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Surface expressions of plate tectonics include subsiding back-arc basins, intra-plate plateau, subduction trenches and uplifting orogenic belts. While geodetic measurements, coupled with geological observations, enable to achieve a fairly good understanding of the dynamic evolution of these active features, the origins of this kinematics are still controversial. For example, mantle flow is often proposed as a driver of plate tectonics, but lithospheric processes such as continental collision, subduction and trench motion are also known to affect mantle flow.

Relations between subduction dynamics, upper mantle flow and the tectonic history recorded in the continental crust, in particular, have attracted significant interest. Major results confirmed that mantle convection is a valuable mechanism behind much of the observed dynamic topography and plate motion. However, the degree to which mantle flow controls surface deformation is a major open question and more definitive conclusions, especially regarding how horizontal to sub-horizontal mantle flow affects crustal deformation, require the investigation of the three-dimensional relations between mantle flow, slab rollback and trench migration.

We compare new high-resolution 3D thermo-mechanical numerical models with observations from the Aegean-Anatolian and eastern Indian-Eurasian margins. We show that the mantle flow due to slab rollback and tearing can modulate surface deformation by locally enhancing trench retreat and actively dragging the upper plate from below, especially in a hot environment such as a back-arc domain, with a ductile lower crust at direct contact with the asthenosphere. The similarities between modeled and natural kinematics suggest that horizontal to sub-horizontal mantle flow due to slab rollback and tearing codetermined the surface strain across the Aegean-Anatolian and eastern Indian-Eurasian domains