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Site classification of Italian accelerometer stations from analysis of residuals of GMPE application to the national seismic database

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Ground motion prediction equations (GMPE) are a basic tool for seismic hazard assessment, in that they provide an empirical method to estimate ground shaking expected for future earthquakes of given magnitude and distance. The calibration of these relationships relies on seismic databases derived from accelerometer large-scale networks. However, locally recorded shaking are strongly influenced by site effect that can cause ground motion amplification phenomena. This has led to introduce, in data processing, some type of site classifications, typically expressed in form of soil categories, or to adopt some parameter representative of site propensity to amplification, e.g. the mean velocity of shear-waves over the upper 30 meter of subsoil (Vs30). Soil categories defined from geological evaluations, possibly supported by Vs30 measurements, or even, directly, the same Vs30 values, have been thus proposed among the explanatory variables of GMPE, which implies the need of a classification of accelerometer sites whose data are used for GMPE calibration. In the last decade, however, several doubts have been raised about the effectiveness of Vs30 as a proxy of seismic amplification and, more in general, on the reliability of anticipatory site classifications, preceding the direct observation of site response to seismic shaking. Since the Italian National accelerometer network has accumulated a great deal of recordings, it would be now possible to base station classification on a statistical analysis of such data. In particular, we propose a method based on the application of GMPEs to the events recorded and on an analysis of residuals resulting from the comparison between observed and predicted values of shaking parameters. In view of an effort for GMPE optimisation, the effectiveness of the resulting classification, in comparison with the pre-existing ones, was tested subdividing the accelerometer database into a “training” and a “validation” dataset. The former was used for the calibration of GMPEs having different functional forms, whereas the latter was used to compare the predictive efficacy of the different functional forms when employed on data different from those used for the calibration. Tests were focused, in particular, on GMPE predicting peak ground acceleration (PGA) and peak ground velocity (PGV). After having calibrated GMPEs not including a term representative of site effect, a cluster analysis was applied to the residuals in order to redefine the accelerometer station classification based on the minimisation of the rms of differences of residuals relative to single stations from the average value of each class. Then, the new classification was applied to the calibration of GMPE including explanatory variables representing the site classes. The effectiveness of the introduction of such variables in the GMPE functional form was checked applying GMPE with or without such variables to the validation dataset. Test results showed that, while for PGV the introduction of site terms actually improve the GMPE predictive capacity, this does not occur for PGA, for which the site amplification factor shows a strong variability depending on event magnitude and distance, so that its influence on ground motion cannot be effectively modelled without introducing a dependence on event characteristics.