3D Rheology effects on postseismic viscoelastic surface displacement fields in subduction zones

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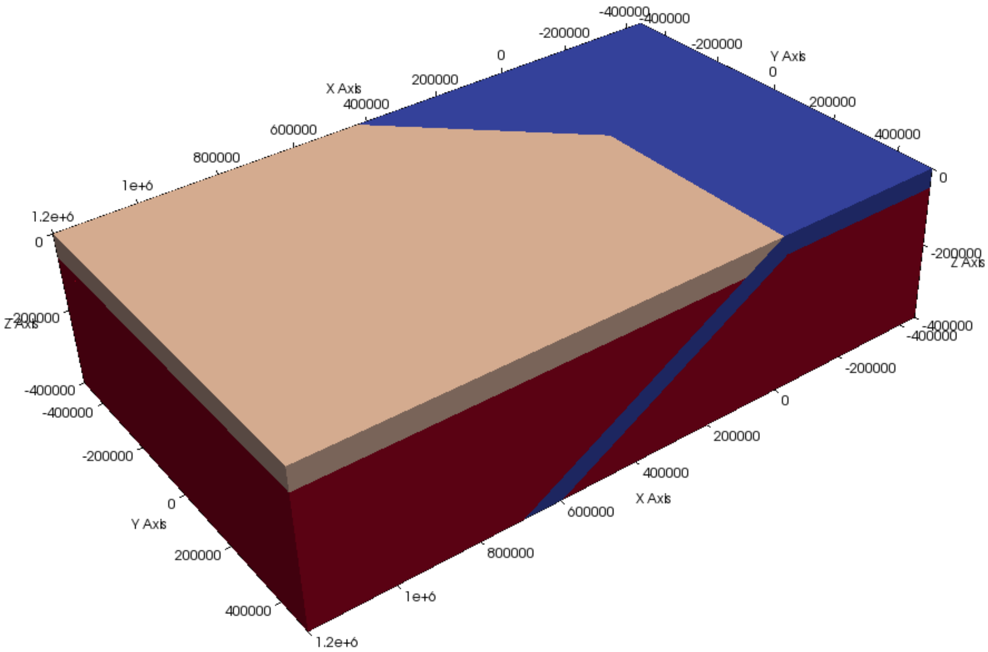
Viscoelastic relaxation makes up a significant portion of postseismic deformation in subduction zones, where the mantle is hot enough to exhibit non-elastic behaviour. In some subduction zones, such as northeast Japan, there is substantial lateral variation in rheology, including viscosity, due to the existence of the cold subducting oceanic plate. Moreover, there is variation in subduction angles and other characteristics of different subduction zones.
In light of that, we tested how different kinds of variations in rheology affect viscoelastic relaxation in subduction zone settings. For this purpose, we constructed a series of finite element models of viscoelstic relaxation associated with a coseismic fault slip with various trench shapes, slab shapes, viscosity, and fault parameters. These models represent hypothetical end-members of possible situations.
Our results show that the main characteristics of viscoelastic displacement fields are not controlled by fault parameters, but the rheology. Dissimilarity between different models was more apparent in the vertical component of displacement than horizontal one. When the subducting oceanic plate is concave on the seaside, there is greater landside subsidence over a large area away from the fault, especially where the continental crust is protruding into the ocean. Horizontal displacement radiate from the plate boundary. Near-fault subsidence on the landside decreases as the subduction angle increases, while being compensated by larger subsidence further inland. Horizontal displacement decreases near fault with larger subduction angles, but is larger inland. Viscoelastic displacement fields after a coseismic slip on a fault with strike-slip component are also affected by slab shape. If the slab is concave on the seaside, the amounts of the near-fault vertical and horizontal displacements at the curve are reduced, compared to a slab with straight trench axis, regardless of the sign. A convex slab causes the opposite effect. Models excluding a cold, rigid mantle wedge corner (cold nose) and ones with a steep subduction angle are lacking a near-fault landside subsidence. Near-fault landward displacement is slightly reduced without a rigid corner, while landside seaward displacement is increased. In case a slab along the trench truncated abruptly in the vicinity of the fault, more positive values of vertical displacement appear over the missing slab, and much more positive values over all the landside if the slab is completely absent. Horizontal displacement does not radiate from the plate boundary where the slab is absent.
In conclusion, three-dimensional rheological variation had a profound effect on the distributions and amounts of the vertical and horizontal displacement fields caused by postseismic viscoelastic relaxation in subduction zone settings. These results can be used as a benchmark for realistic postseismic viscoelastic relaxation models.

Keywords: Subduction zone, Crustal deformation, Numerical simulation, Rheology, Postseismic deformation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