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Fast asthenosphere motion in high-resolution global mantle flow models

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A variety of geologic observations point to fast upper mantle flow that may exceed plate tectonic velocities by an order of magnitude. At the same time there is mounting evidence from seismology for flow like structures in the upper 100-200 km of the mantle. Here we present a set of geodynamic simulations to link these observations. We model asthenospheric channels of varying thickness, in a range from a wide 1000 km channel to an extremely thin channel of 100 km, and viscosity contrasts between one and four orders of magnitude relative to the lower mantle. Using our new global high resolution mantle convection prototype Terra-Neo, we obtain an increase in velocity by a factor of ten between the thick and the very thin channel, translating into velocities of about 20 cm/a within the narrow asthenosphere. We further present and verify a simple Poiseuille flow model, which predicts that the upper mantle velocity scales with the inverse of the asthenosphere thickness.