Geophysical Research Abstracts
Vol. 15, EGU2013-3425, 2013
EGU General Assembly 2013

Atmosphere/mantle coupling on Venus and long term planetary evolution.

Cedric Gillmann (1) and Paul Tackley (2)

(1) ORB, Brussels, Belgium (cedric.gillmann@observatoire.be), (2) ETHZ, Zurich, Switzerland

We propose to investigate the evolution of the atmosphere and surface conditions on Venus and how they are linked with mantle dynamics. The key point of the study is the interaction between mantle and atmosphere. Coupling occurs on one hand due to mantle degassing, releasing volatiles into the atmosphere, and on the other hand through surface conditions and surface temperature that provide a boundary condition for convection processes.
Thus, we focus on mechanisms that deplete or replenish the atmosphere: volcanic degassing and atmospheric escape. These processes are linked together to obtain a coupled model, using retroaction of the atmosphere on the mantle.

Two aspects of the atmospheric escape are taken into account. During early evolution, hydrodynamic escape is dominant. We use a model developed to take into account the linked escape of Hydrogen and Oxygen (Gillmann et al., 2009). A significant portion of the early atmosphere can be removed this way. For later evolution, we focus on non-thermal escape, as observed by the ASPERA instrument and modeled in various recent numerical studies. Post 4 Ga escape is low. Water escapes moderately, while we are not able to detect the present-day escape of CO_2.
The atmosphere is replenished by volcanic degassing. We use the advanced StagYY code (Armann and Tackley, 2012) for mantle dynamics to compute the evolution of the interior of Venus and corresponding volcanic output. Volatile fluxes are estimated for different mantle compositions and partitioning ratios.
We use a gray radiative-convective model for the atmosphere of Venus. By tracking the evolution of greenhouse gasses in the atmosphere (water and CO_2) we follow surface conditions and temperature over time. Our mantle convection code then uses this temperature as a boundary condition, which in turn affects mantle dynamics.

Our results show that we are able to obtain a Venus-like behavior for the solid planet, with resurfacing events constituting an efficient way of losing Venus' internal heat. We are also able to create evolutions leading to present-day conditions. CO_2 pressure seems unlikely to vary much over the history of the planet, only slightly increasing due to degassing. A late build-up of the atmosphere with several resurfacing events seems unlikely. On the other hand, water pressure is strongly sensitive to volcanic activity and varies rapidly leading to variations in surface temperatures of up to 200K. We observe a clear negative feedback of the atmosphere on volcanic activity, as higher surface temperatures lead to a stagnant or episodic lid convection and less melt production. On the other hand, a lower surface temperature seems to favor mobile lid convection. Mobilization of the upper layers occurs, which imply that our coupling is not complete without taking into account rehydratation of the mantle.