THE PHOENIX TECP RELATIVE HUMIDITY SENSOR:. A. P. Zent, NASA Ames Research Center, Moffett Field, CA 94035. Aaron.P.Zent@nasa.gov

Introduction: The original calibration function of the R_H sensor on the Phoenix mission's Thermal and Electrical Conductivity Sensor (TECP), has been revised to correct the erroneously-published original calibration equation, to demonstrate the value of this unique data set, and to improve characterization of H_2O exchange between the martian regolith and atmosphere. TECP returned two data streams, the temperature of the electronics analog board (T_b) and the digital 12-bit output of the R_H sensor (*DN*), both of which are required to uniquely specify the H_2O abundance. Because the original flight instrument calibration was performed against a pair of hygrometers that measured frost point (T_f), the revised calibration equation is also cast in terms of frost point.

The choice of functional form for the calibration function is minimally constrained. A series of profiles across the calibration data cloud at constant *DN* and T_b does not reveal any evidence of a complex functional form. Therefore, a series of polynomials in both *DN* and T_b was investigated, along with several non-linear functions of *DN* and T_b.

Calibration: Comparing the $DN - T_b$ domain of the calibration data with that of the flight data (Figure 1), it can be seen that the high-T_b (afternoon) and low-T_b (overnight) extrema of the flight data are poorly constrained by the calibration data. In particular, because of the complexity of maintaining very low temperatures and high R_H in the chamber, no calibration data exists at $T_b < 203$K; unfortunately, virtually all overnight data plots at the bottom of the data cloud, below 203 K.

In order to address the fact that the calibration data set does not reach temperatures below 203 K, while the sensor response over the course of the mission was smooth and continuous down to 181 K, we have opted to use flight data, acquired during periods when the base of the atmosphere is known to have been saturated.

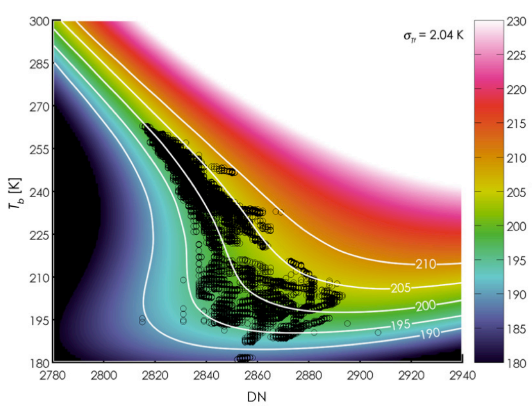

Figure 1. The revised calibration (surface) and the calibration data. The DN-T_b domain of the flight data is indicated.

The best fit to the calibration data was found with a 7-parameter linear equation of the form:

$$T_f = a_1 DN^2 + a_2 DN + a_3 DN T_b^{-1} + a_4 T_b^3 + a_5 T_b^2 + a_6 T_b + a_7 \quad [1]$$

Table 1. Least Squares Fitted Parameters

	a	σ_a
a_1	$-1.724x10^{-3}$	$\pm 1.014x10^{-5}$
a_2	11.460	± 0.055
a_3	-294.484	± 1.717
a_4	$-2.218x10^{-3}$	$\pm 1.504x10^{-6}$
a_5	0.222	$\pm 1.456x10^{-3}$
a_6	-83.956	± 0.523
a_7	-4648.92	± 126.531

The fitted values, *a*, are given in Table 1. For this data set, $\sigma_T = 2.6$.

Heading Styles: The partial pressure of H_2O measured by the TECP over the course of the entire mission is given as a function of Local Mean Solar Time (LMST) in Figure 2. These numbers are lower than originally reported, but otherwise exhibit the same patterns. H_2O vapor varies strongly over daylight hours turbulence in the boundary layer shuttles parcels of air vertically. In the evening, the atmosphere stabilizes and atmospheric temperatures begin a smooth radiatively cooling period (Figure 3). Atmospheric H_2O decreases due to exchange with at least two identifiable reservoirs: ice and adsorbate.

The amount of atmospheric H_2O begins to decrease prior to atmospheric saturation, exhibiting a repeatable slope in *P*-*T* space. The enthalpy change associated

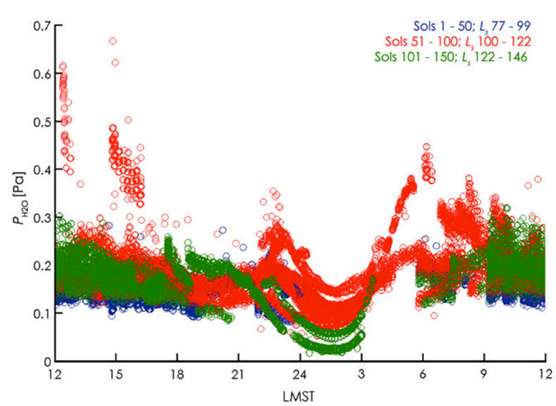

Figure 2. Partial pressure of H_2O as a function LMST for the entire mission.

with this exchange is ~ $3x10^4$ [J/mole]. After about Sol 70, the atmosphere saturated each evening, and ground fogs were observed[1]. The slope of the ln(P)-T curve then transitions smoothly to that of ice condensation, with ΔH = $5.1x10^4$ [J/mole]. As the mission progressed from summer solstice to late summer, nighttime temperatures decreased, and the atmosphere saturated earlier in the evening.

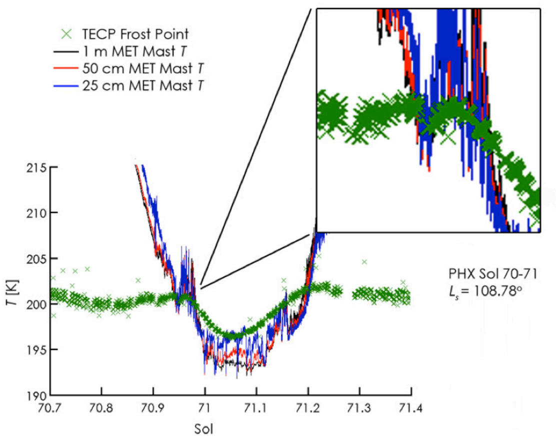

Figure 3. Sol 70 air temperatures from the MET mast, and T_f from TECP. Inset demonstrates TECP also records the onset of atmospheric saturation in the T_f data.

The average daytime [H_2O] varied relatively little from its average value of ~ 0.2 Pa. This corresponds to somewhat less vapor than observed from orbit (Figure 4), which has raised issues about the validity of the data.

It is true that the TECP R_H sensor returned data over only about 5% of its available *DN* range, and therefore there is unavoidable error as a result of ADC process. This problem is particularly acute in the late afternoons when the electronics board temperatures were highest. Nonetheless, we have confidence in the H_2O vapor abundances derived here, in part because of the correspondence with the saturation detection in the MET temperature data.

In addition, the discrepancy between surface measurements of H_2O and orbital determinations (about 50%) was likewise reported by Viking[2], but was then ascribed to overnight exchange. Here we find the discrepancy occurs over the daylit hours as well, which requires another explanation altogether.

References:

[1] Whiteway *et al., Science*, 2009

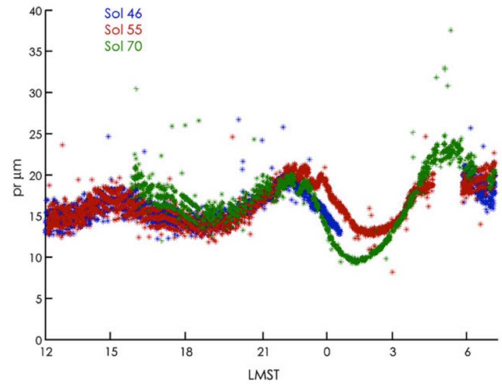

Figure 4. The column abundance of H2O baed on integrating the TECP measurements.