NOAA Satellites and Information

National Environmental Satellite, Data, and Information Service

Radiance Performance of SNPP/ATMS in Comparison to Recalibrated POES/AMSU-A

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21st International TOVS Study Conference, 29 November- 5 December 2017, Darmstadt, Germany

Purpose

I) Evaluation of ATMS Radiance Performance for Climate Trend Detection

- MSU/AMSU-A has been used for creating atmospheric temperature Climate Data Record (CDR) for climate trend detection and monitoring
- The last NOAA satellite carrying AMSU-A is NOAA-19; EUMETSAT will launch its last AMSU-A on MetOp-C next year
- Evaluating the long-term radiance performance of ATMS is the first step toward this merging goal

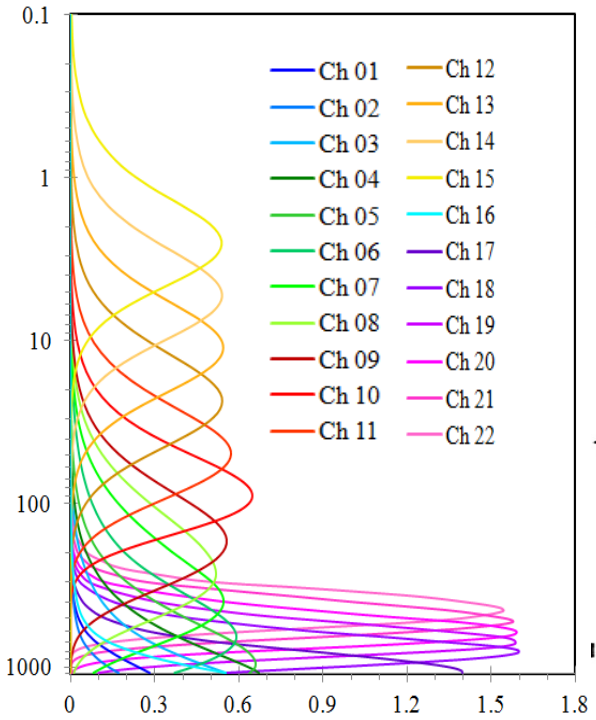
II) Examining the Idea of Using IMICA Re-calibrated MSU/AMSU-A Radiance FCDR as an In-Orbit Reference for Characterizing Biases of Other Microwave Instruments

- STAR has recalibrated AMSU-A temperature sounding channels using Integrated Microwave Inter-Calibration Approach (IMICA, Zou and Wang 2011, 2013)
- There is an interest in the GSICS microwave community to use the IMICA recalibrated MSU/AMSU-A as an in-orbit reference to monitor biases of other microwave instrument

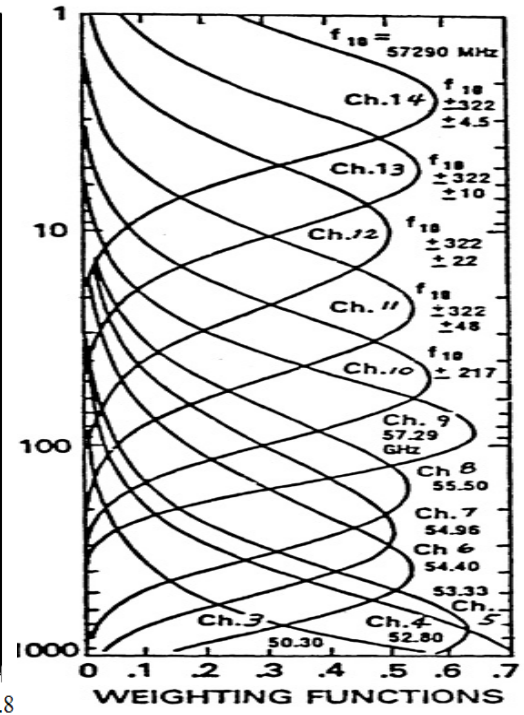
AMSU-A/ATMS Sounding Channels

- Focusing ATMS temperature sounding channels 5-15
- These channels have the same channel frequency as the AMSU-A channels 4-14

ATMS



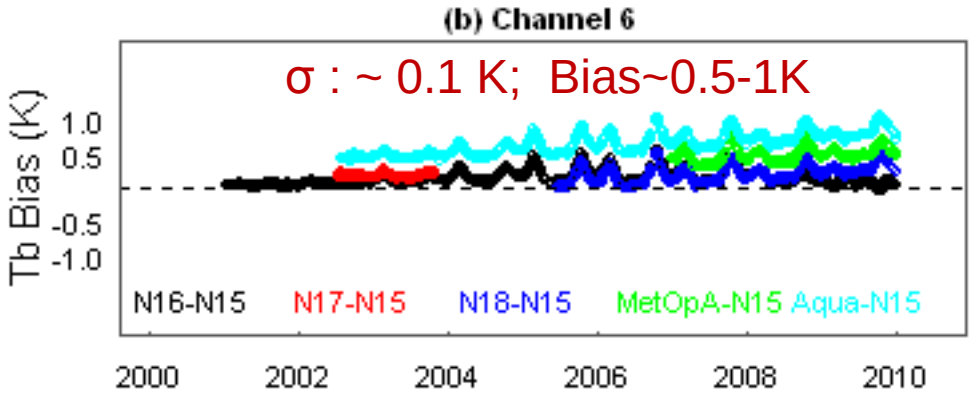
AMSU-A



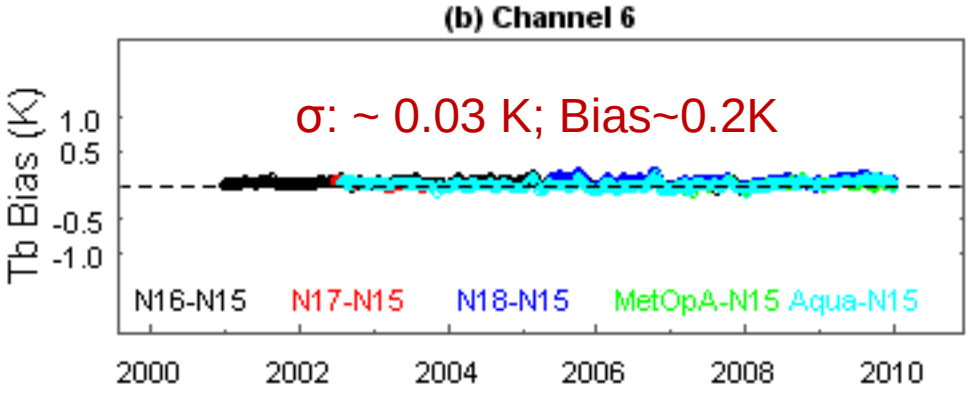
Integrated Microwave Inter-Calibration Approach (IMICA)

- Calibration coefficients were determined by satellite overlap observations
- Calibration coefficients were fixed over the entire life cycle of a satellite
- Using SNO, CRTM, global-ocean means, etc. as tools to calculate calibration coefficients
- Remove or minimize time-varying inter-satellite biases

Before Recalibration (Operational Calibrated)

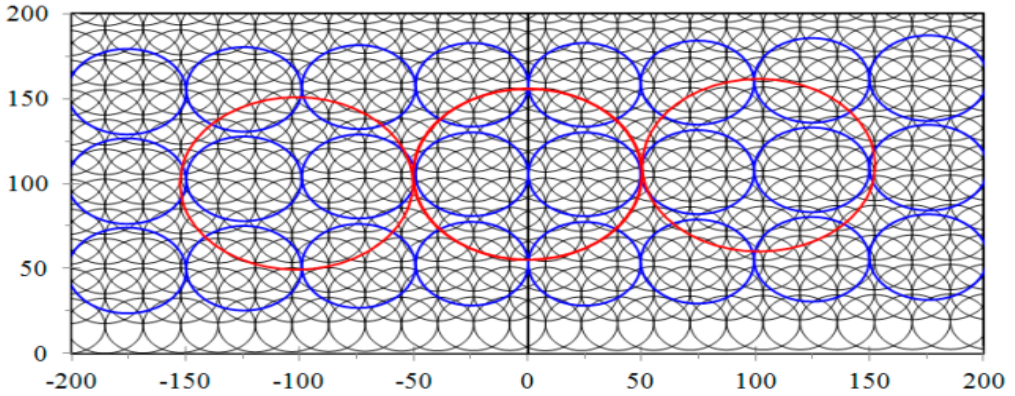


After Recalibration (IMICA recalibrated)

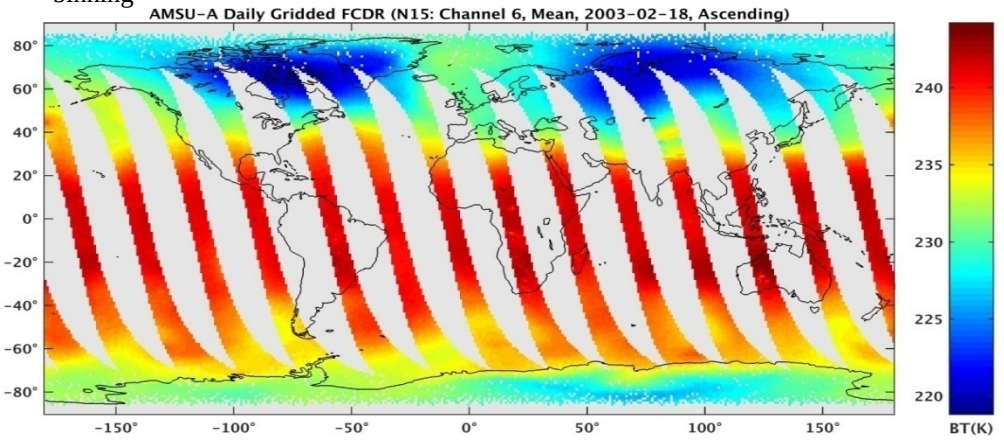


Data Processing Approach

- IMICA calibrated AMSU-A data include limb-adjustment to convert footprints at different angles to nadir observations
- Generate daily and monthly gridded maps for limb-adjusted data from multiple scan positions
- Grid resolution is 1° by 1° lat/lon
- Long-term monthly time series were generated from these maps
- Similar ATMS gridded data were generated from nadir-only observations (observations with scan angles less than 3.3°)
- For both AMSU-A and ATMS, each daily grid cell contains multiply FOVs to reduce noise

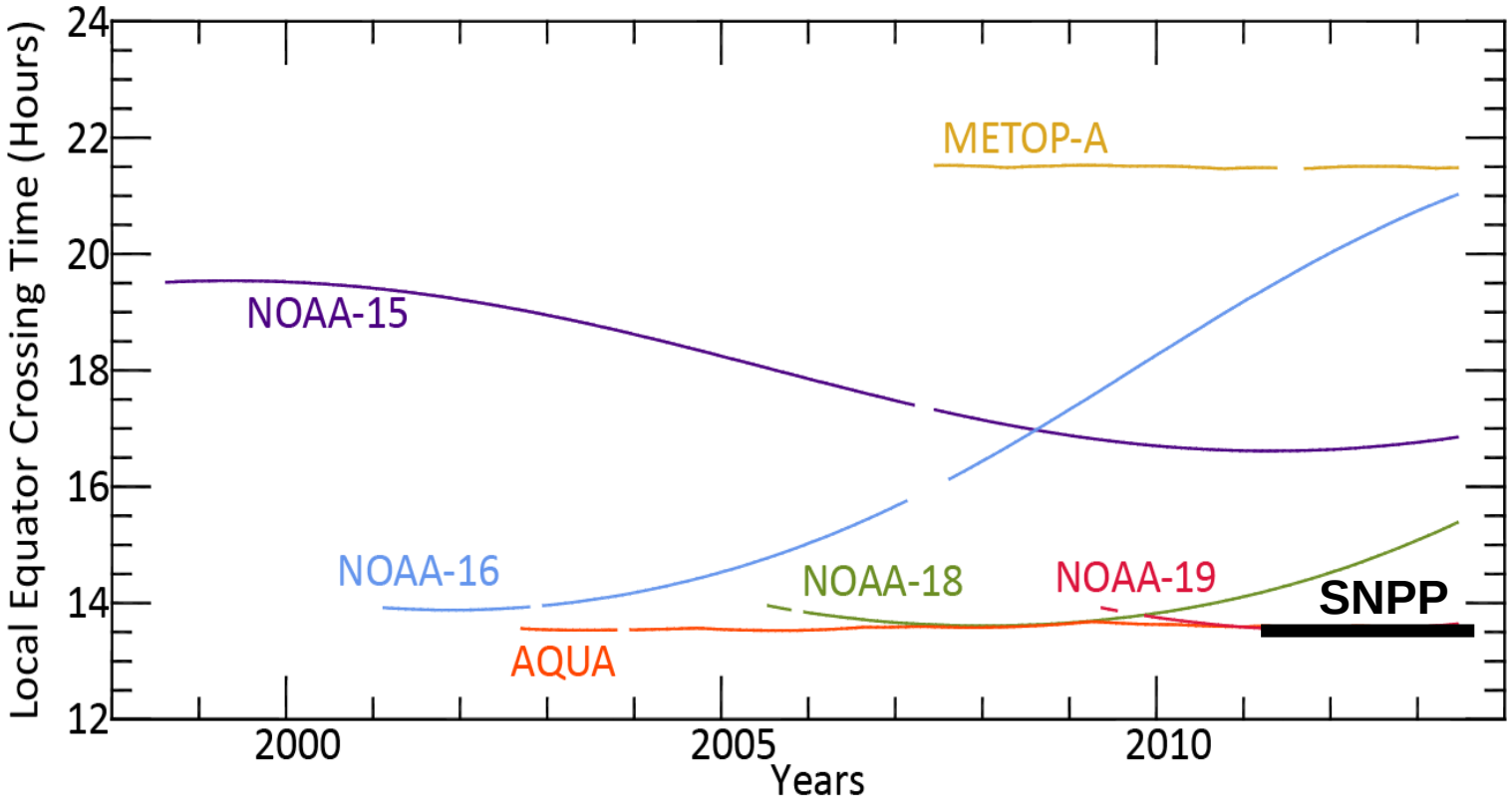


Scanning patterns of AMSU-A (blue) and ATMS (black). The unit is kilometer for both the horizontal and vertical coordinates. The beam widths of FOVs are 3.3° and 2.2° for AMSU-A and ATMS, respectively. Red circle indicates grid boxes for binning



Lower Panel: AMSU-A FCDR daily gridded map for limb-adjusted multi-pixel means

POES Satellite Orbital Drifts

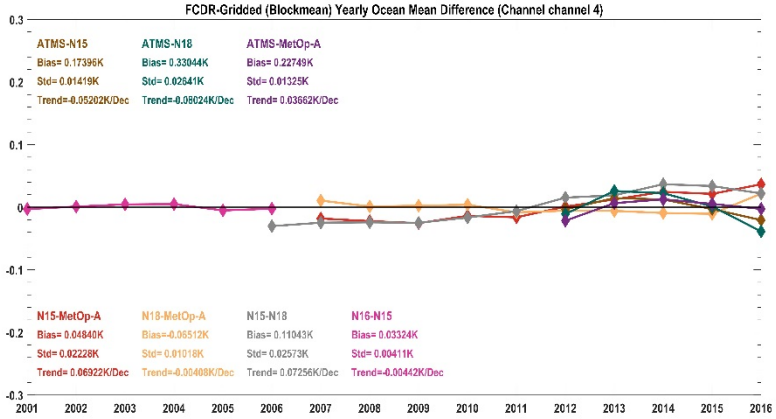


Possible Reasons Causing Inter-Satellite Biases

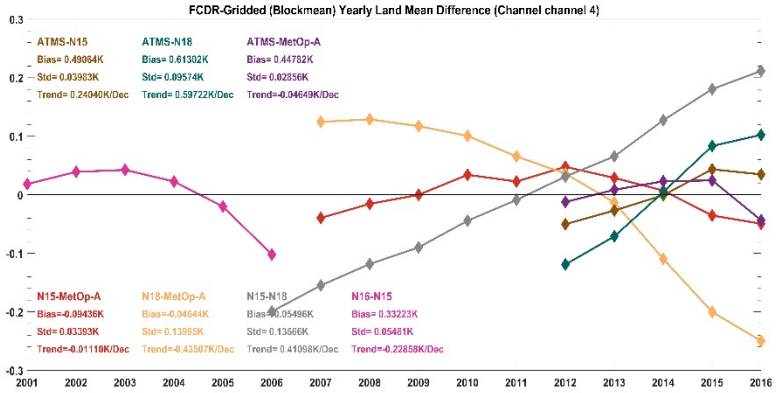
- **Calibration biases**
  - Errors in warm target temperature
  - Errors in cold space view temperature
  - Inaccurate calibration nonlinearity
- **Sampling Biases**
  - Diurnal differences between satellites

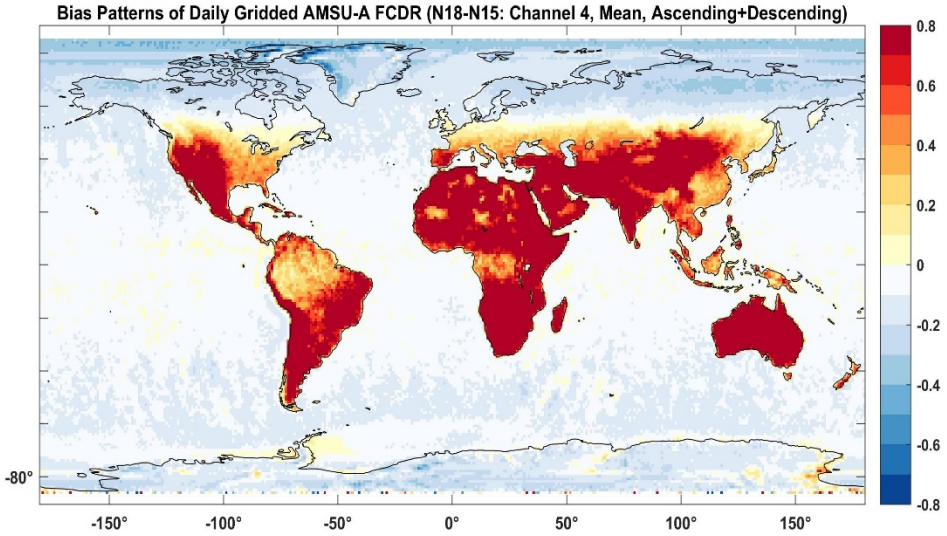
Impact of Diurnal Drift on Inter-Satellite Biases

Yearly Mean Inter-sensor Biases Over Ocean



Yearly Mean Inter-sensor Biases Over Land





Long-term mean bias pattern between NOAA -18 and NOAA-15 for channel 4

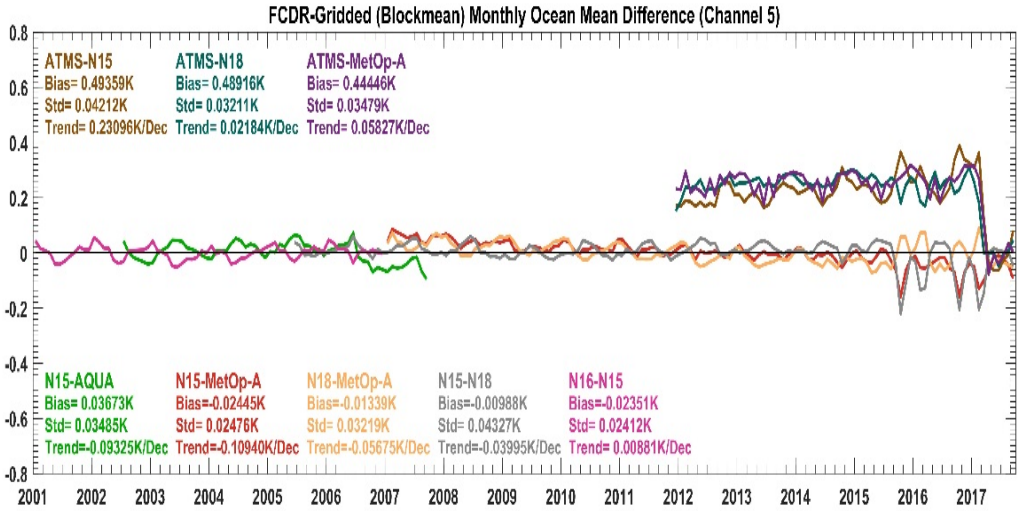
If diurnal drift effects are large, values of inter-satellite biases depend on time periods selected for the calculation

Inter-Sensor Biases Between POES/AMSU-A and SNPP/ATMS

Inter-Sensor Biases: ATMS-AMSU
time period is 12/2011-02/2017

AMSU/ATMS Channels	N18-N15	N18-Aqua	ATMS-N18	ATMS-Aqua
# of months	148	148	63	63
4/5	-0.11	0.07	0.33	Aqua ch4
5/6	0.01	0.03	0.49	Aqua ch4
6/7	N15 ch6	0.11	1.17	Aqua ch4
7/8	-0.02	-0.18	0.88	0.66
8/9	-0.06	-0.18	0.32	0.09
9/10	-0.10	-0.18	0.48	0.25
10/11	-0.04	-0.03	0.62	0.57
11/12	N15 ch11	-0.06	0.59	0.54
12/13	N15 ch11	0.07	0.82	0.87
13/14	N15 ch11	0.11	0.87	0.97
14/15	N15 ch14	-0.08	0.23	0.16

AMSU-A channel 5 vs ATMS Channel 6



Inter-satellite difference time series of global ocean mean brightness temperatures from AMSU-A observations between POES satellite pairs and those between POES AMSU-A and SNPP ATMS

Possible Reasons Causing Non-Zero Trends in Inter-Satellite Difference Time Series

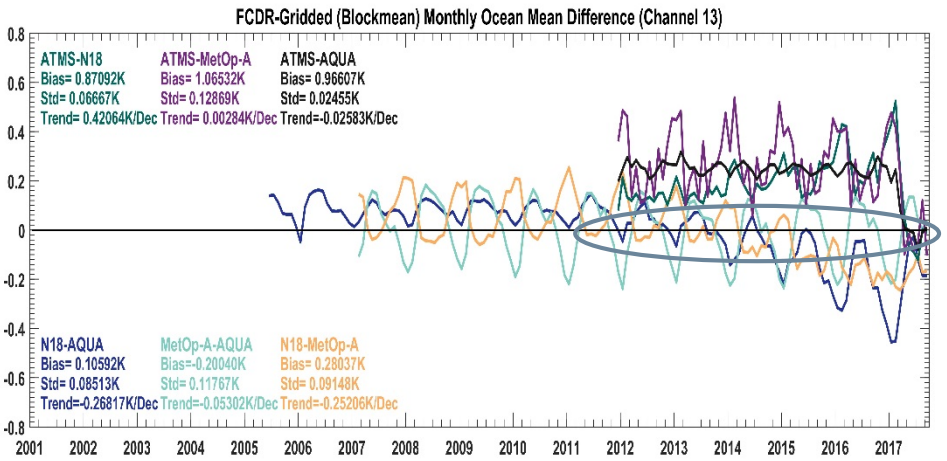
- **Diurnal drifts between satellites**
- **End-point effects**
- **Calibration drift due to inaccurate calibration**
- **Calibration changes**

Absolutely Stability of ATMS Radiances

Trends (K/Dec) of Inter-Sensor Difference Time Series

	N18-N15	N18-Aqua	ATMS-N18	ATMS-Aqua
	148	148	63	63
4/5	-0.064	Aqua ch4	-0.059	Aqua ch4
5/6	0.039	Aqua ch4	0.021	Aqua ch4
6/7	N15 ch6	Aqua ch4	-0.116	Aqua ch4
7/8	0.049	-0.099	0.086	**-0.012**
8/9	-0.085	-0.166	0.088	**0.029**
9/10	0.017	-0.135	0.008	**-0.026**
10/11	-0.015	-0.052	-0.017	**0.011**
11/12	N15 ch11	-0.071	-0.010	**-0.016**
12/13	N15 ch11	-0.160	0.234	**-0.020**
13/14	N15 ch11	-0.268	0.420	**-0.025**
14/15	N15 ch14	-0.352	0.493	**-0.018**

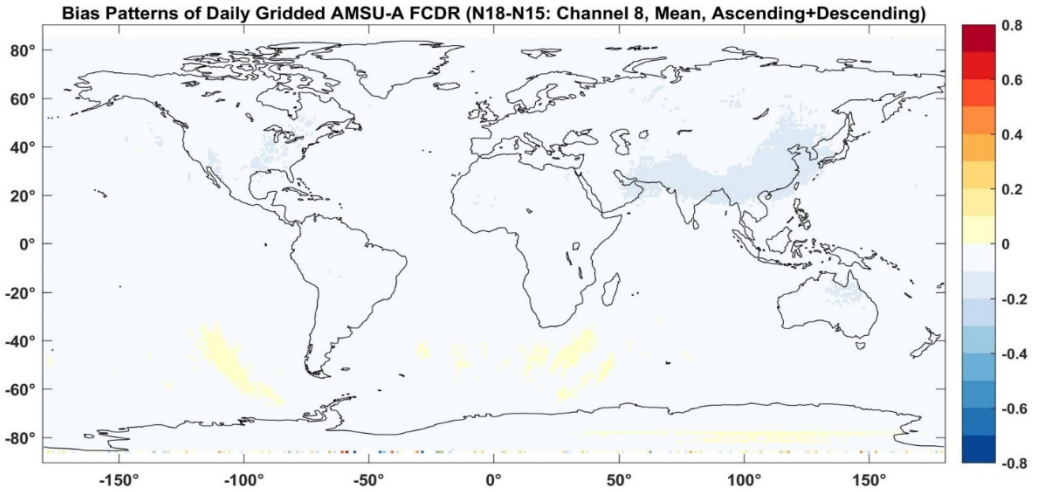
AMSU-A ch13 vs ATMS ch14

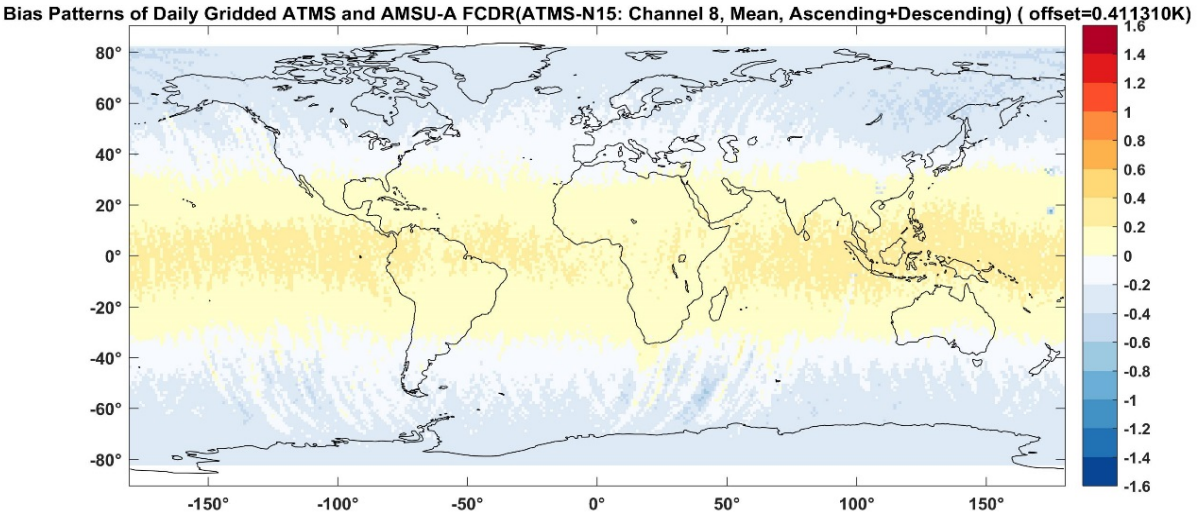


- ATMS-Aqua reached a stability at 0.02K/Dec for all channels; This is good enough for trend detection.
- Because both satellites are calibrated independently, this suggested that both ATMS and Aqua reached an absolute stability within 0.02K/Dec.
- This number could get smaller when overlaps get longer

Scene Temperature Dependent Biases in ATMS

- ATMS shows scene temperature dependent biases; suggesting its calibration nonlinearity is not accurate

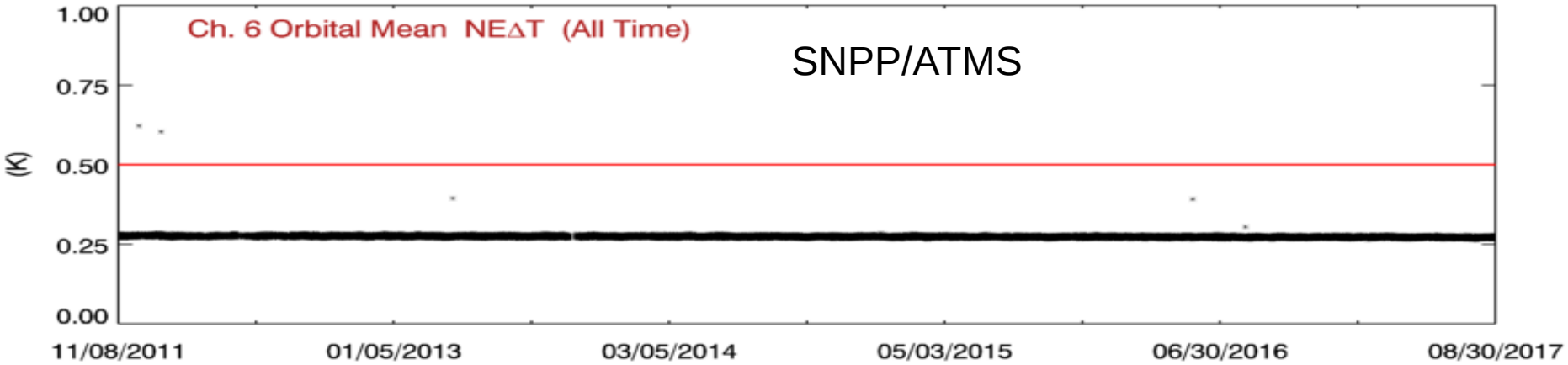


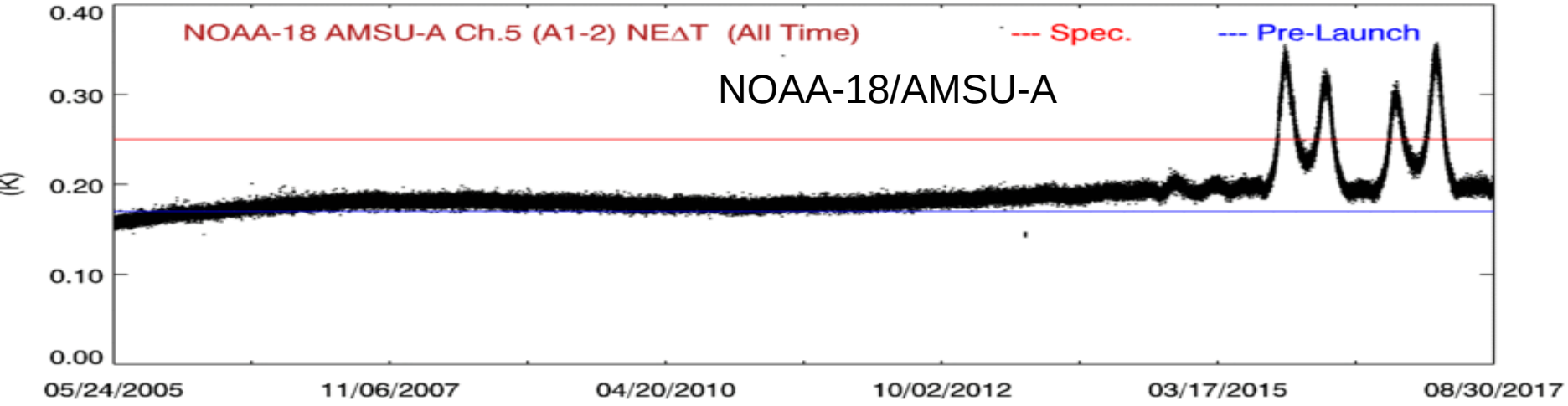


Conclusion

- ATMS had a calibration change in March 2017, causing bias jumps relative to reference satellite
- ATMS are warmer than IMICA calibrated AMSU-A for all channels before March 2017
- ATMS channel 5 is likely to have a frequency mismatch with AMSU-A channel 4 on the order of 10 MHz
- ATMS radiances reached a absolute stability within 0.02K/Dec for all temperature sounding channels
- Calibration nonlinearity of ATMS are inaccurate for certain channels
- NOAA-16 needs further recalibration since the calibration coefficients determined from overlaps before 2010 cannot fully describe its behavior afterwards
- ATMS needs reprocessing/recalibration
- Using re-calibated/inter-calibrated AMSU-A data as a reference provides useful information on ATMS radiance performance

Backup Slide: Instrument Stability





Backup slide: Possible Reasons Causing Seasonal Variability In Inter-Satellite Difference Time Series

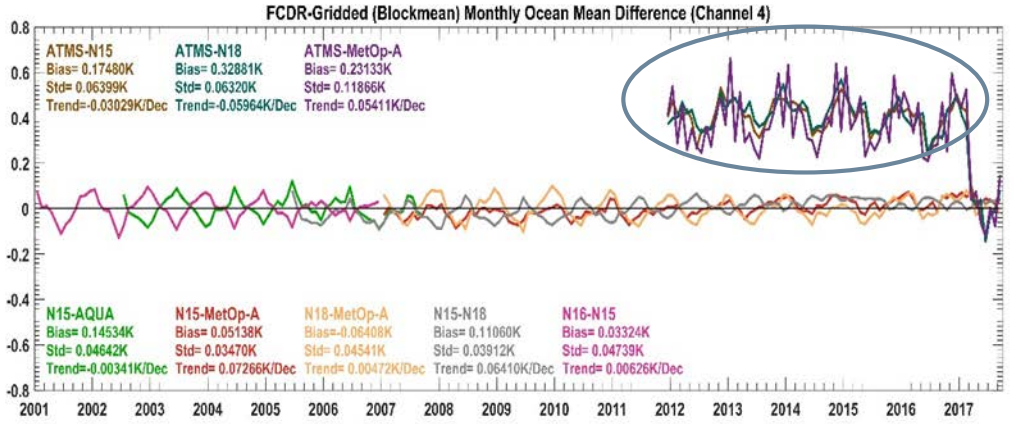
- **Diurnal differences between satellites**
- **Frequency mismatch**
- **Sun-heating inducted instrument temperature variability in radiances due to inaccurate calibration**

  (for IMICA recalibrated AMSU-A data, this effect was minimized because more accurate calibration coefficients were developed and used in the calibration, Zou and Wang 2011)

Backup slide: Standard Deviation Tells Potential Issues in Channel Observations

AMSU/ATMS Channels	N18-N15	N18-Aqua	ATMS-N18	ATMS-Aqua
	148	148	63	63
4/5	0.032	Aqua ch4	0.063	Aqua ch4
5/6	0.043	Aqua ch4	0.032	Aqua ch4
6/7	N15 ch6	Aqua ch4	0.058	Aqua ch4
7/8	0.031	0.033	0.033	***0.026***
8/9	0.020	0.024	0.037	***0.019***
9/10	0.023	0.023	0.023	***0.019***
10/11	0.027	0.016	0.033	***0.025***
11/12	N15 ch11	0.025	0.027	***0.017***
12/13	N15 ch11	0.051	0.042	***0.022***
13/14	N15 ch11	0.085	0.067	***0.024***
14/15	N15 ch14	0.093	0.073	***0.016***

ATMS ch5 needs investigation



AMSU-A ch11 vs ATMS ch12 for a comparison