Dune: How much sunlight is too much? K. J. Zahnle[1], Y. Abe[1], A. Abe-Ouchi[3], N. H. Sleep[4], [1]NASA Ames Research Center (Mail Stop 245-3, Moffett Field C 94035; kzahnle@mail.arc.nasa.gov), [2]University of Tokyo (ayutaka@eps.s.u-tokyo.ac.jp), [3]University of Tokyo (abeouchi@ccsr.u-tokyo.ac.jp), [4]Stanford University (norm@pangea.stanford.edu).

Introduction: We know of one factual habitable planet, although other factual planets can be (and have been) imagined as habitable. Sometimes the allegory is obvious. E.g., H. G. Wells imagined Martians exterminating humans as an allegory to Englishmen exterminating the Tasmanian aborigines, whilst Percival Lowell saw the global network of Martian canals as a world civilization that had progressed beyond war. But most habitable planets are overtly fictional. The planet properly known as Arrakis and colloquially known as Dune (Herbert 1965) provides an exceptionally well-developed example of a fictional habitable planet. In its particulars Dune resembles a warmer Mars with a breathable oxygen atmosphere. Like Mars, Dune is now a parched desert planet but there are signs that water flowed in the prehistoric past. Dune has small water ice caps at the poles and more extensive deep polar aquifers. The tropics are exceedingly dry but the polar regions are cool and moist enough to have morning dew. Dune is sparsely inhabited by a mix of indigenous and terran flora and fauna. The fictional Dune asks us to consider how much water is enough, why does oxygen accumulate in an atmosphere, and what actually sets the inner edge to the habitable zone.

The inner edge of the habitable zone is conventionally set by the onset of the runaway greenhouse effect. The runaway greenhouse occurs when there is enough water vapor in the atmosphere to lift the planet's thermal photosphere off the ground. For a wet planet the mapping between saturation, temperature and optical depth is unique; together these set an upper limit on the rate the amount of thermal radiation that the planet can emit and still maintain a humid atmosphere. A dry atmosphere has a lower opacity for a given temperature, other things equal. With its vast dry equatorial deserts, a habitable Dune can radiate at a significantly higher effective temperature than a wet planet, and so it can provide an abode for life significantly closer to its sun. We use GCM modeling to show that liquid water can exist at places on the surface of a Dune-like planet at insolation levels as much as 170% of the present solar flux of the Earth.