EGU2020-18302
https://doi.org/10.5194/egusphere-egu2020-18302
EGU General Assembly 2020

Intermediate-term narrow-range earthquake forecasting: an interdisciplinary tool based on seismological and geodetic observations

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A novel forecasting tool, able to fully exploit the information content of the available data, is proposed for the synergic use of seismological and geodetic information, in order to delineate, at the intermediate-term narrow-range, the regions where to concentrate prevention actions and seismic risk mitigation planning. An application of the proposed interdisciplinary procedure, defining a new paradigm for time dependent hazard assessment scenarios, is exemplified illustrating its application to the Italian territory.

From seismological viewpoint, long-lasting practice and results obtained for the Italian territory in two decades of rigorous prospective testing of fully formalized algorithms (e.g. CN), proved the feasibility of earthquake forecasting based on the analysis of seismicity patterns at the intermediate-term (i.e. several months) middle-range scale (i.e. few hundred kilometers). An improved but not ultimate precision can be achieved reducing as much as possible the space-time volume of the alarms, by jointly considering seismological and geodetic information. In the proposed scheme geodetic information (i.e. GNSS and SAR) are used to reconstruct the velocity and strain pattern along transects properly oriented according to the a priori known tectonic and seismological information. Specifically, considering properly defined transects within the regions monitored by CN algorithm, the possible velocity variations and the related strain accumulation can be highlighted, with due consideration of the errors involved in GNSS data.

Through a refined retrospective analysis, duly involving the accuracy analysis of the newly available geodetic results, spacetime precursory features could be highlighted within ground velocities and seismicity, analyzing the 2016-2017 seismic crisis in Central Italy and the 2012 Emilia sequence. The analysis, including counter examples, evidenced reliable anomalies in the strain

rate distribution in space, whereas no time dependence was detected in the long term (more than 10 years) preceding the occurrence of the studied events.

With these results acquired, a systematic analysis of velocity variations (together with their accuracy) is performed, by defining a set of transects uniformly distributed, as far as possible, along and across major seismotectonic features of the Italian region, with a spacing of about 40-50 km and properly covering the regions monitored by CN algorithm. As a rule most of the transects contain information that appear to be useful for earthquake forecasting purposes. The few exceptions, naturally connected with the local very limited extension of land, are in Calabria and Western Sicily.

The obtained results show that the combined analysis of the results (time dependent within decadal interval) of intermediate-term middle-range earthquake prediction algorithms, like CN, with those from the processing of adequately dense and permanent GNSS network data (time independent within the same decadal interval), may allow to highlight in advance the localized strain accumulation. Accordingly the extent of the alarmed areas, identified based on seismicity patterns at the intermediate scale can be significantly reduced (from few hundred to few tens kilometres).