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Subduction trench migration as a constraint on absolute plate motions since 130 Ma

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The absolute motions of the lithospheric plates relative to the Earth's deep interior are commonly constrained using observations from paleomagnetism and age-progressive seamount trails. In contrast, a reference frame linking surface plate motions to subducted slab remnants mapped from seismic tomography has recently been proposed. Absolute plate motion (APM) models (or "reference frames") derived using different methodologies, different subsets of hotspots, or differing assumptions of hotspot motion, have contrasting implications for parameters that describe the long term state of the plate-mantle system, such as the balance between advance and retreat of subduction zones, plate velocities, and net lithospheric rotation. Previous studies of contemporary plate motions have used subduction zone kinematics as a constraint on the most likely APM model. Here we use a relative plate motion model to compute these values for the last 130 Myr for a range of alternative reference frames, and quantitatively compare the results. We find that hotspot and tomographic slab-remnant reference frames yield similar results for the last 70 Myr. For the 130-70 Ma period, where hotspot reference frames are less well constrained, these models yield a much more dispersed distribution of slab advance and retreat velocities. By contrast, plate motions calculated using the slab-remnant reference frame, or using a reference frame designed to minimise net rotation, yield more consistent subduction zone kinematics for times older than 70 Ma. Introducing the global minimisation of trench migration rates as a key criterion in the construction of APM models forms the foundation of a new method of constraining APMs (and in particular paleolongitude) in deep geological time.