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Double-Diffusive Layers and Phase Transitions

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Researching the thermal evolution of the Earth's mantle on numerical base is very challenging. During the last decade different approaches are put forward in oder to understand the picture of the today's Earth's mantle. One way is to incorporate all the known features and physics (plate tectonics, phase transitions, CMB-topography, ...) into numerical models and make them as complex (or 'complete') as possible to capture Earth's mantle processes and surface signals. Another way is, to take a step back and look at less complex models which account for single processes and their interaction and evolution. With these 'simpler' models one is able look in detail into the physical processes and dependencies on certain parameters.
Since the knowledge of slab stagnation in the transitions zone of the Earth's mantle the question whether the mantle is or at least has been layered to some degree is still under debate. On this basis we address two important features that lead to layered mantle convection and may affect each other and with this the thermal evolution of the mantle. It is commonly known the main mantle mineral olivine pass through various phase changes with depth [1]. Detailed numerical studies had been carried out to ascertain the influence on convective motion and planetary evolution [2]. It is still heavily discussed whether the endothermic phase change at 660km depth can lead an isolated lower mantle. Most of the numerical studies favour a model which has phases of layering that are disrupted by *catastrophic events*.
In the last years double-diffusive convection has also been intensively studied with regard to planetary mantle evolution such as pile formation and core-mantle boundary topography [3]. However, another striking feature still posing open questions are evolving layers self-organised from a previous non layered state. Considering a chemical component that influences the density of a fluid in addition to the temperature leads to dynamical phenomena that have no counterpart in pure thermal convection.

In oder to determine the interaction of double-diffusive layers with a phase transition we carried out numerical simulations ranging from exothermic to endothermic conditions. Taking into account a depth and temperature dependence of the phase transition the results show that on the one hand double-diffusive layering is strongly affected by the presence of phase transition but on the other hand the equilibrium position of the phase transition is shifted depending on the properties of the considered transition. In addition to that we incorporate the chemical dependence of the phase change and determine the influence on the layer growth and the overall dynamics.

References

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