WATER TRAPPING ON TIDALLY LOCKED PLANETS REQUIRES SPECIAL CONDITIONS. Jun Yang[1], Yonggang Liu[2], Yongyun Hu[3] and Dorian S. Abbot[4], [1]Department of Geophysical Sciences, University of Chicago, Chicago, IL, USA, Email: junyang28@uchicago.edu, [2]Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, New Jersey, USA, [3]Laboratory for Climate and Atmosphere-Ocean Studies, Department of Atmospheric and Oceanic Sciences, School of Physics, Peking University, Beijing, China, and [4]Department of Geophysical Sciences, University of Chicago, Chicago, IL, USA, Email: abbot@uchicago.edu.

Surface liquid water is essential for standard planetary habitability. Calculations of atmospheric circulation on tidally locked planets around M stars suggest that this peculiar orbital configuration lends itself to the trapping of large amounts of water in kilometers-thick ice on the night side [1], potentially removing all liquid water from the day side where photosynthesis is possible. We study this problem using a global climate model including coupled atmosphere, ocean, land, and sea-ice components as well as a continental ice sheet model driven by the climate model output [2]. For a waterworld we find that surface winds transport sea ice toward the day side and the ocean carries heat toward the night side. As a result, nightside sea ice remains $\mathcal{O}$(10 m) thick and nightside water trapping is insignificant. If a planet has large continents on its night side, they can grow ice sheets $\mathcal{O}$(1000 m) thick if the geothermal heat flux is similar to Earth's or smaller. Planets with a water complement similar to Earth's would therefore experience a large decrease in sea level when plate tectonics drives their continents onto the night side, but would not experience complete dayside desiccation. Only planets with a geothermal heat flux lower than Earth's, much of their surface covered by continents, and a surface water reservoir $\mathcal{O}$(10%) of Earth's would be susceptible to complete water trapping.

References: [1] Menou K. (2013), *ApJ, 774,* 51. [2] Yang, J., Liu Y., Hu Y. and Abbot D. S. (2014), *ApJ Letters, 796,* L22.

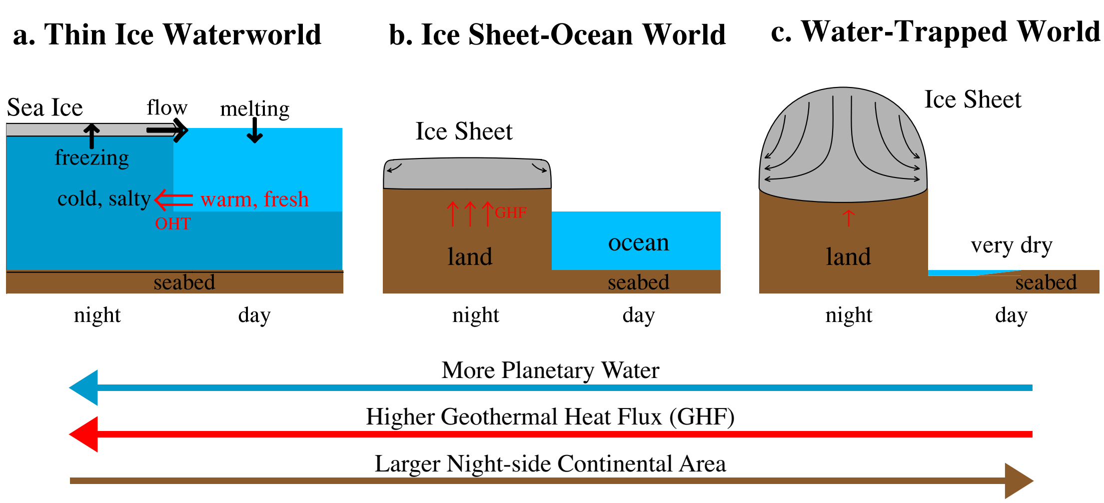

Figure 1: Schematic diagrams of: (a) a planet with thin sea ice on the night side of a waterworld, (b) a planet with a small ice sheet on a nightside continent, and (c) a water-trapped world with a large nightside ice sheet. In (a) sea-ice dynamics and ocean heat transport (OHT) keep the sea ice thin. In (b) the geothermal heat flux (GHF) is large enough to keep the ice sheet small so that it cannot trap all of the planet's water. In (c) GHF is small enough that almost all of the water is trapped on the nightside ice sheet, although subglacial streams and the melting of ice that flows across the terminator allow a small amount of water on the day side. This last configuration will only be possible if the geothermal heat flux is small, the planetary water complement is small, and there are relatively large continents located preferentially on the night side.