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# Inversion Modeling of Satellite Subsurface Subsidence

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## ABSTRACT

A century after the first oil field was discovered in the Middle East, exploration efforts continue to add a significant amount of new hydrocarbon resources every year to the total reserves. As the basins become more mature, an increasing number of the new finds come from by-passed pay zones or from locations adjacent to already discovered and producing fields. Geophysical tools which allow operators to better monitor the drainage of their fields are therefore useful for the planning of infill wells and for identifying reservoir blocks that have not been depleted, yet. Those blocks may be potential development targets.

Surface aperture radar interferometry (InSAR) is a remote sensing technology that may assist the monitoring of reservoir depletion. The technology yields time-lapse subsidence maps on a regional scale by repeatedly scanning the surface elevation from an aircraft or a satellite. In shallow onshore oil and gas fields, such surveys may reveal surface subsidence patterns which can be used to infer the pressure changes in the reservoir. The challenge is the interpretation of the survey results in terms of reservoir flow and compaction. The depletion-induced reservoir deformation is controlled by the geological structure of the field, the reservoir geometry, the distribution of pressure changes, and the stiffness of subsurface rock. Another challenge often arises from delineating near-surface processes such as waste fluid injection from pressure changes in the reservoir.

A technique to link subsurface flow, reservoir deformation, and measured subsidence is numerical simulation of reservoir geomechanics. Based on a geomechanical model, this technology predicts the surface deformation for any given change in reservoir pressure. In order to solve the inverse problem, the reservoir is first divided into a finite number of reservoir segments, taking into account the existing fault system. In a second step, the deformation fields associated with a constant pressure change in each reservoir segment are computed numerically. An inversion algorithm then finds the optimum pressure distribution which minimizes the misfit between the observed and modeled surface subsidence. The inversion result can then be compared to the dynamic pressure results from reservoir flow simulation, such that a disagreement reveals sections of the reservoir with reduced or increased amounts of depletion. In some cases, the inversion process may also provide hints on permanent reservoir compaction which is an important factor for sustaining optimal production.