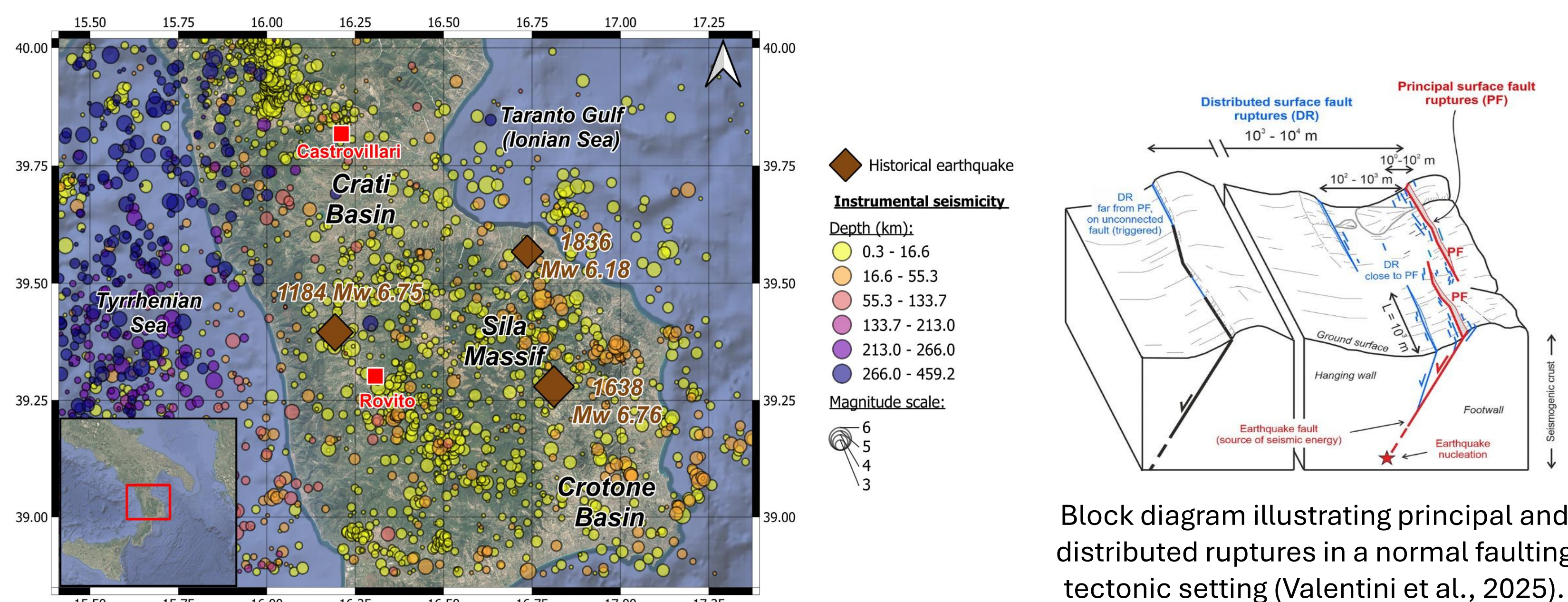


Introduction

Fault Displacement Hazard is a co-seismic natural phenomenon occurring when the rupture reaches and break the surface during an earthquake. It can lead to important damages and is crucial for sensitive infrastructures (nuclear sites, energy storage, pipelines, etc). The objective of this study is to develop a regional PFDHA in northern Calabria, one of the most seismic prone regions of southern Italy, providing alternative seismotectonic scenarios representing the existing epistemic uncertainties. The tectonic complexity, debated kinematics, and infrequent seismic activity make northern Calabria, and specifically the Crati Basin a challenging case study for releasing a first regional-scale PFDHA map, a preliminary tool for investigating and supporting risk reduction planning of critical infrastructures.



Block diagram illustrating principal and distributed ruptures in a normal faulting tectonic setting (Valentini et al., 2025).

Historical (CPT115, Rovida et al., 2020) and instrumental seismicity (ISIDE Working Group, 2007) in the study area.

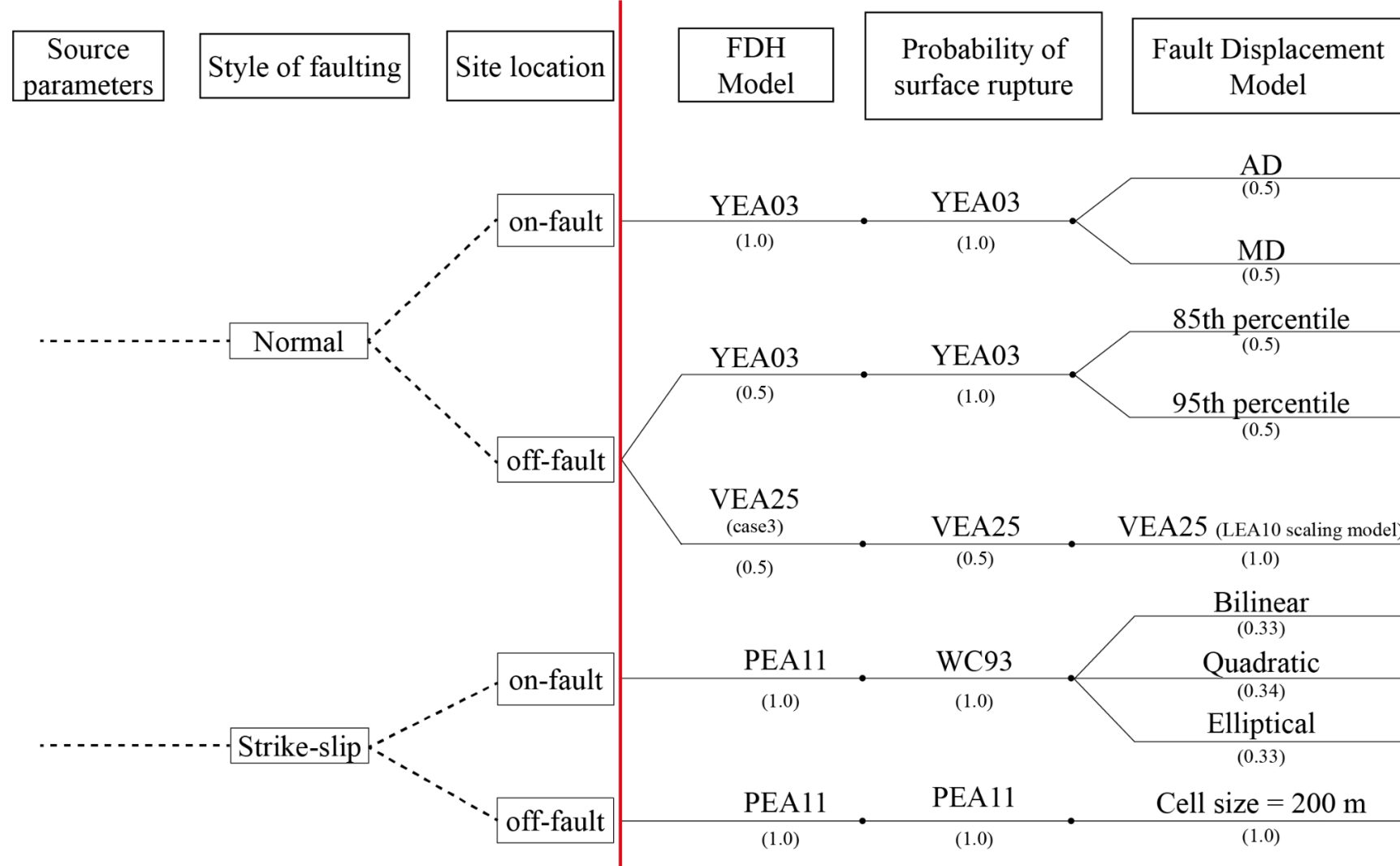
3- Fault Displacement Models selection

Logic flow used for fault displacement hazard map calculations: on the left of the red line, alternative choices are site-dependent; on the right, different branches of the logic-tree approach are modelled for all the sites.

The bottom table represents all the models, and their parameters, used in our site-specific and regional-scale calculations.

All our calculations have been performed using the open-source prototype PFDHA tool designed for integration into the OpenQuake Engine.

For more details on this tool, see poster X1.151
(Chen, Y.-S., Pagani, M., Peruzza, L., and Fernandez, H.: Towards a Unified PFDHA Platform: OpenQuake Engine Implementation, EGU General Assembly 2026, Vienna, Austria, 3–8 May 2026, EGU26-20524, <https://doi.org/10.5194/egusphere-egu26-20524>, 2026)

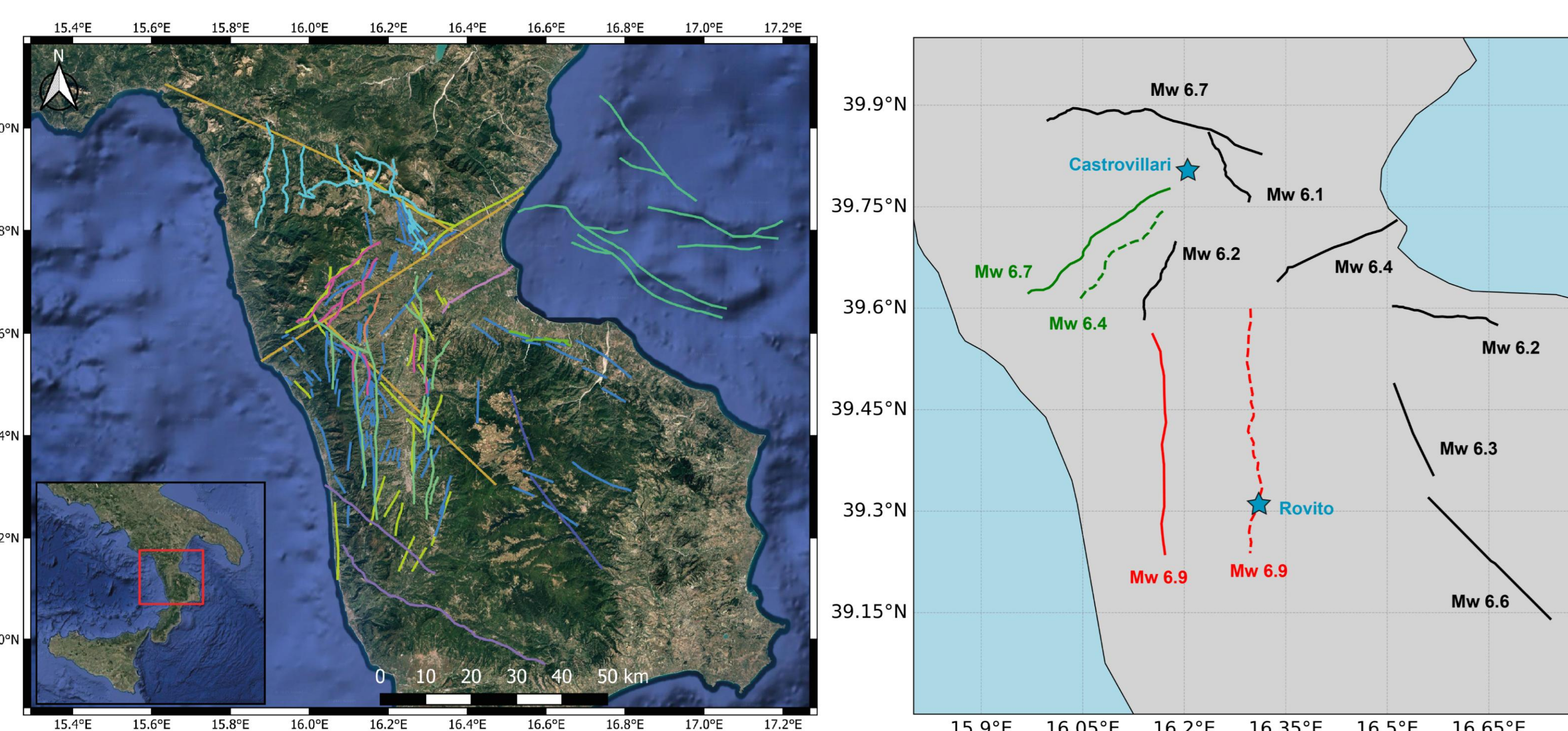


Model	Faulting style	Displacement metrics	Slip component	Displacement type
YEA03 (Youngs et al., 2003)	N	D/AD, D/MD	vertical	Single principal and single distributed
PEA11 (Petersen et al., 2011)	SS	D, D/AD	horizontal	
KEA24 (Kottke et al., 2024)	N SS R	D	net	Aggregate displacement
LEA23 (Lavrentiadis et al., 2023)	N SS R	D, AD, MD	net	Sum of principal & Aggregate displacement
VEA25 (Visini et al., 2023)	N R	D, PF throw	vertical	New definition of distributed faulting (rank 1 / 1.5 / 2 / 3)

Take Home Messages

- First of a kind regional-scale PFDH analysis.
- For on-fault sites, significant displacement (>1cm) can be expected in a 'near' future (about 2-3% in 50 yr, for 10 cm), especially in the Sila Massif and along the Crati faults.
- For off-fault sites, very low probability of surface displacement in a 'near' future (< 0,05% in 50 yr).
- The tectonic model strongly controls the results, making its definition a critical step in fault displacement hazard assessment.
- Logic tree approaches are essential to capture epistemic uncertainties arising from different model formulations, parameter selections, and source configurations.
- Very long return periods produce unrealistic displacement values (e.g., >5 m for Mw 6.9) at the tails of hazard curves, indicating the need for future thresholding approaches.

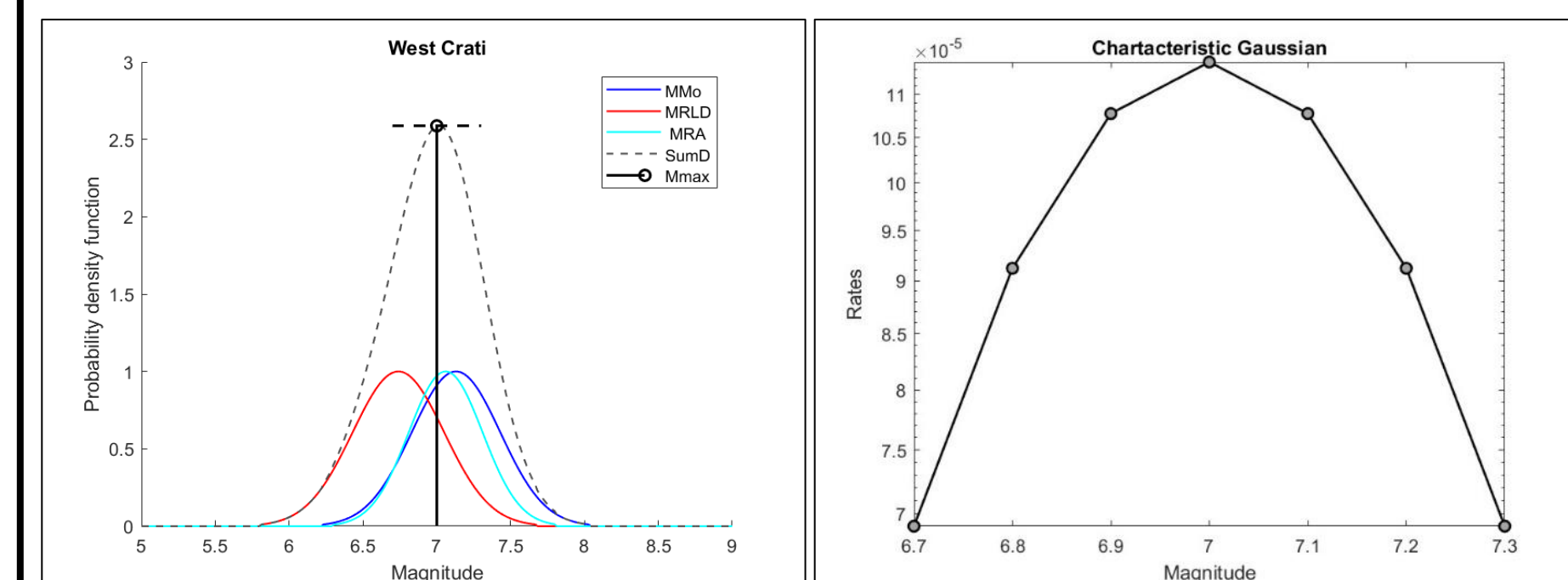
1- Fault source model



Simplified seismotectonic model of Northern Calabria, based on literature data and the ITHACA (ISPRA) and DISS (INGV) fault databases. Left panel: critically revised collection of potential fault sources. Right panel: final source model. The 11 potential fault sources are modelled by 4 alternative scenarios, representing various source configurations, with debated active faults shown in red and green solid and dashed lines.

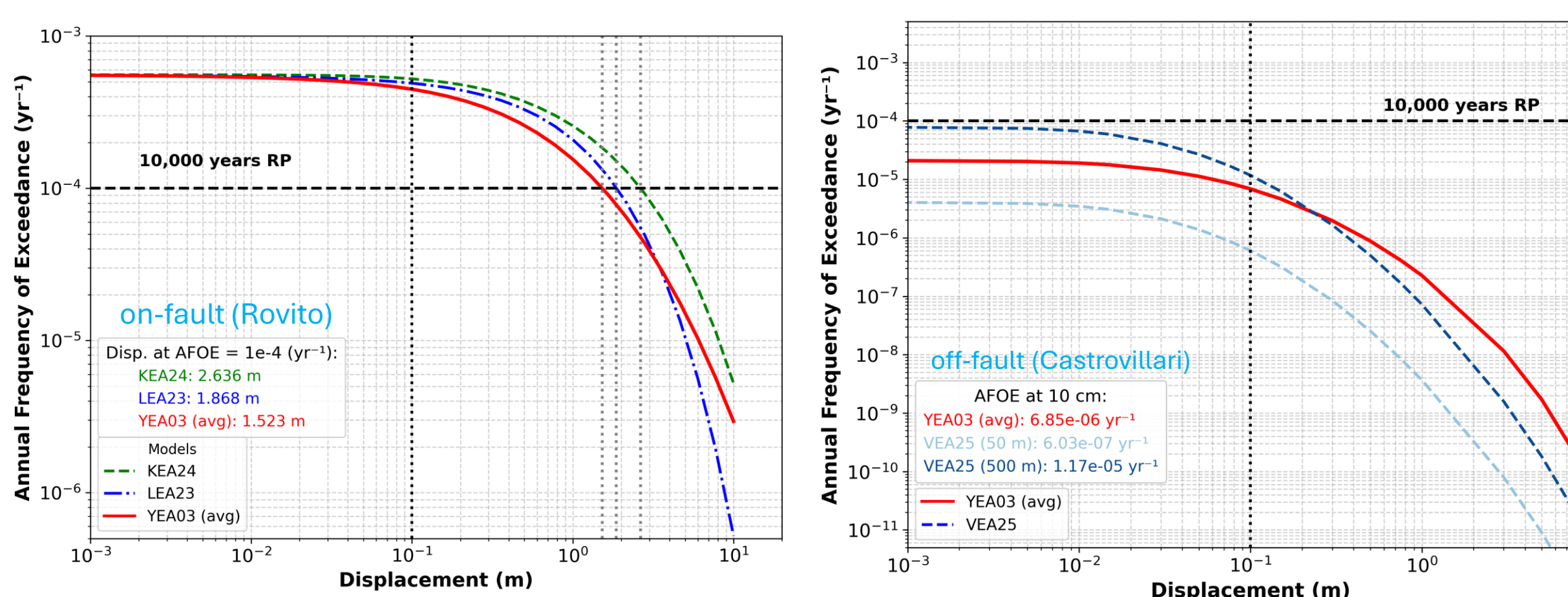
2- Magnitude Frequency Distribution Characterisation

Maximum magnitudes and activity rates are estimated using a Characteristic Gaussian model. The maximum magnitude is derived from various scaling relationships proposed by Wells and Coppersmith (1994), while activity rates are calculated from the total moment budget and distributed across magnitude bins. An example if provided below, for the West Crati Fault (red solid line on previous map).

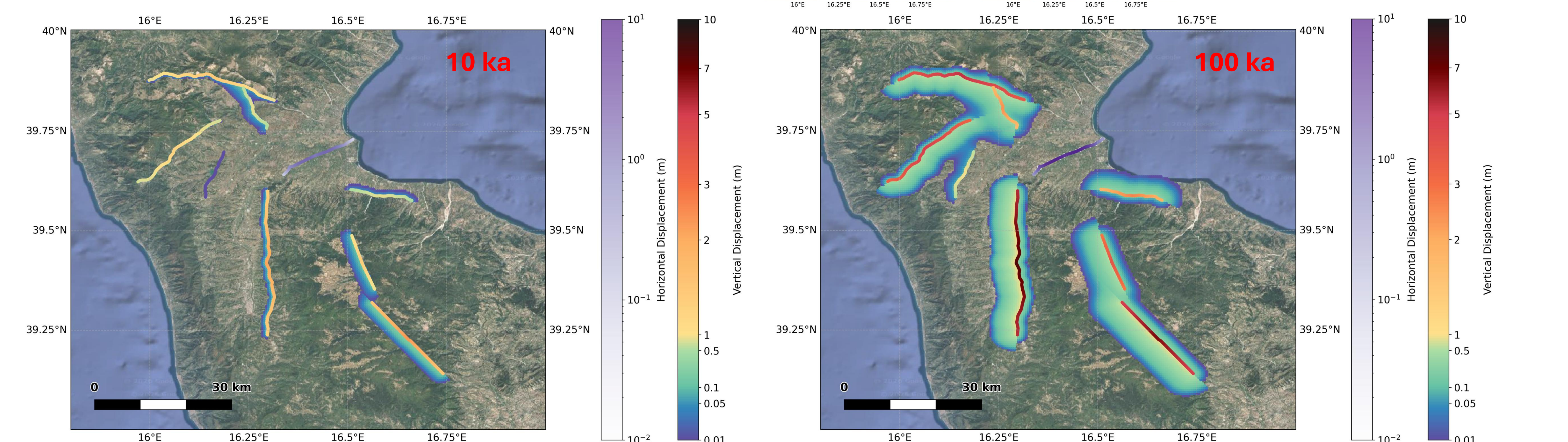


Mmo: Moment magnitude.
MRLD: Magnitude from rupture length at depth.
MRA: Magnitude from rupture area. SumD: sum of the magnitude distributions.
Mmax: Averaged maximum magnitude expected.

4- Hazard curves & hazard maps



Displacement hazard curves at two selected sites (blue stars) for the scenario 3.
Rovito: POE in 50 yr are about 2-3% for 10 cm.
Castrovillari: POE in 50 yr for 10 cm are very low (< 0,05%).



The maps above represent the displacement expected in the next 10 ka (left) and 100 ka (right), using the scenario 3. For 10 ka, the displacement is mainly confined along the surface fault traces while for 100 ka it quickly decreases when going further from the main trace. In terms of displacement values, the maximum reaches about a few meters (on-fault, 8,7 m on the West Crati Fault) and only a few centimeters or tens of centimeters for off-fault.

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References: DISS Working Group: Database of Individual Seismogenic Sources (DISS), Version 3.3.1: A compilation of potential sources for earthquakes larger than M 5.5 in Italy and surrounding areas, Istituto Nazionale di Geofisica e Vulcanologia (INGV) [data set], 2025; **ISIDE Working Group:** Italian Seismological Instrumental and Parametric Database (ISIDE), Istituto Nazionale di Geofisica e Vulcanologia (INGV) [data set], 2007; **ITHACA Working Group:** ITHACA (Italy Hazard from Capable faulting): A database of active capable faults of the Italian territory, Version December 2019, ISPRA Geological Survey of Italy [data set], 2019; **Kuehn, N. M., Kottke, A. R., Sarmiento, A. C., Madugo, C. M., and Bozorgnia, Y.:** A Fault Displacement Model Based on the FDHI Database, Earthquake Spectra, 87552930241291077, 2024; **Lavrentiadis, G. and Abrahamson, N.:** Fault-displacement models for aggregate and principal displacements, Earthquake Spectra, 87552930231201531, 2023; **Leonard, M.:** Earthquake Fault Scaling: Self-Consistent Relating of Rupture Length, Width, Average Displacement, and Moment Release, Bulletin of the Seismological Society of America, 100, 1971–1988, 2010; **Petersen, M. D., Dawson, T. E., Chen, R., Cao, T., Willis, C. J., Schwartz, D. P., and Frankel, A. D.:** Fault Displacement Hazard for Strike-Slip Faults, Bulletin of the Seismological Society of America, 101, 805–825, 2011; **Valentini, A., Visini, F., Boncio, P., Scotti, O., and Baize, S.:** Twenty-Five Years of Probabilistic Fault Displacement Hazard Assessment, Reviews of Geophysics, 63, e2024RG000875, 2025; **Visini, F., Boncio, P., Valentini, A., Scotti, O., Nurminen, F., Baize, S., and Pace, B.:** Empirical regressions for distributed faulting of dip-slip earthquakes, Earthquake Spectra, 87552930241308860, 2025; **Rovida, A., Locati, M., Antonucci, A., and Camassi, R.:** The Italian Archive of Historical Earthquake Data, ASMI, Earth Syst. Sci. Data, 17, 3109–3124, 2025; **Wells, D. L. and Coppersmith, K. J.:** Likelihood of surface rupture as a function of magnitude, Seismol. Res. Lett., 64, 974–1002, 1993; **Wells, D. L. and Coppersmith, K. J.:** New Empirical Relationships among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement, Bulletin of the Seismological Society of America, 84(4), 974–1002, 1994; **Youngs, R. R., Arabasz, W. J., Anderson, R. E., Ramelli, A. R., Ake, J. P., Slemmons, D. B., McCalpin, J. P., Doser, D. I., Fridrich, C. J., Swan, F. H., Rogers, A. M., Yount, J. C., Anderson, L. W., Smith, K. D., Bruhn, R. L., Kneupper, P. L. K., Smith, R. B., dePol, C. M., O'Leary, D. W., Coppersmith, K. J., Pezzopane, S. K., Schwartz, D. P., Whitney, J. W., Olig, S. S., and Toro, G. R.:** A Methodology for Probabilistic Fault Displacement Hazard Analysis (PFDHA), Earthquake Spectra, 19, 191–219, 2003.