

**Brief documentation of the dataset “Lanzano, G., Colavitti L., Sgobba S., Spallarossa D., Pacor F. (2022). CI-FAS\_GMM: Ground Motion Model of the Fourier Amplitude Spectrum ordinates for the shallow active crustal events in Central Italy (Version 1.0) [Data set]. Istituto Nazionale di Geofisica e Vulcanologia (INGV). [https://doi.org/10.13127/CI\\_dataset/CI-FAS\\_GMM](https://doi.org/10.13127/CI_dataset/CI-FAS_GMM)”**

The zip contains several tables that are all related to the ground motion model for PGA (Peak Ground Acceleration) and 69 Fourier Amplitude Spectrum (FAS) ordinates in the frequency interval 0.5 - 25.06Hz<sup>1</sup>, described in Morasca et al. (2022) and Colavitti et al. (2022), that is briefly recalled here:

The assumed functional form for FAS amplitudes at each frequency  $Y$  is:

$$\log_{10}Y = a + F_M(M_w) + F_R(M_w, R_{JB}) + \delta B_e + \delta S2S_{ref,s} + \delta L2L_{source} + \delta P2P_p + \delta W_0 \quad (1)$$

where  $a$  is the offset, while the magnitude  $F_M(M_w)$  and distance  $F_R(M_w, R_{JB})$  scaling's are treated adopting standard dependencies, as:

$$F_M(M) = b_1(M_w - M_h) * (M_w \leq M_h) + b_2(M_w - M_h) * (M_w > M_h) \quad (2)$$

$$F_R(M, R) = [c_1(M_w - M_{ref}) + c_2] \log_{10} \frac{\sqrt{R_{JB}^2 + h^2}}{R_{ref}} + c_3(\sqrt{R_{JB}^2 + h^2} - R_{ref}) \quad (3)$$

The explanatory variables are the moment magnitude  $M_w$  and the Joyner and Boore distance  $R_{JB}$ . The hinge magnitude is  $M_h = 5.0$ , the reference distance is  $R_{ref} = 1\text{km}$  and the pseudo-depth is  $h = 6\text{km}$ .

The random error terms with respect to the median prediction of the GMM in equation (1) and the associated variabilities are defined as follows:

- $\delta B_e$  is the between-event error and  $\tau$  is the associated variability;
- $\delta S2S_{ref,s}$  is the site-to-site term and  $\phi_{S2S}$  is the associated variability;
- $\delta L2L_{source}$  is the location-to-location term and  $\tau_{L2L}$  is the associated variability;
- $\delta P2P_p$  is the path-to-path term and  $\phi_{P2P}$  is the associated variability;
- $\delta W_0$  is the event-, site-, source- and path- corrected term and  $\phi_0$  is the associated variability;

The total variability  $\sigma$  can be computed as:

$$\sigma = \sqrt{\tau^2 + \phi_{S2S}^2 + \tau_{L2L}^2 + \phi_{P2P}^2 + \phi_0^2} \quad (4)$$

The median prediction is calibrated for a reference ground motion level that is observed on two different sets of reference rock sites, that are composed by the 36 sites, identified by Lanzano et al. (2020), and by 6 sites, further subselected by Morasca et al. (2022). This leads to the calibration of two different set of coefficients, random errors and associated standard deviations. Further explanations are available in the papers of Colavitti et al. (2022) and Morasca et al. (2022).

The coefficients, the random errors and the components of the variability are given in the CSVs contained in the zip, that includes:

1. The *Coeff\_36sites.csv* and *Coeff\_6sites.csv* tables include the coefficients of the predictive equation (1) ( $a, b_1, b_2, b_3, b_4, c_1, c_2, c_3, d_1, d_2, M_{ref}$ ) and the variability components ( $\tau, \phi_{S2S}, \tau_{L2L}, \phi_{P2P}, \phi_0$ ) for the model with 36 and 6 reference rock sites, respectively;
2. The *dBe\_36sites.csv* and *dBe\_6sites.csv* tables include the between-event error ( $\delta B_e$ ) for the model with 36 and 6 reference rock sites, respectively. The tables also contain the following event metadata:

<sup>1</sup> The frequencies of the FAS are in the order listed in the tables (Hz): 25.06, 23.66, 22.33, 21.08, 19.91, 18.79, 17.74, 16.75, 15.81, 14.93, 14.09, 13.3, 12.56, 11.86, 11.19, 10.57, 9.98, 9.42, 8.89, 8.39, 7.92, 7.48, 7.06, 6.67, 6.29, 5.94, 5.61, 5.3, 5, 4.72, 4.46, 4.21, 3.97, 3.75, 3.54, 3.34, 3.15, 2.98, 2.81, 2.65, 2.51, 2.37, 2.23, 2.11, 1.99, 1.88, 1.77, 1.67, 1.58, 1.49, 1.41, 1.33, 1.26, 1.19, 1.12, 1.06, 1, 0.94, 0.89, 0.84, 0.79, 0.75, 0.71, 0.67, 0.63, 0.59, 0.56, 0.53, 0.5.

- a) the event internal IDs (field name: *event\_id*); b) the event INGV IDs (*ID\_INGV*); c) latitude (*ev\_latitude*); d) longitude (*ev\_longitude*); e) depth in km (*ev\_depth*); f) local magnitude (*MI*); g) moment magnitude (*Mw*);
3. The *dS2S\_36sites.csv* and *dS2S\_6sites.csv* tables include the site-to-site error ( $\delta S2S_{ref,s}$ ) for the model with 36 and 6 reference rock sites, respectively. The tables also contain the following station metadata: a) FDSN network code (field name: *network*); b) station code (*station\_code*); c) FDSN instrument code (*instrument*); d) latitude (*station\_latitude*); e) longitude (*station\_longitude*); f) flag for the reference rock sites<sup>2</sup> (*reference\_flag*);
  4. The *dL2L\_36sites.csv* and *dL2L\_6sites.csv* tables include the location-to-location error ( $\delta L2L_{source}$ ) for the model with 36 and 6 reference rock sites, respectively. The tables also contain the area sources IDs (field name: *source\_id*), on the basis of the event clusters identified by Sgobba et al. (2021) and also adopted by Morasca et al. (2022);
  5. The *dP2P\_36sites.csv* and *dP2P\_6sites.csv* tables include the path-to-path error ( $\delta P2P_p$ ) for the model with 36 and 6 reference rock sites, respectively. The tables also contain the following source-to-site path metadata: a) path IDs (field name: *path\_id*), univocally identified by the coupling of the area source ID and the ID of a destination cell obtained from a regular grid in the study area (further details in Sgobba et al. 2021 and Morasca et al. 2022); b) the mean latitude of the destination cell (*path\_lat*); c) the mean longitude of the destination cell (*path\_lon*);
  6. The *dW0\_36sites.csv* and *dW0\_6sites.csv* tables include the event-, site-, source- and path- corrected ( $\delta W_0$ ) for the model with 36 and 6 reference rock sites, respectively. The tables also contain the following record metadata: a) the event internal IDs (field name: *event\_id*); b) the event INGV IDs (*ID\_INGV*); c) event latitude (*ev\_latitude*); d) event longitude (*ev\_longitude*); e) event depth in km (*ev\_depth*); f) local magnitude (*MI*); g) moment magnitude (*Mw*); h) FDSN network code (*network*); i) station code (*station\_code*); l) FDSN instrument code (*instrument*); m) station latitude (*station\_latitude*); n) station longitude (*station\_longitude*); o) flag for the reference rock sites<sup>3</sup> (*reference\_flag*).

## Reference

- Colavitti L., Lanzano G., Sgobba S., Pacor F., Gallovič F. (2022). Empirical Evidence of Directivity Patterns for Small-to-Moderate Earthquakes on Normal Faults: The Study Case of Central Italy. *Journal of Geophysical Research: Solid Earth* (submitted).
- Lanzano G., Felicetta C., Pacor F., Spallarossa D., Traversa P. (2020). Methodology to identify the reference rock sites in regions of medium-to-high seismicity: an application in Central Italy. *Geophysical Journal International*, 222(3), 2053–2067 DOI: 10.1093/gji/ggaa261.
- Morasca P., D'Amico M., Sgobba S., Lanzano G., Colavitti L., Pacor F., Spallarossa D. (2022). Empirical correlations between a FAS non-ergodic ground motion model and a GIT derived model for Central Italy. *Geophysical Journal International* (submitted).
- Sgobba S., Lanzano G., Pacor F. (2021). Empirical non-ergodic shaking scenarios based on spatial correlation models: an application to central Italy. *Earthquake Engineering and Structural Dynamics*.

<sup>2</sup> the flag is 0 for the reference rock sites and 1 otherwise.

<sup>3</sup> the flag is 0 for the reference rock sites and 1 otherwise.