3D fluid migration due to complex slab geometries and its implications for short-term slow slip events

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In Cascadia and Nankai where relatively dense seismic and geodetic networks are available, short-term slow slip events (SSEs) generally occur at ~30-40 km depth along the subducting plate interface near the continental Moho of the overriding plate. This location roughly corresponds to the down-dip limit of large underthrusting earthquakes where the transition from stick-slip to stable sliding is thought to occur. An important characteristic of short-term SSEs is their spatial variation in activity. The average slip rate tends to be large where the slab geometry is convex (i.e., the slab bends toward the mainland) and it tends to be small where the slab geometry is concave (i.e., the slab bends away from the mainland). Considering that fluids play an important role in generating short-term SSEs, it may reflect the along-arc variation in fluid flux due to complex slab geometries. In this presentation we will demonstrate how fluids migrate in subduction zones by taking into account the effects of 3D slab geometries.
We construct 3D finite element models based on a theory of two-phase flow, which allows us to consider the movement of matrix and fluid phases at the same time. The location of fluid source is determined based on the computed slab surface temperature. Fluids are assumed to migrate in a thin serpentinite layer just above the slab in the direction sub-parallel to the slab surface by the effects of permeability anisotropy in the serpentinite.
We find that fluids migrate in the maximum-dip direction of the slab by the combined effects of permeability anisotropy and 3D slab geometry. It leads to the concentration of fluid paths where the slab geometry is convex and porosity increases there. Fluid paths diverge and porosity decreases where the slab geometry is concave. These results suggest that the along-arc variation in short-term SSEs can be explained by 3D fluid focusing possibly through changing pore-fluid pressure and/or formation of wet clay minerals.

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