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How seismological and geodetic tools can jointly contribute to the understanding and forecasting of earthquakes

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Long-lasting practice and results obtained for the Italian territory in two decades of rigorous prospective testing of fully formalized algorithms (e.g. CN), support feasibility of earthquake forecasting based on the analysis of seismicity patterns at the intermediate-term middle-range scale. The algorithms permit to deal with multiple sets of seismic transients and allow for the identification of the region and time interval where a strong event is likely to occur. Based on routinely updated space-time information provided by the forecasting algorithms, an integrated procedure has been developed for the definition of time-dependent seismic hazard scenarios at the bedrock through realistic modeling of ground motion by the neo-deterministic approach (NDSHA).
A first attempt to jointly use seismological tools, like CN and NDSHA on one side, and geodetic methods and techniques, like GPS and SAR, on the other, to constrain priority areas where to concentrate prevention and seismic risk mitigation, was made in the framework of project SISMA funded by Italian Space Agency. Here a novel scheme for the integrated use of seismological and geodetic information is proposed, based on the retrospective analysis of both SAR and GPS data (including stability tests) preceding the Central Italy seismic crisis, which started on 24 August 2016 with the Amatrice earthquake. Differently from the common approach, GPS data are not used to estimate the standard 2D velocity and strain field in the area, but to reconstruct the velocity and strain pattern along transects, properly oriented according to the known tectonic setting. SAR data related to the Amatrice earthquake co-seismic displacement are used as independent check of the GPS results.
Considering properly defined transects within the area alarmed by CN algorithm, it is possible to highlight the velocity variation and the related strain accumulation in the area of Amatrice event. Some counter examples, across CN alarmed and not-alarmed areas, do not show any spatial acceleration localized trend, comparable to the one well defined along the Amatrice transect.
The analysis has been recently updated and expanded to further recent earthquakes (including the 2012 Emilia earthquake), and tools have been developed to allow for a systematic analysis of the velocity variations along a number of transects, properly located according to the tectonic and seismological information. The results obtained so far show that the combined analysis of the results of intermediate term middle range earthquake prediction algorithms, like CN, with those from the processing of adequately dense and permanent GNSS network data, possibly complemented by a continuous InSAR tracking, may allow the routine highlight in advance of the strain accumulation. Therefore the extent of the alarmed areas, identified based on seismicity patterns at the intermediate scale (i.e. few hundred kilometers), can be significantly reduced.