The Eurasian stress field: important role of topography and mantle flow

Warners-Ruckstuhl, Govers, Wortel

The large-scale lithospheric stress field results from lithospheric body forces, from interaction with adjacent plates, and from tractions at the base of the tectonic plates. We recently established (Warners-Ruckstuhl et al., 2010) that tractions from an actively convecting mantle are required to mechanically balance the Eurasian plate. Here we constrain the forces that cause the Eurasian stress field.

We use SEATREE (Milner et al., 2009) to a priori compute mantle flow tractions for a wide range of forcings and radial viscosity profiles. Lithospheric body forces (and uncertainties) are computed a priori from the topology of major density interfaces. Directions of edge forces are parallel to relative motion directions. Edge force magnitudes follow from solving the torque balance equations. Stresses are calculated in a spherical elastic shell containing major faults.

The net shear of the different mantle flow models varies considerably. Only those that are forced by mantle densities from published S-wave tomographic models mechanically balance Eurasia for a certain ratio range of magnitude of convective shear versus shear due to plate motion. The intra-plate stresses corresponding with these balanced models turn out to be mostly sensitive to uncertainties in lithospheric body forces. Stresses in Europe fit the observations best if we assume that its topography is partly dynamically supported and partly results from crustal thickness variations. Observed stress orientations in the Tibetan plateau are significantly better explained by crustal thickness variations alone. The small-scale horizontal distribution of the mantle shear stress affects model stresses only mildly.