Subject offered for a contract starting October 2016

SUBJECT TITTLE: Exploiting the space-based synergy between radar and optical data to measure tectonic deformation in continental areas

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Financing: Doctoral contract with or without teaching assignment

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Presentation of the subject: (1 or 2 pages)

Tectonic deformation operates over a broad range of scales in time and space. A significant part of the deformation, if not all, is accommodated in a localized fashion, on faults. In the case of continental deformation, large faults can have a lithospheric scale, cross-cutting the whole thickness of the brittle upper crust up to the surface. Such fault systems exhibit complex geometrical features (change in azimuth, kinks, secondary branches, partitioning), thereby indicating an that their orientation is not always fully in accordance with the regional stress field. These systems hence tend to evolve with time, most evidently during large earthquake events. The occurrence of big quakes allows for shedding light onto the way parts of a fault system operate during a slip increment. Static deformation recorded by earthquakes, in the near-field and in the far-field, therefore allow for assessing the interactions between the different parts of a given fault system, and to bring crucial evidence about the behavior of the system as a whole. Furthermore, these pieces of information represent the raw material needed to put constraints on seismic hazard assessment models.

Measuring exhaustively the strain field induced by an earthquake represents a major challenge. The affected area (several hundred to thousands of square kilometers) and the range of displacements involved (from the meter to the millimeter) impose the use of space-based observations. The full measurement of the displacement field is based on two complementary tools : synthetic aperture radar (SAR) and optical imagery. SAR allows for retrieving the vertical component of surface displacement, with a centimeter accuracy (by means of SAR interferometry, InSAR) or decimetric accuracy (by image correlation). On the other hand, optical imagery at medium- and high-resolution makes it possible, by photogrammetric analysis, to access the horizontal component of displacement, as well as topographic changes as part of the computation of a digital elevation model by-product. The SAR-optical synergy allows for reconstructing the strain field, in three dimensions, with a pluri-metric to metric planimetric resolution, and with decimetric accuracy. Such a density of measurements makes it possible to feed into mechanical models of earthquakes that take into account complex geometries, as well as damage processes that govern the evolution of fault systems over the scale of several seismic cycles.

In this project, the applicant will develop tools for mapping surface deformation by coupling observations from satellites Sentinel-1 (SAR), Sentinel-2 (medium resolution multispectral optical), SPOT-5-6-7 (high resolution optical) and Pléiades (very high resolution optical). He / she will benefit from the expertise gathered in the team to implement innovative methods for measuring surface displacement in three dimensions, by fusion of SAR and optical data and geophysical inversion of the data through the use of realistic mechanical models. A number of recent earthquakes that have been captured by these data will be targeted first, including the Balotchistan earthquake (September 2013) and the Pamir earthquake (December 2015).