A Bayesian probabilistic approach to estimate the focal mechanism of micro-earthquakes occurring at the Irpinia fault system, southern Italy

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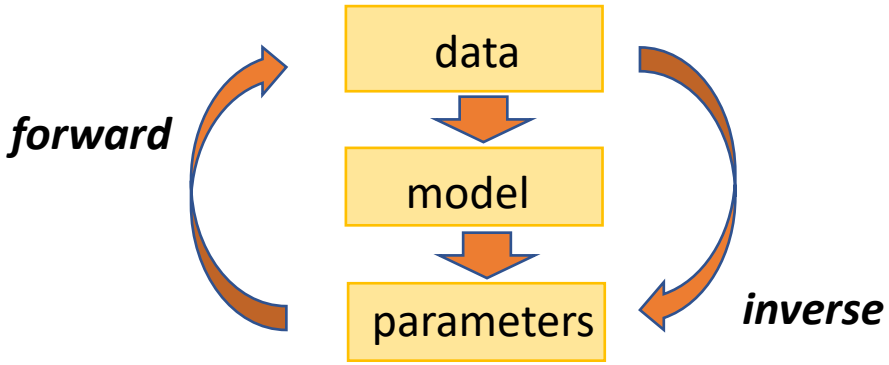
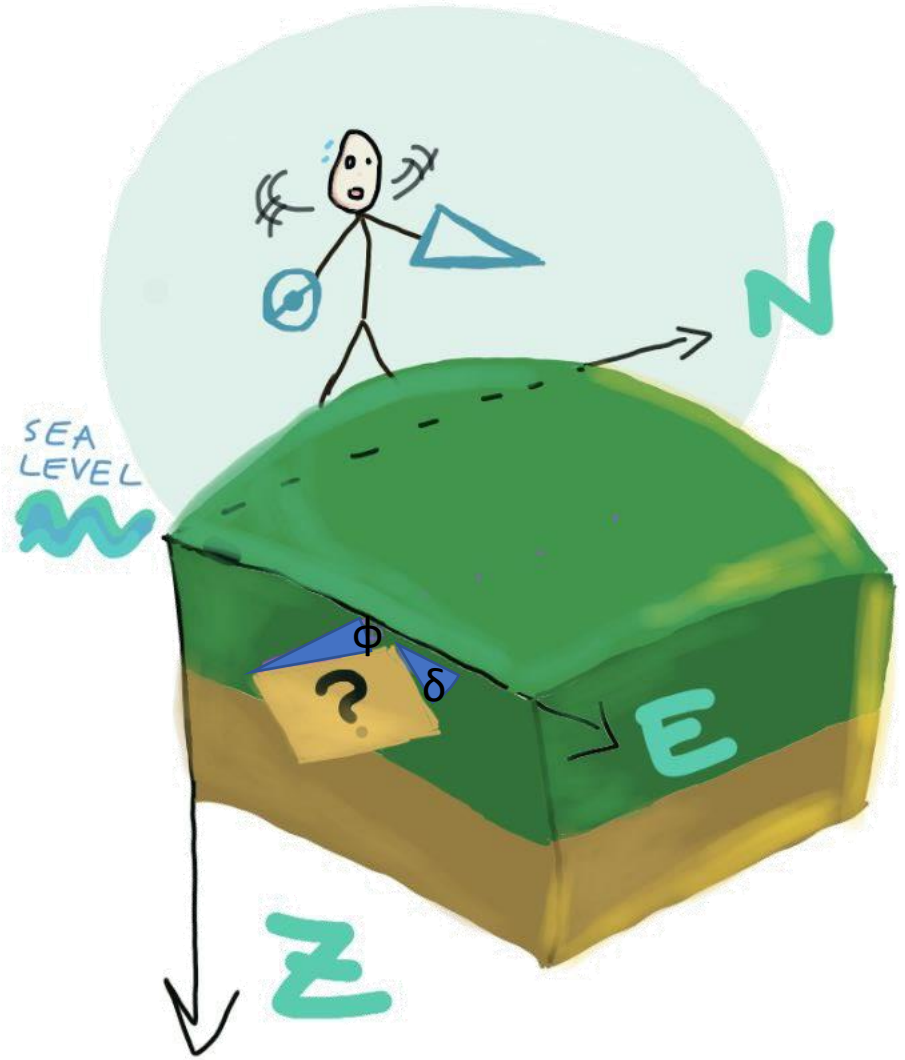
A Non-Linear Inverse problem!

The Focal Mechanism provides the orientation of the fault plane and the direction of the slip vector on it.

These parameters of the fault are not directly measurable and are non-linearly related to the observables.





Focal Mechanism limitations for micro-seismicity

Stations geometry could not allow to constrain fault planes

Very few available records

Low Signal-to-Noise Ratio

Limited number of Polarities

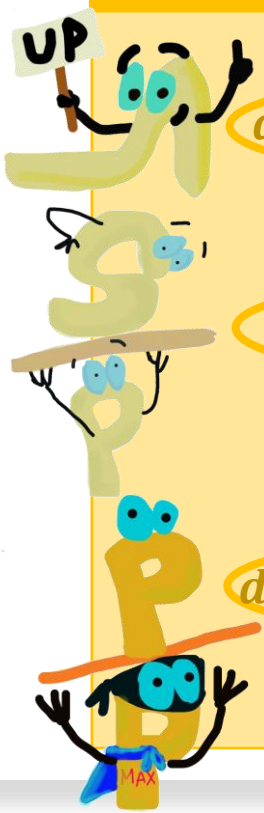
Polarities not readable

Few number of data!

use the all information contained in the seismograms, i.e, all components

A Bayesian Approach

INDEPENDENT DATASETS



d^P ***P-wave polarity***

d^R ***S/P Amplitude***

d^A ***P-wave Amplitude***

$$p(\boldsymbol{m}|\boldsymbol{d}) = c^{-1} f(\boldsymbol{d}|\boldsymbol{m}) q(\boldsymbol{m})$$

$p(\boldsymbol{m}|\boldsymbol{d})$: *Posterior* probability
$f(\boldsymbol{d}|\boldsymbol{m})$: data conditional *pdf*
$q(\boldsymbol{m})$: prior *pdf*
c : normalization constant.

$$f(\boldsymbol{d}|\boldsymbol{m}) = f(\boldsymbol{d^A} \cap \boldsymbol{d^P} \cap \boldsymbol{d^R}|\boldsymbol{m}) = f(\boldsymbol{d^A}|\boldsymbol{m}) * f(\boldsymbol{d^P}|\boldsymbol{m}) * f(\boldsymbol{d^R}|\boldsymbol{m})$$

Inversion

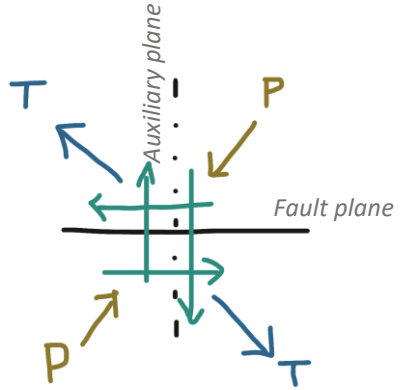
OUTPUT: *Posterior probability*

Solution: Maximum A Posteriori (MAP) model;
Uncertainties: projections of semi-axis of the 68% confidence ellipsoid centered on the MAP

Micro-earthquakes orientation is not casual

The study of micro-seismicity in areas characterized by the presence of active fault systems could reveal larger-scale characteristics, i.e the regional stress features.

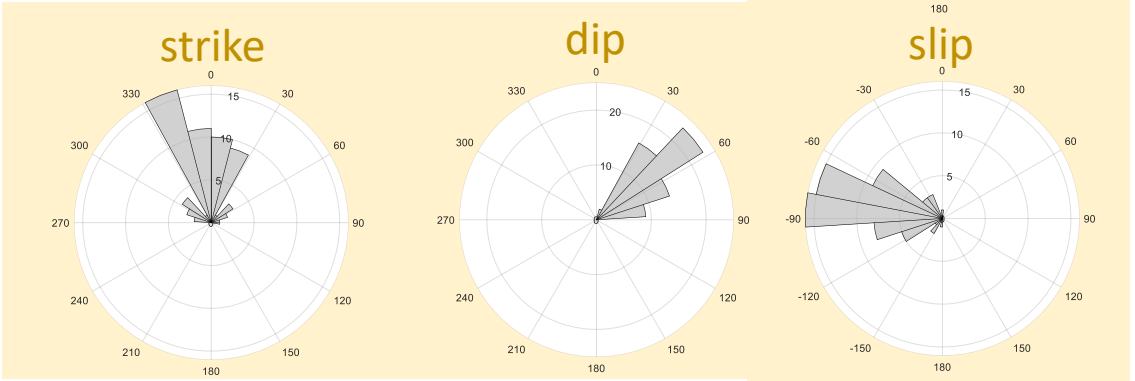
Micro-earthquakes in the Irpinia region are not randomly oriented, but they occur along subparallel fracture planes, highly organized inside a volume delimited by the fault segments activated by the 1980, Ms 6.9, Campania-Lucania earthquake (*De Matteis, 2012*).

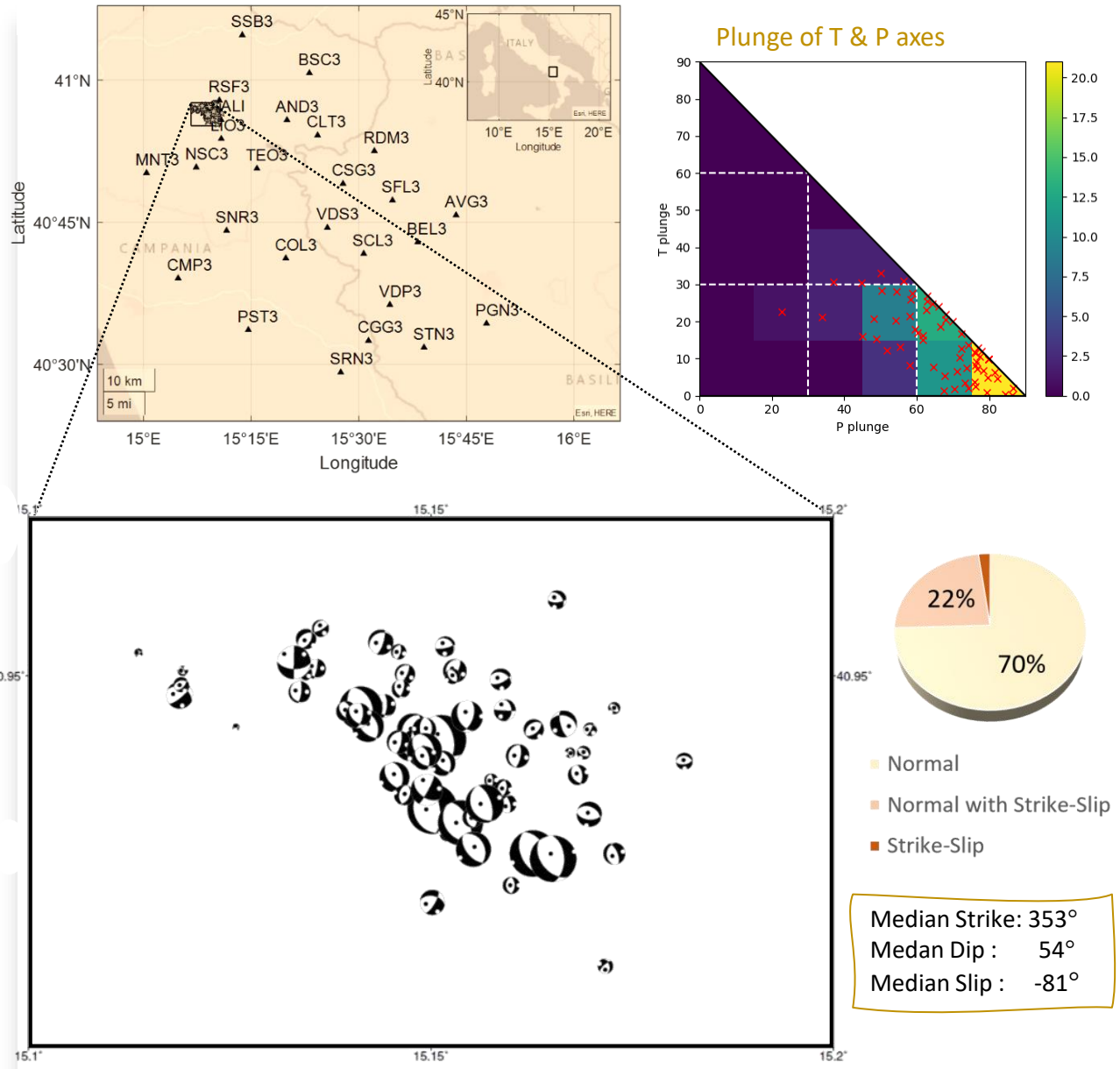


Rocca San Felice sequence, Italy

ISNet, Irpinia Seismic Network, is installed around the active faults system responsible for the 1980 Campania-Lucania earthquake.

In July 2020, 64 events with M_L in the range 0.4-3.0 occurred in Rocca San Felice village (*Festa, 2021*).





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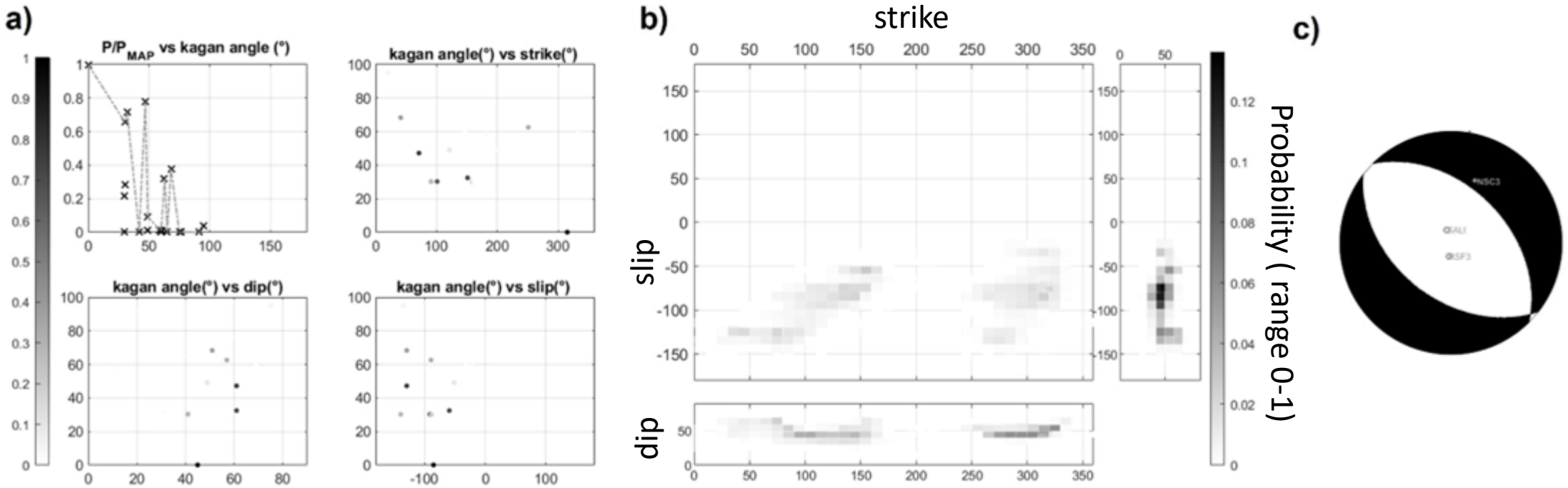
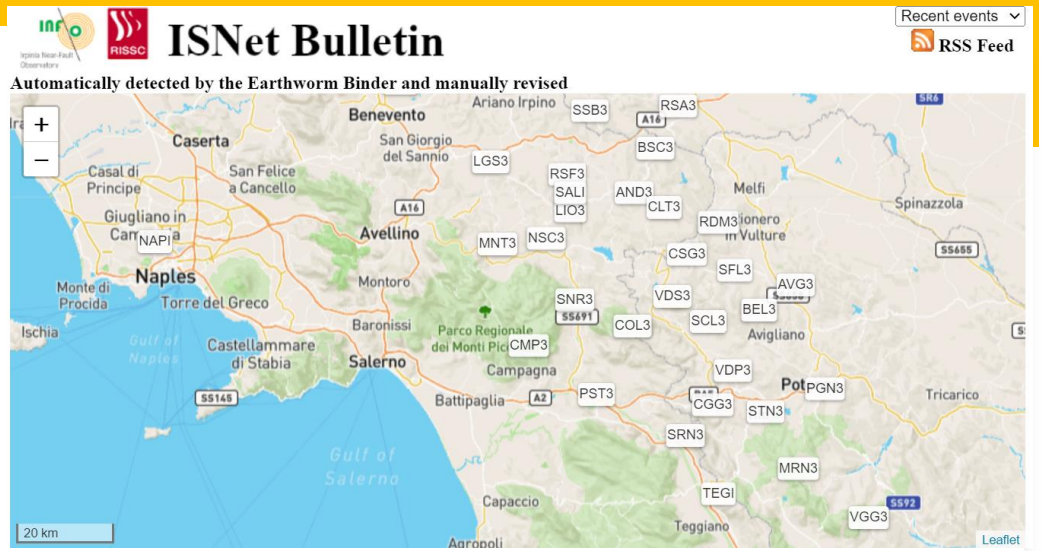
2020-07-03 19:42:24, M_L0.7



The number of available station is 6 , with 6 amplitudes P, 4 polarities and 3 S-wave/P-wave ratio amplitudes. Strike: 315° ± 21°; Dip: 45° ± 4°; slip: -85° ± 30°. (Auxiliary Plane: 128° ± 24°,45° ± 6°,-95 ± 27°).

Work in progress

Make the method operational for declaring Focal Mechanisms for the ISNet bulletin available at
http://isnet-bulletin.fisica.unina.it/cgi-bin/isnet-events/isnet.cgi



Further informations:

De Matteis, Matrullo, Rivera, Stabile, Pasquale, & Zollo, (2012). Fault Delineation and regional stress direction from the analysis of background microseismicity in the southern Apennines, Italy. In *Bulletin of the Seismological Society of America* (Vol. 102, Issue 4). https://doi.org/10.1785/0120110225

Festa, Adinolfi, Caruso, Colombelli, De Landro, Elia, Emolo, Picozzi, Scala , Carotenuto, Gammaldi , Iaccarino , Nazeri, Riccio, Russo, Tarantino and Zollo (2021). Insights into Mechanical Properties of the 1980 Irpinia Fault System from the Analysis of a Seismic Sequence. Geosciences 11 (1), 28 https://doi.org/10.3390/geosciences11010028

Tarantino, S. Colombelli, S., Emolo, A., Zollo, A. (2019). Quick Determination of the Earthquake Focal Mechanism from the Azimuthal Variation of the Initial P-Wave amplitude. Seismological Research Letters, 90 (4): 1642–1649. https://doi.org/10.1785/0220180290

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Thank you!