FIFTHTEENTH SYMPOSIUM ON GLOBAL CHANGE AND CLIMATE VARIATIONS

9.2 UPDATE ON MICROWAVE-BASED ATMOSPHERIC TEMPERATURES FROM UAH

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1. INTRODUCTION

Constructing datasets for climate purposes involves retrospective analysis of the data as new information and techniques come to light. In version 5.1 of the microwave-based bulk atmospheric temperatures we have updated the target coefficient for one of the products and extended the data back in time to 16 Nov 1978. The main thrusts of this paper are 1) to describe the main dataset difference between the University of Alabama in Huntsville (UAH, Christy et al. 2003) and Remote Sensing Systems (RSS, Mears et al. 2003) and 2) to compare version 5.1 with independent datasets of lower tropospheric temperature to understand the precision of the measurement.

2. ADJUSTMENT FOR CALIBRATION DRIFT

The NOAA polar orbiting spacecraft are nominally referred to as sun-synchronous, meaning they are placed in an orbit that crosses the Equator at the same local time (Local Equatorial Crossing Time or LECT) on each pass. In practice, the spacecraft experience a slight E-W drift (or equivalently a local time drift) during the course of their operational life. In particular, the afternoon orbiters begin their observations with a LECT of 0200/1400 but drift “later” to 0500/1700 after a few years. As these “pm” satellites drift to later times, the instrument is exposed to more direct sunlight and warms as a result. This warming is evidenced in the on-board platinum resistance thermometer which is embedded in the hot-target plate. Christy et al. 2000 discovered the dependency of variations in the hot-target plate temperature (HTPT) and errors in the atmospheric temperature reported by the instrument.

The instrument error was eliminated by determining a linear coefficient which when multiplied by the HTPT anomaly would account for much of the error. The values of these coefficients were determined as the solution to a matrix of equations relating the HTPT and intersatellite error. It was determined that the highest level of error reduction was found when the daily data were smoothed. This had the added advantage of reducing the small intersatellite trend differences which was a goal of the merging process as well.

A key difference between UAH and RSS is the value of the target coefficient that explains the error between NOAA-6 and NOAA-9. Two main differences in procedure are followed. RSS solves the system of equations using pentad averages (UAH smoothes to 60 to 110-day averages) and RSS applies all available intersatellite overlaps to the problem (UAH uses only those with a minimum of one-year overlap).

The results for a series of target coefficients is shown in the following table (UAH blue, RSS red). While RSS has the most significant reduction of high frequency variance (0.037), UAH produces the lowest trend difference between NOAA-6 and NOAA-9.

NOAA9 Coeff.	Daily Error □	Overlap Trend Differ.	Global Trend 79-01
	°C	°C/yr	°C/decade
-0.10	0.049	0.013	+0.032
-0.08	0.045	0.022	+0.046
-0.06	0.042	0.030	+0.059
-0.04	0.039	0.036	+0.072
-0.02	0.037	0.042	+0.086

The differing philosophies of the level of smoothing is shown in which error parameter is minimized. When UAH performed this technique after discovering it in 1998, our goal was to reduce in the intersatellite trend differences as a priority. In fact, the R.M.S. of all of the intersatellite trend differences of at least a year in length was 0.008 °C/yr (Christy et al. 2003).

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Because the philosophies of calculating the target coefficients differs, it is perhaps most useful to appeal to independent data sources rather than to appeals about merging philosophy which are complicated and obscure to the average climate scientist.

3. RADIOSONDE DATA

In direct comparison of UAH data with radiosondes, we estimated the 95% Confidence Interval (C.I.) as ±0.05 °C/decade for both LT and MT based on site by site and on global average comparisons with radiosondes and radiosonde based analyses. This trend error range is smaller than the 0.08 °C/decade difference between the UAH MT and RSS MT products (+0.032 vs. +0.115 °C/decade for UAH and RSS respectively). We have found that the largest difference between UAH MT and RSS MT occurs in the SH during the pre-1990 period where the mean difference of the average of years (1987-1990) minus (1979-1982) is 0.12 ±0.03 °C between the two.

Unfortunately, the layer MT requires data up to at least 50 hPa to properly account for the long term trends and anomalies, and thus a direct comparison between UAH and RSS. Radiosonde data have significant shifts in temperatures in the lower stratosphere due to instrument and procedural changes that have occurred since 1979. Some stratospheric shifts are as large as 3°C (Parker et al. 1997). Thus we cannot with high confidence compare many MT soundings with UAH and RSS, though a small NH set was used in Christy et al. 2003.

However, changes to instruments and procedures have only a minor and relatively systematic impact on temperatures below 200 hPa, which is sufficient to define profiles of LT. Consequently, we shall focus on LT profiles in the following comparisons noting that the same target coefficient and merging procedures were employed for both MT and LT. Thus the results of UAH LT should be applicable to UAH MT. RSS does not produce an LT product.

We examined all radiosonde stations in the SH (85S to Eq.), about 320. Of those, 89 contained sufficient data up to 200 hPa to populate 60% of the months in the 1979 to 2001 period (which we shall call "all"). A higher threshold of 75% reduced the number to 72 (which we shall call "best".) We shall also include 29 NH stations utilized in Christy et al. 2003 for some of the comparisons.

Though spurious tropospheric temperature shifts are relatively small for composites, they can be significant for trend determination. We therefore calculated a generic shift in temperature for specific instrument changes based on a composite direct comparison with UAH LT values before and after the shifts. For each type of instrument change, we aligned the affected time series to a uniform point in time to make the shifts coincident. A difference of 36-months average on either side of the break was calculated. In the table below we show the correction value applied as well as the values calculated by this and other studies. In every case we adopted the value with the greatest number of comparisons, or one that benefited the RSS data over UAH.

Change	Applied	This Study	Durre et al.	Thorne
A	-0.27	-0.28 (29)	-0.18 (1)	-0.27 (11)
B	+0.24	+0.24 (28)	+0.22 (3)	
C	+0.24	+0.11 (10)	+0.24 (14)	
D	+0.00	-0.11 (8)		
E	+0.16	+0.16 (28)		

A = Philips to Vaisala RS80, B = Vaisala RS21 to RS80, C = VIZ to Vaisala, D = Mesural to Vaisala RS80, E = VIZ B to VIZ B2. Durre et al. used UAH data with NH stations. Thorne used only radiosonde data within a sphere of influence. In "D" the Mesural time series were more noisy than others and did not exhibit a distinct break separate from the background noise in the overall time series. In "E", the value of a similar shift for MT temperatures was identical whether using RSS or UAH data.

As will be shown, the impact of the adjustments was insignificant for the issue at hand. If the data are from the adjusted version we use "adj" and for the original data we use "unadj".

4. RADIOSONDE COMPARISONS

The first metric examined was the 4-yr differences for the SH stations. Because this is a comparison of small subsets of the station data, we limited the use to "all" and "adj" data. The results show that there is no difference in the metric defined as the difference in 4-yr averages: (1987-1990) minus (1979-1982). For UAH LT vs. Radiosondes, the difference of the differences was only 0.01 ± 0.06 °C. By contrast the same metric difference between UAH MT and RSS MT was 0.08 ±0.03 °C at the 72 SH stations. The conclusion here is that the radiosondes do not suggest a spurious shift in UAH LT and MT data prior to 1990.

For a more general result, we compare the metric of 23-year trends for large composites of the radiosonde stations (Fig. 1). Here the various combinations of SH radiosonde data ("all", "best", "unadj" and "adj") all reveal the same result: There is no significant difference in trends between UAH LT and Radiosonde LT (blue). When the 29 NH stations are also included, the agreement continues to be remarkably close. However, for those same sets of locations, we see a significant difference between UAH MT and RSS MT (orange). Additionally, there is no information here that would contradict the conclusion of Christy et al. 2003, based on NH stations, that the global trend error range is ±0.05 °C/decade for LT. A final point is to note that the results of Vinnikov and Grody (2003) would be off the page, showing trend differences vs. UAH of greater than 0.20 °C/decade

It is important to emphasize that these radiosonde data are independent from the UAH products. Indeed the CARDS data provided by Dr. Imke Durre (NOAA/NCDC) were accessed during the summer of 2003, well after all UAH procedures were completed.

We show one other interesting figure. We compare UAH LT with a similar product calculated from the pressure level temperature data of the NCEP Reanalyses 2 (NCEP R2, Fig. 2). The interesting point here is that for the entire globe, all land, all ocean or tropics, the 24 year trends are almost identical (1979-2002). However, for specific regions there are differences. For example, in Europe and South America, we know the radiosonde type was changed generally from Vaisala RS21 to Vaisala RS80, leading to a spurious cooling trend. Because NCEP did not adjust radiosonde data over continents, this is revealed in the trend comparisons here. Note too that in Australia, the spurious warming found when the Philips was changed to Vaisala RS80 is apparent, though not significant.

The exceptionally close agreement between UAH LT and radiosondes is consistent with other comparison tests shown elsewhere (Stendel et al. 2000, Folland et al. 2001). By implication, the UAH MT trends should also be characterized by a similar trend precision (±0.05 °C/decade) as concluded in Christy et al. using the 29 NH stations.

5. REFERENCES

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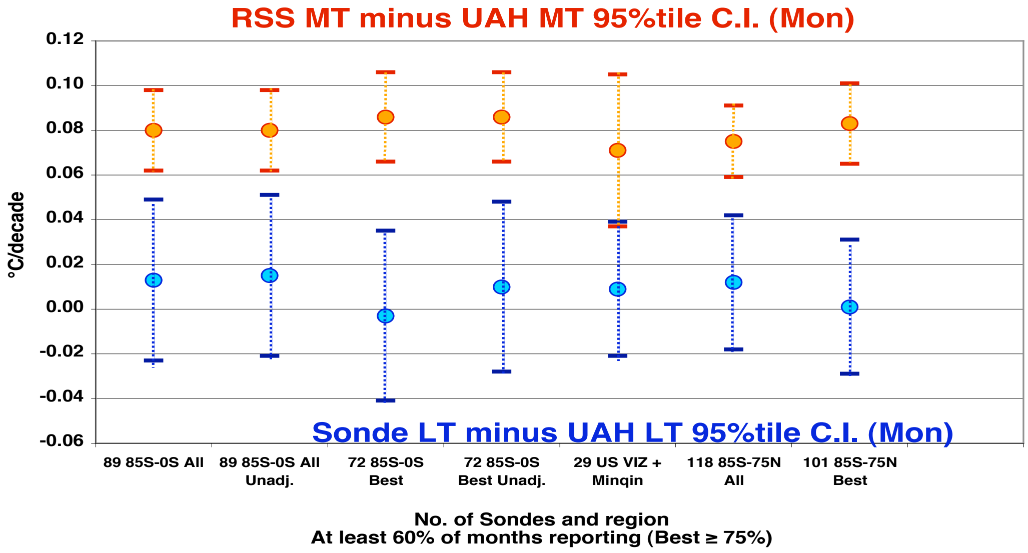
Trend Differences 1979-2001
Sondes LT v. UAH LT, RSS MT v. UAH MT



UAH minus NCEP Lower Troposphere
Trend Difference