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Observational constraints of Polar Ice Deposits on Mars Atmospheric GCMs

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Much of our current knowledge about Mars' climate and atmospheric global circulation stems from measurements taken by landers and orbiters. Thus for many years the details of the atmospheric circulation were studied using numerical global circulation models (GCMs) that have been successful in reproducing most of the available observations [1]. More than ever, GCMs will play a central role in analyzing the existing data and in planning and execution of upcoming missions.

The Mars Odyssey Neutron Spectrometer (MONS) has enabled a comprehensive study of the overall distribution of hydrogen in the surface of Mars [2]. Deposits ranging between 20% and 100% Water-Equivalent Hydrogen (WEH) by mass are found pole-ward of 55 deg. latitude, while less H-rich deposits are found at lower latitudes. These results assume that the H distribution is uniform in the top meter of the martian soil. The Mars Reconnaissance Orbiter-Compact Reconnaissance Imaging Spectrometer for Mars (MRO-CRISM) has identified numerous locations on Mars where hydrous minerals occur [3]. The information collected by MRO-CRISM samples the top few mm's to cm's of the surface. This independent information can impose additional constrains on the 3-D H distribution inferred from the MONS data. For instance, the absence of a correlation between WEH wt% drawn from the MONS and CRISM data at a location where the neutron data indicate high WEH implies the presence of a 3-D structure that is characterized by a top layer with a low abundance of water, either ice or hydrated minerals, and some buried layers where the concentration of H is higher than that expected in a uniformly mixed layer.

However, the spatial resolution of MONS and MRO-CRISM are ∼550 km and ∼20-200m, respectively. Hence, one must assure the MRO-CRISM and MONS data are on the same scales. The MRO-CRISM data can be re-binned to lower resolution, but additionally the MONS instrumental smearing must be properly understood and removed. Usually, in the presence of noise, this is an ill posed problem that requires the use of a statistical approach [4,5]. Here we present the most recent results of applying such an approach to the MONS epithermal neutron data coupled with independent information regarding the distribution of water and hydroxyls, including hydrous mineralogy. An exciting prospect is that this approach can provide estimates of the real extent or the original volume of surface water ice. Such estimates can then be used to constrain the Mars GCM.

The Ames Mars GCM depends on several important parameters associated with the atmosphere and surface properties. In particular ice content is directly related to thermal conductivity and thermal inertia, and spatial variations of these govern the input and release of energy (and water vapor) seasonally [6] . Deviations from a uniform ice distribution poleward of 80 deg. N may thus influence local circulation and precipitation. Replicating the Viking and later missions atmospheric pressure histories requires taking into account near-surface water ice content and spatial distribution at high latitudes. To the extent that these can be constrained by MONS measurements, the results of the GCM can be tied to physical parameters that characterize the near-surface materials at high latitudes. Perhaps more important is what the derived distribution of polar ground ice reveals about recent climatic trends.

[1] Forget et al, 1999, JGR, 104, 24155; [2] Feldman et al, 2004, JGR, 109, 9006; [3] Brown et al, 2010, In LPSC, report 1278; [4] Pina et al, 1992, PASP, 104, 1096, [5] Eke, 2001, MNRAS, 324, 108; [6] Haberle et al, 2008, PSS, 56, 251