IMPROVED MARS ODYSSEY NEUTRON SPECTROMETER (MONS) MAPPING OF NEAR-SURFACE WATER-EQUIVALENT HYDROGEN.
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Introduction: To date, more than 3.5 mars years of neutron data measured using the Mars Odyssey Neutron Spectrometer (MONS) have been analyzed to develop global maps of hydrogen concentration (quantified in terms of Water-Equivalent-Hydrogen, WEH) interpreted using a simple two-dimensional model of the outer ~0.5 meter of Martian crust [1]. A 2-layer near-surface regolith model is assumed that expresses hydrogen concentration in terms of; 1) an upper layer of weight fraction W_{up} having 2) thickness D overlying a 3) semi-infinite lower layer of weight fraction W_{dn}. Uncertainties have been estimated using measured variances of individual thermal, epithermal and fast neutron counting rates in a 2 x 2 degree (at equatorial latitudes) equal-area grid [1]. However, the effects of different soil compositions and the potential non-uniqueness of derived values of W_{up}, D, and W_{dn} using such models have not been considered.

Another first-order source of uncertainty is the method chosen to determine W_{up}. Previously, we showed [2] that for a single-layer WEH deposit (WEHD0), the different Y = WEHD0[fast] and X = WEHD0[epithermal] counts in any pre-chosen Region of Interest (ROI) follow a nearly linear trend, having slope and ordinate-intercept parameters, Y=mX+b, that can be inverted to find a "Crossover" such that

$$W_{up} = Y = X = b/(1-m). \qquad (1)$$

This method relies on the fact that simulation of the WEH content of the near surface yields different WEH estimates based on fast and epithermal counting rates simulated using a two-layer model (see refs in [2]).

Application of this Crossover technique using a sliding ROI on a latitude-longitude map of fast and epithermal counting rates having sharp 1800 km diameter boundaries yielded the map of W_{up} shown in Figure 1 (from [2]). Inspection of Fig. 1 reveals large regions between latitudes of ±60° that yield unphysical negative values (corresponding to the grey areas at lower and mid-latitudes).

Weighted Results: To correct this problem, we are investigating the effects of using a weighted least-squares fitting algorithm to define the ROIs instead. Here, Gaussian weighting functions of various full-widths at half maximum (FWHM) that depend on counting rates and latitude in sliding ROIs were explored using a standard chi-squared minimization line-fitting approach. As shown in Figure 2, we determined that we could eliminate almost all of the negative values of W_{up} by using a single FWHM Gaussian of 1800 km between ±60° latitude: compare the relative paucity of dark blue features in Fig. 2 to the more widespread negative-value grey areas in Fig. 1.

As a further test of the validity of our Crossover approach, we also calculated W_{up} directly from the Gaussian-weighted means and covariance matrices, and obtained results that were nearly identical to the chi-squared minimization line-fitting technique (Fig. 2) at Martian mid-latitudes.

Further Work: We will continue to explore the range of ROI sizes and shapes that can eliminate unphysical negative W_{up} values in order to minimize the spatial resolution of the ROIs. We will ascertain the limits allowed by changing the latitude-longitude shapes to ellipses with latitude widths less than the longitude widths (due to the strong latitudinal dependence of WEH at higher latitudes), particularly in places where the epithermal and fast neutron counting rates are higher.

We will also improve spatial crossover resolution by deconvolving the intrinsic spatial resolution of the MONS sensors. We have recently successfully applied the Jansson deconvolution algorithm to most of the MONS Prism 1 sensor data, from which we derive fast and epithermal neutron fluxes. This will significantly improve the resolution of the epithermal and fast neutron counting rates needed for determination of W_{up} (see Equation 1) by up to a factor of 2. Subsequent deconvolution of Prisms 2 and 4 will likewise improve the resolution of the thermal neutron mapping needed for definition of W_{dn} and D once our revised global mapping of W_{up} is completed.

We also intend to study the uniqueness of the maps we derive. Toward this end, we have developed a new input generator to our grid simulation code, which relates W_{up}, D, and W_{dn} values to thermal, epithermal, and fast neutron counting rates. For this task, the five different Mars surface compositions assumed by [3] have been constructed and simulated for W_{up} values of 1, 2, 3, 4, 5, 7, 10 and 15%. We will explore the uniqueness of near-surface water-equivalent hydrogen content as a function of soil composition (particularly iron and chlorine abundances).

References: [1] Maurice *et al.* (2011) *JGR Planets*, E11008. [2] Feldman *et al.* (2011) *JGR Planets*, E11009. [3] Diez *et al.* (2008) *Icarus*, 196, 409-421.

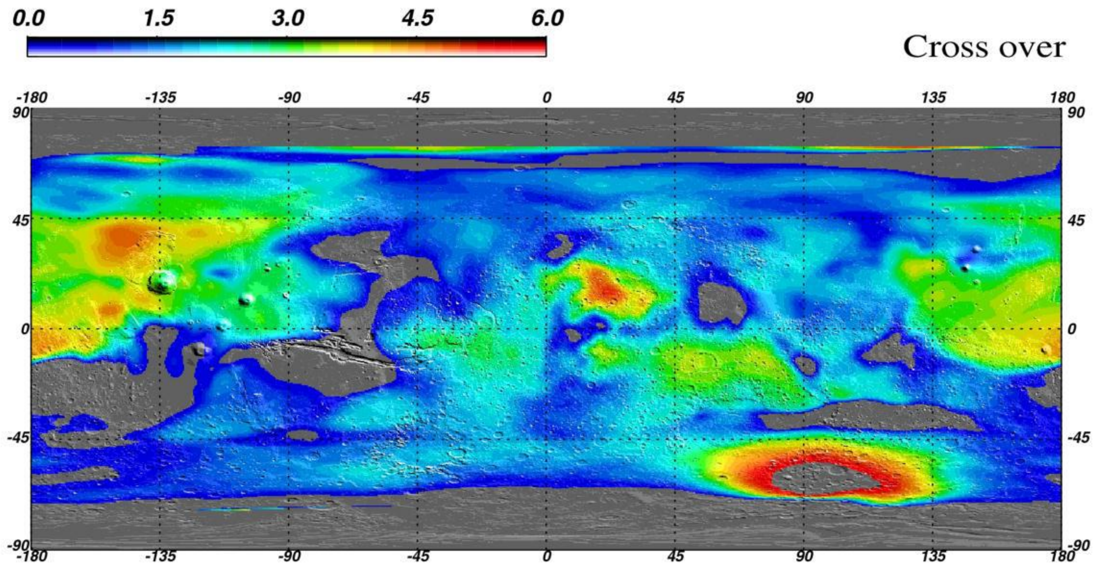

Figure 1: Map of *Wup* = crossover points from the linear regressions between WEHD0(fast) and WEHD0(epi) data in **unweighted** sliding 1800 km diameter circular regions of interest on Mars. The regions colored grey have values that fall outside the limits given by the color bar.

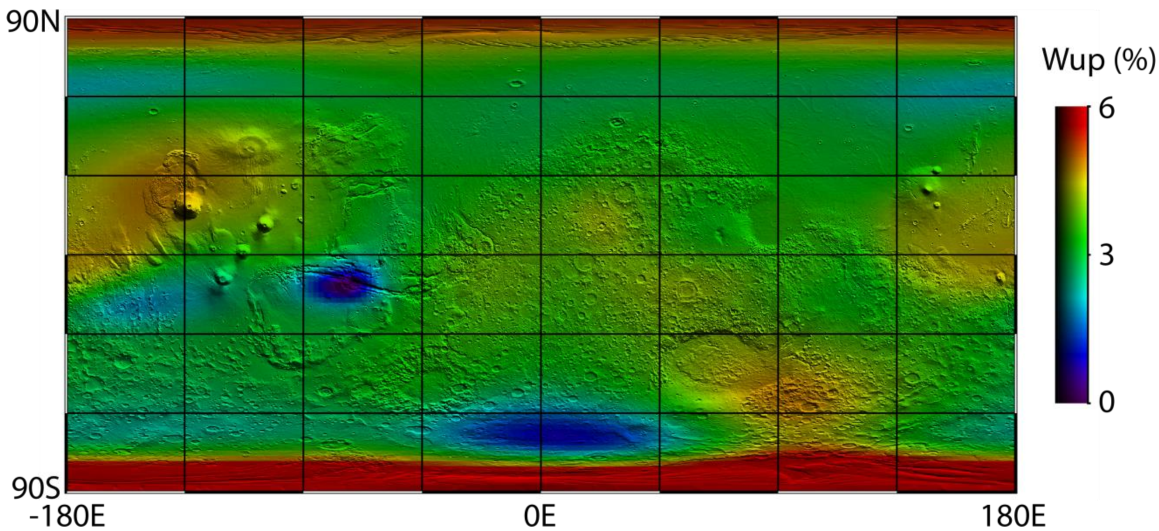

Figure 2: Map of *Wup* = crossover points from the linear chi-squared mininimation regressions between WEHD0(fast) and WEHD0(epi) data in **weighted** sliding 1800 km diameter circular regions of interest on Mars. The dynamic range has been cut off at 0 and 6 to facilitate comparison with Fig. 1, so dark blue regions correspond to negative values and dark red regions to highly positive values. Note the relative paucity of dark blue features in Fig. 2 to the more widespread negative value grey areas at lower and mid-latitudes in Fig. 1. Also note that *Wup* values poleward of 60 degrees will likely be better modeled by a quadratic fit rather than the linear fit shown here [2].