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Water-land ratios of exoplanets

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The habitability of ocean planets has been extensively discussed recently (1). We note that there are several arguments for a habitable planet preferably having a solid surface as well as an ocean as we find on Earth. A simple observation is that on Earth most bioactivity is found on continents and continental shelves while the deep oceans are mostly desert. The constancy of Earth's continental volume during the last hundreds of million years suggests that continental crust formation and erosion today are approximately in equilibrium. Although this equilibrium point depends on planet state variables such as the mantle temperature, it could appear reasonable to conjecture that a planet with a similar mass and total water inventory as Earth would possess a similar water-land surface fraction (of 3:2 if continental shelves are accounted for or 2:1 if the water covered surface is compared with the land surface). However, this conjecture neglects self-reinforcing mechanisms associated with continental growth, including a temperature rise below insulating continents and an increased subduction rate of sediments with the emergence of continents. These positive feedbacks become even more pronounced when the mantle-water cycle is accounted for (2). From extensive model calculations varying initial conditions and model parameters over wide ranges, we conclude that bifurcation occurs in the continental growth system and that the water-land fraction that characterizes the present-day Earth is not necessarily a typical result. Most of our models rather show a small continental volume accompanied by a large surface water fraction (water-world) or large continents with little surface water at the present day. An evolution leading to an Earth-like distribution results only for restricted sets of initial conditions. This opens the possibility that planets with Earth-like masses and total water inventory may be found that substantially differ from Earth with respect to their relative land surface distributions.

References:

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(2) Höning, D., Spohn, T., 2016. Continental growth and mantle hydration as intertwined feedback cycles in the thermal evolution of Earth. Physics of the Earth and Planetary Interiors 255, 27-49.