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Resolving 3D coseismic deformation of the 2019 Mw 7.1 Ridgecrest earthquake using radar and optical data

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Measurements of surface displacement have been used in order to learn about seismic cycles, volcanoes, and other tectonic and non-tectonic processes. Ideally, the requirements to obtain useful measurements associated with seismic cycles are related to having a good spatial and temporal resolution, as surface deformation can occur in expected and unexpected faults, and in time intervals which vary from seconds (e.g. earthquake) to hundreds of years or even more (interseismic deformation).

Nowadays, satellite imagery provided by Synthetic Aperture Radar (SAR) or optical satellites fulfills those two aspects. Satellite images can cover large areas so that the fault rupture can be partially or totally visible. The problem of the radar technique is that for large earthquakes with surface rupture it cannot provide displacement maps in the near-field of the fault due to the large displacement gradient which causes phase decorrelation. Moreover, it is less sensitive to the horizontal displacement than vertical displacement. On the other hand, the main advantage of radar observing technique over the optical one is that the waves, emitted from a pulse-generating device, propagate through the atmosphere with almost no signal loss. This means that radar techniques operate under all weather conditions. Additionally, radar sensors are active, providing their own energy source, while optical are passive sensors that depend on external energy sources. Considering the benefits and the drawbacks of both sensing techniques, the opportunity of combining them helps the determination of a three-dimensional displacement field, illustrating a complete map of a seismic event.

In consequence, the objective of this study is to provide a methodology, using radar (Sentinel-1) and optical (Sentinel-2) data, that leads to the determination of the three-dimensional displacement field associated with the 7th of July 2019, M_w 7.1 Ridgecrest earthquake. The interferometric and offset tracking processing were computed using SNAP and GAMMA software, respectively, and for ascending and descending tracks products. For the optical data, cross-correlation using MicMac software was applied so that the displacement in the same area of interest was also derived. After obtaining the displacement for radar and optical data independently, a Least Square Adjustment (LSA) allowed to properly combine them considering the associated weight of each observation and finally compute the three-dimensional decomposition. Finally, it was possible to have a fully covered ground displacement measured from radar and optical sensors, and to better analyze the behavior of the tectonics in the area of study.