AMSU-A Only Atmospheric Temperature Climate Data Records from Lower Troposphere to the Top of Stratosphere

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Introduction

The Advanced Microwave Sounding Unit A (AMSU-A, 1998-present) surpasses the Microwave Sounding Unit (MSU, 1978-2006) capacities in atmospheric temperature observation. It provides valuable satellite measurements for higher vertical resolution and long-term climate change research and trend monitoring.

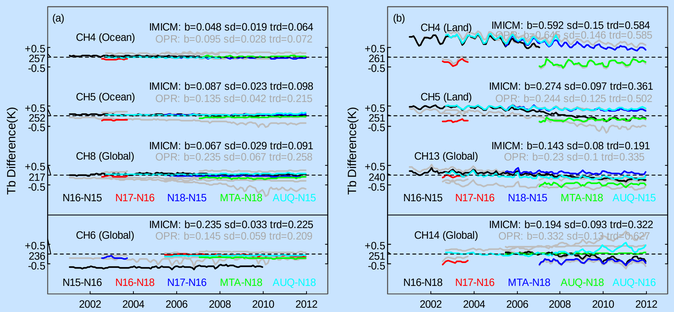
This study presented methodologies for generating 11 channels of AMSU-A only atmospheric temperature thematic climate data records (TCDRs) from lower troposphere to the top of stratosphere.

STAR Recalibrated/Reprocessed AMSU-A Level 1C Radiances

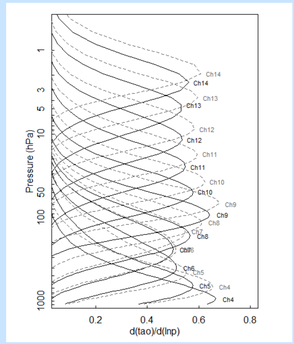
http://www.star.nesdis.noaa.gov/smcd/emb/mscat/index.php

Based an Integrated Microwave Inter-Calibration Approach (IMICA)

- **New constant offsets and nonlinearity coefficients** were estimated using simultaneous nadir overpass (SNO) matchup regressions and global mean temperatures analysis to minimize sun-heating-induced instrument temperature variability in radiances and scene temperature dependency in biases
- **Time-dependent bias drifts for NOAA 16 and MetOp-A were corrected** using global mean temperature time series analysis
- **Time-dependent nonlinearity drift in NOAA-15 channel 6 was corrected** using global mean temperature regression; channel frequency shift was determined from the radiative transfer model simulation experiments.



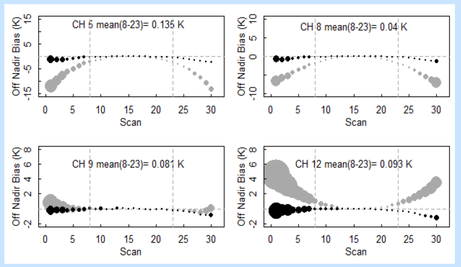
Global mean inter-satellite differences time series for the IMICA recalibrated (non-gray lines) and the NOAA operational calibrated (OPR, gray lines in the background) level 1c radiances



AMSU-A atmospheric temperature channel (4–14) weighting functions at near nadir (1.67°, solid lines) and limb scan positions (48.33°, dash lines).

Sensor Incidence Angle Effect Correction

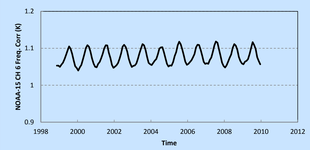
- Based on pixel level radiative transfer simulations, using
  - NOAA/Joint Center for Satellite Data Assimilation Community Radiative Transfer Model (CRTM), and
  - MERRA Reanalysis hourly surface skin temperatures & 3-hourly atmospheric profiles
- Mean off-nadir biases less than 1 K for all cases



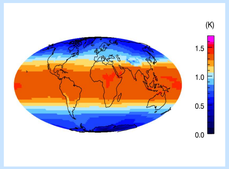
Off-nadir bias statistics for representative channels on NOAA-15 AMSU-A. Each point summarizes off-nadir bias time series for one scan, with y values representing mean bias. The size of each point is proportional to the standard deviation of the off-nadir bias time series for this scan.

NOAA-15 Channel 6 Frequency Shift Correction

- Also based on pixel level radiative transfer simulations
  - Same input parameters as sensor incidence angle effect correction



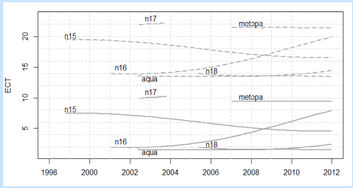
Global mean time series for the NOAA-15 AMSU-A channel 6 frequency shift correction term



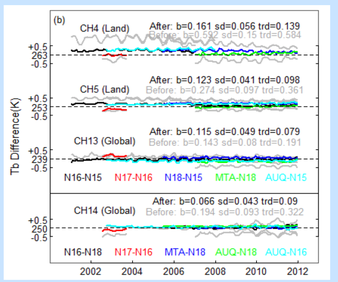
Global map of the multi-year averaged adjustments applied to NOAA-15 AMSU-A channel 6 by the frequency shift correction.

Diurnal Drift Effect Correction

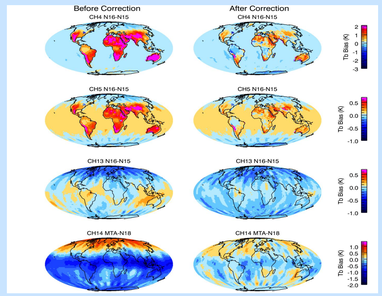
- CH 4-5 : using the RSS five-year averaged monthly diurnal anomaly climatology, with scaling factors of 0.917 & 1.875
- CH 13-14: using CRTM simulated multi-year averaged diurnal/semidiurnal anomaly climatologies



AMSU-A local equator crossing times

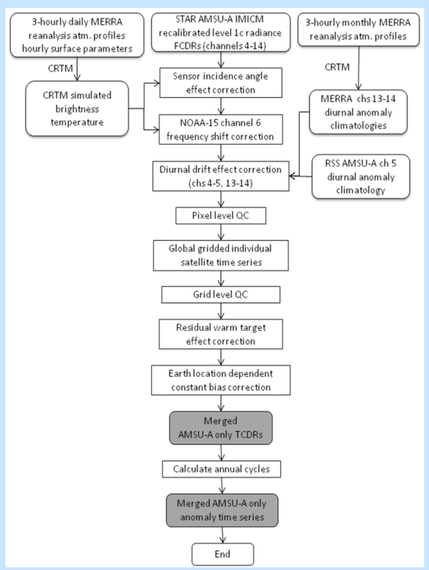


Global mean inter-satellite diff. time series for after the corrections of the sensor incidence angle effect and the diurnal drift effect. Time series for after the correction of the sensor incidence angle effect but before the correction of the diurnal drift effect were showed in the background (gray lines).



Multi-year averaged inter-satellite difference spatial patterns for before and after the correction of the diurnal drift effect.

Methodologies



Flowchart of the procedure for generating AMSU-A only TCDRs

Pre-merging Adjustments to Level 1c Radiances:

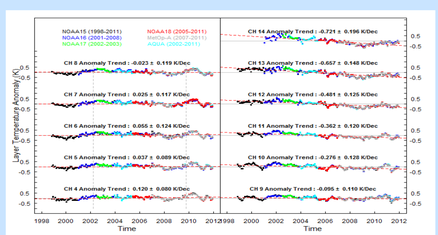
$$T_{O,i,\theta 0,f0,t0} = T_{O,i,\theta,f,t} + \Delta T_\theta + \Delta T_f + \Delta T_t$$

- ΔT_t: correction term for the diurnal drift effect
- ΔT_f: correction term for the NOAA-15 channel 6 frequency shift effect
- ΔT_θ: correction term for the sensor incidence angle effect
- $T_{O,i,\theta,f,t}$: IMICA recalibrated temperature before the adjustments
- $T_{O,i,\theta 0,f0,t0}$: Adjusted temperatures at nadir, local solar noon time, and pre-launch specified channel freq.

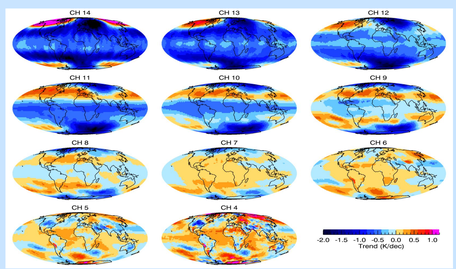
O -- satellite observations;
i -- AMSU-A channel (i = 4-14)
f -- channel central frequency (f_0 represents pre-launch specified channel central frequency)
t -- satellite observation time (t_0 represents local solar noon time);
θ -- sensor incidence angle (θ_0 represents nadir);

Major Trend Features in the AMSU-A TCDRs (1998-2011)

- **Warming in troposphere**
  - -- robust warming in lower troposphere (CH4)
- **Robust cooling in stratosphere**
  - -- systematic increase of stratospheric cooling trends as the center of channel weighting functions move higher
- **Lower and mid-troposphere (CH4-5) warming over tropics, but cooling over the US & China**



AMSU-A only TCDR global mean layer temperature anomaly time series and trends



Spatial trend patterns derived from AMSU-A only TCDRs (1998-2011 for channels 4-13, 2001-2011 for channel 14).

References

Zou, C.-Z., and W. Wang, 2011: Intersatellite calibration of AMSU-A observations for weather and climate applications. *J. Geophys. Res.*, **116,** D23113.

Zou, C.-Z., and W. Wang, 2009: Diurnal drift correction in the NESDIS/STAR MSU/AMSU atmospheric temperature climate data record *SPIE*, San Diego, CA.