
A photochemical model of Triton's atmosphere with an uncertainty propagation study

Benjamin Benne^{*1}, Michel Dobrijevic¹, Thibault Cavalié^{1,2}, Jean-Christophe Loison³,
and Kevin Hickson³

¹Laboratoire d'Astrophysique de Bordeaux – Université de Bordeaux (Bordeaux, France), CNRS :
UMR5804 – France

²Laboratoire d'études spatiales et d'instrumentation en astrophysique – Institut National des Sciences de
l'Univers : UMR8109, Observatoire de Paris, Sorbonne Université, Centre National de la Recherche
Scientifique : UMR8109, Université Paris Cité : UMR8109 – *France*

³Institut des Sciences Moléculaires – Université de Bordeaux (Bordeaux, France), CNRS : UMR5255 –
France

Résumé

Triton is the biggest satellite of Neptune. It was only visited by the Voyager 2 spacecraft in 1989. Triton's surface temperature is only 38 K and the surface pressure was measured to 16 bar during Voyager's flyby. It has a tenuous nitrogen atmosphere similar to the one of Pluto. The latest photochemical models of Triton's atmosphere date back to the post-flyby years (Strobel et al. 1990, Krasnopolsky et al. 1993, Krasnopolsky and Cruikshank 1995). A new mission to Triton is now needed to improve our understanding of the formation and evolution of this moon. In order to prepare such a mission, we have developed a new photochemical model of Triton's atmosphere with an up-to-date chemical scheme.

Voyager detected traces of CH₄ near Triton's surface and as the main atmospheric species is N₂, the composition of Triton's atmosphere seems similar to the one of Titan. Thus, we utilized a photochemical model of Titan's atmosphere from Dobrijevic et al. (2016) and adapted it to Triton's conditions. This led us to modify the critical input parameters and the chemical scheme by adding new reactions and atmospheric species. With this, we first computed the nominal composition of Triton's atmosphere. Next, we took chemical uncertainties of all reaction rates into account by using a Monte-Carlo procedure. With these results, we performed a sensitivity analysis to identify key chemical reactions.

With the nominal results, we identified which reactions are important for the production and loss of the dominant atmospheric species. We highlight critical parameters that influence the most the abundance profiles. Using results from the Monte-Carlo procedure, we find large uncertainties over the abundance profiles of the main atmospheric species. For some species, we observe epistemic bimodalities in their abundance distributions. This is mainly due to the extreme conditions in Triton's atmosphere, implying large uncertainties on reaction rates. Finally, with the sensitivity analysis, we identify key chemical reactions that cause large uncertainties on the results. These reactions must be studied in priority to reduce these uncertainties, consequently improving the significance of our results. Epistemic bimodalities should also be removed with better knowledge of the key reactions.

^{*}Intervenant