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Probabilistic constraints on lithospheric forces, fault tractions, and rheology in the eastern Mediterranean region

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The Aegean Sea region sits in a complex deformation zone between the African, Eurasian, and Anatolian plates. It contains the Hellenic subduction zone, where African oceanic lithosphere descends under the Aegean Sea. The subducting slab may be torn or fragmented at both its eastern (Pliny-Strabo zone) and western (Kefalonia fault) edges. The overriding Aegean Sea is cut by numerous active normal faults accommodating north-south extension. On top of this, the collision of Arabia with Anatolia farther east drives Anatolia and the connected Aegean Sea westward, resulting in the left lateral North Anatolian fault (and its extension into the Aegean), as well as greater relative velocities between the subducting slab and the overriding plate. These geodynamic processes and geological features all affect the present-day kinematics of the Aegean region.

Surface velocities measured at Global Navigation Satellite System stations throughout the Aegean provide important constraints on these underlying geodynamic forces. Previous studies have attributed the surface motions to some combination of plate boundary interactions, lateral variations in gravitational potential energy (GPE), subduction and slab tearing, internal faulting, and mantle tractions. The expected imprint of these processes also varies with the rheology of the lithosphere. Up to this point, there has been little effort to systematically evaluate the relative contributions of these different forces. In this study, we implement a Markov Chain Monte Carlo approach to efficiently and precisely determine the likely values and uncertainties of these geodynamic forces and the lithospheric rheology. We also identify trade-offs between processes that produce similar surface signals.

Preliminary results indicate that the dominant imprint on surface velocities comes from the southwestward rollback of the Hellenic slab and the westward escape of Anatolia. Although lateral variations in GPE also have an effect on the velocities, these are generally less important than slab rollback and Anatolian escape. At a lithospheric scale, the North Anatolian fault has little shear resistance to allow a relatively sharp velocity transition across it. Including resistive tractions on intraplate faults within the Aegean Sea has a smaller effect on the modeled velocity field. By using the velocity field to guide a statistical analysis of the geodynamic drivers, we have been able to better constrain the primary drivers of deformation in the eastern Mediterranean.