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Boundary layer circulation on Titan

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Abstract

A new climate model for Titan's atmosphere has been developed, using the physics of the IPSL Titan 2-dimensional climate model with the current version of the LMDZ General Circulation Model's dynamical core. The GCM covers altitudes from the surface to 500 km with the diurnal cycle and the gravitational tides included.

We realized a complete study of thermal structure of Titan's lower troposphere at the Huygen's site [2]. We show that a convective boundary layer develops during the morning on Titan reaching a maximal height of 800 m. We interpreted the slope change in the HASI' s thermal profile at 2 km corresponding to a trapping of the Hadley circulation. Then we discuss the consequences of this boundary layer circulation for winds, clouds and exchange of momentum.

1. Introduction

Titan's lower troposphere is of particular interest because it controls the evolution of many surface features (dunes, lakes) and the exchange of methane between surface and the atmosphere. Yet its study is quite difficult, few observations are available. GCM appear as useful tools to understand the climate and aeolian processes on Titan. With the IPSL-GCM, we succeeded to reproduce profiles of temperature and winds measured by Huygens quite well. We interpreted these profiles and their consequences.

2. Boundary layer and thermal structure

The HASI profile of potential temperature shows a layer at 300 m, an other at 800 m and a slope change at 2 km ([5],[3]). Dune spacing on Titan is consistent with a 2-3 km boundary layer ([4]). We have reproduced this profile (see figure) and interpreted the layer at 300 m as a convective boundary layer, the layer at 800 m is a residual layer corresponding to the maximum diurnal vertical extension of the PBL [2]. We interpret the slope change at 2 km as a weakening of the Hadley's circulation, what produces an increase with altitude of zonal wind into stratosphere.

When averaged over more than one day, only the slope change at 2-3 km remains significant, in agreement with dunes spacing.

Finally we interpret the fog discovered in summer polar region ([1]) has clouds produced by the diurnal cycle of the PBL (as fair weather cumulus on Earth).

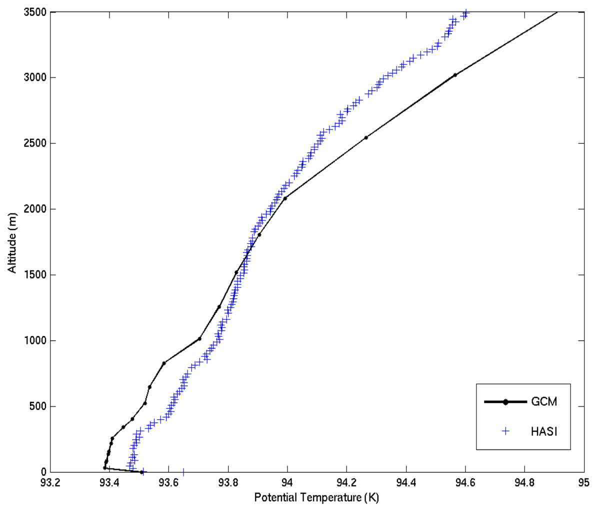

Figure: Profile of potential temperature measured by HASI and simulated by GCM [2]

3. Consequences of the boundary layer circulation

3.1 Winds and waves

We make an analogy between Titan's boundary layer circulation and the terrestrial tropospheric circulation. This allow us to explain the wind profile measured by the Huygens probe and the presence of baroclinic waves in Titan's lower troposphere.

3.2 Exchange of momentum

We discuss the consequences of the boundary layer circulation for the exchange of momentum between surface and atmosphere and so for the variation of Titan spin rate.

4. Conclusion

GCM appear as perfect tools to study Titan's lower troposphere from which we have few observations. Titan's boundary layer appears to have consequences on every aspects of Titan weather.

References

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