

**METHANE CLOUD FORMATION AND IMPACT ON THE CLIMATE OF TITAN
WITH THE TITAN PLANETARY CLIMATE MODEL**

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The thick atmosphere of Titan, Saturn's biggest moon, is home to complex cloud activity. Due to the abundance of methane, as well as the atmospheric and surface conditions, Titan's lower atmosphere hosts a methane cycle similar to that of water on Earth, with convective methane clouds forming in the troposphere [1]. In addition to the methane cycle, stratiform hydrocarbon clouds at the poles, or HCN clouds at high altitude have also been observed [2]. In this context, climate models are great tools for understanding the mechanisms at work and further our interpretation of these observations. The focus here will be on the atmospheric portion of the methane cycle, specifically the impact of the methane distribution on the formation and structure of the clouds, and the repercussions on the climate of Titan.

The Titan Planetary Climate Model (Titan LMDZ PCM [3]) is a 3D climate model that simulates Titan's climate at a global scale. It includes coupling between the various modeled physical processes, among which a microphysical model in moments for haze and clouds [4]. The model takes into account the condensation of four species (CH₄, C₂H₂, C₂H₆, HCN) in the form of ice only, and independently of each other. The abundance of methane in the model was also previously constrained by Huygens measurements, with a minimum concentration set at 1.4%. Recent reanalysis of CIRS observations show that the Huygens measurements were atypical and that the concentration of methane in the stratosphere is generally lower, around ~1%, varying seasonally by +/-0.4% [5]. We therefore decided to remove this minimum value from the model and allow methane to evolve freely. We observe that this affects the altitude of saturation of methane and thus cloud formation in the model. The vertical and seasonal distribution of methane clouds is improved. The top altitude of methane clouds increases, and the seasons and latitudes of formation are consistent with the observations. The tropospheric thermal structure is also improved with respect to the observations.

The vertical development of the modeled clouds remains however limited, and the model currently lacks processes to effectively replenish the stratosphere with methane, which slightly decreases year after year, reaching 0,7% after 30 years of simulation. Ongoing work focuses on implementing such mechanisms. We are currently adding to the model the latent heat release due to the condensation of condensible species, which is the main mechanism underlying the development of methane storms, that are thought to allow methane to be transported to higher altitudes [6].

References

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