Use of FY-3C/GNOS Data for Assessing the on-orbit Performance of Microwave Sounding Instruments

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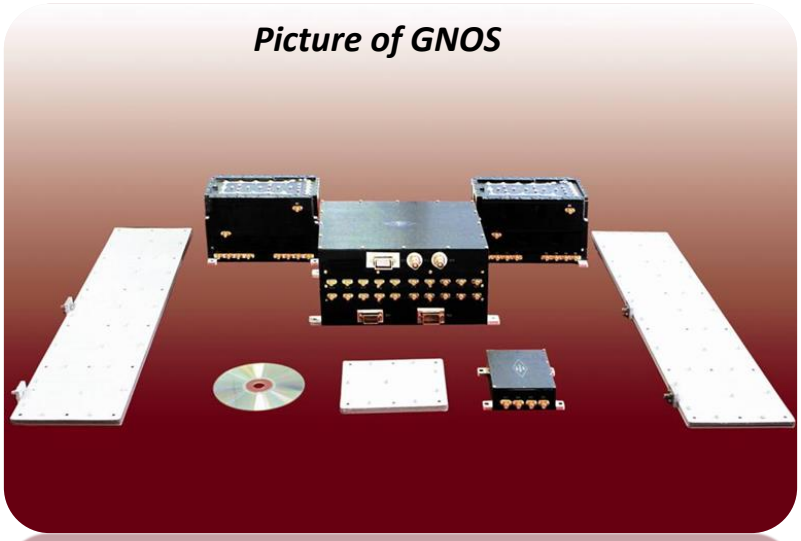
FY3C GNOS Overview

GNOS----*Global Navigation Satellite System Occultation Sounder*

Designed by NSSC/CAS, Operated by NSMC/CMA

Launch date	Sep.23rd , 2013
Mission	Refractivity/Temperature/Humidity soundings with highest vertical resolution; also space weather
Scanning technique	Limb scanning from the satellite altitude to close-to-surface by time sampling - Azimuth: 90° sectors fore- and aft-
Coverage/cycle	2 GNSS constellations tracked. About 800 soundings/day - Average spacing 710 km - Global coverage (300 km spacing) in 5 days
Resolution	About 300 km horizontal, 0.5 km vertical

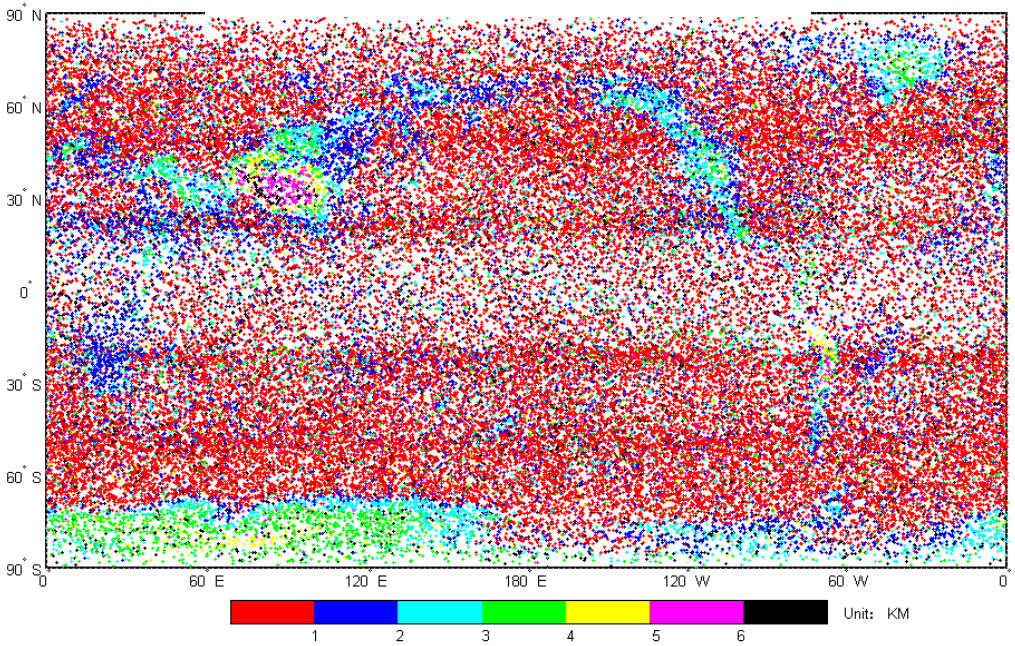
Picture of GNOS



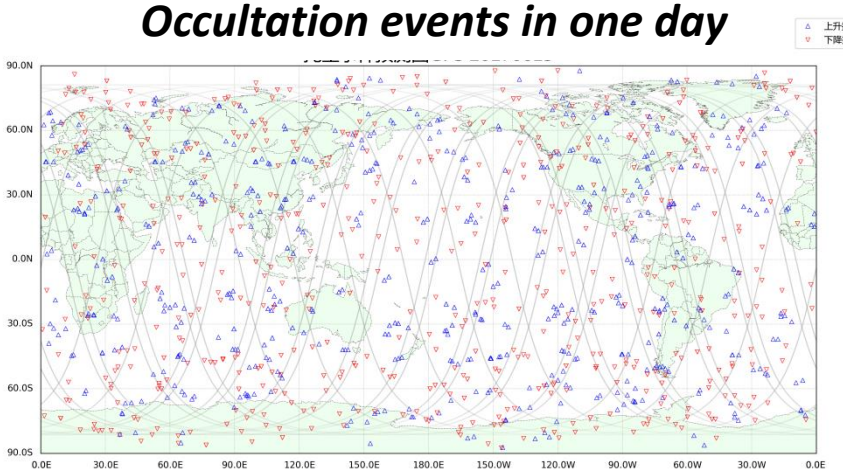
	GNOS/FY3C	COSMIC
Orbit Height	836 km	~800 KM
Orbit Type	sunsynchronous	non-sunsynchronous
Spacecraft mass	~750kg	~40 KG
Instrument mass	7.5kg	5.4kg
channels	GPS：14 BDS：8	GPS：16
Antenna gain	11dbi	10dbi

FY3C GNOS Overview (Continued)

Lowest Occultation Altitude

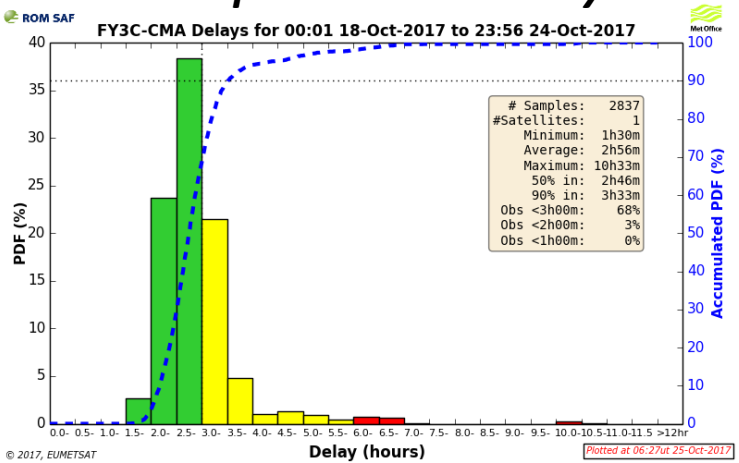


Occultation events in one day



➢ ~90% soundings within 2 kilometers.

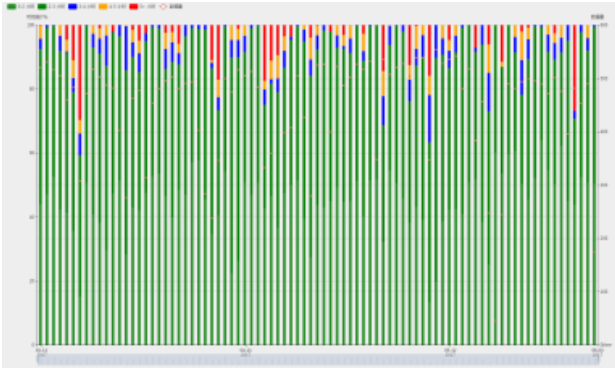
Operational Latency

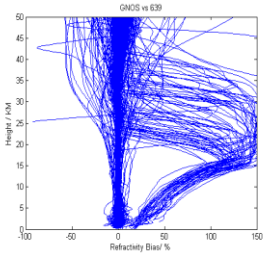


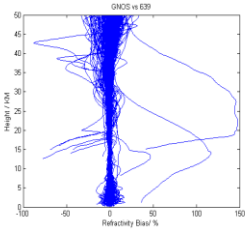
GNOS Team

GNOS Improvements after its launch

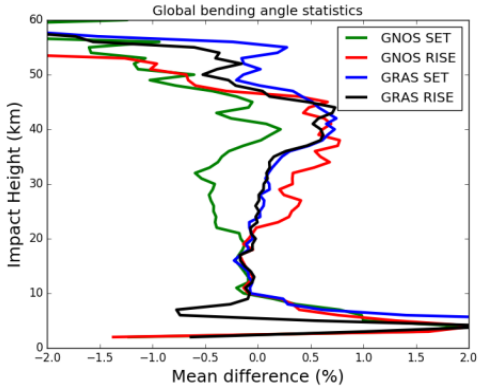
- Latency----from 5 or 6 hours to 3 hours for 90% data, making sure the operational use by NWP agencies.
- Outliers identified----L2 P signal stops too high, results in large bias.
- Apply new algorithm for correcting outliers--- new extrapolation method for L2 signal based on normal L1 and L2 data
- Find and Fix the bug which caused different descending and ascending system bias



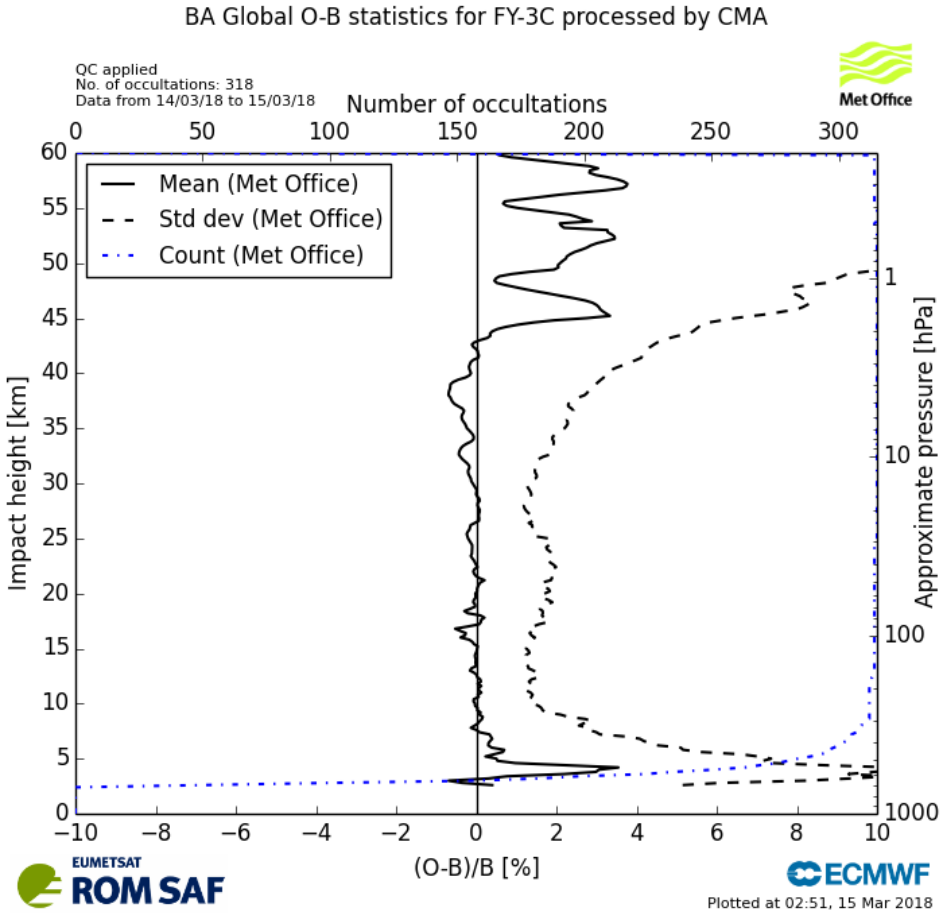


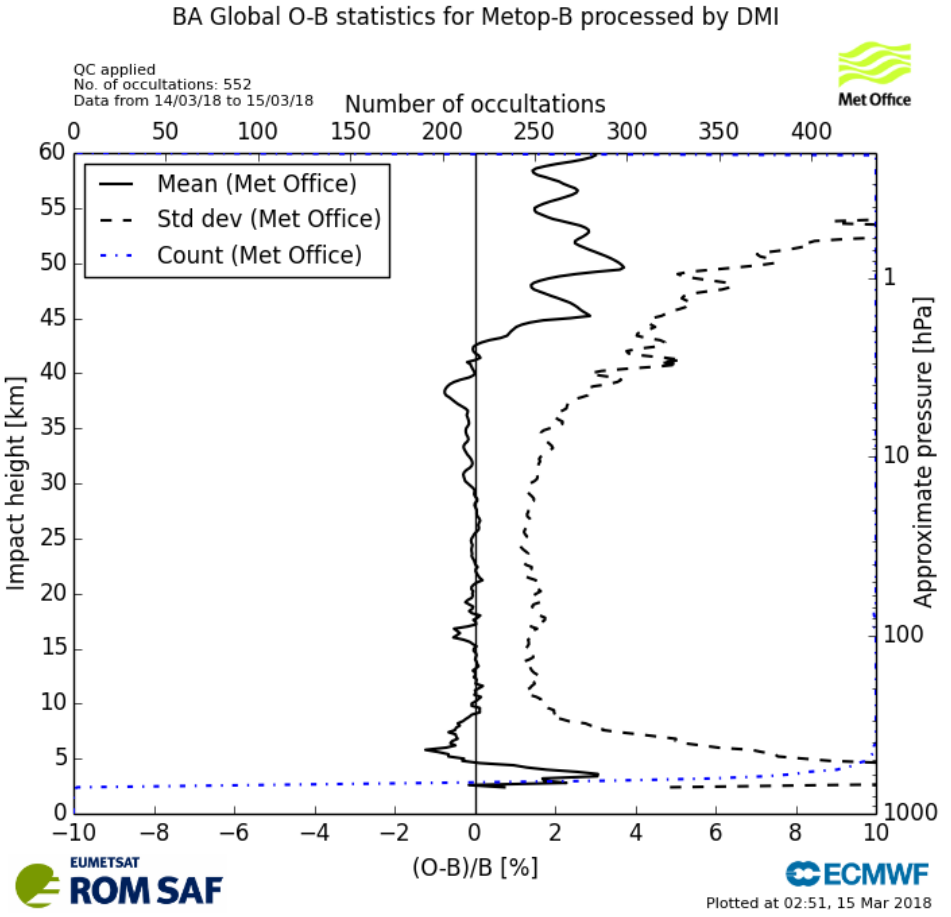


- 30th June,2016 **NWPC/CMA** started to assimilate GNOS in operational system.
- 6th March,2018 **ECMWF** started to assimilate GNOS in operational system.



Validation Results by EUMETSAT ROM SAF

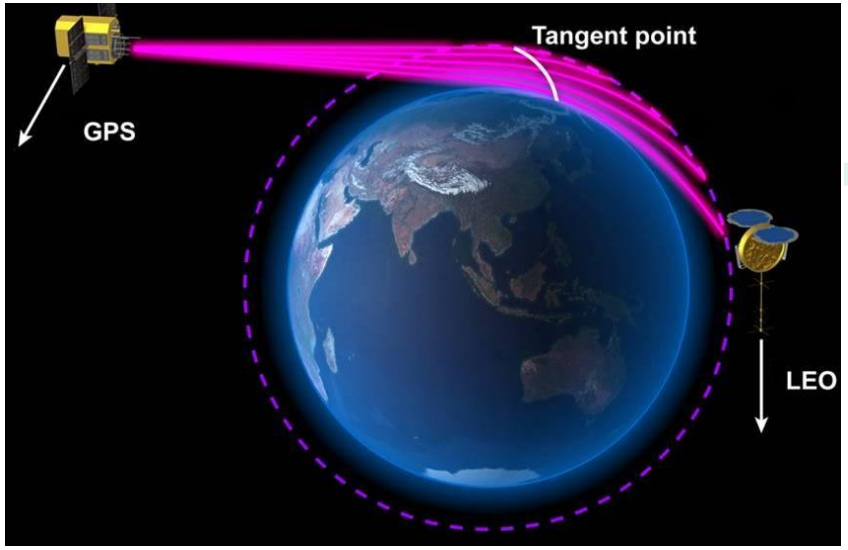




GNOS retrieved profiles are excellent and the quality is as good as to Metop-B/GRAS

Establish an on-orbit Calibration Standard for Microwave Sounders Using RO Profiles

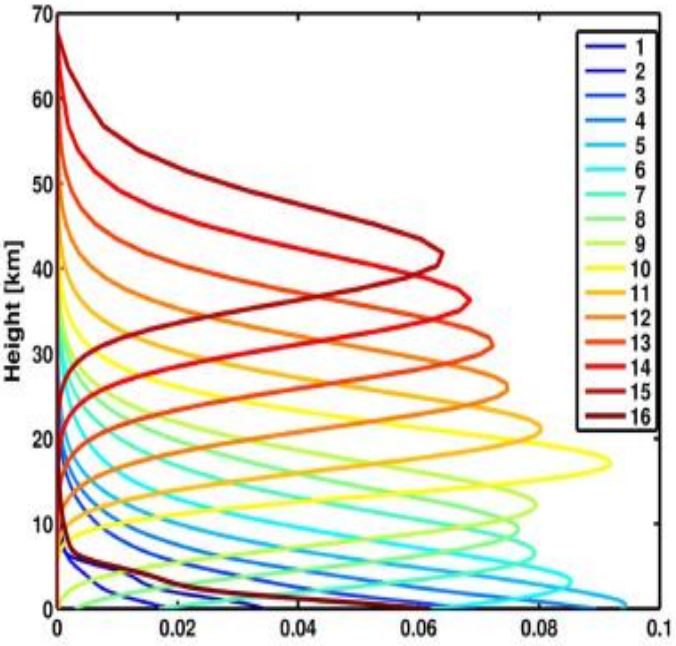
- Atmospheric profiles from GPSRO are stable and accurate, especially for temperature profiles in upper troposphere and stratosphere
- In microwave wavelengths, brightness temperatures can be simulated very accurately since atmospheric absorption lines are well defined
- RO profiles are abundantly available from many space agencies (e.g. COSMIC, COSMIC2, GRAS, GNOS, KOMPSAT)
- RO data sources are perfect for microwave sounder calibration and cross calibration
- We are using GNOS to simulate ATMS brightness temperatures, and comparing results with COSMIC-derived.
- CRTM is the forward model used for simulating ATMS



- Assured long-term stability
- All-weather operation
- Global 3-D coverage: 40 km to the surface
- Vertical resolution: ~100 m in the lower troposphere
- Independent height, pressure, and temperature data
- High accuracy: Averaged profiles to < 0.1 K (Anthes et al., 2008)

ATMS Instrument Characterization

ATMS WF (U.S. Standard Atmosphere)

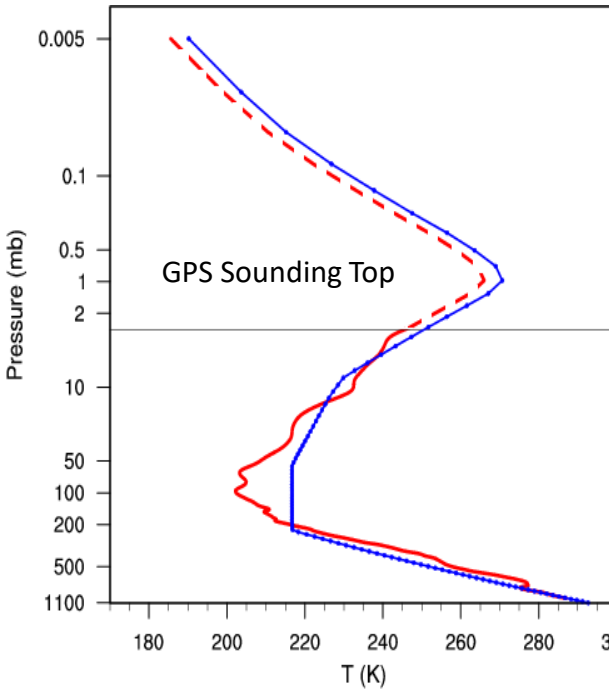


Weighting Function

Moradi et al. (2015)

Channel	Central Frequency (GHz)	Beam Width (deg)	NEΔT (K)	Peak WF (mb)
1	23.8	5.2	0.5	1085.394
2	31.4	5.2	0.6	1085.394
3	50.3	2.2	0.7	1085.394
4	51.76	2.2	0.5	1085.394
5	52.8	2.2	0.5	891.7679
6	53.596± 0.115	2.2	0.5	606.847
7	54.4	2.2	0.5	351.237
8	54.94	2.2	0.5	253.637
9	55.5	2.2	0.5	165.241
10	f_o	2.2	0.75	86.337
11	f_o± 0.217	2.2	1.0	49.326
12	f_o ± 0.322 ± 0.048	2.2	1.0	24.793
13	f_o ± 0.322 ± 0.022	2.2	1.5	10.240
14	f_o ± 0.322 ± 0.010	2.2	2.2	5.385
15	f_o ± 0.322 ± 0.004	2.2	3.6	3.010
16	88.2	2.2	0.3	1085.394
17	165.5	1.1	0.6	1085.394
18	183.31 ± 7	1.1	0.8	790.017
19	183.31 ± 4.5	1.1	0.8	695.847
20	183.31 ± 3	1.1	0.8	606.847
21	183.31 ± 1.8	1.1	0.8	506.115
22	183.31 ± 1	1.1	0.9	450.738

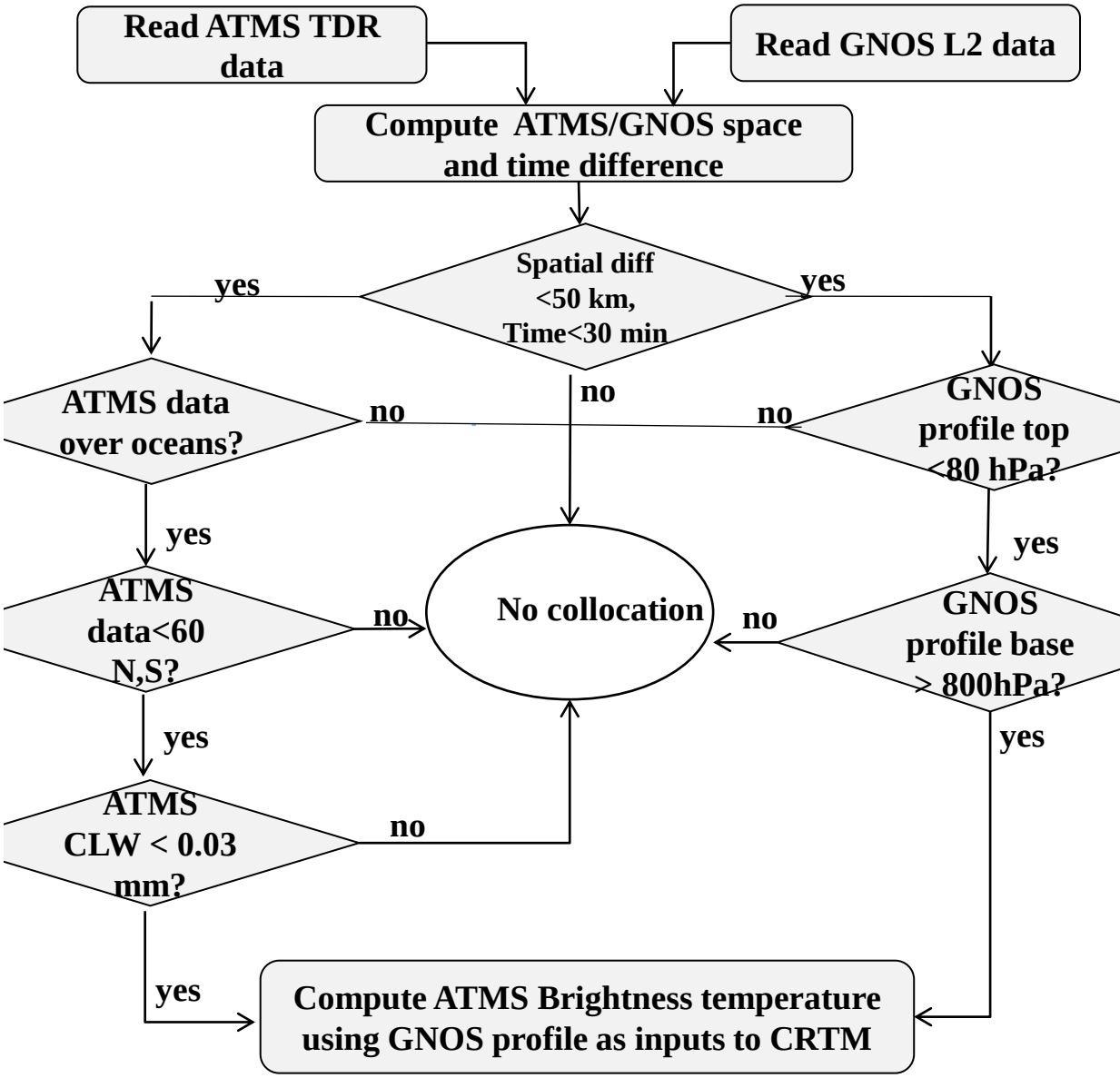
Add 1976 U.S. Standard Atmosphere State to GPS Soundings



1051 UTC on January 1, 2012

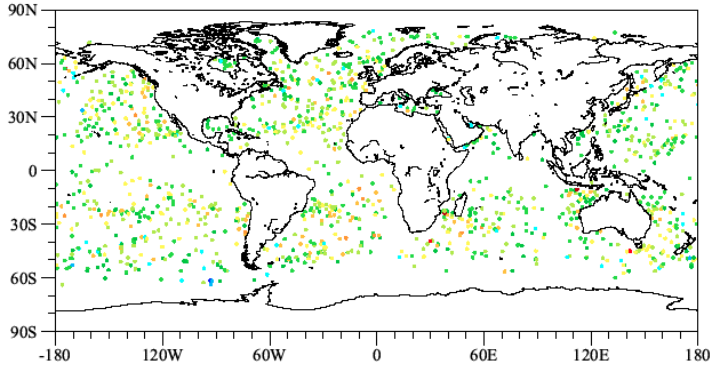
ATMS and GNOS Collocation Flowchart

- GNOS profiles are matched with ATMS in space and time.
- The latitude and longitude of the GNOS profile (perigee point at occultation point) is located within the ATMS latitude-longitude bounding box (50 km)
- GNOS profile occurs within 3 hours. Ideally, the time difference should be smaller and less than 30 min. For this study, we want to get more matchup since we only using two month's ATMS and GNOS data in August, 2017
- Since each RO profile is composited within 200 km, it is not very useful for characterizing the bias at ATMS window channels and water vapor channels.

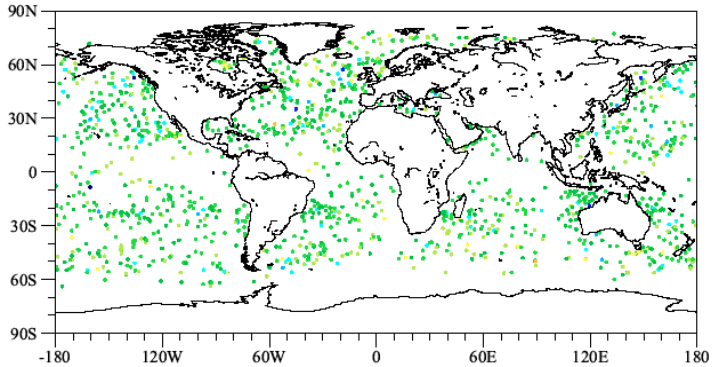


Global Distribution of $O^{(Obs)}$-$B^{(GNOS)}$ (Channels 5-8)

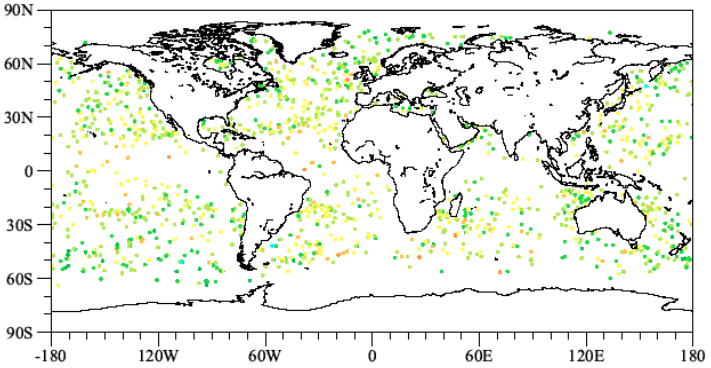
Ch 5



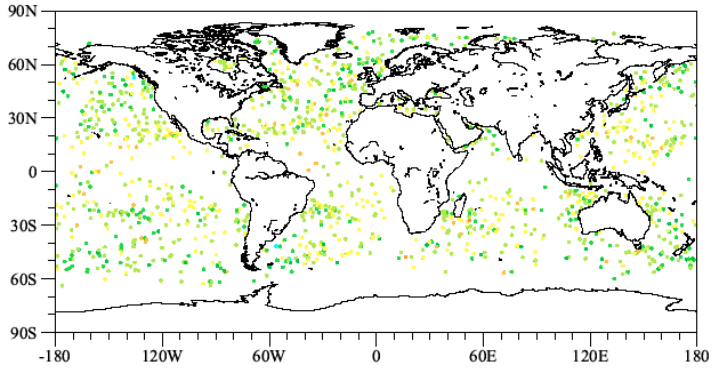
Ch 6



Ch 7



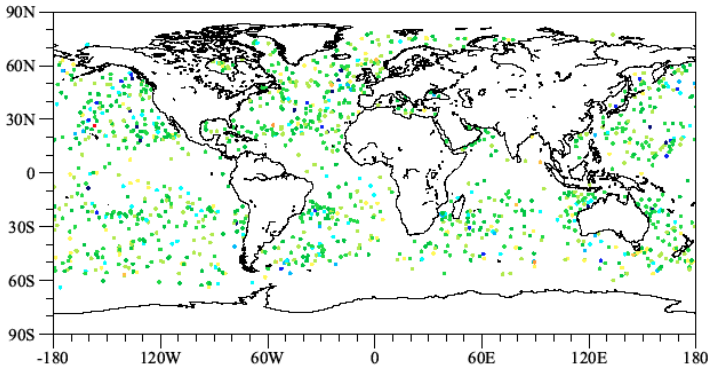
Ch 8



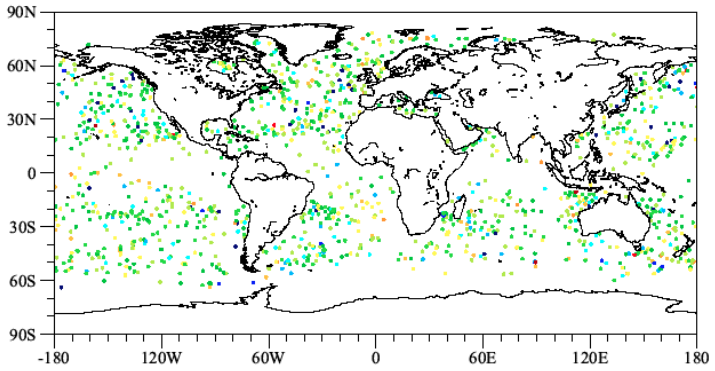
ATMS global bias is quite uniform and small, less than 0.5K

Global Distribution of $O^{(Obs)}$-$B^{(GNOS)}$ (Channels 9-12)

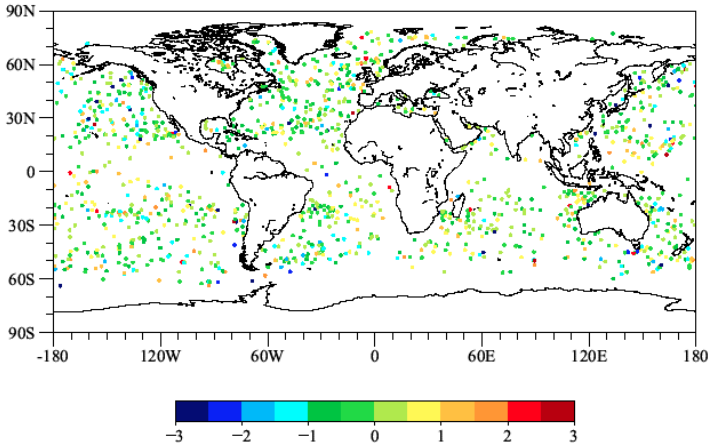
Ch 9



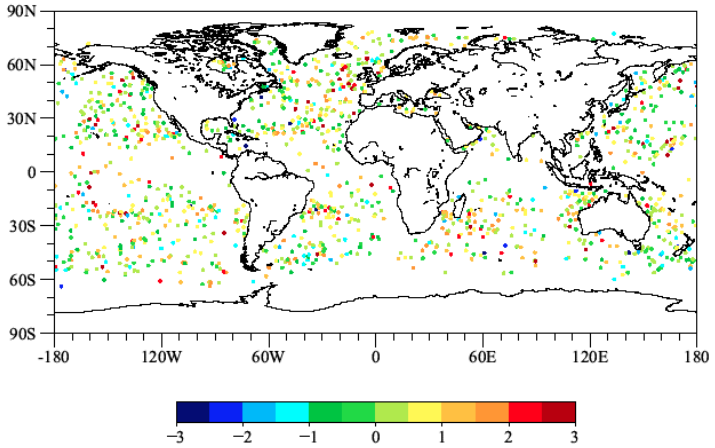
Ch10



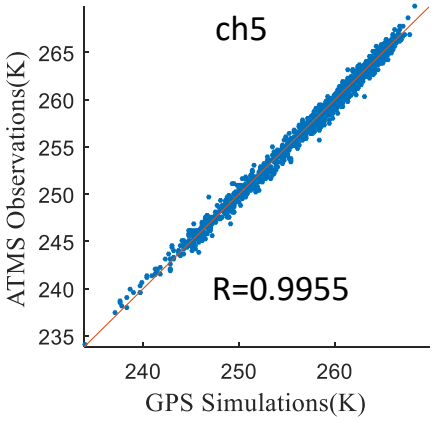
Ch 11

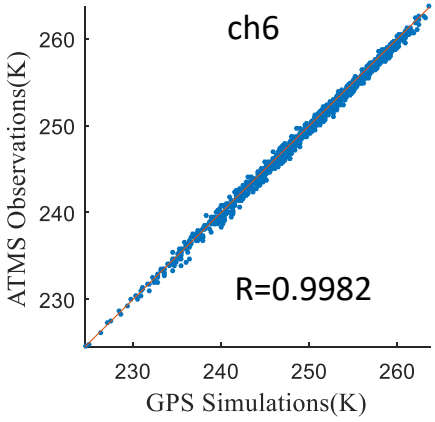


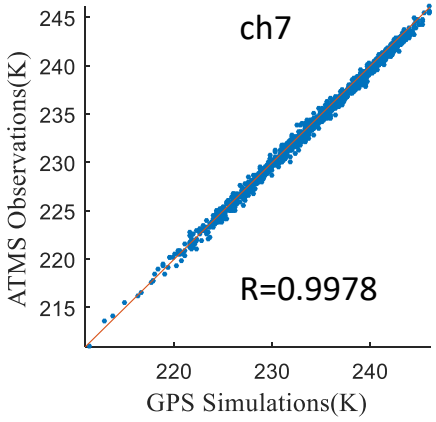
Ch 12

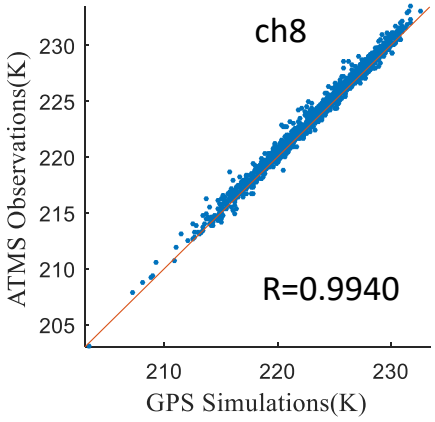


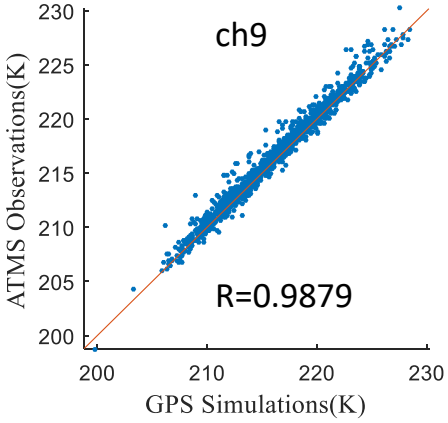
Scatter Plots of $O^{(Obs)}$-$B^{(GNOS)}$ (Channels 5-12)

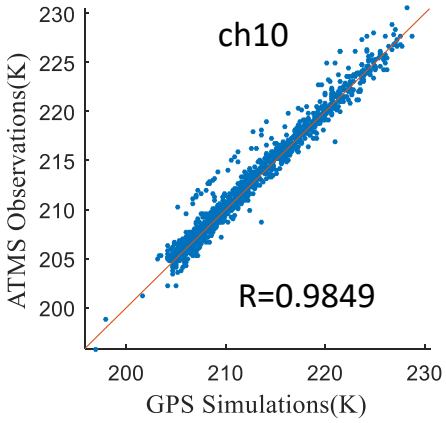


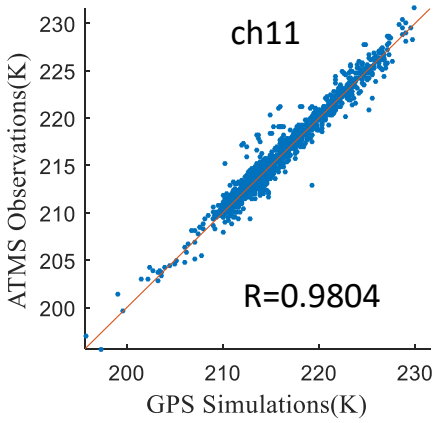


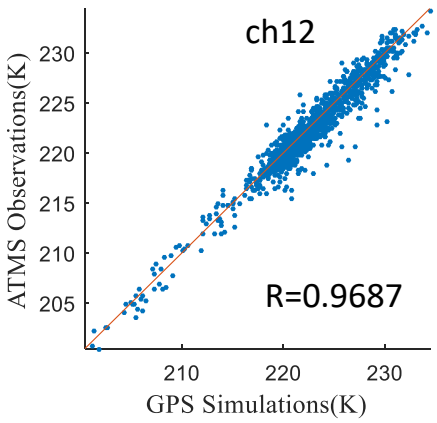




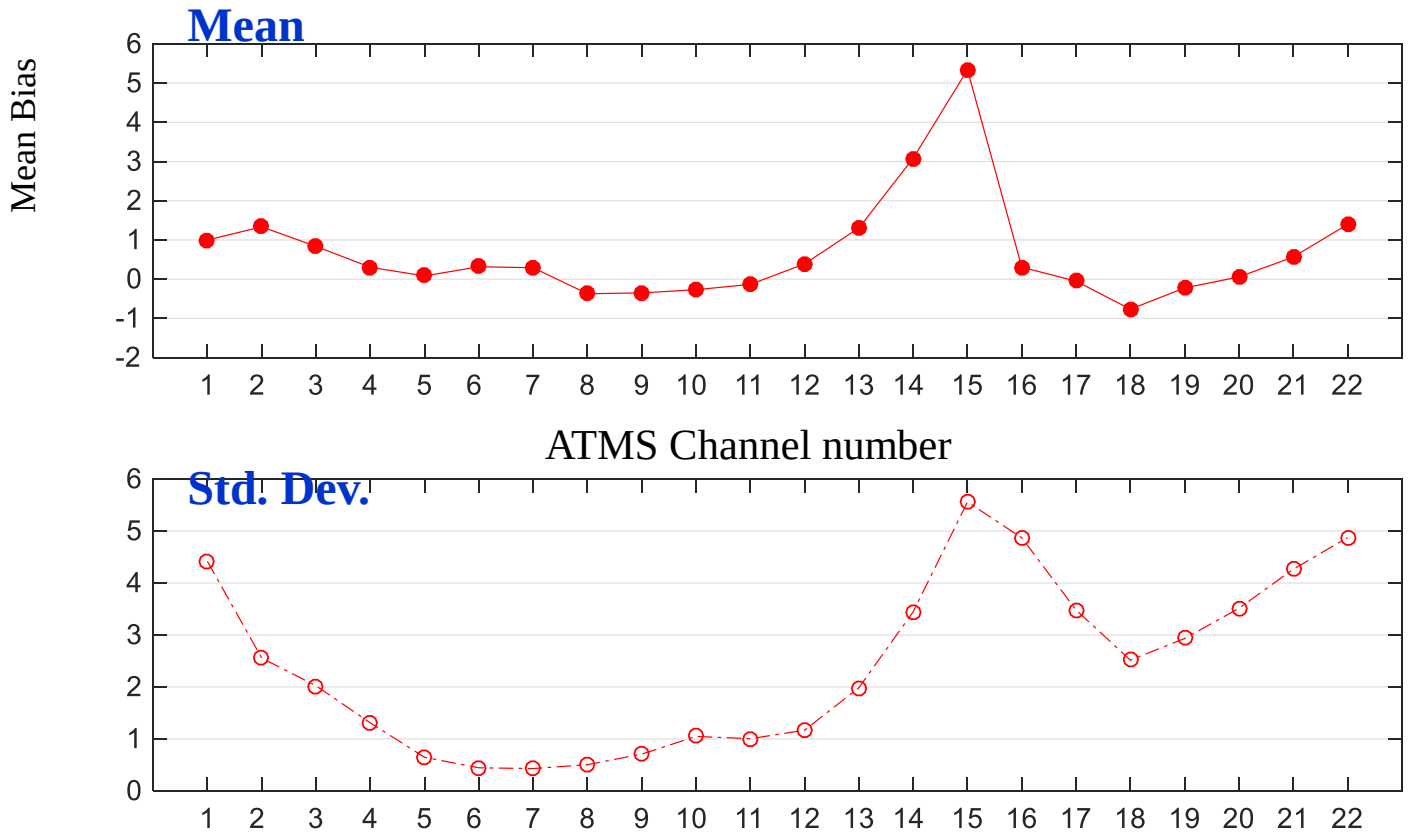






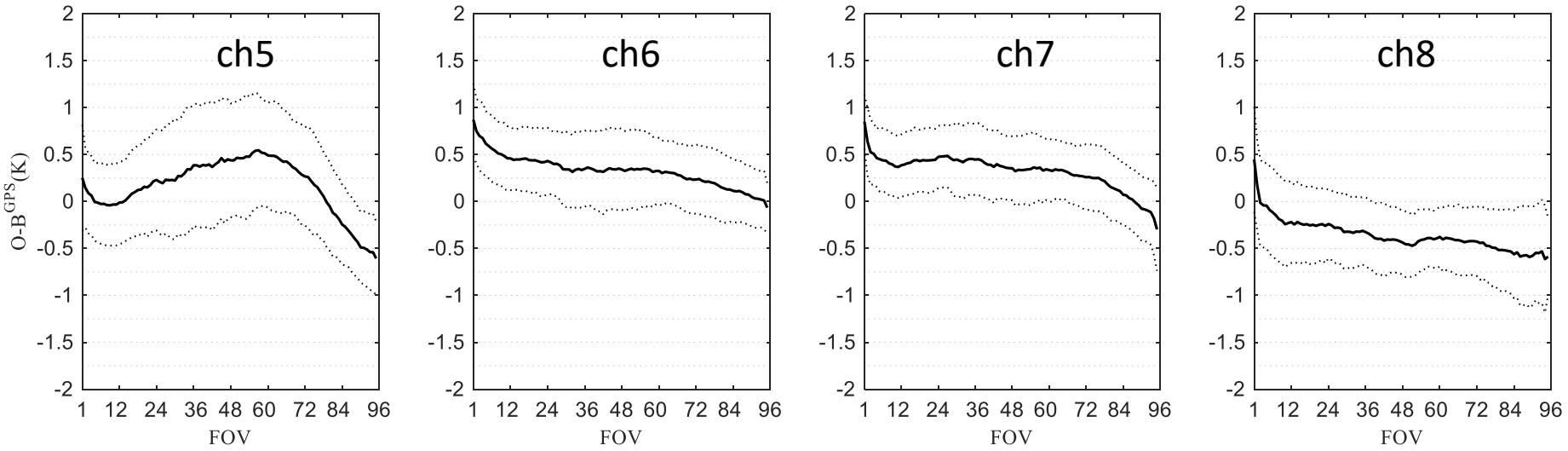


ATMS Mean Bias and Standard Deviation

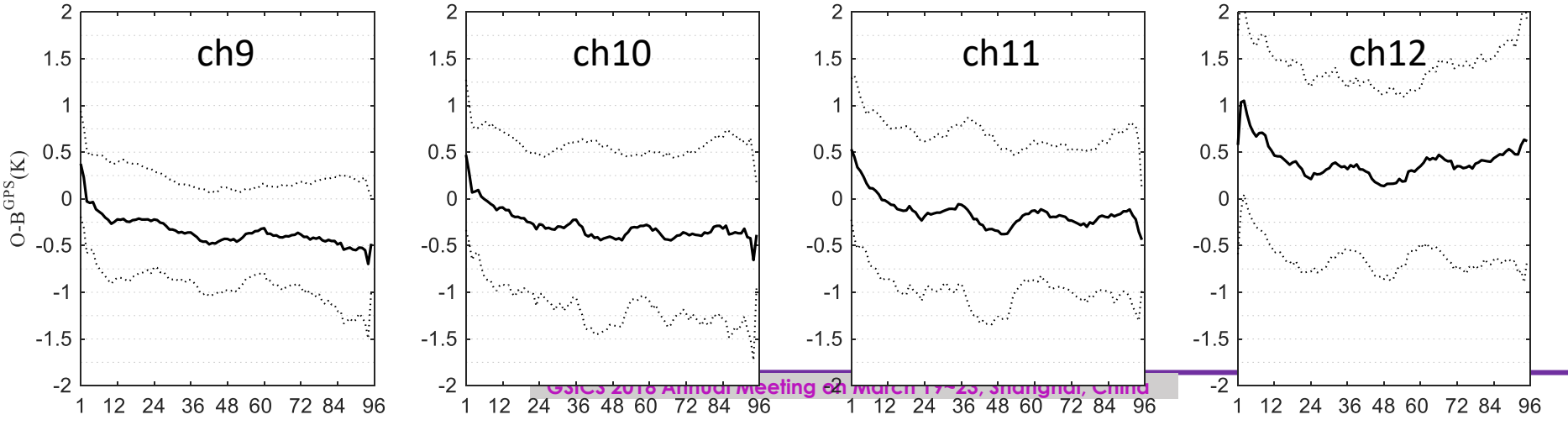


While brightness temperatures at Suomi ATMS 22 channels are simulated, the results for those channels affecting by water vapor and surface emission are less reliable since RO profiles are less accurate. If we trust GPSRO as an absolute standard, the TDR bias Must be zero or slightly negative.

ATMS Angular-Dependent Bias (O-B)



ATMS angular dependent bias is small assuming GNOS simulation is used as on-orbit truth



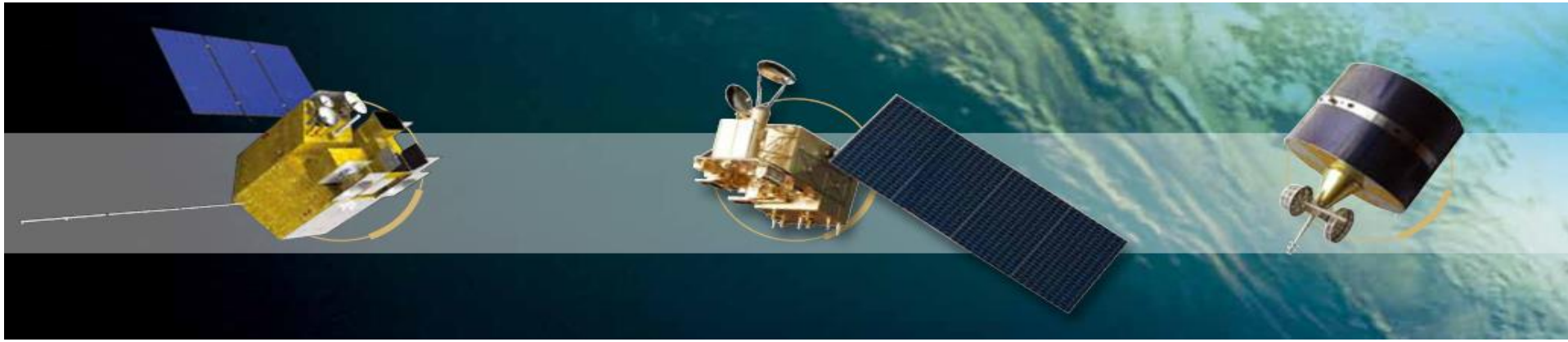
Summary

- FY-3C GNOS data quality is very good for many applications, including establishing an on-orbit truth for microwave sounder calibration
- ATMS bias characteristics with respect to GNOS simulations are very similar to those derived from COSMICS
- FY-3C/3D will have two GNOS and more RO profiles will be derived through other GNSS systems such as Beidou (BDS) and Galileo.

Future Plan

- Application of GNOS data to the assessment of the on-orbit performance of FY-3C/D Microwave Temperature Sounder (MWTS) .
- Use of GNOS data for assessing the on-orbit performance of FY-3C/D Microwave Humidity Sounder (MWHS) near the 118-GHz.
- Validation of FY-3C/D MWTS and MWHS using COSMIC RO data and comparing results with GNOS-derived.

Thanks !



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