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Ground-motion simulation of a major historical earthquake in the French Pyrenees from instrumental data

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Although the Pyrenean range is characterized by a moderate seismic activity, it has been affected by strong earthquakes in the past. One of the most destructive event occurred in the Bigorre region (Central French Pyrenees) on June 21, 1660, with a maximum macroseismic intensity of IX and a magnitude 6.1 inferred from isoseists. If such an earthquake were to occur today, it would be more likely to produce more destruction, because of the higher population density. Thus, it is of utmost importance to study the seismic risk in this region.
The aim of this study is to generate ground-motion simulations of the historical M=6.1 earthquake, from instrumental data of two recent smaller earthquakes (the November 17, 2006, Ml=5.0 earthquake and the November 15, 2007, Ml=4.1 earthquake). These events occurred in the suspected epicentral area of the 1660 historical earthquake and were recorded by a large number of stations in the region of interest. We used a simulation method based on empirical Green's functions (EGF) principle. It consists in simulating ground-motions produced by a large earthquake by using stochastic summation of small earthquake recordings regarded as EGF. This method has the advantage of incorporating wave-propagation effects and site effects.
We first used the Ml=4.1 earthquake as an empirical Green's function in order to reproduce the Ml=5.0 earthquake. Afterward, we simulated the ground-motions generated by a magnitude 6.1 earthquake using successively the Ml=4.1 and Ml=5.0 earthquakes.
We first analyzed the displacement waveforms obtained from accelerometric and broadband vertical records, in order to determine the corner frequencies and the stress drop ratio between the EGF and the target event (a crucial parameter in this simulation). Using simple spectral ratios, we found a clear directivity effect of the rupture process for the Ml=5.0 earthquake. Hence, this led us to investigate how this directivity effect can be taken into account or can be removed in our simulation method. The simulation results obtained for the magnitude 6.1 event are then compared with different empirical ground-motion prediction models on rock site stations in order to calibrate the stress drop ratio parameter to be used. The acceleration response spectra are compared to those recommended by the French regulation (deduced from the EC8) for similar soils.