The evolution of geochemical reservoirs over Earth's history depends to a large extent on the slab-related mass transport from the upper to the lower mantle. While some form of whole mantle convection is now the generally accepted paradigm, there are still large remaining uncertainties about the subduction flux, the degree and nature of mid-mantle slab stagnation, and how regional dynamical effects, such as changes in plate motions and slab fragmentation, affect slab ponding. Part of this uncertainty is caused by a relative disconnect between high-realism, regional subduction models, and rather simplified global geodynamic approaches. We present two lines of work where we aim to construct an improved, global modeling approach and a better understanding of the imaged character of mantle convection. Comprehensive, joint inversions of a range of seismological data for shear wave structure are conducted, where our imaging focuses on the degree to which global tomography can detect vertical correlation or absence thereof. Several recent tomographic models show a roughening of their spectral character at depths of ~800-1000 km, which substantiates slab stagnation at depths larger than the 660 km phase transition. We explore the robustness of such signals with a range of different damping and resolution tests. Further, we study improved, global subduction models in terms of their correlation and spectral character to understand which features of tomography are accessible to forward modeling, and which processes need to be implemented and understood better in order to arrive at more realistic global estimates of slab flux.