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Could we detect earthquake nucleation from surface observations ?

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We analyze in this paper the possibility of detecting the nucleation phase of an earthquake (see [1] for a detailed analysis) from non-dynamic displacements observations.
The expected observable duration of the nucleation is about 1-3 minutes and the nucleation could be seen as " short time" precursor. An important issue is to develop very fast inversion techniques (computationally inexpensive).
Our study (see [2]) uses extensively an asymptotic estimate for the observed surface displacement (GPS observations). This estimate is first used to derive what we call the moments reconstruction method. Then it is also used for finding necessary conditions for a surface displacement field to have been caused by a slip on a fault. These conditions lead to the introduction of two parameters: the activation factor and the confidence index. They can be computed from the surface observations in a robust fashion. They indicate whether a measured displacement field is due to an active fault. We carefully assess how our reconstruction method is affected by the sensitivity of the observation apparatus and the stepsize for the grid of surface observation points. The maximum permissible stepsize for such a grid is computed for different values of fault depth and orientation. Finally we present numerical examples of reconstruction of faults. We demonstrate that our combined method is sharp, robust and computationally inexpensive.

In conclusion we point out that for a typically earthquake nucleation of 1km square patch and a slip of 1 m could be observed at the surface if the observation sensitivity is better than 0.1mm, the observation grid is less than 20km and the nucleation is located at less than 50 km depth. For a good inversion we need at least 10-20 active observation points. The inversion is fast enough to get a "real time precursor" and we could also estimate the inversion's confidence index.

[1] - M. Campillo and I. R. Ionescu, "Initiation of antiplane shear instability under slip dependent friction", Journal of Geophysical Research, vol. 122, No. B9, 20363-20371, 1997

[2] - I. R. Ionescu and D. Volkov, Detecting tangential dislocations on planar faults from traction free surface observations, Inverse Problems, 25, 1, (2009), 25 pages