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3D high-resolution displacement field of a complex rupture zone (Baluchistan earthquake, Pakistan, 2013)

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In the recent years, it appears that Fault Displacement Hazard Assessment is becoming critical to plan sensible infrastructures. Measuring the full near-field deformation field associated with large earthquakes, however, has long been challenging as classical InSAR methods usually decorrelate close to the rupture and field investigations have a hard time grasping the distributed part of the deformation. High-resolution optical imagery and new image correlation technics open new avenues to circumvent these obstacles and to provide an integrated view of co-seismic horizontal deformation.

Here, using the 2013, Mw7.8, Baluchistan earthquake as a case study, we show how co-seismic deformation distributes within the first kilometers around the fault zone in relation with fault geometry. We use a combination of very high-resolution optical images Pleiades and Worldview (0.5 meters ground resolution) that are correlated with a sub-pixel correlation software (MicMac, IPGP-IGN) to explore the three-dimensional co-seismic displacement field.

Our results show complex deformation patterns related to geometric complexities in the fault trace. When focusing on relay zones, we are able to image nascent fault strands that might indicate future shortcut of the relay, as well as zones of distributed volumetric deformation in-between the different active fault strands. We question how these surficial deformation patterns could be guided by some preexisting geological basement fabrics. Further quantification of the deformation along and across the complexities also show slip partitioning, compressional over-shoot associated with hanging wall extension, significant inelastic deformation etc. These phenomena are described and quantified using strain maps to better define the surface rupture models.

Future studies aim at expending this work to the entire Baluchistan rupture and also at characterizing horizontal post-seismic deformation using series of images taken after the earthquake.