Radiation Dry Bias in the TWP-ICE Radiosonde Soundings

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Introduction

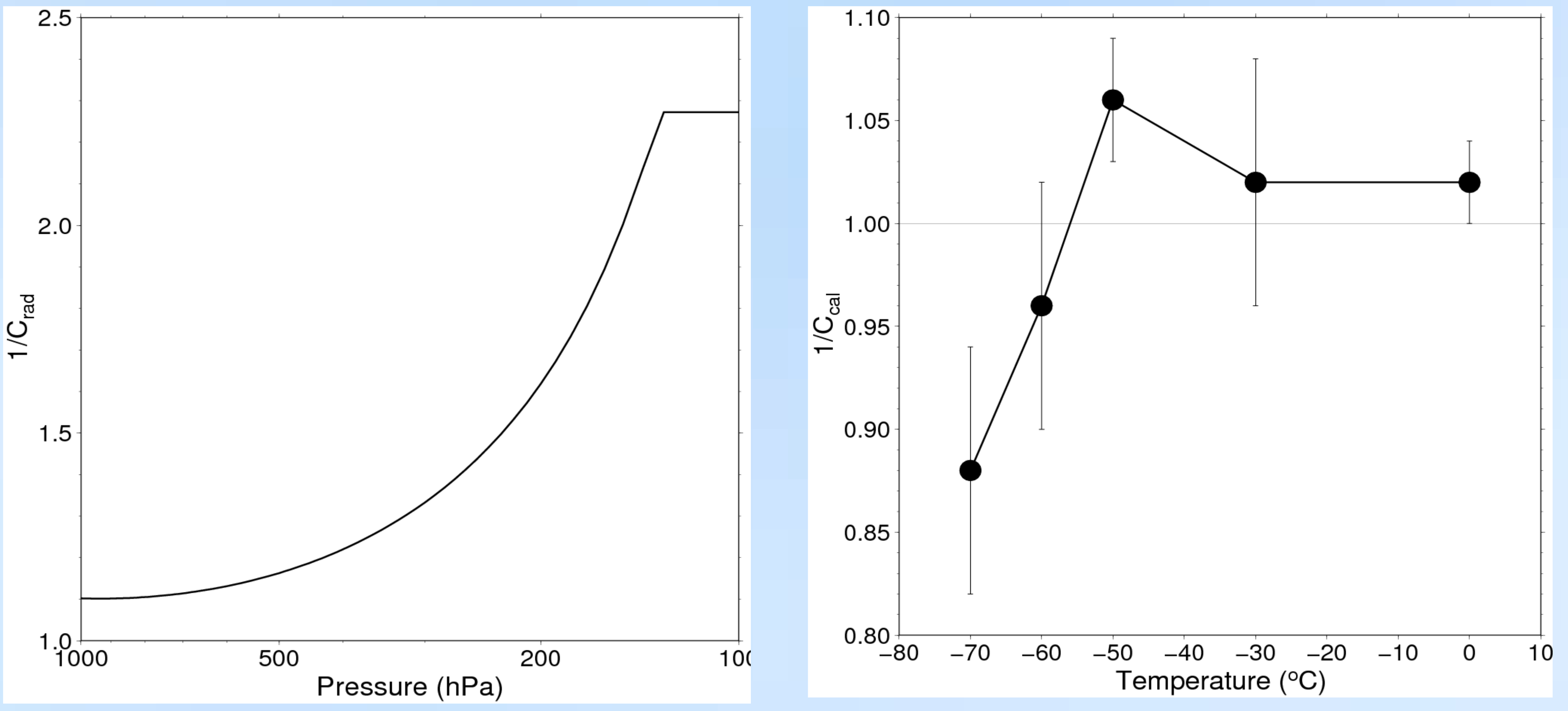

Figure 1: Pressure dependent radiation dry bias correction (left panel) and temperature dependent RH calibration factors (right panel) determined by Voemel *et al* (2007).

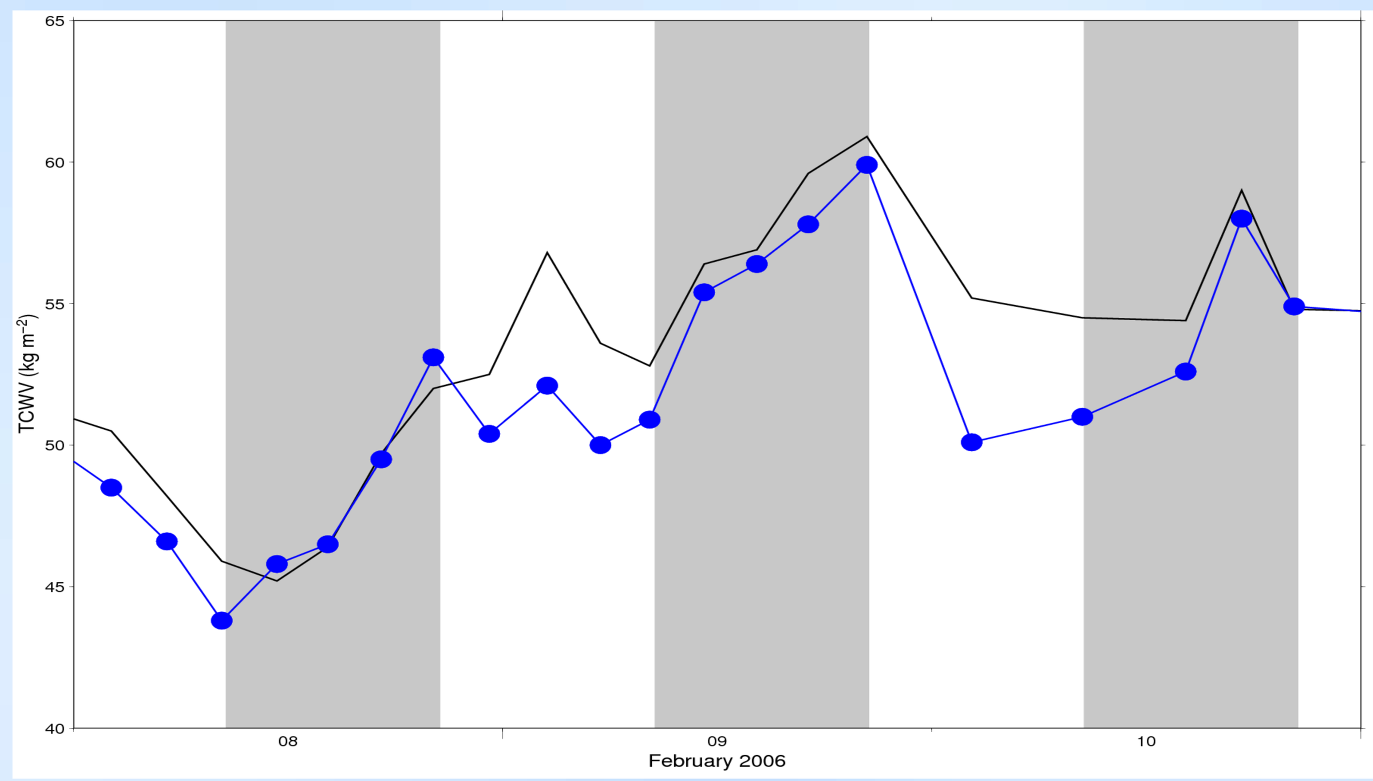

Figure 2: Effect of the radiation dry bias on TCWV derived from radiosondes launched on the *Southern Surveyor* (blue dots) compared with TCWV derived from MWR data (black line). Shading indicates night-time.

The RS92 sonde, used in TWP-ICE, is known to be affected by a significant day-time radiation dry bias. The dry bias is caused by solar heating of the radiosonde's humidity sensor; at 15 km it can be as great as 50%. Voemel *et al.* (2007) describe pressure dependent correction factors for the RS92 radiation dry bias, which are applied to soundings made near local noon (Figure 1, left panel). They also describe a smaller temperature dependent RH calibration factor which applies to soundings made at any time during the night or day (Figure 1, right panel):

$$RH_{corr} = RH \cdot \left(\frac{1}{c_{rad} \cdot C_{cal}} \right)$$

Where *RHcorr* is the corrected relative humidity (*RH*), and *Crad* and *Ccal* are respectively the radiation dry bias correction factor and temperature dependent calibration factor (Figure 1).

The corrections described in Voemel *et al* only apply to soundings near noon, and at night. Due to a lack of soundings, they were unable to study the early morning and late afternoon radiation dry bias. During TWP-ICE, three hourly soundings were made from the *Southern Surveyor*. Additionally, the PARSL microwave radiometer (MWR) on the ship measured the total column water vapour (TCWV). By comparing TCWV derived from radiosonde data with MWR data, the diurnal effect of the radiation dry bias is clear (Figure 2). Utilising these high frequency radiosonde data, we can estimate the effect of the solar zenith angle on the RH, and propose a simple correction factor to take account of this.

Solar Zenith Angle Correction Factor

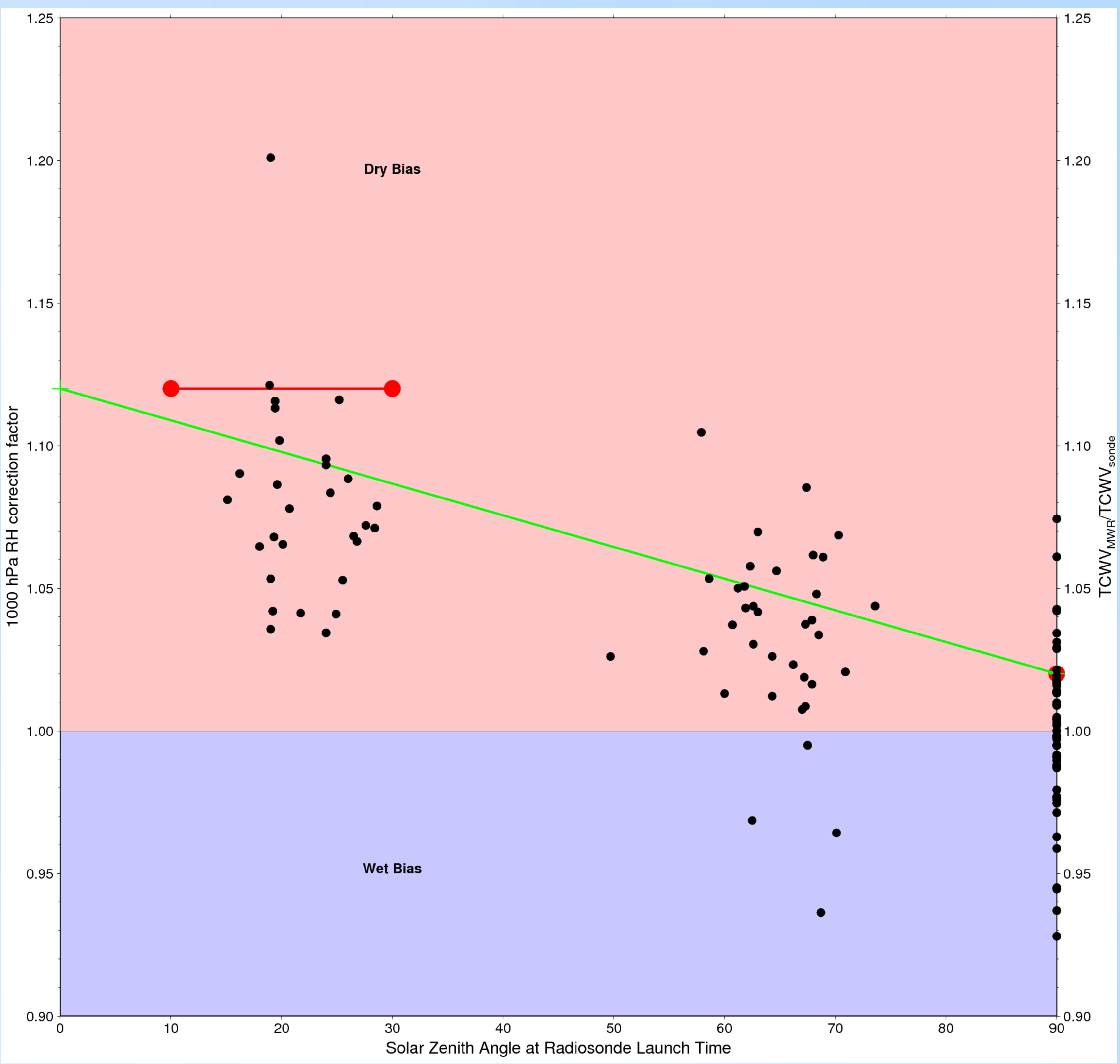

Figure 3: Ratio of MWR TCWV to radiosonde derived TCWV, and the solar zenith angle at the radiosonde launch time (black dots). The dry bias observed in sonde TCWV values is mainly attributable to a dry RH bias near the surface The red dots show the 1000 hPa RH correction factors suggested by Voemel et al for sondes launched near noon (10-30 degree solar zenith angle), and at night time (90 degree zenith angle). The green line shows a modified RH correction factor which is a function of the solar zenith angle.

Figure 3 suggests the RH correction factor is a function of the solar zenith angle, at least at low levels, where most of the atmospheric water vapour is. Therefore, a new correction factor, *Cz*, is introduced, to take account of the effect of the solar zenith angle on the radiation dry bias:

$$RH_{corr} = RH \cdot \left(\frac{c_z}{c_{rad} \cdot C_{cal}} \right)$$

$$\text{where} \quad c_z = 1 + \min(z, 90) \cdot \left(\frac{c_{rad} - 1}{90} \right)$$

z is the solar zenith angle

At noon, *RHcorr* is the same as the day-time correction described by Voemel *et al*. The correction factor then decreases linearly, until only the temperature dependent calibration factor applies for night-time soundings.

	Corrections applied to RH profile		
	No Correction	**Crad & Ccal**	**Crad, Ccal & Cz**
Near Noon (z < 30)	-3.9	2.5	1.3
Day-time (z < 90)	-2.6	3.8	1.2
Night-time (z ≥ 90)	0	1	1

Table 1: Bias (kg/m^2) of radiosonde derived TCWV compared to TCWV measured by PARSL at the Southern Surveyor, 23 January 2006 – 14 February 2006.

- During the day-time, the TCWV bias is significantly smaller when the zenith angle correction is applied than when no correction, or only the *Crad* and *Ccal* corrections are applied.
- The night-time TCWV data show a smaller bias when the temperature calibration is not applied. The larger bias in the calibrated values might be caused by uncertainties in *Ccal* at low levels and warm temperatures (see Figure 1, right panel).

Conclusions

The inclusion of a solar zenith angle correction factor to RH profiles measured by RS92 sondes makes a significant improvement to the derived TCWV values, compared to TCWV derived from uncorrected profiles, or profiles where only the *Crad* and *Ccal* correction factors have been applied. It is reasonable to assume the zenith angle correction factor will also reduce the bias in the low level relative humidities. It would be useful to validate the corrected upper tropospheric humidities against a reference sounding system (e.g. The cryogenic frostpoint hygrometer).

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Reference: Voemel, H., H. Selkirk, L. Miloshevich, J. Valverde-Canossa, J. Valdes, E. Kyro, R. Kivi, W. Stolz, G. Peng, J. A. Diaz (2007): Radiation Dry Biasof the Vaisala RS92 Humidity Sensor, *J. Atmos. Ocean. Tech.* (in press)