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Numerical Experiments on Climate of Terrestrial Exoplanets: Aquaplanet and Land Planet

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Abstract Text:

Aiming for examining the habitable zone around stars, the existence condition of liquid water on surfaces of extrasolar terrestrial planets has been discussed (e.g., Kasting et al., 1993, Icarus). One of the main issues is where the inner-edge of habitable zone lies. For aquaplanets which are covered with ocean all over the surface, the runaway greenhouse state has been discussed as an important concept for determining the inner-edge of habitable zone. The runaway greenhouse state is defined as a state in which incident flux given to the atmosphere exceeds the radiation limit: the upper limit of outgoing longwave radiation emitted from the top of the moist atmosphere on a planet with ocean (Nakajima et al., 1992, J. Atmos. Sci.). In the runaway greenhouse state, thermal equilibrium can not be realized. Some numerical experiments, using atmospheric general circulation models, has shown that non-equilibrium states in which atmospheric temperature keeps increasing are obtained with increased incident flux (e.g., Leconte et al., 2013, Nature). On the other hand, a land planet is considered as one kind of candidate of habitable planets. A land planet is a planet which possesses water on its surface much less than Earth. It was shown that liquid water can exist on planet surface for incident flux of 1.7 times of present Earth's value by AGCM experiments (Abe Y. et al., 2011, Astrobiology). Abe et al. (2011) discussed that complete evaporation of all surface water occurs on land planets with incident flux more than 1.7 times of present Earth's value. Abe et al. (2011) called the occurrence of complete evaporation as the occurrence of the runaway greenhouse state in land planets, and discussed that the critical value of incident flux determines the position of inner-edge of habitable zone. In this presentation, we will discuss parameter dependence of the occurrence condition of the runaway greenhouse state and the relationship between complete evaporation and the runaway greenhouse state using our atmospheric general circulation model, DCPAM5, with aquaplanet and land planet configurations.

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Aquaplanetology: Aqueous Environments and Habitability in the Solar System

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