Subject offered for a contract starting october 2016

SUBJECT TITTLE: Toward continuous monitoring of the slip behavior of active faults: InSAR and GPS data assimilation along the North Anatolian fault zone.

Advisor:
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Second Advisor:
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Host lab/ Team : **ENS- Laboratoire de Géologie de l'ENS- UMR 8538**

Financing: Doctoral contract with or without teaching assignment

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The seismic behaviour of active faults is controlled by the spatial distribution of rheological properties of fault zones and by the space and time evolution of stress in the crust. Measuring surface displacements in active fault zones allows exploring these properties in order to constrain dynamic models of the earthquake cycle. Over the last 25 years, geodetic techniques allowed to measure finely the temporal evolution of surface displacements with continuous GPS. However, these measurement have limited spatial coverage. In addition, Satellite Synthetic Aperture Radar Interferometry allowed to measure ground velocity or pluri-annual variations of ground displacements over large areas (100x100 km). However, uneven acquisitions and the scarcity of data has not permitted to explore short term variations of surface deformation with a wide spatial coverage.

Using data from the SAR satellite constellation Cosmo-SkyMed, we have recently shown that the spatio-temporal behaviour of slip along the North Anatolian fault was not consistent with previous measurement of subsurface slip and models of the earthquake cycles developed for this area. This major strike slip fault, accommodating the relative displacement of Anatolia with respect to Eurasia, ruptured during major earthquakes (M7+) over the last century and its central section slips aseismically since the 1944, M7.3, earthquake. Ground- and space-based geodetic measurements have shown the fault slips aseismically at a 7-8 mm/yr velocity, as predicted by the dynamic model developed for this fault section. Thanks to the high temporal sampling of our data set (1-6 days), we have shown that slip is actually not constant, hence a need for a revisit of the physical model.

The recent launch of the Sentinel 1A and of the planned Sentinel 1B satellites represent a major opportunity to measure finely, with a high temporal sampling and a wide coverage, surface deformations in active fault zones. Together, these 2 satellites will provide a worldwide coverage of

actively deforming regions every 6 days. This change in data acquisition plans calls for a major modification of our processing techniques, toward a continuous assimilation of various sources of displacement data for a continuous monitoring of surface deformations.

We therefore propose to work toward the following two objectives:

1. Develop an InSAR time series analysis method based on data assimilation techniques for continuous and automated monitoring of ground deformation
2. Apply this method to measure ground deformations along the central North Anatolian fault creeping section and compare with continuous GPS measurements.

The PhD candidate will first develop a method that will possibly be used anywhere the ground is actively deforming (e.g. tectonics, hydrology, volcanology). Then, the PhD candidate will apply this method to refine our understanding of the seismic and aseismic behaviour of a fault segment that has ruptured in the past and slip aseismically today. We are currently developing a network of continuous GPS stations to track the temporal evolution of slip. InSAR will provide constraints on the spatial distribution of slip along the fault. The development of the GPS network will be continued in the following years.

The PhD candidate will visit Turkey to install and maintain continuous GPS sites. The PhD candidate will have to be familiar with the Python programming langage in a Unix environment. Knowledge of advanced computing langages (c++, fortran, cuda) will be appreciated but is not mandatory. The PhD candidate should be fluent in English (French is optional). ENS is providing initial fundings to support expenses for the PhD candidate and for the installation of the GPS network in Turkey.

Collaborations: C. Vigny (ENS, Paris), C. Lasserre (ISTerre, Grenoble), Z. Çakir (ITU, Turquie), M. Simons (CalTech, USA)