Geophysical Research Abstracts
Vol. 20, EGU2018-9704, 2018
EGU General Assembly 2018

Illuminating with InSAR time series the strain distribution and evolution over a seismically active fault-bend-fold structure

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Recent developments in space geodesy monitoring and rupture inversion have highlighted the variability in fault deformation style along a fault, from segments classically remaining locked in the inter-seismic period and subsequently breaking in earthquakes, to others undergoing slow inter-earthquake and post-earthquake aseismic sliding. Today, we want to localise these fault slip phenomena such as slow-slip and aseismic events to understand if they are permanent or if they represent transient fault behaviour. Therefore, we want start constructing realistic fault slip models constrained by the temporal evolution of the surface displacements and that take into account additional information from structural geology and fault mechanism.

We here present a tool able to invert geodetic and seismological data in time and space using the open source toolbox Pyrocko (http://pyrocko.org), which allows a fast forward calculation of synthetic waveforms and static displacements (InSAR or GPS) in a layered medium. We have several objectives. First, we aim to develop a common modelling framework for near-field and far-field data in order to limit the model biases and parameter trade-offs of source inference that usually starts with a first-order model using one single data set. Secondly, we aim to develop joint spatial and temporal inversions of satellite data to reduce trade-offs between long-wavelength orbital ramps and deformation, and derive the spatio-temporal evolution of strain. Finally, we aim to bridge the gap between earthquake cycle modelling and structural geology by adding kinematic and connectivity constraints in the source inference.

We apply the developed software on a fault-bend-fold thrust system in the Qinghai province in Tibet, which experienced two Mw 6.3 earthquakes in 2008 and 2009. We take advantage of the Envisat SAR archive to produce an InSAR time series deformations with the NSBAS processing software. We specifically address phase unwrapping challenges by applying a series of corrections on the wrapped phase and by using a deformation template of the surface rupture to assist the unwrapping of coseismic interferograms. We successfully produce time series displacements maps in this mountainous area to capture the complete seismic cycle of this fault-bend-fold structure. These measurements are then combined with teleseismic data to derive the spatio-temporal evolution of the seismic and aseismic slip and better quantify their maximum spatial and temporal overlap.