EGU24-18221, updated on 11 Aug 2024
https://doi.org/10.5194/egusphere-egu24-18221
EGU General Assembly 2024

An analytical tool for estimating fault slip probability for CO_2 storage resources under pressure constraints

Iman R. Kivi[1], Silvia De Simone[2], and Samuel Krevor[3]
[1]Department of Earth Science and Engineering, Imperial College London, London, UK (i.rahimzadeh-kivi@imperial.ac.uk)
[2]Institute of Environmental Assessment and Water Research, Spanish National Research Council (IDAEA-CSIC), Barcelona, Spain (silvia.desimone@idaea.csic.es)
[3]Department of Earth Science and Engineering, Imperial College London, London, UK (s.krevor@imperial.ac.uk)

The majority of pathways toward net-zero CO_2 emissions propose carbon capture and storage (CCS) at rates of several gigatonnes per year by mid-century. However, there are limits on the rates at which storage resources can be used. In addition to the total storage resource, constraints are imposed by reservoir injectivity and the possibility of triggering large earthquakes by injection-induced overpressure. Such dynamic constraints are rarely considered in the assessments of available resources and possible CCS deployment rates. In this work, we have extended an open-source tool, named CO2BLOCK, from calculating reservoir pressurization during CO_2 injection to additionally estimating the probability of fault slip in the region. This provides a computationally efficient methodology for screening dynamic CO_2 storage resources. The code features a deterministic hydrogeology module that employs analytical solutions of radial, multiphase flow for a single site with time-varying injection rates and the superposition principle to calculate the spatiotemporal evolution of pore pressure in multisite, basin-scale injection scenarios. The calculated overpressure is used to analyze the slip tendency of the faults imported or randomly distributed across the basin. A probabilistic geomechanical module runs Monte-Carlo simulations to generate cumulative distribution functions of slip probability as a function of pore pressure changes for each fault from statistical ensembles of uncertain parameters including the state of stress and fault attributes and frictional strength. A combination of the two modules yields the evolution of fault slip probability as a function of time through the project life. The proposed approach allows for optimizing large-scale CCS project designs for the number and spacing of injection sites to return maximum storage rates and capacities while maintaining the risk of induced seismicity at a low level. The application of CO2BLOCK could assist in developing more realistic representations of CCS scale-up potential and the subsurface resource use in different climate change mitigation pathways.