Impact of the precipitation of magnetospheric electrons on the composition of Triton's atmosphere

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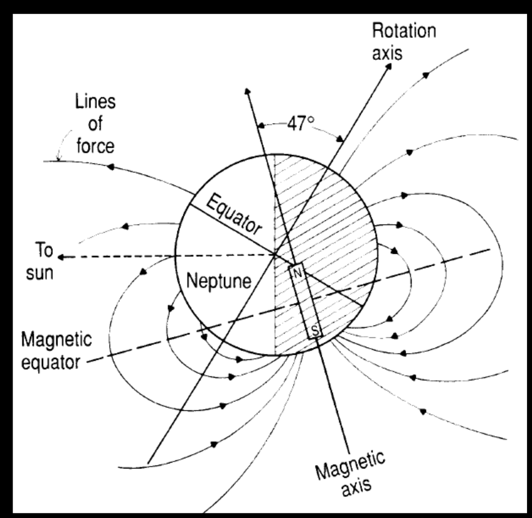
The magnetic environment of Triton is highly variable due to the combination of its inclined orbit and of the complex geometry of Neptune's magnetic field. Thus, the electron precipitation in Triton's atmosphere varies strongly. As this precipitation is supposed to have an important effect on the atmosphere, a better understanding of the interaction between magnetospheric electrons and the atmosphere is necessary.
In this work, we coupled a 1D photochemical model of Triton's atmosphere with the electron transport code TRANSPlanets. The latter code is used to compute the rates of the electron-impact ionization and dissociation reactions depending on the electron precipitation, the orbital scaling factor and the magnetic field strength. These rates are then used in the photochemical model to compute the atmospheric composition. We did these computations for various initial conditions to find the ones allowing to better match Voyager 2 observations. We found that, contrary to previous models, the main ionization source in the atmosphere is photoionization instead of electron-impact ionization.

I. Introduction

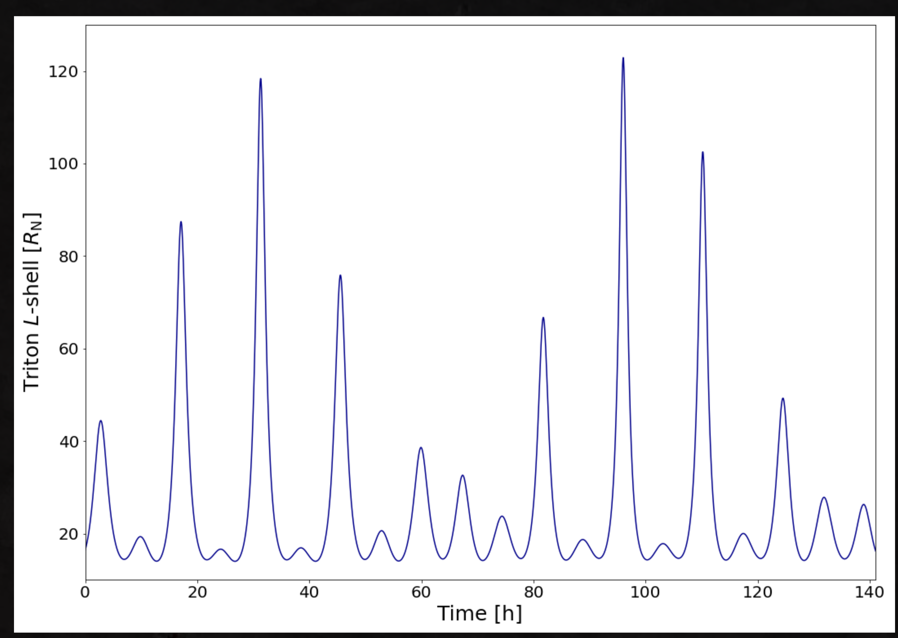
- Triton has a dense ionosphere, with a peak electronic number density of $(3.5\pm1)10^4$ cm^{-3} at (340-350) km [1]
- Photoionization at 30 UA seems too weak to explain this → Additional source of ionization was hypothesized → Electrons from Neptune's magnetosphere [2]
- Neptune's magnetic field + Triton's inclined orbit → Highly variable magnetic environment → Varying precipitation
- We studied how this varying precipitation impacts Triton's atmospheric composition
  → Coupling an electron transport code with a photochemical model

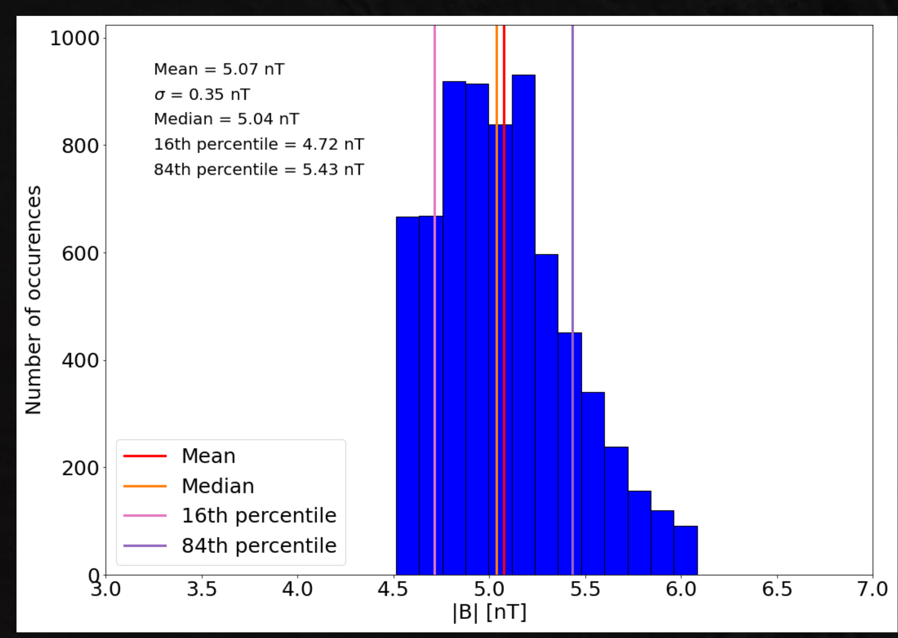


Ness et al. (1995)[3]

II. Triton's variable magnetic environment

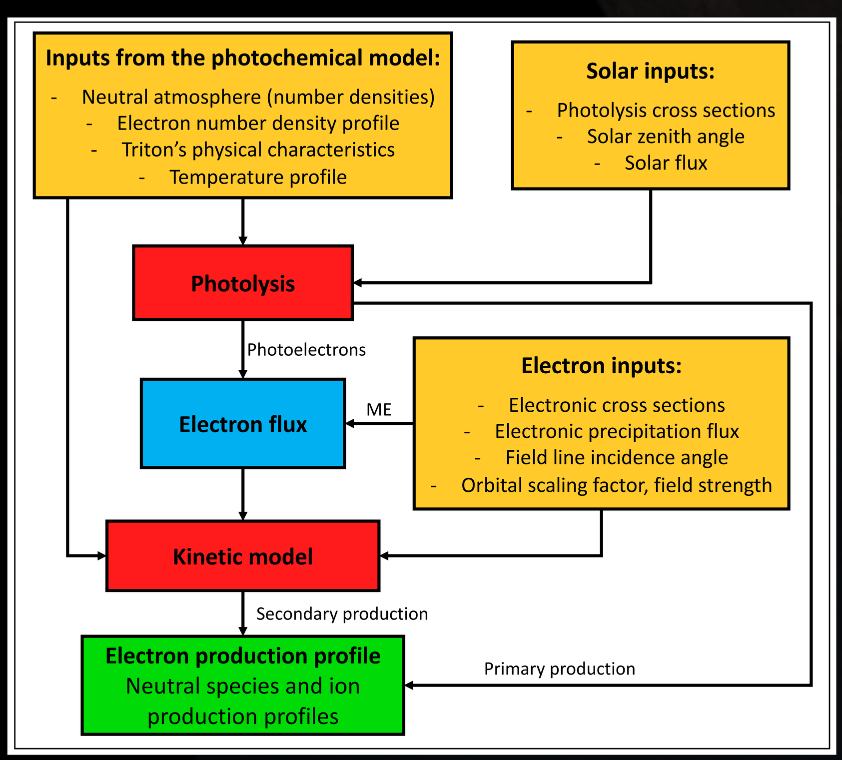
- At Triton's distance, Neptune's magnetic field can be approximated by an Offset-Tilted Dipole (OTD)
- In the existing OTD models, the dipole is inclined by ~46° with respect to Neptune's rotation axis and its center is offset from Neptune's center by ~0.5 R_N [3]
- Combined with Triton's highly inclined orbit, this makes Triton's *L*-shell vary from 14 to ~120
- [4] supposed that electron precipitation occurred only for *L*<15.5, when Triton is near Neptune's magnetic equator. → 27% of an orbit → Mean magnetic field = (5.07±0.35) nT

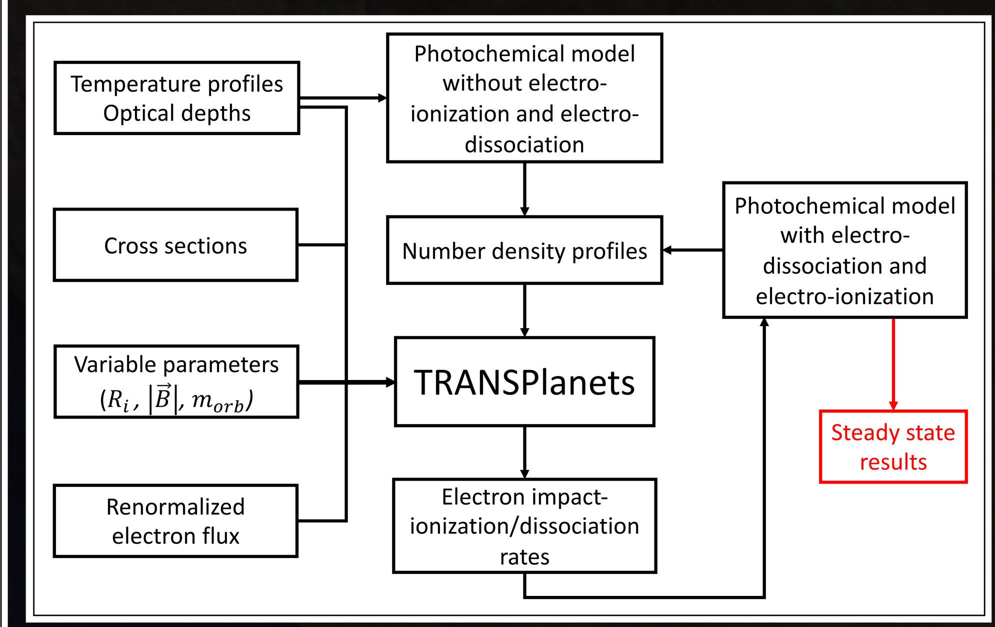




III. Coupling TRANSPlanets and the photochemical model

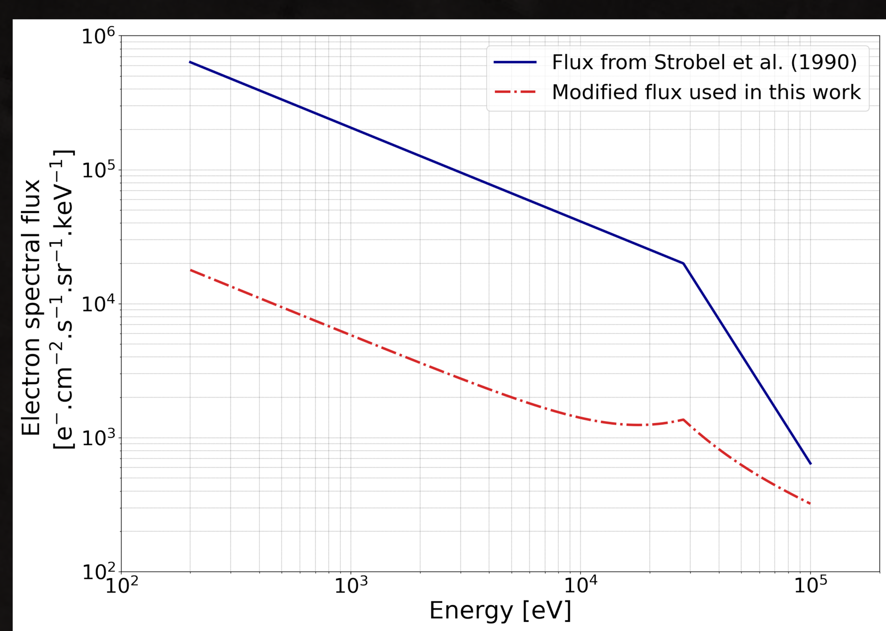
- TRANSPlanets = generic version of the TRANS* model, used to compute electronic transport in various atmospheres [5]
- Electron flux = Photoelectrons + magnetospheric electrons
- Use the most recent photochemical model of Triton's atmosphere from [6]

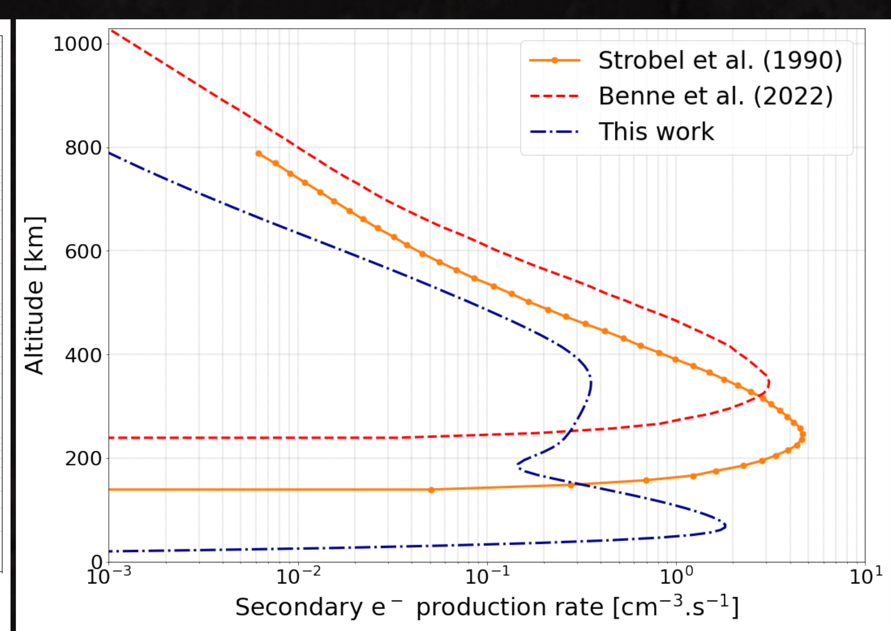




IV. Inputs and results of TRANSPlanets

- We considered a vertical precipitation (other geometries not usable for the moment in TRANSPlanets), at the difference of [4], where the line is inclined by 9°/horizontal
- Inputs:
  - Electron precipitation flux from [4] modified following the work of [7]
  - Orbital scaling factor of 0.27; Magnetic field of 5 nT; Atmosphere of N_2, CH_4, N, C, CO

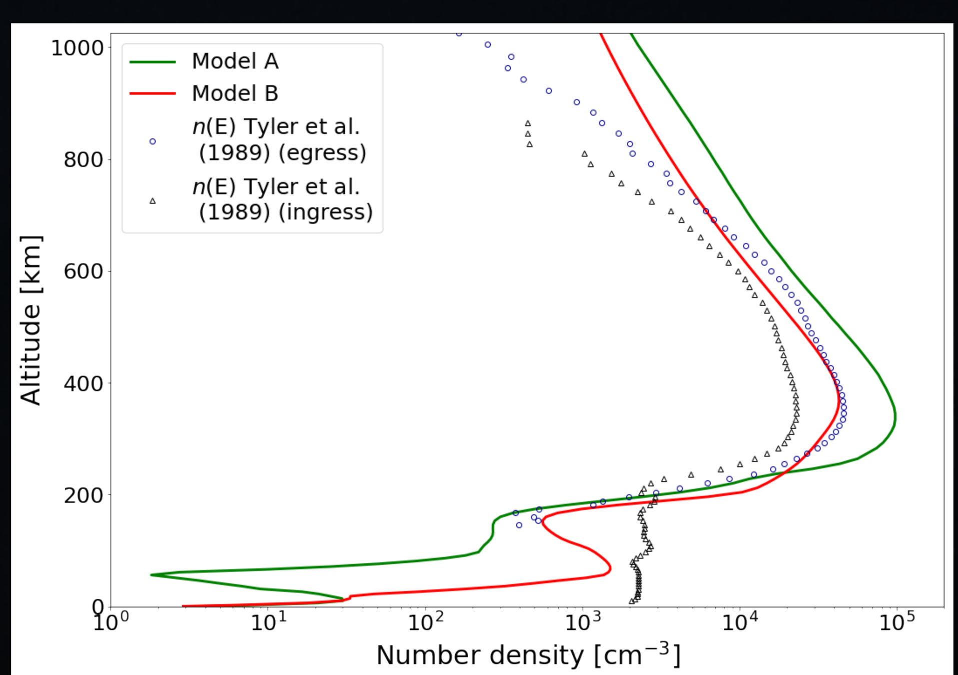




- Peak at 350 km → Due to electron-impact ionization by photoelectrons
- Peak at 71 km → Due to electron-impact ionization by magnetospheric electrons

V. Nominal results from the photochemical model

- Model A = [6] ; Model B = This work
- Electron-impact ionization integrated rate decreases by 77% between model A and model B
- Photoionization/electron-impact ionization ratio = 6/5 (model B) and 2/5 (model A)
  → **Photoionization is the main ionization source**
- Electron peak number density = 4.4×10^4 cm^{-3}, consistent with Voyager 2 observations
- Better consistency between the modelled electron profile and Voyager 2 observations



VI. Summary and Conclusion

- Goal: Couple a photochemical model of Triton's atmosphere and an electron transport code to better understand the impact of electron precipitation on atmospheric composition
- We modelled the varying magnetic environment of Triton to determine values of the TRANSPlanets input parameters (orbital scaling factor, magnetic field strength)
- We computed the electro-ionization and electro-dissociation rates with TRANSPlanets
- We used these rates in the photochemical model and determined the atmospheric composition

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- The nominal electron number density profile is consistent with Voyager 2 observations
- Photoionization is the main ionization source of Triton's atmosphere
- Model can be improved:
  → Add the possibility to use other magnetic field line geometries
  → Implement the computation of the heat deposited by the electrons
  → Add relativistic computations for high-energy electrons

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