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Improving the location performance of a seismic network through the SNES method

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Seismic networks are powerful tools for understanding active tectonic processes in monitored seismically active regions. The magnitude of completeness and the accuracy of hypocenter location estimates are highly dependent on the network geometry, density and noise level. To improve the location performance of a seismic network in areas of high seismicity, or to better monitor the aftershocks following strong earthquakes, an improvement of the seismic network around the epicentral area is necessary. Planning the installation of a new seismic station is a tricky stage. It is important to select sites that maximize the location performance in a target volume. In areas with high seismic hazard, it is useful to prepare "a priori" network optimization procedures based on realistic earthquake scenarios.
In this paper we apply the SNES method (D'Alessandro et al., 2011) to the INGV Italian National Seismic Network (RSN-INGV) to maximize the accuracy of location estimates in the epicentral area of the recent L'Aquila earthquake (2009, Mw 6.3), and other regions where large earthquakes might occur. The SNES method gives, as a function of magnitude, hypocentral depth and confidence level, the spatial distribution of the: number of active stations in the location procedure and their relative azimuthal gaps along with confidence intervals in hypocentral parameters and magnitude of completeness.
We select a target volume containing the hypocenter of the L'Aquila mainshock and most of its strongest aftershocks. The target magnitude was determined on the basis of the current magnitude of completeness of the RSN-INGV in this volume. We choose as objective function the volume of the confidence ellipsoid of the hypocenter location. In the simulation, we add a new seismic station at the nodes of a regular grid of 1 km side covering the target area and determine the mean reduction of the confidence ellipsoid for the target volume. The first theoretical best site is the one involving the maximum reduction of the location error. After the validation of the site, checking the real possibility of station installation, the theoretical station is added at the RSN-INGV. Then we start seeking the second theoretical best site in the same way, and so on for the other sites. We indentify the first six best sites and compare the location performance of the RSN-INGV, before and after their theoretical deployment.
Soon after the L'Aquila mainshock many seismic stations of the mobile network were installed in the area, six of which are still in operation. We compare the improvement of the location performance after the installation of these six stations to that obtained using the six best theoretical sites indentified with the SNES method. We show that the SNES method is a valid support to select new sites for seismic network optimization.
We also show some applications of the method to other critical regions of the INGV permanent network.