Sensitivity of surface deformation to reservoir and overburden characteristics in the Groningen (Netherlands) gas field: first results

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Since the start in 1963 of gas production from the Groningen gas field in the northeast Netherlands, considerable surface subsidence (>30 cm) has occurred in the area. Seismic activity started in 1986 and is now known to be concentrated on reservoir cutting faults. The subsidence has mostly been caused by pressure depletion which lead to reservoir compaction. However, the spatial and temporal distribution of reservoir compaction is incompletely known because other processes likely contribute to the surface deformation also.

Our study is part of the DeepNL/Subsidence project. Its aim is to identify the subsurface drivers of subsidence above the Groningen gas field and to forecast future subsidence, by assimilating geodetic time series into geophysical models of both the shallow soils and the deeper overburden and reservoir. Since data assimilation can be computationally intensive, our eventual aim is to design geophysical models with the minimum complexity that will be needed to reproduce the observed total surface deformation. Therefore, in the present study we explore which sub-soil processes, and other elements, may possibly have a resolvable expression in the geodetic time series.

We examine the following sub-soil processes: variations in reservoir compaction due to permeability and/or production variations, seismic and aseismic slip on faults, and viscous flow of the evaporitic caprock. We also investigate the sensitivity to realistic variations in mechanical rock properties of the reservoir and overburden, and sensitivity to its geometric complexity. We present first 3D surface displacement results based on analytical models, and on Finite Element models with simplified representations of the subsurface geometry from seismic imaging studies in Groningen.