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Diurnal Habitability of Frozen Worlds

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We investigate the surface temperature and the biological productivity of a hypothetical Earth-like planet covered by continents and ocean on diurnal and seasonal time scales. We assume that the whole ocean has the same temperature independent of latitude and time while the temperature of the continents depends on latitude and on the thermal inertia of the land mass that may storage heat received from the central star during mid-day. Four latitudinal belts are considered where time dependent insolation is derived for three different obliquities.

We find that under certain conditions the local continental temperature may rise well above the average temperature. In this way, biological productivity can become periodically possible on a planet that has average temperature clearly below zero. Linking habitability to the temporarily non-vanishing biological productivity on at least one continental latitudinal belt we find for high obliquities and high atmospheric carbon dioxide partial pressures a remarkable extension of the habitable zone from 1.58 AU to 1.86 AU. Our results may be important for Earth-like planets situated near the outer edge of the habitable zone and for so-called frosted Earths hosted by M dwarfs.