VARIABILITY IN MARS' NORTH SEASONAL CO_2 POLAR CAP OBSERVED BY THE MARS ODYSSEY NEUTRON SPECTROMETER FROM MY 26-34 K.E. Mesick[1] and W.C. Feldman[2], [1]Los Alamos National Laboratory, Los Alamos, NM 87545 USA (kmesick@lanl.gov), [2]Planetary Science Institute, Tuscon, AZ 85719 USA

Introduction: The polar caps on Mars are dynamic regions that affect the global Martian climate through the condensation each Fall/Winter of ∼25% of the atmosphere as CO_2 frost. Insolation in the Spring causes the nothern seasonal CO_2 polar cap to recess completely, leaving behind a water-ice perennial cap, while in the south a small perennial CO_2-ice cap remains throughout the southern Summer. One method of observing the seasonal cap extent, growth and recession rates, and the overall CO_2 column-integrated mass, is using neutron spectroscopy from orbiting spacecraft. Galactic cosmic rays (GCRs) bombard the surface of Mars producing spallation neutrons, which through scattering and nuclear excitation in the top meter of the Marian surface lead to neutrons and gamma-rays that escape and can be detected.

The Mars Odyssey Neutron Spectrometer (MONS) [1] has been in polar orbit around Mars since early 2002, measuring the neutron leakage signal from GCR bombardment on the Martian surface. Through these measurements, one can infer the water content and layering on the surface [2, 3] and characterize the seasonal CO_2 polar caps [4]. With Mars Odyssey still in operation, there are now nearly 9 full Mars Years of data available to study seasonal variations in the Martian polar caps. To fully utilize the MONS dataset, a new analysis code to process the raw data was developed [5]. Preliminary results on the inter-annual variability based on this new MONS dataset over 9 seasons at the Northern seasonal cap will be presented.

MONS Instrument: The MONS instrument, shown schematically in Fig. 1, consists of a $11 \times 11 \times 10$ cm^3 boron-loaded plastic scintillator segmented into four optically isolated prisms that provide neutron spectral information in three distinct energy bands – thermal, epithermal, and fast. Thermal and epithermal neutrons are detected through the neutron capture reaction ^{10}B(n,α)^{7}Li*, while fast neutrons (E>0.7 MeV) are detected through the coincidence of a fast scatter followed by a thermal capture within 25.6 μs.

The nadir-facing scintillator prism (P1) is covered by a cadmium sheet and therefore mainly sensitive to epithermal neutrons above the Cadmium cutoff (E>0.4 eV to E<0.7 MeV). The Doppler filter technique is used to measure thermal neutrons; Prism 2 (P2) faces the direction of the spacecraft velocity while Prism 4 (P4) faces opposite. P2 records thermal and epithermal neutrons, while P4 records only epithermal neutrons that can

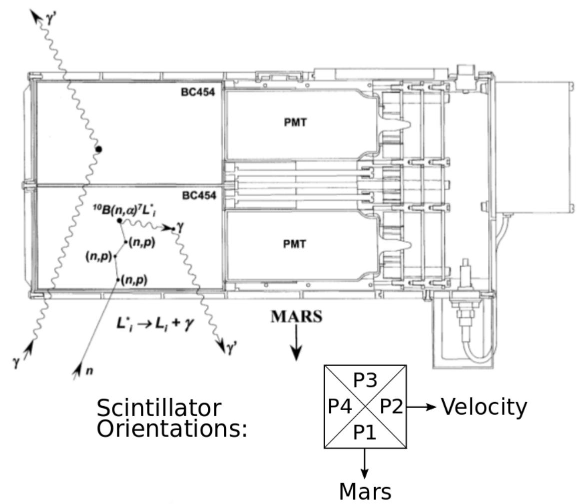

Figure 1: Schematic of the Mars Odyssey Neutron Spectrometer (MONS).

"catch up" to the spacecraft velocity of 3.4 km/s, corresponding to an energy cutoff of 0.019 eV. The thermal neutron counting rate comes from a subtraction of P2-P4. The last prism (P3) faces upward from Mars and is mostly sensitive to background.

New Data Processing: A new data processing effort was undertaken to convert the raw binary MONS data, located in the Planetary Data System, to processed counting rates with appropriately labeled ephemeris data. At this time, only Category 1 data (thermal and epithermal) were processed, discussed in detail in [5]. The resulting data set contains counting rates for each prism and associated latitude, longitude, and time stamp. An example of the time coverage provided by the new data set is shown in Fig. 2. Data from the beginning of the mission in February 2002 through the end of 2018 have been processed, corresponding to about 9 Mars Years (MY).

Inter-annual Variability in the North: Preliminary results in the form of thermal and epithermal counting rates measured for the North pole ($> 84°$) are shown overlayed in Fig. 3. The data are binned in $10°$ L_s. There is little inter-annual variability observed in the neutron counting rates, which are proportional to the overall integrated CO_2 column mass (g/cm^2). The only exception are the thermal neutron counting rates in the MY 28-29 Winter, which are approximately 15% lower than the average over all years at the peak. Analysis of thermal in-

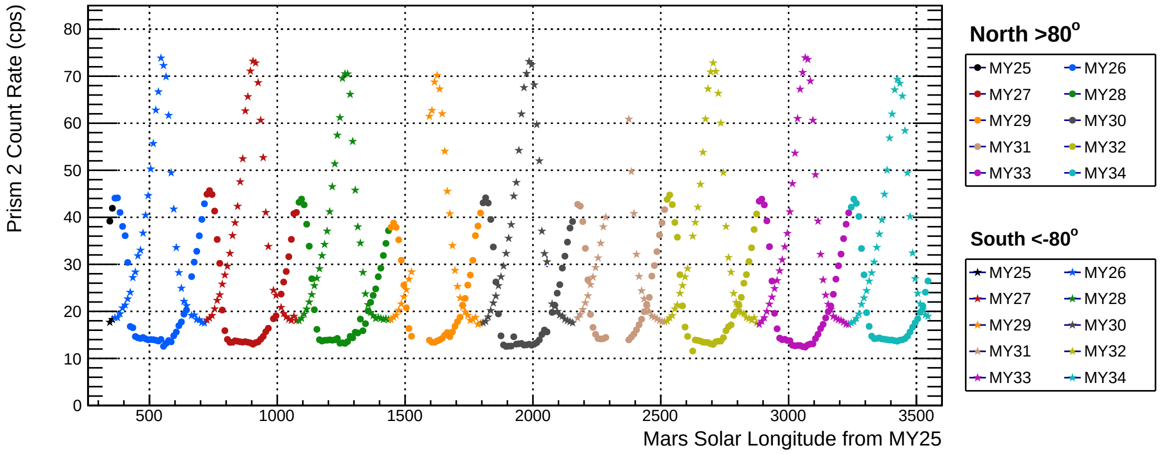

Figure 2: MONS Prism 2 counting rates through 2018, corresponding to about 9 Mars Years, from [5].

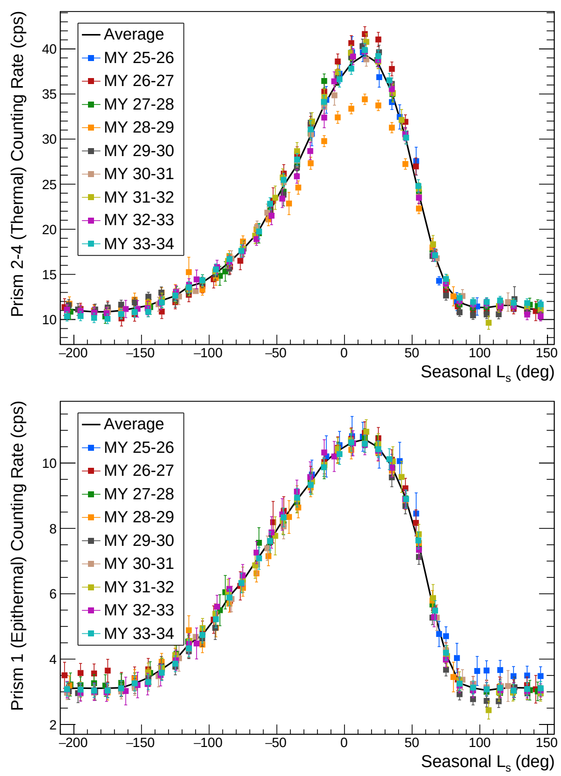

Figure 3: Thermal (top) and Epithermal (bottom) counting rates at the north pole ($> 84°$) as a function of solar longitude for the newly processed MONS data.

frared data in [6] show a similar reduction in total surface area of the CO_2 cap size in this year, which follows a global dust storm that originated late in MY 28.

However, that the reduction in counting rates is not observed in the epithermal channel suggests the origin may not be due to changes in the seasonal CO_2 deposition alone. We are working on simulations to form hypotheses as to what scenarios could result in the observed trends from the MONS data. The observed inter-annual variability and status of simulations to understand the observed effect in MY 28-29 will be presented.

References: [1] W.V. Boynton *et al.* (2004), *Space Science Reviews, 110*. [2] W.C. Feldman *et al.* (2002), *Science, 297*. [3] A.V. Pathare *et al.* (2018), *Icarus, 301*. [4] T.H. Prettyman *et al.* (2009), *JGR: Planets, 114*. [5] K. Mesick *et al.* (2020), *Icarus, 335*. [6] S. Piqueux *et al.* (2015), *Icarus, 251*.

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