EPSC Abstracts
Vol. 6, EPSC-DPS2011-1165, 2011
EPSC-DPS Joint Meeting 2011

A GCM of Pluto's atmosphere

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1. Introduction

Pluto currently generates much interest, notably because it is the target of the mission New Horizons. Pluto has a predominantly tenuous N_2 atmosphere, in which CH_4 and CO are present. This atmosphere results from the sublimation equilibrium of these ices at surface temperatures near 40K. During the last twenty years, observations by stellar occultations have shown that this atmosphere is in expansion with a pressure increase between 1988 and 2002, followed by a stabilization[2,6], and that its upper part is isothermal with a temperature of 100±20K. However, these observations don't enable to probe the low atmosphere which may include a cold troposphere[1,5,7]. However, the models simulating this troposphere disagree on the height of this tropopause[1,5,7,10].

For the first time, we have built a GCM of Pluto's atmosphere, adapted from the model of Triton's, recently developed[9] . In fact, Pluto and Triton have a lot of similarities (atmospheric, orbital). This GCM will allow to better understand the complex mechanism of the planet and to study the variation of the thermal profile during time.

2. Description of the 3-D model

Our General Circulation Model takes into account the N_2 condensation and sublimation both in the atmosphere and on the ground, the vertical turbulent mixing and the convection in the planetary boundary layer, the radiative transfer due to methane and carbon monoxide, using the correlated k method to generate radiative transfer calculation, the surface and subsurface thermal model with 22 layers and the molecular thermal conduction. However, here the prescribed flux at the top of the model representing heating from the upper atmosphere is equal to 0 W m^2. Unlike on Triton, the radiative processes through CH_4 and CO have an important effect on the thermal profile of the atmosphere[8]. The representation of the large-scale dynamics is based on a grid point model composed of 32 longitudes, 24 latitudes and 25 layers distributed from the surface to about 100 km.

3.Results

The model has been run for three different periods : 1989, 2002 and 2015. For every date, we have varied the emissivity, the surface albedo and the amount of CH_4 and CO in the atmosphere. The initial surface distribution corresponds to a planet with an extended south polar N2 ice cap, a smaller northern polar N2 ice cap and a dark equatorial band without N_2 ice [4]. For a run corresponding to 1989 with an albedo of 0.6 and an emissivity of 0.7, first results show an atmospheric structure in accordance with the observations : isothermal upper atmosphere with a weak cooling due to CO molecules, a high temperature inversion just below and a surface temperature about 40K at most latitudes. However, with a CH_4 mixing ratio of 0.55% as reported by the measurements of Lellouch et al. [3,5], the temperature in the upper atmosphere and the stratospheric gradient is a little low compared to the one infered from stellar occultation [8]. To get a steeper gradient, we need more CH_4. We also note the absence of a troposphere. We can also notice from first results that the N2 ice sublimates in the North and condensates in the southern hemisphere as it is the winter hemisphere in 1989. So, a clear nitrogen transport from the summer hemisphere to the winter hemisphere takes place. It will be also interesting to study the circulation of the zonal winds and the results for other dates as 2002, 2015... and others albedos, emissivities and quantities of CH_4 and CO.

4. Summary and Conclusions

This GCM is the first to study the Pluto's atmosphere taking into account a maximum of physical processes present on this body. The found results will allow to give a prediction about how Pluto will be in 2015. In the future, we will be very interested in the study of the evolution of N_2 ice on Pluto as it is made on Triton.

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