A reversed Monte Carlo radiative transfer model for Titan's PCM

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Titan and particularly its thick atmosphere, unique among solar system objects, has been a center of interest for many decades. Titan's atmosphere has been thoroughly studied, notably with the use of Planetary Climate Models (PCM) (Lebonnois et al. 2012, Lora et al. 2015, de Batz de Trenquelléon, Rannou, Burgalat, Lebonnois & d'Ollone 2025, de Batz de Trenquelléon, Rosset, d'Ollone, Lebonnois, Rannou, Burgalat & Vinatier 2025). Most of which consider a plan parallel atmosphere for the radiative transfer calculation (Lora et al. 2015, de Batz de Trenquelléon, Rosset, d'Ollone, Lebonnois, Rannou, Burgalat & Vinatier 2025). However, this assumption has limitations in the case of Titan, since its thick atmosphere makes sphericity effects prominent. For instance, the Titan's PCM from IPSL simulates up to 500 km altitude, while Titan radius is 2575 km, therefore the atmosphere extension is not negligible, representing 20% of Titan's radius. In such a case, sphericity effects are important and may result in variations of the radiative budget with retroactions on the circulation and cloud formation.

Plane parallel radiative transfer models cannot catch those effects, therefore calling for a more sophisticated approach. We have developed a new 3D radiative transfer model, with spherical geometry and heterogeneous layers: htrdr-planets (`https://www.meso-star.com/projects/htrdr/htrdr.html` He et al. submitted), to be implemented in Titan's PCM and study its atmosphere. This model is based on a reversed Monte Carlo algorithm incorporating recent developments in computing science (Villefranque et al. 2019), able to calculate radiative budget within each PCM cell with very little approximations.

In this presentation, we present the project and the model, as well as, results from preliminary tests.

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