IMPROVING THE CO-SEISMIC SLIP DISTRIBUTIONS OF SYNTHETIC CATALOGS WITH REAL OBSERVATIONS

HAFIZE BASAK BAYRAKTAR[1,2], ANTONIO SCALA[1], GAETANO FESTA[1], STEFANO LORITO[2]

[1]*Department of Physics "Ettore Pancini", University of Naples, Naples, Italy*
[2]*Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Roma 1, Rome, Italy*

hafizebasak.bayraktar@unina.it

EGU 2020-SM2.5 D1642

MOTIVATION OF THE STUDY

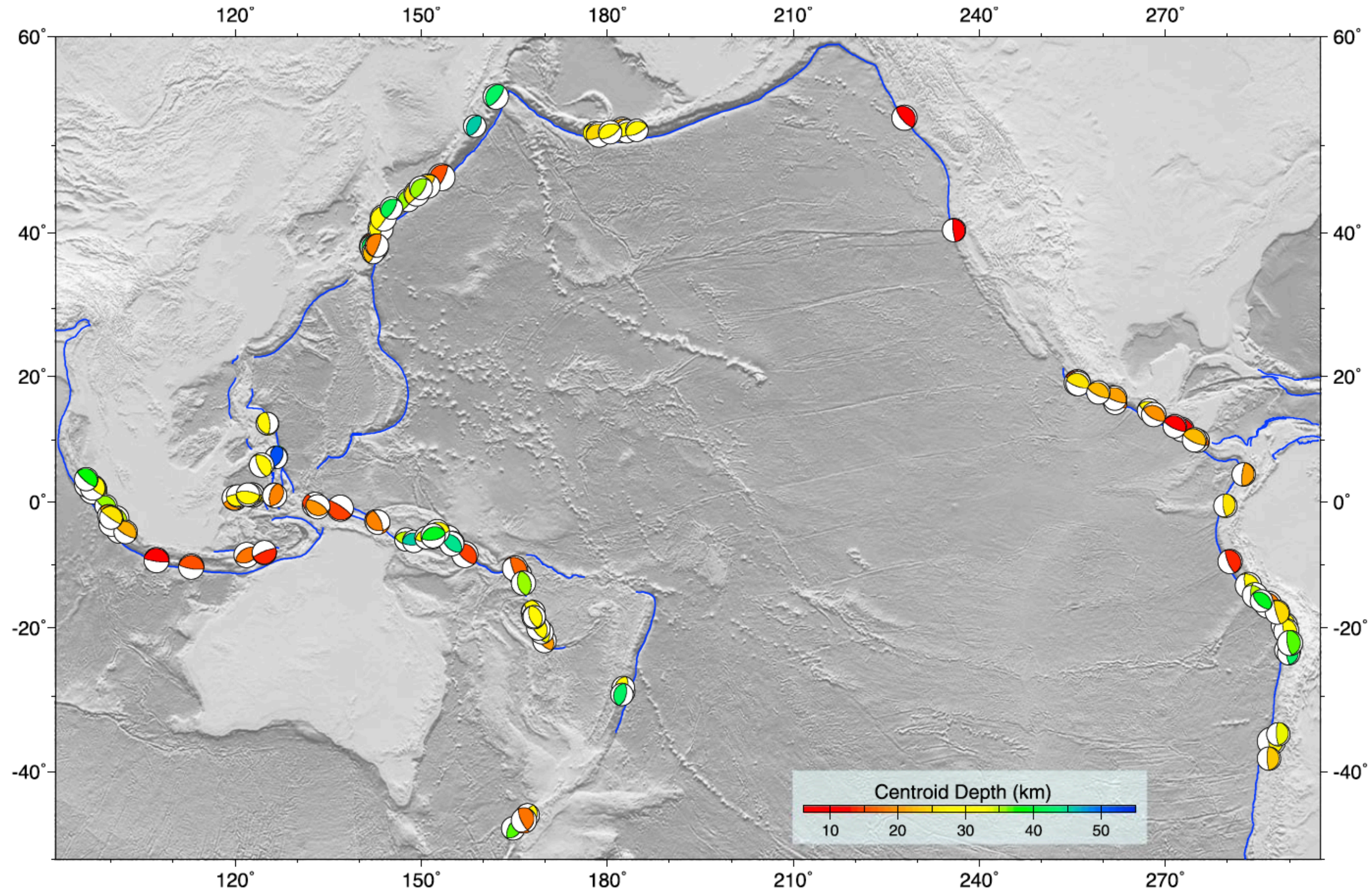


Figure 1: Epicenteral Locations of 114 earthquakes analyzed in Ye et al., 2016

Ye et al., 2016

- Subduction zones host about 90% of historical events, including the largest ones with the magnitude M>9.
- Some of these events were followed by devastating tsunamis with, in some cases, perhaps unexpected wave height distributions.
- Hence, subduction earthquakes are a main driver for tsunami hazard, with large associated uncertainty.

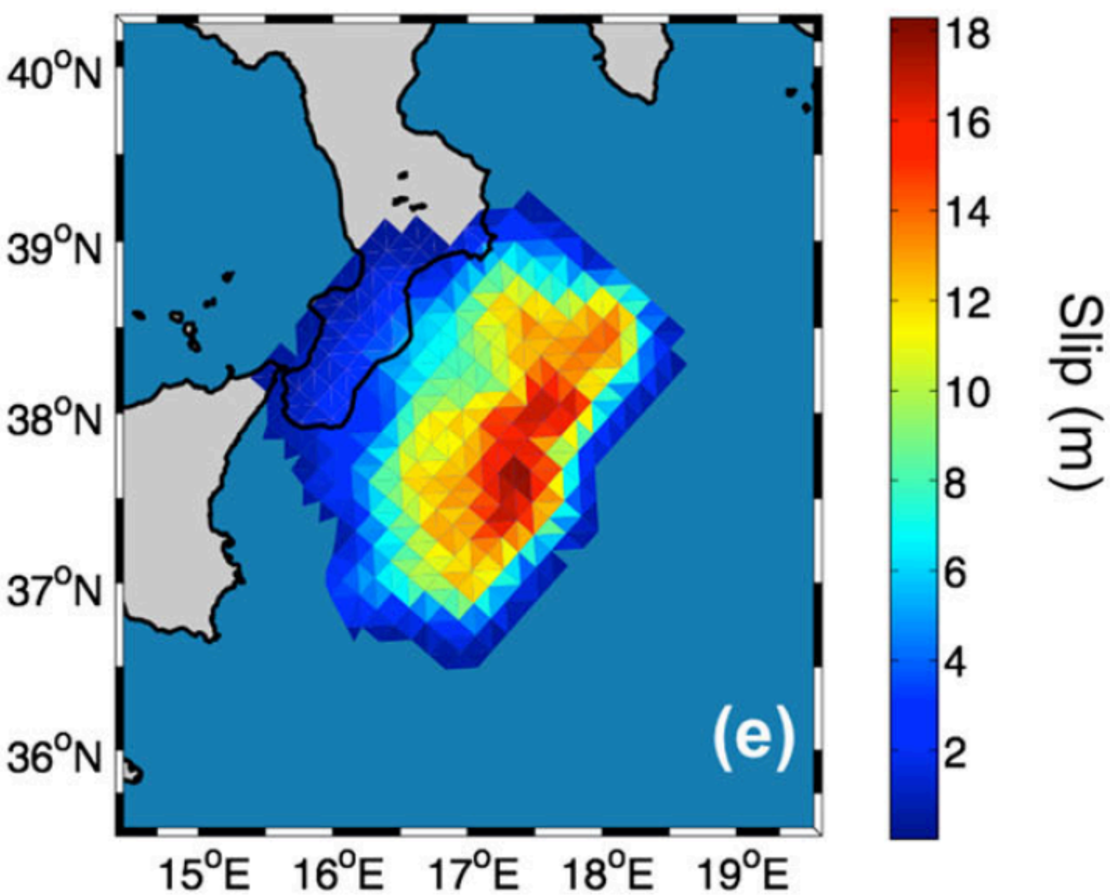
MOTIVATION OF THE STUDY

- Using homogenous slip distributions as an earthquake and tsunami sources in tsunami hazard analyses is a widespread approach, despite the co-seismic slip distribution complexity has an important impact on the hazard results.

- Numerous methods have been proposed to generate synthetic heterogenous slip distributions for tsunami hazard calculations (Davies et al., 2015; Le Veque et al., 2016; Murphy et al., 2016; Sepulveda et al., 2017; Scala et al., 2019).

- Slip distributions informed by kinematic models from inversion of real events are also employed (Goda et al., 2014). However, **it is not certain to what extent tsunami waveforms generated by these models are consistent with available tsunami observations.**

MOTIVATION OF THE STUDY



Scala et al., 2019

Figure 2: An example to the synthetic slip distribution

- A set of data from 3 different subduction zones in Mediterranean Sea, adopting a realistic 3D fault geometry for each zones.
- The method uses the classic "k-square" stochastic slip distributions.
- Earthquakes with Mw between 6.0 - 9.0.
- Shallow slip amplification is imposed depending on the variation of rigidity with depth and coupling.
- Probability of occurrence of each single event is adapted to have the total slip along the interface, in long term, equal to the relative plate convergence.

MOTIVATION OF THE STUDY

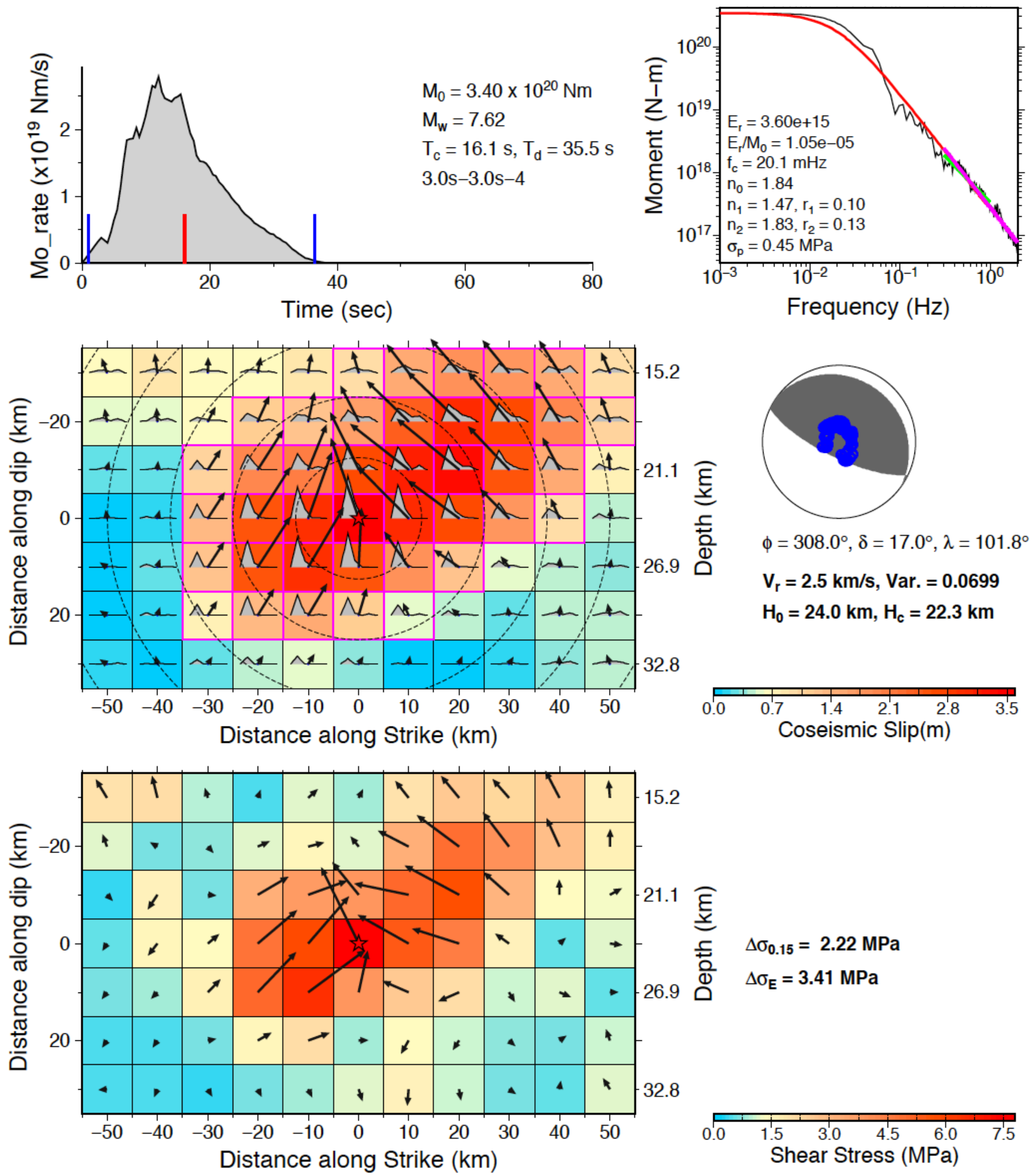


Figure 3: An example to inversion result of an event from the catalog. *Ye et al., 2016*

- The teleseismic finite-fault inversion results of Ye et al.2016.
- A catalog of kinematic slip models of 114 Mw≥7.0 interplate megathrust earthquakes which occurred between 1990 and 2015 on the circum-Pacific subduction zones.
- Provides co-seismic slip distribution models, focal mechanism, source time function, static stress drop etc. for each event.

MOTIVATION OF THE STUDY

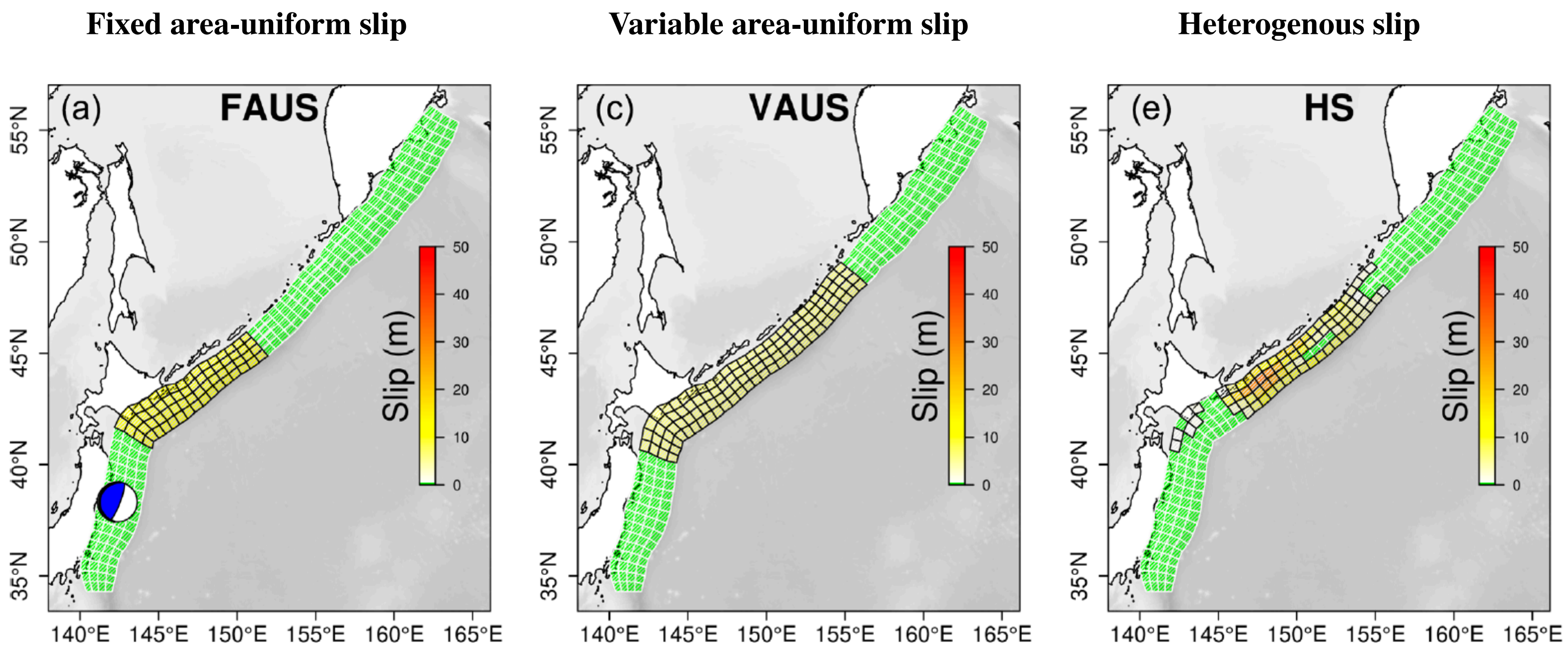


Figure 4: Example earthquake scenarios generated by different models. *Davies, 2019*

- In the study of Davies (2019) three different models, fixed area-uniform slip, variable area-uniform slip and heterogenous slip, for tsunami source modeling in subduction zones are tested by comparing the simulated tsunami waveforms with DART records of **18 tsunami events** (Fig. 5).
- Scenarios are generated assuming synthetic event has a similar magnitude and location of events and subduction geometry.
- Earthquake and tsunami scenarios are generated for both depth-independent (constant rigidity) and depth-independent (rigidity varies with depth) cases.

MOTIVATION OF THE STUDY

- In the study of Davies (2019), a variety of different approaches for tsunami source modelling in subduction zones are tested by comparing the simulated tsunami waveforms with DART records of 18 tsunami events.

- Kinematic slip models on planar faults obtained with tele-seismic inversion for 13 out of these 18 events are also present in the earthquake catalog of Ye et al. (2016).

AIM OF THE STUDY

The main goal of this study is to test synthetic tsunamis produced by different slip generation techniques against tsunami observations from open ocean DART buoys.

- In this study, we will compare the tsunamis generated by these slip models of real events (Ye at al., 2016) generated by telesismic inversion with tsunami observations.

- The approach proposed in Scala et al. (2019) for the generation of depth-dependent stochastic slip models in the context of PTHA will also be used for generating further set of scenarios of magnitude and location similar to all the 18 events on the same geometries used by Davies (2019) and the modelling results are tested and compared to the others in the same framework.

DATA

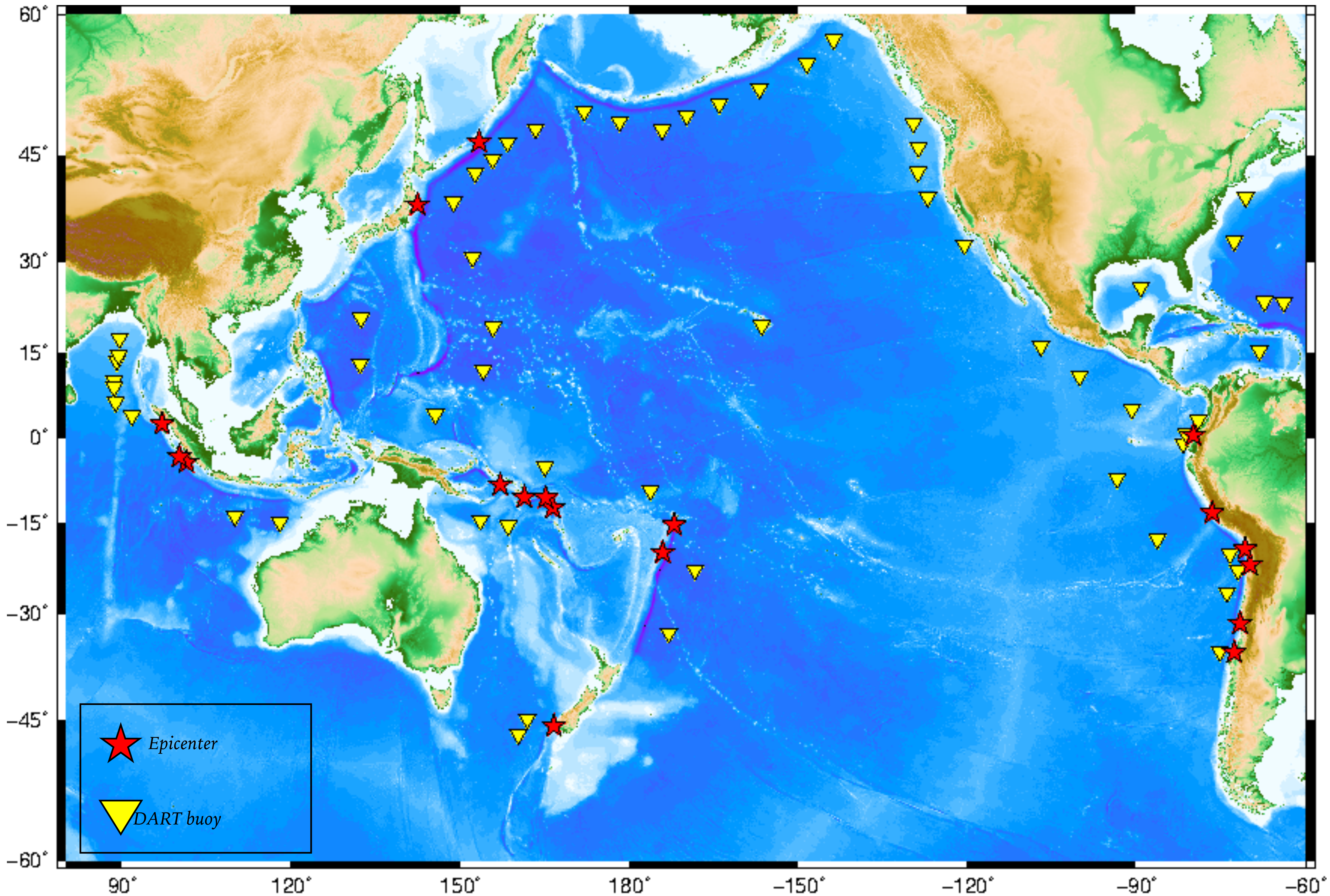


Figure 5: Location of 18 events and Dart buoys.

DATA

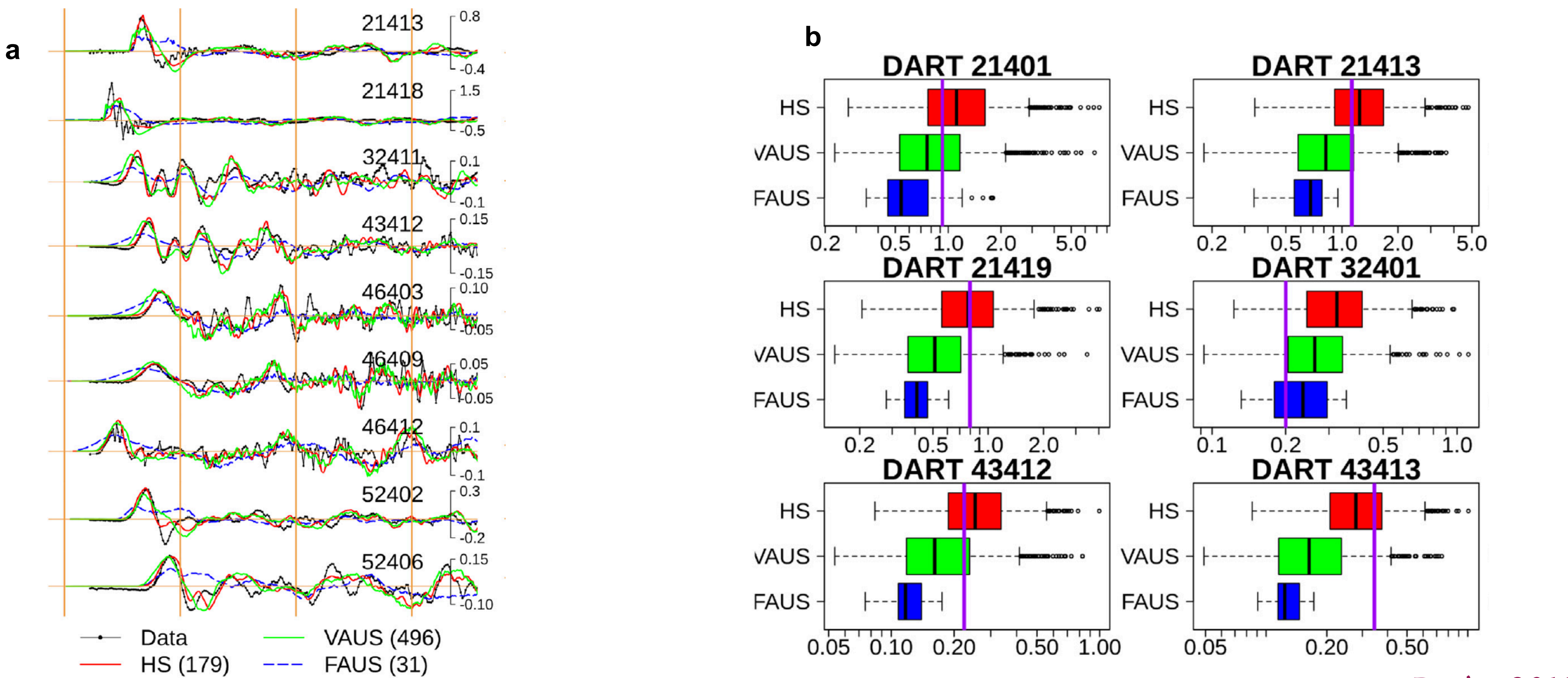
- These 18 earthquakes are tsunamigenic earthquakes, which occurred between 2006-2016, in the Global Centroid Moment Tensor (GCMT) catalogue.

- The moment magnitude of the events varies from M_w 7.8 up to M_w 9.1 2011 Great Tohoku Earthquake (Fig. 5) with hypocentral depths≤71 km.

- It is also taken into account whether deep ocean tsunami data was recorded after the earthquake.

- 64 deep DART buoys measurements were obtained from the National Oceanic and Atmospheric Administration National Data Buoy Centre historical DART data website (NOAA/NDBC 2017).

METHODOLOGY FOR COMPARISONS



Davies, 2019

Figure 6:Time-series observed at DART buoys with best-fitting model scenarios Hazard curves at three reference point of interest (a), Distribution of modelled stage-ranges at each DART buoy site (boxplots) in each corresponding family of model scenarios (b)

- **Davies (2019) proposes some criterions for comparison of tsunamis generated by models and Darts observations.**
- **First of all, a goodness-of-fit criterion is developed to identify stochastic scenarios which generates most similar behavior to the observed tsunamis.**
- **The statistical properties of the tsunami stage-range (difference between the maximum and minimum tsunami height) for scenarios are compared to analyze biases in the representation of tsunami size by the different models with the de-tided stage-range observed during the event.**
- **The statistical properties of slip for stochastic earthquake scenarios are also compared against earthquake scenarios that best fit the observations.**
- **The techniques provided by this study to compare model results with real observations can be applied to test other stochastic tsunami scenario generation techniques to identify and partially correct biases of these scenarios, and provide better justification for their use in applications.**
- **Davies and Griffin (2020) also propose a bias-adjustment of synthetic tsunamis produced with variable-area-uniform-slip and heterogeneous-slip models.**

SETTING UP THE EXPERIMENT

- Conversion of slip models of 13 events from Ye et al., (2016) to Tsunami-HySEA tsunami model as initial condition has been done (Fig. 7).

- Tsunami numerical modelling for these earthquakes has been performed.

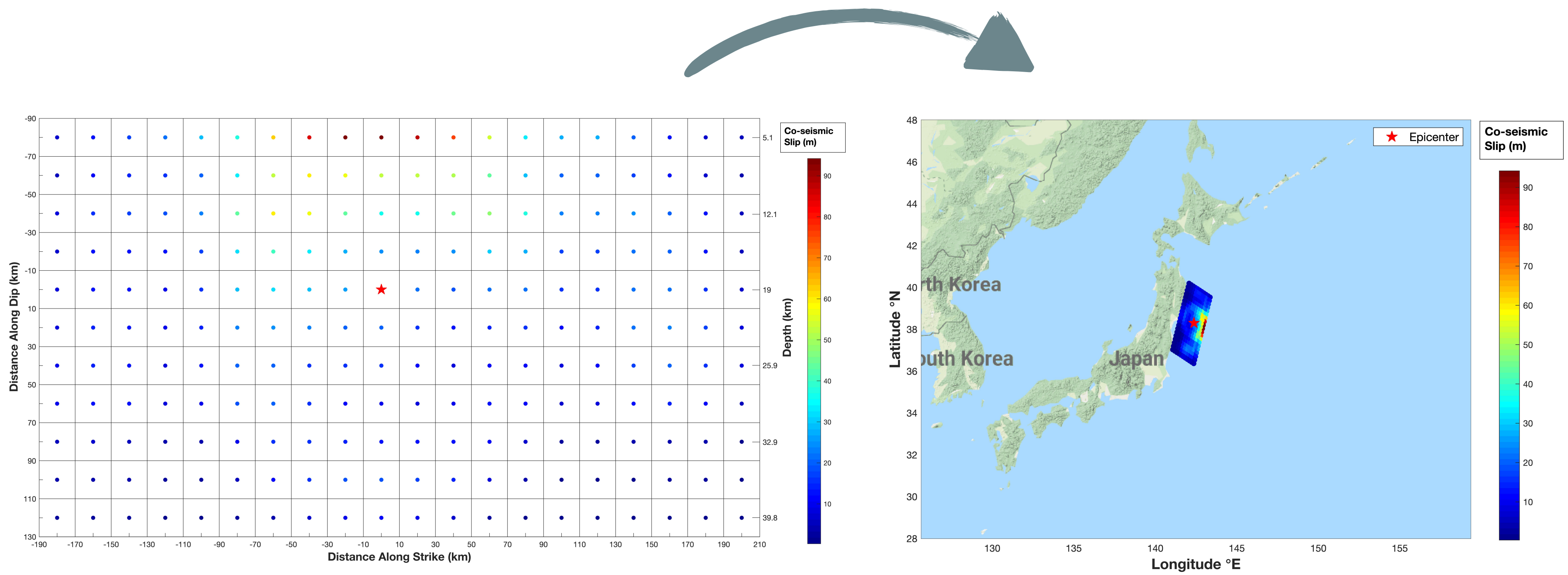


Figure 7: An example to conversion of a slip model from Ye et al., 2016 to Tsunami-HySEA format.

FUTURE DEVELOPMENTS

What is next?

- Comparison of tsunamis generated by Ye catalog with observed tsunamis.
- Application of Scala's source models (both depth-dependent and depth-independent) on realistic source geometry considering magnitude and location similar to all the 18 events.
- Tsunami numerical modeling using Scala's source models as initial condition.
- Comparison of tsunami generated by these different techniques with tsunami records and other model results.