Abstract

Precise documentation of the spatial pattern and magnitude of surface slip produced co-seismically in earthquakes, and in the post- and inter-seismic phases of the seismic cycle, is essential for understanding the mechanics of how faults slip. Modern techniques in satellite geodesy, such as GPS and InSAR, provide powerful tools for retrieving surface displacements at high precision produced by earthquakes. However, GPS measurements are typically very sparse, while InSAR often fails close to faults, where strain gradients are large. Optical image correlation is a relatively new technique for retrieving earthquake deformations close to faults. Sub-pixel phase correlation of satellite (or aerial) images acquired before and after an earthquake can resolve displacements as low as 1/20th of the input imagery pixel resolution. Because optical image correlation retrieves the displacement averaged over small areas (compared with spot measurements collected in the field), they include any off-fault deformation (OFD) occurring on secondary or distributed structures, as well as deformation localized on the main fault. Comparison with co-seismic field measurements for large strike-slip earthquakes provides a unique opportunity determine the magnitude of OFD occurring in earthquakes globally. I discuss several case studies from earthquakes (including Landers, Hector Mine, Balouchistan, Norcia, and Kaikoura) where optical image correlation has been used to characterize near-field co-seismic displacements. OFD appears to correlate with total geological offset on strike-slip faults, suggesting an increase in localisation and decrease in OFD as faults mature. Better characterization of the magnitude and width over which OFD occurs is essential for the correct assessment of fault slip rates using Quaternary dating techniques, and earthquake slip histories determined from paleo seismology, which are both key ingredients in seismic hazard assessment. I finish with several examples of future research directions in which optical image correlation can be further developed to provide more detailed and precise 3D measurements of ground deformation over time; with huge potential for studying active fault zones, as well as a wide range of other surface phenomena occurring on Earth and throughout the solar system.