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On the comparison between physics-based numerical simulations and observations from real earthquakes

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Physics-based numerical simulations of earthquake ground motion, including a full 3D seismic wave propagation model from the source to the site, are expected to become, in near future, the most promising tool to generate ground shaking scenarios from future realistic earthquakes. These simulation methods are, in fact, able to model within a single computational domain all factors that affect earthquake ground motion, i.e.: the features of the seismic fault rupture, the propagation path in heterogeneous Earth media, directivity of seismic waves, complex site effects due to localized topographic and geologic irregularities, variability/specificity of soil properties at a regional and local scale.

Stimulated by the increasing availability of computational resources, such sophisticated tools are now mature enough to provide realistic estimates of earthquake ground motion in a variety of geomorphological conditions and to favor a deeper understanding of the effect of the main physical parameters on ground shaking and on its spatial variability. Nevertheless, to be accepted and used by the engineering community as an alternative tool to standard empirical approaches (i.e., Ground Motion Prediction Equations) and within a Probabilistic Seismic Hazard Assessment (PSHA) framework, physics-based numerical simulations still need further validation studies, i.e. to compare with observations from real earthquakes.

In this contribution, we summarize the experience and the most salient results of the 3D numerical modelling work carried out by a high-performance spectral element code, SPEED (http://speed.mox.polimi.it/), developed at Politecnico di Milano, to simulate real earthquakes which occurred in Europe. Specifically, the following case studies will be presented:

- the May 29 2012 M_W 6.0 Po-Plain earthquake, Northeastern Italy;
- the April 6 2009 M_W 6.3 L'Aquila earthquake, Central Italy;
- the June 20 1978 M_W 6.5 Volvi earthquake, Northeastern Greece.

In the discussion of the results, emphasis will be placed on the comparison with earthquake recordings and empirical soil amplification functions, impact of the input parameters regarding the kinematic seismic source and the soil model on numerical predictions, the comparison with GMPEs, and the analysis of the spatial variability of earthquake motion in near-fault conditions and complex geological configurations.