An Update on Development of MSU/AMSU/SSU Sounding Channel Radiance FCDR and Upper-Air Temperature TCDR

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Outline

- Overview of NOAA MSU/AMSU/SSU Atmospheric Sounding CDR Project
- Results/Accomplishments
- Validation
- Issues & Work-Off Plans

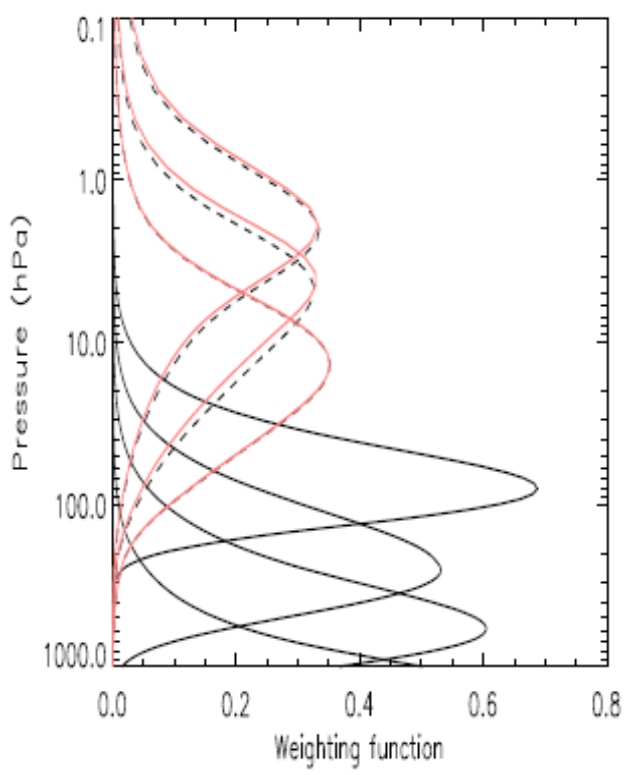
OVERVIEW-Goals for CDR Project

- Develop consistent radiance Fundamental Climate Data Record (FCDR) for MSU/AMSU/SSU sounding channels to support consistent modeling reanalysis activities and consistent satellite retrievals

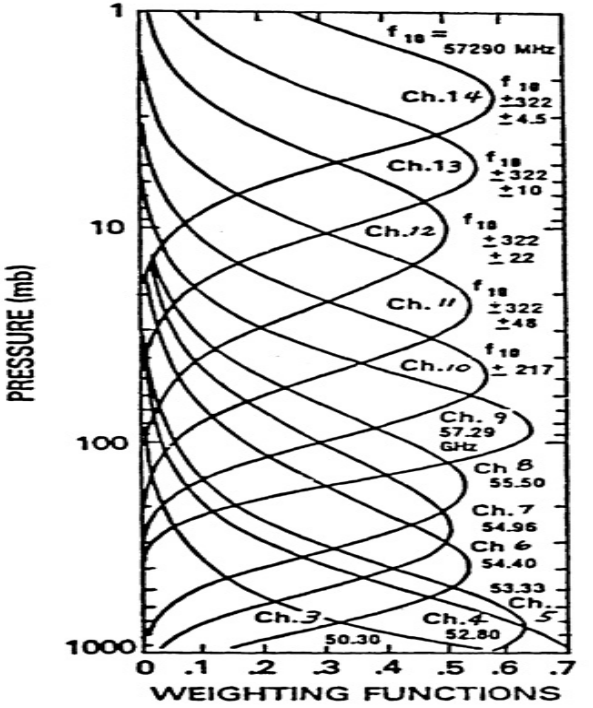
- Develop consistent atmospheric temperature thematic climate data record (TCDR) for climate service support – climate change research, climate change monitoring, validating climate model simulation…

OVERVIEW-Source of Data

MSU+SSU; 1978-2007



AMSU; 1998-present



MSU/AMSU/SSU

Total 22 channels

16 atmospheric channels

Left: Weighting functions for the MSU and SSU instruments, where the black curve represent the MSU weighting functions and the dashed and red curves are the SSU weighting functions for different time period, showing a shift due to an instrument CO_2 cell pressure change; Right: Weighting functions for AMSU-A. All weighting functions are corresponding to nadir or near-nadir observations.

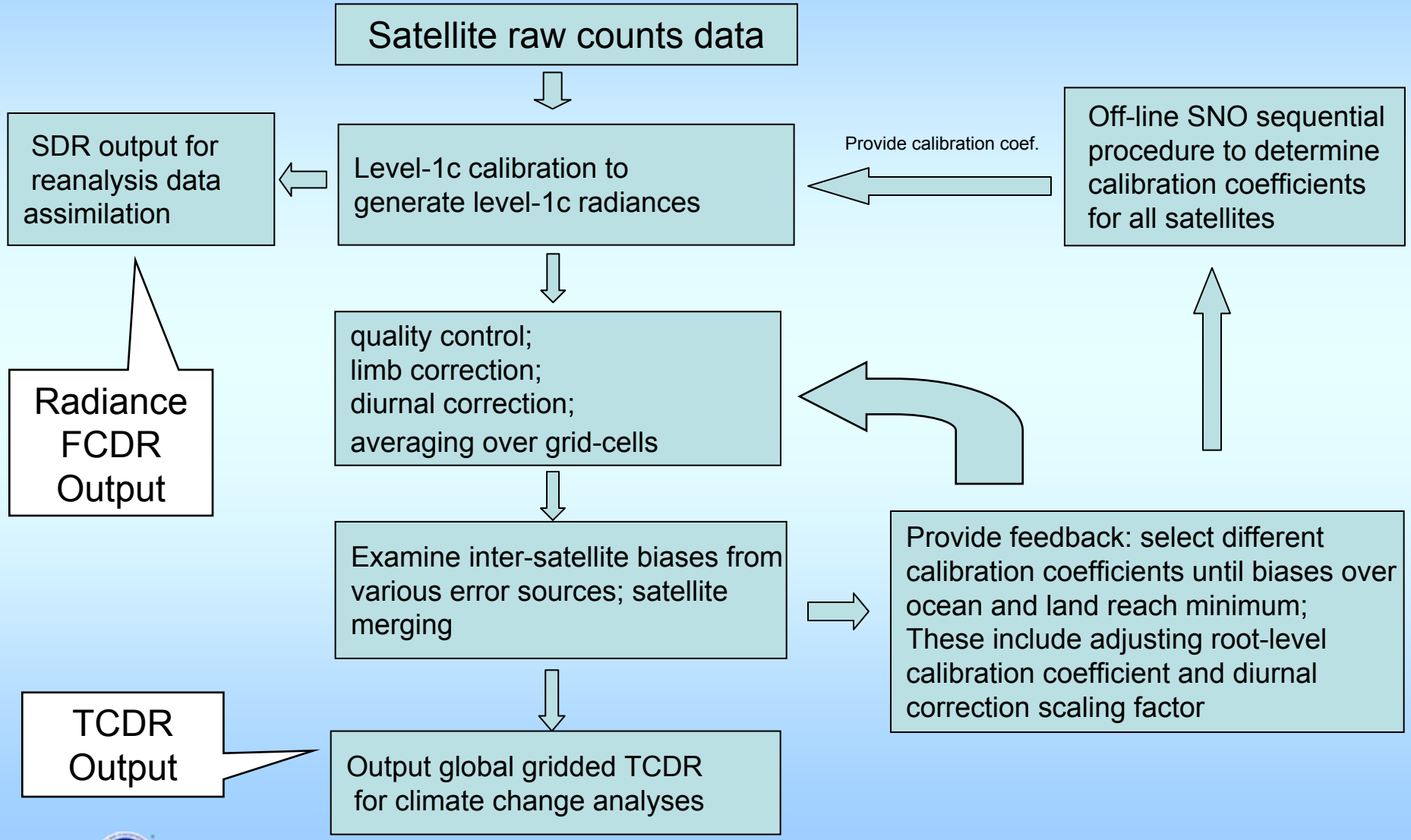
OVERVIEW

- ECVs addressed

--Upper-Air Temperature

- Current/expected user communities
  - IPCC climate assessment
  - NCDC climate report
  - Reanalysis community
  - Climate research community
  - General public engaged in global warming debate

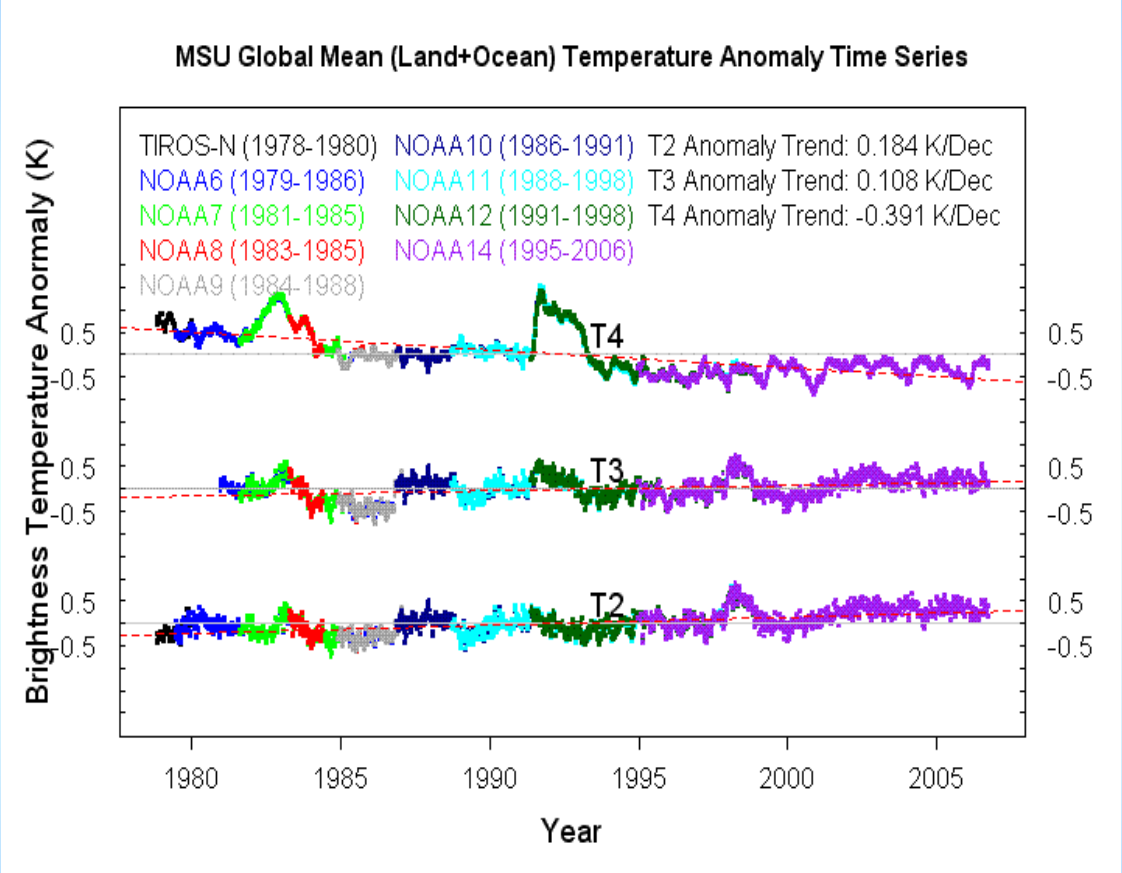
NOAA MSU/AMSU CDR Development System



Achievements - - MSU

- Maturity Level: 80% (4.8 out of 6)

- Recalibrated Radiance FCDR for MSU channels 2-4 from 1978-2006
- Developed well inter-calibrated upper-air layer temperature TCDR
- FCDR being assimilated into MERRA and CFSR reanalysis systems; improved bias correction pattern found
- TCDR being used in climate trend investigations, validating climate model simulations…
- FCDR and TCDR delivered on STAR websites
- Papers published
- Last step: ATBD need completed



• Five-day averaged, global-mean MSU-only temperature anomaly time series

Achievements--SSU

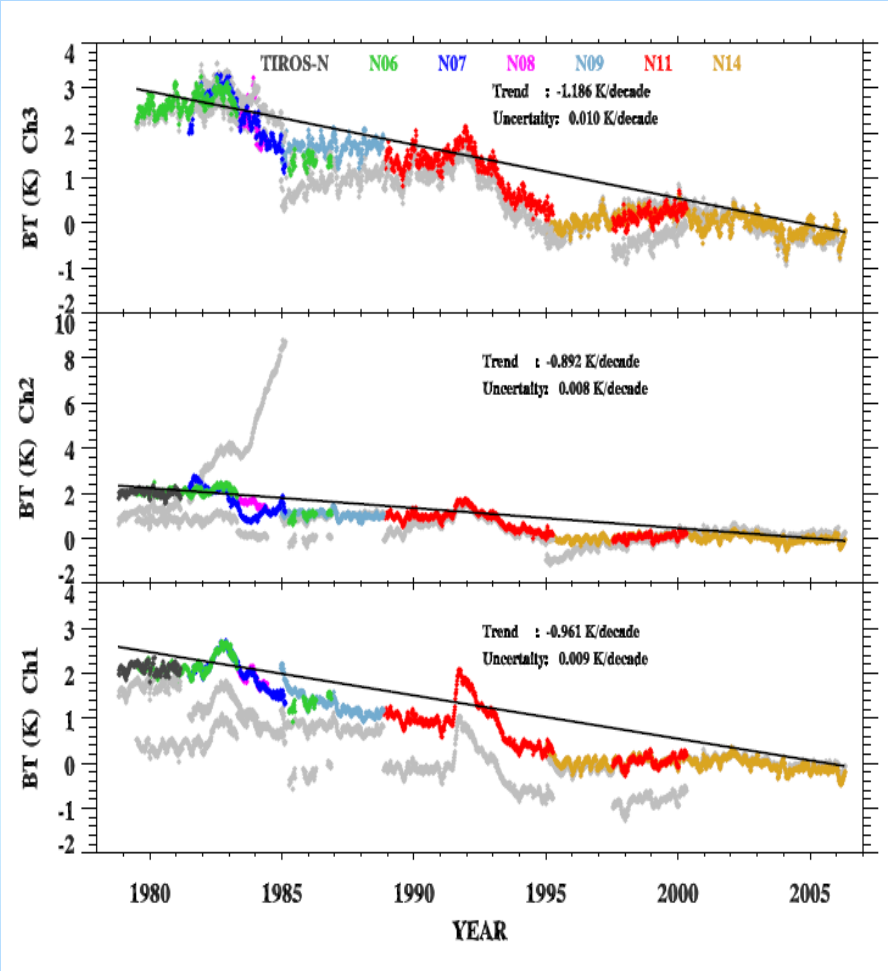
- Maturity Level: 45%
  (2.7 out of 6)

- FCDR/TCDR recalibration algorithm developed, involving corrections of
  - ✓ instrument CO2 leaking problem
  - ✓ atmospheric CO2 variations
  - ✓ limb-effect
  - ✓ diurnal drift effect
  - ✓ inter-satellite biases

- Version 1.0 TCDR to be released in two months at STAR website

- Preliminary evaluation of TCDR conducted by NCEP/CPC

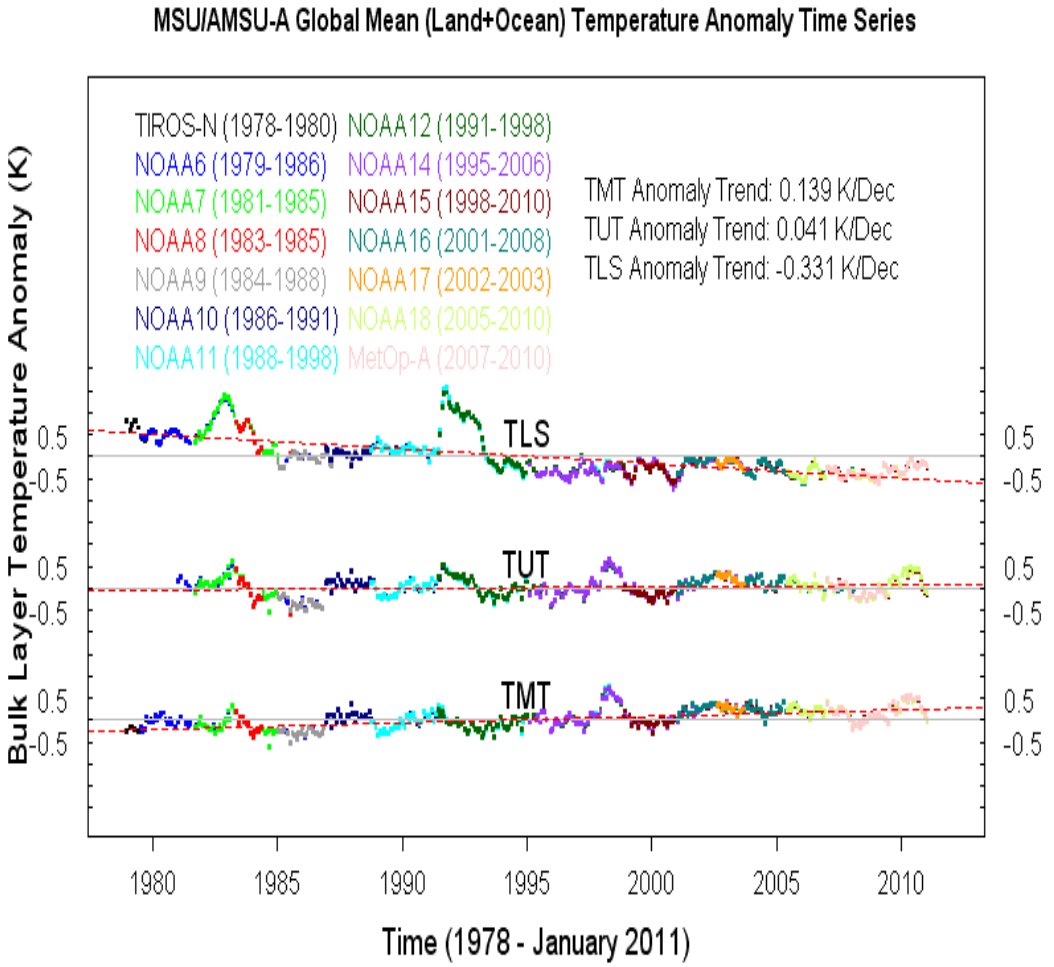
- Documentation to be completed



The time series of SSU brightness temperature before recalibration/reprocessing (gray) and recalibrated CDRs (color). The different colors represent the observations from different satellites.

Achievements: AMSU-A

- Maturity Level: channel dependent
  - Recalibrated channels 4-10, 12, 13
  - Recalibrated radiance FCDR released on STAR website
  - Merged channels 5, 7, and 9 with respected MSU channels 2, 3, and 4 to generate MSU/AMSU-A upper-air temperature TCDR
  - MSU/AMSU-A TCDR version 2.0 released on STAR websites
  - Temperature TCDR updated every month to 'operationally' monitor climate change
  - Both FCDR and TCDR validated against limited GPSRO observations
  - TCDR being used for climate trend monitoring, validation of climate model simulations
  - Working on documentation



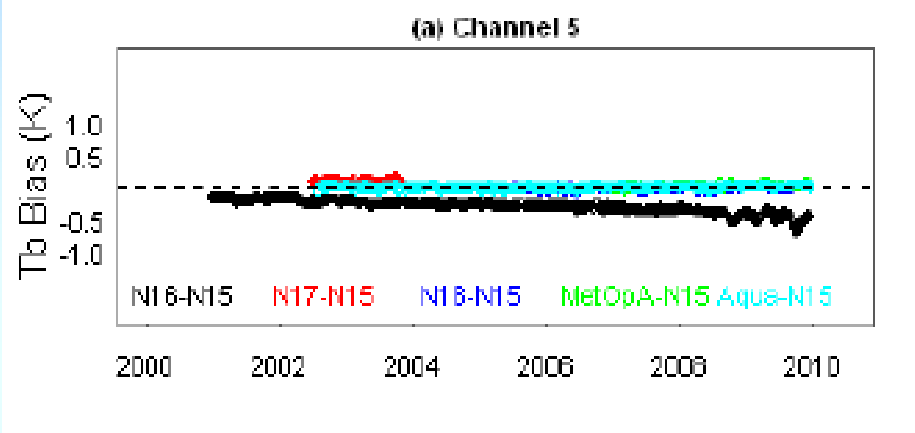
Monthly anomaly time series and trends for the global mean TMT, TUT and TLS, where TMT, TUT, and TLS represent deep-layer temperatures at mid-troposphere, upper-troposphere, and lower-stratosphere.

AMSU-A Bias Classification

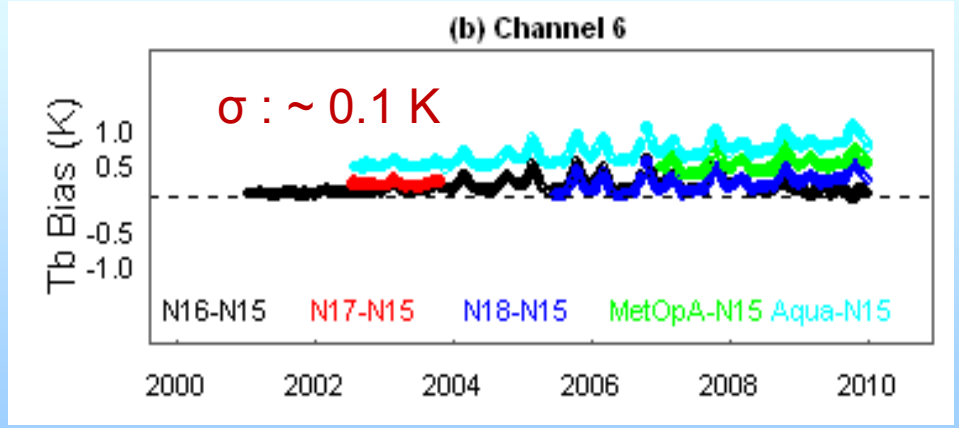
The following biases were identified in pre-launch calibration and were removed or minimized in our SNO recalibration effort

- Constant inter-satellite biases
- Bias drifts in most NOAA-16 channels and some MetOp-A channels
- Temperature-dependent biases in most channels on most satellites
- Sun heating induced temperature variability in NOAA-15 channel 6
- Channel frequency shift in certain channels

NOAA operational calibrated inter-satellite difference time Series; ch 5 Ocean Mean, before SNO inter-calibration



NOAA operational calibrated inter-satellite difference time Series; ch 6 Ocean Mean, before SNO inter-calibration



SNO Method to Remove Sun-Heating Induced Instrument Temperature Variability

Nonlinear calibration

$$R = R_L - \delta R + \mu Z$$

R_L is the linear calibration term

$$R_L = R_c + S(C_e - C_c)$$

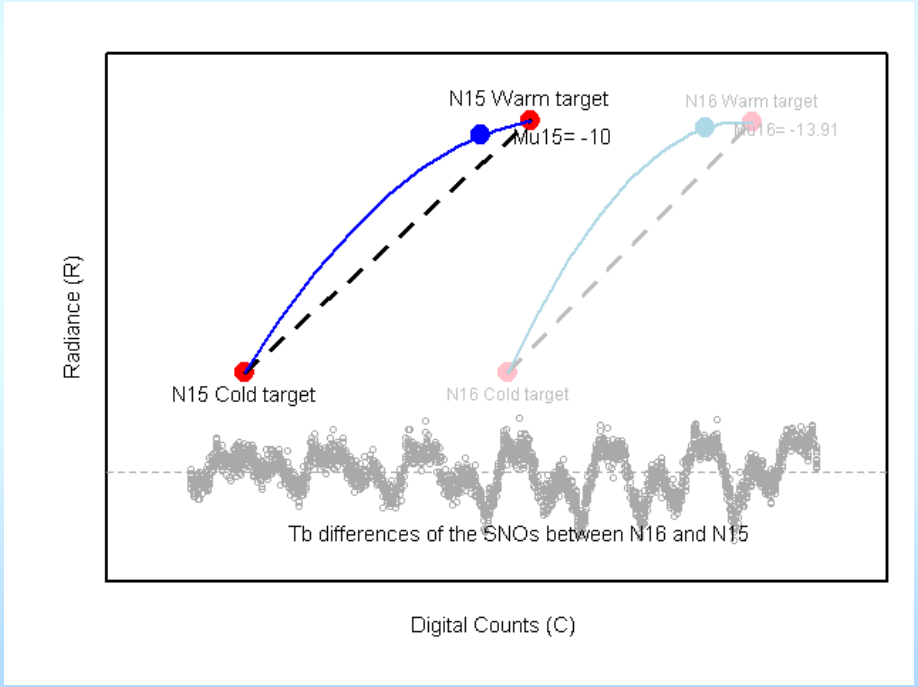
$S \longrightarrow$ Slope

$$Z = S^2 (C_e - C_c)(C_e - C_w)$$

C_e - scene count

C_c – cold space count

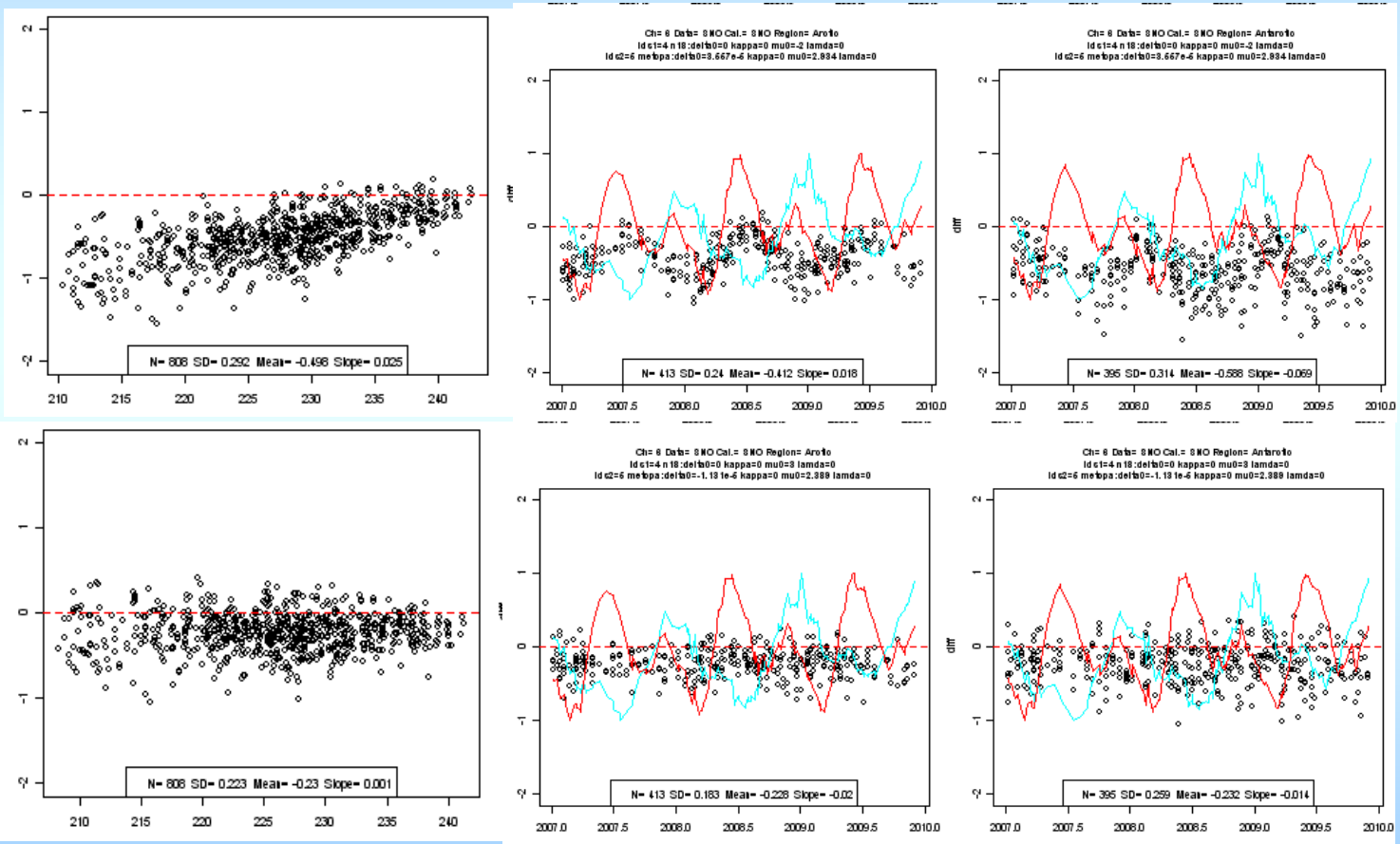
C_w - warm target raw count



SNO Method to Remove Scene Temperature-Dependent Biases

Before recalibration

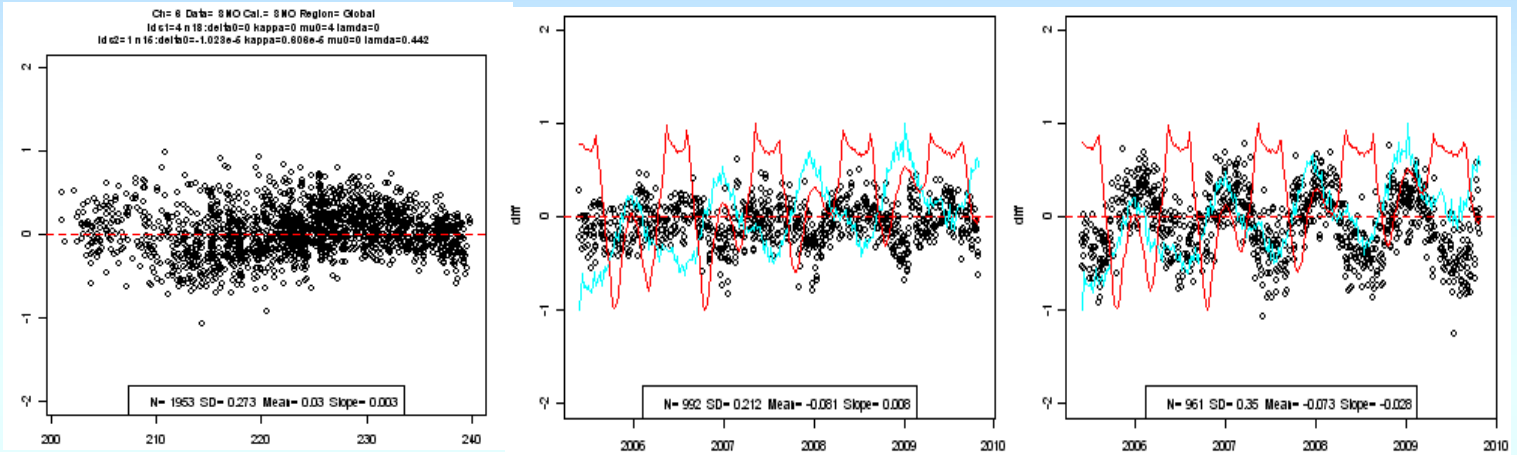
After recalibration



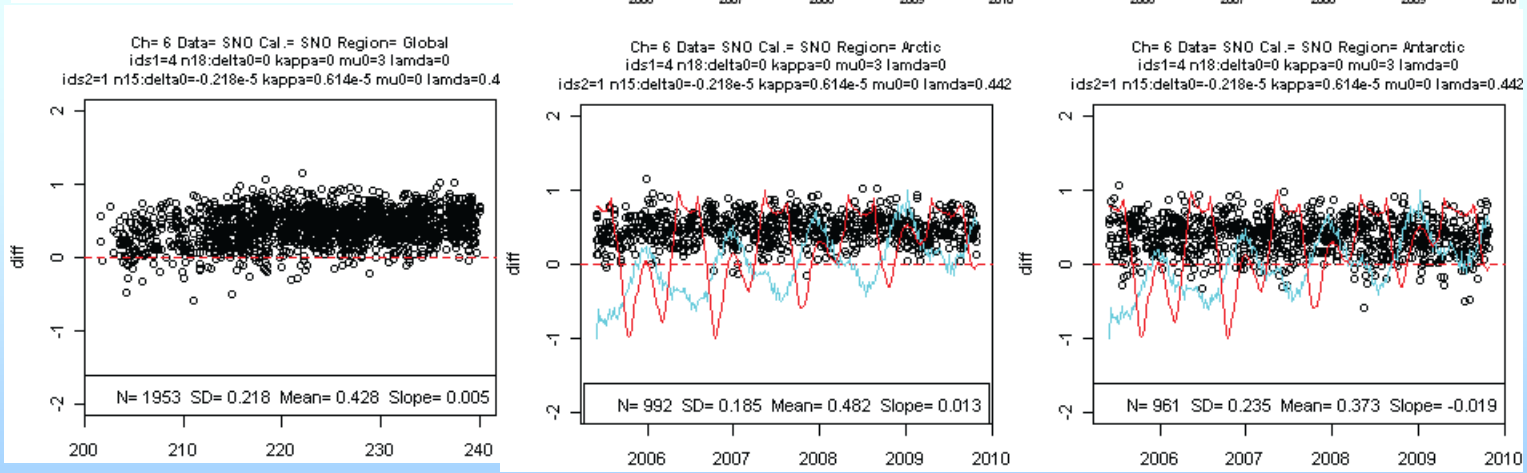
SNOs between NOAA-18 and MetOp-A, channel 6

SNO Method to Remove Biases Caused by Channel Frequency Shift

Before recalibration

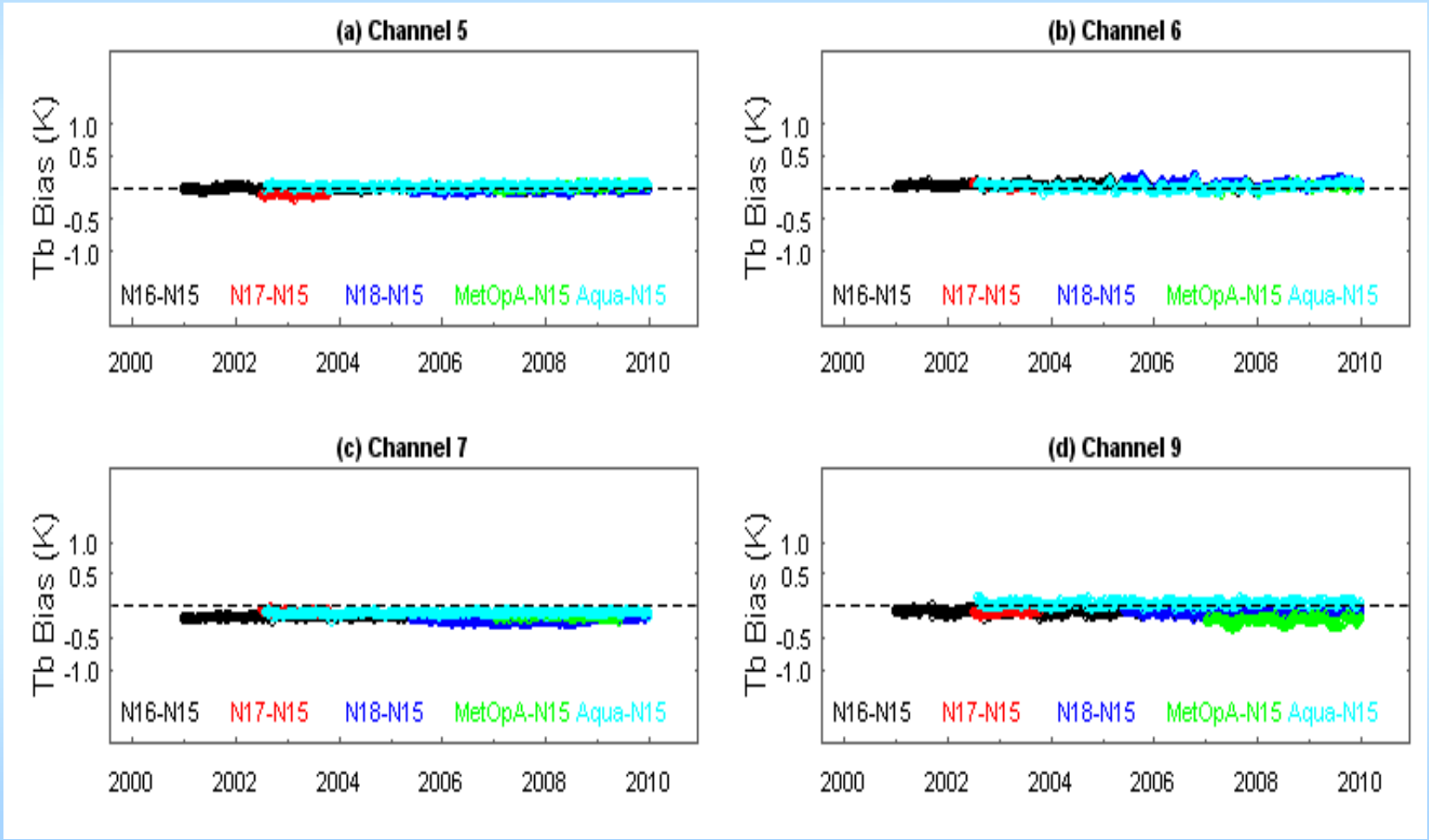


After recalibration



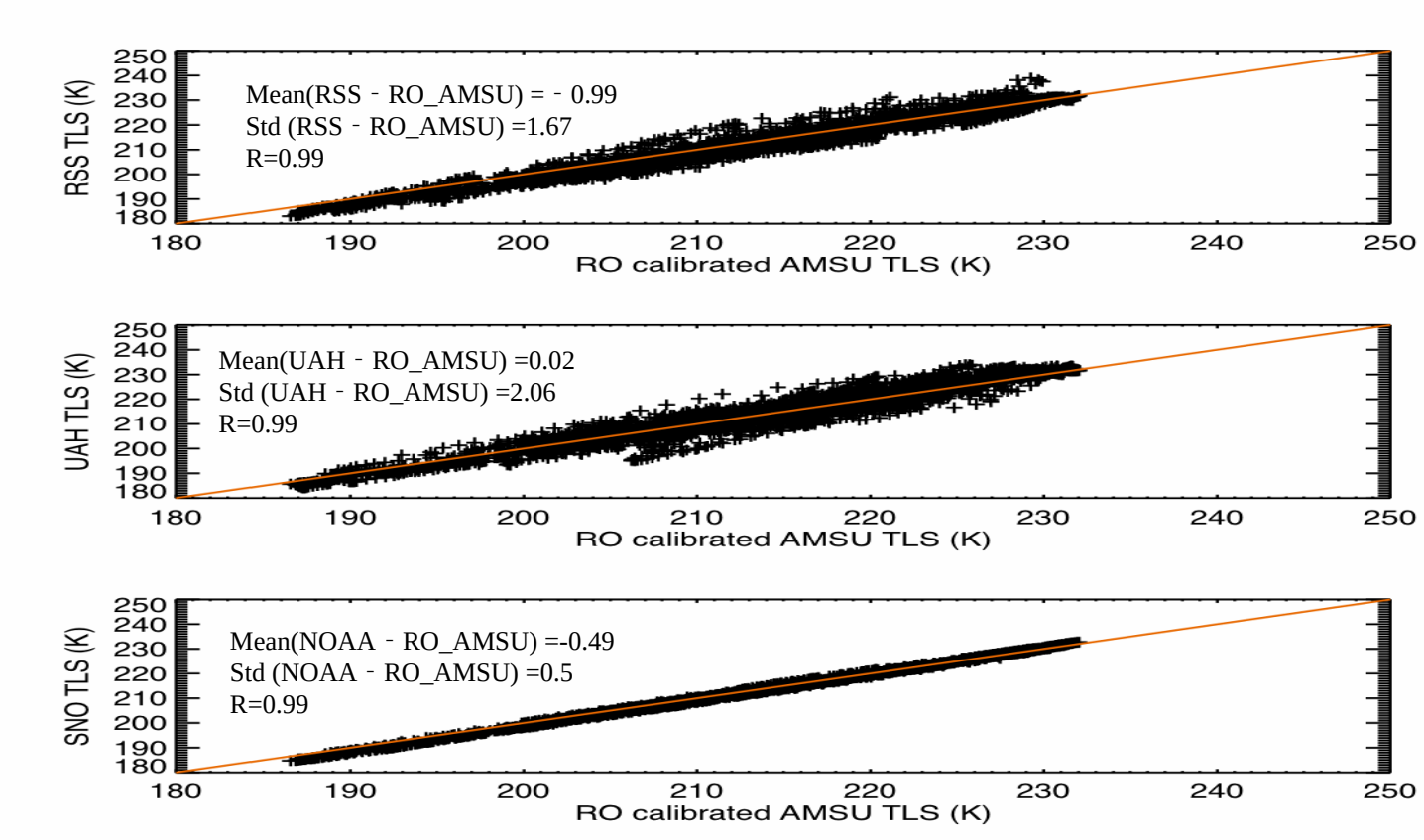
SNOs between NOAA-18 and NOAA-15, channel 6

SNO inter-calibrated AMSU-A Observations



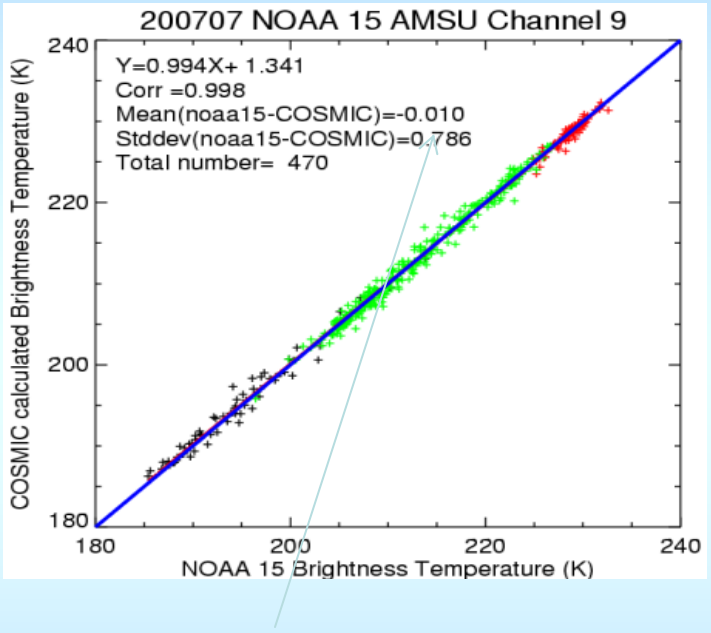
Validation — GPSRO vs SNO recalibrated MSU/AMSU products

Scattering plots of 10 x10 degree binned TLS from 200106 to 200812

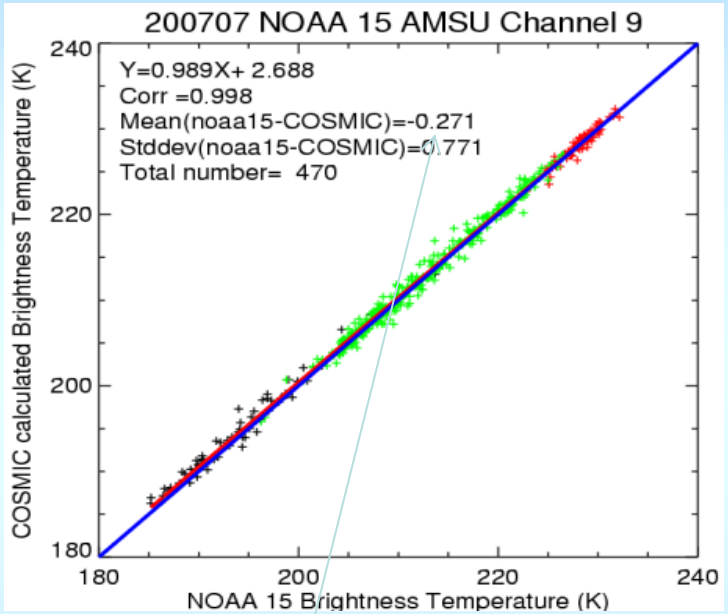


From Ben Ho of NCAR, NOAA CDR Workshop, Silver Spring, Maryland March 22-24

Validation — GPSRO vs SNO recalibrated AMSU Radiances, channel 9



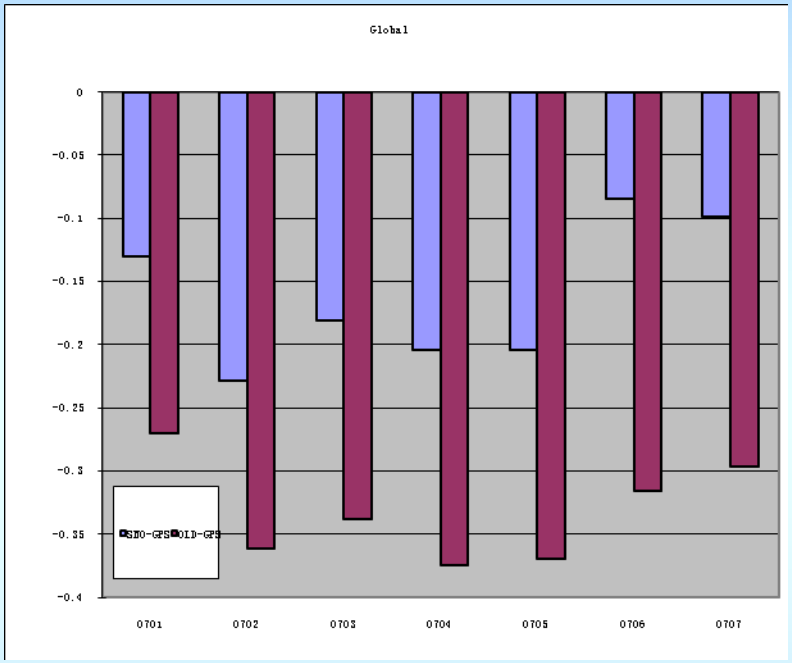
SNO calibration



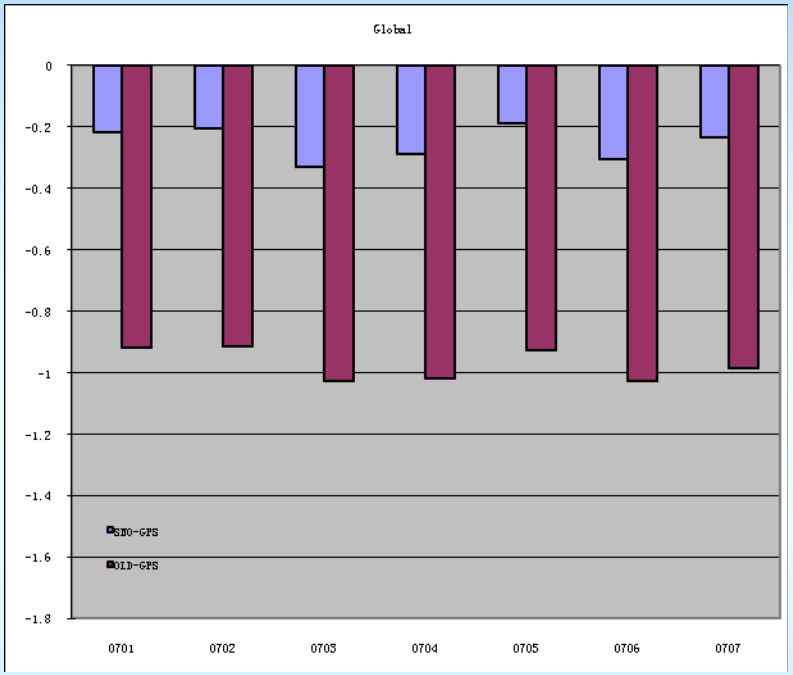
NOAA Operational Calibration

Slides courtesy of W. He from IAP of China

Validation — GPSRO vs SNO recalibrated AMSU Radiances, channel 9



NOAA-15

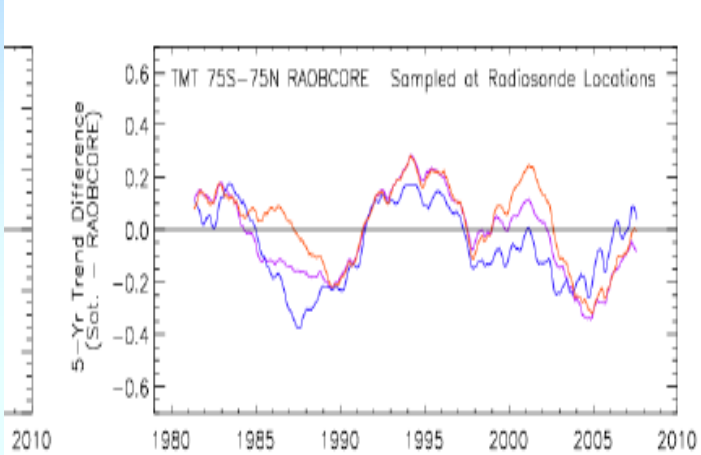


NOAA-18

Global comparisons in 7 consecutive days from 2007/7/1 to 2007/7/7

Slide courtesy of W. He from IAP of China

Validation — RAOB vs SNO recalibrated MSU/AMSU trends, channel 5



Pink: STAR
Blue: UAH
Purple: RSS

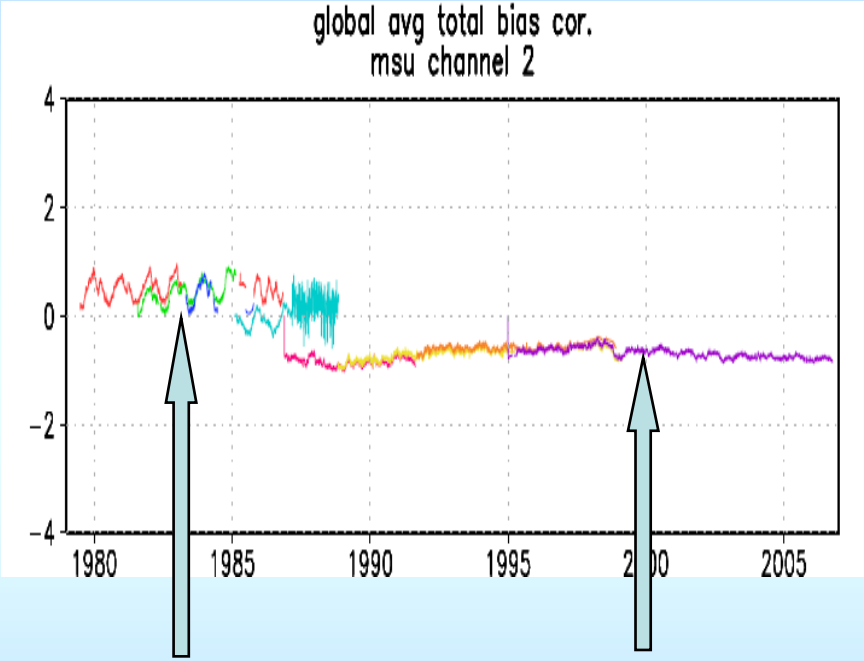
RMS Differences between 5-year trends.

Radiosonde Dataset	RSS	UAH	STAR
Globe 75S-75N			
HadAT	0.219	0.236	**0.198**
RAOBCORE	0.157	0.157	**0.150**
RICH	0.185	0.198	**0.163**
IUK	0.191	0.204	**0.181**
RATPAC	0.236	0.230	**0.221**
RATPAC_RH	0.238	0.243	**0.215**
South 75S-20S			

Five-year trends comparisons between different homogenized RAOB analysis and different satellite datasets. Note STAR dataset is closest to RAOB trends for ALL different RAOB analysis in terms of RMS. Plot and table from Mears (2011).

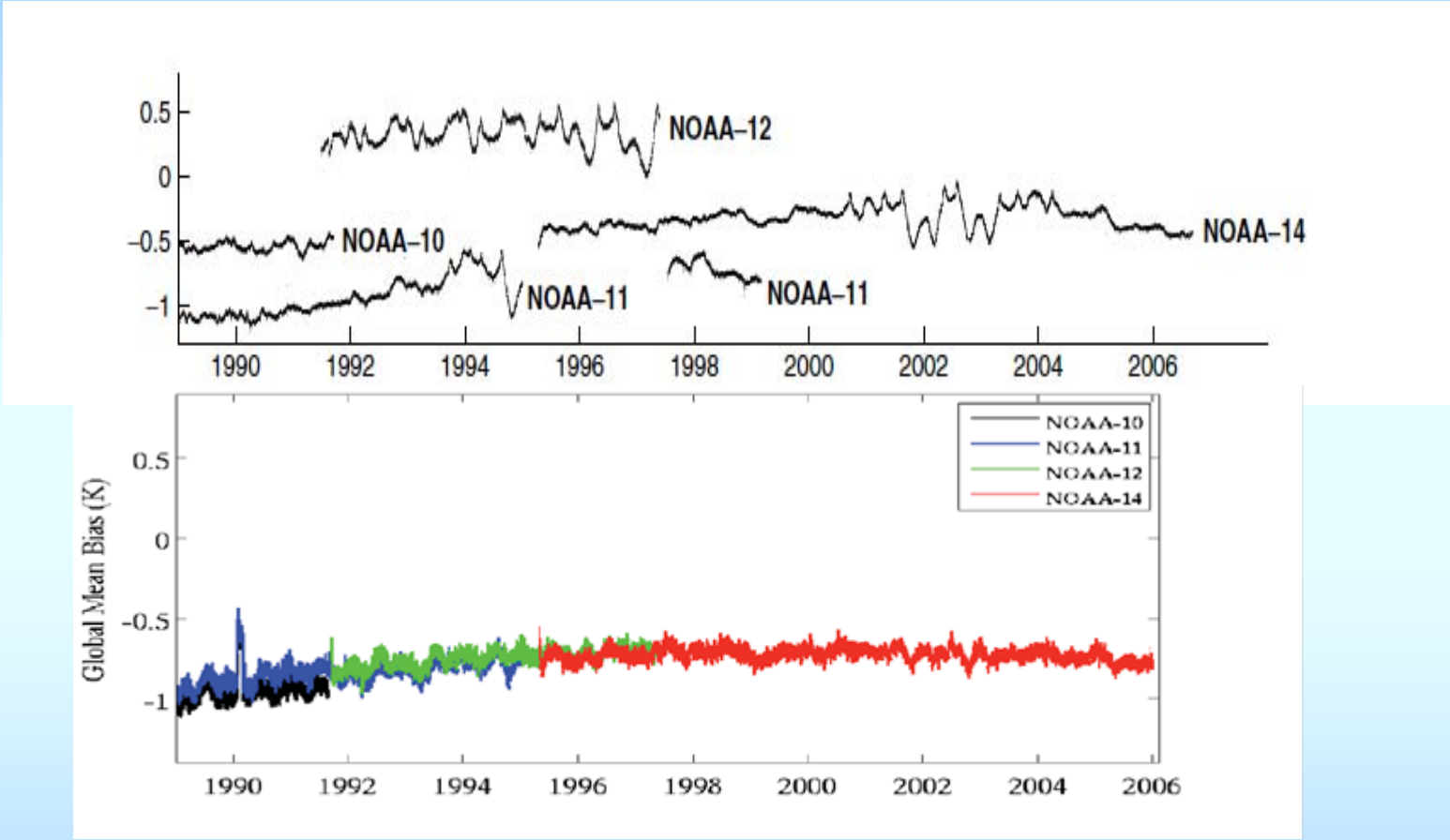
MSU: Bias Correction of MSU data in NCEP CFSR Reanalysis: Before and After Recalibration

- Recalibrated MSU level-1c data were assimilated into NCEP CFSR and NASA MERRA reanalysis systems
- Bias correction pattern for recalibrated MSU data are much smoother, since instrument errors were removed before assimilation
- Need to adjust the absolute values of the recalibrated MSU/AMSU data so that the absolute value of the bias correction is close to zero



MSU Channel 2 bias correction patterns in NCEP CFSR reanalysis from 1978-2007. Recalibrated MSU data after 1987 were assimilated into CFSR (plot from Saha et al. 2010)

NASA MERRA vs ERA-Interium



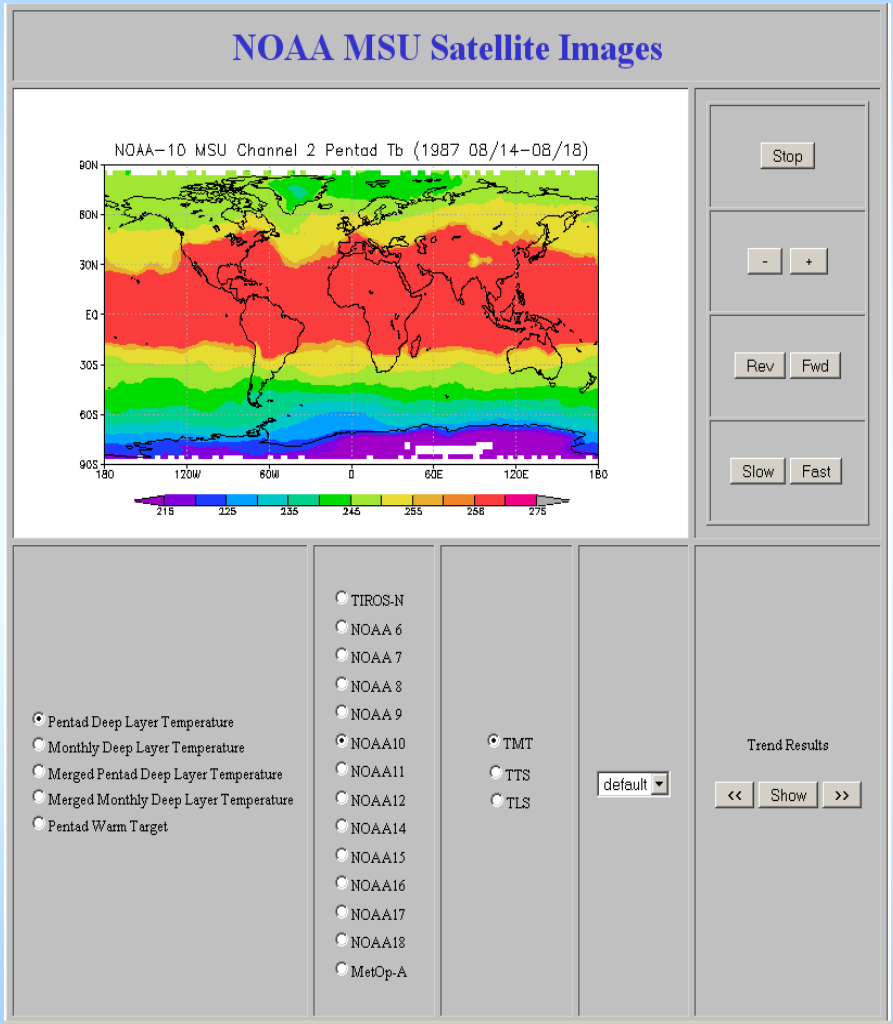
Global mean 12-hourly variational bias estimates (K) for MSU channel 2 radiance data from NOAA-10, NOAA-11, NOAA-12, and NOAA-14 . The upper panel is from ERA-Interim and the lower panel is from MERRA. The latter uses the NOAA/STAR SNO cross-calibrated MSU data. (Plot from Dee 2010)

Data Archive and Download

❑ Website address:
http://www.orbit.nesdis.noaa.gov/smcd/emb/mscat/mscatmain.htm

❑Datasets for public access:

- Level -1c calibration coefficients
- Level -1c radiance:
  - — SNO calibrated
  - — pre-launch (operationally) calibrated
- Level 3 gridded products: 2.5°×2.5 °
  - — MSU/AMSU merged pentad and monthly TMT, TTS, and TLS



Issues & Work-Off Plans

- Issues
  - No microwave SI-traceable standards for absolute validation
  - Only two PRTs on MSU, thermal gradient problem may never be solved. AMSU maybe OK
  - Difficult to use SNO to resolve higher order nonlinearity than quadratic
  - Chanel failures affect accuracy (e.g., N15 channels 4, 11, 14)
- Work-Off Plans
  - Use best practice inter-calibration algorithms to produce multiple identical satellite observations
  - Implement comprehensive validation/comparison plans

Thank You!