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Water worlds: characterization, thermal evolution and habitability limitations

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Water is necessary for the origin and survival of life like we know it. In the search for life-friendly worlds, water-rich planets therefore seem to be obvious candidates and have attracted increasing attention in the past years. The water layer on such planets could be hundreds of kilometers deep depending on the water content and the evolution of the proto-atmosphere. A deep water layer will likely form high-pressure ice from a specific depth on.

We study possible constraints for the habitability of deep water layers and introduce a new habitability classification to be applied to water-rich planets (from about Mars-size to almost Neptune-size planets). A new ocean model has been developed coupled with an interior structure model to infer the depth-dependent thermodynamic properties of high-pressure water and the possible formation of high-pressure ice.
We find that the ice layer can be molten from beneath by heat flowing out of the silicate mantle [Noack et al., in review, "Water worlds: how life-friendly is an ocean deeper than on Earth?"], depending amongst others on the thickness of the ocean-ice shell and the mass of the planet.
From our results we conclude that water-rich planets with a deep ocean, a large planet mass, a high average density or a small surface temperature are less habitable than a planet with an Earth-like ocean and might not be suitable candidates for the origin of life.

Ocean planets, that can be clearly detected as such, contain a large amount of water (to significantly reduce the average density of the planet) and are likely to have a thick high-pressure ice layer which cannot be molten from beneath - these planets might therefore not be habitable.