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High frequency directivity effect for a Mw 4.1 earthquake (Barcelonnette event, 2012), widely felt by the population

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Can the directivity effect of a rupture process be detected by the population 100 km away for a moderate size Mw 4.1 earthquake? The February 26th 2012, earthquake that occurred in the French Alps proved that it can !
During the night of February 26, 2012, the inhabitants and winter holidaymakers of the Vallée de l'Ubaye in the French Alps were woken by a brutal vibration due to an earthquake. This event that occurred at 8km depth was widely felt in the epicentral area and caused some light damage to houses (25 chimneys were broken, and a great deal of non-structural damage was detected). This event occurred in a mountainous area populated only by villages or small cities, the two largest cities (Grenoble and Nice) being both situated about 100 km from the epicenter. A rapid inspection of the macroseismic intensity values (collected by the BCSF) estimated in both cities immediately proved the fact that this event was much more felt in Nice and its surroundings than in Grenoble.
This discrepancy is very well correlated with Peak Ground Acceleration (PGA) values measured on the 16 accelerograms of the RAP network (Réseau Accélérométrique Permanent Français) in the two cities, the values measured in Grenoble being in average 8 times smaller than the one measured in Nice (smaller PGA value in Nice/ smaller PGA value in Grenoble, on good rock sites). A factor 10 was also observed inside both cities due to site effects, which results in a variability that reaches a factor 60 between the smallest and the largest PGA values recorded at 100km.
In order to explain these observations, we selected French and Italian broad band stations in different azimuths and deconvolved the mainshock velocity recordings by the one of an aftershock (Mw 2.3) taken as empirical Green's function. The apparent source time functions obtained clearly show that the Barcelonnette event had a strong directivity effect of its rupture process. We found, using a simple linear source model inversion that the rupture propagated toward the direction N155° during 0.85 seconds on a 1.9-km-long fault. This direction is coherent with one nodal plane of the focal mechanism we have found for this event.

This study highlights the fact that, even for moderate size earthquakes, directivity effect plays a main role in the generation of ground motions and also in the spatial distribution of macroseismic intensities. This last point has to be taken into account for the analysis of historical earthquakes, because it may lead to an over- or under-estimation of the magnitude.