How Accurate is the NCEP Analysis (Reanalysis) in the East Atlantic? A Comparison with NAMMA Dropsondes

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Motivation

To evaluate the accuracy of the NCEP modeled (reanalysis and analysis) environment over the East Atlantic by comparing NCEP Reanalysis and operational GDAS analysis output with DC-8 dropsonde data.

3 datasets are evaluated: The entire set of 127 dropsondes passing quality control criteria, a subset of 104 dropsondes excluding only those released within 5° of the center of Debby and Helene, and a small subset of sondes dropped into an environment dominated by the Saharan Air Layer.

Data

NCEP/NCAR Reanalysis – 2.5°×2.5°, 28 levels, hourly – for NAMMA flight days.

NCEP GDAS (Global Data Assimilation System) Analysis – 2.5°×2.5°, 64 vertical levels, initial analysis, available hours 00, 06, 12, 18 – for NAMMA flight days.

NAMMA - NASA DC-8 dropsondes – 127 total dropsondes over 13 flights. For the subset excluding the immediate tropical cyclone environment, 19 were eliminated from the Debby flight (23 August 2007) and 4 from the Helene flight (12 September 2007).

Methodology

Dropsonde temperature, relative humidity, U- and V-winds were compared to the nearest grid-point values from NCEP Reanalysis and GDAS analysis for 7 mandatory pressure levels: 1000, 925, 850, 700, 600, 500 and 400 hPa.

For each dropsonde location, the reanalysis sounding at the nearest hour and the GDAS analysis sounding within 3 hours were selected.

Quality control criteria: Dropsondes missing the wind profile, dropsondes with data voids greater than 15 hPa, and dropsondes with a depth less than 1000-400 hPa were eliminated.

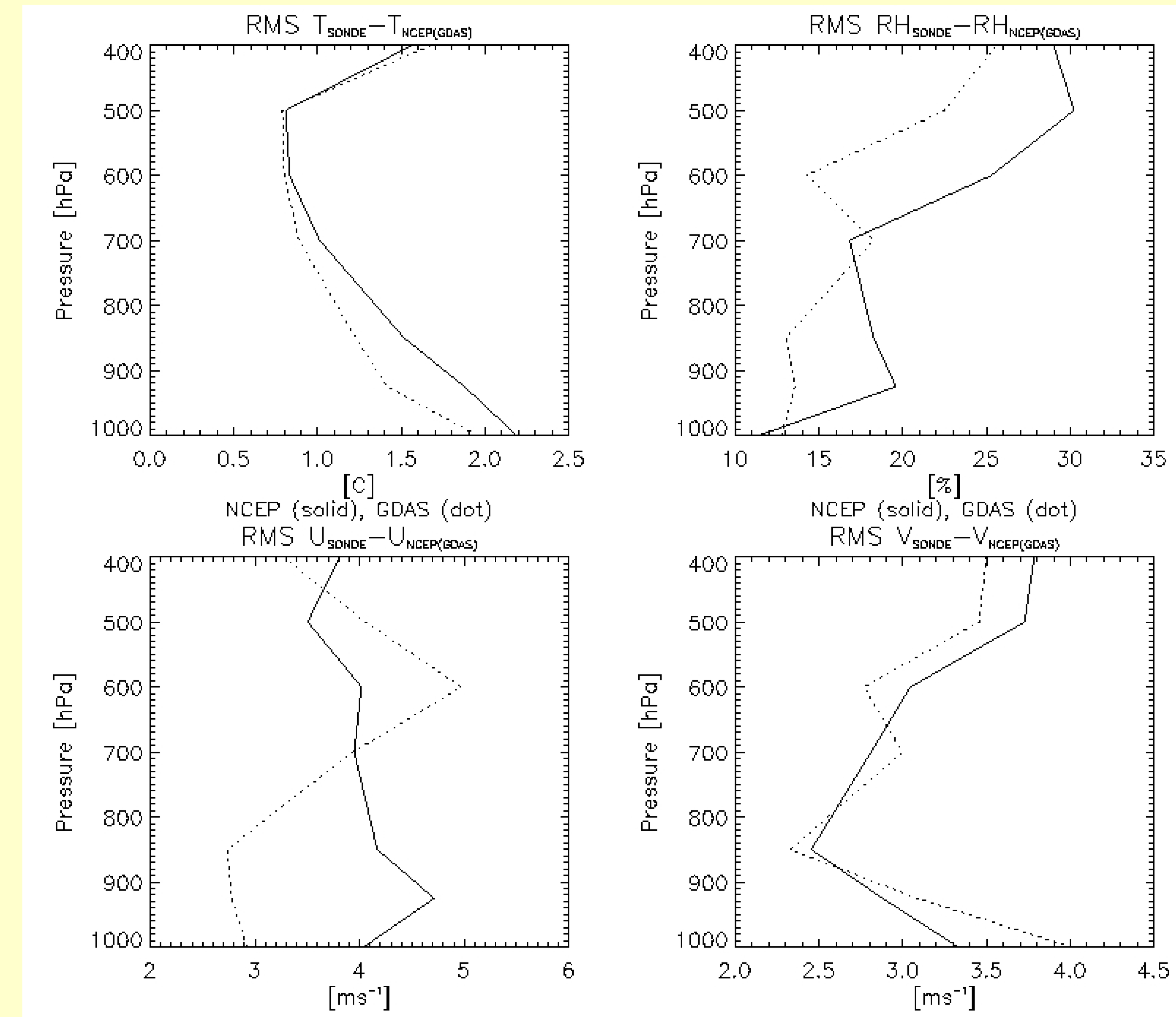
RMS differences between NCEP and dropsondes (for subset of 104 sondes to exclude problems near storms)

Temperature: The RMS difference between dropsonde and NCEP reanalysis is large, 2.2°C, at 1000 hPa, while 1.9°C for the GDAS analysis. This difference decreases with height, the reanalysis and analysis converging at 500 hPa.

Relative Humidity: The RMS is lowest for both reanalysis and analysis at the surface, 11 and 13%, respectively. While the analysis is consistently closer to the sondes than the reanalysis at each pressure level, these differences increase strongly with height, both exceeding 25% above 500 hPa.

U-Wind: The RMS difference between dropsonde and reanalysis is signifcant, about 4 ms^{-1}. The RMS for the analysis is 2.9 ms^{-1} at the surface and reaches 5 ms^{-1} at jet level (600 hPa).

V-Wind: The RMS difference is significant for both reanalysis and analysis at the surface; 3.3 ms^{-1} and 4.0 ms^{-1} respectively. There is an improvement at mid-levels, however the error increases again from 600 hPa to 400 hPa.

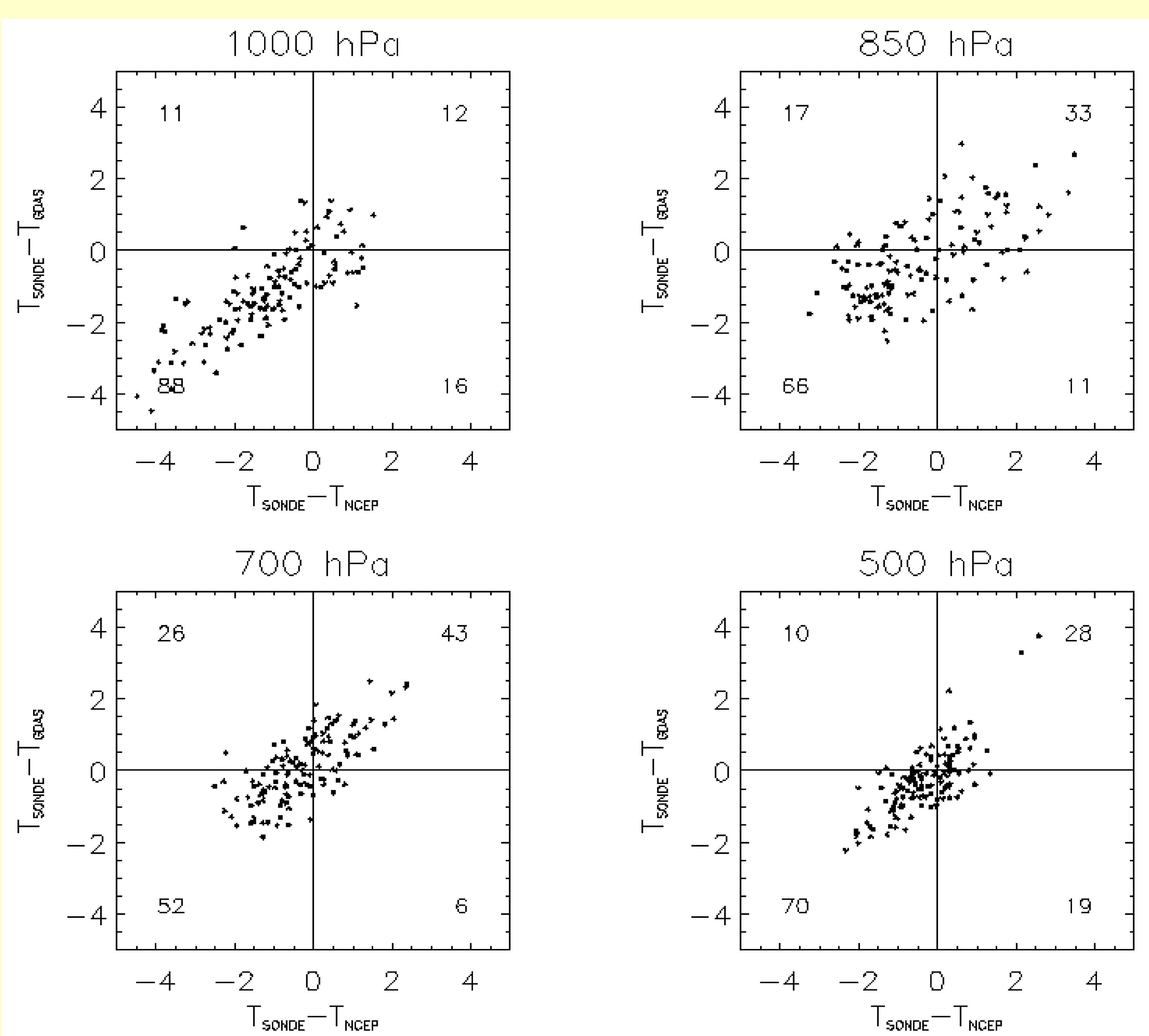


Figures: ('NCEP': Reanalysis; 'GDAS': Analysis)

Above,Right: RMS differences between the dropsonde and reanalysis, and dropsonde and analysis, for temperature, RH, U-wind and V-wind.

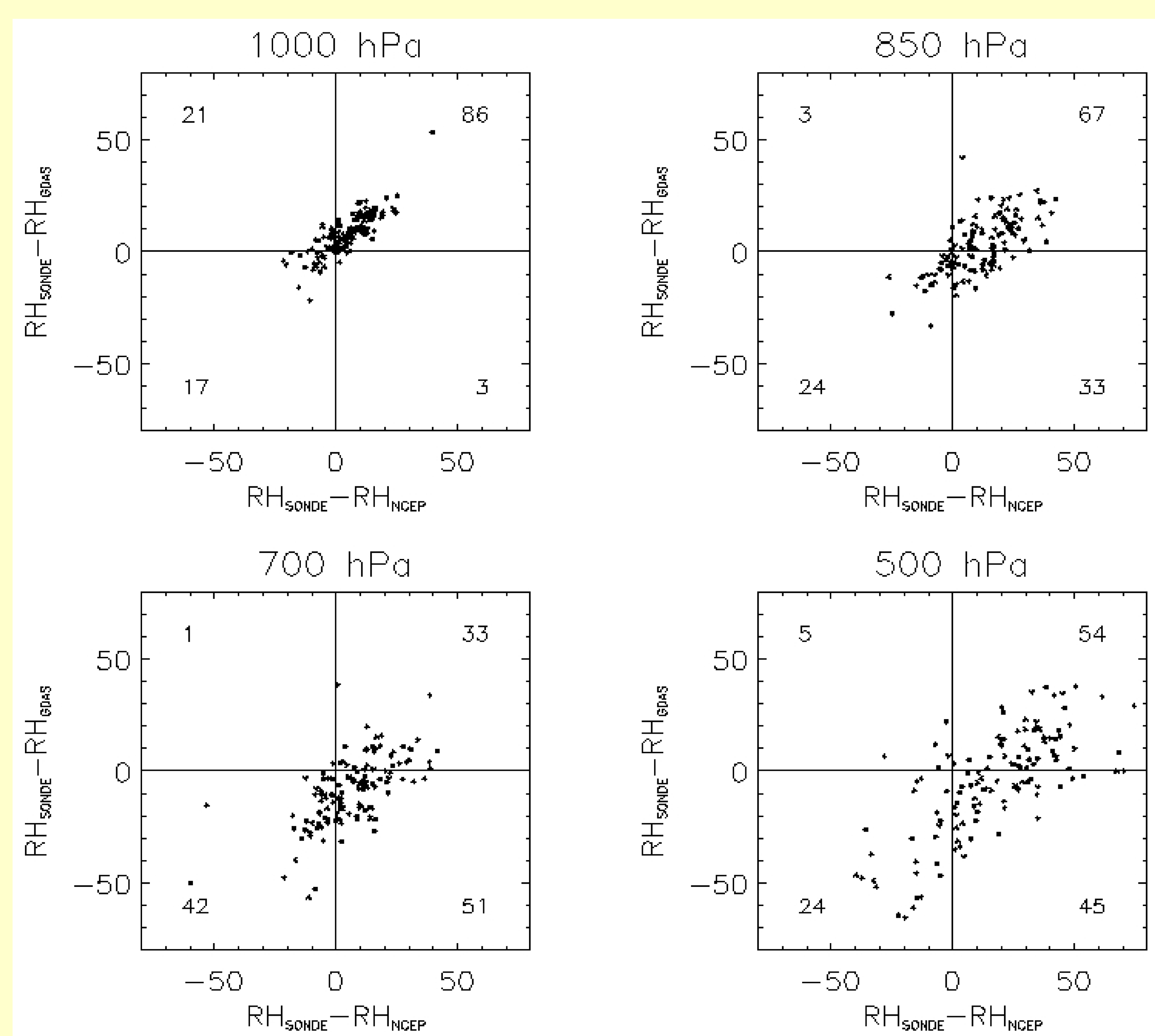
Below this caption: Distributions of temperature (lower left) and RH (lower center) differences for the dropsonde minus reanalysis (x-axis) and dropsonde minus analysis (y-axis) at 1000 hPa, 850 hPa, 700 hPa and 500 hPa.

Below,Right: Temperature and RH dropsonde, reanalysis and analysis profiles for Aug. 30, 2006 flight, 1804 UTC drop.



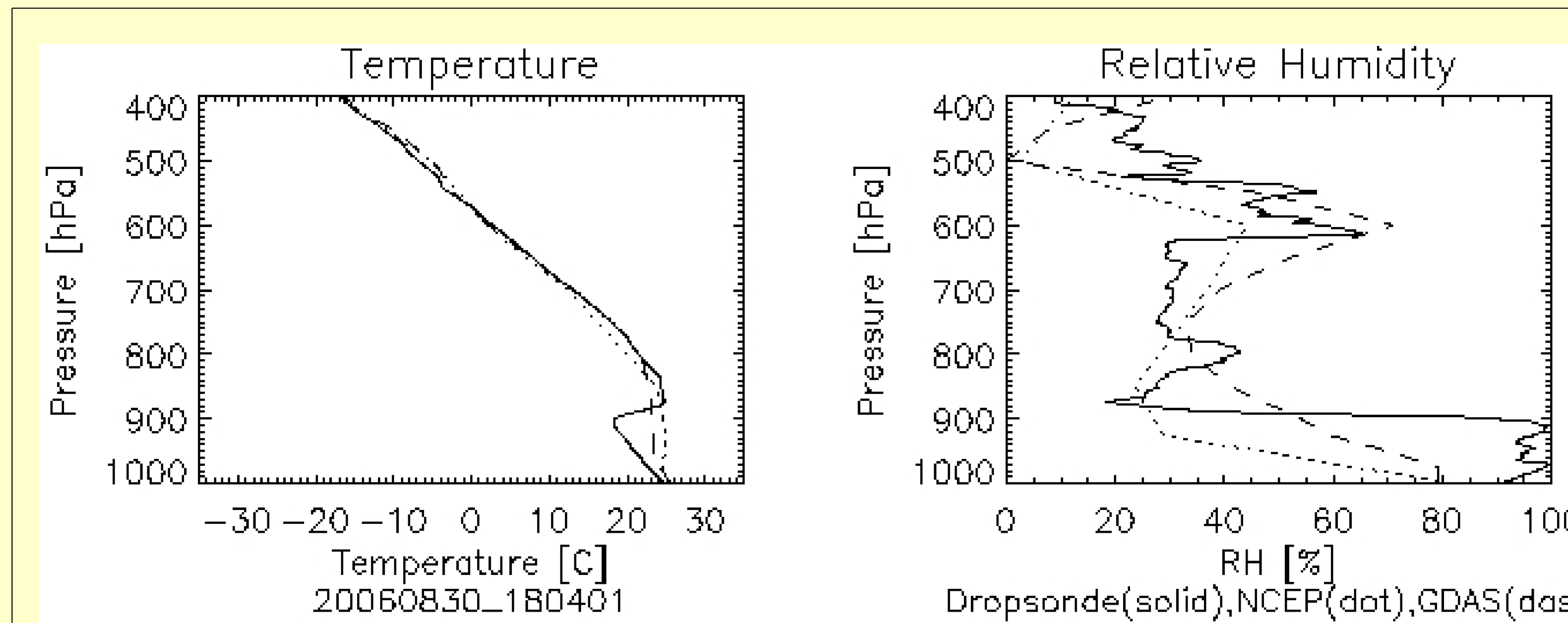
Temperature (127 dropsondes):

At 1000 hPa there is a clear **high bias** in the NCEP reanalysis and GDAS analysis; the dropsondes consistently exhibited a lower temperature. These results are similar at all pressure levels, while both the bias and the dispersion are reduced as a function of height.



Relative Humidity (127 dropsondes):

At 1000 hPa there is a clear **low bias** in the NCEP reanalysis and GDAS analysis; the dropsonde RH is consistently higher. This implies a **low bias** in CAPE. These results are similar at 850 and 500 hPa; less distinct at 700 hPa. The spread is especially great at 500 hPa, sometimes exceeding 40%.



Saharan Air Layer (SAL): In SAL sounding comparisons, both NCEP reanalysis and GDAS analysis have significant and consistent errors in the transition from the marine boundary layer to the upper mixed layer. Neither can resolve the sharp transition between the two mixed layers, such as seen in the dropsonde profile above. Errors in the marine layer would be expected to affect surface fluxes.

Conclusions

- NCEP reanalysis and GDAS analysis winds depart significantly from the dropsonde-measured winds, with RMS differences in the 3-5 ms^{-1} range for both U- and V-components.
- There is a high bias in temperature and low bias in RH in both reanalysis and analysis. The bias for both decreases with height, but the dispersion for RH becomes very large with height.
- Caveat: Dropsondes are not error-free. However, unless their errors are much greater than generally believed, these comparisons raise questions about the utility of derived parameters such as vorticity and divergence from the analyses and reanalyses.
- Comparisons with additional observations such as those from airborne instruments and radiosondes may yield additional insight into the discrepancies observed.

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