Spectral inversion for seismic source characterization in Northeastern Italy

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Northeast Italy is a region characterized by moderate to high seismic hazard. The regional seismic activity has been recorded since the late 1970s by both local and national networks, with a progressive expansion in the monitoring coverage after the destructive sequence of the 1976 Friuli earthquake. The recorded seismicity during the last decade, when the networks in the area have reached a stable configuration and high density of stations, is dominated by low to moderate magnitude earthquakes. So far, no comprehensive analysis of the source characteristics for the recorded seismicity at regional level has been made available yet. This study aims at providing an ample characterization of the components that contribute to the regional spectral model, with a focus on the source term, by applying the Generalized Inversion Technique (GIT; Castro *et al*. 1990) to an up-to-date dataset.

A broad, high-quality dataset is assembled based on the selection of all local earthquakes that occurred in the time period 2016 – 2024 in the geographical area of interest ([45 N; 47 N] latitude, [10 E; 15 E] longitude), and recorded by stations within a distance of 130 km from each epicenter. The dataset comprises all data available from the many seismic networks monitoring the area, both permanent and temporary, both accelerometric and velocimetric, for a total of 172 stations . This initial pool of events included ~13500 earthquakes available the National Institute of Oceanography and Applied Geophysics (OGS) bulletins Bulletin of the Seismometric Network of North Eastern Italy (https://www.crs.inogs.it/bollettino_new/). All events are relocated and their local magnitude recalculated for improved homogeneity and accuracy in the focal depth resolution. An accurate preliminary data selection and processing is performed on this initial pool of events, with constraints applied on azimuthal gap (<200°), minimum number of phases per event (12), minimum number of records per event and of events recorded by each station (8), signal to noise ratio of the corresponding S-wave Fourier amplitude spectra (SNR≥2.5). The resulting dataset (Figure 1) consists of 1191 seismic events (1.65<ML<4.55) and 172 stations, with over 20000 spectral amplitude values associated with each frequency in the range 1.2 – 25 Hz. It is

thus considerably expanded with respect to previous studies focused on the same region (e.g. Castro *et al*. 1996, Malagnini *et al*. 2002, Franceschina *et al*. 2006, Klin *et al*. 2021, Cataldi *et al*. 2023), both in terms of number of events and of stations.

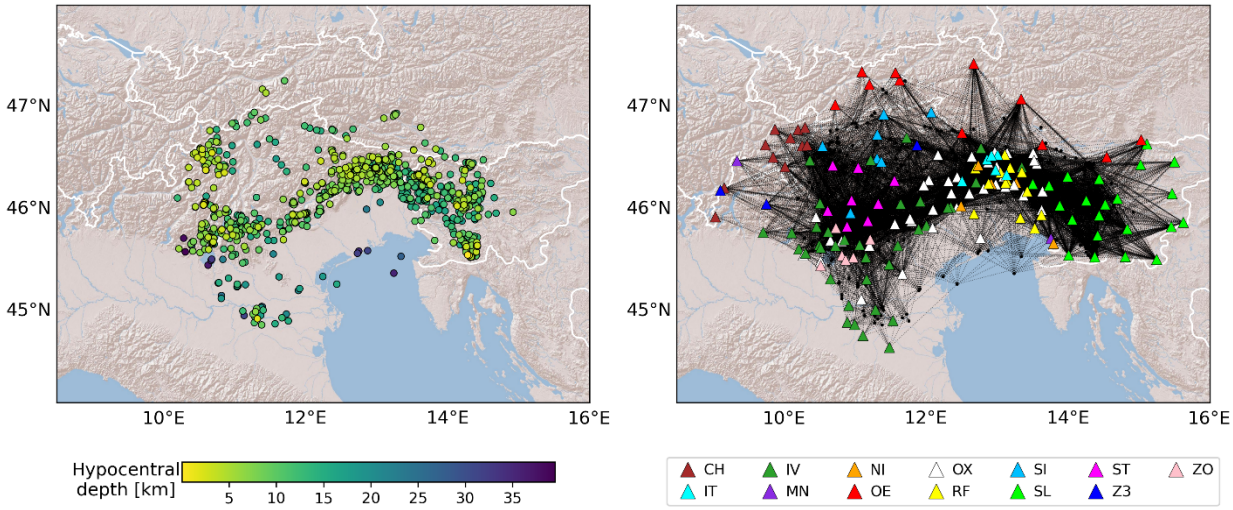

Fig. 1 – The 1191 events included in the dataset used for GIT inversion on Northeast Italy (left), with colour scale corresponding to focal depth. A ray map of the same events (black dots) and the associated recording stations (coloured triangles) is displayed on the right panel.

A nonparametric GIT approach that benefits from the good data coverage over the region is applied to separate the contributions of source, path and site effects (Figure 2), and each term is subsequently analyzed and inverted using standard seismological models. A specific focus is posed on the inversion of source spectra, in order to produce a set of source parameters that can be used to calibrate regional relationships, such as that between seismic moment and local magnitude and between seismic moment and seismic energy. Specifically, S-wave spectra are fitted to the Brune model to obtain seismic moments estimates ranging between 2.1×10^{11} and $2.7 \times 10^{15}\, Nm$. Brune stress drop values are confined to the range from 0.02 and $9.04\, MPa$, with an average value of $0.72\, MPa$ which is consistent with previous studies (e.g. Franceschina et al., 2006). A preliminary analysis of the spatial variability of the resulting source-related parameters is proposed.

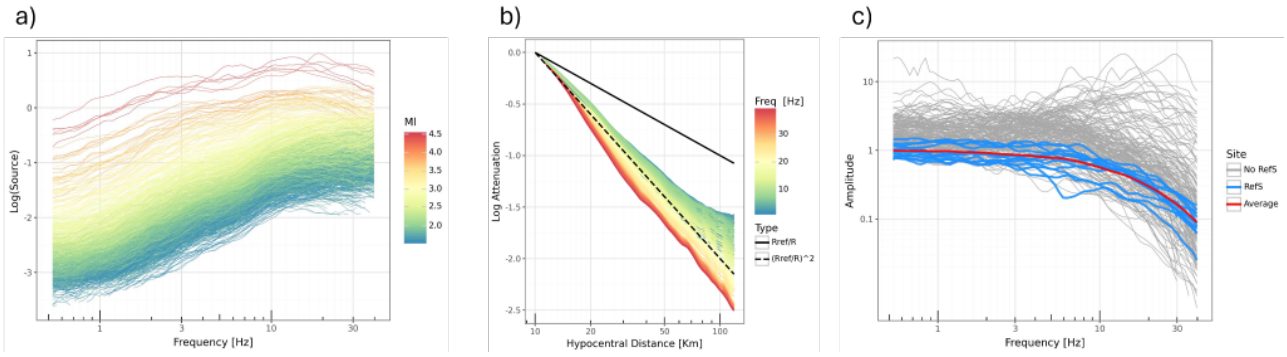

Fig. 2 – The resulting curves obtained from GIT inversion performed on the Northeast Italy dataset for source spectra (a), attenuation curves (b) and site functions (c).

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