ONE MARTIAN YEAR ON ORBIT: REDISTRIBUTION OF CO_2 SEASONAL DEPOSITS BETWEEN THE NORTH AND SOUTH POLAR REGIONS OF MARS FROM HEND/ODYSSEY DATA AND MOLA/MGS.

M.L. Litvak[1], I.G. Mitrofanov[1], D.E. Smith[2], M.T. Zuber[3,2], A.S. Kozyrev[1], A.B. Sanin[1], V. Tretyakov[1], W.V. Boynton[4], D.K. Hamara[4], C. Shinohara[4], R. S. Saunders[5], [1]Space Research Institute, RAS, Moscow, 117997, Russia, max@cgrsmx.iki.rssi.ru, , [2]Laboratory for Terrestrial Physics NASA/Goddard Space Flight Center, MD,20771,USA; [3]Massachusetts Institute of Technology, Cambridge, MA, 02139-4307,USA [4]University of Arizona, Tucson, AZ 85721, USA, [5] NASA Headquarters, Washington, DC 20514, USA.

Introduction. One martian year of neutron mapping measurements onboard the Mars Odyssey spacecraft is presented based on High Energy Neutron Detector (HEND) observations. We interpret the HEND results along with elevation changes from the Mars Orbiter Laser Altimeter (MOLA) instrument on Mars Global Surveyor to address the seasonal cycling of CO_2 between the atmosphere and surface of polar latitude regions of Mars.

It is known that Mars' North and South polar regions are affected by the global redistribution of atmospheric CO_2. This process results in the exchange of more than 25% of the mass of the atmosphere [1] over the course of a martian year. The maximum thickness of CO_2 snow depth may exceed 1 m at latitudes close to the martian poles [2]. The change in thickness of deposited CO_2 is the reason for significant variations in the neutron flux above the martian poles between the summer and winter seasons. The flux varies because CO_2 frost effectively hides the upper surface layers of Mars from orbital observations of neutrons (see Figs. 1 & 2) and gamma-rays [3-5]. From the varying neutron flux, it is possible to estimate the column density of CO_2 deposits at different latitudes [3-5] in the Northern and Southern hemispheres. In this study we tracked changes in the distribution of CO_2 deposits at different north and south regions in terms of the deposit's mass and density.

Data Analysis. The estimation of CO_2 column density requires a two-step procedure. The first part of the analysis involves processing of the summer data (when the surface was free of seasonal CO_2 frost). During this time it is possible to estimate parameters describing regolith structure in a given region.

Our estimation of the structure of the shallow regolith utilized models of one (homogeneous) layer or two layers. In the case of the homogeneous model a single free parameter was used to describe the average mass fraction of water (hydrogen) in the regolith. For a model with two layers there are two free parameters: the thickness of an upper relative dry (~2% of water) layer and the mass fraction of water in a lower ice-rich layer.

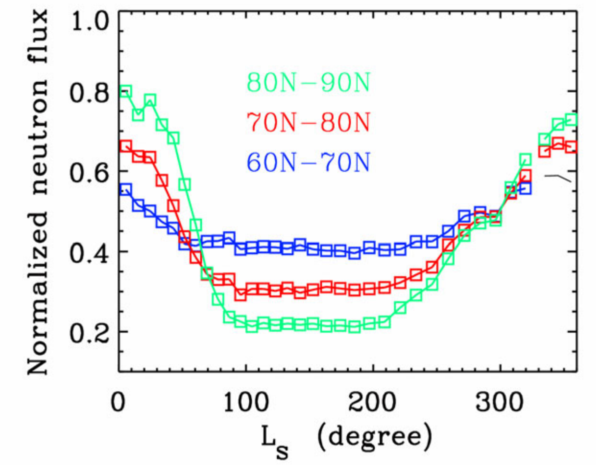

Fig. 1. Neutron flux through martian seasons at different northern latitudes.

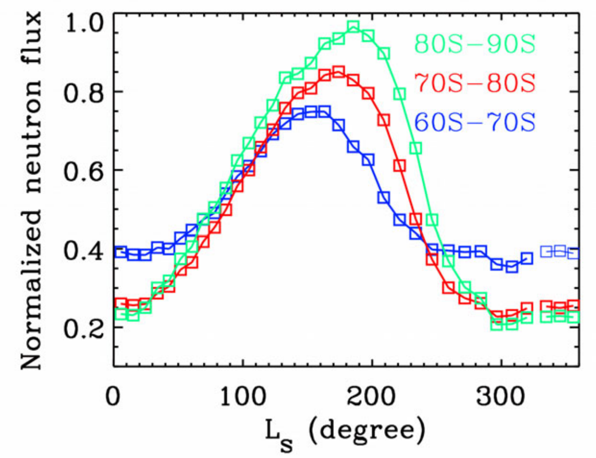

Fig. 2. Neutron flux through the martian seasons at different southern latitudes.

In the next step of the data reduction, an additional layer was added to the model to simulate a seasonal CO_2 frost deposit with a given thickness. Application of a statistical minimization between the observations of neutron flux and model predictions then yields a best-fit value of column density of the CO_2 deposit for the selected region at a specified martian season. Figures 3 and 4 summarize results of the model-dependent deconvolution, where polar maps of CO_2 column density were estimated from the neutron flux measured during winter seasons.

Results. Neutron and gamma spectrometry is sensitive to the column density of near-surface material where cosmic ray- produced neutrons and gamma radiation are emitted. The column density is measured in g/cm^2 and can be used to estimate the deposited mass of CO_2 (M) from the following formula:

$$M = C_d \cdot S, \quad (1)$$

where C_d is the column density and S is surface area of the observation [6].

The analysis of HEND data shows that the maximal masses of the seasonal caps may be estimated as ~4.0 x 10^{15} kg for the Northern hemisphere and ~ 6.5 x 10^{15} kg for the Southern hemisphere. The total masses agree well with model predictions by a recent estimate from the Ames GCM [7], but the time histories of seasonal caps derived from neutron observations and the GCM do correlate as well. Specifically, neutron spectrometry indicates that the time of maximal accumulation occurred later than expected from the CGM.

A comparison between the column density of seasonal deposits and direct observations of frost thickness (MOLA, see [2]) may be used for estimations of CO_2 density. Using data from both experiments we tracked the distribution of CO_2 frost as function of latitude. For high polar latitudes (> 80N) the density varies in the range from 0.6-0.75 g/cm^3 which is below an estimation made by MOLA [2]. But for lower latitudes (70N-80N) the observed value of density is found to be close to 1g/cm^3, in good agreement with the previous seasonally-averaged estimation [2].

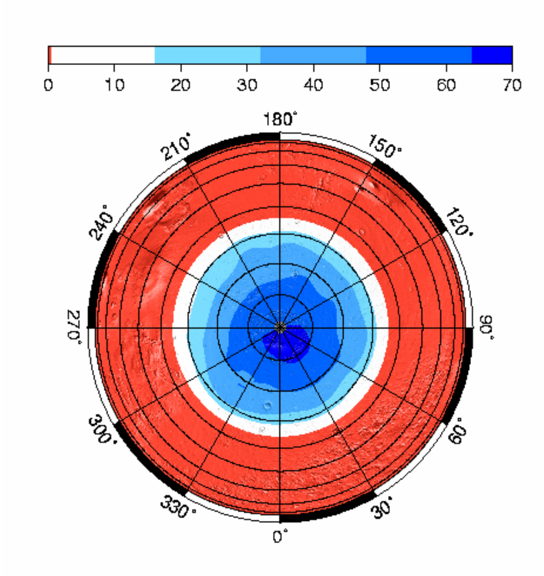

Fig 3. Map of column density (g/cm^2) of CO_2 deposit observed in the Northern hemisphere during winter.

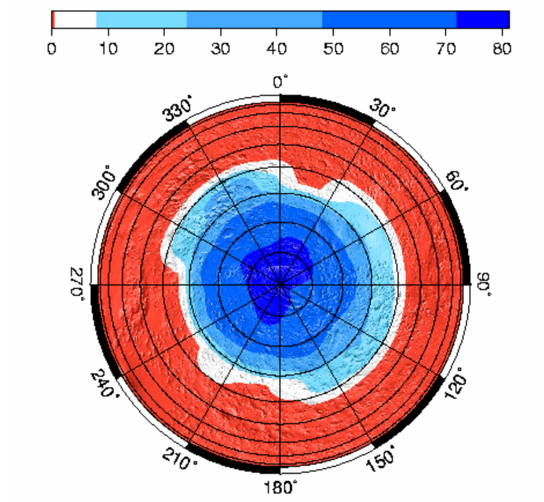

Fig 4. . Map of column density (g/cm^2) of CO_2 deposit observed in the Southern hemisphere during winter.

References:

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