Recalibration and Reprocessing of MSU/AMSU Observations for Climate Studies

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NOAA MSU/AMSU Satellites

- Each satellite has a life cycle of a few years
- Each satellite overlaps with other satellites
- LECT gradually changes with time–orbital drift phenomenon
- Merging these satellites is a non-trivial task

Satellite Local Equator Crossing Time (LECT) vs time
Past MSU CH 2 Trend Studies

- Spencer and Christy (1992): 0.02 K Dec\(^{-1}\), 1979-1988
- Christy et al. (2003): 0.02 K Dec\(^{-1}\), 1979-2002
- Prabhakara et al. (2000): 0.13 K Dec\(^{-1}\), 1980-1999
- Mears et al. (2003, 2005): 0.10 K Dec\(^{-1}\), 1979-2001
- Vinnikov and Grody (2003): 0.22-0.26 K Dec\(^{-1}\), 1979-2002
- Grody et al. (2004): 0.17 K Dec\(^{-1}\), 1979-2002
- Vinnikov et al. (2006): 0.20 K Dec\(^{-1}\), 1978-2004
Fake Trend Problems

- **Intersatellite Biases:**
  - 0.1K biases enough to lead different conclusion

- **Warm target temperature Contamination**
  - Require brightness temperature not a function of warm target temperature

- **Diurnal cycle effect**
  - Convert observations of different local time to a common time to remove diurnal cycle effect
SNO Definition

Method to find SNO matchups:

- Use Cao’s (2004) method to find the orbits that have intersections

- Use time and location information in the 1B file to determine simultaneity between two pixels

Schematic viewing the overpasses between two NOAA satellites
SNO Temperature range for CH. 2: 200-250 K
Global temperature range for CH. 2: 200-260 K
• $T_b$ difference gets larger when the SNO pixel distance gets larger

• SNO numbers increase with the distance

• Different satellite pairs have different SNO numbers because of different overlap period
STD and biases of channel 2 brightness temperature differences between satellite pairs versus center distance of the nadir overpass pixels. (a) Biases (b) STD. Linear calibration algorithm at level 0 is used.
MSU In-Orbit Calibration Process

Conceptual diagram of MSU observational procedure

MSU Sensor

Warm Target
Temperature is measured by PRT

Cold Space
T=2.73K

Earth

T=2.73K

Earth
Level 0 Calibration Equation

Linear Calibration

\[ R_L = R_c + S(C_e - C_c) \]

S → Slope

Nonlinear Calibration (Mo 1995)

\[ R = R_L - \delta R + \mu Z \]

\[ Z = S^2 (C_e - C_c)(C_e - C_w) \]
SNO Radiance Error Model

\[ R_k = R_{L,k} - \delta R_k + \mu_k Z_k \]
\[ R_j = R_{L,j} - \delta R_j + \mu_j Z_j \]

Radiance Error Model for SNO Matchup K and J:

\[ \Delta R = \Delta R_L - \Delta \delta R + \mu_k Z_k - \mu_j Z_j \]

\[ Z_j = \beta Z_k + \alpha \]
Scatter plots showing effects of the nonlinear calibration on the error statistics and distribution of the brightness temperature differences between NOAA 10 and NOAA 11.
SNO Sequential Calibration Procedure

- Assuming NOAA 10 as the reference satellite and using its pre-launch coefficient for reference
- Obtain calibrated radiance (1b) for NOAA 10
- Compute NOAA 11 coefficients from regressions of N11-N10 SNO
- Obtain calibrated radiance (1b) for NOAA 11
- Repeat above procedure for NOAA 12 with calibrated NOAA 11 as references
Effect on time series and trend

- Intersatellite biases largely reduced
- Trend values are more reliable

Trend = 0.22 K Decade^{-1}

(Vinnikov and Grody, 2003)

Trend = 0.17 K Decade^{-1}
Spatial Distribution of Biases

- Ocean OK
- Land needs diurnal cycle corrections
Warm Target Contamination

Brown Line: $T_b$ differences between NOAA 10 and 11
Blue Line: $T_w$ of NOAA 10
Pink Line: $T_w$ of NOAA 11
Determine Absolute Calibration by Removing $T_w$ Contamination

- $\mu_{N10}$ small or large, large warm target temperature contamination
- When $\mu_{N10}$ is 25% larger than its pre-launch value, averaged warm target temperature contamination reaches a minimum (4%)
- Corresponding trend is $0.198 \pm 0.02$ K Dec$^{-1}$
- Degree of freedom about 30, correlation is significant at 95% when $r^2>13%$
Summary on SNO Calibration

- Post-launch coefficients larger than Pre-launch values

Dots: Pre-launch values
Line: SNO calibration values.
Spatial Distribution of Trend


ARCTIC SEA ICE EXTENT - SEPTEMBER TREND, 1978-2005
On-going Work and Future Plans

- Diurnal cycle corrections
  -- land problems
- Recalibrate and Reprocess all MSU satellites
  -- TIROS-N to NOAA 14, for all channels 2,3,4
- Connect MSU with AMSU
  -- Consider different pixel resolutions and frequencies
- Impact on Reanalyses
  -- Assimilate SNO calibrated MSU/AMSU 1b to next generation reanalyses
  -- affect trend of all reanalysis variables
  -- diurnal cycle problem resolved
- Compare with other data
  -- Radiosonde (Tony Reale)
    -- GPS Radio Occultation (Ben Ho, Bill Kuo)
- Other instruments
  -- SSM/I and SSMIS (Weng)
Reference and Website


- [http://www.orbit.nesdis.noaa.gov/smcd/emb/mscat/mscatmain.htm](http://www.orbit.nesdis.noaa.gov/smcd/emb/mscat/mscatmain.htm)
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