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IMPACTS OF HUMIDITY-CORRECTED SONDE DATA ON TOGA COARE ANALYSES

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1. INTRODUCTION

Following the field phase of TOGA COARE, it became evident that the sounding systems in the COARE domain exhibited a variety of humidity errors. Vaisala RS80-H (VaH) and RS80-A (VaA) sensors used at several key sites generally reported humidities too dry. In contrast, the sounding systems around 10°N and at several Indonesian sites used a VIZ hygristor sensor which displayed a moist bias. Because of the importance of the COARE sounding dataset to describe and understand the coupled ocean-atmospheric system in the western Pacific warm pool region, a humidity correction procedure was developed by NCAR/ATD and then applied to correct 11,540 soundings from 42 sites. The impacts of these humidity corrected sondes are considered here.

2. NATURE OF HUMIDITY ERRORS

Compelling evidence for humidity errors in COARE sounding data was presented by Johnson and Ciesielski (2000, figure 2) in their analysis of the specific humidity difference (Δq) between the surface and the mixed layer. While evidence from surface measurements combined with low-level COARE aircraft observations and Monin-Obukhov similarity theory indicate that Δq should be ~ 1 g kg^{-1} over the warm pool region, the majority of the Vaisala systems had $\Delta q > 2$ (indicative of a low-level dry bias) and the VIZ systems had $\Delta q < 0.5$ (indicative of a low-level moist bias). In a recent paper, Guichard et al. (2000) showed that the specific humidity errors at the RV *Moana Wave* occurred over the entire depth of sounding profile, but were largest at low levels.

Based on extensive laboratory tests, six different humidity measurement errors were identified in Vaisala sondes. The most serious of these errors was caused by the sonde packaging material, which contaminated the polymer used as the dielectric in the capacitive humidity sensor. This error affects the entire sounding profile, increases with the age of the sonde and humidity, and can be as large as 10% (2%) for a one year old VaH (VaA) sonde at high humidity. A summary of the different humidity errors in the Vaisala system and a correction procedure is described in detail in Wang et al. (2002).

Comparison of COARE-mean uncorrected relative humidity (RH) vertical profiles from Vaisala and VIZ systems shows the VIZ profile to be moister by 10-20% below 750 hPa and drier by 10-20% between 300 and 750 hPa. While differences in geographical location may explain some of this behavior, similar features have been observed in other tropical regions where these two sonde system were in close proximity to each other (Jeff Halverson, personal communication). While the reasons for the mid-level dryness in the VIZ sondes are uncertain, the low-level moist bias was substantially reduced by a correction scheme developed at NCAR/ATD by adjusting the response curves (resistance versus RH) for the VIZ hygristor at different temperatures.

3. IMPACT ON CONVECTIVE PARAMETERS

Because the specific humidity corrections are largest in the lowest layers, their impact on convection within numerical models could be substantial since convective available potential energy (CAPE) and convective triggering are quite sensitive to boundary layer moisture. The difference in CAPE and convective inhibition (CIN) between corrected and uncorrected sondes are shown for several warm pool sites in Figs. 1 and 2. Computation of these quantities was made for parcel temperature and dewpoint averaged over the lowest 50 hPa.

RH corrected sondes have more reasonable CAPE values with an average increase in the VaH sites from 822 to 1272 J kg^{-1}, and a decrease in the VIZ sites from 1535 to 1241 J kg^{-1}. CIN values computed using corrected humidities are also more reasonable with an average increase in the the VaH sites from -139 to -43 J kg^{-1}, and a slight decrease from -20 to -22 J kg^{-1} at the VIZ sites. The consistency in CAPE and CIN values among the sites computed with RH corrected sondes is no-

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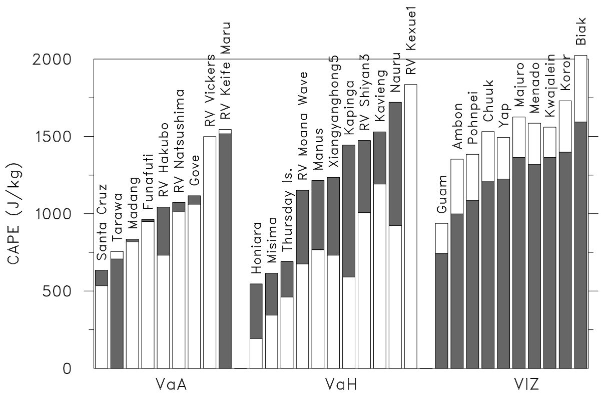

Figure 1: COARE-mean CAPE values at several warm pool sites for humidity corrected (top of gray bar) and uncorrected (top of white bar) data. Sites are grouped according to sonde type: VaA, VaH and VIZ.

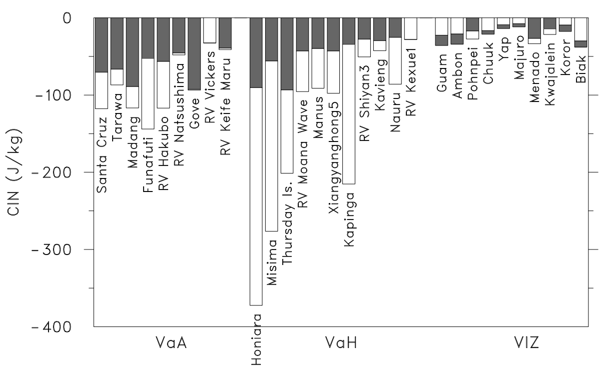

Figure 2: As in 1, except for CIN: uncorrected (bottom of white bar) and corrected (bottom of gray bar).

tably better, with much of the remaining variability likely physical in nature due to differences in when and where sondes were launched. In this paper, corrected data was not used for two sites: RV *Vickers* and RV *Kexue#1*. At the *Vickers* the newness of the sondes used there minimized the contamination problem described above, such that no corrections were necessary. Unlike the other Vaisala sites, the *Kexue#1* sondes had a low level moist bias due to condensation on the humidity sensor caused by storing the sondes in a cold air-conditioned room. Application of the correction scheme to the *Kexue* sondes produced even moister low-level humidities, such that uncorrected humidity data were considered to have smaller errors and thus are used here.

4. IMPACT ON BUDGET ANALYSES

To assess the impact of the humidity corrections on atmospheric budget analyses, two high-resolution (1° horizontal, 25 hPa vertical) gridded data sets were produced: one using uncorrected humidity data and a second using corrected humidity values. The data were objectively analyzed over the region (10°S-10°N, 140°E-180°E) using multiquadric interpolation with ECMWF reanalysis in data-sparse regions. These analyses were produced for every 6 hr period for the entire 120 day intensive observing period (IOP) of TOGA-COARE.

Using these gridded analyses, budget-derived rainfall (P_o) and net radiative heating rates ($< Q_R >$) were computed using the method described in Johnson and Ciesielski (2000). Table 1 shows the IOP mean of these quantities averaged over the COARE intensive flux array (IFA) for the uncorrected and corrected humidity analyses.

TABLE 1. IFA-IOP mean budget-derived rainfall and net radiative heating rate estimates computed using uncorrected and corrected humidity data.

	P_o (mm/day)	$< Q_R >$ (K/day)
uncorrected	8.16	-.31
corrected	8.68	-.46
net change	+.52	-.15

The impact of the humidity corrected data on diagnosed rainfall is modest, increasing it by 6%. On the other hand, the net radiative cooling rate increases nearly 50% to -0.46 K day^{-1} bringing the budget diagnosed $< Q_R >$ estimate in better agreement with other independent estimates of this quantity.

5. SUMMARY

Use of the TOGA COARE humidity-corrected data has a substantial impact on CAPE and CIN values over the warm pool, as well as, on budget-derived quantities. These findings suggest that simulations from single column models and global models, such as NCEP and ECMWF, which generate valuable reanalysis products, would greatly benefit from using the humidity-corrected data set.

6. REFERENCES

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