Photochemical modeling of Triton's atmosphere: methodology and first results

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Introduction

Triton is the biggest satellite of Neptune. Discovered in 1846 by W. Lassell, it was visited by Voyager 2 in 1989. It was the only spacecraft to study the neptunian system. Very little was known about Triton at the time of the flyby, except its highly inclined retrograde orbit suggesting that it is a Kuiper Belt object captured by Neptune. The flyby allowed to take high resolution pictures of the surface, to determine its temperature, pressure and the composition of the surface ices (N_2, CH_4, CO, CO_2 and water ice). Clouds and haze were also observed respectively under 10 and 30km of altitude as well as plumes of organic material propagating up to 8km, pointing out the existence of a troposphere. The atmosphere was also studied by measuring its airglow and by performing stellar occultations (Broadfoot et al. 1989). It revealed that it is mainly composed of N_2, and N with traces of CH_4 near the surface. CO was not detected and so only an upper limit on its abundance had been set. An important ionosphere was also observed with an important peak at 340km (Tyler and al. 1989).

The photochemical model

As a starting point, we used the photochemical model of Titan (see Dobrijevic et al. 2016) and adapted it to Triton. In particular, we used the chemical scheme developed for Titan as the two atmospheres are mainly composed of N_2, with presence of CH_4. Our model takes actually into account 204 species (117 neutrals and 87 ions). Our chemical scheme is composed of 1570 reactions (154 photodissociations, 597 neutral reactions, 31 photoionizations and 788 ionic reactions). Our model takes the interplanetary Ly-Alpha flux into account as well as the energy input of precipitating electrons from the neptunian magnetosphere by adding reactions of electron impact ionization and dissociation for N_2. To obtain a first validation of our model, we compare our results with the Voyager 2 data and with the results presented in the principal articles about the photochemistry of Triton published after the Voyager 2 flyby.

First results

Our first results confirm that precipitation of magnetospheric electrons is very important to explain the composition of the ionosphere. The solar flux is also a critical parameter of the model since the CH_4 abundance profile near the surface depends on the solar activity (the Voyager 2 flyby occurred near a solar maximum). This abundance profile also depends on the eddy diffusion coefficient. We also observed that the results depend strongly on some reactions. A study of the model's uncertainties seems mandatory and will allow us to identify these key reactions. Uncertainties may indeed be large due to the low temperature of Triton's atmosphere.