Characterizing Time-Dependent Deformation Processes in Imperial Valley, California

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The Imperial Valley region in Southern California straddles the transitional zone from the southern terminus of the San Andreas fault to a series of right-lateral faults and extensional structures that extend to the south of the US-Mexico border. Along with frequent earthquakes and seismic swarms, the region is marked by widespread agricultural activities and geothermal power plant operations that take place to the south of the Salton Sea. In this study, we characterize ground deformation in the Imperial Valley with InSAR time series and investigate its relation with anthropogenic activities and seismicity in the region. We use data from the Sentinel-1a/b and Envisat satellites to construct surface displacement time series for the time periods of 2015–2019 and 2003–2010, respectively. Our goal is to address the challenges associated with agriculture and other noise sources, and extract persistent, smaller-scale signals amid low-correlation areas. In our workflow, we identify pixels with high phase stability, apply spatial filtering, and masking to aid phase unwrapping of individual interferograms, and recover unfiltered phase, thereby allowing us to retrieve high-resolution line-of-sight (LOS) displacements with minimal impacts from filtering. We also apply corrections for tropospheric water vapor using independent observations, a step that is important given the large elevation contrasts within this area. The interseismic deformation associated with the San Andreas-Imperial faults dominates over larger scales, whereas anthropogenic signals occur over smaller scales, in some cases complicated by local tectonics. For example, subsidence patterns in the Salton Sea geothermal areas revealed by Sentinel-1a/b span agricultural fields and roads, with variations over smaller (~1 km) and larger (~20 km) spatial scales that are potentially attributable to both tectonic and anthropogenic processes, including changes in lake level. We also resolve mixed uplift and subsidence at East Mesa, as well as time-dependent changes at the Brawley and Heber geothermal fields. We use the surface deformation along with industrial operational data in these fields to test plausible subsurface source models and the evolution of strain changes and seismicity in the region.

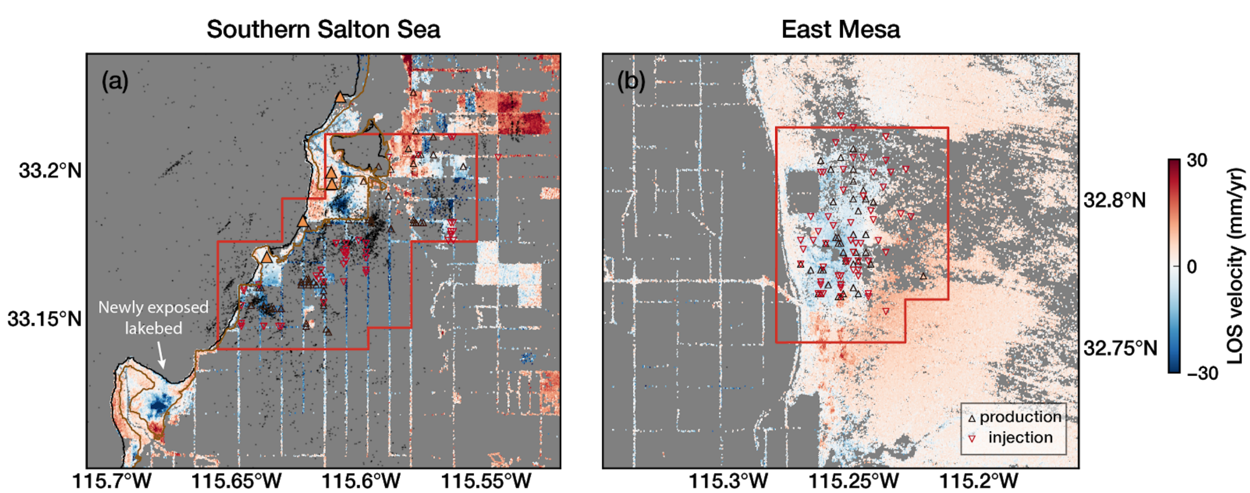

Figure. Surface deformation LOS velocity (in color), injection/production wells (red/brown triangles), and seismicity (black dots) at the (a) Salton Sea and (b) East Mesa geothermal fields (outlined with red polygons). Shorelines in 2001 and 2016 are marked in light brown and black, respectively.