# Earth Thermal History Models with Continental Growth and Mantle Water Budget

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Plate-tectonics models of the cooling Earth are calculated along with the evolution of the continental coverage and the mantle water budget. We identify feedback cycles that govern the mantle water budget and continental crust growth. The first feedback includes cycling of water into the mantle at subduction zones and outgassing through volcanism. Because of water reducing the viscosity of mantle rock, the speed of mantle convection and plate subduction will increase with the mantle water concentration, enhancing the rates of mantle water regassing and outgassing.

The second feedback loop includes the production and erosion of continental crust. Continents grow by volcanism above subduction zones. The erosion rate of continents is proportional to the total surface area of continental crust. The rate of sediment subduction affects the rate of transport of water to the mantle and the production rate of new continental crust. We show how the system develops two stable and one unstable fixed point in a plane defined by mantle water concentration and surface area of continents.

The stable points represent either an Earth mostly covered by continents and a wet mantle or an Earth mostly covered by oceans with a dry mantle. The presently observed Earth is in-between these extreme states, but the state is intrinsically unstable on geological time-scales.

Evolving to the present Earth requires a trade-off between initial mantle temperature, water content and onset of plate tectonics, depending on the coupling between surface heat flow $q$ and vigour of mantle convection. Even biologically enhanced weathering should matter.

Thus, plate-tectonics planets can evolve substantially differently, even for similar masses, composition, solar distances, and total water inventories.