Geophysical Research Abstracts
Vol. 17, EGU2015-1458, 2015
EGU General Assembly 2015

Three-dimensional finite-element modelling of horizontal surface velocity and strain patterns near thrust and normal faults during the earthquake cycle: implications for interpreting geological and geodetic data

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In recent years, more and more geological and space-geodetic data on the surface deformation associated with earthquakes on intra-continental normal and thrust faults have become available. Here we use three-dimensional finite-element models that account for gravity, far-field ("regional") extension/shortening and postseismic relaxation in a viscoelastic lower crust to quantify the surface deformation caused by an Mw 7 earthquake on a dip-slip fault. The coseismic deformation is characterized by horizontal shortening in the footwall of the normal fault and extension in the hanging wall of the thrust fault – consistent with elastic dislocation models, geological field observations and GPS data from earthquakes in Italy and Taiwan. During the postseismic phase, domains of extensional and contractional strain exist next to each other near both fault types. The spatiotemporal evolution of these domains as well as the postseismic velocities and strain rates strongly depend on the viscosity of the lower crust. For viscosities of 1e18-1e20 Pa s, the signal from postseismic relaxation is detectible for 20-50 years after the earthquake. If GPS data containing a postseismic relaxation signal are used to derive regional rates, the stations may show rates that are too high or too low or even an apparently wrong tectonic regime. By quantifying the postseismic deformation through space and time, our models help to interpret GPS data and to identify the most suitable locations for GPS stations.