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Recent continental earthquakes constrained by InSAR: determining source complexity

J. R. Elliott (1), Z. Li (2), E. K. Nissen (3,4), J. A. Jackson (4), S. Lamb (5), B. Parsons (1), and R. A. Sloan (4)

(1) COMET+, Department of Earth Sciences, University of Oxford, UK. (john.elliott@earth.ox.ac.uk), (2) COMET+, School of Geographical & Earth Sciences, University of Glasgow, UK., (3) School of Earth & Space Exploration, Arizona State University, USA., (4) COMET+, Department of Earth Sciences, Bullard Laboratories, Madingley Road, Cambridge, UK., (5) Institute of Geophysics, Victoria University of Wellington, P.O. Box 600, Wellington 6140, New Zealand.

We present fault slip models for a number of recent continental Mw 6-7 earthquakes that have been constrained primarily by InSAR phase observations. Other observations such as field measurements of surface slip, SAR pixel offsets, remote imagery, DEMs and seismology were used to inform our choice of fault geometry. We ask how well can we determine faulting at depth that is consistent with any surface observations, and what is the limit to the complexity of these models that can be found reliably?

In the recent case of the New Zealand Mw 7.1 Darfield earthquake, a mixture of reverse, right lateral and left-lateral faulting was observed on at least eight fault segments. These were constrained by ALOS InSAR phase and azimuth offsets, field observations of the rupture and a postseismic LiDAR DEM. Six months later, the Christchurch Mw 6.2 event occurred just 20 km east of the Darfield rupture, also with a mixed mode of reverse and strike-slip faulting. Faulting on a pair fault segments inferred from the InSAR is required to fit the apparent large non-double couple component of the moment tensors.

A pair of reverse faulting Mw 6.2 earthquakes occurred 10 months apart in 2008-09 in almost the same epicentral location of NE Tibet (Qaidam Basin). Using ENVISAT InSAR observations we were able to separate these events spatially and show the most plausible scenario was a 10 month arrest in up-dip rupture as the faulting propagated through the seismogenic crust, this hiatus most likely due to the intersecting fault structures of opposing thrusts. In the case of the deeper event of the pair, surface observations of fault geomorphology in the area are required to identify the fault plane, the phase pattern in the interferogram alone not being sufficient because of the small extent of the rupture combined with smoothing due to the greater depth.

Finally we examine the 2009 left-lateral Mw 6.8 Yushu earthquake in eastern Tibet. This strike-slip event initially looks simpler than the previous examples. However, the SAR phase and offset measurements indicate a relatively long rupture for an earthquake of this magnitude. We show this is due to slip on three segments: the first segment is associated with mapped field observations of the rupture; a buried off-vertical segment associated with a small pull-apart basin comprises the second; and the last segment is due to a large Mw 6.2 aftershock 2 hours after the main event, The latter identification is confirmed by the azimuthally dependence of the delay/advancement in seismic P arrivals for the aftershock relative to the main shock.