VARIATIONS IN NORTH POLAR SEASONAL CO_2 ICE: IMPROVED DISTRIBUTION MAPS USING PIXON IMAGE RECONSTRUCTION. Luis F.A. Teodoro[1], William C. Feldman[2], Mary Bourke[2], [1]BAER, NASA Ames Research Center, Moffett Field, CA 94035-1000 (luis.f.teodoro@nasa.gov); [2]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ, 85719, USA.

Introduction: H_2O and CO_2 are exchanged between the atmosphere and the surface of Mars from autumn through spring. Deposition extends from the Poles to the mid latitudes with approximately 30% of CO_2 condensing out of the atmosphere when temperatures reach 148°K [under typical martian pressures, 1]. Work has shown that CO_2 may precipitate as snowfall and although not directly observed due to observational constraints, 'cold spots' [20 µm brightness temperatures as low as 130°K, 2] are considered to be a signature of combined CO_2 atmospheric condensates and freshly fallen CO_2 snow [3-8]. However the majority of CO_2 ice is thought to form directly on the surface as a result of radiative cooling [9] or as direct condensation onto the surface.

Pressurized CO_2 gas that forms beneath the seasonal ice cap during sublimation [10] has been shown to be an important geomorphic process that can transport sand on North Polar sand dunes. Hansen et al, [10] proposed that subsurface pressurized gas can mobilize sediment down avalanche faces, contributing to dune migration. Bourke and Cranford [11] demonstrated that dune 'furrow' formation was linked to the polygonal cracking of the seasonal CO_2 ice and documented that these dune surface morphologies formed seasonally.

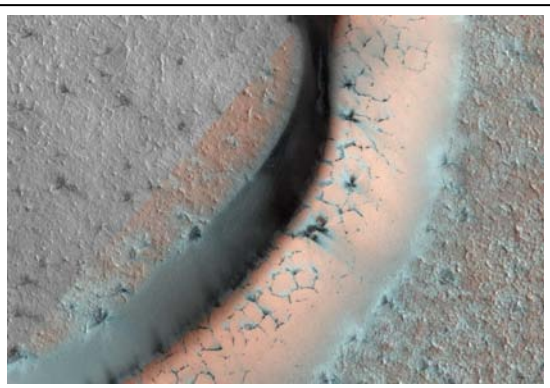

Figure 1: Subset of HiRISE Image ESP_024537_2600 taken at L_s= 18.4. showing polygonal cracking in seasonal CO_2 frost on dune.

It is important therefore to document the distribution, thickness and persistence of the seasonal CO_2 deposit, particularly those that overlap dunes on the North Polar Sand Seas (Figure 1).

Previous estimates of the distribution of CO_2 frost at the North Pole using data from the Neutron Spectrometer on board the Mars Odyssey Spacecraft plotted the deconvolved epithermal neutron count rates and estimated the CO_2 ice column abundance for the North Polar Region [12]. Our work builds upon this. We apply Pixon image reconstruction methods to the North Polar Epithermal Neutron data to increase the spatial resolution of the count rates.

Method: During CO_2 ice-free conditions, the epithermal range of neutron energies is nearly uniquely sensitive to the hydrogen content of surface soils, which should likely be in the form of H_2O/OH molecules/radicals. We therefore convert epithermal counting rates in terms of Water-Equivalent-Hydrogen, WEH. Given the summer count rates as a proxy for water content in the top meter of soil we can compute the CO_2 ice column abundance using Prettyman et al's [12] results. However, MONS counting-rate data have a FWHM of ~550 km., which is sufficiently broad to prevent a close association of WEH variability with images of geological features. In this study, we reduce spurious features in the instrument smeared neutron counting rates through deconvolution. We choose the PIXON numerical deconvolution technique for this purpose. This technique uses a statistical approach [13, 14] which is capable of removing spurious features in the data in the presence of noise. We have previously carried out a detailed study of the martian polar regions applying such a methodology to Martian epithermal neutrons [15,16]. In the present study, we will apply this technique to the recent reanalysis of MONS epithermal data [17], which is marked by significantly lower statistical and systematic uncertainties that have plagued older versions of these data.

Results: Preliminary data are encouraging. Figure 2 shows a pixon reconstruction of the Mars

Odyssey data for 0° <Ls < 30°. It shows the large deposits of CO_2 on the top of the water ice perennial cap. In addition it shows a spatial pattern that is consistent with the spatial distribution of the most dense distributed sand dunes. Previously we have shown a similar pattern of the epithermal count rates for H_2O [17] suggesting a genetic link between the water distribution in the dune subsurface and the spatial variation in the seasonal CO_2 ice deposits.

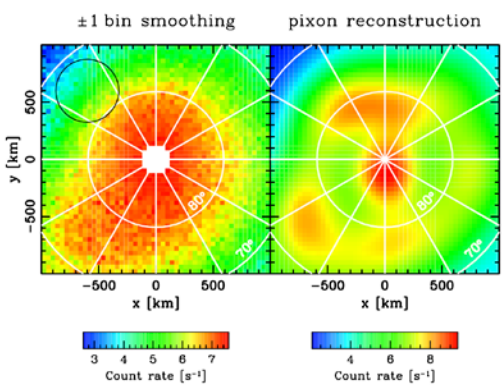

Figure 2: Left Panel Mons epithermal count rates data in 40X40 km bins. The dark circle in the top left corner represents the MONS point spread function. **Right panel** From the left to the right we show the MONS data and pixon reconstruction for 0° < Ls < 30°. The
dark circle in the left panel represents the MONS response function. The red area is the CO_2 polar cap. Whilst the dark blue regions indicate the presence of water ice.

Conclusion:

● The application of the Pixon technique improves the spatial resolution of the MONS data to ~150 km FWHM.

● A heterogeneous distribution in the deconvolved epithermal count data suggest spatial variability associated with the dunes in the CO_2 abundance of the circum-polar area.

● Ongoing work will determine the potential role of buried H_20 ice within the dunes in controlling the build up and decay of seasonal CO_2 ice and its annual variability.

References

[1] James, P.B. *et al.*, The Seasonal Cycle Of Carbon Dioxide On Mars in *Mars*, edited by H.H. Kieffer *et al.* (The University of Arizona, Tucson, Arizona, 1992), pp. 934-968.

[2] Kieffer, H.H. *et al.*, (1976) *Science* 194, 1346-1351.

[3] Neumann, G.A. *et al.*, (2003) *J. Geophys. Res.* 108 (E4), 5023.

[4] Pearl, J.C. *et al.*, (2001) *Journal of Geophysical Research (Planets)* 106 (E6), 12,325-12,338.

[5] Kieffer, H.H. *et al.*, (2001) *Icarus* 154 (1), 162-180.

[6] Titus, T.N. *et al.*, (2001) *Journal of Geophysical Research* 106 (E10), 23,181-23,196.

[7] Forget, F. *et al.*, (1995) *J. Geophys. Res.* 100 (E10), 21219-21234.

[8] Ivanov, A.B. *et al.*, (2001) *Icarus* 154 (1), 190-206.

[9] Forget, F. *et al.*, (1998) *Icarus* 131 (2), 302-316.

[10] Kieffer, H.H., (2007) *Journal of Geophysical Research (Planets)* 112, 08005.

[11] Bourke, M.C. *et al.*, (2011) Fifth International Conference on Mars Polar Science.

[12] Prettyman, T.H. *et al.*, (2009) *Journal of Geophysical Research (Planets)* 114 (E08005).

[13] Pina, e.a., (1992) *PASP* 104 (1096).

[14] Eke, (2001) *MNRAS* 324 (108).

[15] Teodoro, L.F.A. *et al.*, (2011) AGU.

[16] Teodoro, L.F.A. *et al.*, (2012) EGU General Assembly.

[17] Feldman, W.C. *et al.*, (2012) 43rd LPSC Conference, abs# 2170.