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CIDGA - Coupling of Interior Dynamic models with Global Atmosphere models

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Atmosphere temperatures and in particular the surface temperatures mostly depend on the solar heat flux and the atmospheric composition. The latter can be influenced by interior processes of the planet, i.e. volcanism that releases greenhouse gases such as H_2O, CO_2 and methane into the atmosphere and plate tectonics through which atmospheric CO_2 is recycled via carbonates into the mantle. An increasing concentration of greenhouse gases in the atmosphere results in an increase of the surface temperature. Changes in the surface temperature on the other hand may influence the cooling behaviour of the planet and hence influence its volcanic activity [Phillips et al., 2001]. This feedback relation between mantle convection and atmosphere is not very well understood, since until now mostly either the interior dynamic of a planet or its atmosphere was investigated separately. 2D or 3D mantle convection models to the authors' knowledge haven't been coupled to the atmosphere so far.

We have used the 3D spherical simulation code GAIA [Hüttig et al., 2008] including partial melt production and coupled it with the atmosphere module CIDGA using a gray greenhouse model for varying H_2O concentrations. This way, not only the influence of mantle dynamics on the atmosphere can be investigated, but also the recoupling effect, that the surface temperature has on the mantle dynamics. So far, we consider one-plate planets without crustal and thus volatile recycling. Phillips et al. [2001] already investigated the coupling effect of the surface temperature on mantle dynamics by using simple parameterized convection models for Venus. In their model a positive feedback mechanism has been observed, i.e., an increase of the surface temperature leads to an increase of partial melt and hence an increase of atmosphere density and surface temperature.

Applying our model to Venus, we show that an increase of surface temperature leads not only to an increase of partial melt in the mantle; it also strongly influences the style of mantle convection. As a consequence, the positive feedback processes as suggested by Phillips et al [2001] is not predicted in our model for all cases in particular when the surface temperature is very high and reaches a critical value for which convection turns from a stagnant lid regime in a sluggish-like regime.

References

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