Observation of Martian Seasonal Caps: Dimensions, density, mass, inter annual variations.

M.L. Litvak[1], W.V. Boynton[2], A.S. Kozyrev[1], I.G. Mitrofanov[1], A.B. Sanin[1],V. I. Tretyakov[1], A. Varenikov[1], D. Golovin[1] [1]Space Research Institute, RAS, Moscow, 117997, Russia, litvak@mx.iki.rssi.ru, [2]University of Arizona, Tucson, AZ 85721, USA.

Introduction: For this investigation we have used neutron spectroscopy data gathered with HEND/GRS instrument onboard Mars Odyssey. Starting from 2002 this mission passed through primary and several extended phases accumulating enormous data volume. During this mission one has been proved that orbital mapping of neutron flux from martian surface (instruments HEND, NS and GRS) is powerful method for exploration of water ice distribution [1-6] as well as for observation of martian seasonal caps [7-9]. It is possible because hydrogen in the upper (1-2 m) layer of subsurface is most efficient material for moderation of fast and epithermal neutrons and seasonal CO_2 frost (with thickness more than several centimeters) changes the structure of subsurface and distribution of water ice in upper layers of regolith causing significant changes of neutron flux.

Data Analysis: The growing and sublimation of martian snow caps is seen as seasonal variations of neutron flux above Martian polar regions (see figure 1 and 2). At near polar latitudes difference in neutron flux value between summer and winter seasons may achieve as high as 3-5 times and ~20% at the border of snow cap (see examples at figure 1). It means that counting statistic in neutron detectors may be used to map contours of snow caps at different seasons. The statistical criteria >5σ (it corresponds to the presence of 2.5-5 cm of CO_2 frost) has been applied here to distinguish between summer map of martian polar regions (no CO_2 frost) and fall, winter and spring seasons when surface is covered with CO_2 frost.

To convert counts in neutron detectors to real physical values such as column depth (g/cm^2), mass, density it is necessary to use more complicated approach based on numerical modeling of nuclear processes happened when neutrons are produced, scattered and captured in martian regolith, atmosphere and spacecraft body. Comparison between modeled counts (numerically simulated for the given model of regolith + CO_2 frost) and observed counts is used to extract best fit parameters of model: water ice distribution and column density of CO_2 frost (see example on figure 2).

Mars Odyssey operates at martian orbit more than 7 years which corresponds to 4 martian years. It has been used to search inter annual variations of seasonal cycles trying to compare dimensions and thickness of snow caps for different martian years.

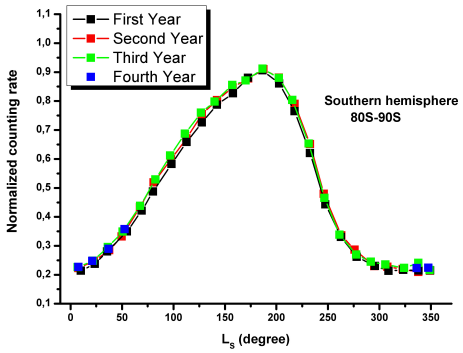

Fig. 1. The seasonal profile of neutron flux for near polar southern latitude.

Results: Concluding results of our investigations we may list them in the following order:

1) Using of neutron counting statistic to follow up contours of Martian snow caps for different seasons.

2) Comparison with the visual and infrared observations.

3) Modeling of snow caps with estimations of column density and mass of snow deposit.

4) Comparison with other nuclear instruments such as NS, GRS and climate models.

5) Calculation of volume density through comparison with MOLA.

6) Search of inter annual variations in growing/sublimation of snow caps and thickness of snow deposit.

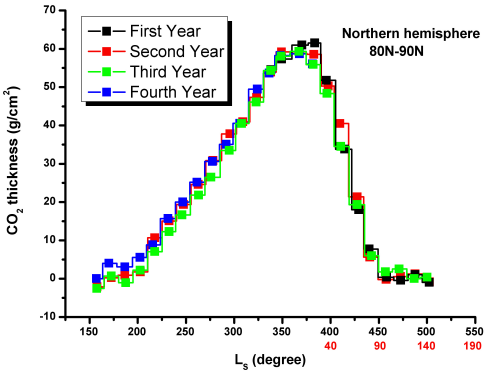

Fig. 2. Modeling of martian snow caps with definition of snow depth column density for near polar latitude.

References: [1] Feldman W.C. (2002), *Science*, 297, 5578, 75-78. [2] Mitrofanov I.G et al. (2002), 297, 5578, 78-81. [3] Boynton W.V. et al. (2002) *Science*, 297, 5578, 81-85. [4] Mitrofanov I.G. et al. (2003) *Science*, 300, 2081-2084. [5] Litvak M.L. et al. (2006)

ICARUS, 180, 1, 23-37. [6] Feldman W.C. et al., (2004), 109, *J. Geophys. Res*., E09006. [7] Feldman, W. C., et al. (2003) *J. Geophys. Res*., 108. [8] Kelly N. J. et al (2006) *J. Geophys. Res*., E03S07. [9] Litvak M.L. et al (2007) *J. Geophys. Res*., E03S13.