A Revised Calibration Function for the TECP Humidity Sensor of the Phoenix Mission A. P. Zent[1], M H. Hecht[2], T. L. Hudson[2], S. E. Wood[3], V. F. Chevrier[4], [1]NASA Ames Research Center, Moffett Field, CA (Aaron.P.Zent@nasa.gov), [2] Jet Propulsion Lab, Pasadena CA, [3]University of Washington, Seattle, WA, [4]University of Arkansas, Fayetville, AR

Introduction: The original calibration function of the R_H sensor on the Thermal and Electrical Conductivity Sensor (TECP), a part of the MECA payload of the Phoenix mission, has been improved in order to extend the range of the valid calibration, and to improve its accuracy. 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.

Model: The original model for the calibration function yielded the relative humidity of the ambient atmosphere, using two essential data streams. One was the temperature of the electronics board, which is a proxy for the sensor temperature, and the second is the DN output of the sensor itself.

The original function had several shortcomings, including failure to return realistic R_H values for the ADC and board temperature occupied by the flight data (Figure 1).

The revised function assumes second order variation in both variables, and includes a cross-product term which improves the fit.

Due to resource limitations, it was not possible to calibrate the TECP R_H sensor in the laboratory at air temperatures < 208 K. The sensor response during flight was a smoothly continuous function down to the lowest temperatures detected, ~ 181 K. To improve the reliability and range of the calibration, the decision was made to use flight data, acquired during periods when the atmosphere is known to have been saturated. The following criteria were used to select the flight data for inclusion in the calibration:

1. The data were acquired after sol 70, (L_s = 108º) and between the hours of 0000h and 0400h LMST. During these periods, the LIDAR detected a regular pattern of cloud formation each night within the PBL. A shallow surface-based cloud formed near midnight (Mars local solar time), and a second cloud layer formed after 1 a.m. at heights around 4 km, because these were the coldest parts of the atmosphere[1].
2. The TECP board temperature (T_b) varied by no more than 1K, and was within ± 1.5 K of the MET mast 1m temperature. This criterion assured that the humidity measurement, which is made at T_b, was acquired at the same temperature as the ambient air. The standard deviation assigned to the R_H = 1 flight data was $10^{-4}T_f$, which is not unreasonable compared to the laboratory calibration data.

These criteria led to the inclusion of two sets of data in the calibration, as detailed in Table 1.

Although data were acquired during cruise (P_{H2O} = 0), that data could not be used in this calibration, since we

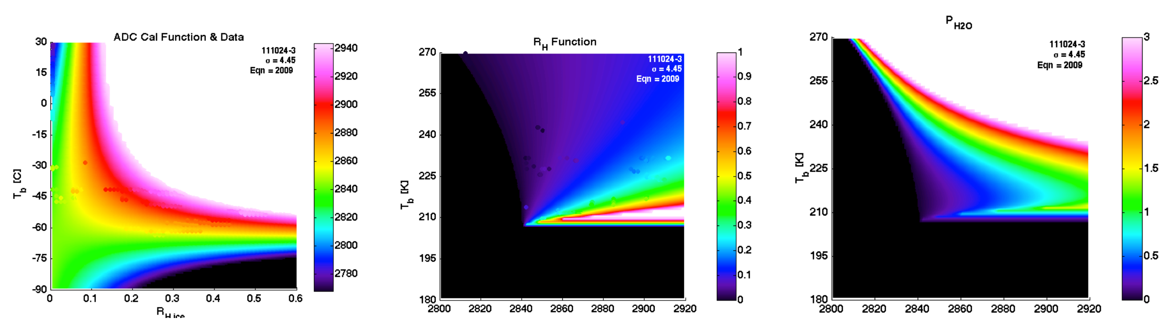


Figure 1. The original calibration function, and the predicted R_H and P_{H2O} for the flight data domain.

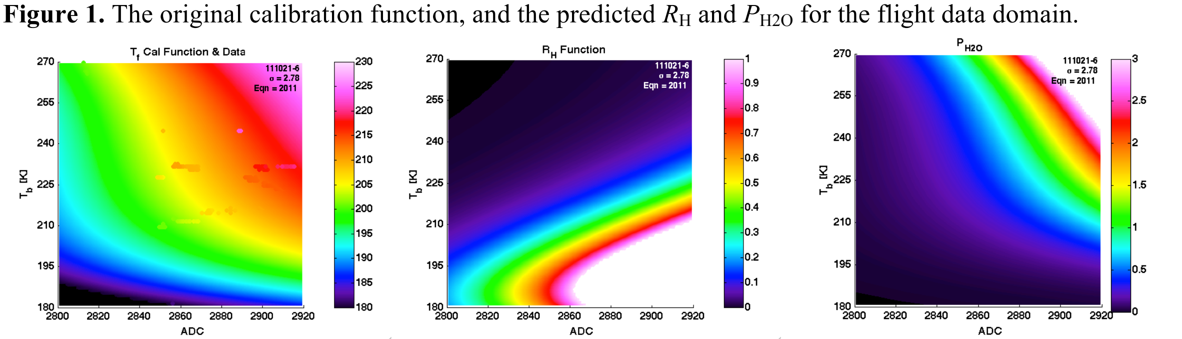


Figure 2. The revised calibration function, and the predicted R_H and P_{H2O} for the flight data domain.

Table 1	*Pt 1*	*Pt. 2*
L_s	115.9	133.4
Sol	86	122
S/C Clock Start	903802401.287	906999999.088
S/C Clock Stop	903804626.475	907002546.355
LMST Start	0.59519 h	1.0518 h
LMST Stop	1.19677 h	1.7405 h
n, Measurements	95	55
$\bar{x}$, ADC	2878.8	2856.1
σ, ADC	0.637	0.348
$\bar{x}$, T_b	192.98	181.64
σ, T_b	0.1488	0.1138

are calibrating to T_f.

Over the course of the mission, no data were acquired at T_b > 260K. The original laboratory calibration however incorporated data acquired up to ~300 K. It was found that inclusion of this high-temperature calibration data adversely affected the goodness-of-fit metric (c^2) in the T_b domain relevant to the mission data ($T_b \leq$ 260 K). Therefore, laboratory calibration data acquired at T_b > 280 K were omitted from the data for fitting.

The final calibration equation for conversion of TECP R_H ADC and T_b to atmospheric frost point (T_f) is:

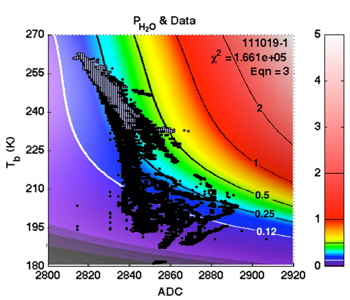
term1 = X_1*ADC^2;
term2 = X_2*ADC;
term3 = X_3*(ADC/T_b);
term4 = X_4*T^2
term5 = X_5*T_b;
term6 = X_6;

T_f = term1 + term2 + term3 + term4 + term5 + term6;

X_i = [-2.394x10^{-4}; 2.0425; -100.58; 0.0229; -15.825; -0.2636]
χ^2 = 451946; σ = 2.64226

The revised calibration function results in daytime H_2O partial pressures that are considerably lower than those originally reported. Figure 4 shows the flight data overlain on the new calibration function. Figure 5 shows the resulting change in the diurnal H_2O partial pressures, as predicted by the new calibration function.

REFERENCES:
Whiteway *et al.*, *Science*, 2009



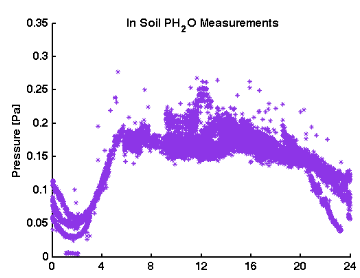


Figure 3. The outline of the TECP flight data (black) overlain on the revised calibration function. The daytime afternoon data are shaded in gray.

Figure 4. The revised daytime H_2O partial pressures for data acquired while the TECP was in the soil, which peak at around 0.2 Pa.