Title: Exploring proposed deep slab-deformation processes behind potential precursory signals preceding large subduction zone earthquakes with finite element analysis

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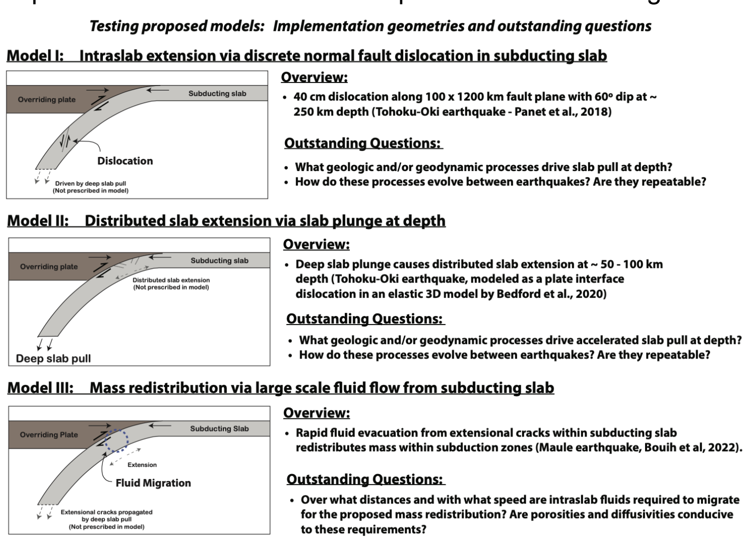
Abstract:

Recent studies suggest that large-scale, transient signals in GNSS velocities, satellite gravity measurements, and intermediate-depth foreshock occurrences may precede large earthquakes in subduction zones. Specifically, investigations focused on the 2011 Mw 9.0 Tohoku and the 2010 Mw 8.8 Maule earthquakes found that these precursory signals preceded the respective main shocks by ~3 months. If correctly resolved, these precursory signals of deformation appear to record a rapid geodynamic process that occurs deep within subduction zones and that may be instrumental in the initiation of megathrust earthquakes. Qualitative models have been put forth to explain the physical processes behind these potential precursory signals; proposed initiatory mechanisms include slab plunge and acceleration, mineral phase changes, and rapid, large-scale fluid flow. However, numerical models exploring Earth's geodynamic response to the proposed processes have yet to be investigated.

In this project, we use the finite element method to model geodynamic processes that plausibly occur deep within subduction zones, and that may be responsible for the potential precursory signals observed. Given the high density of GNSS stations across Japan, we focus our study on deformation preceding the 2011 Mw 9.0 Tohoku Earthquake. We compare the modeled distribution and magnitude of surface displacements induced by these physical processes to GNSS observations of deformation preceding the earthquake. We also hope to explore how changes in rheology and subduction zone structure impact modeled predictions of surface displacement and gravity measurements for the geodynamic processes we test. We use these model predictions and respective data comparisons to assess the feasibility of the proposed physical processes in generating the deformation signatures observed. Furthermore, these models help to establish how transient deformation deep within subduction zones may be expressed at Earth's surface independent of their timing with respect to great earthquakes.



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