Habitability of planets on eccentric orbits: limits of the mean flux approximation?

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Abstract

A few of the planets found in the insolation habitable zone (as defined by Kasting et al. 1993) are on eccentric orbits, such as HD 136118 b (eccentricity of _˜0.3, Wittenmyer et al. 2009). This raises the question of the potential habitability of planets that only spend a fraction of their orbit in the habitable zone.
Usually for a planet of semi-major axis a and eccentricity e, the averaged flux over one orbit received by the planet is considered. This averaged flux corresponds to the flux received by a planet on a circular orbit of radius r = a(1-eˆ2)ˆ1/4. If this orbital distance is within the habitable zone, the planet is considered "habitable". However, for a hot star, for which the habitable zone is far from the star, the climate can be degraded when the planet is temporarily outside the habitable zone.

The influence of the orbital eccentricity of a planet on its climate has already been studied for Earth-like conditions (same star, same rotation period), with Global Climate Models (GCM) such as in Williams & Pollard 2002 and Linsenmeier et al. 2014. Spiegel 2010 and Dressing et al. 2010 have also studied the effect of eccentricity for more diverse conditions with energy-balanced models.
We performed a set of simulations using the Global Climate Model LMDz (Wordsworth et al. 2011, Forget et al. 2013, Leconte et al. 2013). We computed the climate of aqua planets receiving a mean flux equal to Earth's, around stars of luminosity ranging from 1 Lsun to 10-4 Lsun and of orbital eccentricity from 0 to 0.9. We show the limits of the mean flux approximation, depending on the previous parameters and also the thermal inertia of oceans.

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