**THE ROLE OF AEROSOLS IN PLUTO’S C₂ HYDROCARBON PHOTOCHEMISTRY.** A. Luspay-Kuti¹, K. E. Mandi¹, K. Jessup¹, V. Hue¹, J. A. Kammer¹, R. Filwett³. Southwest Research Institute, Department of Space Research. ³University of Texas at San Antonio, Department of Physics and Astronomy (aluspaykuti@swri.edu).

**Introduction:** On July 14, 2015 the *New Horizons* spacecraft successfully flew through the Pluto system, providing critical details about Pluto’s atmosphere. Measurements made by the various instruments onboard *New Horizons* confirmed that the chemistry in Pluto’s atmosphere is strikingly similar to Titan’s, including the growth of aerosols [1, 2]. Chemistry is initiated by UV photons dissociating and ionizing N₂ and CH₄, whose products lead to the formation of complex molecules and organic haze in Pluto’s atmosphere.

Vertical profiles of N₂ and CH₄, C₂H₄, C₂H₆, and C₃H₈ were derived from *New Horizons* Alice transmission data. These vertical profiles now allow the more accurate modeling of Pluto’s atmosphere than in the pre-*New Horizons* era, and help better understand the physical and photochemical processes at play. The atmospheric C₂ hydrocarbon profiles in Pluto’s atmosphere indicate that processes other than chemistry have a major impact on their altitude profiles [3]. The condensation and incorporation of hydrocarbons and nitriles onto Titan aerosols has recently been modeled providing good agreement with observations [4], suggesting that these processes may be important in the atmosphere of Pluto.

We present here our Pluto photochemical model, and evaluate the photochemistry of C₂ hydrocarbons in Pluto’s atmosphere. We compare the dominant production and loss processes with a special emphasis on the role of aerosol interaction.

**The Pluto INP model:** We developed a coupled Ion Neutral Photochemistry model for Pluto’s atmosphere (Pluto INP) based on our well-established Titan photochemical model [5-7]. Pluto INP is a 1D model which couples the ion and neutral chemistry by solving the continuity equation at each 10 km altitude grid from the surface up to 1800 km [8]. It includes a total of 46 neutral and 29 ion species. We use a constant thermal profile consistent with the line-of-sight *New Horizons* Alice transmission results [1]. The eddy diffusion profile (K) was determined by fitting the measured CH₄ densities with the model via [9]:

\[ K = K_0 \frac{N}{n} \]

**Photon absorption.** Pluto INP employs temperature-dependent high-resolution (HR) ¹⁴N₂, ¹⁴N¹⁵N cross-sections from the coupled-channel Schrödinger equation for 70 K, binned into 0.03 Å bins between 845 Å and 1000 Å. HR CO cross sections were generated between 900-990.99 Å, and at shorter wavelengths used the available coarse resolution room temperature CO cross-section data sampled to 0.03 Å. In the higher wavelength range where HR cross-sections were not available, we used low resolution cross-sections in 50 Å bins [5-7]. The HR solar flux for F10.7cm = 160 s.f.u. was calculated with a bin size of 0.1 Å, and interpolated into 0.03 Å bin sizes [6, 7]. In addition, we scaled the Ly α photon flux by 1.43 [3].

**Chemistry.** Because of the similarities between the atmospheres of Pluto and Titan, the chemical schemes and reaction rate coefficients were based primarily on our Titan model [5-7]. We also added the most important CO reactions to Pluto INP.

**Condensation.** The option of two methods [4, 10] for calculating the saturation vapor densities of atmospheric species have been incorporated into Pluto INP. Condensable species will have a higher atmospheric density than their saturation vapor density.

**Sticking to aerosols.** We use the effective aerosol surface area inferred from *New Horizons* observations [2], and estimate the sticking of C₂ hydrocarbons to aerosols particles. We determined the sticking efficiencies of C₂ hydrocarbons, and the stickiness of aerosol particles through empirical fits to the *New Horizons* data.

**Results:** Our best-fit eddy profile, and the Pluto INP fits to the *New Horizons* data are shown in Fig. 1. We found that an eddy profile of \( K_0 = 10^6 \text{cm}^2 \text{s}^{-1} \) at \( z = 0 \text{ km} \) reaching \( K_{\text{max}} = 3 \times 10^5 \text{cm}^2 \text{s}^{-1} \) at \( z = 160 \text{ km} \) satisfies the *New Horizons* data best.

Our results show that the *New Horizons* observations cannot be fit with photochemistry only, in agreement with recent results [3]. The inversion in the C₂ profiles indicates a significant nonchemical loss process between ~100 and 400 km. However, we find that condensation has minimal effect on the C₂ hydrocarbon altitude profiles, regardless of the method used. Instead, the dominant loss process that defines the altitude profiles below 500 km is loss by sticking to aerosols.

**Discussion and Conclusions:** With our coupled ion-neutral-photochemistry model developed for the atmosphere of Pluto, we were able to match the observed density profiles of CH₄, N₂, and the C₂ hydrocarbons. Our result implies a high eddy diffusion in Pluto’s atmosphere, which is in agreement with [1] and [11], but is a factor of 500 higher than reported in [3].
We found that the sticking efficiency of C\textsubscript{2} hydrocarbons is inversely related to the aerosol surface area (Fig. 2), which has been inferred from observation to increase as altitude decreases \[2\]. This suggests that, similarly to Titan, the aerosols in Pluto’s atmosphere harden and become less sticky as they age \[1\]. Such hardening with ageing is both necessary and sufficient to explain the vertical profiles of C\textsubscript{2} hydrocarbons in Pluto’s atmosphere.