METER
ENVIRONMENT

ATMOS 41—CORRECTION OF AIR TEMPERATURE MEASUREMENTS FROM A RADIATION-EXPOSED SENSOR

Contributors

Despite its seeming simplicity, air temperature is one of the most difficult environmental parameters to measure accurately. The current best practice involves housing the air temperature sensor in a radiation shield that is either passively ventilated or actively aspirated. Due to design constraints, the air temperature sensor in the new ATMOS 41 all-in-one weather station cannot be fully shielded from solar radiation.

However, since the ATMOS 41 measures wind speed and solar radiation, both of which are primary factors affecting the accuracy of the air temperature measurement, correction is possible.

PROBLEM

The air temperature sensor on the new ATMOS 41 weather station is partially exposed to solar radiation, which may result in large errors in measured air temperature (T_{air}).

Uncorrected measurements showed errors ranging to 3 °C when compared to measurements made in a state-of-the-art aspirated radiation shield.

OPPORTUNITY

Because the ATMOS 41 also measured wind speed and solar radiation, it was possible to use a simple energy balance calculation to correct the T_{air} measurement. After correction, error decreased to < 0.5 °C and yielded better accuracy than commonly used passive ventilation radiation shields.

THEORY

The energy balance of the thermometer has been re-arranged below to correct for errors due to solar radiation.

$$T_{air} = T_{measured} - \left(\frac{a_s S_t}{c_p k \sqrt{\frac{u}{d}}} \right)$$

Equation 1

α_s = absorptivity of temperature sensor to solar radiation (unitless)
S_t = total incoming shortwave radiation (W m^{-2})
c_p = specific heat of air (J mol^{-1} C^{-1})
k = constant describing boundary layer heat conductance
u = wind speed (m s^{-1})
d = characteristic dimension of temperature sensor (m)

EXPERIMENT

An Apogee TS-100 aspirated air temperature sensor was chosen as the reference standard for T_{air}. The ATMOS 41 and Davis instruments air temperature sensor in non-aspirated, louvered radiation shield were co-located with the TS-100. A Davis sensor/radiation shield was included to compare ATMOS 41 performance to a typical T_{air} measurement. Five-minute averaged data was taken over a five day period of variably cloudy conditions in late summer 2015. α_s and k from Equation 1 were used as fitting parameters to minimize error in T_{air} for the ATMOS 41 correction.

RESULTS

The simple energy balance approach worked well to correct air temperature from a partially radiation exposed sensor.

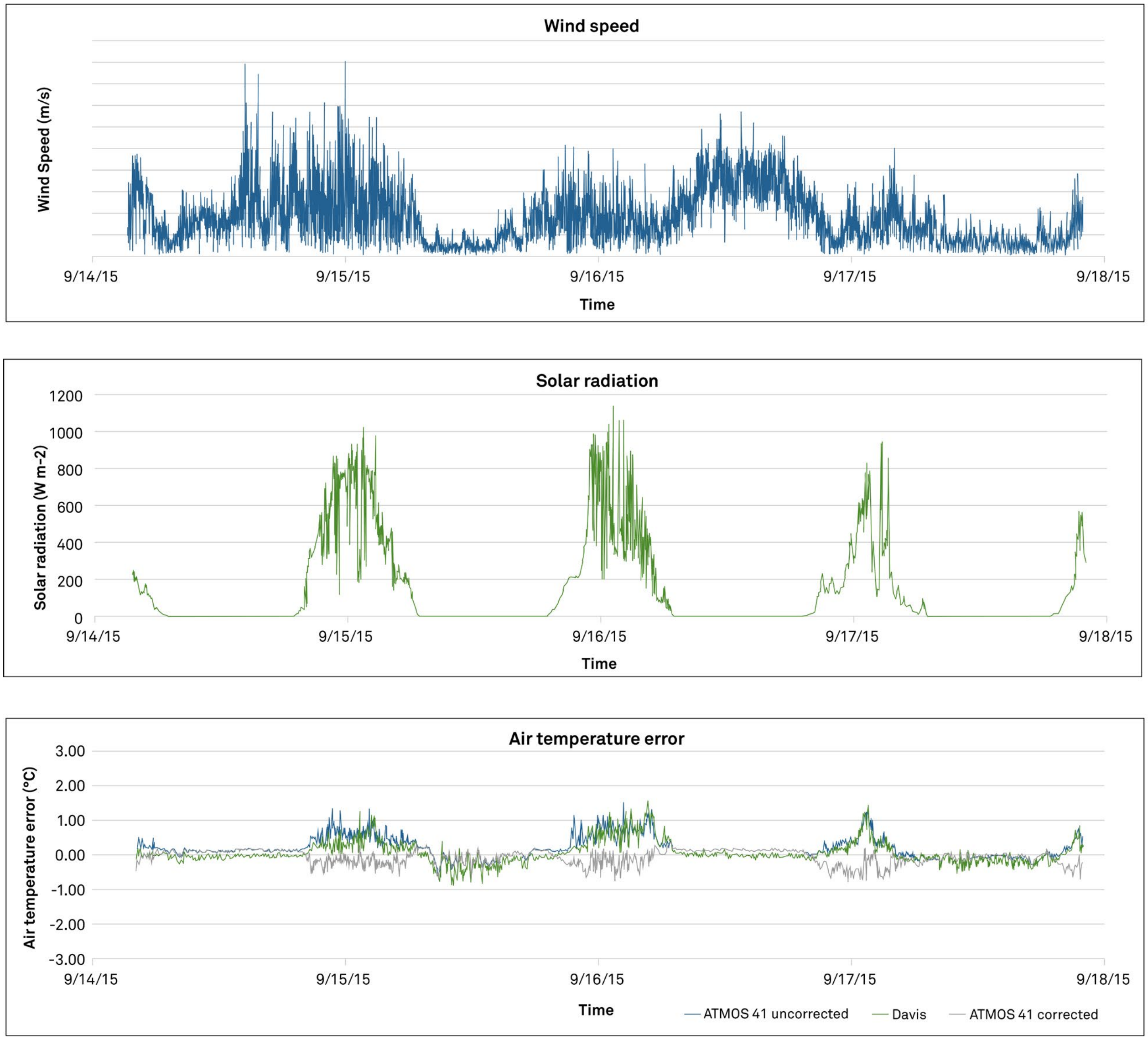

Figure 1. Environmental conditions and air temperature error ($T_{measured} - T_{TS\text{-}100}$) for the two air temperature sensors under evaluation

DISCUSSION

Uncorrected T_{air} accuracy from ATMOS 41 is comparable to typical non-aspirated radiation shielded air temperature measurement but showed positive bias from solar radiation effects. Radiation-corrected ATMOS 41 outperformed typical radiation-shielded air temperature measurement and yielded 95% confidence interval of well less than ±0.5 °C accuracy.

(All units °C)	ATMOS 41 uncorrected	Non-aspirated	ATMOS 41 corrected
Average error (bias)	0.20	0.07	-0.06
95% conf interval	0.60	0.66	0.42
Max positive error	1.51	1.58	0.36
Max negative error	-0.66	-0.87	-0.77

Table 1. Summary statistics for air temperature measurements for two sensors under evaluation

Explore which weather monitoring system is right for you.