# Integrated GPS and SAR Interferometry to Measure Time-varying Surface Deformation Over a Giant Oilfield in California*

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We combine campaign GPS measurements with interferometry synthetic aperture radar (IntSAR) images to map the deformation around and above the Lost Hills oilfield, one of the biggest fields in the USA. GPS at several dozen benchmarks every six months provides a long time series of total vertical and horizontal position change for monuments in the rapidly subsiding ground surface above the oilfield. IntSAR maps using data from the ERS satellites measure relative changes at high spatial resolution with some moderate- to long-wavelength noise sources such as orbit error and atmospheric delays. The GPS data are used to model the moderate to long-wavelength surface deformation field so that the error contributions at those wavelengths in the IntSAR images can be estimated and removed. The rapid subsidence (rates greater than 1 mm/day in 1995) and small size (roughly 3 km wide by 10 km long) require the use of short time intervals for the IntSAR pairs (between 35 days and 8 months), and also processing with the smallest possible sample spacing of 20 by 20 meters to resolve the extreme strain rates.

Previously published comparison of the tiltmeter measurements with well fluid extraction demonstrated both an immediate elastoplastic response to depletion and a time-dependent creep response. The high spatial and temporal resolution of the IntSAR measurements will be combined with well records on fluid extraction and injection to separate the delayed response from the immediate reponse to better understand the processes of compaction in the oil reservoir rocks, extremely high-porosity diatomite. This will have direct relevance to the oilfield operations as the compaction can damage the wells and should be minimized. Surprisingly, in some parts of the oilfield, injecting more water to replace the pressure of the oil and gas extracted causes the subsidence rates to increase. Because the fluid input and output at the oilfield is measured, it provides an excellent test bed for understanding the response of the earths surface to fluid movements at depth.

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