THE EFFECT OF PHOTOOABSORPTION CROSS SECTION AND SOLAR FLUX ON ETHANE PRODUCTION IN TITAN’S IONOSPHERE A. Luspay-Kuti1, K. E. Mandt2, J. H. Waite2, V. de la Haye3.
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Introduction: Titan’s dense atmosphere is of high interest due to the ongoing active organic chemistry. These complex processes are initiated by the photochemistry of the two main atmospheric constituents: molecular nitrogen and methane. EUV photons dissociate and ionize \( \text{N}_2 \) and \( \text{CH}_4 \) (at \( \lambda \leq 145 \) nm) molecules, whose products then participate in the production of heavier hydrocarbons and nitriles. The exact chemical pathways at different altitudes and the production rates are determined by the complex relationship of several parameters, making modeling complicated.

Instruments such as the Ion Neutral Mass Spectrometer (INMS) onboard Cassini allow a deeper understanding of atmospheric interactions, as well as the characterization of Titan’s atmosphere and ionosphere as a function of altitude, latitude and local solar time and provides improved constraints for models.

Considering the role of the main atmospheric constituents in the initiation of chemistry, it is evident that differences in model input parameters, such as the \( \text{N}_2 \) cross sections for photoabsorption, might lead to different results [1].

Here we present results on the effects of varying solar flux, along with low and high resolution nitrogen cross sections on the global average ethane production in the upper atmosphere of Titan. Ethane is the second most abundant hydrocarbon in Titan’s atmosphere and an important component of the surface liquids, therefore its abundance on the surface begins with its production in the upper atmosphere.

Model: The model used for this study was developed specifically for INMS data comparison and was validated using INMS data from the first two Titan flybys [2]. It calculates the altitude profiles of neutrals and ions between 600 and 1600 km and includes chemistry due to photodissociation and photoionization, electron impact dissociation, electron recombination of ions, ion-molecule reactions and neutral-neutral chemistry for a fixed temperature profile. The model was later updated to include high resolution cross sections and nitrogen isotope chemistry [3]. It now calculates the absorption of solar photons by \( ^{14}\text{N}_2, ^{14}\text{N}^{15}\text{N}, ^{14}\text{N}(4s), ^{15}\text{N}(4s), \text{H}, \text{H}_2, \text{CH}_3, \text{CH}_4, \text{C}_2\text{H}_2, \text{C}_2\text{H}_4, \text{C}_2\text{H}_6, \text{C}_4\text{H}_2, \text{HC}^{14}\text{N} \) and \( \text{HC}^{15}\text{N} \).

The high resolution cross sections for \( ^{14}\text{N}_2 \) and \( ^{14}\text{N}^{15}\text{N} \) used in the model were between 845 and 1000 \( \AA \)[4], and the cross sections for the other components were interpolated to 0.03 \( \AA \) resolution in this wavelength range.

The model uses the HEUVAC model [5] for the wavelength range relevant to the nitrogen cross sections, which calculates the solar flux as a function of wavelength for any F10.7 value. In the present work, F10.7 values of 70, 160 and 260 were used for the cases of solar minimum, moderate and maximum, respectively.

The total density and mixing ratios at the lower boundary of the model (600 km) were fixed input parameters. We looked at global, daily averages.

Results: Figure 1 shows the ethane mixing ratio calculated in simulations with both low and high resolution cross sections, each containing three runs for the three F10.7 values. As seen in the figure, the solar minimum results show the biggest variation depending on cross section used, while the solar moderate and maximum curves essentially have the same trend and value under an altitude of \( \sim 1100 \) km. Above this altitude these latter profiles differ too. Under \( \sim 950 \) km the solar maxi-
maximum produces the highest mixing ratios. Above this altitude, the maximum mixing ratio is produced by the high resolution solar minimum simulation.

At 850 km a prominent bulge is observable in all simulations, providing a peak for ethane abundance at this altitude. The main production results from termolecular reactions, followed by neutral-neutral reactions, and finally ion-molecule (Fig. 2).

Conclusions: The bulge at ~ 850 km in Fig. 1 coincides with the maximal production rates at the same altitude (Fig. 2) which explains the peak in abundance.

The results at solar minimum appear to be more sensitive to cross sections than solar moderate or maximum conditions. Cross sections appear to only influence the mixing ratio above 1100 km. In Figure 2 the production rates show little to no variation, while the loss rates and the mixing ratios vary from one simulation to the next suggesting that the changing solar flux has an effect on ethane mixing ratios, but the production depends less on the solar flux than loss. Also, cross section resolution appears to be modifying the loss rates both at solar minimum and maximum. High resolution cross sections result in increased neutral-neutral and ion-molecule loss rates.

Our preliminary results show that the choice of cross sections in modeling is of significant importance regarding the outcome. Future simulations will explore the role of the lower boundary condition on the altitude profile, sensitivity of production and loss rates to various model parameters, and downward ethane flux and possible variations in the surface ethane reservoir based on changes in these parameters.