FOURTEENTH SYMPOSIUM ON GLOBAL CHANGE AND CLIMATE VARIATIONS

4.2 GLOBAL ATMOSPHERIC TEMPERATURES: ERROR ESTIMATES OF AMSU/MSU V. 5.0

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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 5.0 of the microwave-based bulk atmospheric temperatures we have (1) developed a new non-linear approximation to account for the diurnal drift and (2) megered into the time series data from the new Advanced Microwave Sounding Units (AMSUs). Independent comparison with radiosonde and radiosonde-based datasets indicate good agreement in variability and trends since 1979, except in the stratosphere where in-situ data are troublesome (Christy et al. 2003.)

The three temperature products addressed here are TLT (previously T2LT or low-mid troposphere), TMT (T2 or mid-troposphere) and TLS (T4 or lower stratosphere).

2. DIURNAL DRIFT CORRECTION

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. Thus, the natural cooling the Earth experiences in its diurnal cycle between 0200/1400 and 0500/1700 becomes part of the measurement and thus introduces a spurious cooling signal in this case. Christy et al. 2000 described a linear approximation to this effect in which a temperature correction (ΔT) was determined based on LECT drift (Δt) from the initial LECT.

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$$\Delta T = a\Delta t$$

The value a was a function of latitude, surface type (land/ocean) and time of year. Because the diurnal temperature phenomenon resembles a skewed sine curve, we have developed a non-linear approximation.

$$\Delta T = a_1\Delta t + a_2\Delta t^2$$

The data used to determine the a's were the cross-swath temperature differences of the 11 view angles of the MSU. Because the sensor mirror sweeps roughly left to right as it observes the surface, encompassing about 2000 km per swath, the differences between temperatures on one side versus the other describe the local temperature difference between the local times represented by those view angles. The non-linear adjustment improved the statistical noise characteristics of the two tropospheric data sets and was applied.

3. AMSU DATA

With the launch of NOAA-14 in 1995, the last 4-channel MSU was placed into service. In September 1998, NOAA-15 became operational with its next generation instrument, AMSU. The 15 temperature channels on AMSU-A provide frequencies comparable to MSU2 (TMT) and MSU4 (TLS), being AMSU5 and AMSU9 respectively. The TLT product is created from linear combinations of the various view angles of MSU2 and the same strategy is applied to AMSU5 to continue the TLT time series. The weighting function of MSU2 is slightly higher in elevation than AMSU5 (in terms of temperature about 2.1°C cooler.) However, in tests comparing MSU vs. AMSU and AMSU vs. AMSU we found in every case that the AMSU products met or exceeded the statistical noise characteristics calculated from MSU vs. MSU comparisons.

4. RADIOSONDE COMPARISONS

In an effort to assess the precision of the variability and trends of the time series we have generated from radiosonde (or sonde) station data simulated microwave-based temperatures (termed RLT, RMT and RLS for radiosonde). Figure 1 displays the monthly anomaly time series for the comparison between the sonde at Minqin China (RMT) and the associated TMT time series. The results are exceptionally good as shown by the correlations and trend agreements.

The same quantities were calculated for 28 U.S. stations which utilized VIZ instrumentation. Those results are given in Table 1. Note that the stratospheric trends are quite different and this has been related to the spurious cooling created by the failure of early balloon data to reach the higher altitudes on the coldest days.

In Fig. 2 we show the comparison between global data sets of the low-mid tropospheric temperature (TLT). The HadRT (Hadley Centre Radiosonde Temperature) dataset is constructed from about 400 world-wide radiosonde stations which report monthly mean temperatures on manditory pressure levels (Parker et al. 1997). These data were convolved with the appropriate weighting function for comparison with the MSU/AMSU products. Also shown are the global averages produced from the NCEP Reanalyses where the pressure level data were again appropriately weighted to match the profile of the MSU/AMSU LT product (Stendel et al. 2000.)

Table 2 displays the statistical values of the metrics often found useful in understanding the error of a particular dataset. The results suggest the global trend of TLT and TMT are known within ±0.05 °C decade^{-1}, while that of TLS is known to about ±0.10 °C decade^{-1}.

The agreement in correlation and trend is again exceptional and lends support to the three University of Alabama in Huntsville MSU/AMSU time series as useful hypotheses for exploring global and regional temperature variations and trends of deep atmospheric layers (Folland et al. 2001.)

5. REFERENCES

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Table 1 Statistical comparison of 28 U.S. VIZ station radiosonde temperature anomalies against collocated MSU/AMSU anomalies for the three products, TLT, TMT, TLS. r = correlation, b = trend, σ = standard deviation, MON = monthly, ANN = annual, Neff = effective number of independent values, Sat = satellite MSU/AMSU, Δ = differences between sonde and satellite.

28 U.S. VIZ Stations 0-90N	***LT Adj.***	***MT Adj.***	***LS***
r_{MON}	0.95	0.95	0.97
r_{ANN}	0.98	0.96	0.98
b, sondes (°C decade^{-1})	+0.16	+0.05	-0.73
b, Sat (°C decade^{-1})	+0.17	+0.09	-0.53
r.m.s. ($b_{sondes} - b_{sat}$) (°C decade^{-1})	0.105	0.095	0.230
σ_{MON} sondes, Sat (°C)	0.42, 0.39	0.34, 0.30	0.81, 0.77
$\sigma_{\Delta\ MON}$ (°C)	0.15	0.10	0.19
N_{eff} of monthly Δ's (N=264)	115	90	64
σ_{ANN} sondes, Sat (°C)	0.26, 0.24	0.22, 0.19	0.63, 0.53
$\sigma_{\Delta\ ANN}$ (°C)	0.051	0.068	0.16
N_{eff} of annual Δ's (N=22)	21	8	6

Table 2 Summary of 95% confidence interval estimates from calculations for global temperature statistics based on upscaling (where needed) each dataset, assuming all of the differences are due to satellite error. The global spatial degrees of freedom are estimated as 26.

Global	***TLT***	***TMT***	***TLS***
95% C.I. Trend	**°C decade^{-1}**	**°C decade^{-1}**	**°C decade^{-1}**
Minqin	±0.031	±0.015	±0.033
U.S. VIZ Sondes, composite σ_{ANN}	±0.016	±0.039	±0.113
U.S. VIZ Sondes, r.m.s. Δb	±0.043	±0.039	
HadRT	±0.075		±0.127
NCEP	±0.067		?
R.M.S. consensus	**±0.051**	**±0.033**	**±0.100**
95% C.I. Monthly Global Anomalies	**°C**	**°C**	**°C**
Minqin	±0.24	±0.12	±0.25
U.S. VIZ Radiosondes	±0.20	±0.15	±0.35
NCEP	±0.16		±0.41
R.M.S. consensus	**±0.20**	**±0.14**	**±0.35**
95% C.I. Annual Global Anomalies	**°C**	**°C**	**°C**
Minqin	±0.08	±0.04	±0.09
U.S. VIZ Radiosondes	±0.04	±0.10	±0.27
HadRT, NCEP	±0.20, ±0.18		±0.38, ?
R.M.S. consensus	**±0.14**	**±0.08**	**±0.27**

Fig. 1. Minqin, China radiosonde vs. MSU/AMSU TMT. Correlation of annual anomalies = 0.97, 0.98 and 0.96 for TLT, TMT and TLS respectively. Trend differences (Minqin minus satellite) = +0.01, +0.01 and –0.03 °C decade^{-1} for TLT, TMT and TLS respectively.

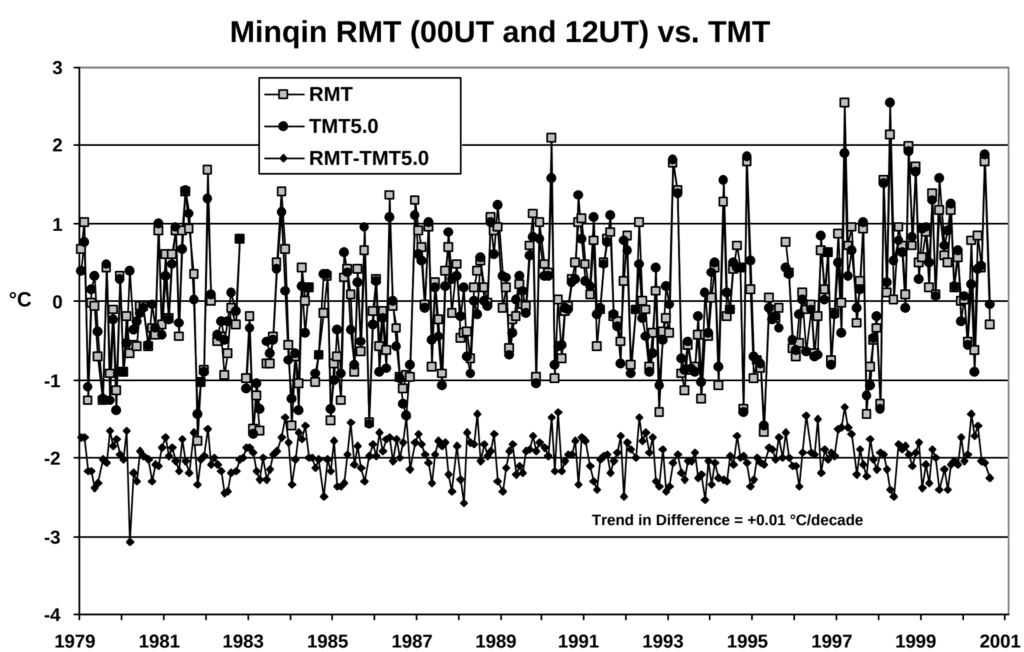

Fig. 4 Christy et al. 2002

Figure 2. Comparison of annual anomalies of MSU/AMSU TLT, HadRT LT and NCEP LT. See Table 2 for statistical results. Intercorrelations are +0.94 or greater. Difference between MSU/AMSU (TLT) and the other two are offset by –0.6 °C for clarity.