Geophysical Research Abstracts
Vol. 14, EGU2012-3491-3, 2012
EGU General Assembly 2012

Realistic thermal evolution models for Superearth Exo-solar planets

A. van den Berg (1), D. Yuen (2), K. Umemoto (3), R. Wentzcovitch (3), and M. Jacobs (4)

(1) Dept. Theoretical Geophysics, Inst. Earth Sciences, Utrecht University, Utrecht, Netherlands (berg@geo.uu.nl), (2) Department of Earth Sciences and Minnesota Supercomputing Institute, University of Minnesota, Minneapolis, (3) Dept. Chemical Engineering and Materials Science and Minnesota Supercomputing Institute, University of Minnesota, Minneapolis , (4) Institut für Metallurgie, TU Clausthal, Clausthal-Zellerfeld, Germany

Massive superearth exoplanets in the range of one to ten times the Earth's mass have a much extended pressure regime compared to Earth, up to about 1 TPa, that may give rise to different material behavior. This has an impact on planetary evolution, and the evolution of a magnetic field and planetary atmosphere, and is therefore also relevant for habitability conditions.

The material properties concerned include the mantle rheology where pressure affects both deep mantle viscosity and the brittle-ductile transition, both with a direct impact on lithosphere dynamics and the heat transport capacity of superearth mantle convection.

Besides rheological considirations, other material properties also show strong variation with both pressure and temperature, in particular thermal expansivity and thermal conductivity. At ultra-high pressure they will exert a strong impact on the effectiveness of convective heat transport.

The commonly used (extended) Boussinesq (EBA) convection model is not well suited for the pressure regime of superearth exoplanets becuase of the high value of the surface dissipation number involved, typically Di $\sim$ 5 (van den Berg et al., Phys. Earth Planet. Inter.,178, 136-154). We therefore use a compressible convection model based on the anelastic liquid approximation and apply a selfconsistent model for the thermophysical properties based on ab-initio and lattice dynamics for relevant mantle silicates, perovskite, post-perovskite and periclase (Umemoto et al., Science,311, 983-986, 2006; Jacobs and van den Berg, Phys., Earth Planet. Inter.,186, 36-48, 2011). In particular our model includes, in a selfconsistent way, the significant temperature dependence of thermal expansivity, important in controlling the dynamics of cold downwellings in the upper mantle.

We present results of convection modelling experiments exploring the forementioned model sensitivities on mantle heat transport both in transient cooling models and expressed in terms of Nusselt-Rayleigh number relationships.

We show that deep mantle rheology parameterized through an activation volume of the dominant creep mechanism as well as a pseudo-brittle lid controlling stagnant behavior are important factors determining the thermal state.