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Heterogeneous distribution of mineral phases and seismic velocity in the transition zone from convection modelling based on selfconsistent thermodynamics

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We have modelled convection in the Earth's mantle using a selfconsistent thermodynamical model for an olivine-pyroxene composition in the SiO_2, MgO system. The thermodynamic model is based on a lattice vibrational method allowing the calculation of density, thermal expansion, compressibility, specific heat, phase equilibria and seismic velocities in the complete P-T regime of the Earth's mantle.

Our modelling results show a complex structure in the behavior of physical properties, in particular the seismic shear velocity, in the depth range of the mantle transition zone, 400-660 km. We demonstrate that this behavior is related to the distribution of mineral phases in the olivine-pyroxene system. Especially near cold downwelling flows, representing subducting lithopheric plates, the results of our model show strong lateral variation of mineral phases and associated shear velocity. We show that, typically, pockets of contrasting mineral phases smaller than 100 km occur in subduction regions.

In line with current developments in seismic imaging of the mantle transition zone we have computed reflectivity profiles from the shear velocity distribution obtained from the convection results. We applied frequency filtering to the raw reflectivity data to investigate the requirements for resolving the heterogenous structure of the transition zone. Our results show that heterogeneous structure from contrasting mineral phase regions is resolved for periods of ten seconds which may be feasible in seismic imaging applications.