EGU24-5492, updated on 22 Mar 2025
https://doi.org/10.5194/egusphere-egu24-5492
EGU General Assembly 2024

A Neural Network to Reduce Subsurface Uncertainty Based on Ground Deformation Measurements

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Subsurface uncertainty is large because we have limited access to it. Reducing uncertainty is important for geo-energies in order to increase the reliability of the simulation results used to define safe operation conditions. In particular, subsurface uncertainty can be reduced by analyzing ground deformation. A clear example of this is the CO_2 storage project at In Salah, Algeria, where a double lobe ground deformation shape revealed the presence of a vertical fault zone at depth. Here, we propose a workflow to reduce subsurface uncertainty by inferring the subsurface characteristics from ground deformation measurements. As a foundation step of the workflow, we train a supervised neural network-based regression approach for predicting ground deformation caused by reservoir pressurization due to fluid injection. To train the neural network, we use a recently developed analytical solution to assess ground displacement in response to pressurization of a reservoir that is intersected by a permeable or an impermeable fault (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4503451). The instantaneous solution provided by the analytical solution allows us to generate a large dataset to train the neural network. We have varied eleven variables, including fault and reservoir geometry and mechanical properties. Simultaneously, a simplified parametric space analysis is also performed. Results show that the reservoir thickness, Biot´s coefficient, and the pore pressure buildup impact the displacement the most. This study highlights that an appropriately trained neural network can effectively predict the ground deformation and give insights into the corresponding subsurface characteristics.