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The amounts of liquid water when the oceans occupy half of the planet, under the local precipitation

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It is more than 15 years since the first discovery of extrasolar planet, and more than 500 planets have been discovered. Most of the known exoplanets are gas giant planets like Jupiter. However, the discovery of terrestrial planets is just beginning through the improvements in observational instruments, which make us expect that some exoplanets may have life.

The presence of liquid water on the planetary surface is considered to be an important condition for habitable planets. But exoplanets with liquid water do not always have globally covered oceans like Earth. Some exoplanets may have a small amount of liquid water on their surface as the lakes, which may be also habitable.

Abe et al. (2005) considered a hypothetical planet not having topography and transportation of liquid water on its surface. Precipitation and evaporation are balanced in local on such planets. Abe et al. (2005) called them 'land planets'. Numerical experiments with 3 dimensional atmospheric general circulation model (GCM), assuming that the planet have a very little water (less than 1 meter on average), showed that liquid water localizes at high latitude and it is dry at low latitude of land planets. It is also found that the habitable zone of land planets is 3 times wider than that of planets with globally covered oceans like Earth (we call them 'aqua planets'). This is because the destabilizing effect of water on climate, (i.e., the runaway greenhouse effect and the ice albedo feedback), are both weaken on land planets.

The condition for being land planet is that the location where evaporation is higher than precipitation maintains wet owing to the transportation of liquid water on the surface. To extract a condition for distinction between land planets and aqua planets, systematic GCM experiments with various amounts of water under a lot of topographic maps are needed.

However, doing experiments with all parameters on GCM is very difficult, because the experiments using GCM take a lot of time. In this research, for preparing the experiments on GCM, we estimate the amounts of water for a distinction between land planets and aqua planets as follows. Abuku (2009) used percolation theory and showed mathematically that a condition for global covered oceans is equivalent to a condition that oceans occupy about a half of the planet, assuming that low potential area become ocean on a 2 dimensional random potential area. But on real planets, all low potential area does not always become ocean because precipitation localizes. Precipitation occurs at high latitude on land planets (Abe et al., 2005). So we made a lot of random topographic maps using planets' topographic data and poured water from north and south poles. We consider that the amounts of liquid water when oceans occupy a half of the planet is close to the amounts of liquid water for distinction between land planets and aqua planets. So we estimated the amounts of liquid water when oceans occupy a half of the planet, under various topographic maps.