OGS National Institute of Oceanography and Applied Geophysics

A multi-parametric space-time analysis of seismicity clustering

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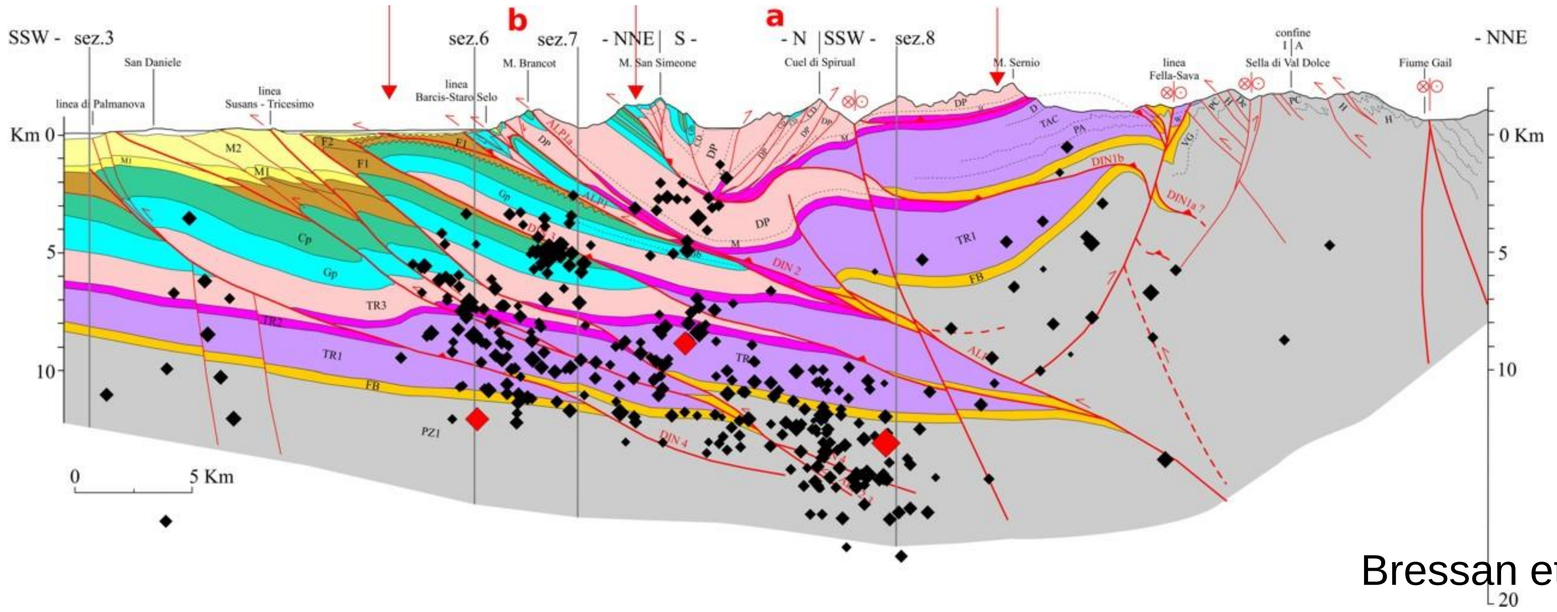
A multiparameter method for the space-time analysis of seismicity clustering

1) Based on 5 different parameters and techniques

2) Suitable to areas of complex tectonics

3) Enables to explore both the memory of the system and the evolution with time



Bressan et al., 2016

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1) Shannon Entropy: Energy distribution in space (Bressan et al., 2017; 2021)

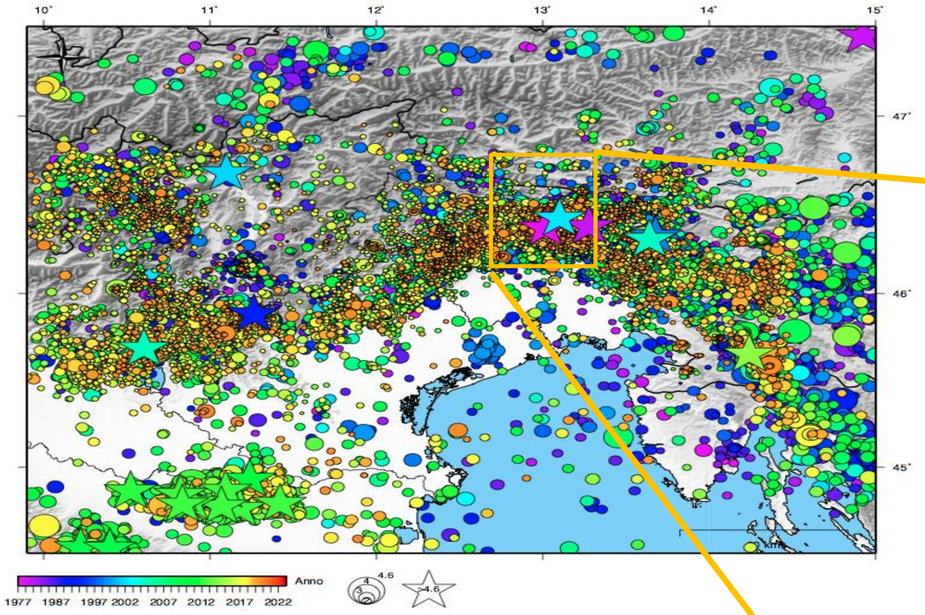
2) b-value : Energy distribution in time (Gutenberg and Richter, 1944)

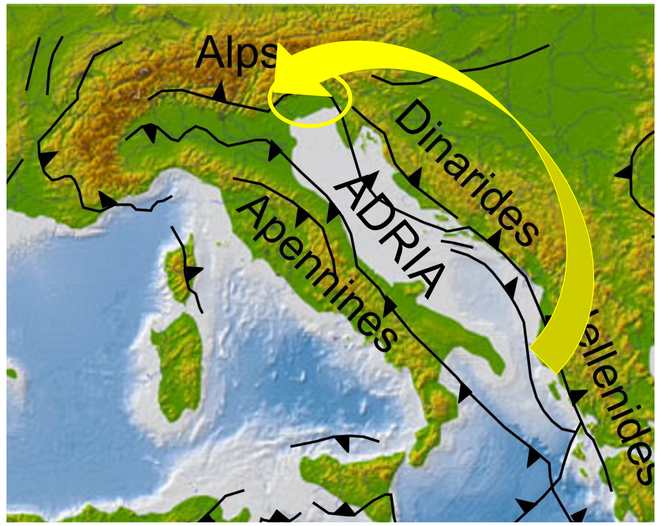
3) Fractal dimension of the spatial distribution: Spatial event distribution
   (Correlation integral method, Grassberger 1983, Rossi, 1990)

4) Nearest Neighbour distance: Space, time and energy event inter-relation
   (Baiesi and Paczuski, 2004)

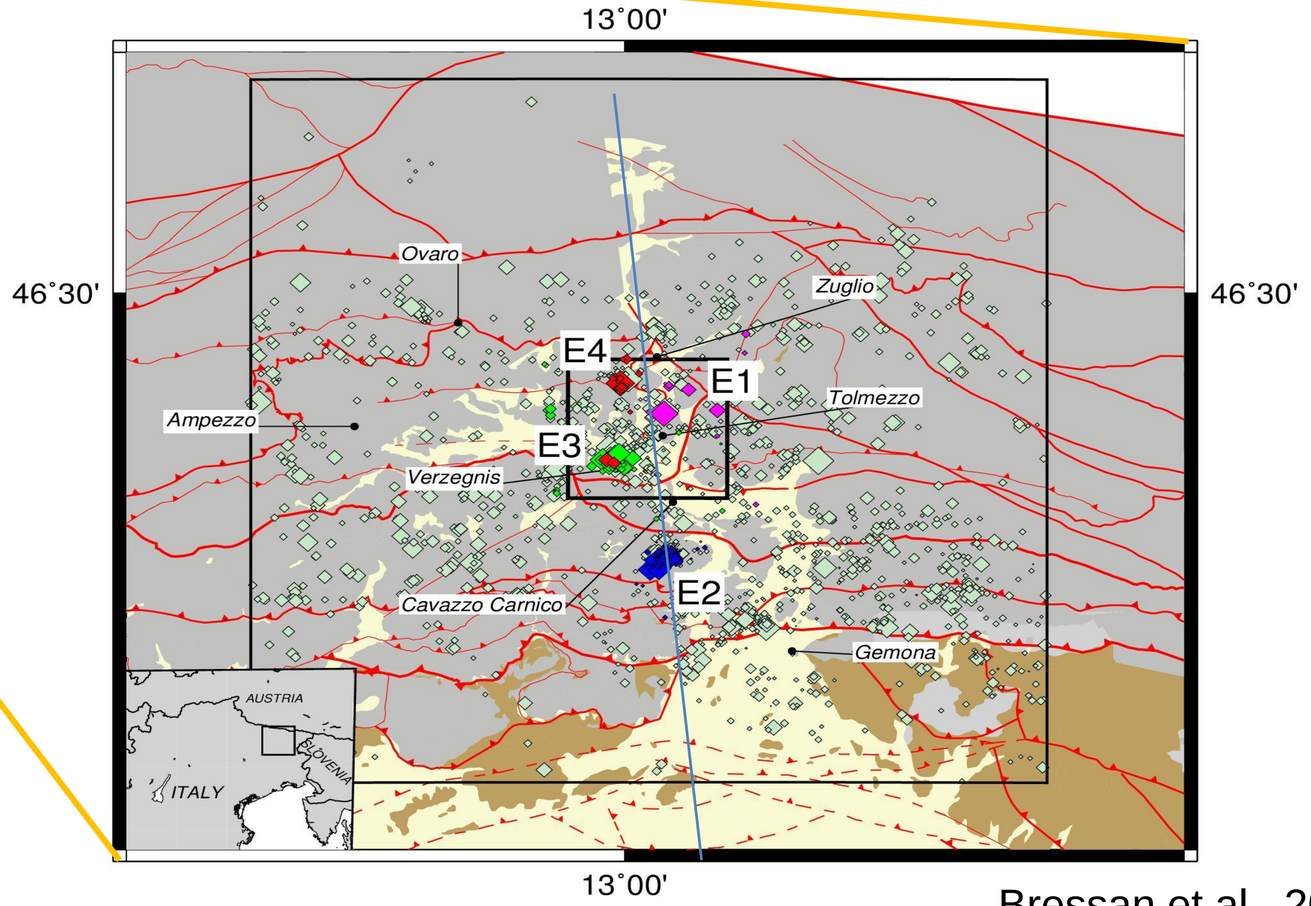
5) 4D Principal Component Analysis: Geometry of the spatial event distribution and propagation direction
   (Rossi and Ebblin, 1990; Bressan et al., 2021)

The area of interest: Tolmezzo area in Northern Adria plate





The Tolmezzo area, after a 15 years period of low seismic activity, was characterized in 2018 and 2019 by an increase of seismic energy, clustered in space and time, bound to four main shocks (E1-E4).



Bressan et al., 2021

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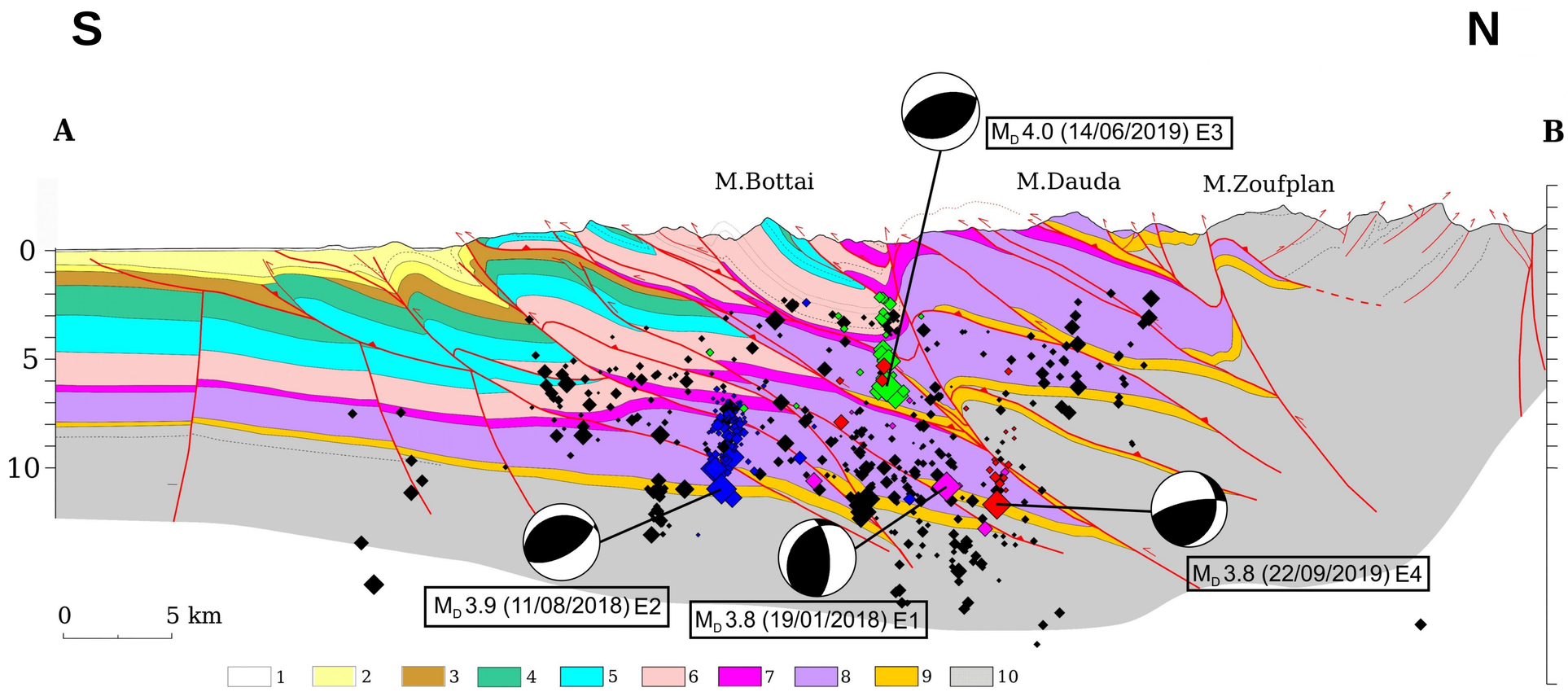

Bressan et al., 2021

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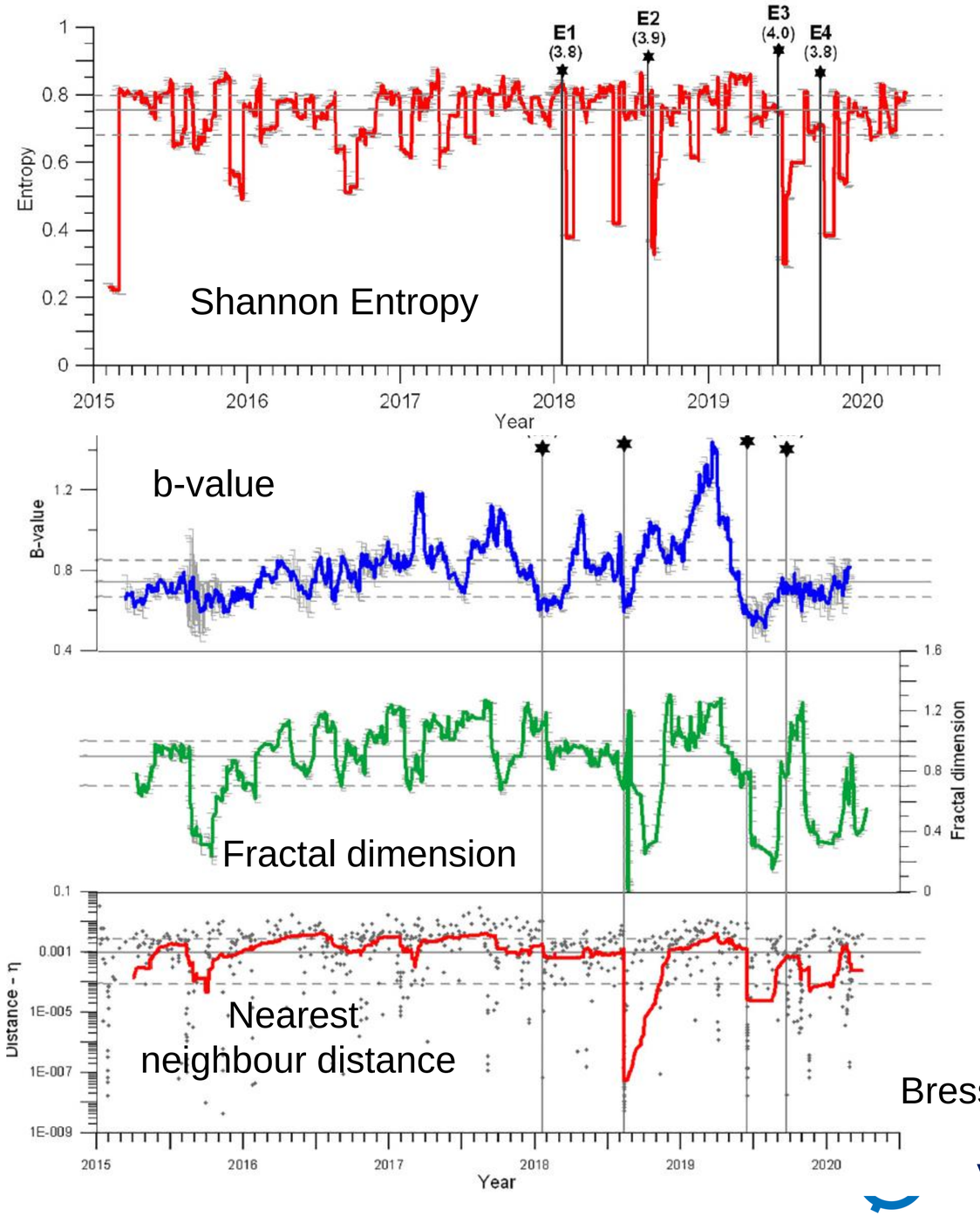


Shannon Entropy decreases after the main shock and for high-energy clusters

b-value increases before the mainshock, and then decreases

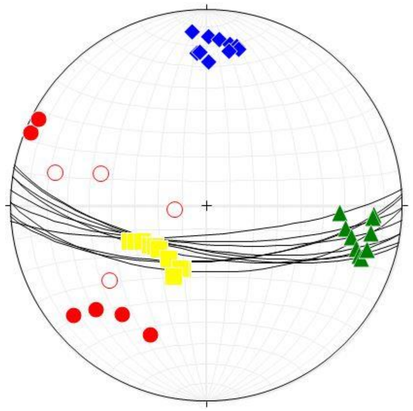
Fractal dimension: decreases after the mainshock

Nearest neighbour distance decreases after the mainshock

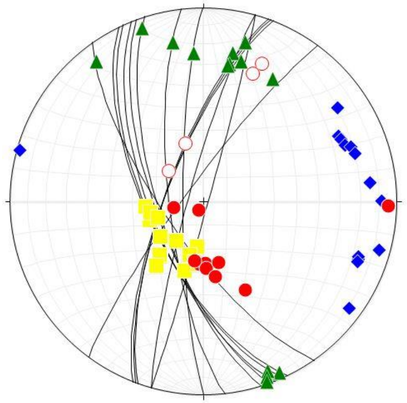
Bressan et al., 2021

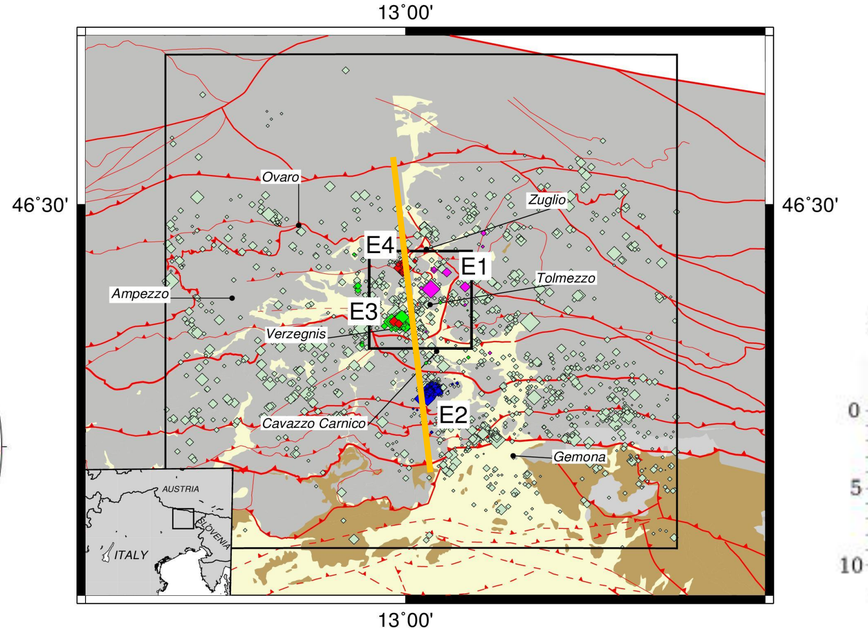
4D Principal Component Analysis

E4

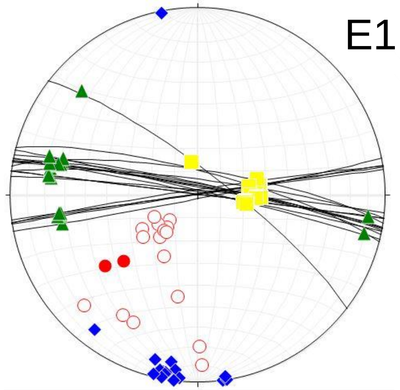


E2





E1 and E3



Bressan et al., 2021

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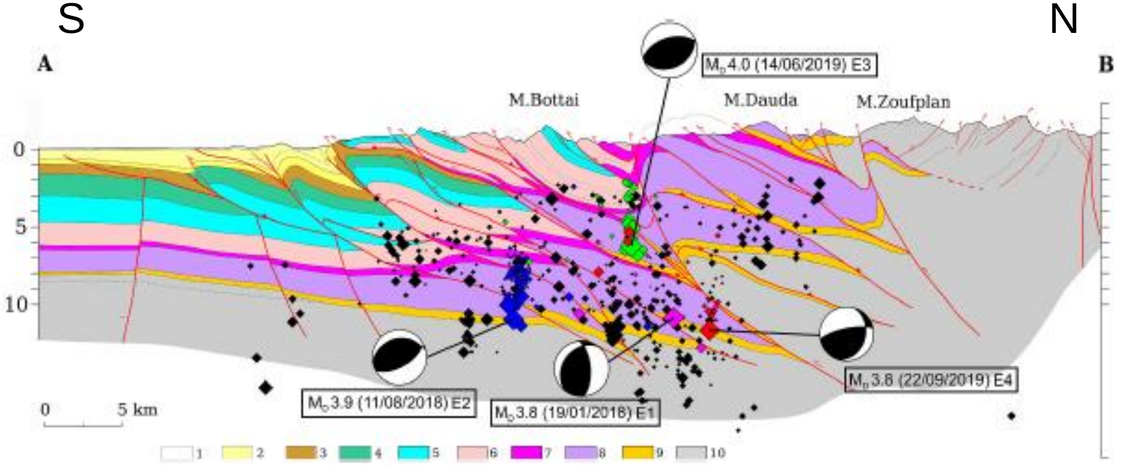

The planes fiting the foci distribution in space do not coincide with the FPS of the main shock, nor to the known faults, but reflect the tendency to upwards propagation of the aftershocks. The propagation direction (red dots, full or empty) is vertical for E2, indicates activation of parallel planes for E1/E3 and the extension of seismicity to other areas (E4).

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Seismicity is bound to damage evolution in heterogeneous rocks:

- b-value variations reflect crustal stress changes in the medium;
- Fractal dimension changes indicate clustering and hence damage localization;
- Shannon entropy and nearest neighbour distance reflect the damage evolution with time due to continuous strain energy redistribution, and hence are related to the memory of past deformations;
- 4D PCA enables to reconstruct the geometry of the seismic event distribution and its time evolution.

THANK YOU!
and for more details:

Bressan, G. et al, 2021. Physics of the Earth and Planetary Interiors, 320, 106787, https://doi.org/ 10.1016/j.pepi.2021.106787.