Determination of regional stress tensors from fault-slip data

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Stress tensors are almost routinely determined from fault-slip and/or earthquake mechanism data in structural geology and seismotectonics. The inverse problem is nonlinear, unless empirical rules of rupture and friction are employed. All the methods to determine the stress tensor to this nonlinear inverse problem are of local nature, and thus cannot guarantee to produce the global optimal stress tensor. We will apply a hybrid global optimization method to find the global optimal stress tensor, which was recently developed by Xu (2002, J comput appl Math, 147, 301-314) and Xu (2003a and b,J comput appl Math, both in press, see the journal website of Elsevier). Although the inverse problem is nonlinear, the effect of nonlinearity on the biases of stress tensors has not been investigated. We will examine the biases of the inverted stress tensors and their effect on the principal orientations of stress and the shape parameter of the stress ellipsoid. The biases of stress parameters have been shown to be comparable with the estimated stress parameters numerically. We compare the accuracy of four stress parameters, with and without taking the errors of fault planes into account. If the errors of fault planes are not taken into account, the stress parameters are optimistically estimated by a factor of four to nine in the example. We will also mathematically reformulate the assumption that the directions of maximum shear stress represent those of slips on fault planes as two functionally independent but equivalent constraints of equality. The new formulation is computationally more effective and provides a correct method to calculate the accuracy of stress parameters.