

Bias Characterization for Five-year Reprocessed S-NPP ATMS Data Using RO Data from COSMIC, MetOp-A/-B and KOMPSAT

Xiaolei Zou

Earth System Science Interdisciplinary Center (ESSIC)
University of Maryland, USA

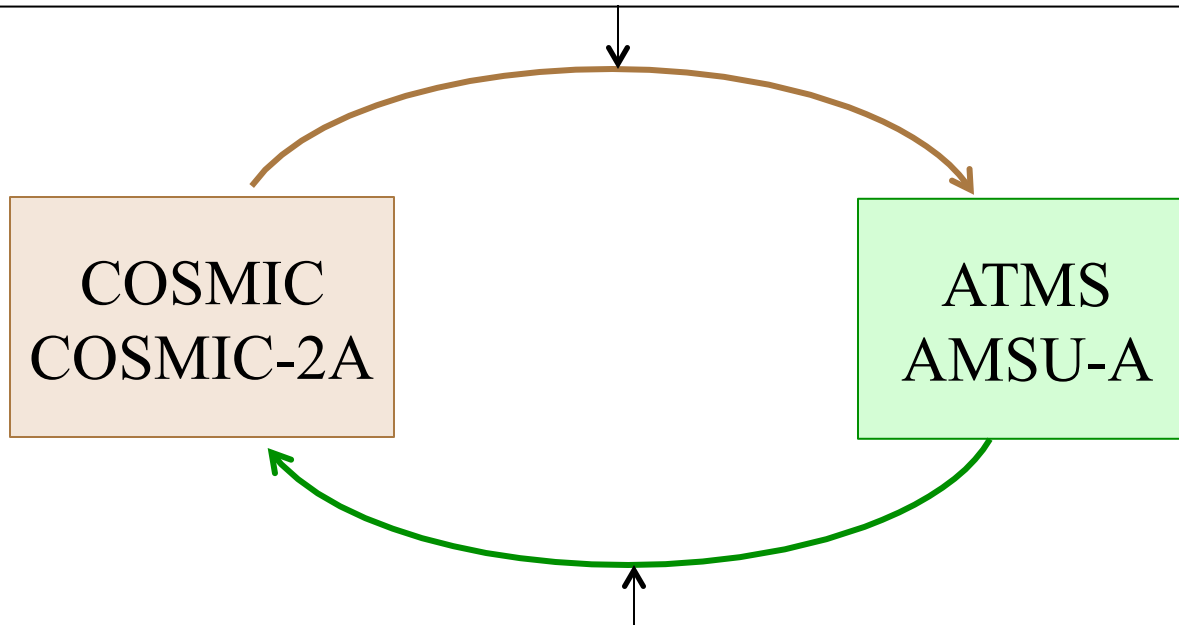
Presented by Lin Lin

March 2018

- Data Description
- Quality Control (QC) Scheme
- Comparison of ATMS Biases with and without QC
- Comparison of ATMS Biases between Operational and Reprocessed Data
- Annual Variability of ATMS Biases at Nadir
- Scan-dependent Biases and their Annual Variability
- Summary

Mutual Benefits between ROs and Microwave Sounding Data

Post-launch calibration for ATMS/AMSU-A using ROs due to the fact that ROs have no bias in no heavy precipitation conditions



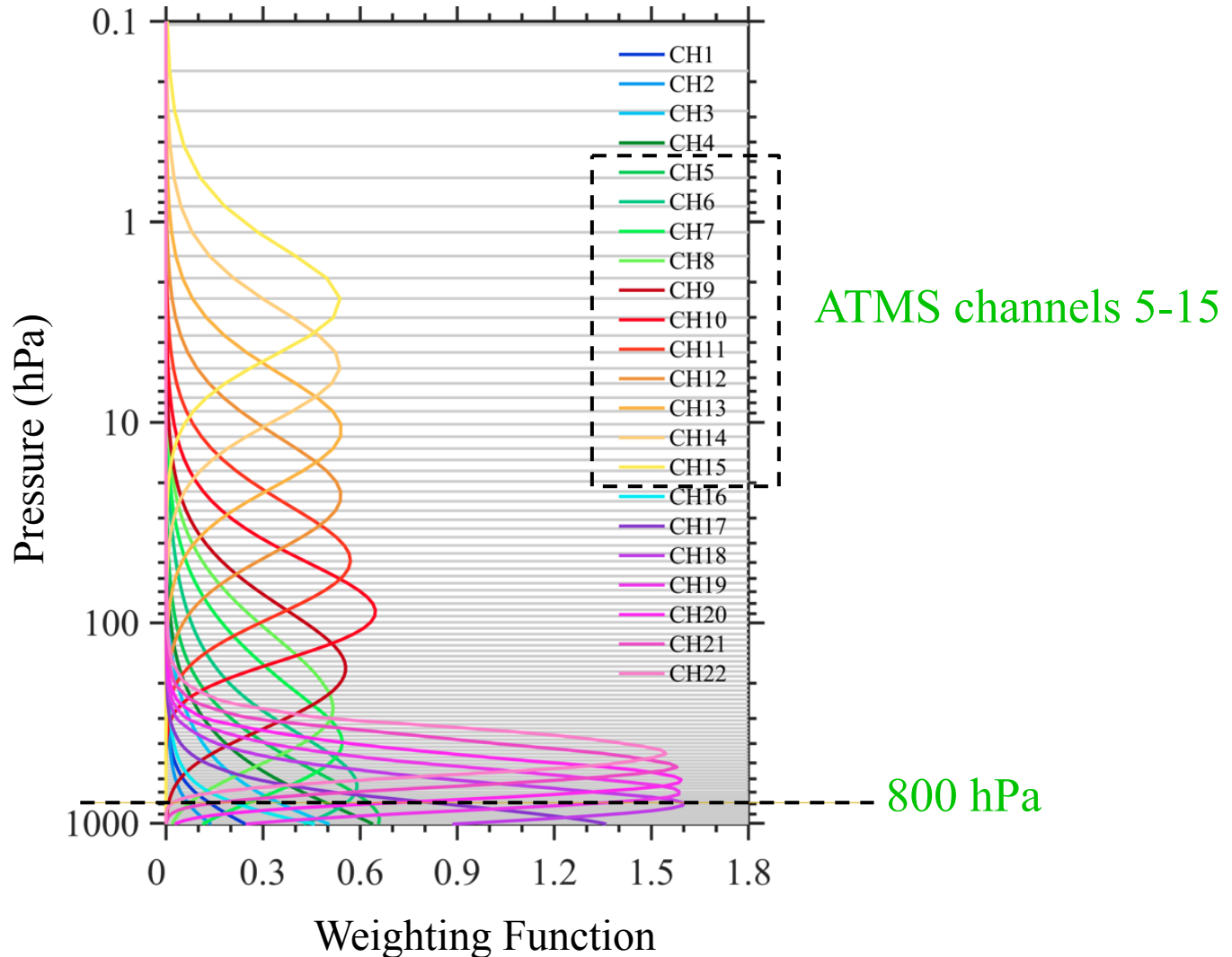
Provide information on the presence of cloud and precipitation and validation of RO Level-2 temperature using ATMS/AMSU-A retrieval

ATMS Instrument Characteristics

Channel NO.	Frequency (GHz)	NE Δ T (K)	Beam Width (deg)	Peak WF (hPa)	
1	23.8	0.5	5.2	Surface	Surface sensitive channels
2	31.4	0.6	5.2	Surface	
3	50.3	0.7	2.2	Surface	
4	51.76	0.5	2.2	950	Temperature sounding channels
5	52.8	0.5	2.2	850	
6	53.596 \pm 0.115	0.5	2.2	700	
7	54.4	0.5	2.2	400	
8	54.94	0.5	2.2	250	
9	55.5	0.5	2.2	200	
10	57.29	0.75	2.2	100	
11	57.29 \pm 0.217	1	2.2	50	
12	57.29 \pm 0.322 \pm 0.048	1	2.2	25	
13	57.29 \pm 0.322 \pm 0.022	1.25	2.2	10	
14	57.29 \pm 0.322 \pm 0.010	2.2	2.2	5	
15	57.29 \pm 0.322 \pm 0.0045	3.6	2.2	2	
16	88.2	0.3	2.2	Surface	Window channels
17	165.5	0.6	1.1	Surface	
18	183.31 \pm 7.0	0.8	1.1	800	Humidity sounding channels
19	183.31 \pm 4.5	0.8	1.1	700	
20	183.31 \pm 3.0	0.8	1.1	500	
21	183.31 \pm 1.8	0.8	1.1	400	
22	183.31 \pm 1.0	0.9	1.1	300	

ATMS Weighting Functions

Vertical Distribution of Weighting Functions for 22 ATMS Channels



Four-Step QC Procedure (1/4)

A four steps quality control (QC) procedure for data selection:

Step 1: A Range Check

- RO profiles cover the layer 50-800 hPa
- T (unit: K) and N (unit: N unit) are positive

Step 2: Observation outliers are eliminated

- Observation with a z-score greater than 2.5

Step 3: Simulation outliers are eliminated

- Simulation with a z-score greater than 3.5

Step 4: O-B^{ECMWF} outliers are eliminated

- O-B with a z-score greater than 2.5

Given a sample $\{X_i, i=1, 2, \dots, n\}$,

Biweight Mean:

$$BM(X_i) = M + \frac{\sum_{i=1}^n (1-w_i^2)^2 (X_i - M)}{\sum_{i=1}^n (1-w_i^2)^2}$$

Biweight STD:

$$BSD(X_i) = \frac{\left(n \sum_{i=1}^n (1-w_i^2)^4 (X_i - M)^2 \right)^{1/2}}{\left| \sum_{i=1}^n (1-w_i^2)(1-5w_i^2) \right|}$$

Z-score:

$$Z_i = \frac{X_i - BM(X_i)}{BSD}$$

M — Median

MAD — Median absolute deviation

$$w_i = \frac{X_i - M}{7.5 \times MAD} \text{ — Weighting coefficient}$$

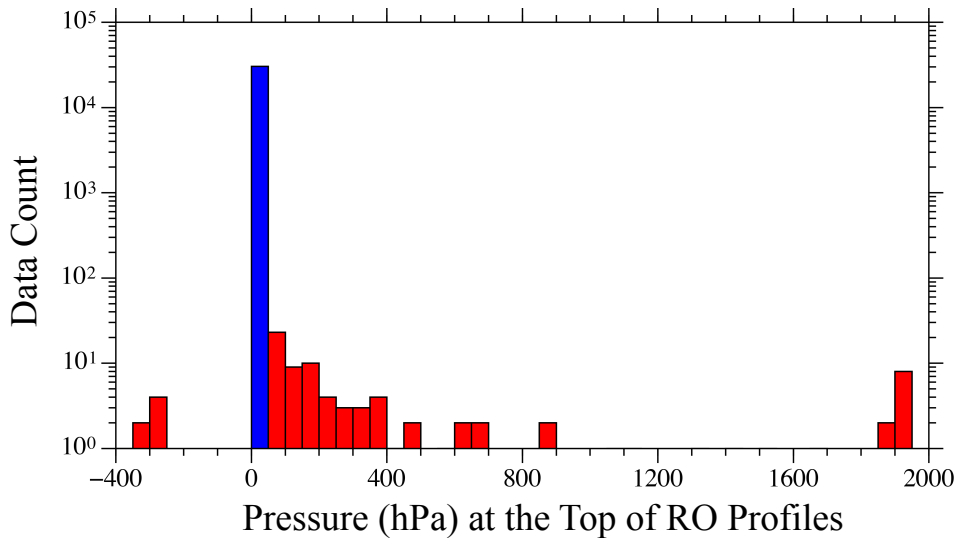
Some details of the above quality control (QC) can be found in the following article:

Zou, X. and Z. Zeng, 2006: A quality control procedure for GPS RO data. *J. Geoph. Res.*, **111**, D02112, doi:10.1029/2005JD005846.

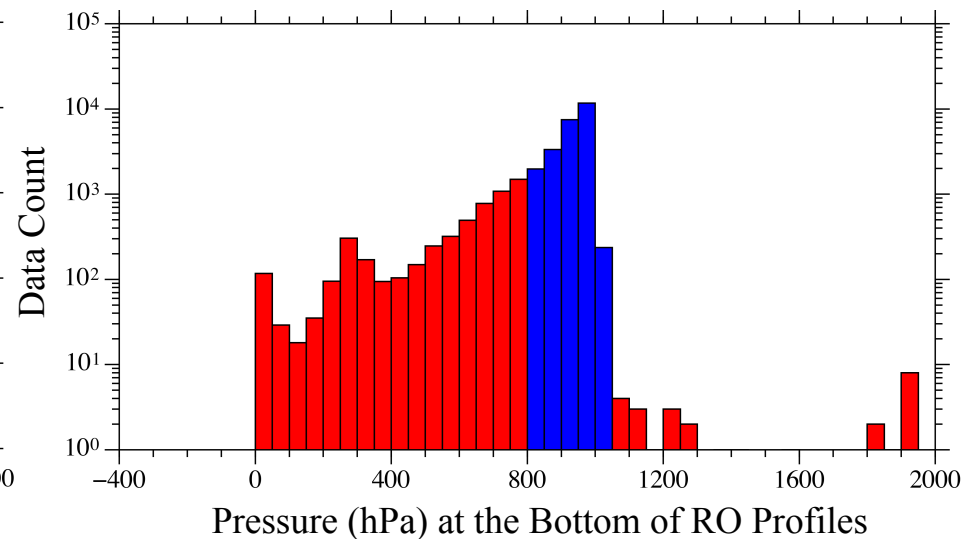
QC Step 1 — Range Check

COSMIC RO Data in January 2012 as an Example

RO Profile Top



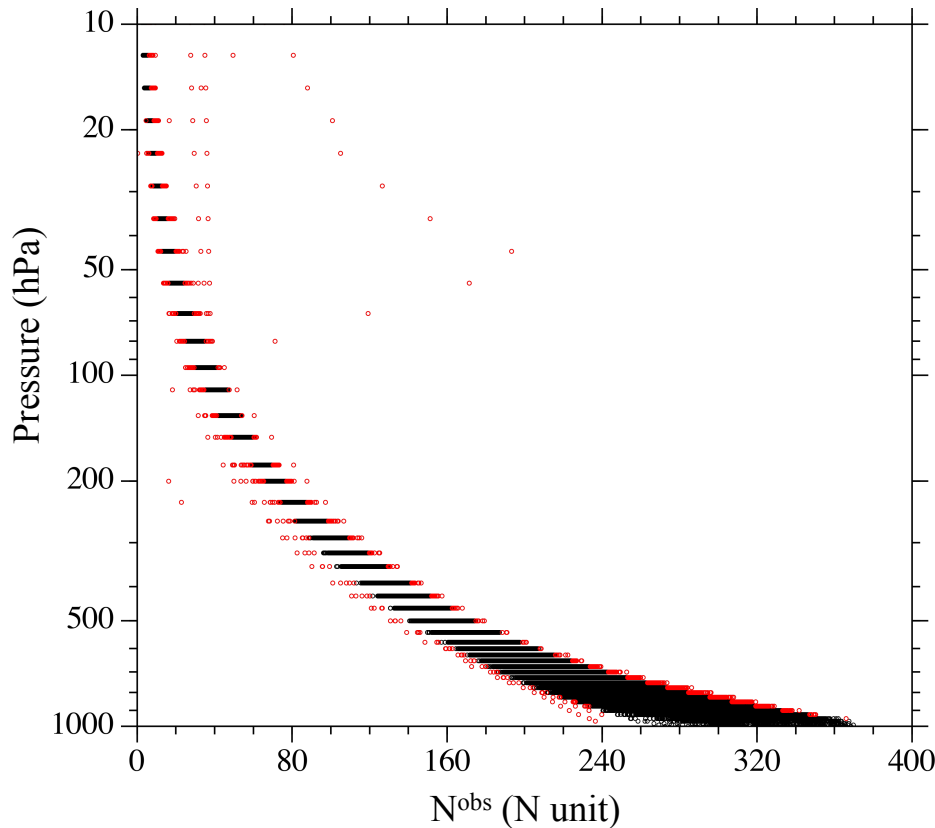
RO Profile Bottom



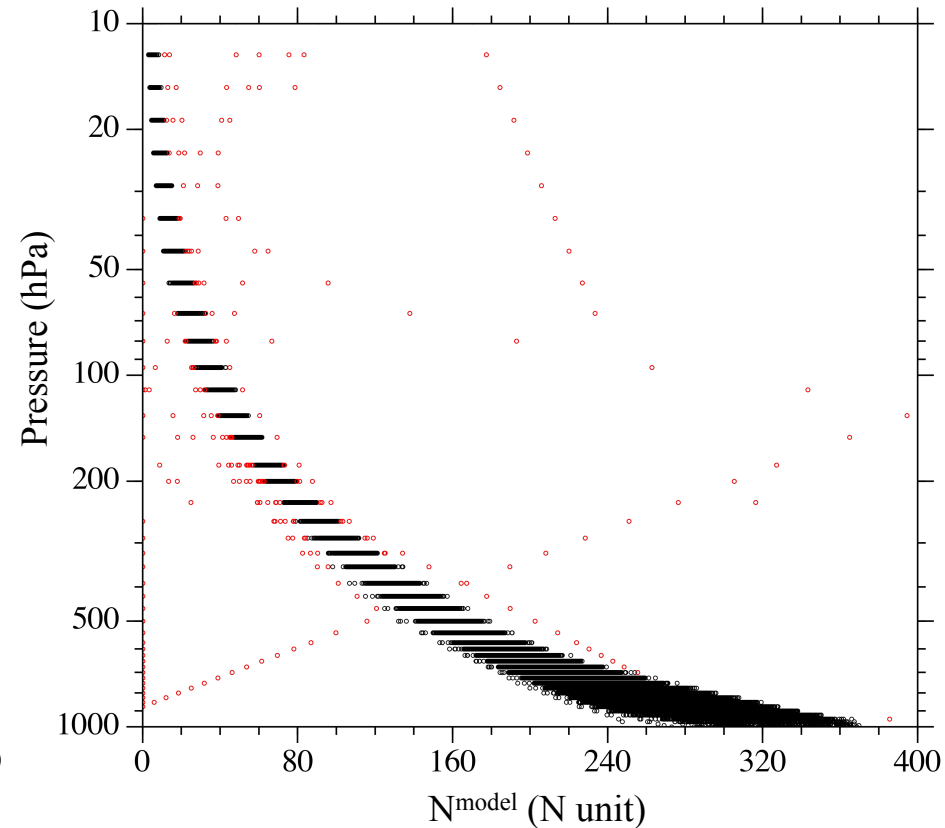
- The top of all selected RO profiles is above 50 hPa
- The bottom of all selected ROs reaches below 800 hPa

QC Steps 3 and 4 — Removing Outliers

QC Step 2 (Observation Outliers)

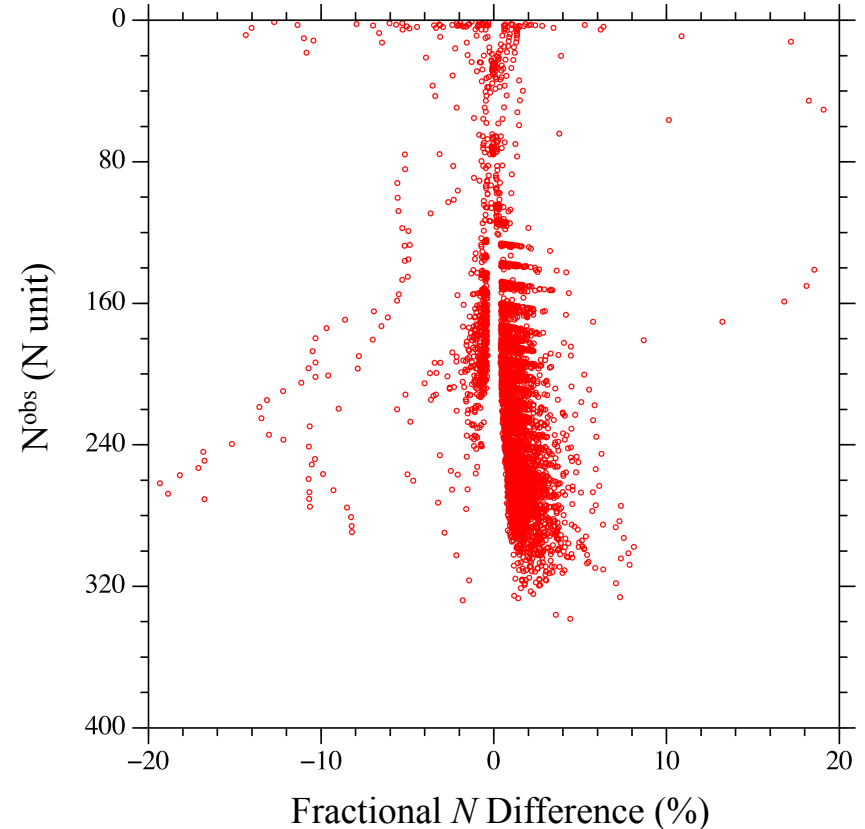
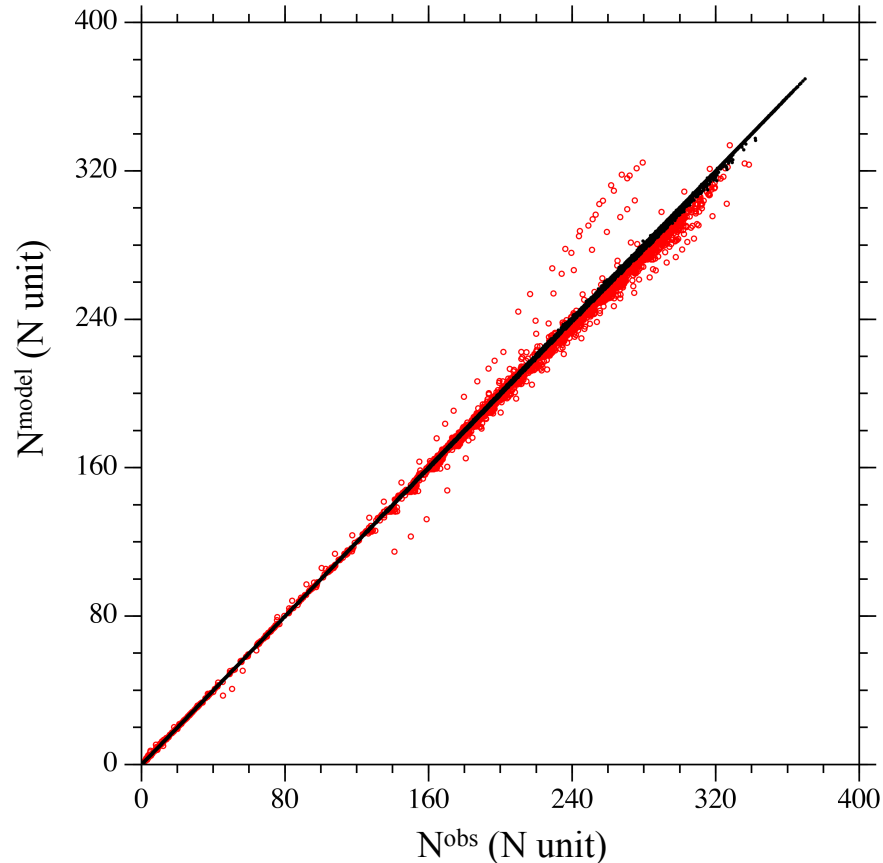


QC Step 3 (Simulation Outliers)



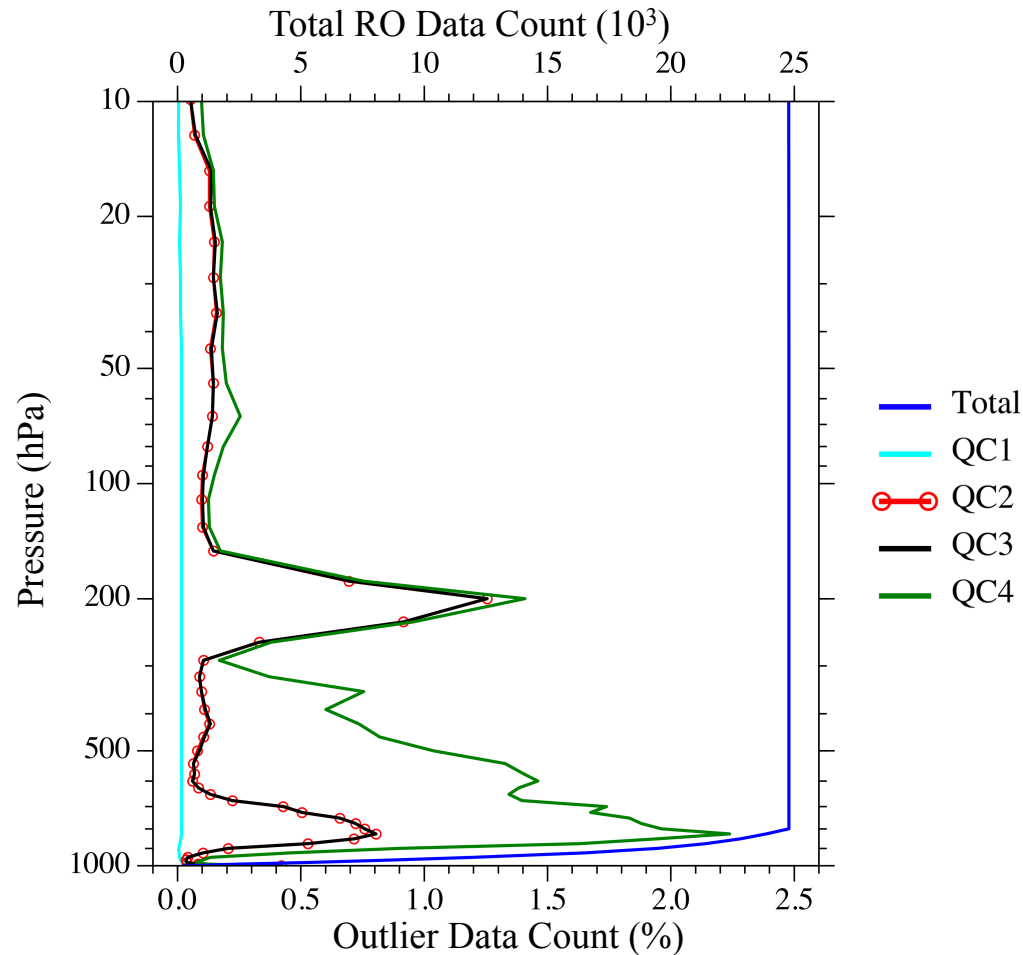
- RO data points that are removed by QC steps 1 and 2 are indicated in red
- Outliers (red) are found in observed (left) and simulated (right) refractivity

QC Step 4 — Removing O-B Outliers



- Some observations deviate greatly from model simulations
- Observations deviate **greatly** from model simulations are removed

Total Number of RO Data not Selected



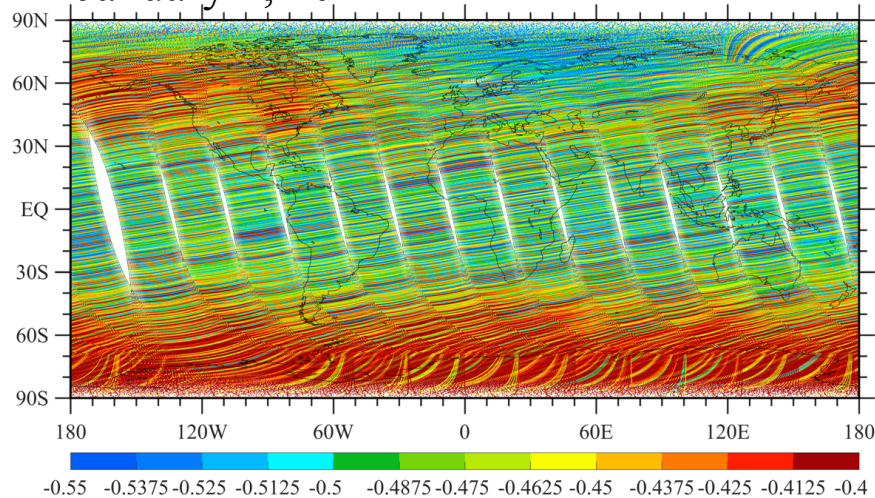
- Very little data are removed by the range check
- Outliers removed by QC steps 3 and 4 are less than 1.3%
- Data removed due to large O-B deviations are less than 2.2%
- More data are removed near 200 hPa and below 700 hPa

The S-NPP Life-Cycle Reprocessed ATMS Data

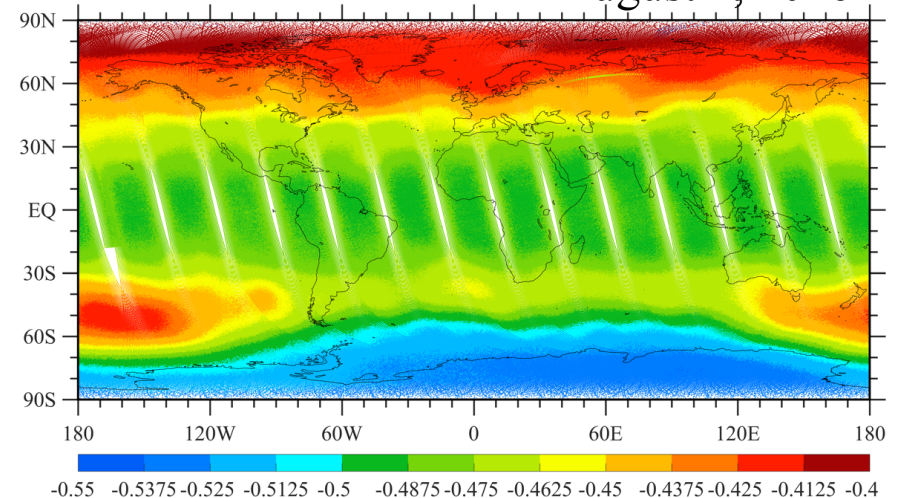
- Operational ATMS SDR data may have different bias characteristics over its life cycle due to constant updates of the cal/val algorithms
- Reprocessed ATMS SDR data are generated with the same cal/val algorithms throughout the S-NPP life cycle to remove calibration induced inconsistency
- The ATMS reprocessing involved a major update of a non-linearity coefficients correction (*wrong sign*)

DT_b of Ch10 (reprocessed minus operational)

January 2, 2012

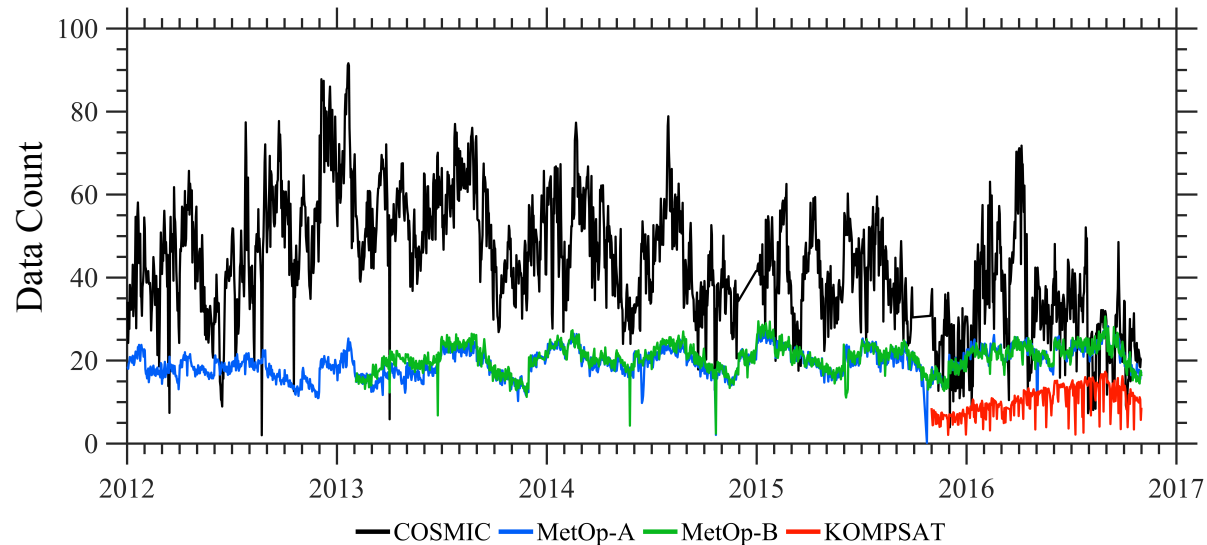


August 1, 2016

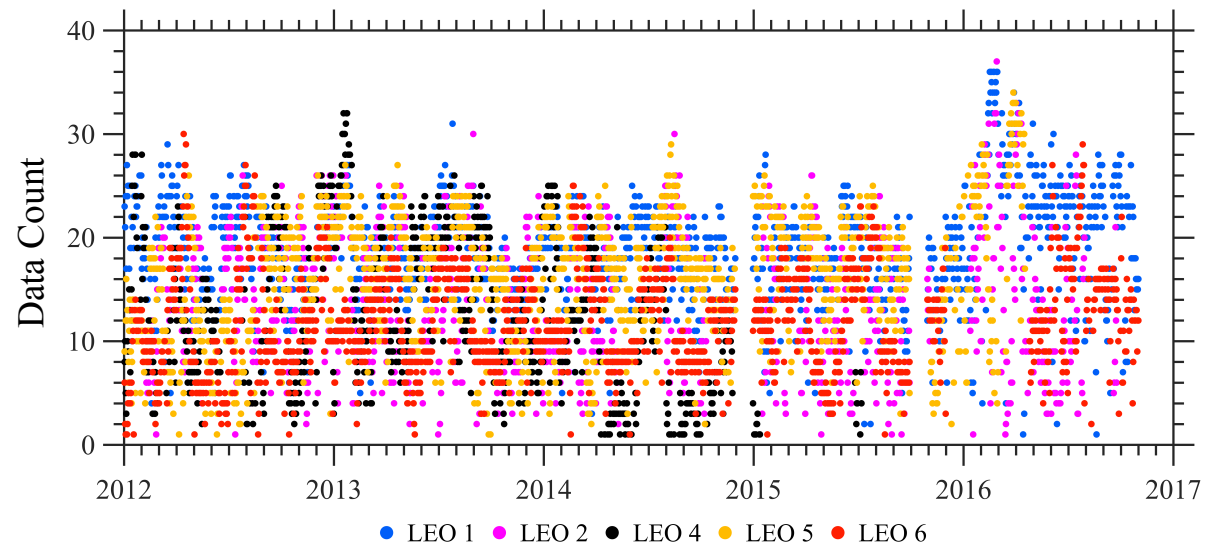


Selection of ATMS Data Bias at Nadir

Daily RO profile counts from
 COSMIC
 MetOp-A
 MetOp-B
 KOMPSAT
 Collocated with nadir ATMS



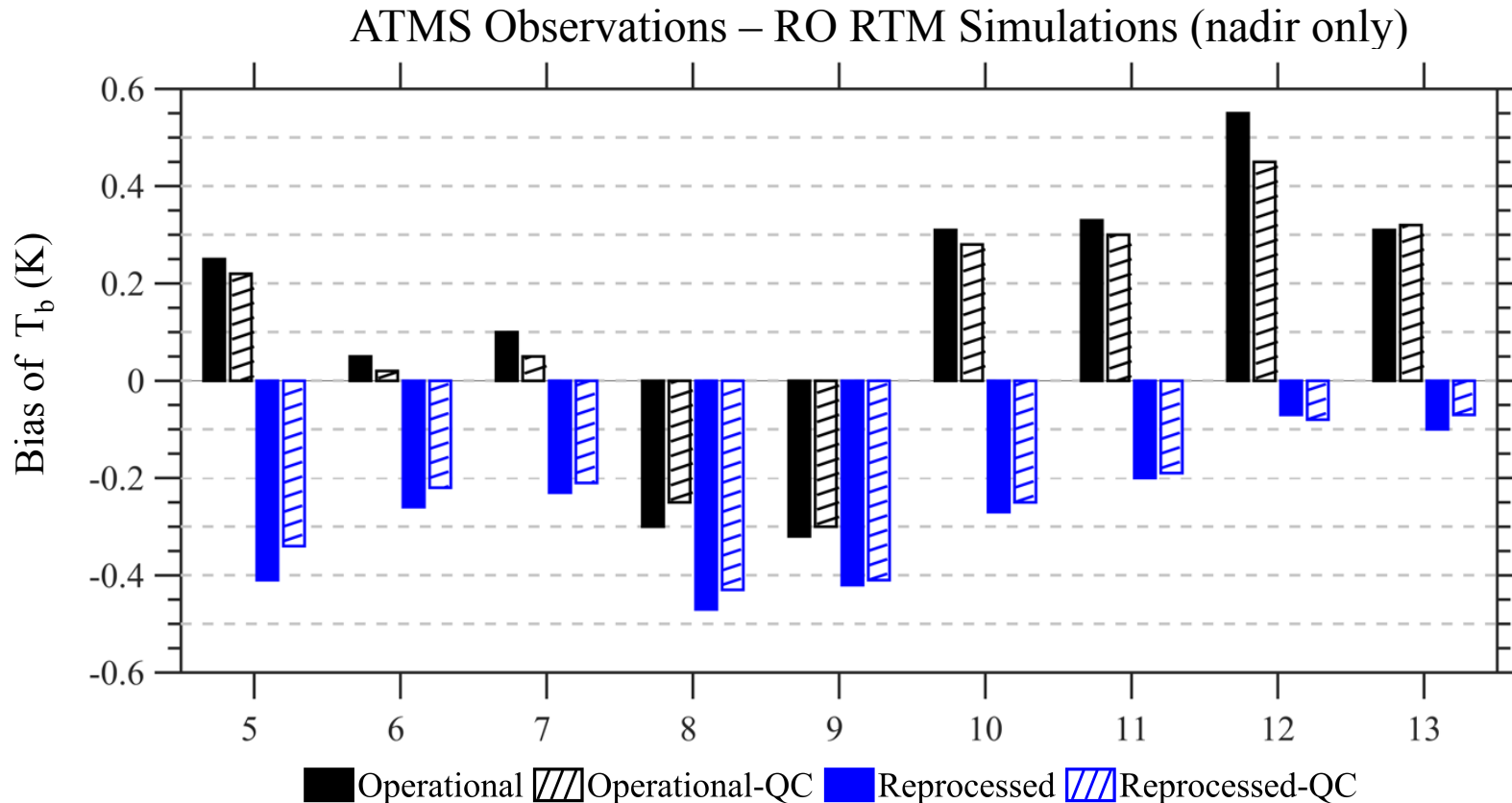
Daily COSMIC RO profile
 counts from
 LEO 1
 LEO 2
 LEO 4
 LEO 5
 LEO 6
 Collocated with nadir ATMS



(<50 km, <3 hours)

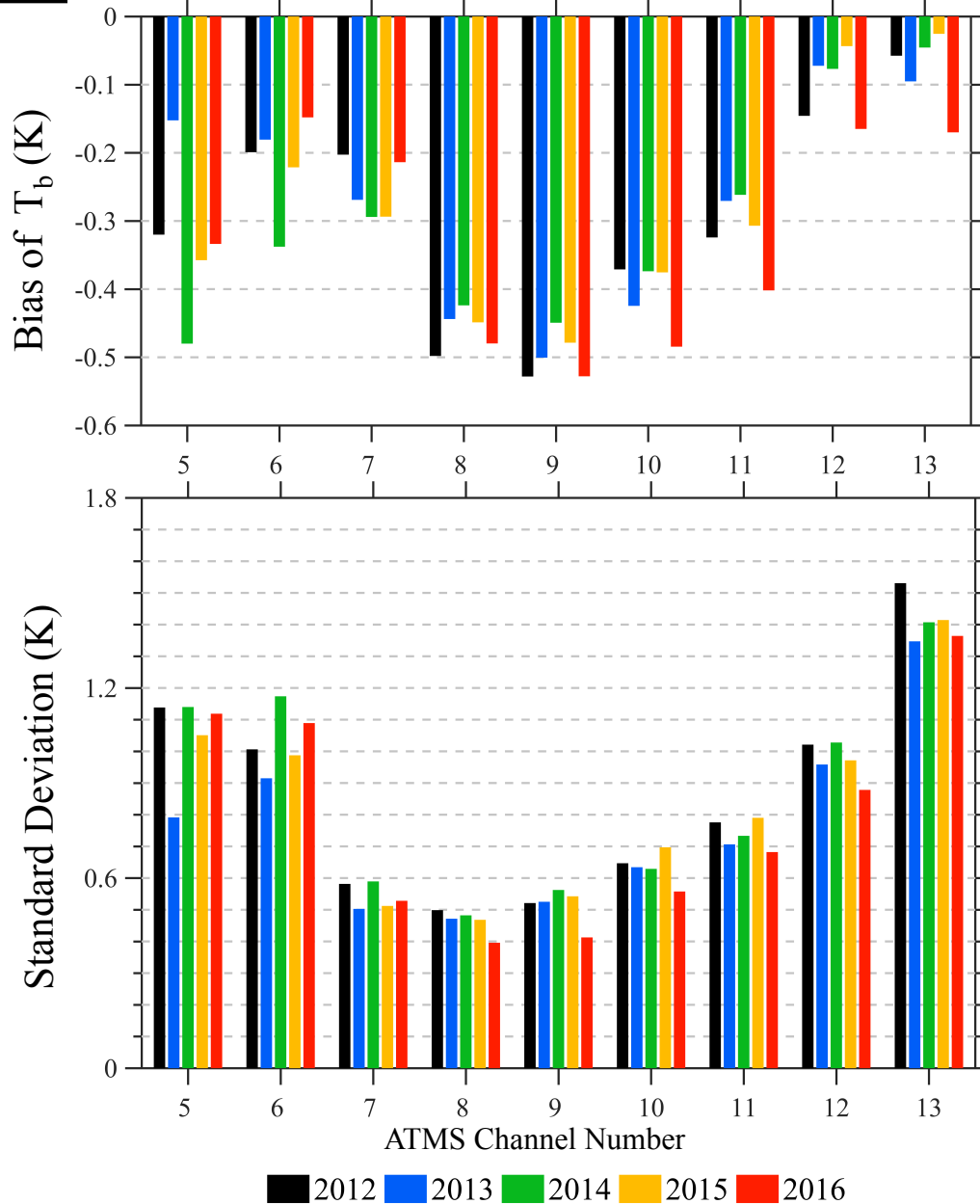
Importance of QC for Bias Estimate

Post-Launch Calibration of ATMS Channels 5-13 by COSMIC and MetOp-A RO Data in 2012



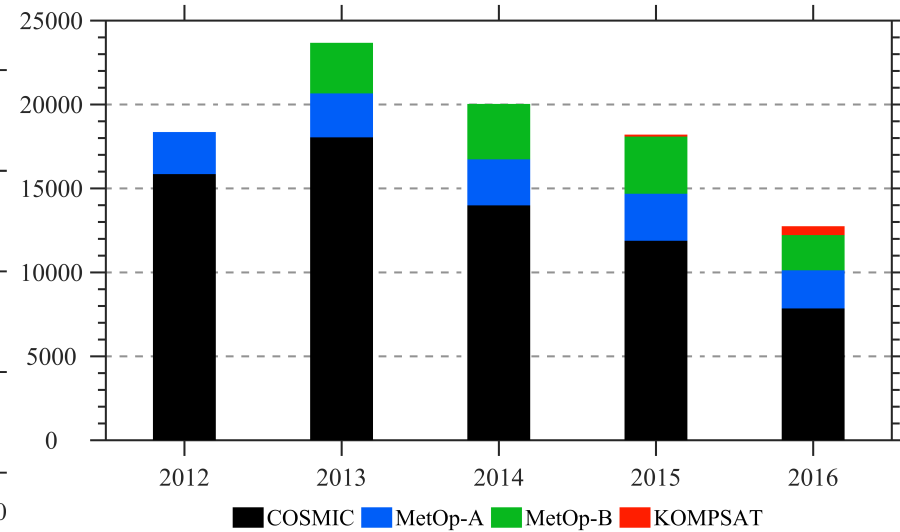
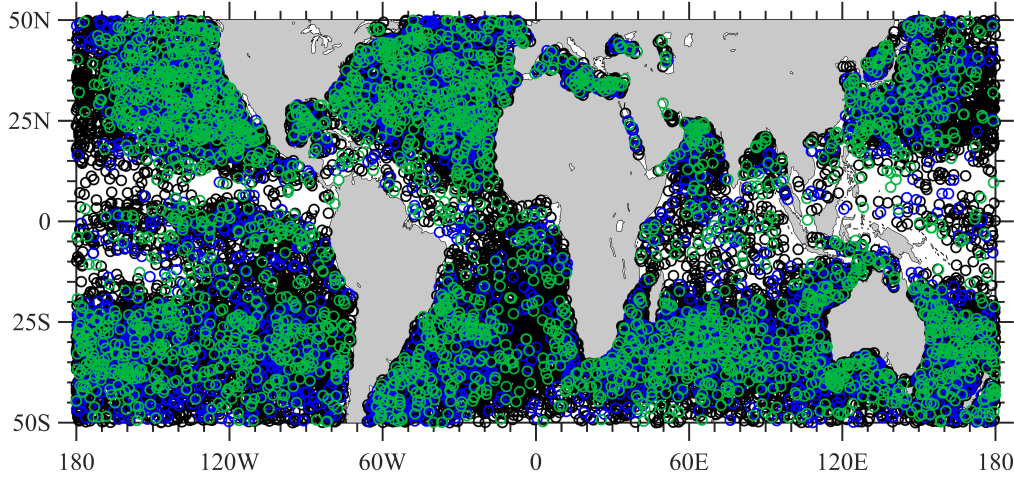
- Biases are consistently negative for reprocessed ATMS channels 5-13
- Impacts of the proposed RO QC on ATMS biases are noticeable (The QC eliminated less than 4% of RO data as outliers.)
- ATMS biases are significantly different between operational and reprocessed data

Annual Variability of ATMS Bias and Std. Dev.

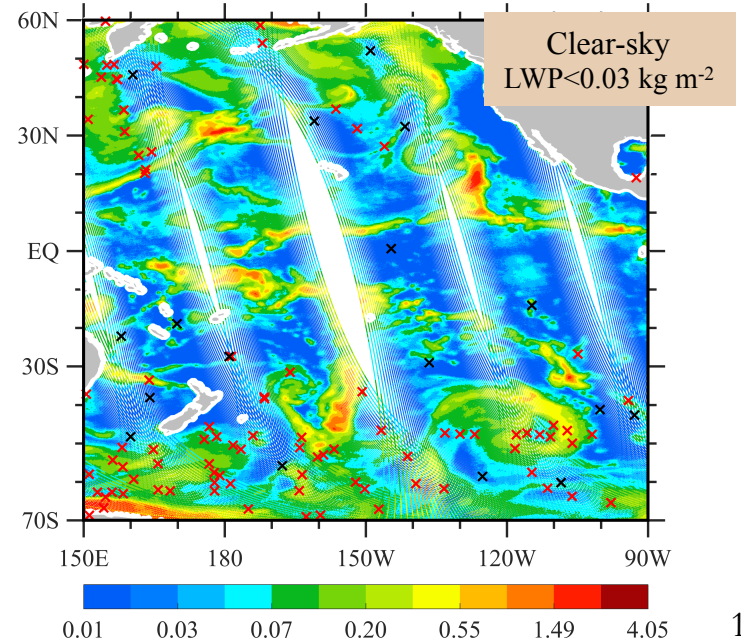
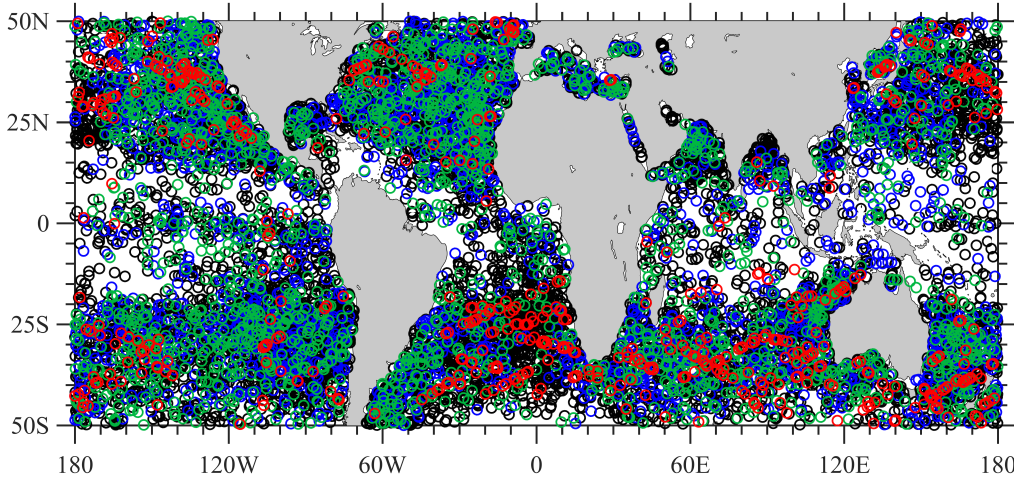


ATMS Data at All Field-of-VIEWS (FOVs)

2013 (COSMIC, MetOp-A, MetOp-B)

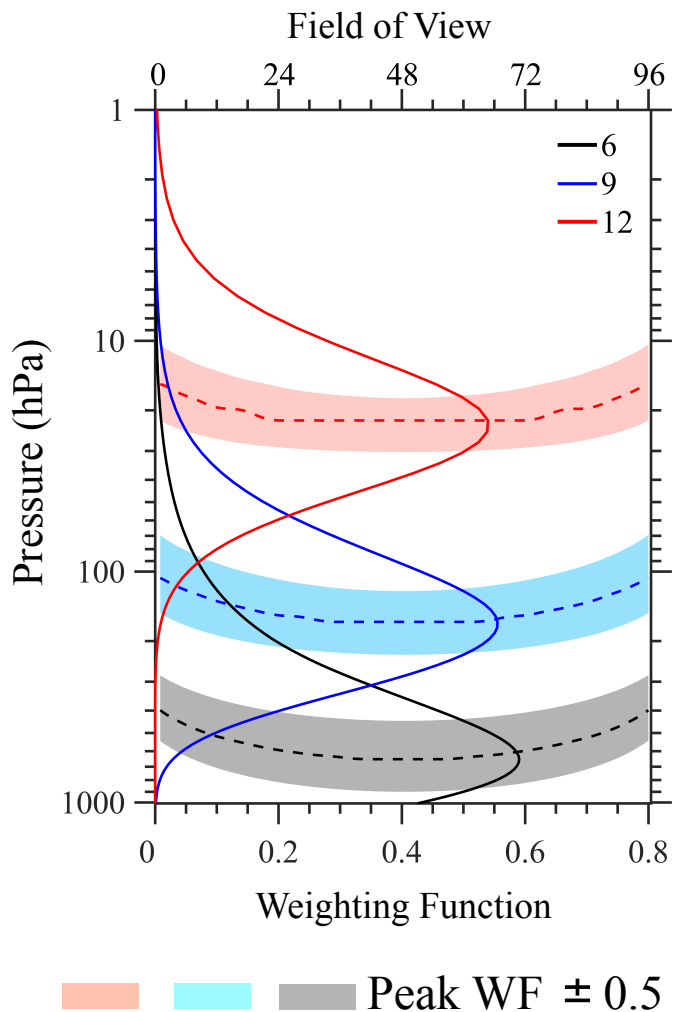


2016 (COSMIC, MetOp-A, MetOp-B, KOMPSAT)

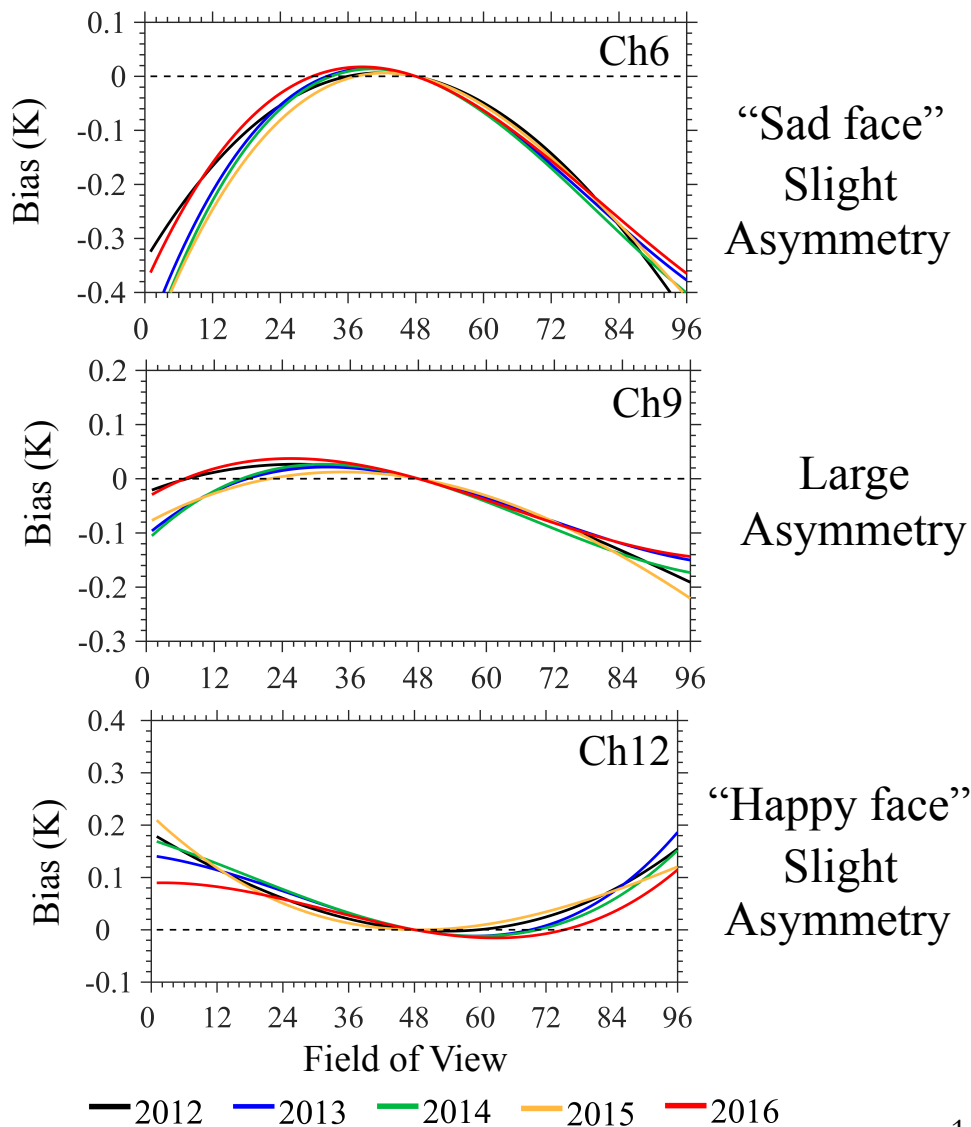


ATMS Scan-Dependent Biases

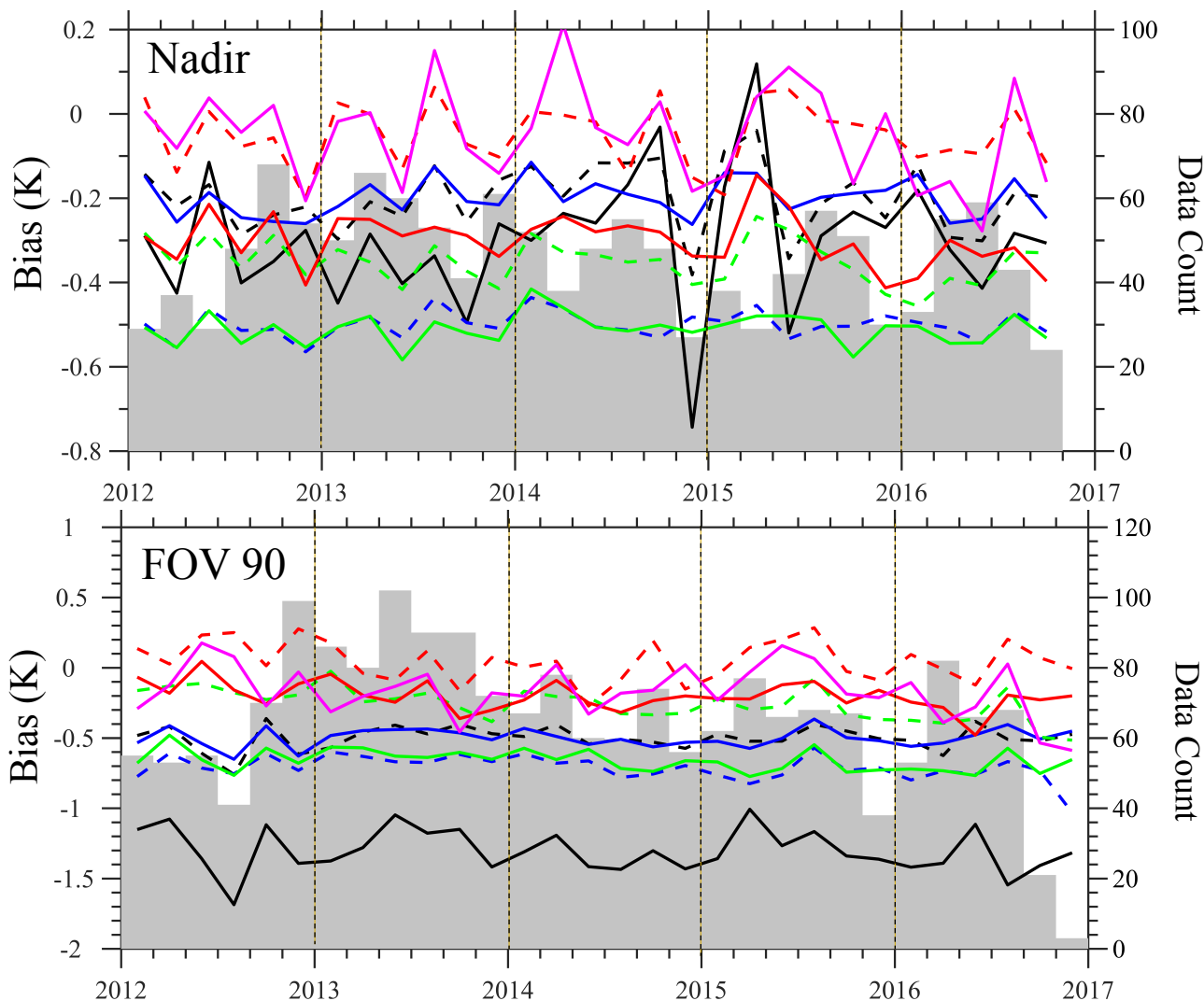
Scan Variation of WFs



Scan Dependence of Bias



Five Year Evolution of ATMS Biases



ATMS channel number: —5 ····6 —7 ····8 —9 ····10 —11 ····12 —13

1. A QC procedure was developed for selecting appropriate RO data for post-launch calibration of ATMS temperature sounding channels.
2. Biases estimated for reprocessed ATMS data by RO data are physically sound and reliable.