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Modelling episodic induced seismicity with poroelastic dynamic rupture and large-scale wavefield propagation

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Modelling dynamic rupture is essential to correctly describe the process of induced seismicity. Defmod, an open-source finite-element code featuring quasi-static loading, co-seismic volumetric strain, and dynamic rupture, is used to simulate the entire chain of induced seismicity, from pressure evolution due to fluid injection and extraction, building up of stress, and nucleation of dynamic faulting, to wavefield propagation towards the surface. To study induced earthquakes caused by fluid extraction, we modelled the behaviour of a 2-D poroelastic medium including a predefined fault by assigning a fluid source, either constant or varying, in a homogeneous reservoir layer to induce a pressure-field change. For each quasi-static step, the pressure field difference generates a displacement field that in turn affects the pressure through a coupling matrix, depending on Biot's coefficient. The rate of pressure variation is subject to the fluid source as well as the material properties, e.g., porosity and fluid mobility, which affect the speed and distribution of the stress build-up on the fault and thus the pattern of rupture nucleation. In addition, we implemented a predefined pressure profile to simulate the induced rupture in case of a uniform depletion of the reservoir to allow for a comparison with other studies. The results provide useful insights on the causality between reservoir-pressure behaviour and the induced seismicity.