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On the origin of long-wavelength structure in compressible mantle convection simulations with plate-like behavior in a 3-D spherical shell

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Numerical simulations of compressible mantle convection with self-consistently generated plate-like behavior are performed in order to determine what physical properties are the most important in obtaining long-wavelength flow: plate tectonics, or the depth-dependent properties viscosity, and thermal expansivity and conductivity arising from compressibility. Isoviscous compressible cases display dominant wavelengths with spherical harmonic degree L=2-4, becoming shorter-wavelength (up to L=7-9) with increasing internal heating rate. With temperature-dependent viscosity and yielding-induced plate tectonics, the patterns are dominated by long wavelengths with L=1-2, regardless of internal heating rate and yield stress, except at high yield stresses when a stagnant lid is obtained. Adding depth-dependence of viscosity to cases with plate tectonics makes the pattern shorter-wavelength, which is opposite to what was found in previous results without a lithosphere, and the wavelength becomes longer as internal heating rate is increased, opposite to the trend for isoviscous cases. High viscosity in the deep mantle also results in strong heterogeneity extending further from the core-mantle boundary (CMB). With yielding-induced plate tectonics, the viscosity contrast across the lithosphere adjusts to the range 1.5-3 orders of magnitude. We are currently testing the sensitivity of these preliminary findings to the exact viscosity law, attempting to get as close as possible to an Earth-like viscosity variation with temperature, and testing the effect of any upper or lower viscosity cutoffs that are applied.