

Geo-INQUIRE Transnational Access Project Report: Impact of tsunami generation models in flooding (FLOOD-IMG) - Alice Abbate (GFZ, Germany)

Geo-INQUIRE installation: HySEA - Earthquake and landslide generated tsunami simulations (TA2-531-3)

Project title: Impact of tsunami generation models in flooding

Transnational access principal investigator: Alice Abbate (GFZ, Germany)

Collaborators: Piero Lanucara (CINECA), Stefano Lorito (INGV), Roberto Tonini (INGV), Roberto Basili (INGV), Hafize Basak Bayraktar (INGV), Antonio Scala (INGV), Andrey Babeyko (GFZ)

Project acronym: FLOOD-IMG

Project report ID: C1-TA2-531-3-7

Transnational access team: Prof. José Manuel González Vida, Prof. Jorge Macías Sánchez (Universidad de Málaga (UMA), Spain)

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Geo-INQUIRE Virtual Access: in progress

Data/Products: A scientific paper based on this work is being prepared. Simulation results will be uptaken on the Simulation Data Lake at CINECA.

Project report:

Probabilistic tsunami hazard assessments rely on large ensembles of earthquake scenarios to represent variability in rupture mechanisms, source zones, and source parameters. At local scales, high-resolution inundation simulations are combined with earthquake occurrence rates to estimate the probability that a given site will experience flooding exceeding a specified threshold over a given time span. Earthquake source parameters are commonly derived from empirical scaling relationships that predict rupture dimensions and slip as a function of magnitude. To limit the computational cost, only average values are considered, while deviations from these average values are typically neglected. For the same reason, uncertainties related to inundation modelling are poorly explored.

To overcome these limitations, Alice developed an automated workflow to run large numbers of inundation simulations on the Leonardo HPC cluster and to extract tsunami metrics through a dedicated post-processing. After testing the workflow at the site of Marzamemi (Sicily), using scenarios from the regional NEAM Tsunami Hazard Model 2018, she constructed a new ensemble focused on subduction interface earthquakes along the Calabrian, Hellenic, and Cyprus slabs, using the same magnitude discretization. The approach incorporates standard errors in earthquake dimensions, allowing rupture area, length, and width to vary according to normal distributions for each magnitude. These variations were constrained by the three-dimensional slab geometry, and the effects of renormalization were evaluated. Additionally, multiple stochastic slip distributions were generated for each scenario, either assuming a depth-dependent or independent rigidity, to investigate their influence on near-field tsunami.

Inundation simulations were carried out with two digital elevation models varying Manning coefficient values to investigate how bathymetric models and bottom friction affect tsunami inundation. The analysis of the results is still ongoing and has the aim of evaluating whether consistent relationships can be established between earthquake source characteristics and inundation metrics such as flow depth, velocity, maximum values, and inundation extent.

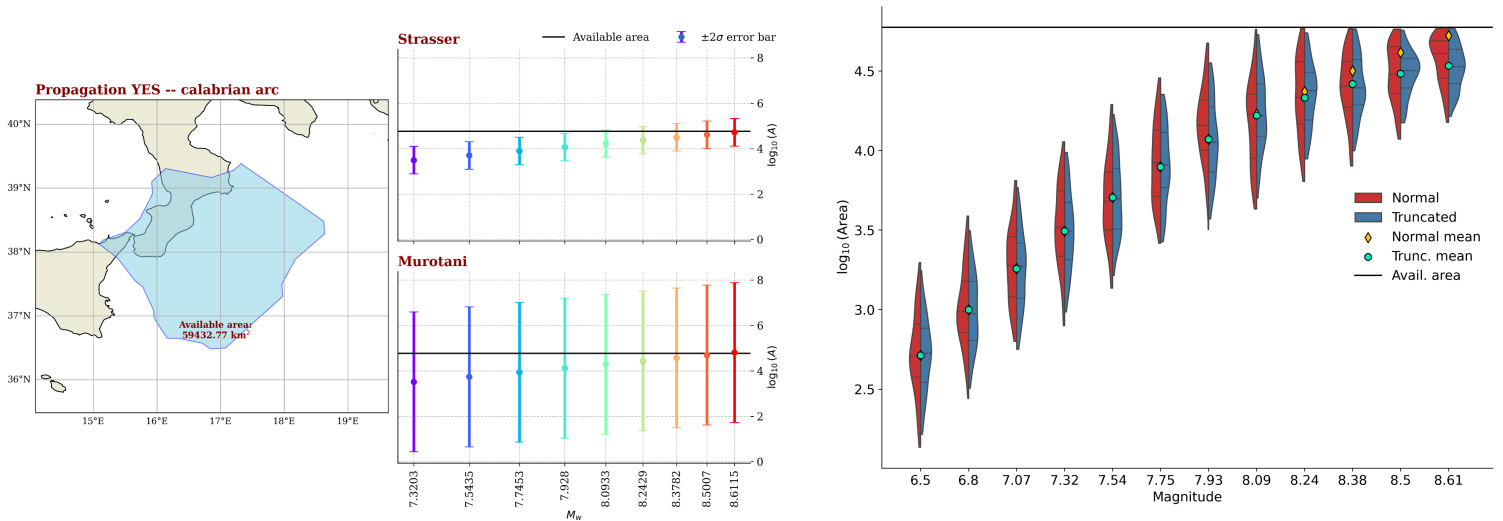


Fig. 1: Test case for the Calabrian Arc. (Left) When accounting for standard error in empirical scaling relationships (Strasser et al. 2010, Murotani et al. 2008), the range of possible values must be constrained by the slab geometry. (Right) Rupture dimensions are assumed to follow a normal distribution and independent samples are drawn to create earthquake scenarios. Slab geometry constrains samples through acceptance/rejection methods or by drawing from a truncated normal distribution.

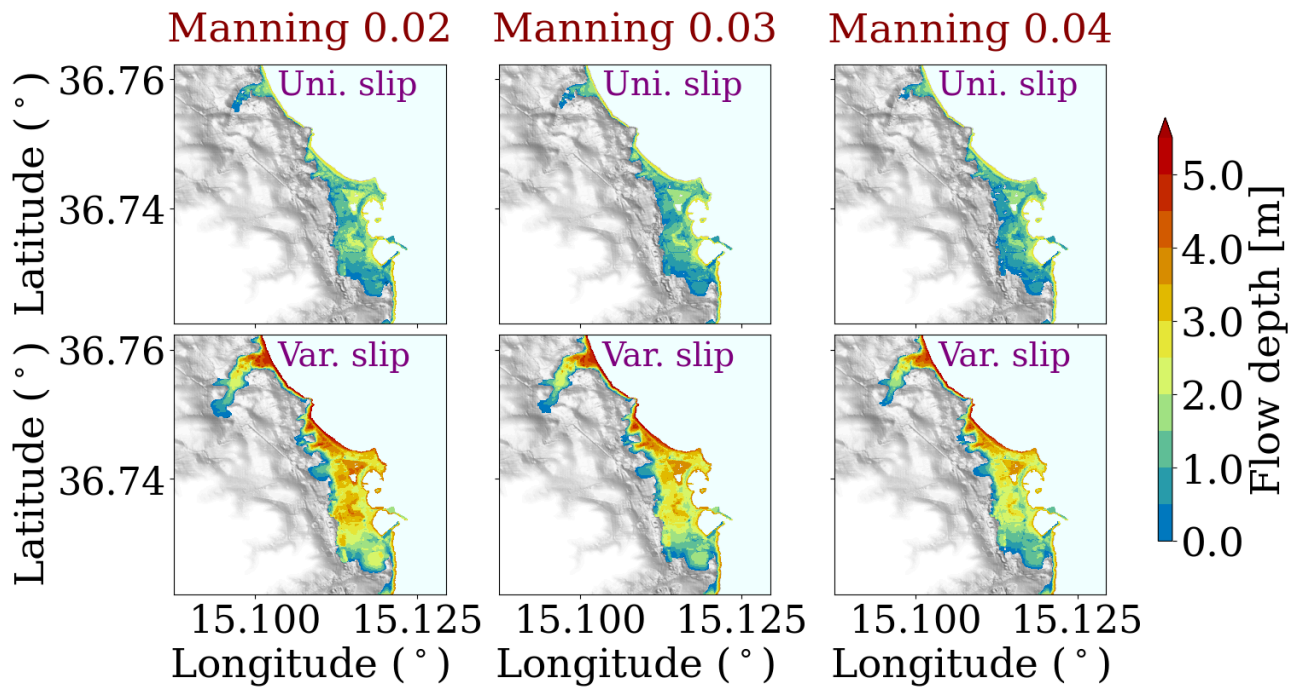


Fig. 2: Example of inundation simulations for a magnitude $M_w = 8.5$ on the Calabrian Arc. Tsunami propagation is initiated by the instantaneous sea floor deformation resulting from either uniformly distributed (top) or heterogeneously distributed (bottom) slip. Inundation is calculated using nested grids at progressively finer resolution (up to 5 m). The Manning coefficient is varied between 0.02 and 0.04 in steps of 0.1. A Digital Terrain Model (DTM) is used in this case.

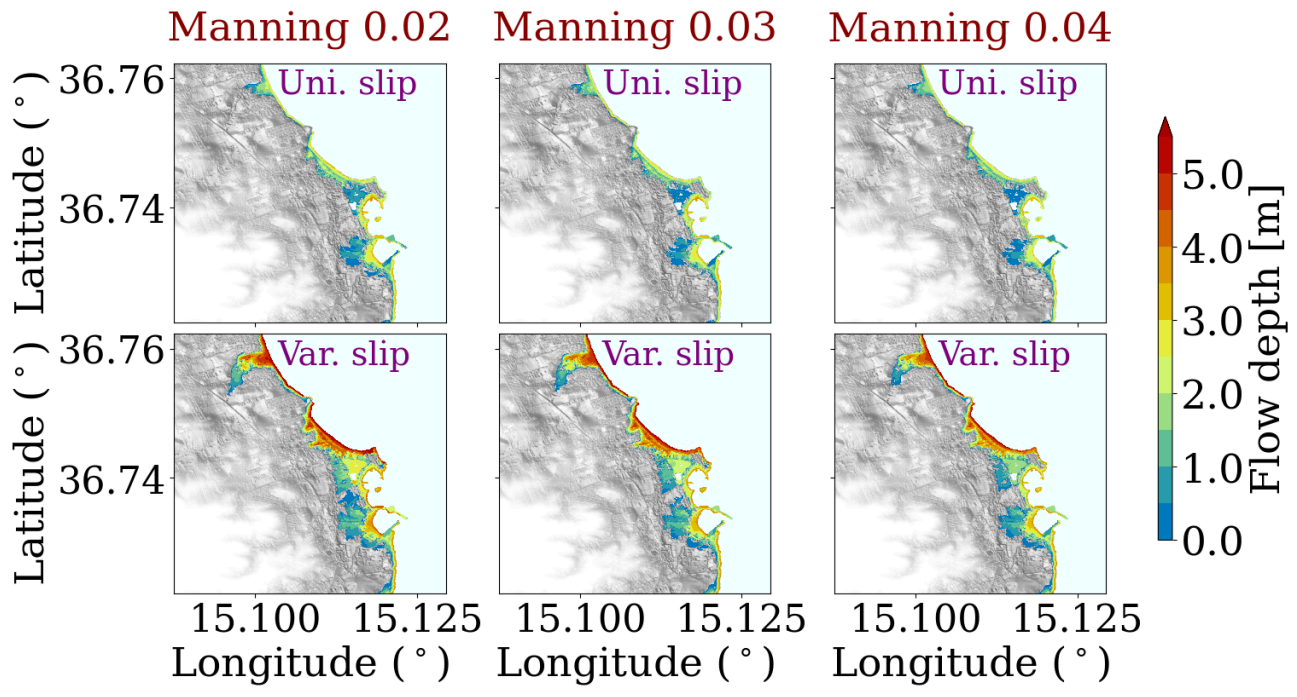


Fig. 3. Same as Fig. 2, but using a Digital Soil Mapping (DSM).