

Tracking process of atmospheric collapse: new scheme for multi-species condensation

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Exoplanets around M dwarfs are remarkable targets for observation as they are the most amenable planets to detection and characterization. Due to their closer orbital distance, these planets would be tidally-locked, with a permanent irradiated hemisphere (dayside) and opposite one (nightside). If nightside temperature is low enough, atmospheric CO₂ condenses, resulting in CO₂ removal from atmosphere and reduction of CO₂ greenhouse effect. We previously investigated the impact of this phenomenon (known as atmospheric collapse) to greenhouse effect and habitability on tidally-locked planets by using the Generic PCM, a global climate model (GCM) developed at Laboratoire de Météorologie Dynamique. We simulated several cases changing initial CO₂ partial pressure (from 1 bar to 10⁻⁶ bar), and then we verified if atmospheric collapse occurs in each case. As a result, we found that atmospheric collapse decreases not only greenhouse effect but also day-night atmospheric heat transport, resulting in low heat transport efficiency keeping dayside warm (Taniguchi et al. in prep). However, these simulations could not completely follow the transition process by atmospheric collapse (by interpolating the results with different initial CO₂ partial pressure, we guessed the climate during/after atmospheric collapse event). This is because current GCM can treat only one condensable gas species (H₂O in our simulations, and not CO₂). To simulate condensation of not only H₂O but also CO₂, we developed new schemes which can treat multi-species condensation. These schemes take into account the changes of CO₂ and H₂O mixing ratio, which affect mean molecular mass, greenhouse effect, and pressure gradient. In this presentation, we present the atmospheric H₂O & CO₂ cycles, and transition process throughout an atmospheric collapse event on a cooler tidally-locked planet.

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