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Coupling Time-lapse Monitoring by Satellite Radar Sensors and Numerical Geomechanical Models for Reservoir Management. The Tengiz oil field (Kazakhstan) case study.

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Remote sensing techniques have been widely used in recent decades to monitor earth surface displacements related to seismic faults, volcanoes, landslides, aquifers, hydrocarbon fields.
In particular, advanced InSAR techniques, such as SqueeSAR™, have already provided unique results thanks to both the extension of the area which can be monitored by satellite data (up to thousands of square km) and the accuracy of the displacement measurements (<1 mm/year). One important field of application for SqueeSAR™ is reservoir monitoring, where surface deformation measurements, coupled to numerical modeling, can improve our understanding of reservoir behavior and help achieve more effective reservoir exploitation with obvious economic benefits.
Depending on reservoir depth and the reservoir/overburden rheology, surface deformation data can be used jointly with other measurements to constrain subsurface deformations related to fluid extraction/injection from/into underground formations.
One of the most recent applications is relevant to the Tengiz giant oil field, Kazakhstan. In this case, the top of the reservoir is about 3900 m deep. The results obtained by monitoring surface displacements over Tengiz have been used to calibrate a geomechanical model of the reservoir by means of GEPS3D, a state-of-the-art non-linear elasto-plastic Finite Element (FE) code, developed at University of Padova, Italy. This software has been used over the last 10 years for the simulation and prediction of producing reservoir compaction, land subsidence above over-exploited aquifers, and, more recently, ground uplift induced by subsurface fluid injection. Numerical simulations have been performed considering the first 14 years of the reservoir production life, from 1993 to 2007. Results of the simulation, expressed in terms of averaged subsidence rate in the period 2004-2007, have been compared with InSAR data. The properties of the site have initially been estimated from data available in literature. Afterwards, a global optimization algorithm has been applied to provide the geomechanical and fluidmechanical parameters exhibiting the best fitting between measured and computed deformation data. Results confirm the importance of high-quality displacement measurement in the estimation of some key geophysical parameters.