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Seasonal variations in Titan's stratosphere polar regions addressed with a Global Climate Model

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Abstract

In this study we present results concerning seasonal effects in Titan's stratosphere, modeled with the latest version of the IPSL Global Climate Model, and we compare them to Cassini's observations. Focus is put on the thermal structure on the polar night and especially the destabilization in low stratosphere observed with radio-occultations [4] and now reproduced closer to the observations in the simulations - without any latitudinal variation of composition neither radiative coupling with haze - even though a delay in the occurrence is noticed. This delay is also observed in terms of enrichment of trace compounds above winter pole, but the improvements brought to thermal structure and coupling with photochemical module lead to a better representation of the seasonal variations of minor species.

1. Introduction and Background

Observations of Saturn's moon Titan through exceptional longevity of Cassini's overall mission allowed to map stratospheric thermal structure and composition over almost half a Titan's year. Former works on these observations revealed many seasonal variations [6] among which some features remained unexplained or partially understood, such as the mechanisms in place in the polar vortex, the evolution of the thermal structure at high latitudes and the impact of the strong observed enrichment in trace compounds in winter polar nights.

The latest works on the IPSL Titan's Global Climate Model (GCM) radiative transfer, now based on a flexible correlated-k method and up-to-date gazes spectroscopic data [5], lead to a correct modeling of the temperature profiles in the middle atmosphere. It also induced a better representation of the circulation which bring new results in this part of the atmosphere for simulations coupled with photochemical module. Given this, it is now possible to tackle some scientific issues about seasonal variations of thermal structure and minor species mixing ratio in polar regions.

2 Thermal structure above winter pole

As the former microphysical model used in the reference version of the GCM [3] needed to be switched off so far in this new version, we present in a first time results concerning simulations without radiative retroaction of haze variations, with the same mean vertical profile of haze extinction being used at all latitudes and seasons.

Special interest is bear on the destabilization of lower polar winter stratosphere, such as observed by Cassini radio-occultations [4], now reproduced in simulations as shown in Figure 1.

Nevertheless we notice that in these simulations this destabilization appear in the autumn and early winter whereas it has been observed later, up to the following equinox, by Cassini.

Upper in the stratosphere the thermal profiles are too warm above winter pole as we for now lack the strong infrared cooling caused by accumulation of haze in this area.

3 Seasonal variations of trace compounds

We will also present the coupling of this new version of the GCM with our photochemical solver [2], extended up to 1300 km, and the consequences of the improved thermal structure and mixing in the middle atmosphere on the seasonal distribution of trace compounds. In light of the results of coupled simulations, we will discuss questions raised by observa-

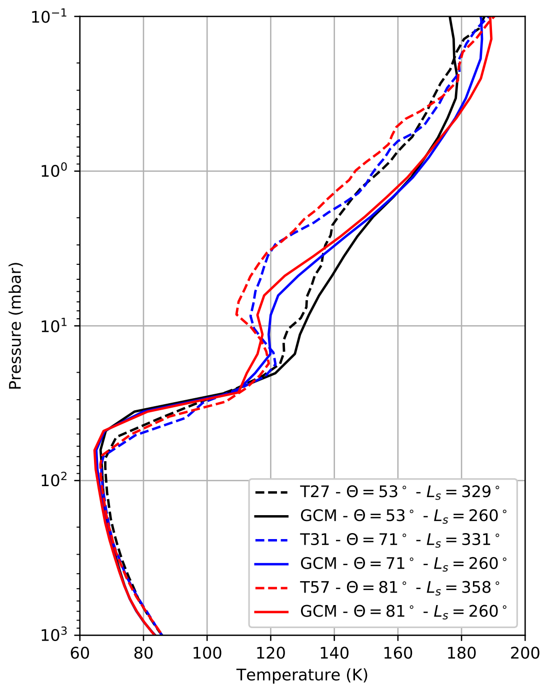

Figure 1: Thermal profiles simulated in the winter hemisphere compared to Cassini radio-occultations [4]. The destabilization in low stratosphere at high latitudes - although it happens too early in our simulations - is obtained without adding any radiative retro-action of haze or chemical compounds.

tions, such as the delay between circulation reversal at the equinox and reversal of the chemical enrichment as well as the strength of this enrichment for various species.

4. Conclusions and Perspectives

In this study we show that interesting results about polar regions thermal structure and composition can be obtained and discussed with simulations without radiative coupling of haze or chemical compounds. As adding these to the model would open broader perspectives, we will discuss the challenges addressed by re-coupling a new microphysical moments scheme developed recently [1] – in the perspective of having a fully interactive microphysical-chemical-dynamical coupled model – and first results of this work will be presented.

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