EGU22-5975, updated on 09 Aug 2022
https://doi.org/10.5194/egusphere-egu22-5975
EGU General Assembly 2022

Water planet thresholds: The topographic scope for land atop a stagnant lid

Claire Marie Guimond[1], John Rudge[1], and Oliver Shorttle[1,2]
[1]Department of Earth Sciences, University of Cambridge, United Kingdom
[2]Institute of Astronomy, University of Cambridge, United Kingdom

Small water budgets produce desert worlds and large water budgets produce water worlds, but there is a narrow range of water budgets that would grant a marbled surface to a rocky planet. A planet's highest point can constrain this range in that it defines the minimum ocean volume to flood all land. Thus we take a first step in quantifying water world limits by estimating how minimum surface elevation differences scale with planetary bulk properties. Our model does not require the presence of plate tectonics, an assumption which has constricted the scope of previous studies on exoplanet land fractions. We focus on the amplitudes of dynamic topography created by rising and sinking mantle plumes—obtained directly from models of mantle convection—but also explore rough limits to topography by other means. Rocky planets several times more massive than Earth can support much less topographic variation due to their stronger surface gravity and hotter interiors; these planets' increased surface area is not enough to make up for low topography, so ocean basin capacities decrease with planet mass. In cooler interior thermal states, dynamically-supported topography alone could maintain subaerial land on Earth-size stagnant lid planets with surface water inventories of up to approximately 100 ppm of their mass (or half Earth's ocean mass fraction). Considering the overall cap to topography on such planets would raise this threshold ocean mass fraction by an order of magnitude. Current estimates of the surface water contents on TRAPPIST-1e to g place these planets near or above the ultimate topographic waterworld threshold, depending on their core masses.