Flat slab subduction, continental faults, and surface uplift: 3D numerical models of south-central Alaska

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Plate boundaries are inherently three-dimensional (3D) tectonic features with variations in geometry and physical properties along their length. For example, subduction zones have significant changes in slab dip along strike, including flat slab segments, as in the eastern Alaska subduction zone, the Peru-Chile Trench, and the southwestern Japan Trench. In addition, the lithospheric structure often includes spatial heterogeneity, including major faults inboard of the plate boundary such as the Denali fault, the Altyn Tagh fault, and the North Anatolian fault. Here we present results from regional 3D numerical models of the eastern Alaska subduction-transform plate boundary system that explore the role of the flat slab geometry and the Denali fault on the surface velocity and dynamic topography in south-central Alaska. The shape of the Aleutian-Wrangell slab is defined by Wadati-Benioff zone seismicity and seismic tomography. The thermal structure for both the subducting and overriding plate is based on geologic and geophysical observables, thereby capturing the regional variability in the plate boundary system. We employ a composite viscosity, which includes both the diffusion and dislocation creep mechanisms. The models suggest the flat slab geometry beneath south-central Alaska controls several first order deformation features in the overriding plate, including subsidence in the Cook Inlet Basin. To reproduce the localized uplift observed in the central Alaska Range, the models require a non-Newtonian rheology and a localized lithospheric weak zone representative of the Denali fault, as well as the shallow slab geometry. Models with only a Newtonian viscosity do not reproduce the observed uplift, even when the Denali fault is included. 3D numerical models of this kind can provide a tectonic framework for observational based studies in Alaska as a part of the upcoming EarthScope deployment.

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