Magnitude scales, attenuation models and feature matrices for the IPOC catalog

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1 License and Citation

> Münchmeyer, J., Bindi, D., Sippl, C., Leser, U., Tilmann, F. (2019): Magnitude scales, attenuation models and feature matrices for the IPOC catalog. GFZ Data Services. http://doi.org/10.5880/GFZ.2.4.2019.004

The data are supplementary material to:

> Münchmeyer, J., Bindi, D., Sippl, C., Leser, U., Tilmann, F. (2019): Low uncertainty multi-feature magnitude estimation with 3D corrections and boosting tree regression: application to North Chile. Geophysical Journal International. http://doi.org/10.1093/gji/ggz416

2 Data description

In Münchmeyer et al. (2019) magnitudes scales for Northern Chile have been derived with a focus on low uncertainties. The data set consists of three parts. First, a version of the IPOC catalog with the derived magnitude scales ML and MA and their uncertainties. Second, the attenuation functions for different waveform features. Third, the full matrix of features and the resulting single station magnitude predictions. The underlying IPOC catalog was obtained from Sippl et al. (2018b) as derived in Sippl et al. (2018a) .
The catalog and feature matrix are provided in csv format. The correction functions are provided as Pickle files. Source code for handling the correction functions is available at `https://github.com/yetinam/magnitude-calibration`.

3 Model description

We model the attenuation through the following relationship:

$$Y_s^e - M^e = \Gamma(r_s^e, d^e) + L_s(p^e) + B_s + \varepsilon_s^e \tag{1}$$

- e: event
- s: station
- Y: measured featue
- M: magnitude

- γ: attenuation correction
- L: source correction
- B: station bias
- r: epicentral distance between event and station
- d: event depth
- p: event hypocenter
- ε: aleatoric variability

The attenuation function Γ is defined as a two dimensional non-parametric function on a grid of epicentral distances and depth values. We use a grid G with 50 linearly spaced distance values between 20 and 500 km and 20 linearly spaced depth values between 10 and 200 km. Values between the grid points are interpolated bilinearly between the four adjacent values.

The correction for a single event is defined through the correction terms l of the $k = 10$ nearest neighbors:

$$L_s(e) = \frac{1}{k} \sum_{e' \in \text{kNN}(e, \bar{E}_s)} l_s^{e'} \tag{2}$$

Here $\text{kNN}(e, \bar{E}_s)$ is the set of the k nearest neighbors of e in $\bar{E}_s$. As distance metric we use the euclidean distance between the hypocenters, but weight the depth difference with a factor of 3, to account for the high importance of the depth.

For further details on the correction functions, please consult the publication.

4 Description of data files

IPOC_catalog_magnitudes.csv

IPOC catalog with magnitudes and uncertainties. Columns (only non-self explainatory columns):

- *cls*: class of the event as defined by Sippl et al. (2018)
- *MA, std_MA, ML, std_ML*: magnitude estimates for M_A and M_L and their standard deviations

IPOC_features.csv.gz

Feature matrix for the IPOC catalog. Most column names are composed of multiple underscore separated parts:

- *DISP, VEL, ACC, WA, ENG* indicate if the feature is derived from displacement, velocity, acceleration, Wood-Anderson or energy
- *Z, R, T, NE, ZNE* at the end of a trace refer to the components used. *NE* and *ZNE* are the combinations of the horizontal respectively all components.

- *P* in the second last position indicates that a feature was extracted on the P wave only. If no indication is given, the feature is from the full wave.
- *ENV5* and *ENV20* denote the 5 s and 20 s envelope values.
- *PRED* indicates the single station prediction after the application of the respective correction functions.
- *MEAN* refers to the mean across all stations for one event.

models/

The directory contains the correction functions for each feature. Files are named indentically as the features in the feature matrix. Models are in Pickle format. Each file contains a tuple of station biases, attenuation function, source correction and grid for the attenuation function. For usage examples please consult the source code at `https://github.com/yetinam/magnitude-calibration`.

References

Sippl, C., Schurr, B., Asch, G., and Kummerow, J. (2018a). "Seismicity Structure of the Northern Chile Forearc From >100,000 Double-Difference Relocated Hypocenters". *J. Geophys. Res. Solid Earth* 123.5, pp. 4063–4087. ISSN: 2169-9356. DOI: 10.1002/2017JB015384.

Sippl, C., Schurr, B., Asch, G., and Kummerow, J. (2018b). "Catalogue of Earthquake Hypocenters for Northern Chile Compiled from IPOC (plus auxiliary) seismic stations". *GFZ Data Services*. DOI: 10.5880/gfz.4.1.2018.001.