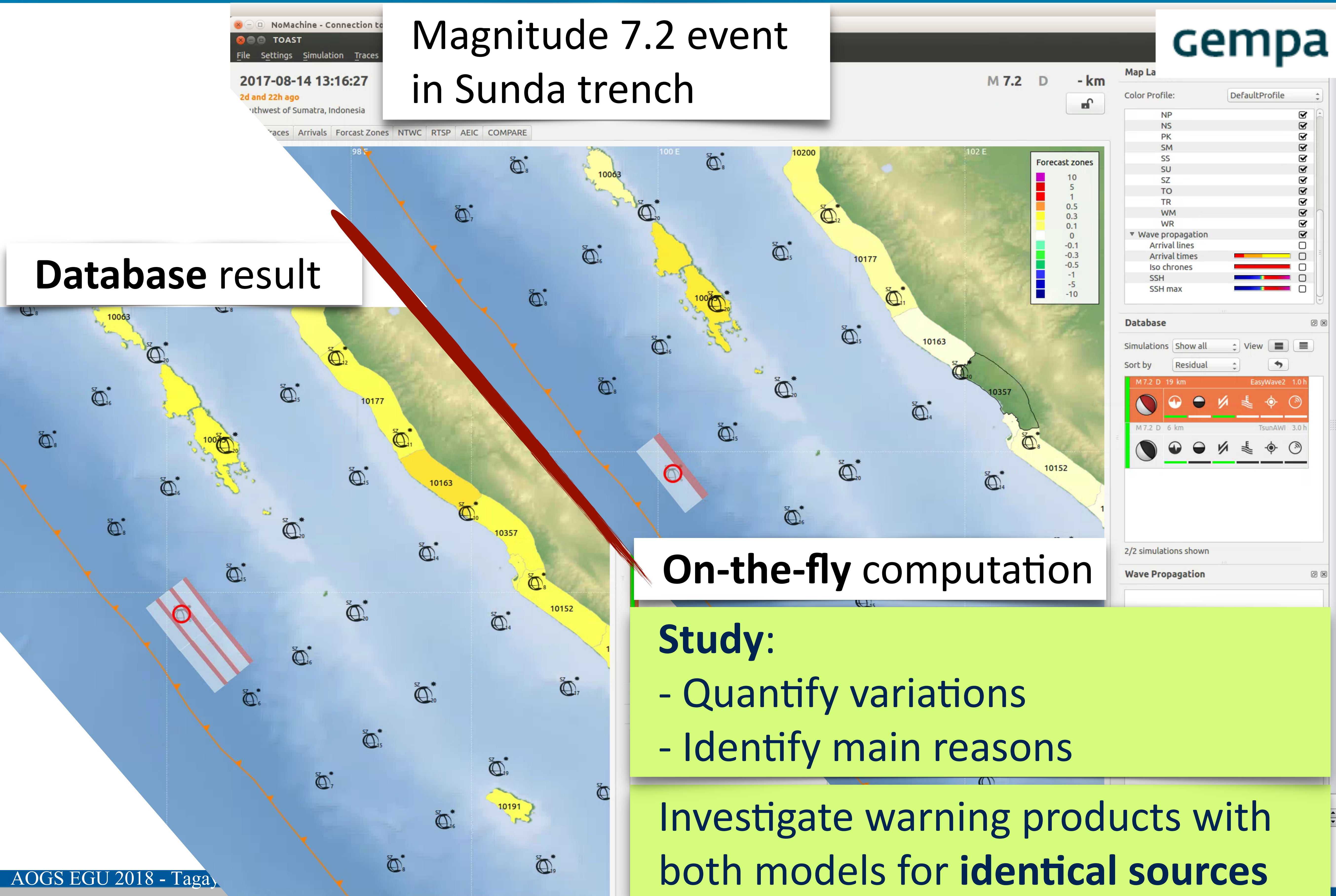




Warning products based on values in points of interest (POIs)

Full set defined by DLR

TOAST Snapshots



Magnitude 7.2 event in Sunda trench

Database result

On-the-fly computation

Study:

- Quantify variations
- Identify main reasons

Investigate warning products with both models for **identical sources**

Sources for varying model results

- Model resolution
- **Topography**
  - easyWave: ETOPO or GEBCO
  - TsunAWI: GEBCO augmented by additional datasets (tcarta, SRTM, some local measurements)
- **Governing equations**: Additional terms in TsunAWI
  - Advection
  - Viscosity
  - Bottom friction
  - Coriolis force

- small impact in deep ocean
- more important close to the coast

- Determination of warning products (Algorithm: direct calculation, projection)

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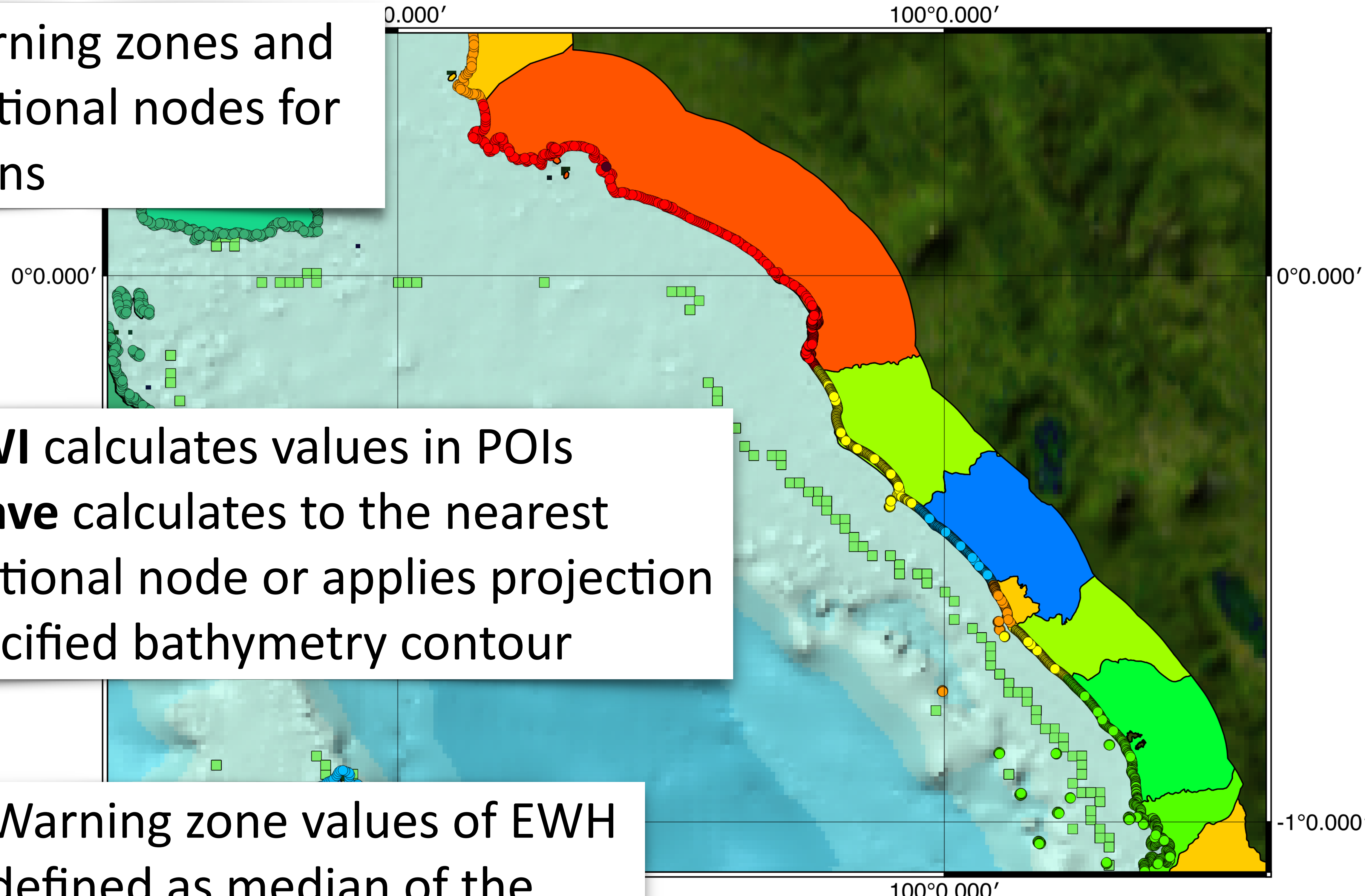
Warning zones and POIs

POIs, warning zones and computational nodes for projections



- **TsunAWI** calculates values in POIs
- **easyWave** calculates to the nearest computational node or applies projection from specified bathymetry contour

Warning zone values of EWH defined as median of the corresponding POI values

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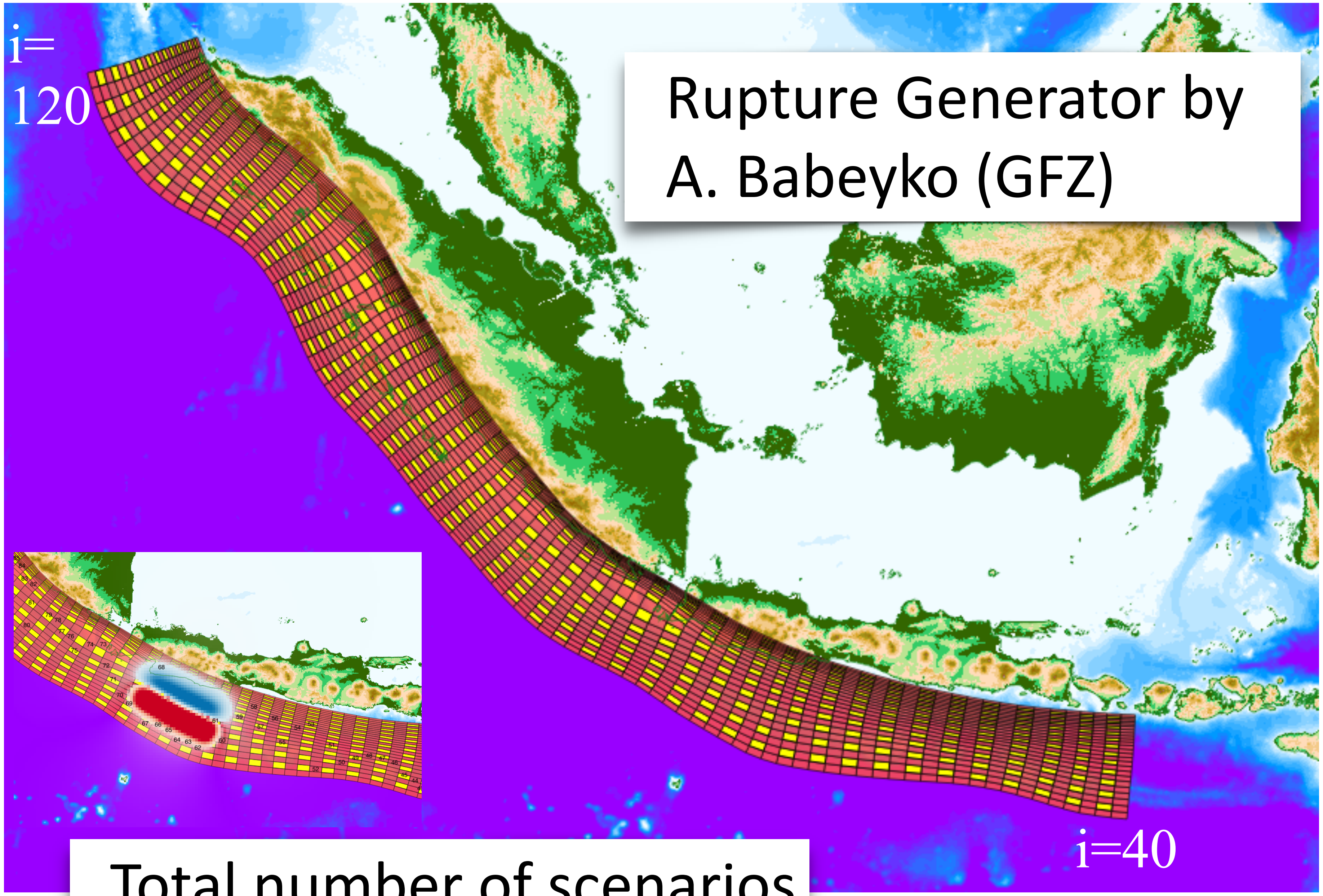
Overview: Scenarios in the study

Magnitude	Total No.
7.0	497
7.2	495
7.4	486
7.6	454
7.8	412
8.0	273
8.2	326
8.4	271
8.6	214
8.8	142
9.0	66
Sum	3636

Central patches of the scenarios involved in the study



Rupture Generator by A. Babeyko (GFZ)

Total number of scenarios in the comparison: **3636**

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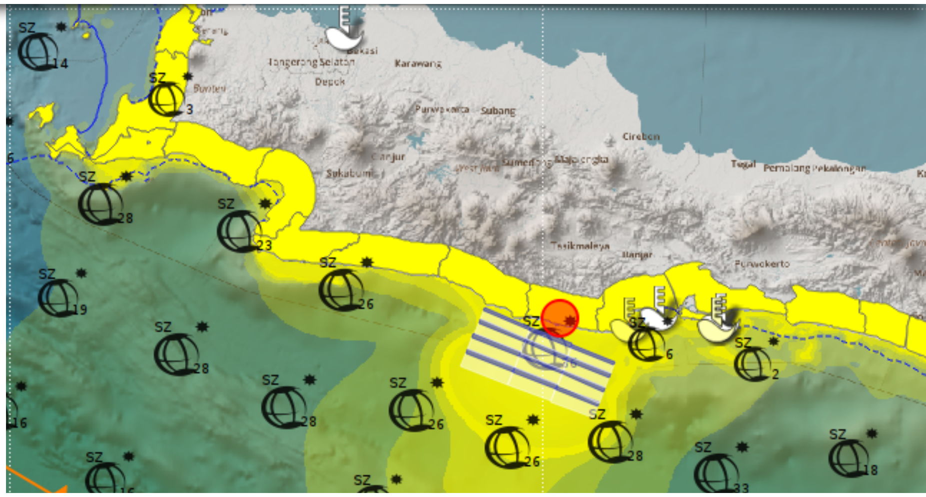
Warning level mismatches

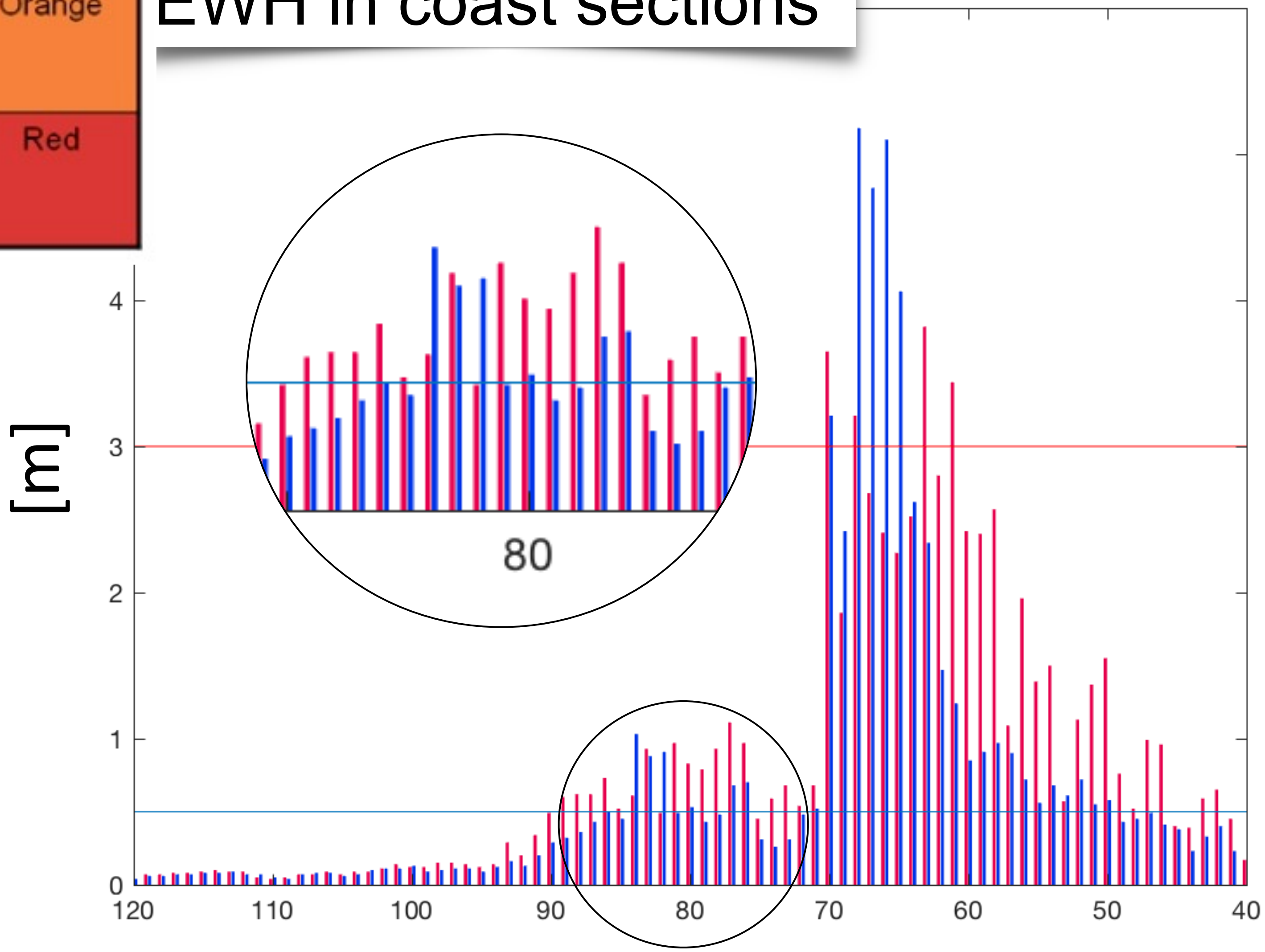
Both models are used to determine warning levels for identical sources

InaTEWS categories:

Tsunami Category	Warning Level	Wave Height (WH) Range [m]	Color
<none>	<none>	0,0 ≤ WH < 0,1 < 0.1m	Gray
Minor Tsunami	Advisory	0,1 ≤ WH < 0,5 < 0.5m	Yellow
Tsunami	Warning	0,5 ≤ WH < 3,0 < 3.0m	Orange
Major Tsunami	Major Warning	3,0 ≤ WH > 3.0m	Red



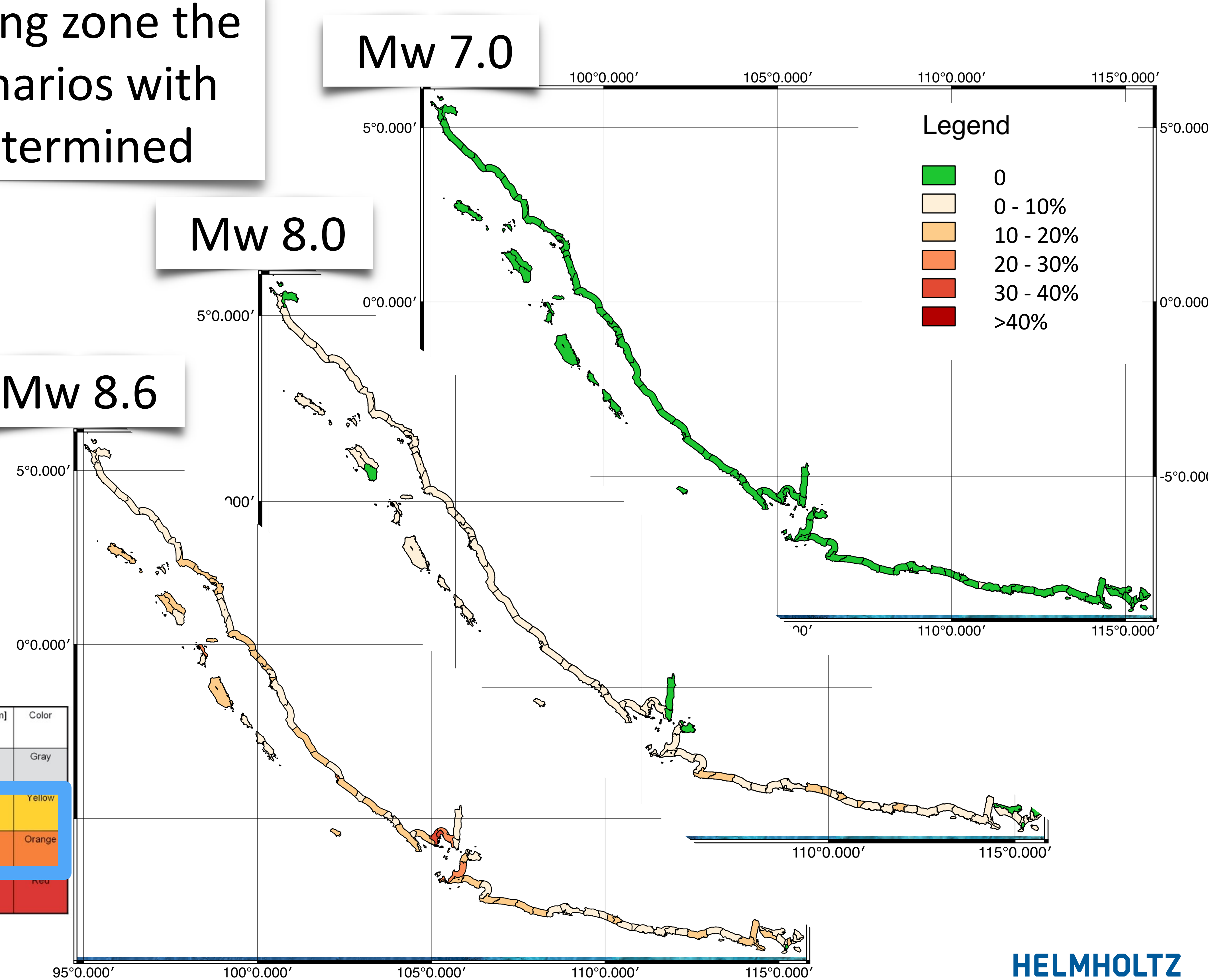
EWH in coast sections



Small variations of the EWH can lead to a mismatch of the warning level

Advisory - Warning mismatches

For each warning zone the fraction of scenarios with mismatch is determined



Tsunami Category	Warning Level	Wave Height (WH) Range [m]	Color
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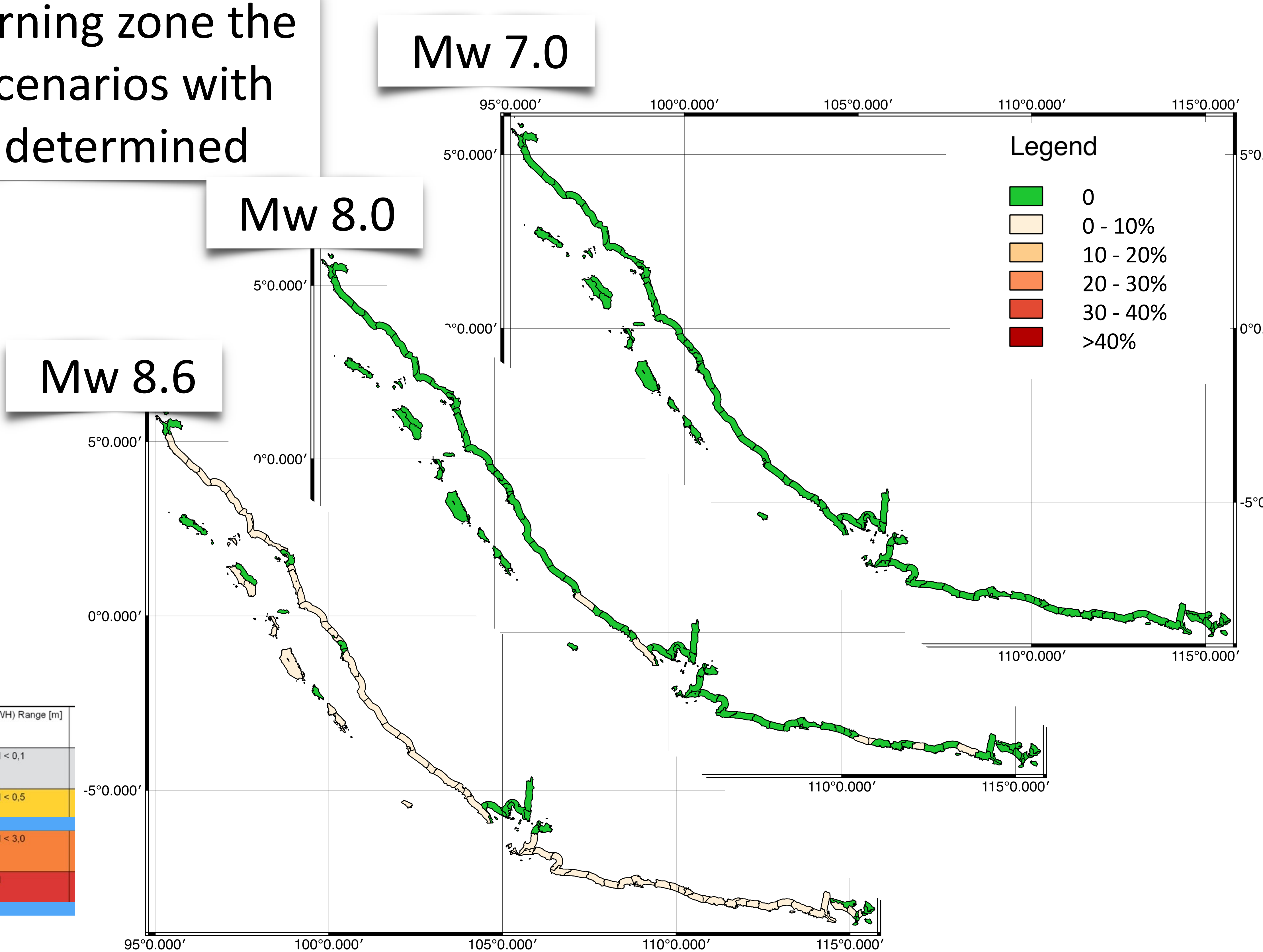
Warning - Major Warning mismatches

For each warning zone the fraction of scenarios with mismatch is determined



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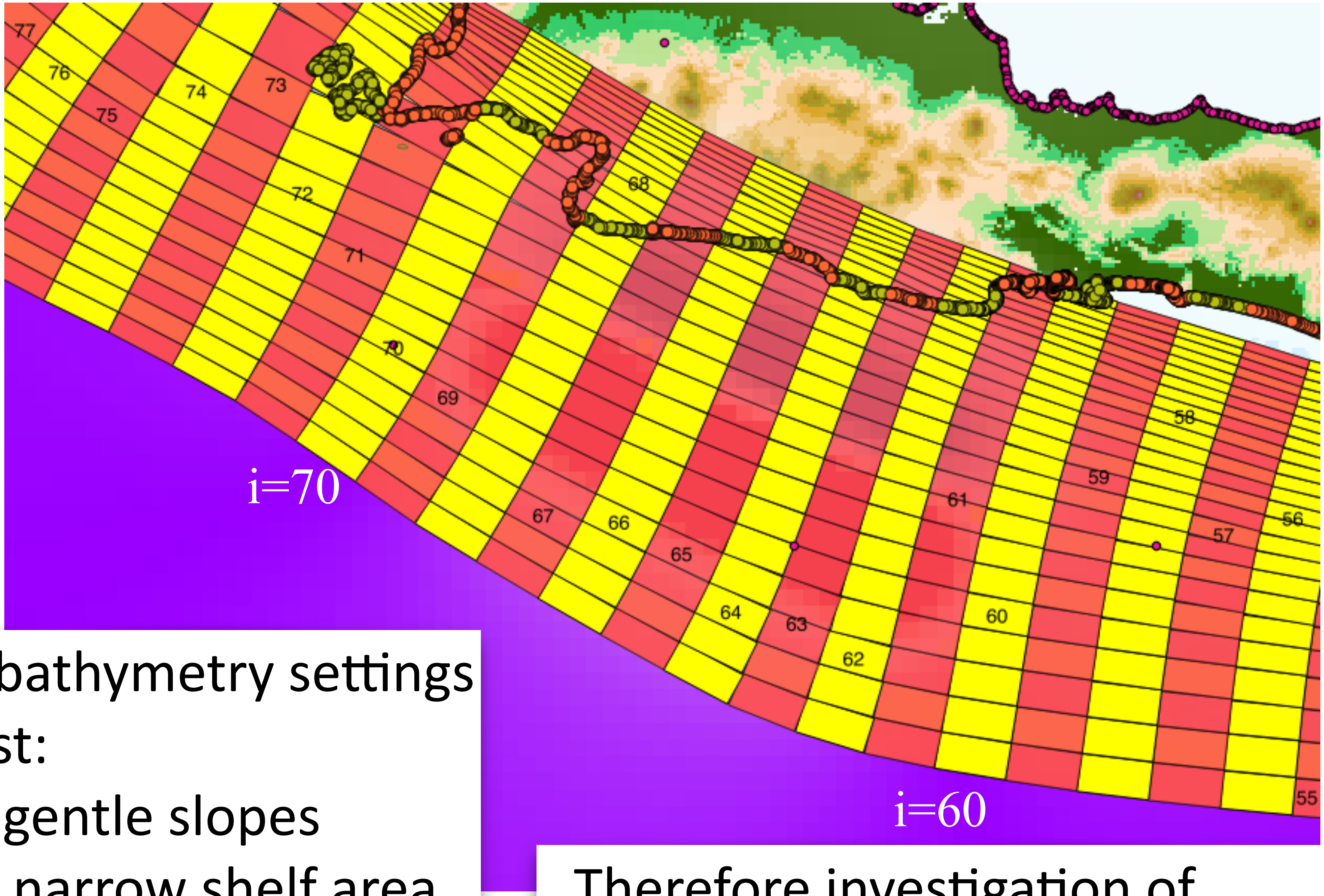
Detailed investigation of coast sections



Vast range of bathymetry settings along the coast:

- steep and gentle slopes
- broad and narrow shelf area
- …

Therefore investigation of wave propagation in **cross trench sections**

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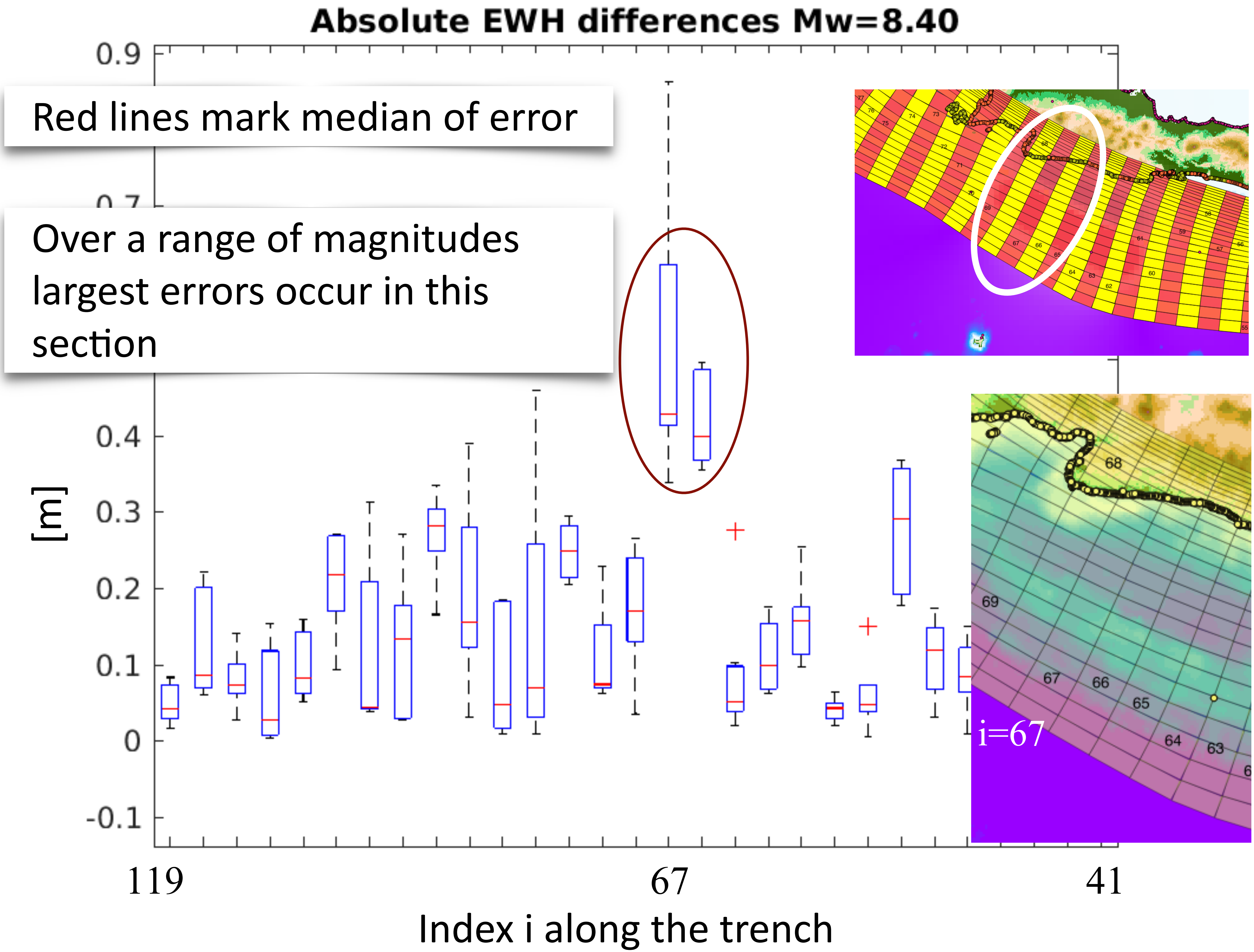
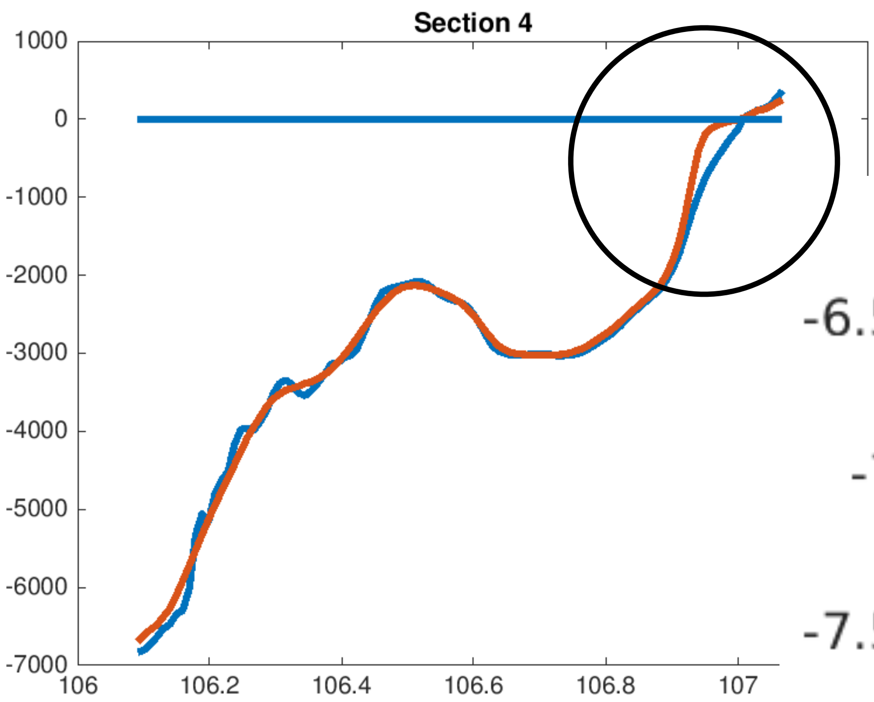
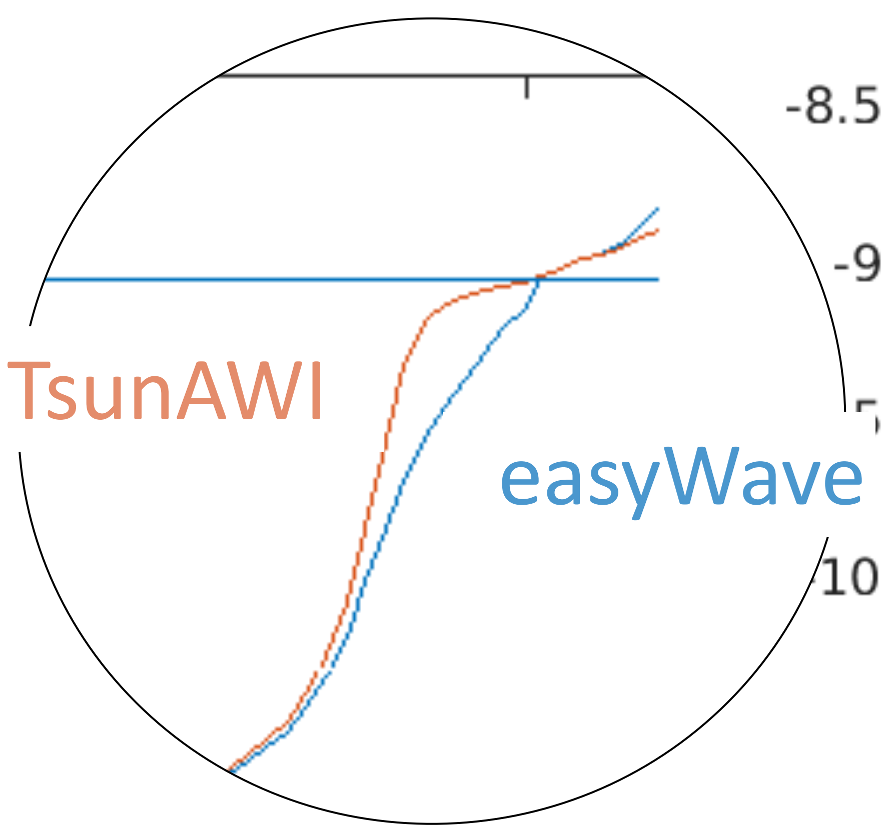
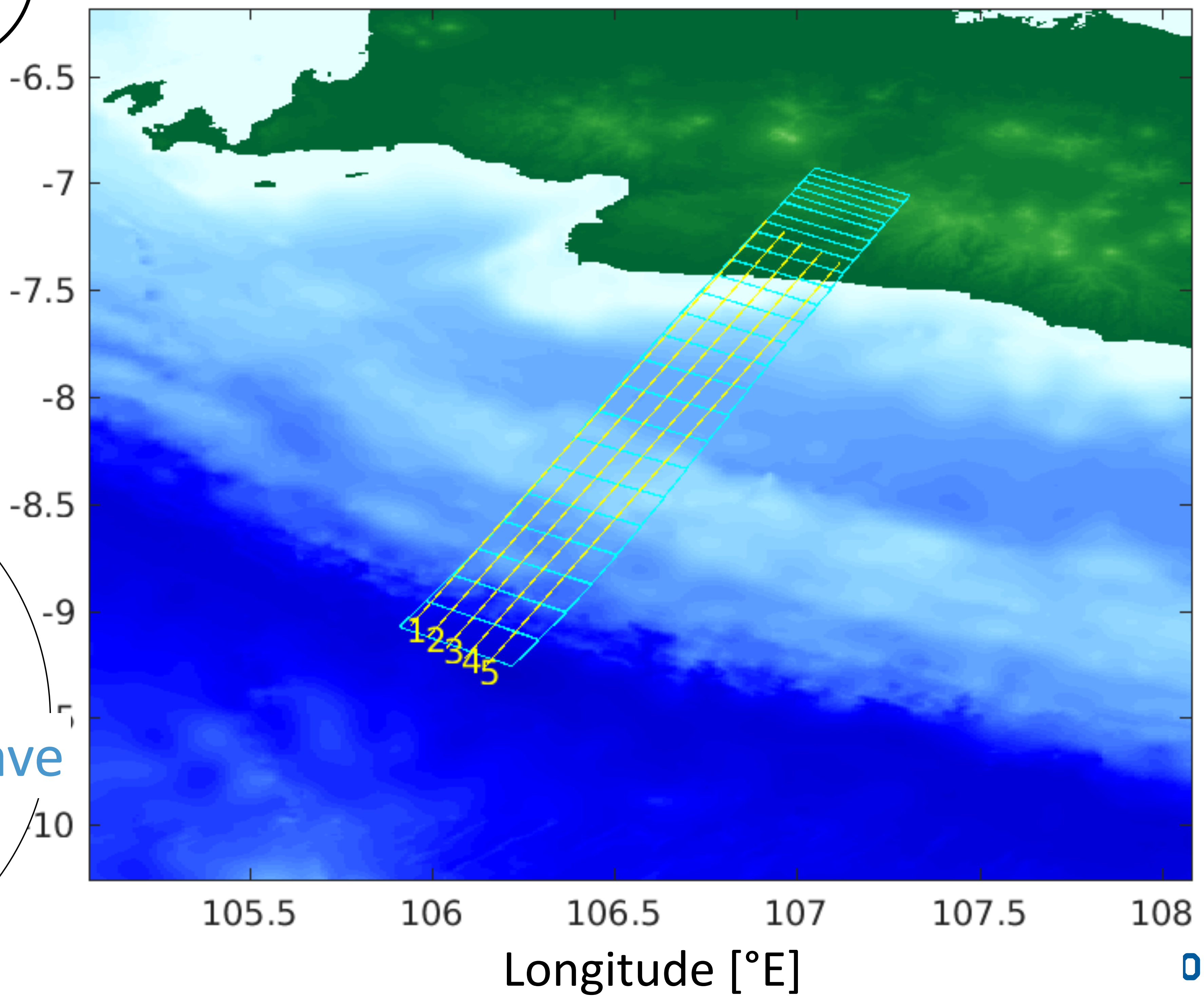


Absolute EWH differences Mw=8.40
Red lines mark median of error
Over a range of magnitudes largest errors occur in this section
[m]
0.9
0.7
0.4
0.3
0.2
0.1
0
-0.1
119
67
41
Index i along the trench
68
69
67
66
65
64
63
i=67

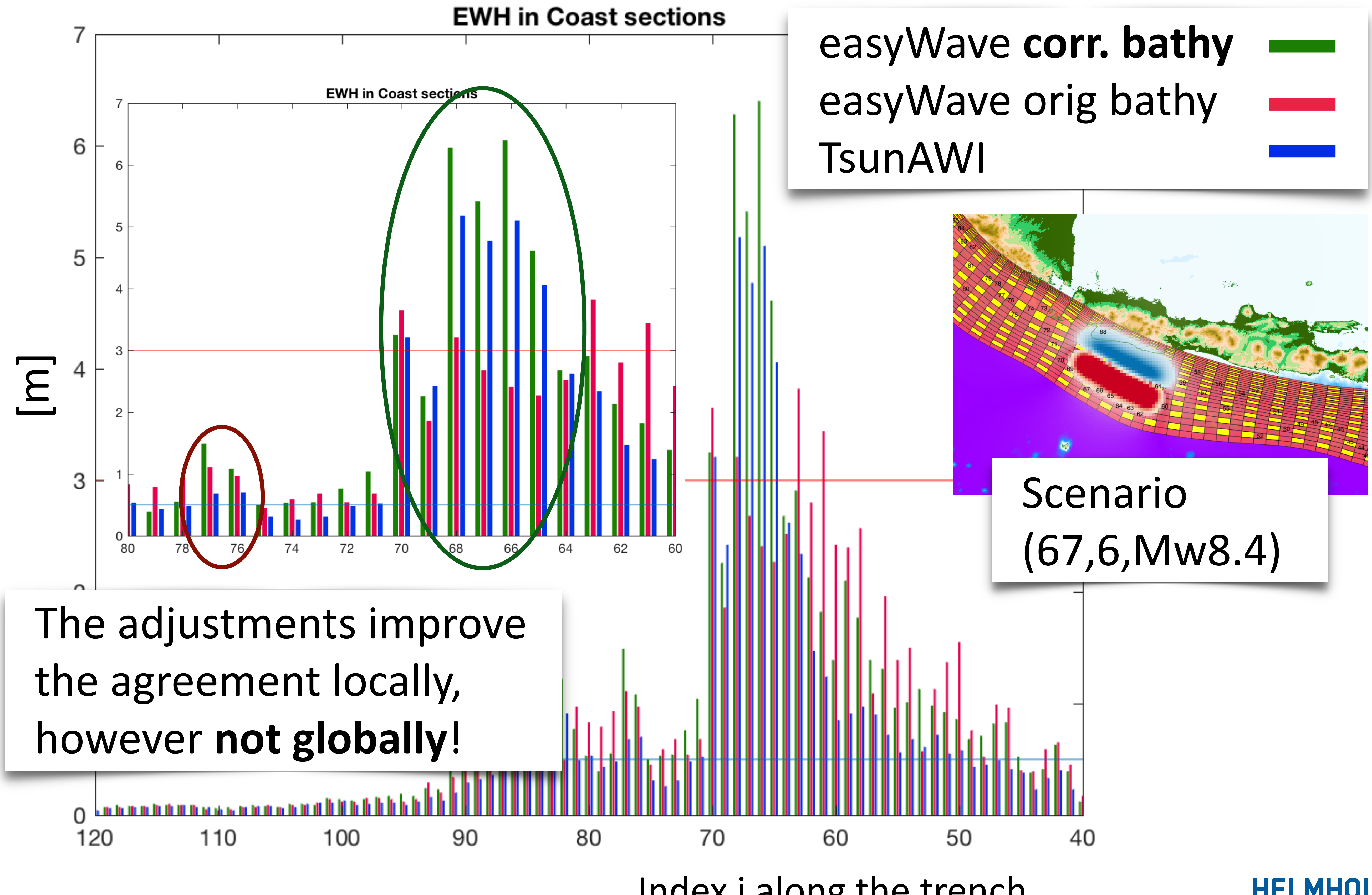
Bathymetry sections







Results **after bathymetry adjustment**



Scenario (67,6,Mw8.4)

The adjustments improve the agreement locally, however **not globally**!

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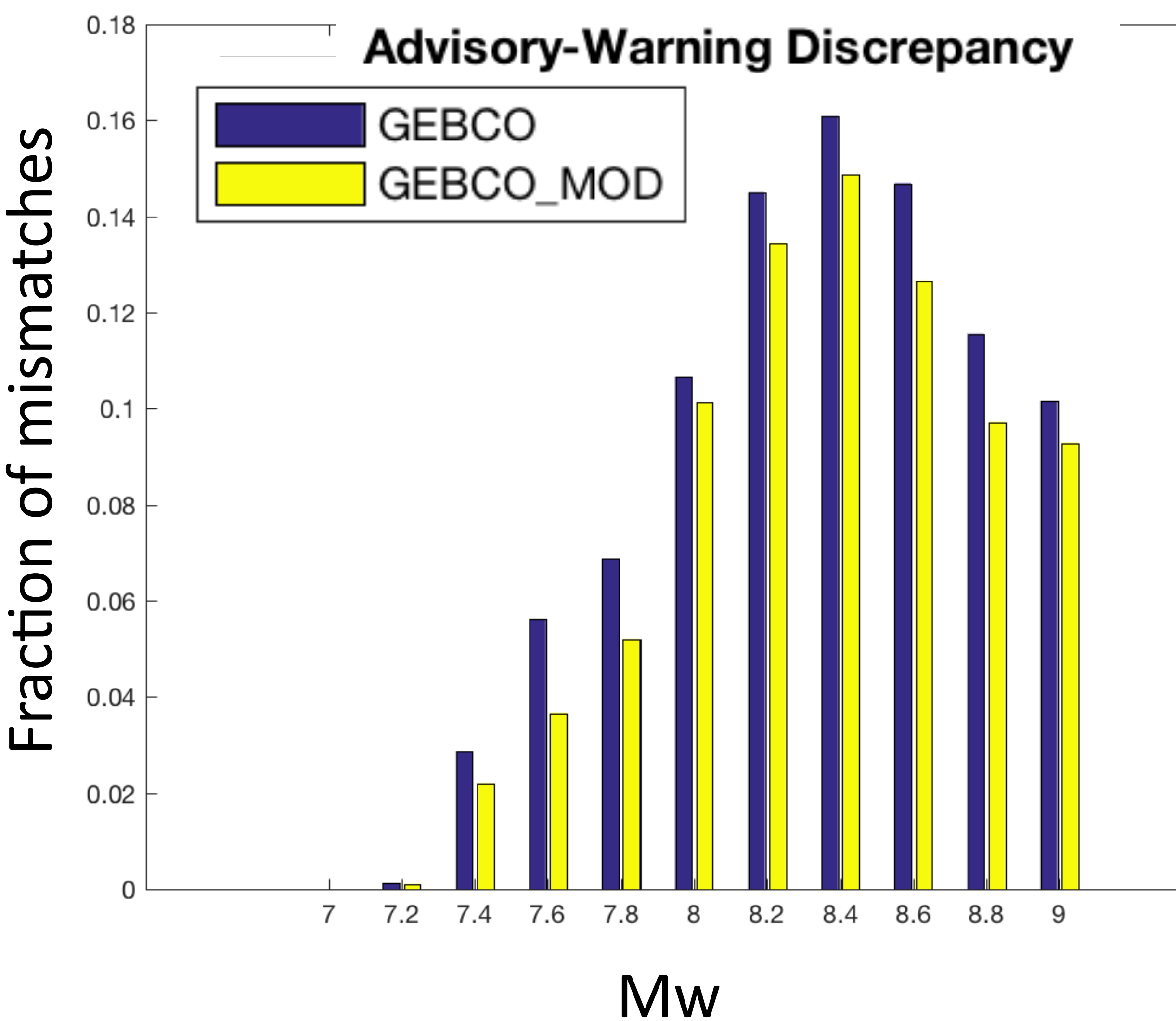
Correlation overview

		Original bathymetry	Corrected bathymetry
Mw 7.0	EWH correlation	0.8576	0.91898
	ETA correlation	0.9410	0.94768
Mw 8.0	EWH correlation	0.89876	0.95222
	ETA correlation	0.94236	0.95046
Mw 8.4	EWH correlation	0.87141	0.95171
	ETA correlation	0.91786	0.92824

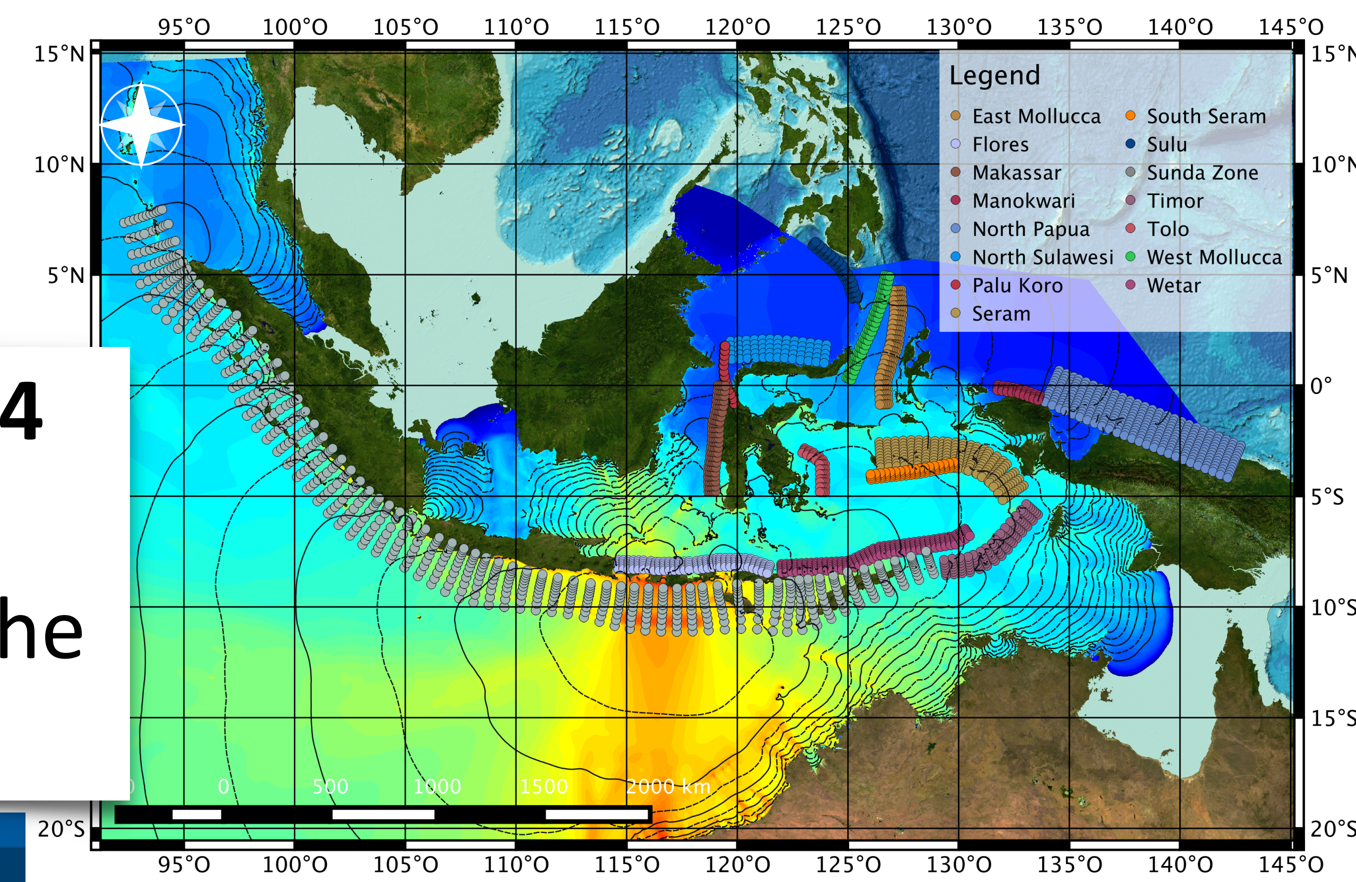
Nevertheless the overall state of the system is improved after topography adjustment:

- Total number of mismatches is reduced
- Correlation between EWH and ETA results of both models improved



Study ongoing - Conclusions so far

- Overall consistency of warning products, especially for low magnitudes very small discrepancies
- Improvements of the consistency in the system are possible
- Due to the vast range of the bathymetry settings implications of adjustments are diverse
- Absolute agreement is not achievable by definition, nevertheless studies like this may help to reduce variations to the minimum



In presentation **NH-A214** on Thursday by Antonia Immerz et al. more on the tsunami database