DISSECTING THE POLAR ASYMMETRY IN THE NON-CONDENSABLE GAS ENHANCEMENT ON MARS: A NUMERICAL MODELING STUDY.

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Introduction: The Infrared Thermal Mapper (IRTM) on board the Viking Orbiters of the 1970's recorded brightness temperatures (~133 K) over the South Pole well below the frost point of CO_2 (~150 K) [1-3]. Of the six spectral bands IRTM operated, the only spectral band with acceptable resolution below 170 K was at 20 microns (here after known as the T20 band) [2]. It was believed at one time that CO_2 depletion over the winter pole and the subsequent enhancement of non-condensable gases was the cause for this low brightness temperature phenomenon [2]. Even though this has been proven to no longer be true [4], it is still intriguing to ponder that non-condensable gases, such as Ar and N_2, can accumulate over the winter pole to values larger than the global mean. Both the Neutron Spectrometer (Figure 1) and the Gamma Subsystem on the Mars Odyssey Gamma Ray Spectrometer instrument suite have measured this enhancement.

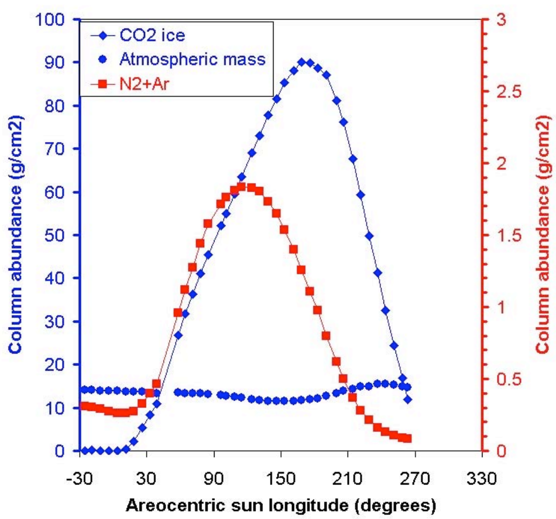

Fig 1. Neutron Spectrometer data of the column abundance of CO_2 ice, Atmospheric Mass and N_2+Ar. This data is for the region 75-90˚ S (Generously provided by T. H. Prettyman)

The Gamma Subsystem has observed the argon cycle for one and a half Mars years and has measured an asymmetric enhancement between the North and South Pole. Using the NASA Ames General Circulation Model (GCM), we modeled the Martian argon cycle (Figure 2 & 3). The model produced a North/South Polar asymmetry, similar to that seen in the observed data. We ran the model under various scenarios in order to understand the dynamic processes that caused this dichotomy.

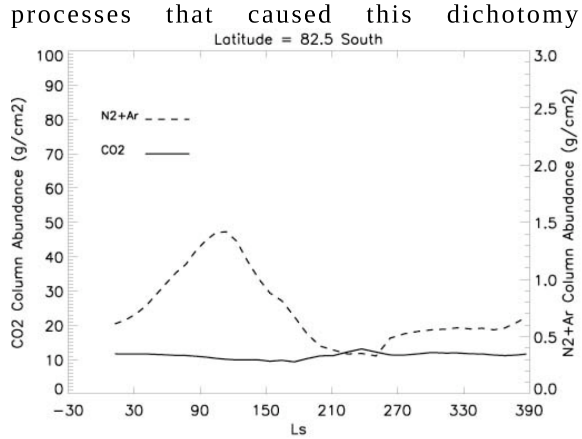

Fig 2. Time and zonal mean of the non-condensable and CO_2 column abundance for 82.5˚ S latitude in the model.

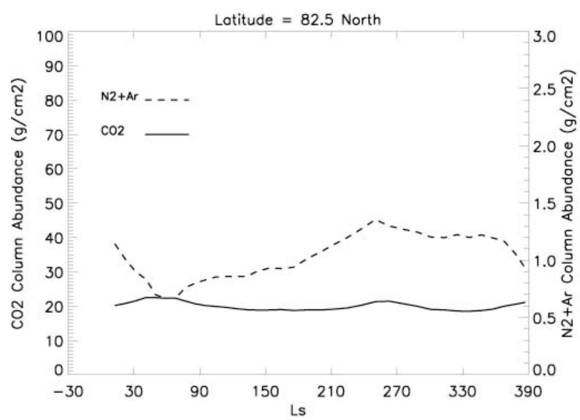

Fig 3. Time and zonal mean of the non-condensable and CO_2 column abundance for 82.5˚ N latitude in the model.

Model: We input into the model the measured values of dust opacity for TES mapping year 1 at the appropriate Ls. The dust opacity affected the heating rates in the model, which in turn affected the temperature, pressure and circulation in the model. We initialized the model with a uniformly distributed passive tracer in the form of a constant mixing ratio (mass of tracer divided by the total gas mass in the grid box). The tracer had no source or sink; only advection and CO_2 condensation changed the mixing ratio in a grid box. (If CO_2 did not condense, the mixing ratio would be constant in space and time) This tracer represented the non-condensable abundance in the Martian atmosphere. This was a tunable parameter and can be changed to fit the absolute abundance of non-condensable gases to observed values.

Conclusions: Initial results suggest that the three main drivers for the polar dichotomy are albedo, topography, and eccentricity. We are still working to understand the effects of albedo. We do know, however, that topography affects eddy mixing; greater eddy mixing off the pole reduces the enhancement. Our model suggests that removing topography in the Southern Hemisphere increases baroclinic wave activity at high southern latitudes and more effectively mixes the enhancement away from the pole. Mars' high eccentricity gives rise to a shorter Northern Hemisphere winter. The shorter season reduces the time the North Pole has to accumulate its enhancement. On a final note of interest, even though opacity does not appear to affect the asymmetry, it does affect the dynamic range of the maximum and minimum column abundance value of the non-condensable gas.

References: [1] Kieffer et al. (1976) *Science*, *193*, 780-786. [2] Kieffer et al. (1977) *JGR*, *82*, 4249-4291. [3] Snyder, C. W. (1979) *JGR*, *84*, 8487-8519. [4] Ditteon R. and Kieffer H. H. (1979) *JGR*, *84*, 8294-8300.