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Inversion of slip distribution from co-seismic deformation data by a sensitivity-based iterative fitting method

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Over the past two decades revolutionary improvements have been made in the detection of ground deformation and computer simulation of associated crustal stress and strain. Especially, since differential InSAR and continuous GPS monitoring have established as standard tools, crustal deformation can be measured at millimeter accuracy. Due to space geodesy, a large set of co-seismic deformation data are available for many recent major earthquakes and provide important constraints on the subsurface fault structure. Here we discuss necessary improvements of the simulation method. Different tools based on the method of least-squares fitting have been developed to inverse the slip distribution from the high-precision geodetic data. However, the least-squares method in its traditional form is known to be sensitive to a number of factors including errors in the data, the number and the size of sub-faults (patches), so that slip models may exhibit unrealistic oscillations. Therefore, artificial conditions like smoothing and optimal patch sizing are usually required. Consequently, information provided by the data may not be used optimally. To overcome these disadvantages, we propose a sensitivity-based iterative fitting approach. For a given fault plane, we first calculate the sensitivity of the data to slip at each fault patch, where the sensitivity is defined by the portion of the data which can be explained per unit slip at that single patch. Assuming that the slip distribution is correlated with the sensitivity function, we obtain a first-order approximation of the slip pattern. Then we scale the slip amplitude so that it best fits the data in the least-square sense. To get higher order approximation, the fitting procedure is iteratively applied to the residual data until the rms (root of mean square) residual decreases to certain minimum. We apply the

sensitivity-based fitting method to inverse the slip distributions of, e.g., the 2003 Mw 6.5 Bam (Iran), the 2007 Mw 8.0 Pisco (Peru), and the 2007 Mw 7.7 Tocopilla (Chile) earthquakes. Compared with the traditional method of least-squares, the new method is considerably faster and less sensitive to errors in the data and particularly, it can achieve an optimal slip resolution without any artificial conditions.