



## **Stabilizing planetary evolution through the coupling of magnetic field, surface tectonics, and atmosphere**

P. Driscoll and D. Bercovici

Yale University, Geology and Geophysics, New Haven, United States (peter.driscoll@yale.edu)

We present a method for coupling the evolution of Earth's surface (atmosphere, tectonics) to the interior (mantle convection, core dynamo) by treating the layers as boundary-coupled one dimensional boxes. Initially atmospheric volatiles ( $H_2O$  and  $CO_2$ ) are degassed from the mantle and remain in the atmosphere until the  $H_2O$  liquid-vapor (T-P) saturation curve is intersected by the greenhouse surface temperature, at which point precipitation and weathering begins, accumulating a water ocean and buffering atmospheric  $CO_2$ . Surface plate motion, a critical component of the carbon buffering cycle, is driven by mantle convection as long as the surface temperature remains below a critical value as predicted by numerical experiments using damage rheology. Active surface tectonics also allows for efficient cooling of the mantle and core, driving the core dynamo and maintaining a strong surface magnetic field. We demonstrate that this coupled model self-stabilizes as a strong magnetic field provides shielding against atmospheric erosion by the solar wind, allowing for the retention of a large water-rich atmosphere that is critical to stabilizing a temperate surface environment, surface tectonics, and whole planet cooling. Such a stabilizing feedback is consistent with observations of Earth's roughly constant surface temperature, plate speeds, and magnetic field intensity going back  $\sim 3.5$  Ga. The model produces a history of Venus with initially active surface tectonics and strong magnetic field before a runaway greenhouse prevents lithospheric damage and subduction, limiting interior cooling and ultimately leading to a decay of the dynamo magnetic field.