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{Interpretation of intersismic deformations and the seismic cycle associated with large subduction earthquakes

Olga Trubienko (1), Luce Fleitout (1), and Jean-Didier Garaud (2)
(1) ENS, Geologie, Paris, France (fleitout@geologie.ens.fr), (2) ONERA, Chatillon

The intersismic deformation of plates in the neighborhood of subduction zones generating large earthquakes are most often modeled with the help of elastic backslip models. However the very large and long post-sismic slip observed in areas around Sumatra or in Chile clearly indicate a relaxation in the asthenosphere with viscosities of the order of 10^{19} Pas. Using a 2D finite element model, we compare the deformations during the seismic cycle predicted by a 'realistic' model with an asthenosphere, plate velocities imposed in the far-field and periodic earthquakes with the deformations predicted from an elastic backslip model, a model with a blocked part of the subduction zone and imposed 'far field' plate velocities and models with viscoelastic backslip. We find quite expectedly that the elastic model provides good predictions only in the case where the viscosities are sufficiently high so that viscous relaxation is negligible on the time-scale of the seismic cycle. In the model with imposed 'far field' plate velocities, the whole plates are progressively compressed and the results strongly depend upon where exactly the velocities are applied. The 'viscoelastic backslip' and the 'realistic' models yield very similar deformations through the sismic cycle. In our view, only these last two models are appropriate to model the intersismic deformations. We show that the nature of the viscoelastic rheology of the asthenosphere (Burger versus Maxwell)) can be quantified from the relative amplitudes of intersismic versus post-sismic deformations. Finally, we find that the details of the mantle wedge area affect significantly the vertical motions away from the subduction zone.