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Optimizing the model resolution in the inversion of geodetic data

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In this work we present a new algorithm for an automatic subdivision of a seismogenic fault into patches whose size is varied according to the resolution power of the data. Objective of the algorithm is the retrieval of a slip distribution over a set of patches that are perfectly solved by the data, avoiding the introduction of mathematical artefacts or the loss of slip details.
The study of a seismogenic fault by means of geodetic data (DInSAR and GPS) is in general carried out with non-linear modelling procedures, searching for the fault geometry, under the assumption of a uniform dislocation. The slip distribution is then calculated via linear inversion by dividing the dislocation plane into patches. The latter are in general equally sized or manually adjusted according to some criteria, like a checkerboard test or an empirical dependence from the depth. In any case, it is very likely to over- or underestimate the correct patch size that can be resolved by data; where the patch dimension is too small, the use of a priori constraints to avoid unrealistic slip fluctuations is required.
The accurate assessment of slip distributions has important implications in the study of the static stress redistribution with the CFF (Coulomb Failure Function), which in turn is one of the parameters for the estimation of time-dependent seismic hazard.
Actually, data distribution, data variance and covariance, geometry and mechanism of the source, number of free parameters and model appropriateness, all contribute to define the smallest detail achievable in the linear inversion. We developed an algorithm that, accounting for these factors, splits the main fault into patches of variable size by keeping the model resolution matrix close to the identity matrix, while maximizing the number of patches. The algorithm is based on the iterative adjustment of the fault subdivision and the dumping of the Green's function matrix via Singular Value Decomposition. A Quality Index is introduced to assess the suitability of the chosen subdivision and can be used to compare any type of subdivision.
We show the performance and results for several test cases, characterized by different fault mechanisms, magnitudes and data availability.