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A new integrated approach to seismic network optimization

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A seismic network is usually deployed to monitor the seismicity, to locate earthquakes and compute source parameters. The network configuration is crucial due to the important implications on the quality of the information that can be obtained, therefore, it requires a detailed study in order to maximize the information-to-cost ratio.
Fundamental, for the network optimization, is the clear definition of the goals which must be reached, the experimental constraints and the physical relationship between data and model. In order to maximize the performance of a particular design a quantitative measure of such performance must be defined. Once a quality function has been rigorously defined for each individual goal, an optimization criterion can be defined, which maximizes it. In particular, for the seismic location problem such criterion may be based on the minimization of the statistical location errors. A similar criterion of error minimization can be equivalently used for moment tensor determination, double-couple focal mechanisms estimation, scalar source parameters determination, etc.
We present here suitable algorithms developed and tested for network optimization. As optimization parameter, we propose to use the ratio between the larger to the smaller eigenvalue of the information matrix. Such ratio is proportional to the ratio between solution and data errors, i.e. it represents the amplification factor which propagates data errors into the solution. The optimization problem tries to define, among a set of M possible sites, which are the N ones (with $N<M$) that minimize a weighted combination of the location errors for a set of simulated earthquakes. The problem to choose, among M possible sites, the most suitable subset represents the most general and practical problem in which seismologists must decide where to install a set of N sensors, among a larger number M of possible sites. The developed algorithms allow both to improve an existing network or to design a new one, considering different earthquake positions and different noise levels for the station sites. The optimization for moment tensor solutions is also implemented, by formally defining the inverse problem in matrix form.
The algorithms are then tested and applied to optimize the network of Campi Flegrei.