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Understanding the difference between the UAH and RSS retrievals of satellite-based tropospheric temperature estimate

Workshop on Reconciling Vertical Temperature Trends
NCDC, October 27-29, 2003

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I. Introduction & philosophy

II. Summary of our merging procedure

III. Compare with UAH Method

Introduction

- We have performed a second comprehensive analysis of the MSU Channel 2 dataset.
- Philosophy:
  - minimize subjective decisions.
  - use procedures suited for making accurate grid point maps.
  - minimize input from other sources
- Focus on differences between our analysis and that of and Christy and Spencer

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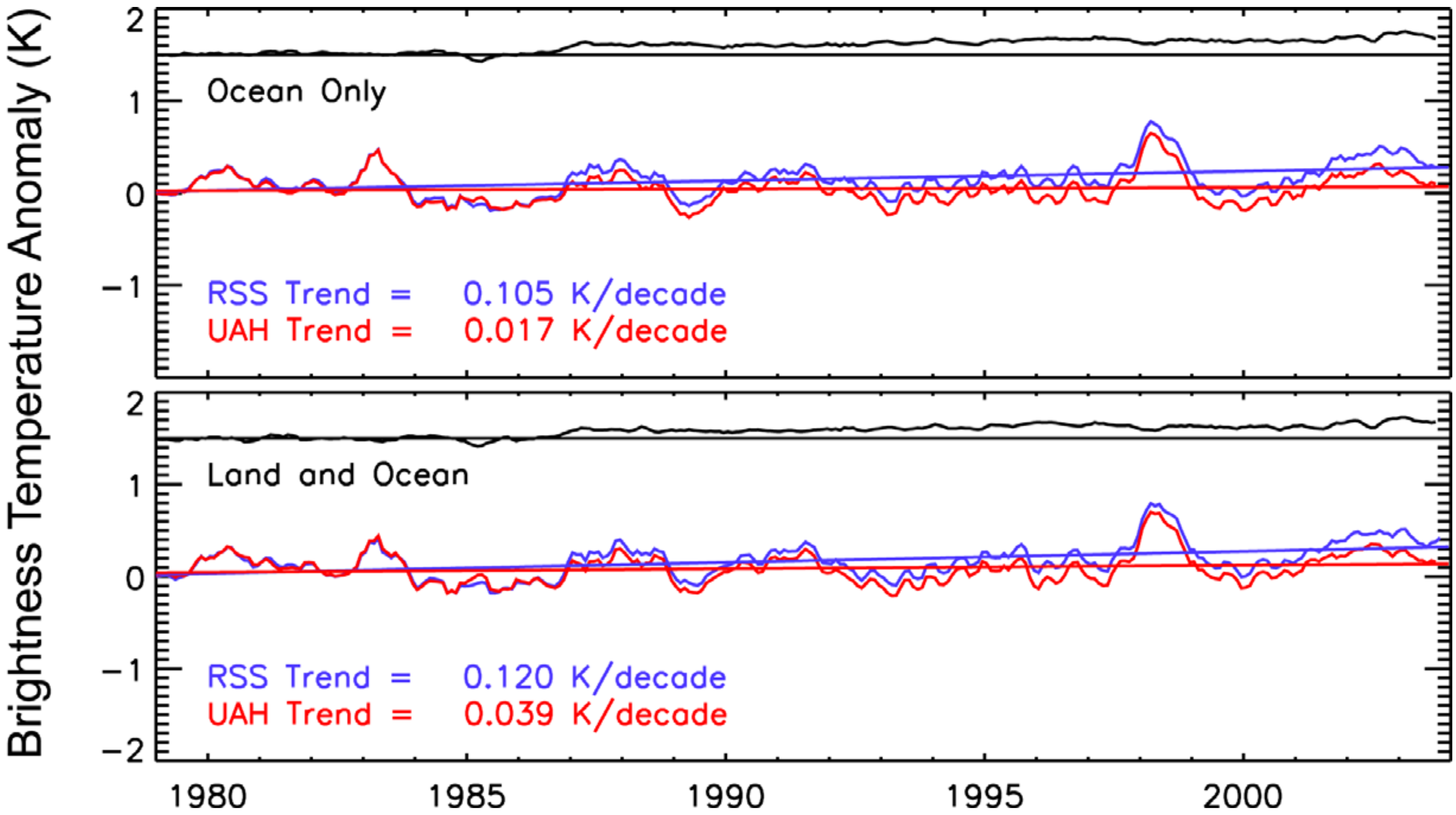
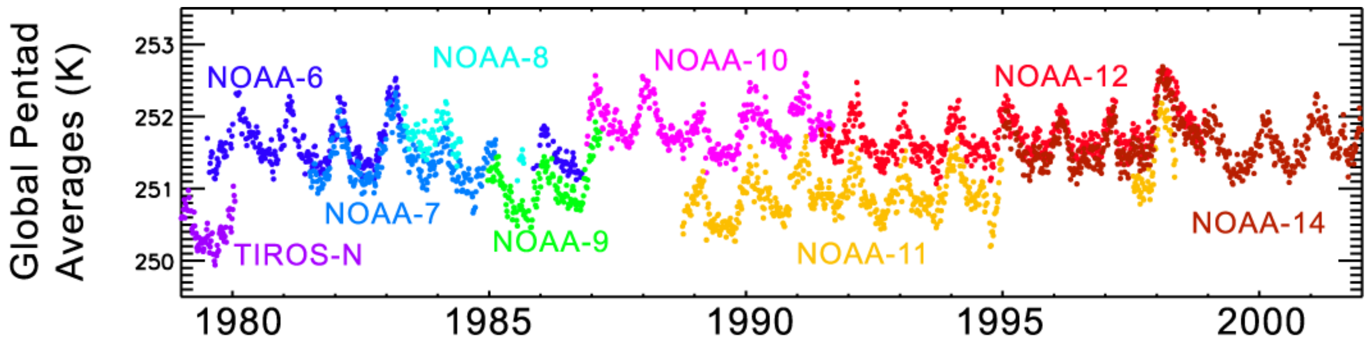
MSU Channel 2 Time Series Comparison
RSS vs. UAH



Computing Global Pentads

- Correct for Orbital Height, Instrument Roll and Diurnal Drift.
- 5-day averages (pentads) used to determine merging parameters
- Zonal averages for each FOV, node, and surface type using 5-degree zonal bands
- Global Pentads computed from zonal pentads weighted by Cosine(Latitude)
- Ocean global pentads computed from zonal ocean pentads using zonal ocean area weighting – Land pentads similar
- Pentad averages with less than 80% of the median number of observations were discarded
- Central 5 FOV’s averaged together

Ocean-Only Merging Procedure 1



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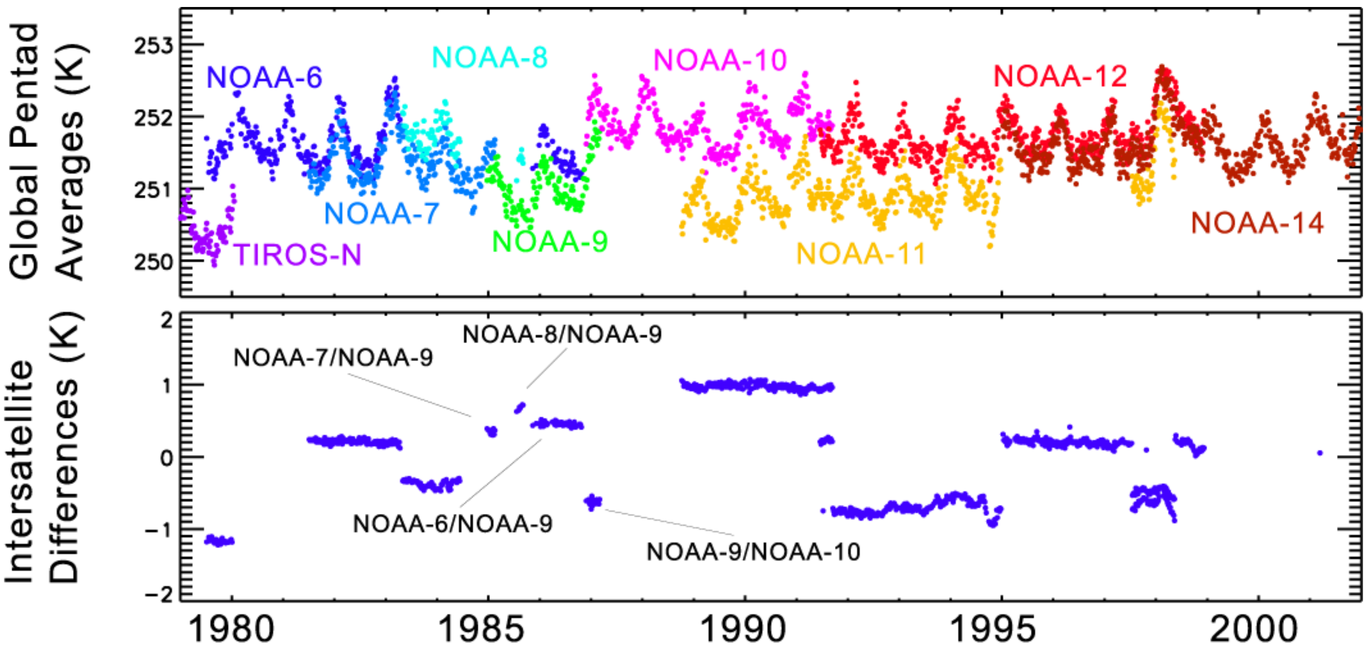
Ocean-Only Merging Procedure 2



Error Model and Pentad Difference Equations

Error model includes intersatellite offsets, plus a dependence on target temperature anomaly (Spencer and Christy, 2000)

$$T_{MEAS,i} = T_0 + A_i + \alpha_i T_{TARGET,i} + \varepsilon_i$$

For each pentad where 1 or more satellites have a good observation, we can from a difference equation for each satellite pair

$$T_{MEAS,i} - T_{MEAS,j} = A_i - A_j + \alpha_i T_{TARGET,i} - \alpha_j T_{TARGET,j} + \delta T$$

Typically ~1150 valid pentad pairs/equations

Solve equations to minimize $\Sigma \delta T^2$

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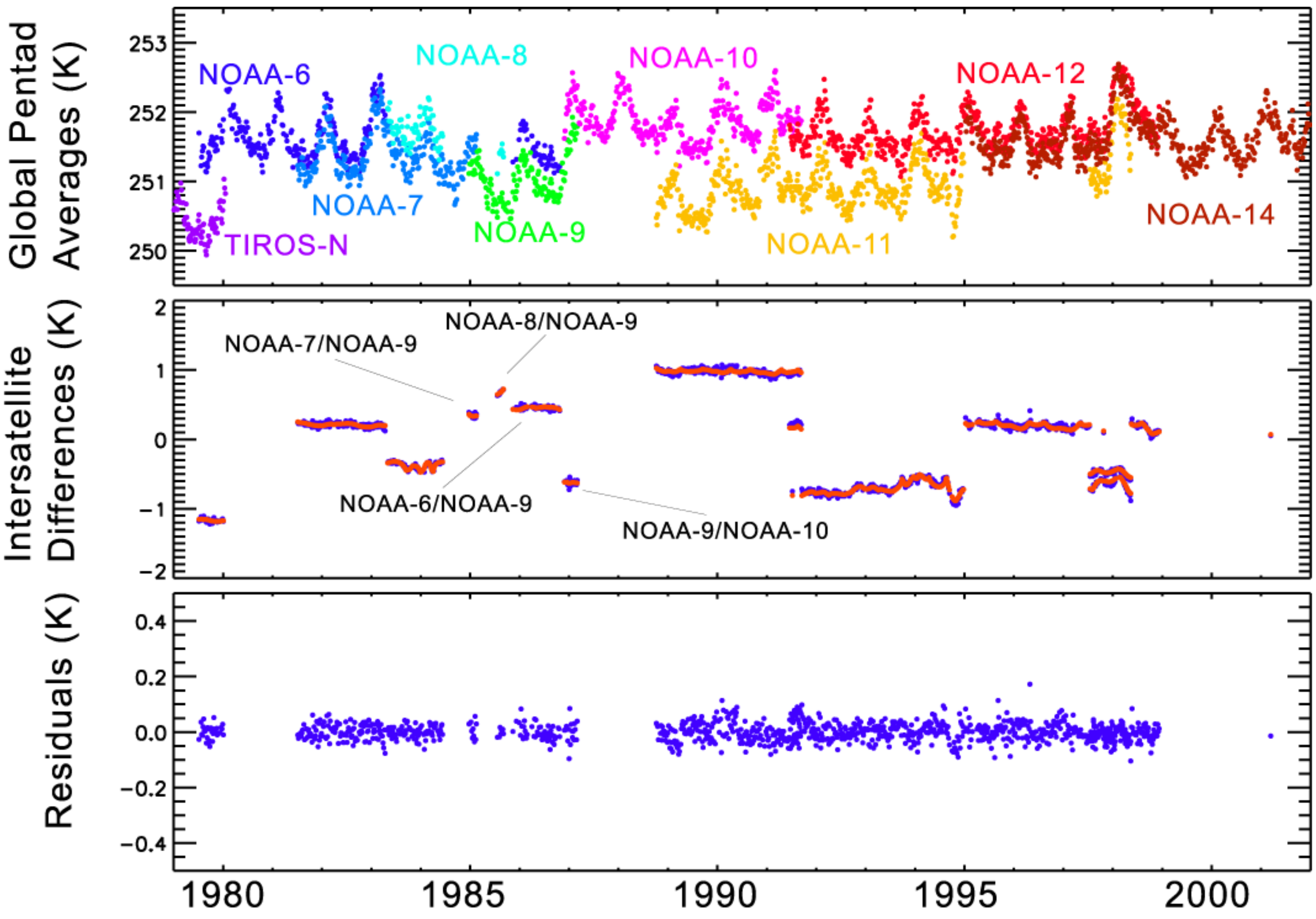
Ocean-Only Merging Procedure 3



Differences in Methodology: RSS vs. UAH

Possible causes of the different results

1. Diurnal Adjustment
2. Smoothing
3. Merging Methodology

   "Unified" vs. "Backbone"

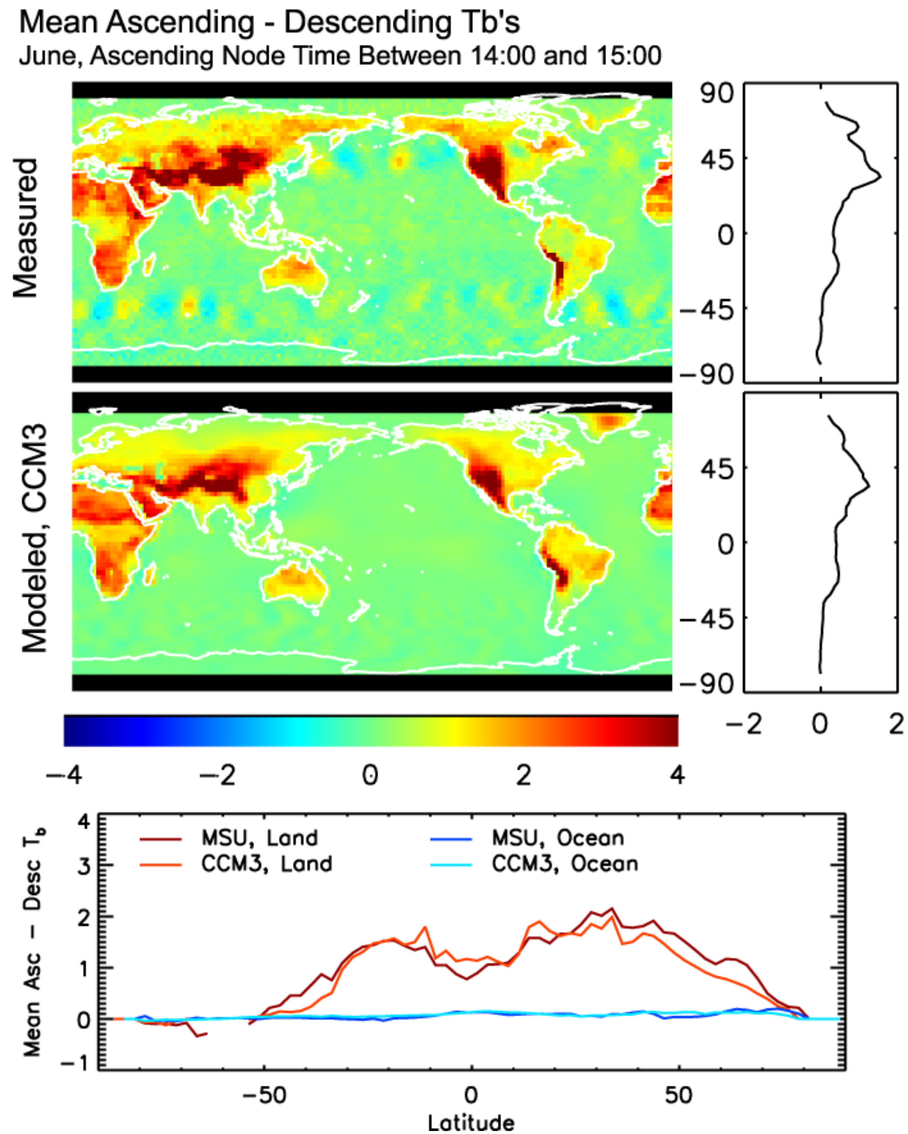
Diurnal Adjustment

LECT and therefore the local measurement time of each satellite drifts.

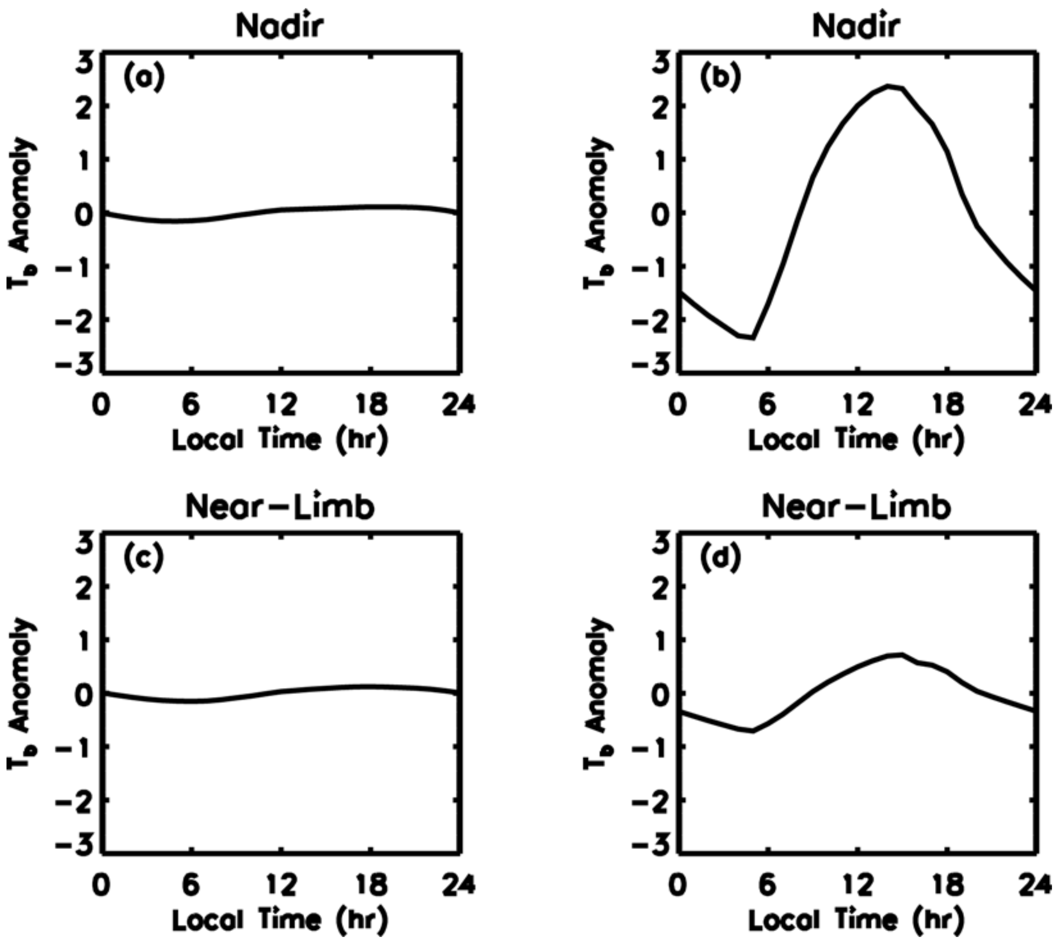
Aliases diurnal cycle into the long-term temperature record – must correct.

We model the T_b diurnal cycle using 5 years of hourly CCM3 model output (1980-1984) (Santer's Group) and our radiative transfer model.

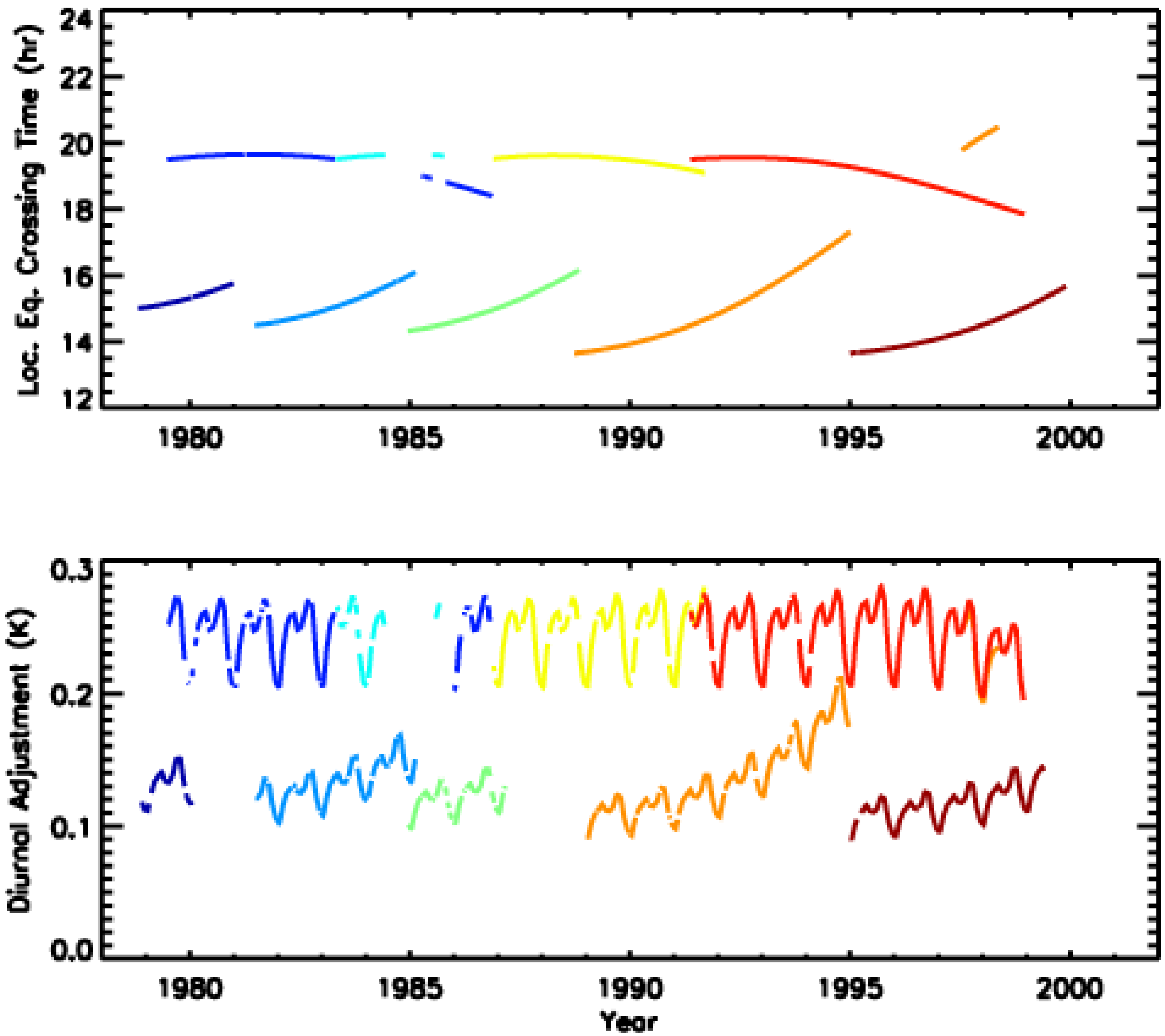
Validate modeled diurnal cycle vs. MSU measurements



CCM3-Derived Channel 2 T_b Diurnal Cycles



Diurnal Correction Applied to Correct to Local Noon



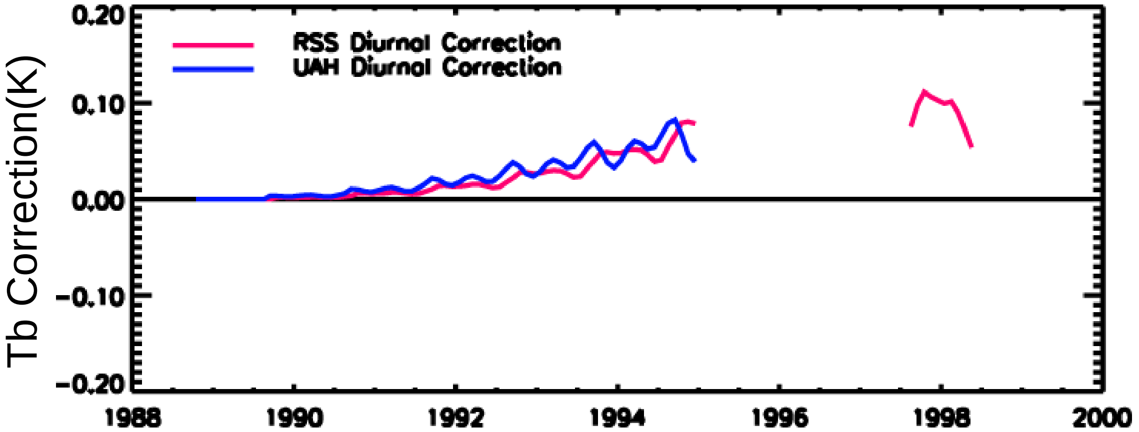
Diurnal Adjustment Comparison

RSS: Model-based

UAH: Derived from zonally-averaged cross-scan differences

Global corrections very similar

Correction applied to NOAA-11



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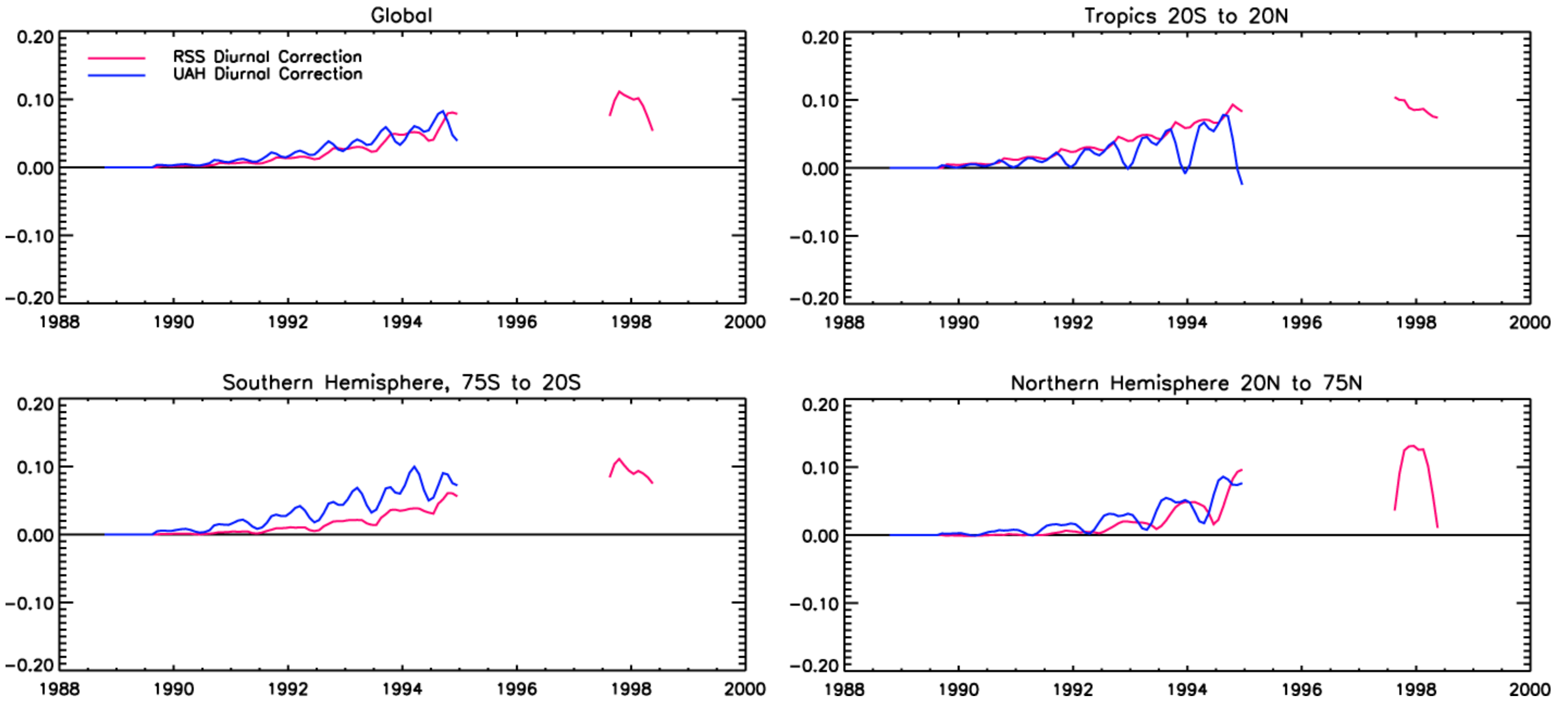
Comparison of Diurnal Cycles



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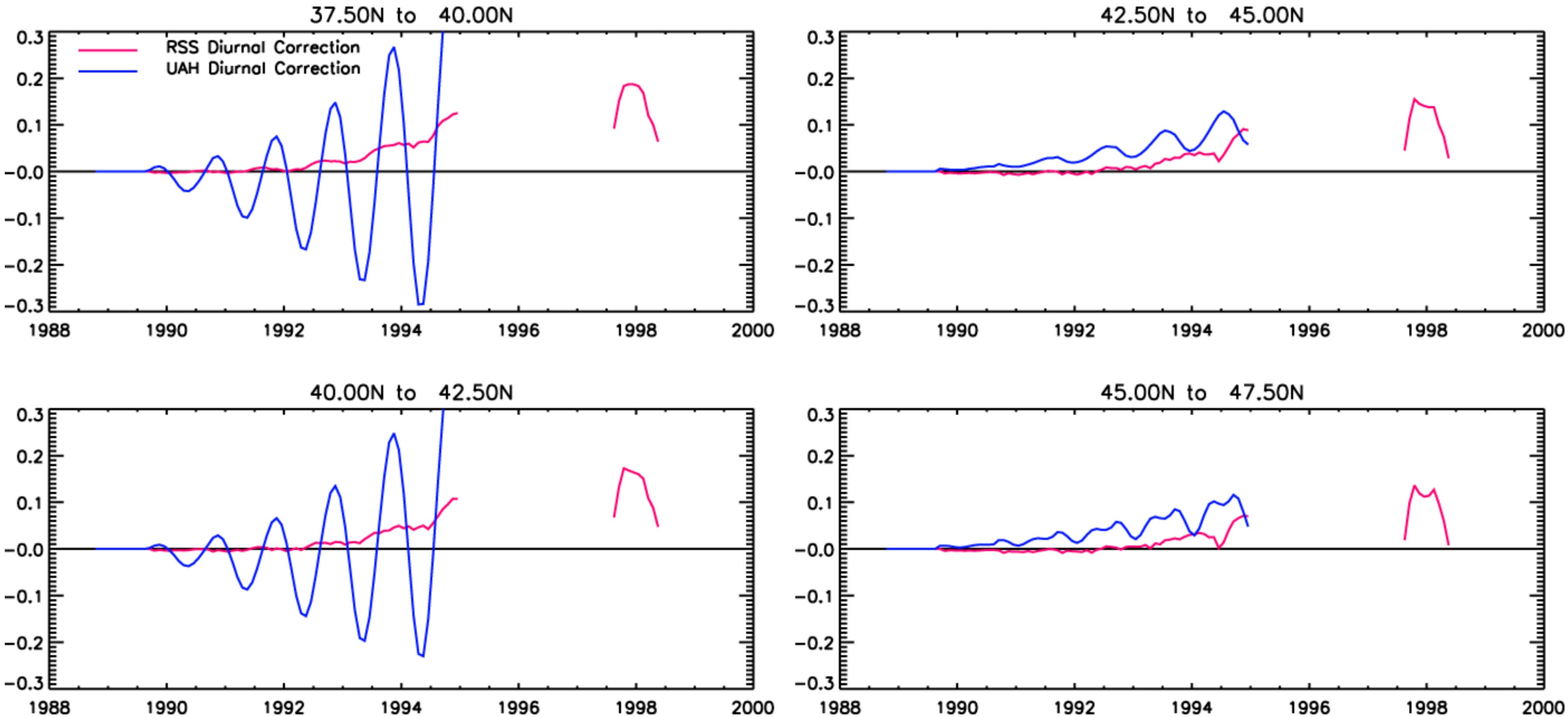
Comparison of Diurnal Cycles



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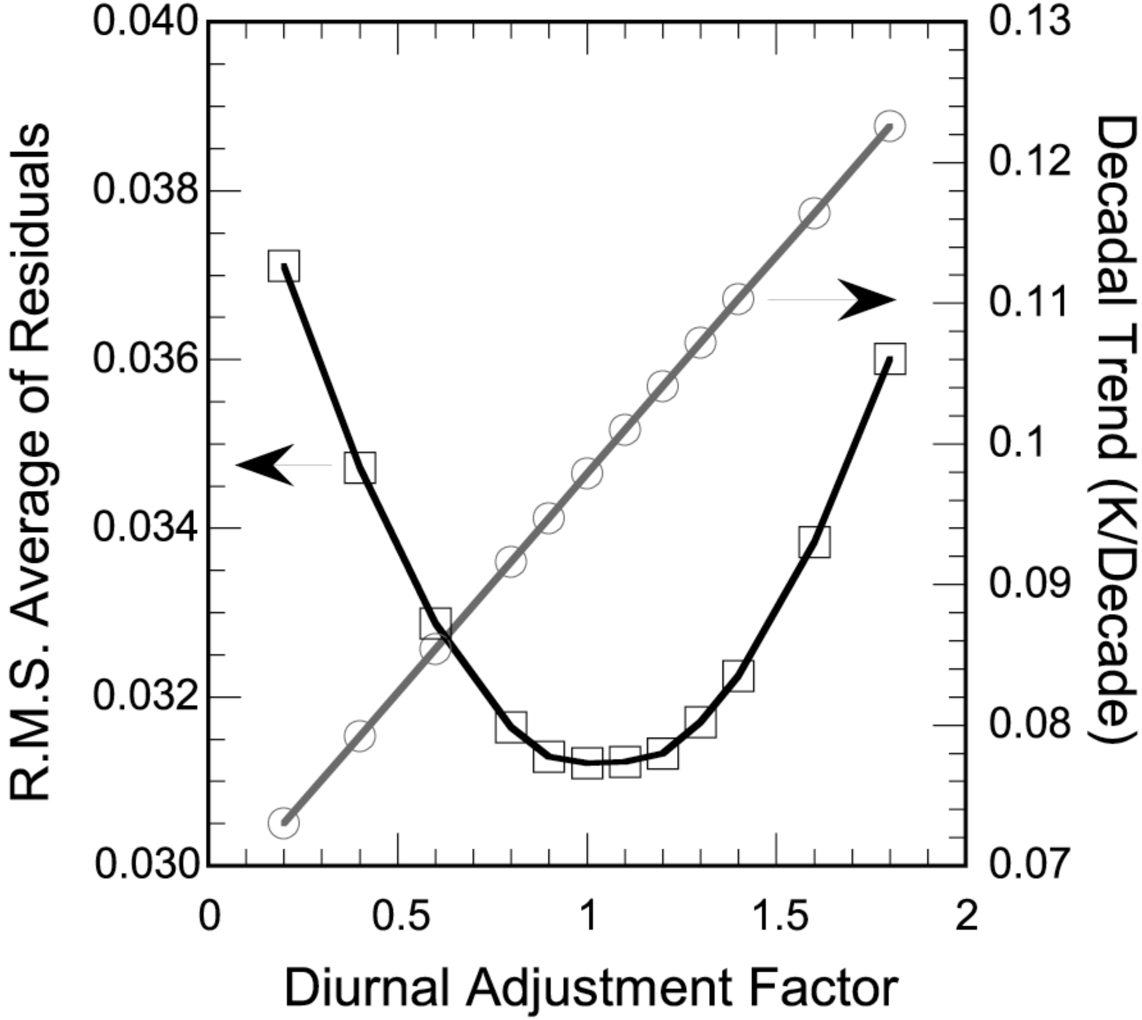
Diurnal Correction Factor Study

(land and ocean)



Differences in Methodology: RSS vs. UAH

Possible Contributors

1. Diurnal Adjustment
2. **Temporal Smoothing**
3. Merging Methodology

Unified vs. Backbone

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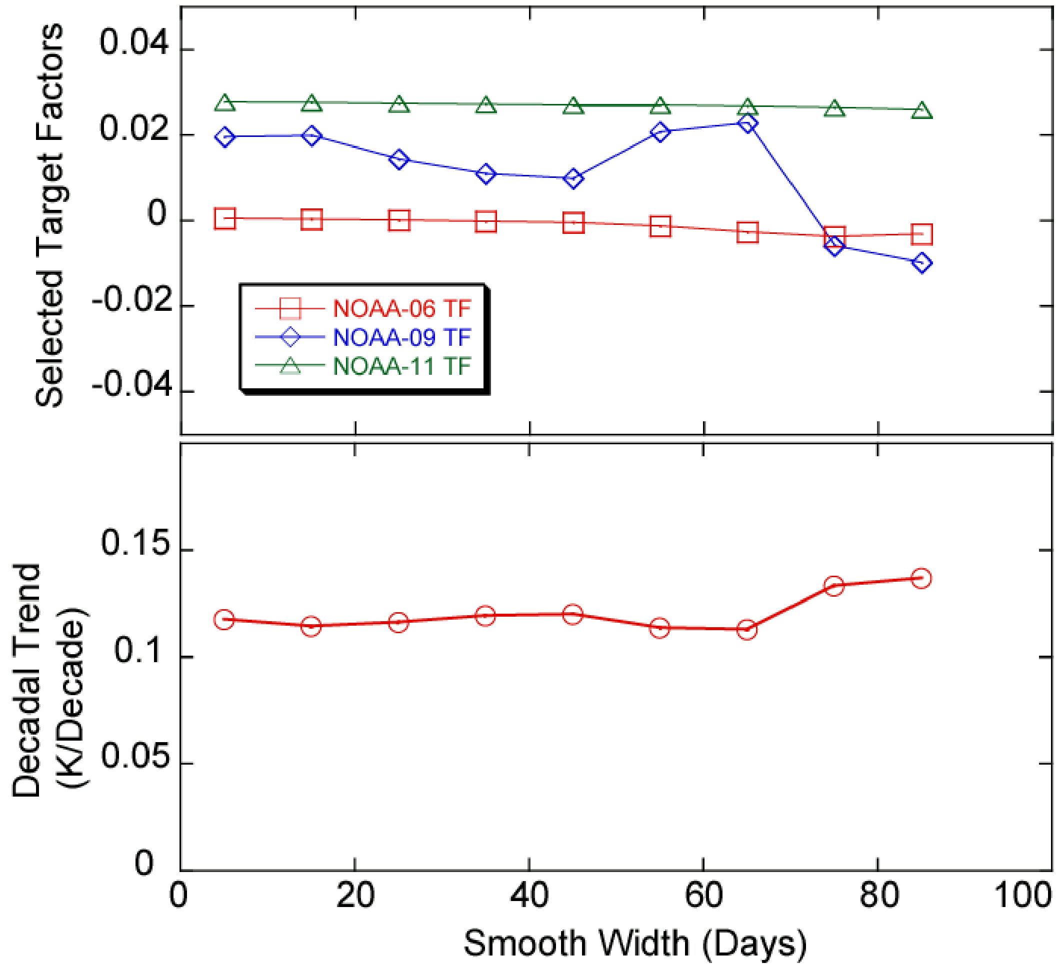
Effects of Smoothing

UAH does substantial pre-merge temporal smoothing (60-120 days)

Effect of Smoothing on RSS merge results



Differences in Methodology: RSS vs. UAH

Possible Contributors

1. Diurnal Adjustment
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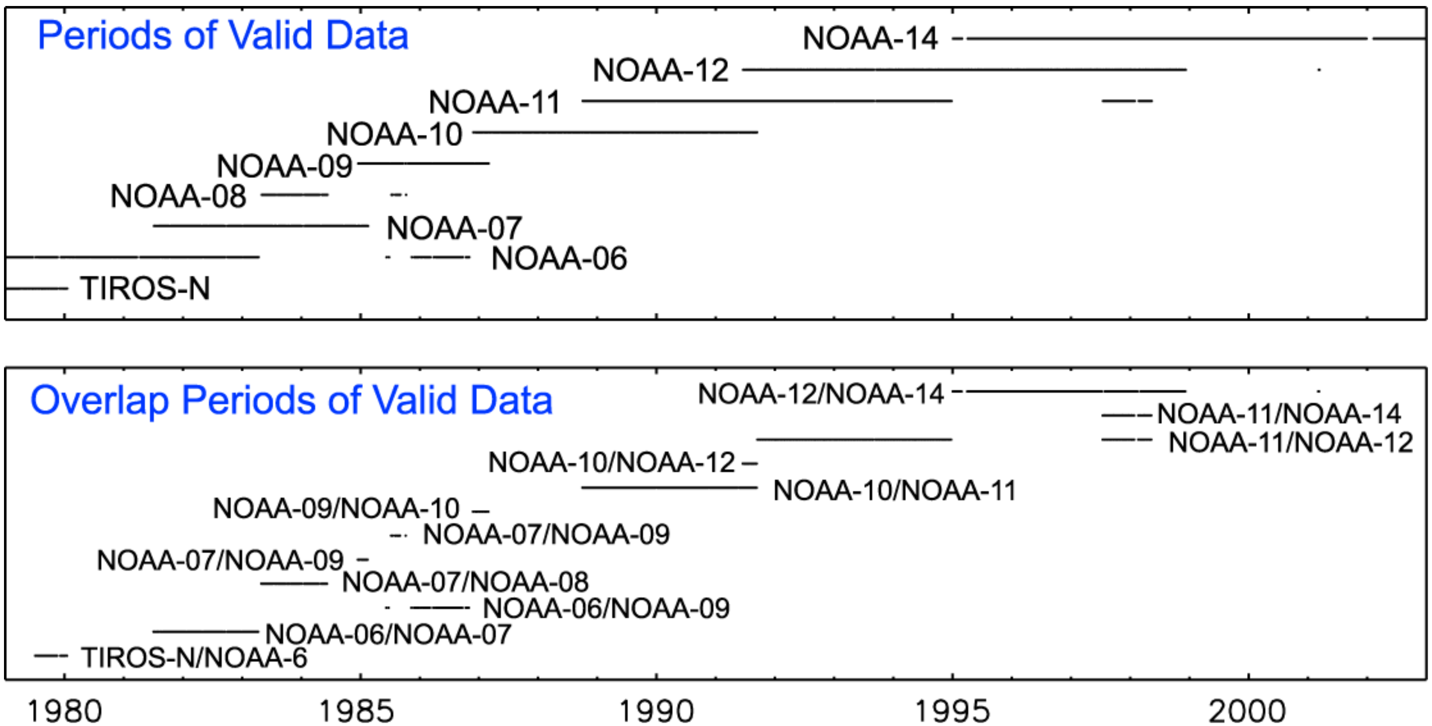
Unified vs. Backbone

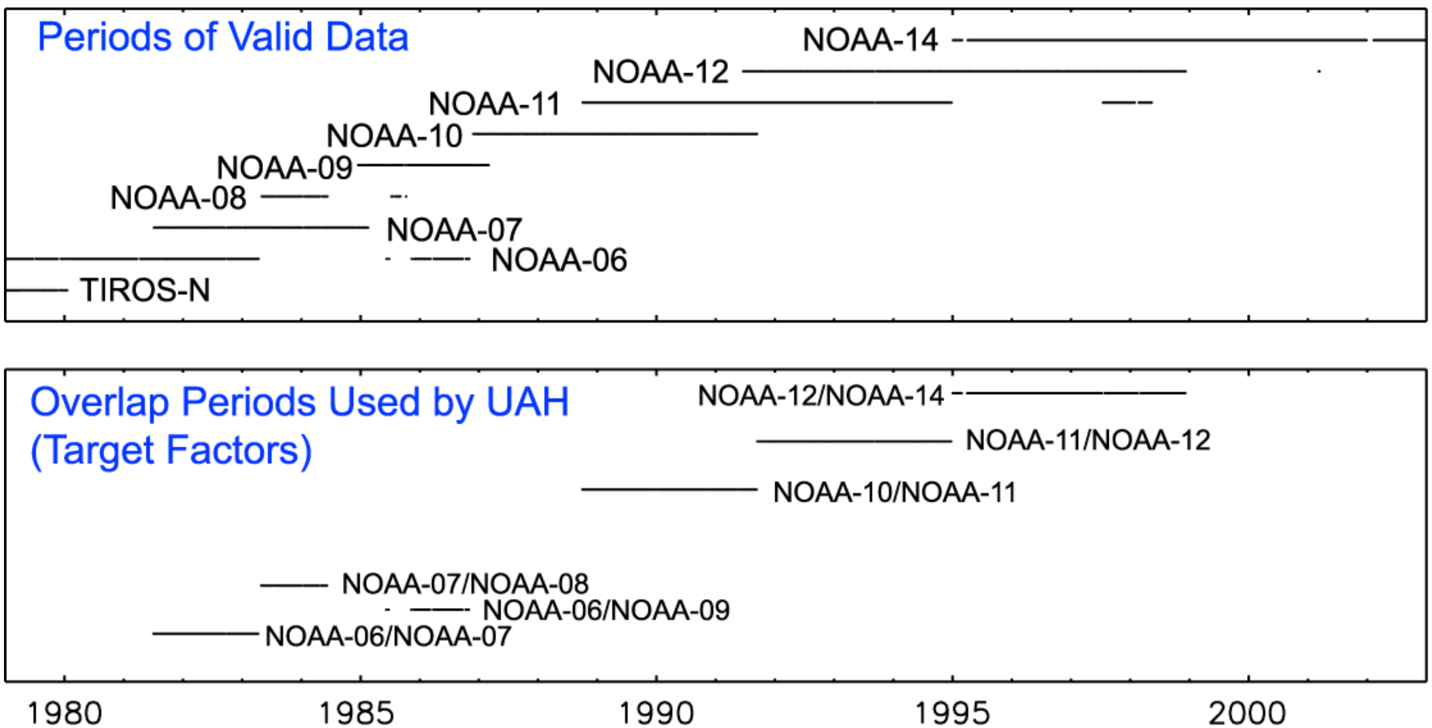
Merging Methodology: RSS

RSS uses all available pentad overlaps, equally weighted



Merging Methodology: UAH

UAH focuses on overlap pairs with long time periods to determine target factors



MSU Channel 2 Decadal Trend Comparison

Trends for 1979-2002

	Ocean Decadal Trend (K/decade)	NOAA-9 Target Factor
RSS	0.098	0.195
RSS Merge UAH TFs	0.054	0.950
RSS, 'UAH Backbone', UAH Diurnal	0.057	0.749
C & S (from monthly maps)	0.017	0.950

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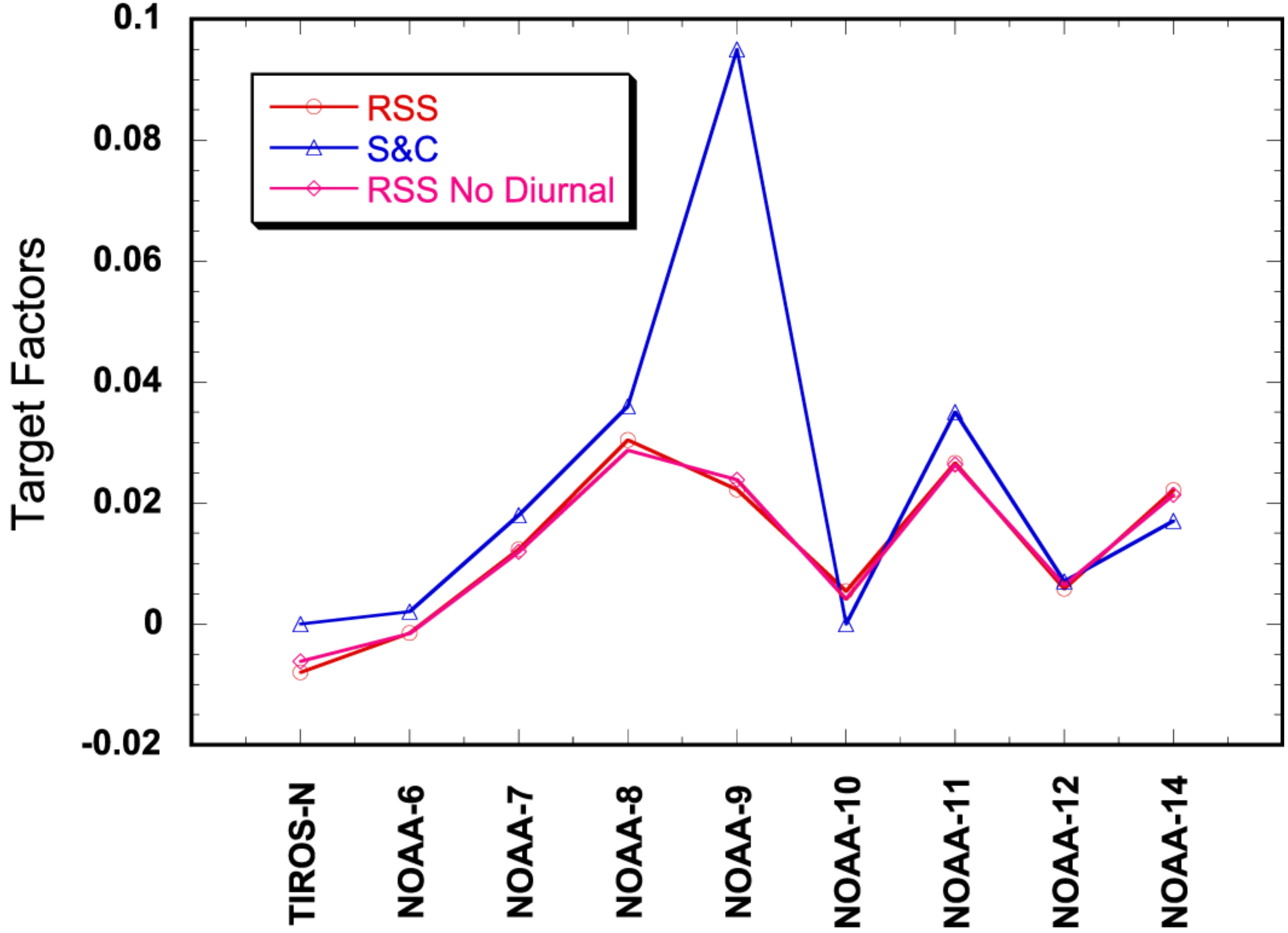
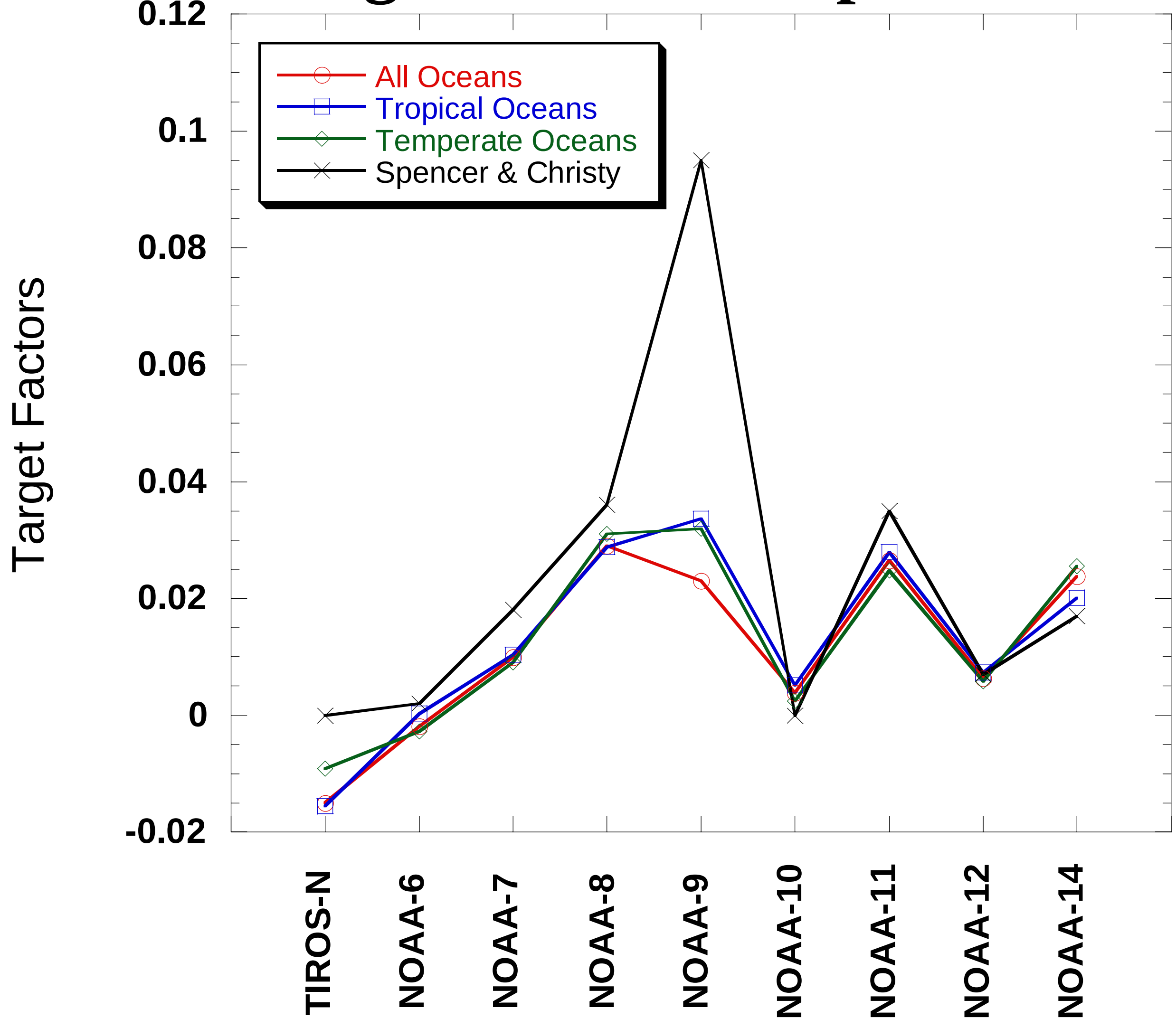
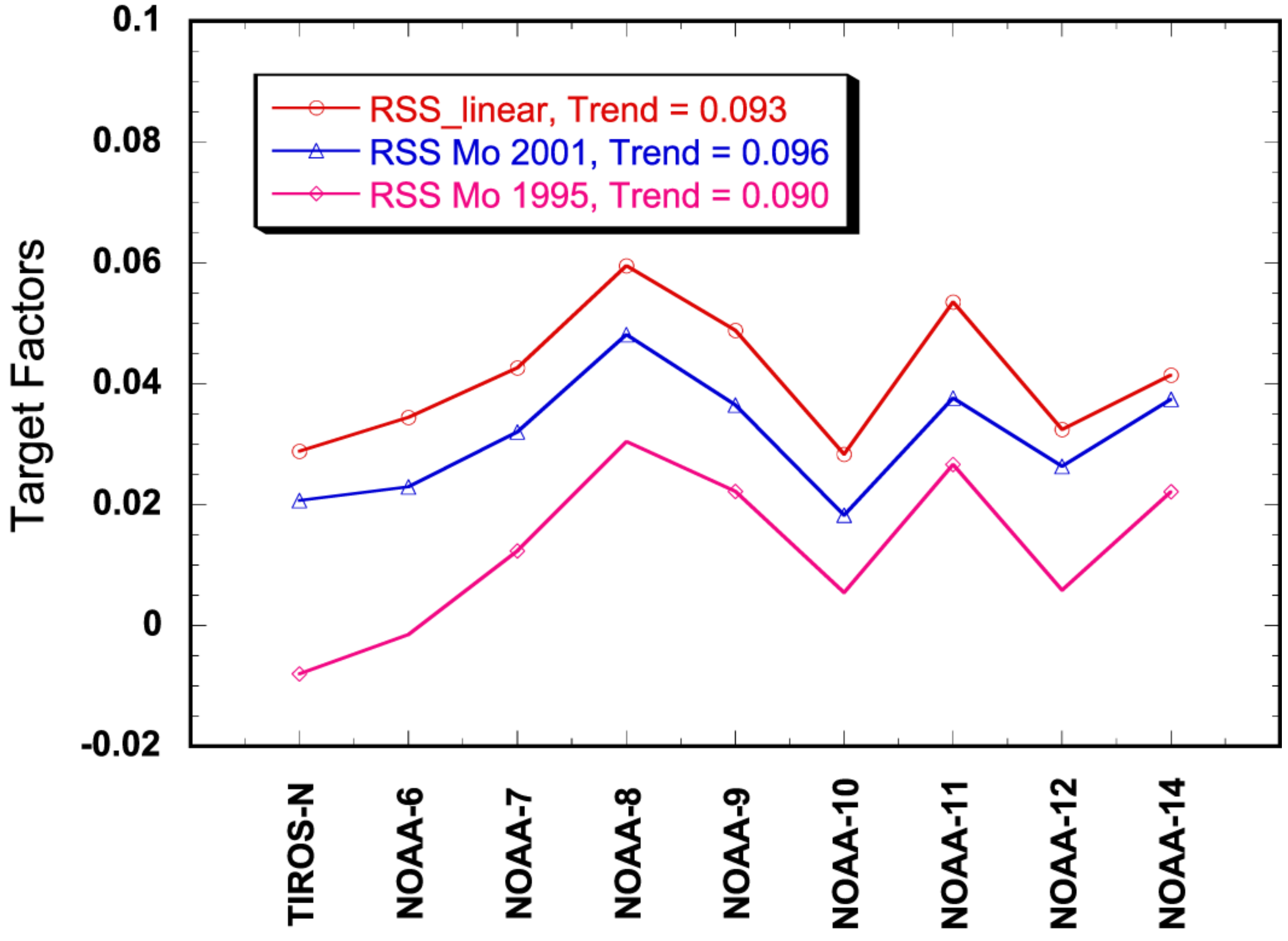
Comparison of Target Factors



Target Factor Comparison



Effect of Non-Linearity Correction



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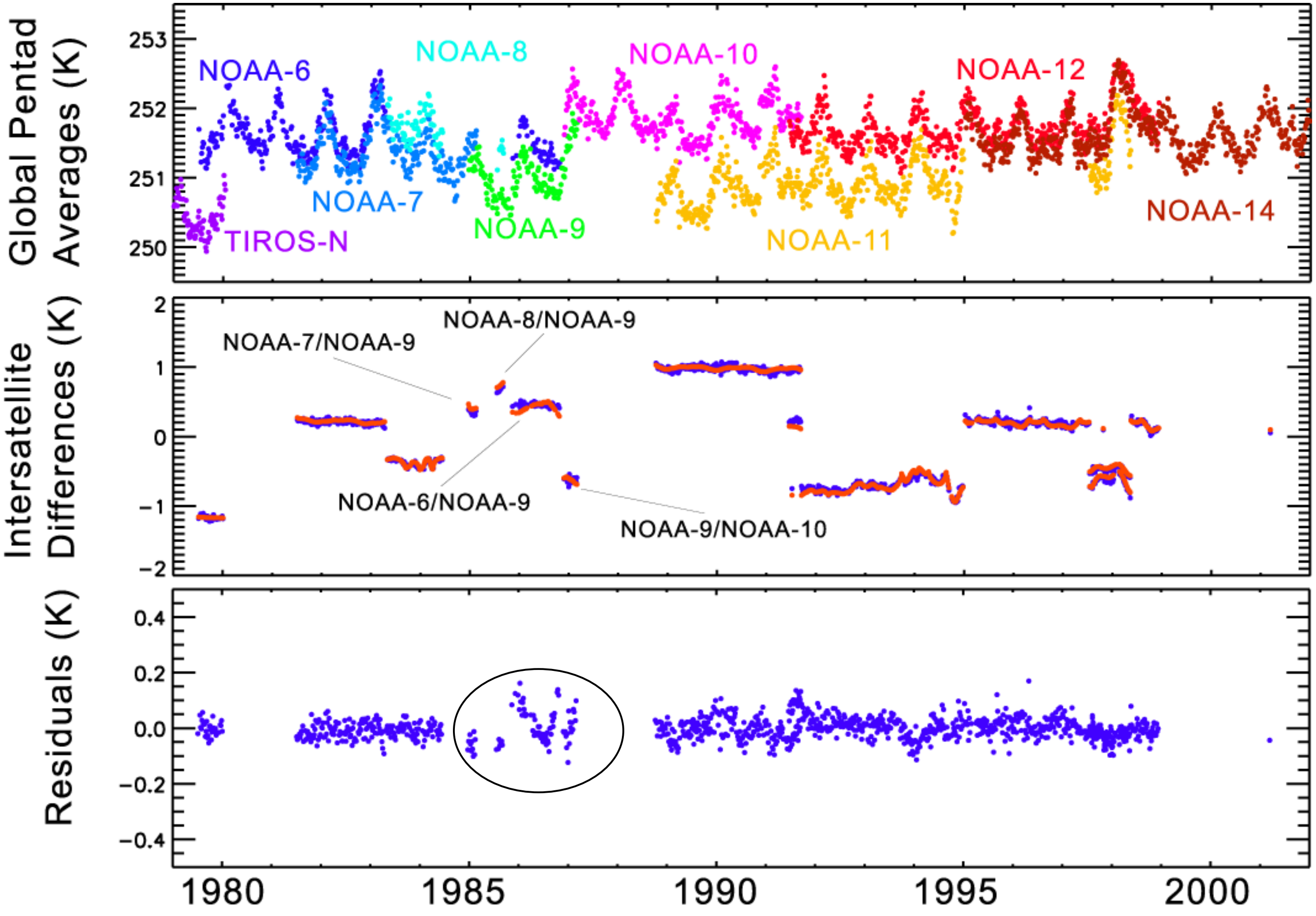
Ocean-Only Merge, S&C Target Factors



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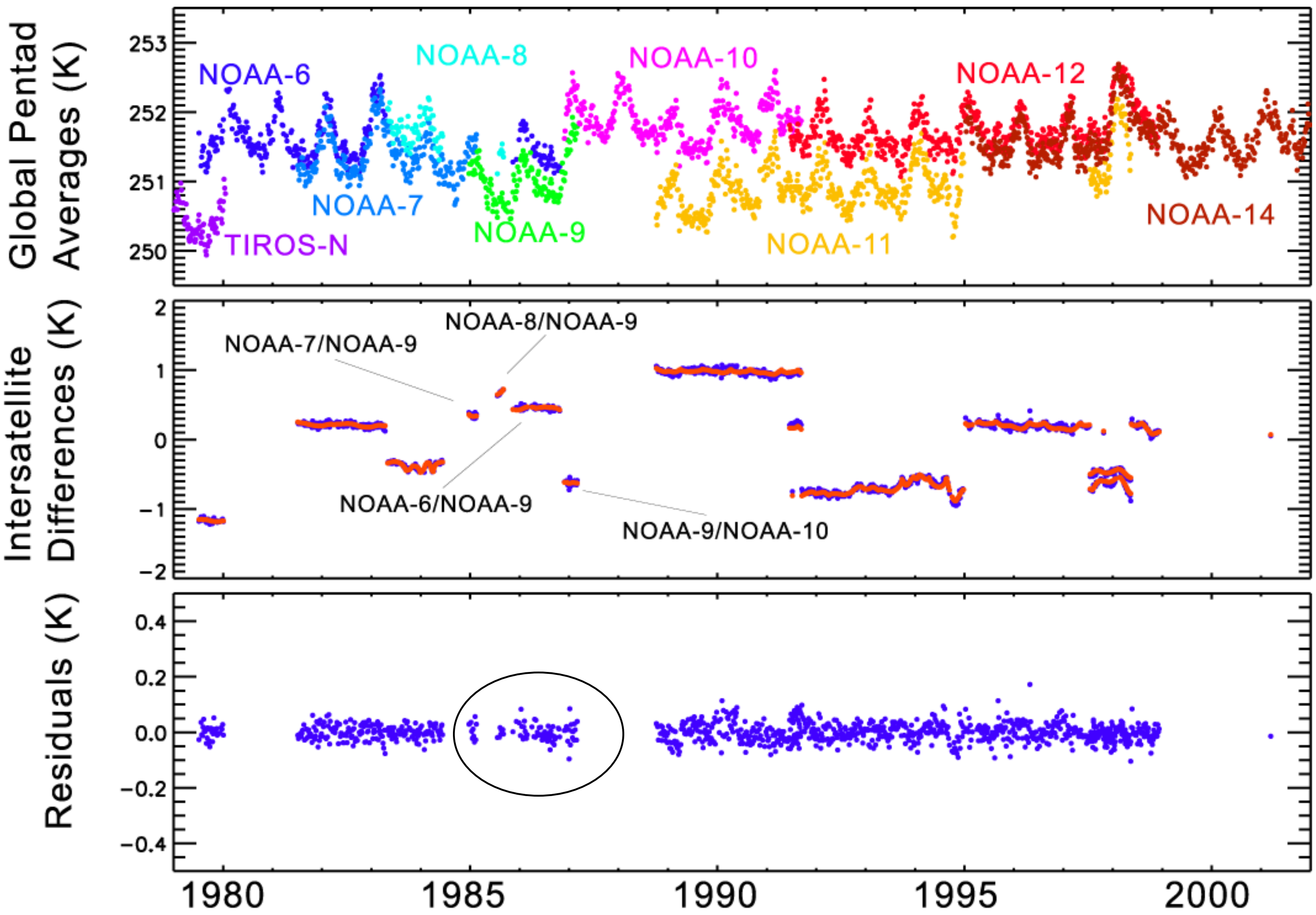
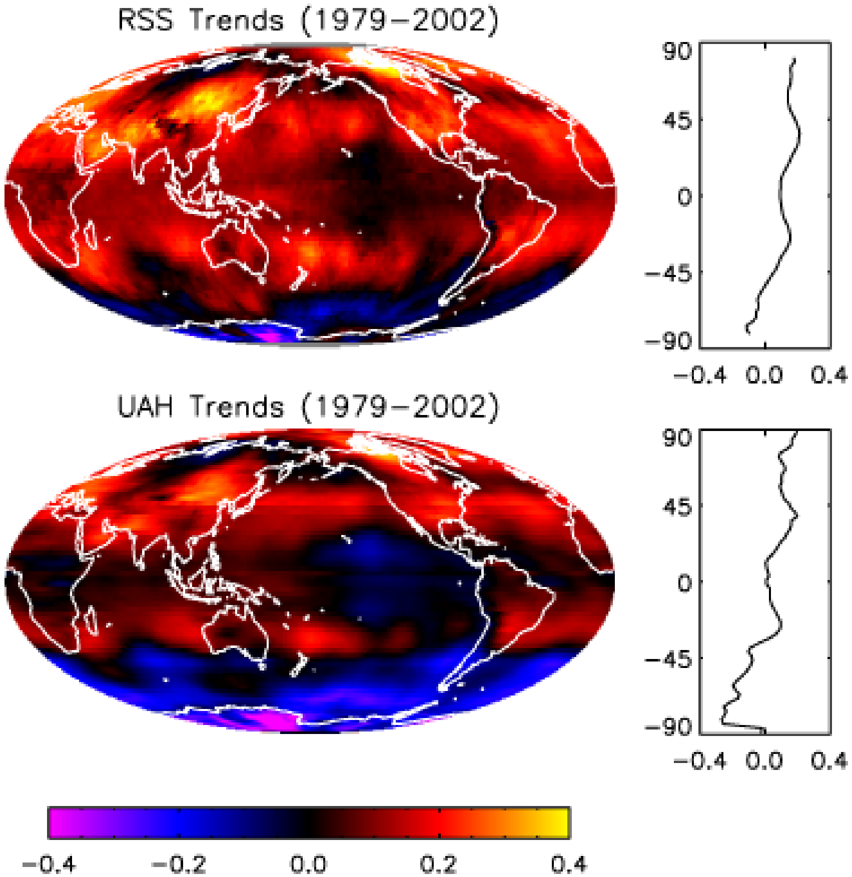
Ocean-Only Merge, RSS Target Factors

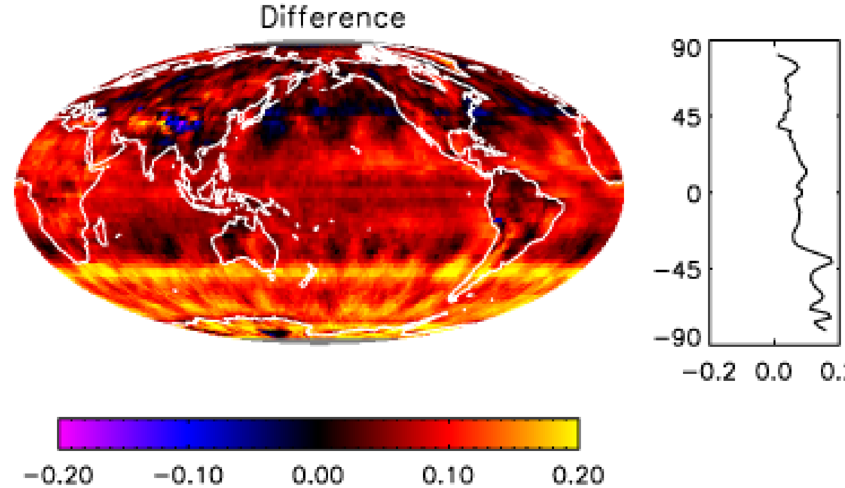


Decadal Trend Map Comparison



Similar Spatial Patterns

RSS trends almost always warmer



Summary

- MSU Trends are Critically Dependent on Merging Parameters
- Differences Between RSS and S&C Trends Mostly Explained by Difference in NOAA-9 Target Factor, which may be caused by differences in which overlaps are used to determine the Target Factors.

Sneak Preview: Channel 1 Ocean Only

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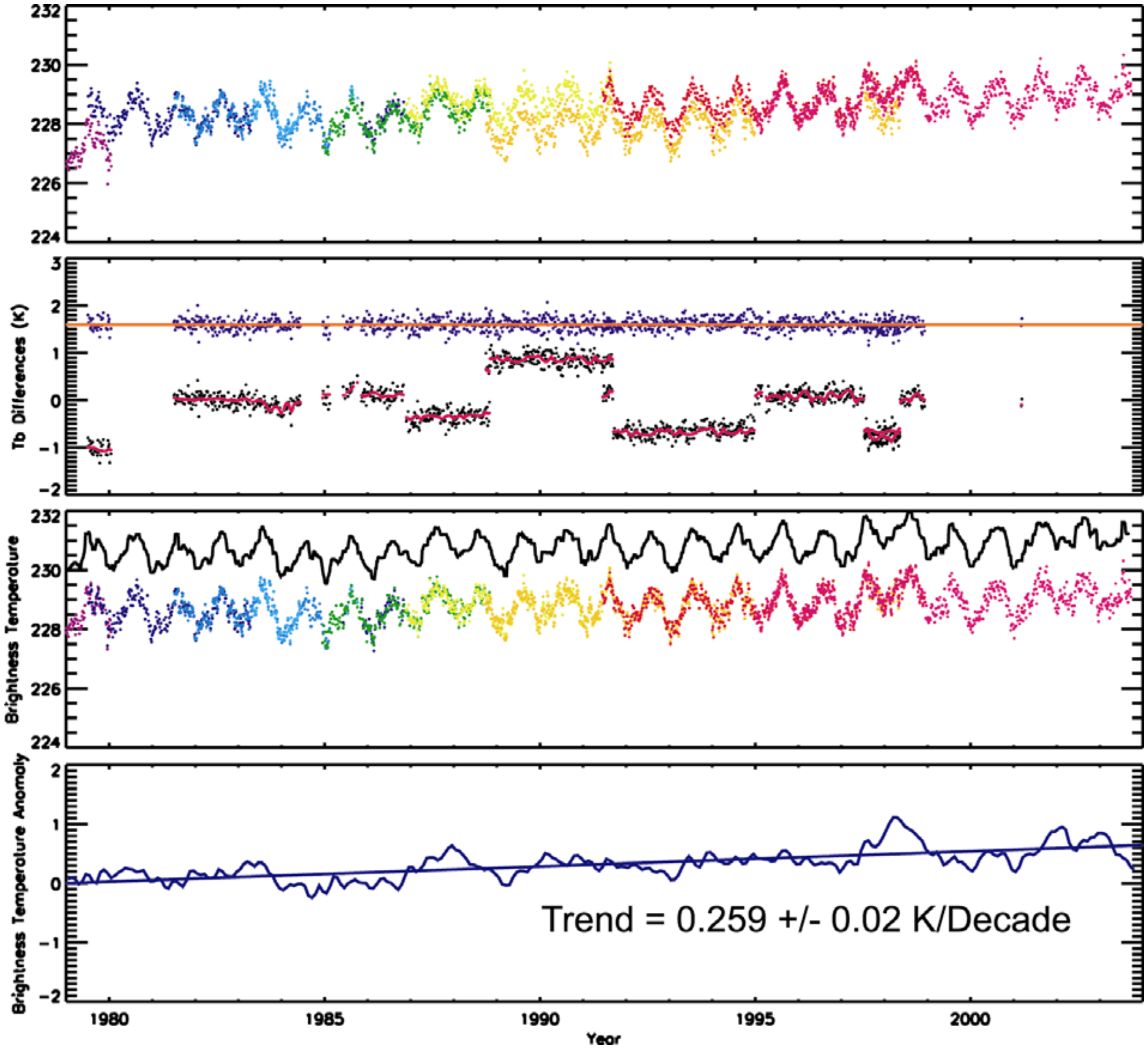
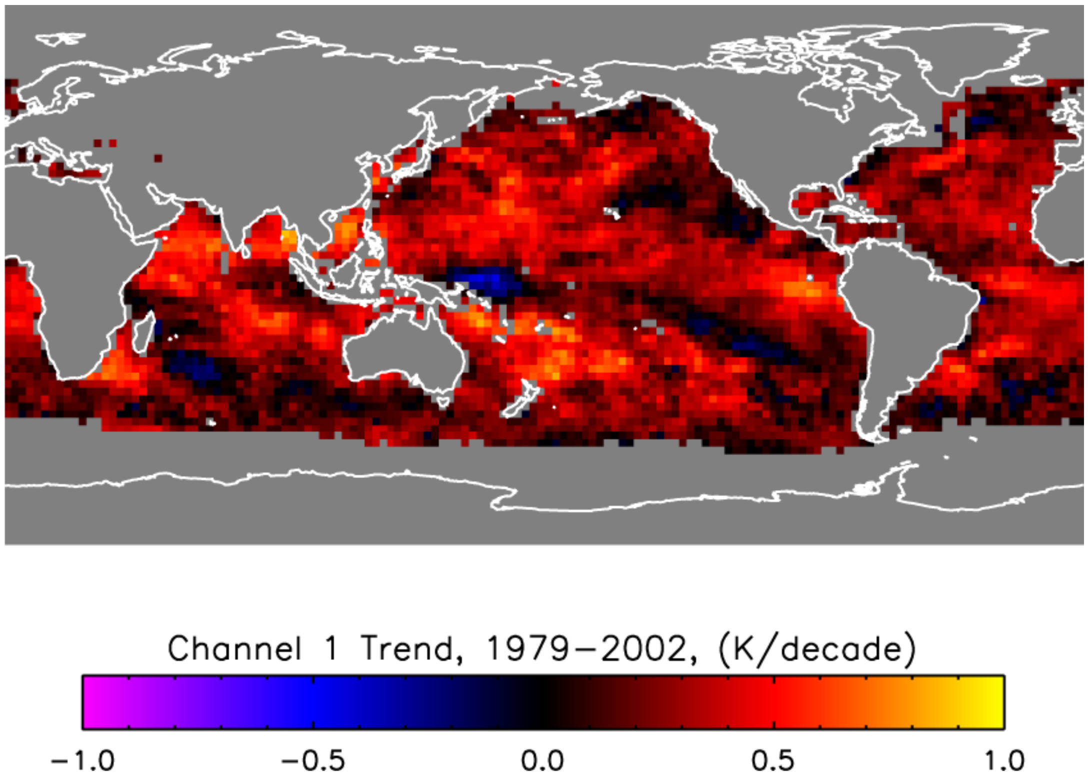
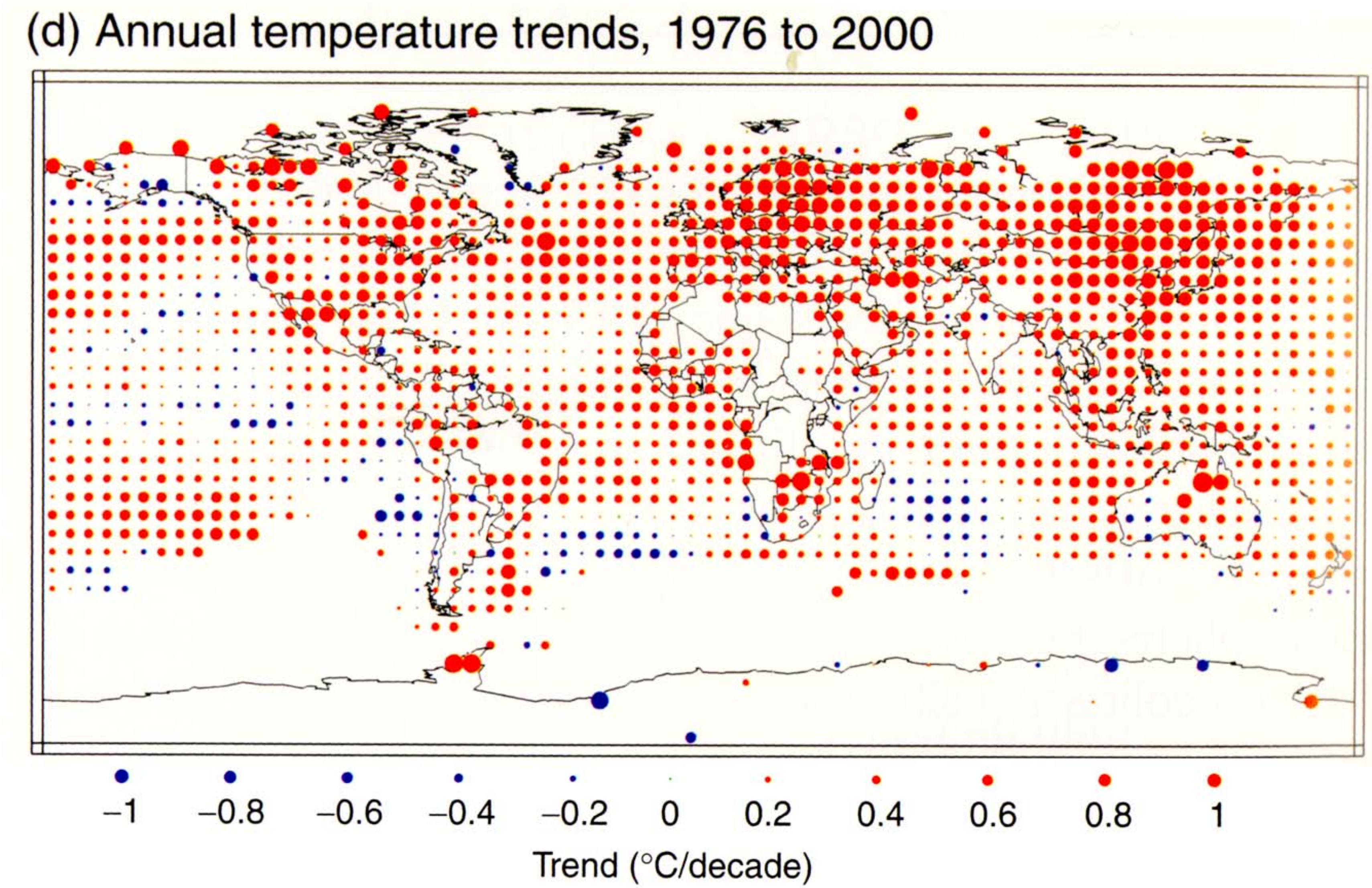


Sneak Preview: Channel 1 Trend Map



Surface Trends from the TAR



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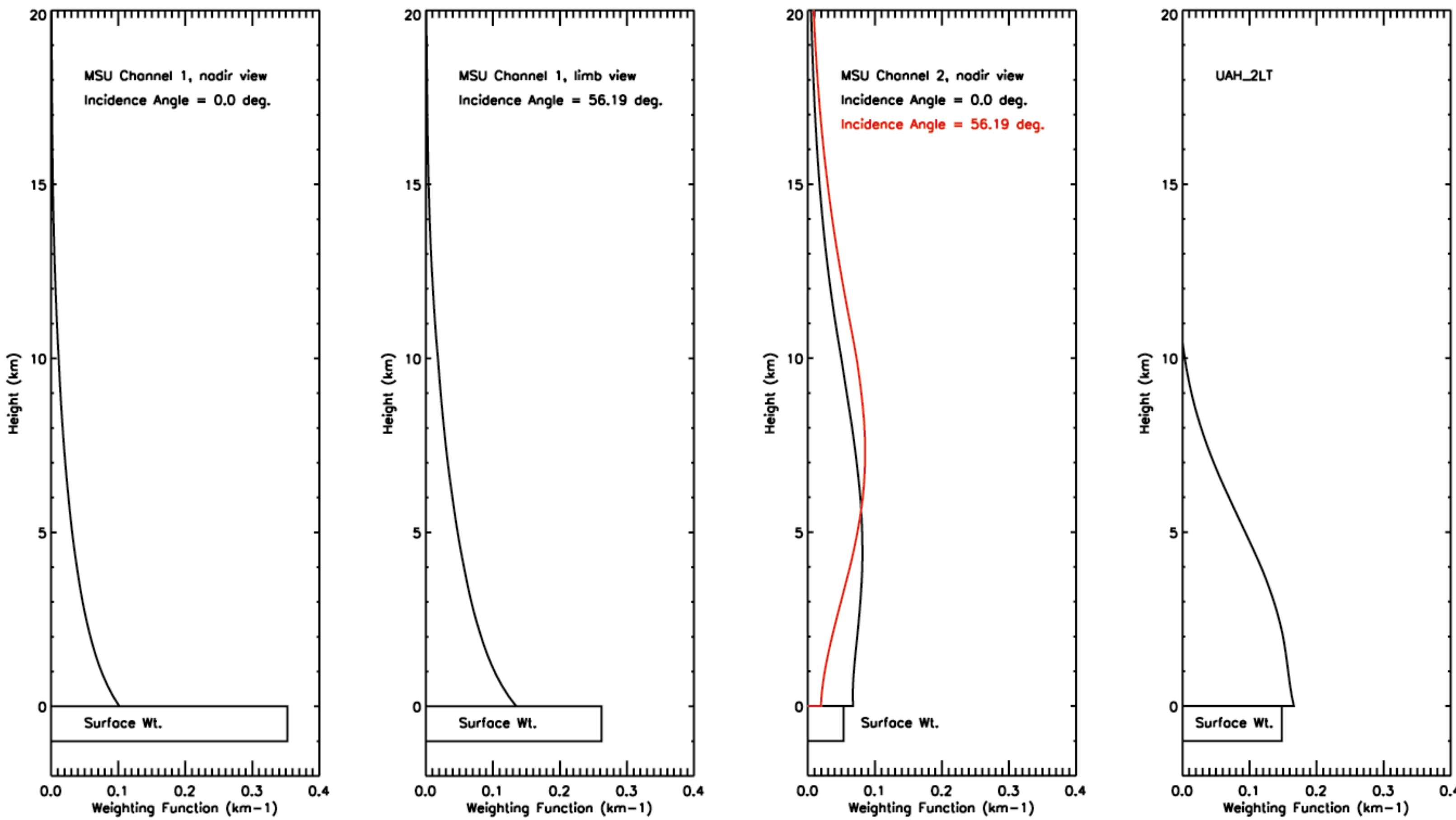
Weighting Functions (Ocean)



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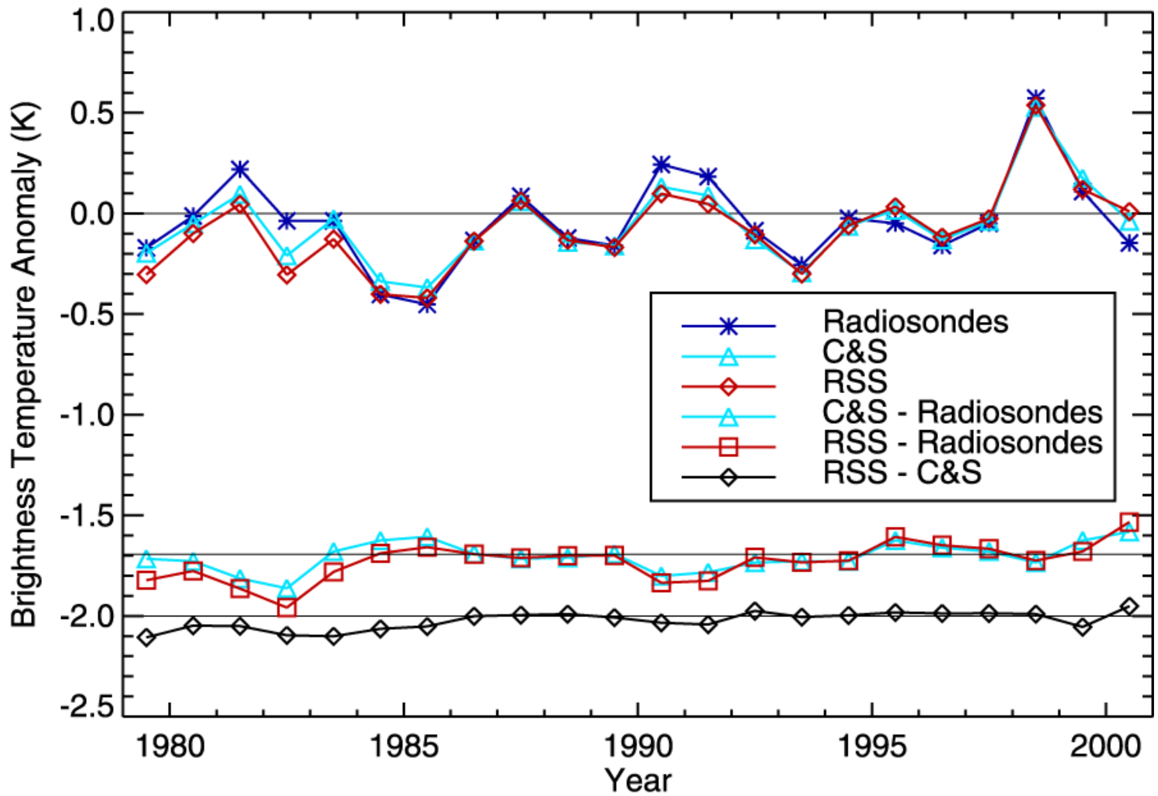
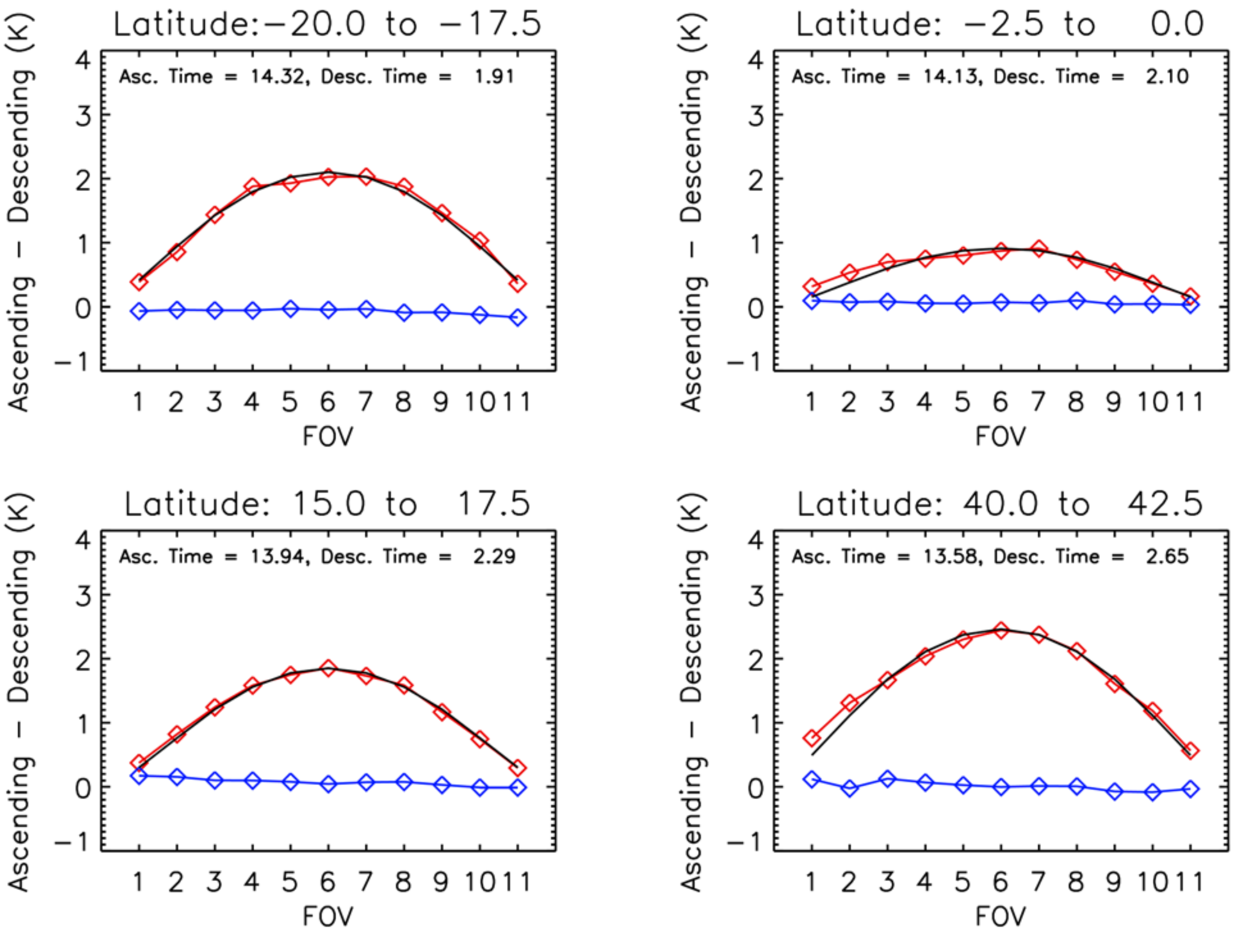
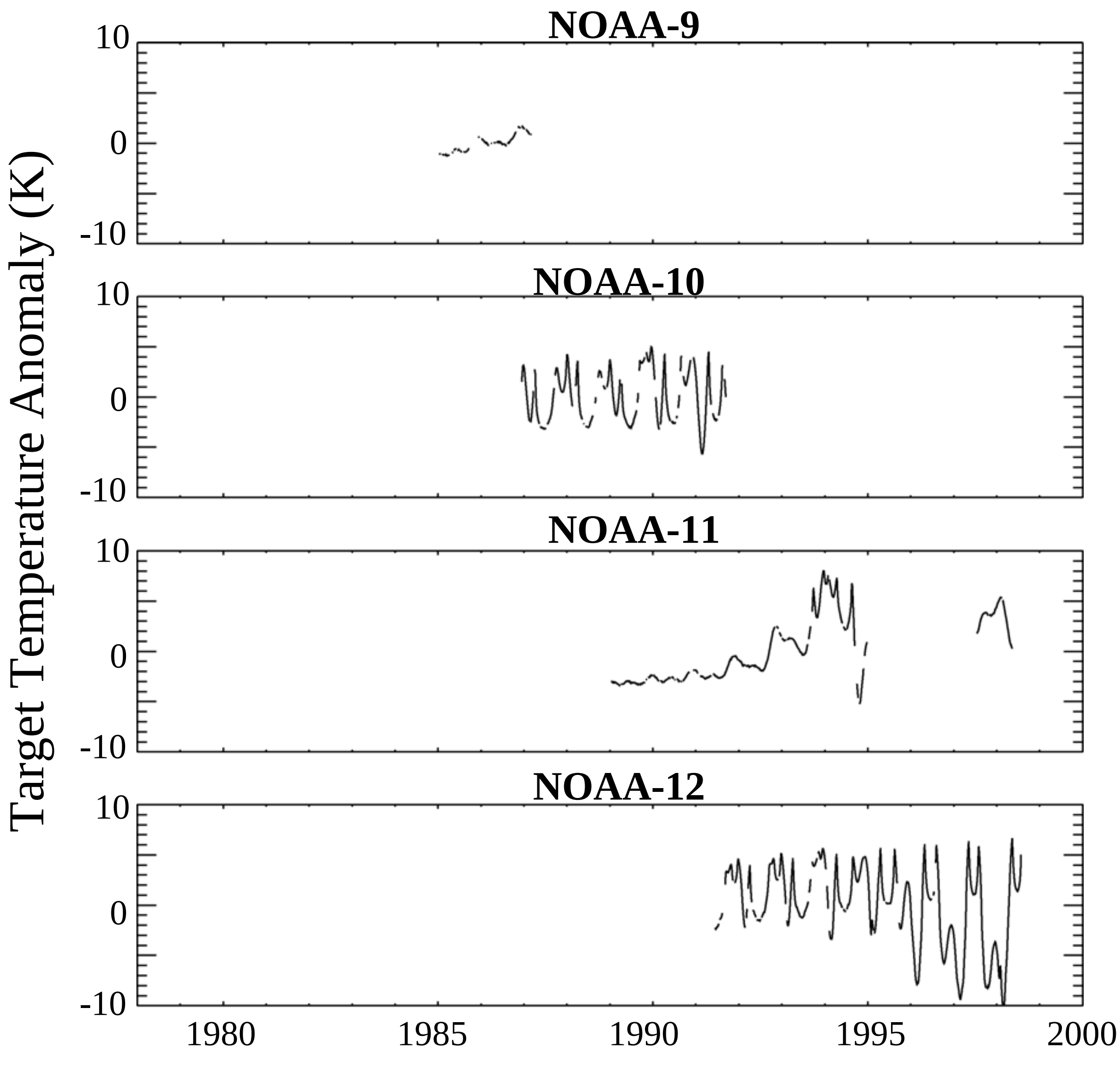
Radiosondes:
Compare with UAH’s Choosen 29 sites with Consistent Instrumentation



Most of the diurnal signal is from the surface…



Examples of Target Temperature Variation



Sensitivity Analysis: Monte Carlo Method

I. Perform Regression to obtain satellite-pair offsets and target multipliers

$$T_{MEAS,i} - T_{MEAS,j} = D_{ij} + \alpha_i T_{TARGET,i} - \alpha_j T_{TARGET,j} + \delta T$$

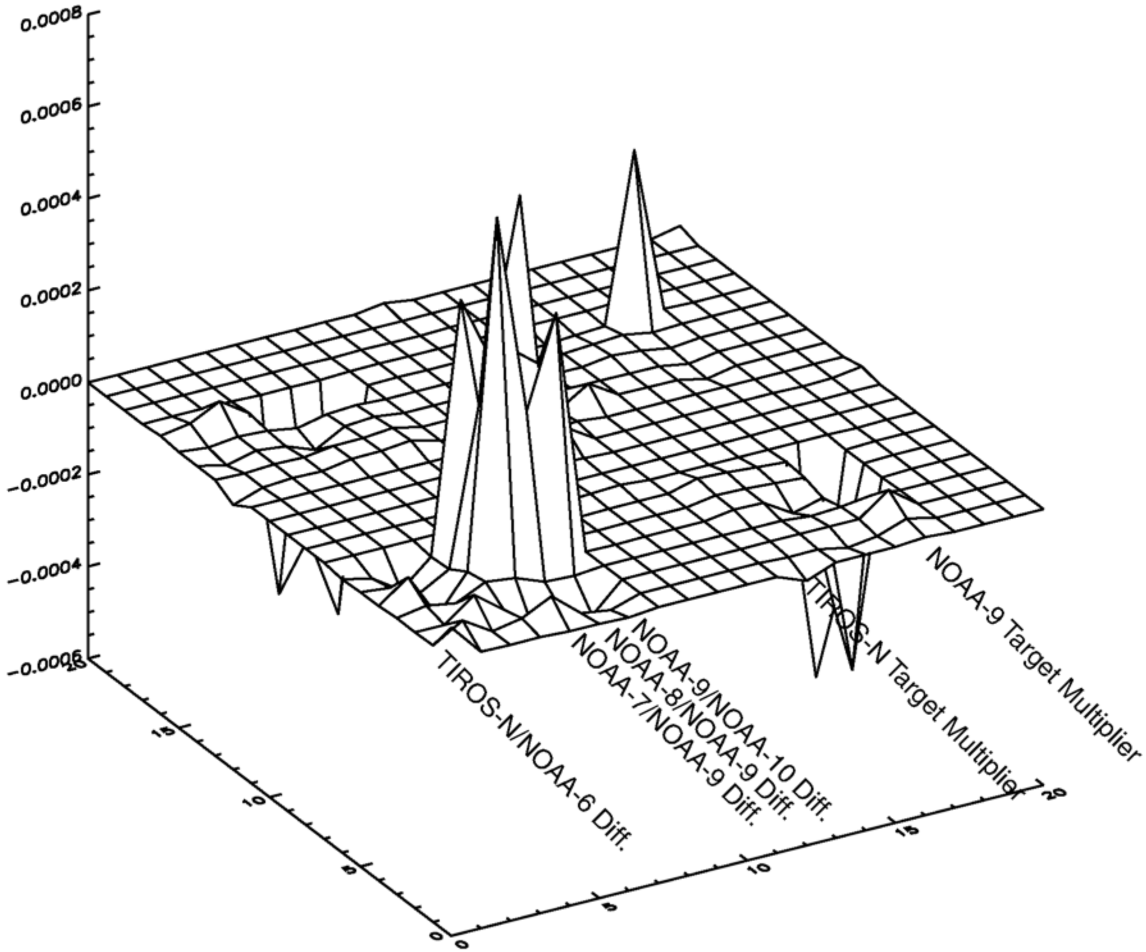
II. Use the covariance matrix from the above regression to create ~100 random sets of fit parameters D_{ij} and α_i consistent with the covariance matrix.

III. Perform a second regression for each of these parameter sets to obtain a distribution of satellite offsets A_i relative to NOAA-10. ($A_{NOAA-10}$ is set to 0)

IV. Use the satellite offsets and the α_i's (from step II) to create a distribution of corrected time series. Each of these is then fit to obtain a distribution of linear trends.

V. These trends are regressed to the distribution of each fit parameter to obtain the sensitivity to changes in that parameter, and the contribution to the overall variance due to that parameter.

Covariance Matrix Surface Plot



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Sensitivity Analysis: Offsets

Sat 1	Sat 2	# Pentads	T_b Diff	St.Dev. T_b Diff	Sens. dTrend/dDiff	St.Dev. Trend
TIROS-N	NOAA-6	29	-1.1572	0.0084	0.6711	0.0049
NOAA-6	NOAA-7	115	0.1769	0.0062	-1.2511	-0.0063
NOAA-6	NOAA-9	40	0.4875	0.0069	-0.4970	-0.0033
NOAA-7	NOAA-8	64	-0.3684	0.0055	-0.7024	-0.0032
NOAA-7	NOAA-9	9	0.2803	0.0279	0.7061	0.0170
NOAA-8	NOAA-9	8	0.6675	0.0211	0.7207	0.0152
NOAA-9	NOAA-10	17	-0.6718	0.0270	0.8074	0.0221
NOAA-10	NOAA-11	168	0.8846	0.0037	0.3541	0.0011
NOAA-10	NOAA-12	15	0.1989	0.0104	-0.1245	-0.0013
NOAA-11	NOAA-12	294	-0.7490	0.0026	2.1681	0.0062
NOAA-11	NOAA-14	59	-0.5682	0.0064	0.5161	0.0029
NOAA-12	NOAA-14	243	0.1955	0.0026	0.3145	0.0009

- NOAA-9/NOAA-10 is the most critical offset difference. NOAA-9 is well defined in the other direction by the NOAA-6/NOAA-9 difference.

- Large values of StDev Trend for NOAA-7/NOAA-9 and NOAA-8/NOAA-9 are due to correlated behavior.

Sensitivity Analysis: Target Multipliers

sat	target mult (α)	St. Dev. α	sens. $dTrend/d\alpha$	St. Dev. Trend
TIROS-N	-0.0133	0.0065	0.6257	0.0033
NOAA-6	-0.0020	0.0014	3.6595	0.0051
NOAA-7	0.0134	0.0032	0.3641	0.0009
NOAA-8	0.0296	0.0029	1.0598	0.0030
NOAA-9	0.0360	0.0191	-1.0262	-0.0193
NOAA-10	0.0041	0.0011	-1.0136	-0.0011
NOAA-11	0.0278	0.0008	-7.6066	-0.0048
NOAA-12	0.0065	0.0004	-3.7392	-0.0015
NOAA-14	0.0170	0.0036	-0.7018	-0.0022

- NOAA-9 target multiplier is the most critical.
- Strongly Correlated with NOAA-9/NOAA-10 Offset.

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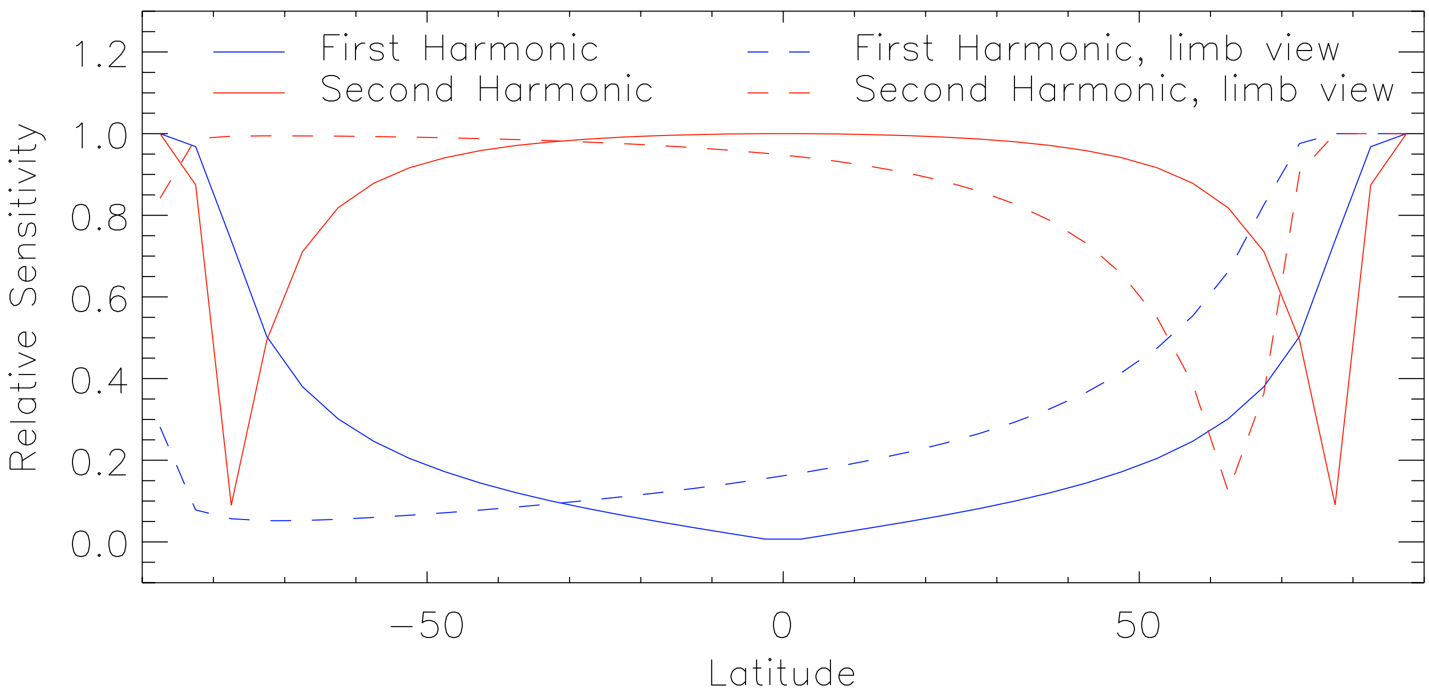
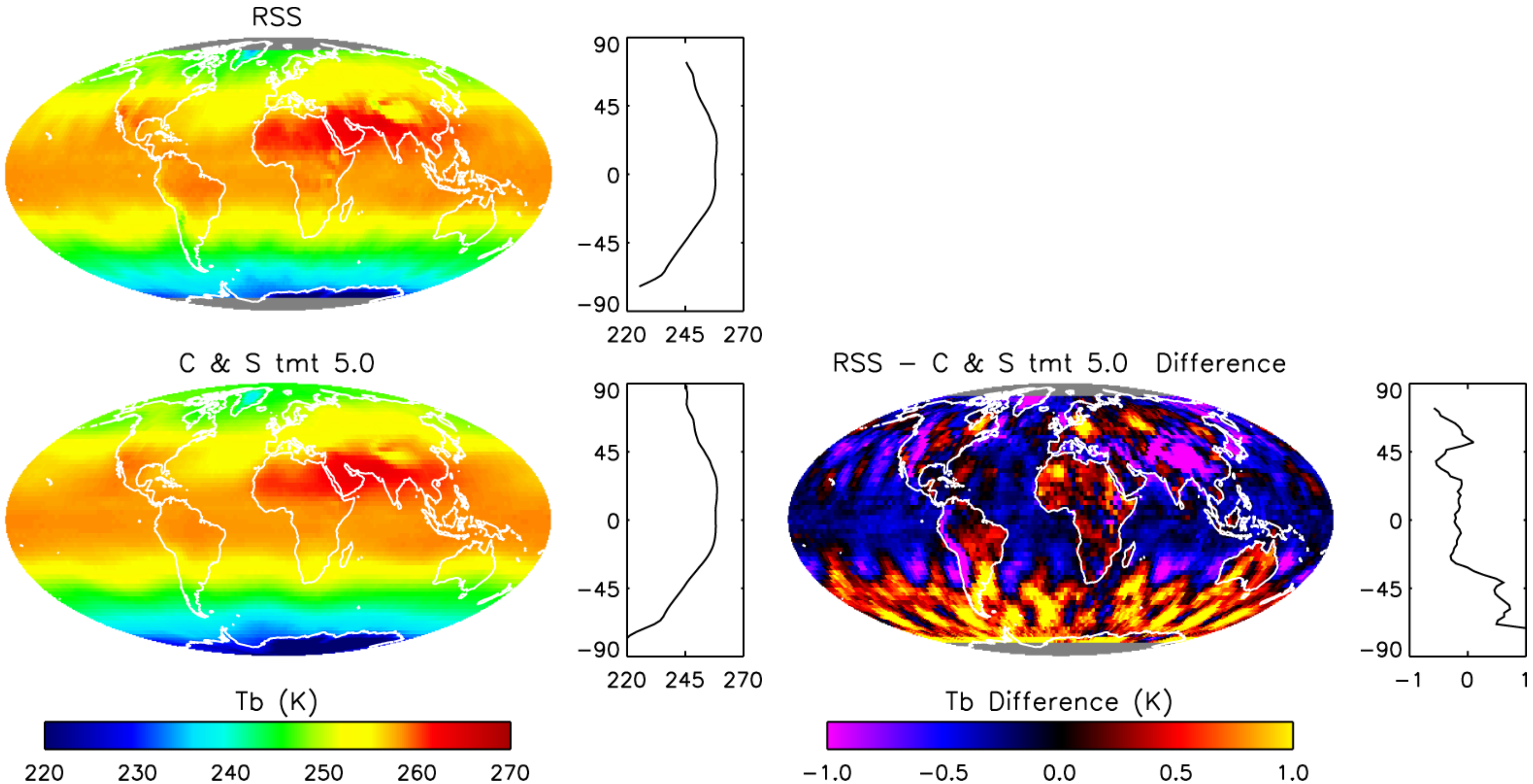
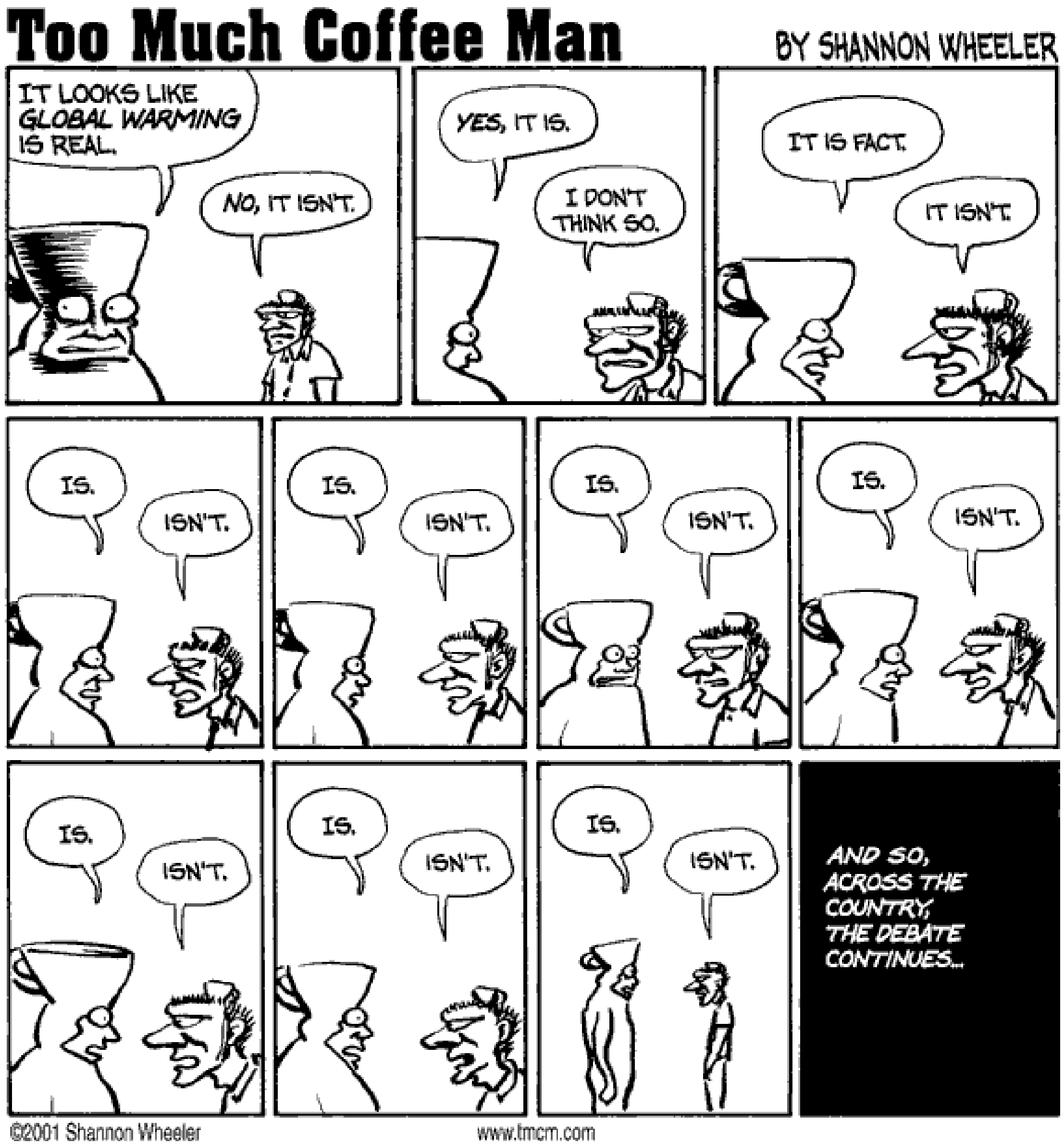
Harmonic Sensitivity of Diurnal Correction



June 2000 Channel 2 Comparison




Too Much Coffee Man
BY SHANNON WHEELER
IT LOOKS LIKE GLOBAL WARMING IS REAL.
NO, IT ISN'T.
YES, IT IS.
I DON'T THINK SO.
IT IS FACT.
IT ISN'T.
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ISN'T.
AND SO, ACROSS THE COUNTRY, THE DEBATE CONTINUES...
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