CO2 ice condensation is not a detriment to the habitability of warm terrestrial planets

Irene Bonati*†[1] and Ramses Ramirez[1]

[1]Earth-Life Science Institute, Tokyo Institute of Technology – Japan

Abstract

The stabilizing effect of the carbonate-silicate cycle has helped Earth maintain habitable surface conditions over long timescales. However, high enough atmospheric CO2 contents can trigger atmospheric collapse via CO2 surface ice condensation at the poles, leading to irreversible glaciation. Such a process would negatively impact the potential for Earth and other rocky bodies to develop and sustain habitable conditions, even if located within the canonical habitable zone.
Here, we use a non-grey energy balance model to determine the threshold at which CO2 ice condensation becomes dominant and leads to a planetary snowball state. We model the surface temperature evolution of Earth-like planets assuming cold (T=230 K) or warm (T=280 K) starts. We vary planetary obliquity, CO2 atmospheric pressures, and distance from Sun-like stars. The model accounts for heat transfer exerted by the presence of a dynamic ocean, which was not featured in previous models.
Results show that planets that start out warm can stave off atmospheric collapse of CO2 ice at significantly higher CO2 pressures and larger semi-major axes than can planets that initially start in a glaciated state. This implies a wide habitable zone, so long as planets begin with habitable surface temperatures.

*Speaker
†Corresponding author: irene.bonati@elsi.jp