THE COMPOSITION OF THE MASS 28U CONSTITUENT OF THE ENCELADUS PLUME.

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Introduction: The vapor plumes of Enceladus are comprised primarily of water vapor. However they contain additional constituents that provide insight into the subsurface ocean on Enceladus. Grains of condensed matter may even contain evidence for life if it exists in Enceladus's ocean.

The Ion Neutral Mass Spectrometer (INMS) on Cassini has detected significant signals in the 28 u and 44 u mass channels in addition to the water detected in the mass 18 u channel. Although the 44 u species is most likely CO_2, the composition of the 28 u species is debated. Mass 28 u could be any combination of CO, N_2, or C_2H_4. However recent work suggests that the 28 u species may be a fragment of a heavier species that is broken up within the instrument [1].

This work investigates the spatial evolution of minor vapor species in the plume through modeling and comparing the output to observations. By comparing the evolution of species that are emitted from the jets on Enceladus as mass 28 to the evolution of heavy parent molecules, we evaluate the likelihood that the 28 u signal measured by INMS is a fragment formed in the instrument.

Model: The Monte Carlo model tracks particles that are emitted from a prescribed spatial and velocity distribution from the point of release near the surface through eventual loss from the Enceladus system [2]. The code steps through the equation of motion under gravity in time using a 4th order Runge Kutta solver and provides the location and velocity of each particle at each time step. These data can be binned to produce density distributions for comparison with in situ measurements, line of sight column density for comparison with remote sensing observation, and can factor in velocity information for field of view considerations.

The model uses a two-component velocity distribution. The model assumes a bulk velocity directed along the jet direction. An additional thermal velocity is selected from a Maxwellian distribution at a constant temperature representing the temperature at the point the gas becomes collisionless. The thermal velocity is ascribed a direction selected from an isotropic distribution and is vectorally superposed on the bulk velocity. Although it is assumed that the flow dynamics are set by the primary constituent of water, this mainly fixes the bulk velocity and the temperature at the point of transition to collisionless flow [3]. Because the thermal velocity is dependent on mass, heavier species have slower thermal velocities at the same temperature than lighter constituents. Thus heavier species are expected to maintain more collimatation than lighter ones. The collimation becomes set at the point the flow becomes collisionless.

We constrain the model of the component coming from sources distributed along the Tiger Stripes by fitting the model to the rise and decay observed on the inbound and outbound broad structure (Figure 1).

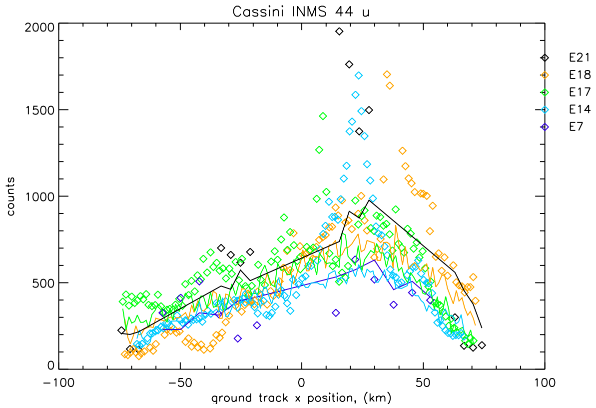

Figure 1. *Model output for the mass 44 INMS tracks that fit the envelope, thought to be the contributions from distributed sources.*

Results: Cassini INMS acquired data from 5 passes over the south polar region that were in a geometry that enables direct comparison: E7, E14, E17, E18, and E21. These data are from passes that have closest approaches of 100 km, 75 km, or 50 km and traverse the active source zones. The varying altitude of the passes allows investigation into the collimation of the sources.

Figures 2 and 3 show results of modeling the emission from the stripes and comparing to the INMS observations. Although there are likely contributions from highly localized jets [4] and distributed sources along the Tiger Stripes [5], this example uses only output from the distributed sources. This provides the general background of vapor in the region surrounding the south pole. Subtracting the model values from the data highlights the places where additional sources are required to reproduce the observations. Figures 2 and 3 plot the excess source (or localized source) for mass 28 u and mass 44 u respectively. Where entire passes show the need for enhanced sources, this can indicate an increase in the source rate during the pass. Small regions of enhanced source indicate where jets are significant contributors to the INMS.

Comparing the passes at high altitude to those at low altitude, we will examine the width of the excess sources and determine the efficacy of a low mass or high mass species in reproducing the 28 u measurements.

References: [1] Waite et al., *Science 311*, 2006. [2] Hurley D. M. et al (2015) *J. Geophys. Res., 120,* 1763-1773 [3] Yeoh S. K. (2017) *Icarus 281*, 357-378. [4] Porco C. et al (2014) *Astron. J., 148,* 45. [5] Spitale J. N. et al. (2015) *Nature 521*, 57-60.

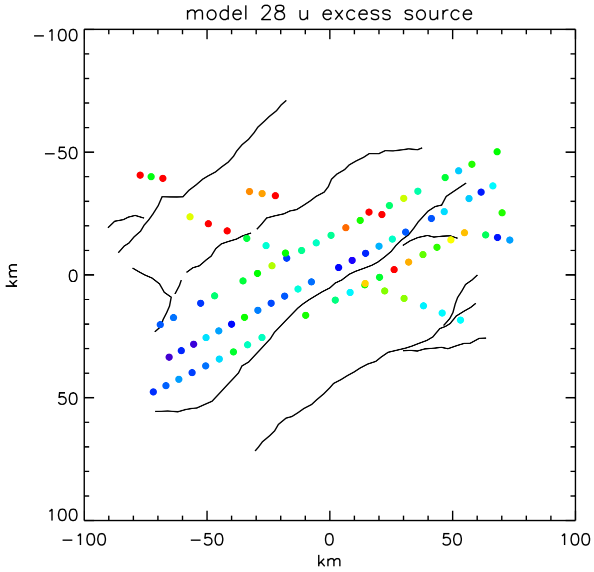

Figure 2. *Excess source needed beyond the distributed "curtain" emissions to reproduce the particles measured by the INMS in the 28 u mass channel on Cassini flybys E7, E14, E17, E18, and E21.*

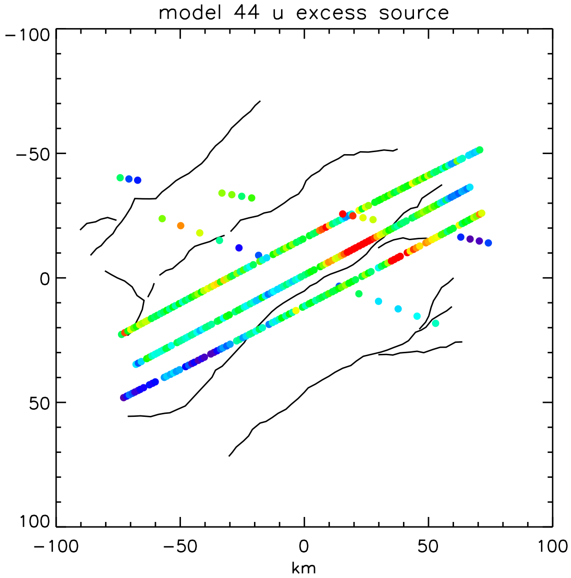

Figure 3. *Excess source needed beyond the distributed "curtain" emissions to reproduce the particles measured by the INMS in the 44 u mass channel on Cassini flybys E7, E14, E17, E18, and E21.*