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Uncertainty Estimates for MSU/AMSU Derived Atmospheric Temperatures.

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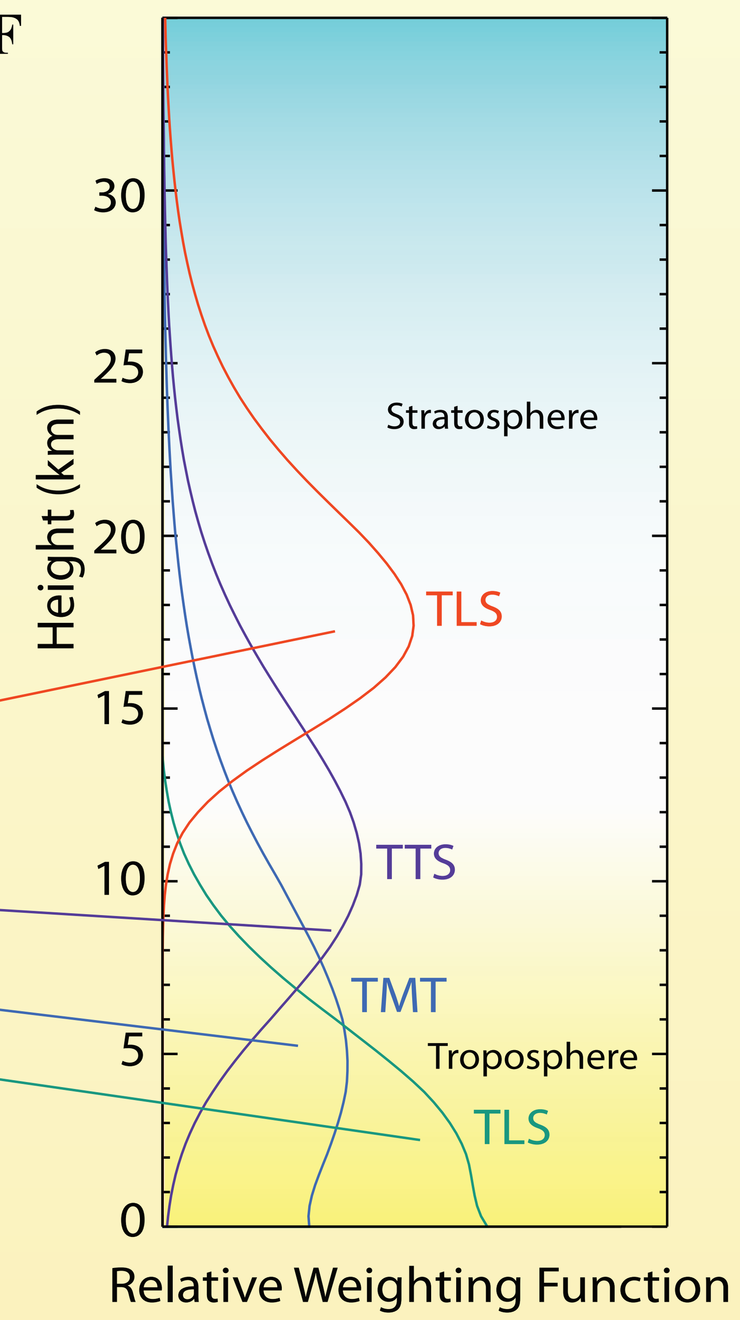
1. SATELLITE-BORNE MICROWAVE SOUNDING OF ATMOSPHERIC TEMPERATURE

The Microwave Sounding Unit (MSU) and the Advanced Microwave Sounding Unit (AMSU) measure thermal emission from Oxygen to deduce the temperature of thick atmospheric layers.

The frequency used determines the opacity of the atmosphere, and thus the location of the measurement in the atmosphere.

These measurements are used to generate 4 atmospheric temperature products:

Temperature Lower Stratosphere TLS
Temperature Troposphere-Stratosphere TTS
Temperature Middle Troposphere TMT
Temperature Lower Troposphere TLT



The measurements begin in late 1978, and continue to the present. The relatively long time period (for satellite measurements) makes the dataset important for climate change analysis

2. WHY UNCERTAINTY?

The longing for certainty is in every human mind. But certainty is generally illusion.
(Oliver Wendell Holmes)

When one admits that nothing is certain one must, I think, also add that some things are more nearly certain than others
(Bertrand Russell)

- Without realistic uncertainty estimates we are not doing science!
- In the past, numerous conclusions have been drawn from with little regard to the statistical uncertainty in the MSU/AMSU datasets.
- Most error analysis for the MSU/AMSU datasets has focused on decadel-scale trends in global-scale means, while many applications are focused on shorter time scales and smaller spatial scales.
- Here we describe a comprehensive analysis of the internal uncertainty in the RSS MSU/AMSU datasets. The results can be used to evaluate the estimated uncertainty on all relevant temporal and spatial scales.

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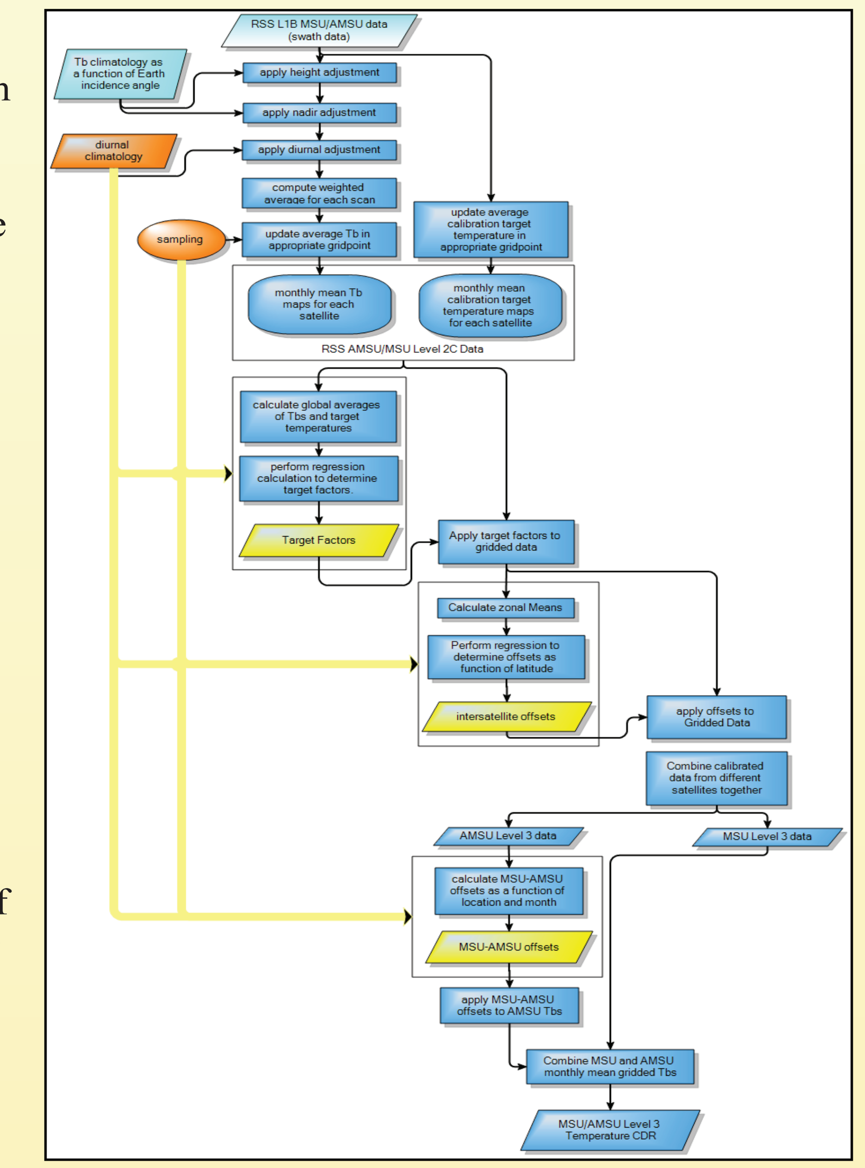
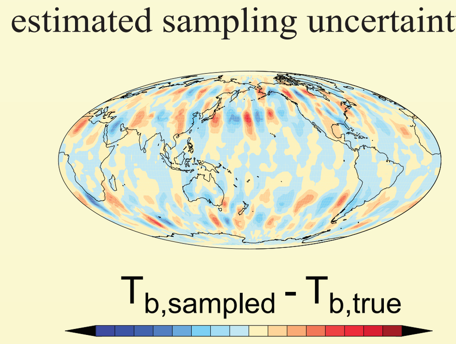
3. ISSUES

- Our MSU/AMSU datasets use data from 14 different satellites. The data need to be intercalibrated before being merged together. This is a complex process (see flow chart)
- First, adjustments are made for changes in local measurement time (diurnal adjustment) and Earth incidence angle.
- Then, intercalibration is performed by comparing measurements from co-orbiting satellites, yielding a set of "merging parameters".
- Uncertainty earlier in the process can cause uncertainty in these merging parameters, which adds to the uncertainty in the final results. This indirect flow of uncertainty is represented by the yellow arrows in the flow chart.
- To account for all the source of uncertainty is the entire system, we use a Monte Carlo technique.

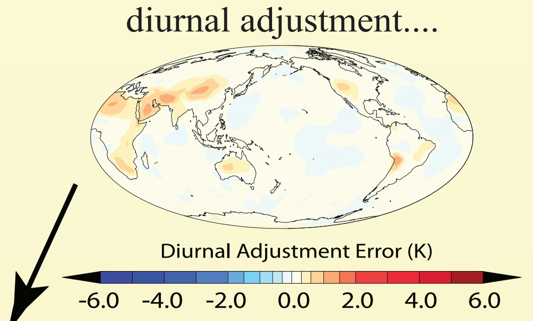


4. MONTE-CARLO APPROACH

Take a series of instances of the estimated sampling uncertainty.....



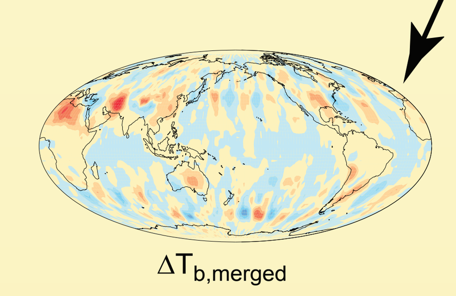
and an instance of the estimated uncertainty in each monthly diurnal adjustment....



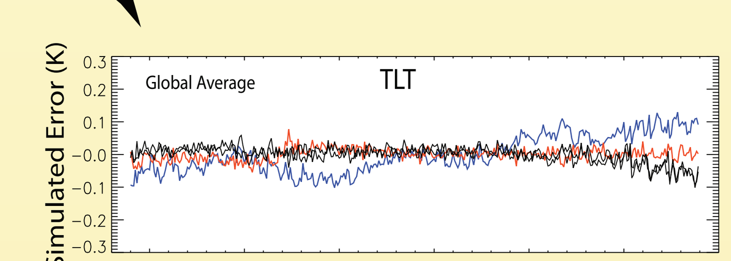
which are combined to make a combined error instance for each satellite and month

These are combined into a single dataset using the same merging system as the actual measurements. (See flowchart above)

To obtain an instance of the estimated error. Each instance is a gridded monthly dataset of the same size as the measured data



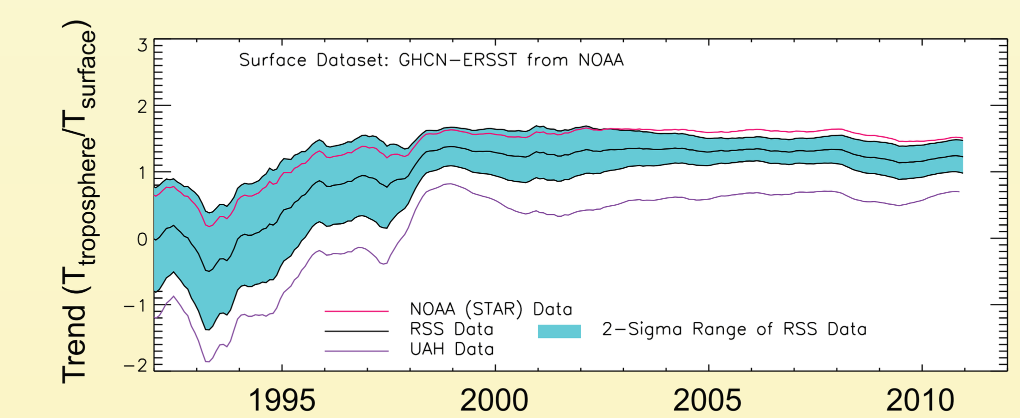
Map of an instance of simulated errors for a single month.



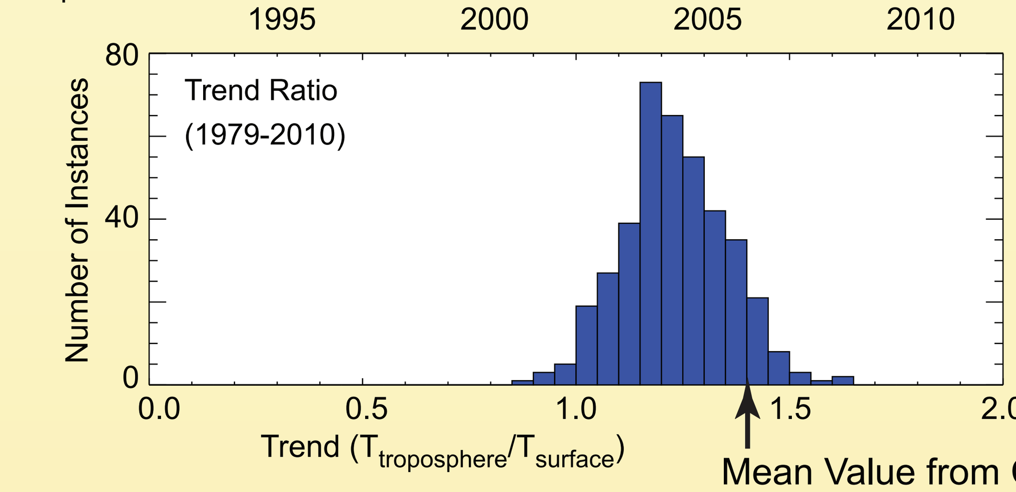
Time series of 3 instances of the globally averaged errors. 400 such instances were generated in total.

5. EXAMPLE OF USE

The degree of vertical amplification of long-term temperature trends in the tropics has been controversial over the past decade. Here we plot the ratio between trends in the tropical troposphere (1.1*TMT - 0.1*TLS as defined by Fu and Johansen 2005), and the surface for 3 different satellite datasets. For RSS, we show the 2-σ error range from our uncertainty analysis. (We assume **NO** error in the surface data-set, so the true error range is likely to be larger). Each trend calculation begins in January 1979, and ends at the time on the x-axis.



The results indicate that ~20 years of data are needed for the trend ratio to achieve a stable value. For time shorter than this, interannual variability dominates the trends.



When uncertainty in the measurements if taken into account, the mean trend ratio from GCMs is within the distribution of possible observed trends.

6. THE CHALLENGE

The single greatest challenge for anyone whole performs an uncertainty analysis is to convince users of the underlying dataset **to also use the uncertainty estimates**.

This is understandable (if not excusable) because.....

Including uncertainty is likely to greatly increase both the intellectual and computational work needed.

So it is important to present the uncertainty in a format that is as easy to use as possible.

The Monte-Carlo approach results in multiple realizations of each dataset. All the user needs to do is to re-run their analysis for each realization. This increases the computational work done by **the computer**, but is a relatively small increase in the intellectual and computational work performed by **the researcher**. We hope this facilitates the use of the uncertainty information.

400 instances of Global and Tropical time series for TLT and TMT are available on our website.

http://www.remss.com/data/msu/data/uncertainty/

Versions for TTS and TLS will follow soon.

The entire gridded uncertainty dataset is available upon request from Remote Sensing Systems.

PLEASE, IF YOU USE OUR MSU/AMSU DATA, USE OUR UNCERTAINTY ESTIMATES TOO!

References

Q. Fu and C. M. Johanson, "Satellite-derived vertical dependence of tropospheric temperature trends," Geophysical Research Letters, vol. 32, 2005.

Mears, CA, FJ Wentz, P Thorne and others, 2011, Assessing uncertainty in estimates of atmospheric temperature changes from MSU and AMSU using a Monte-Carlo estimation technique, Journal of Geophysical Research, 116, D08112, doi:10.1029/2010JD014954.