Dependence of the onset of the runaway greenhouse effect on the surface water distribution for Earth-like planets

*Takanori Kodama[1], Hidenori Genda[2], Ryouta O'ishi[1], Ayako Abe-Ouchi[1], Yutaka Abe[3]

1. Division of Climate System Research, Atmosphere and Ocean Research Institute, The Univ. of Tokyo, 2. Earth-Life Science Institute, Tokyo Institute of Technology, 3. Department of Earth and Planetary Science, The University of Tokyo

The habitability of extrasolar planets has been actively discussed. Liquid water is thought to be necessary for the emergence and evolution of life on the planetary surface. Liquid water vaporizes entirely when planets receive insolation above a certain critical value, which is called the runaway greenhouse threshold. This threshold forms the inner most limit of the habitable zone.

We investigated the effect of the distribution of surface water on the runaway greenhouse threshold for Earth-sized planets using a three-dimensional dynamic atmosphere model. We consider three types of the surface water distribution on a planet: a latitudinally uniform water distribution, a longitudinally uniform water distribution, and water distribution with different water amounts assuming the planetary topography (Earth and Mars). For longitudinally uniform water distributions, we also consider cases for concentrated distribution and equally dispersed distribution even if areas of water distribution are same. We consider a 1-bar atmosphere whose composition is similar to the current Earth’ s atmosphere.

As results, when the water distribution becomes larger, the runaway greenhouse threshold becomes lower and closes to that for an aqua planet, which is covered with ocean globally. We found that the runaway greenhouse threshold for an equally dispersed water distribution is lower than that for a concentrated water distribution even if areas of water distribution are same. This is because the atmosphere for the former globally keeps wetter than that for the latter does.

In this presentation, we summarize the dependence of the onset of the runaway greenhouse effect on the surface water distribution of Earth-like planets.

Keywords: Habitable planets, Runaway greenhouse effect, Water planets