Synthetic Radiance Simulation and Evaluation for a Joint OSSE

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Outline

- Synthetic radiances simulation procedure
- Evaluation of NOAA-15 AMSU-A simulation
- Evaluation of GOES-12 Sounder simulation
- New synthetic radiance data
- Summary and future plan

Joint OSSE Structure

Four Nature Runs:

- NR1: ECMWF T213-L31, 02/05 – 03/07, 1993 (*Masutani et al. 2010, JGR* Impacts of DWL)
- NR2: ECMWF T511-L91, 05/01,2005 – 05/31, 2006 (*Reale et al. 2007, GRL* Nature run validation)
- NR3: ECMWF T799-L91, 09/27 – 11/01, 2005
- NR4: ECMWF T799-L91, 04/10 – 05/15, 2006

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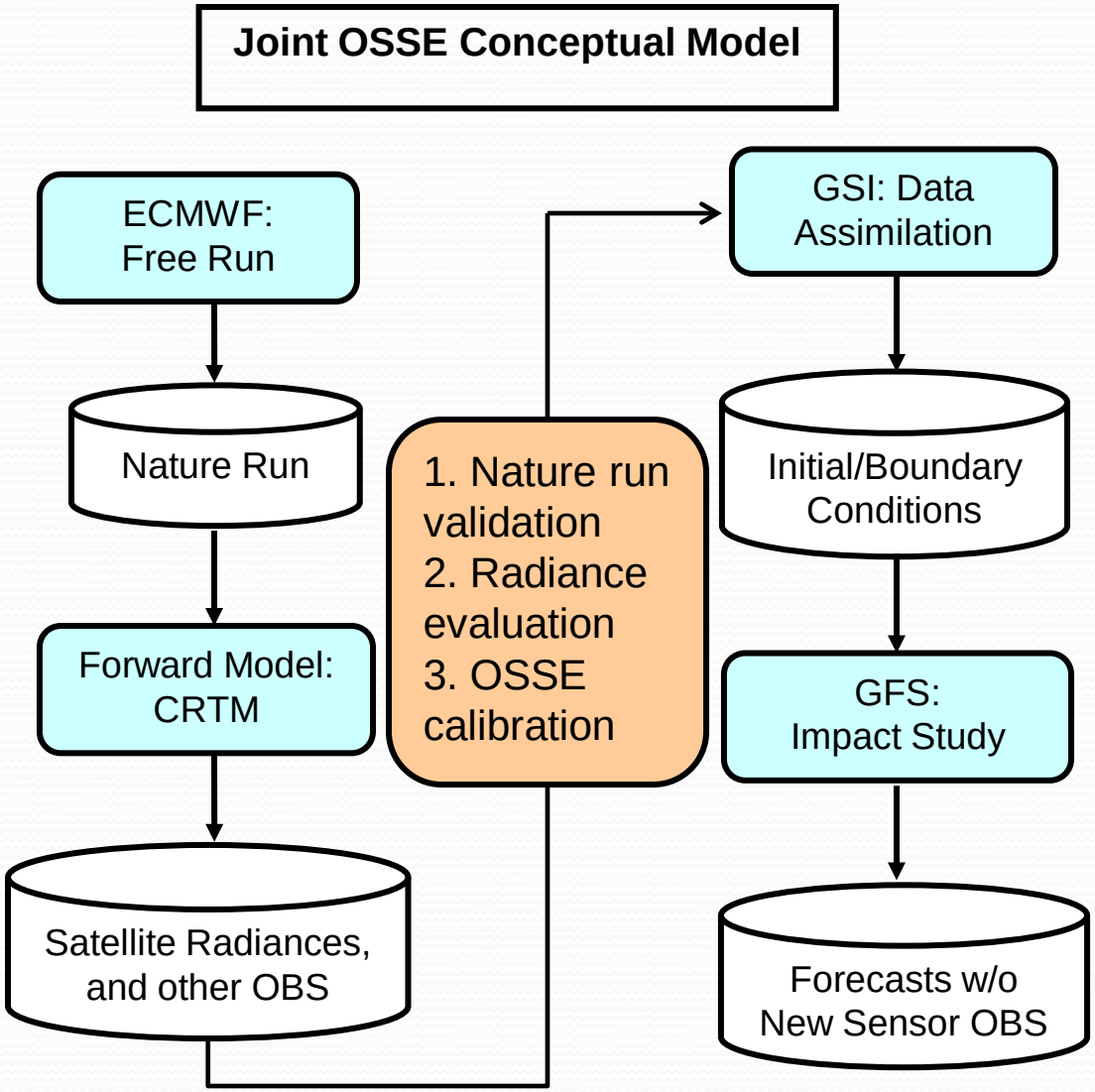
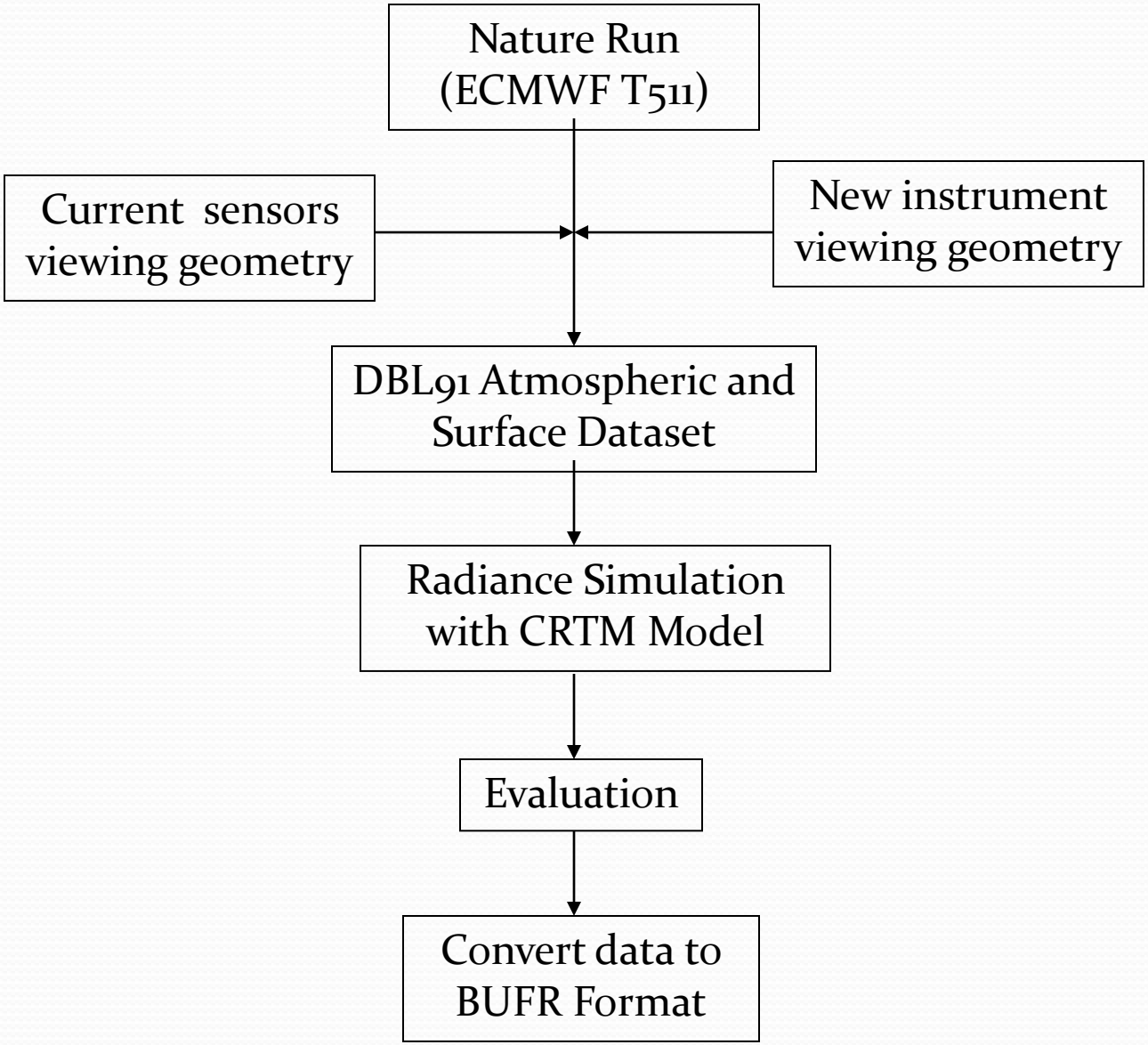


OSSE Radiance Simulation Flow Chart



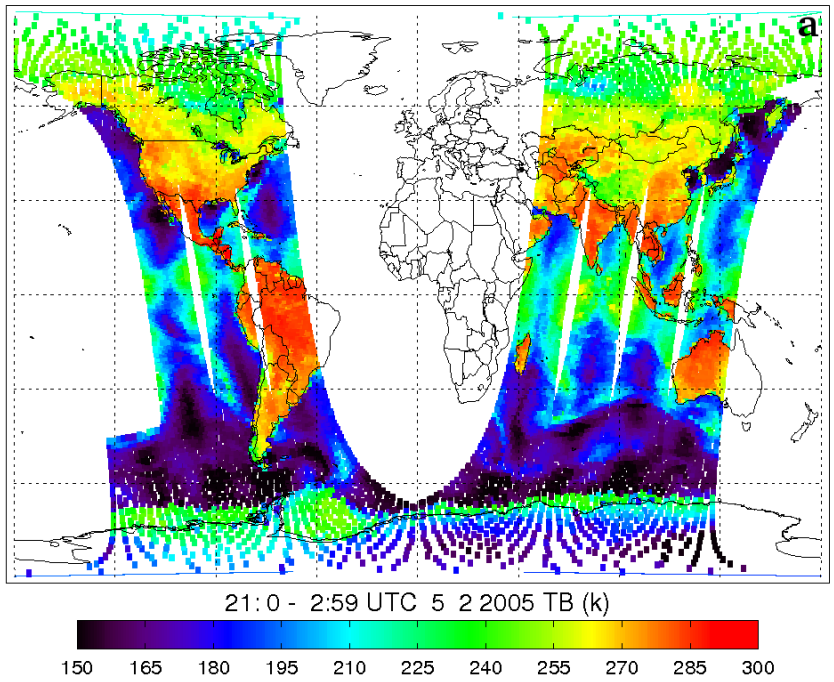
NOAA-15 AMSU-A 15 Bands Characteristics

Band No.	Central Frequency (GHz)	Peak Weighting Function Level (hPa)	GSI Assimilation
1	23.8	Surface	Y
2	31.4	Surface	Y
3	50.3	Surface	Y
4	52.8	1000	Y
5	53.596+0.115	700	Y
6	54.4	400	Y
7	54.94	270	Y
8	55.5	180	Y
9	57.29	90	Y
10	57.29±0.217	50	Y
11	57.29±0.322±0.048	25	**N**
12	57.29±0.322±0.022	12	Y
13	57.29±0.322±0.010	5	Y
14	57.29±0.322±0.0045	2	**N**
15	89.0	Surface	Y

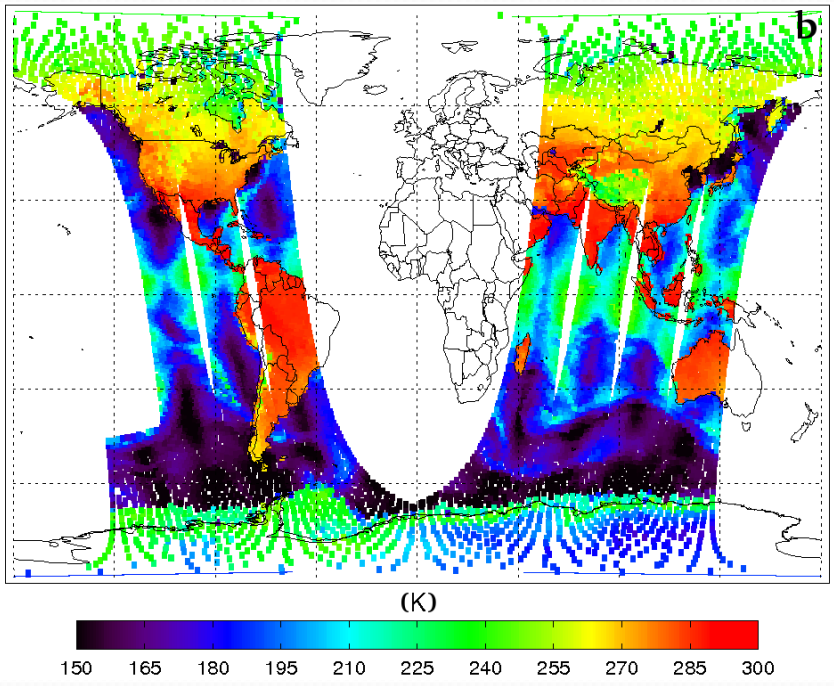
Comparison of Simulated and Observed NOAA-15 AMSU-A Channel-1

At 0000 UTC, 2 May 2005

Observation

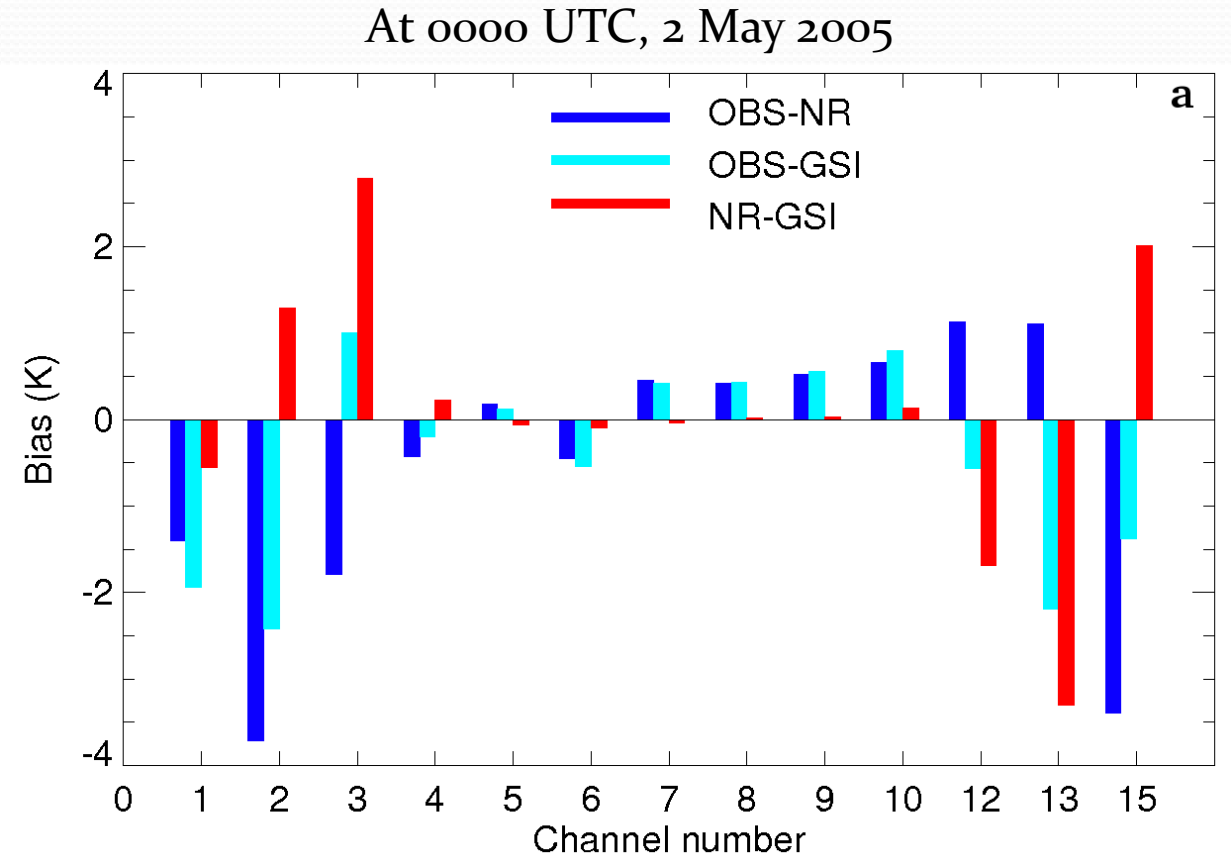


OSSE simualtion



- Near NR initial time, the simulated radiances reproduced many detailed observed features, such as the WV over tropical region, local minimum, warm sea ice.
- Over land, the simulated Tb is about 2 K higher than observation.

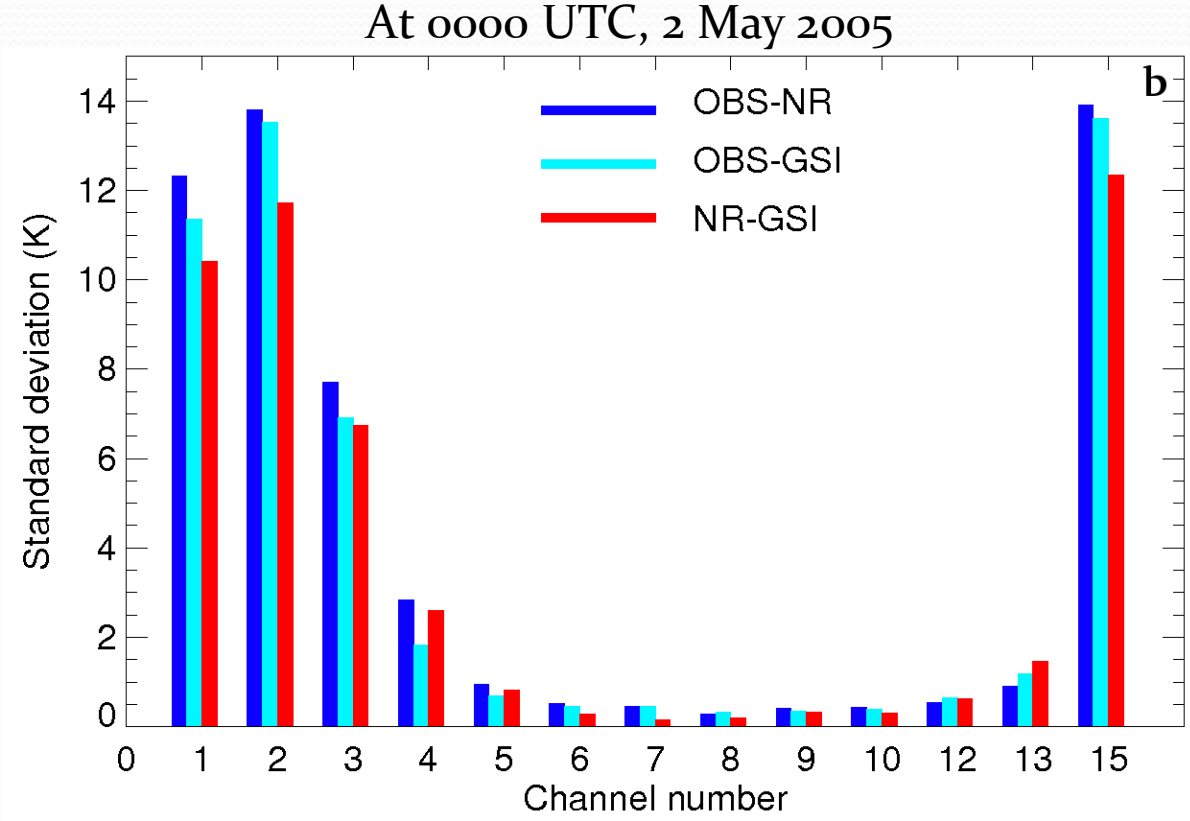
NOAA-15 AMSU-A Simulation Biases



•Biases and the differences of the biases for the mid-level sounding channels, Ch-4-10, are very small (<0.3 K).

•Large biases (>1.0 K) can be found for the NR or GFS simulations at surface sensitive and upper stratospheric channels (i.e. Ch-1, 2, 3, 12, 13, and 15).

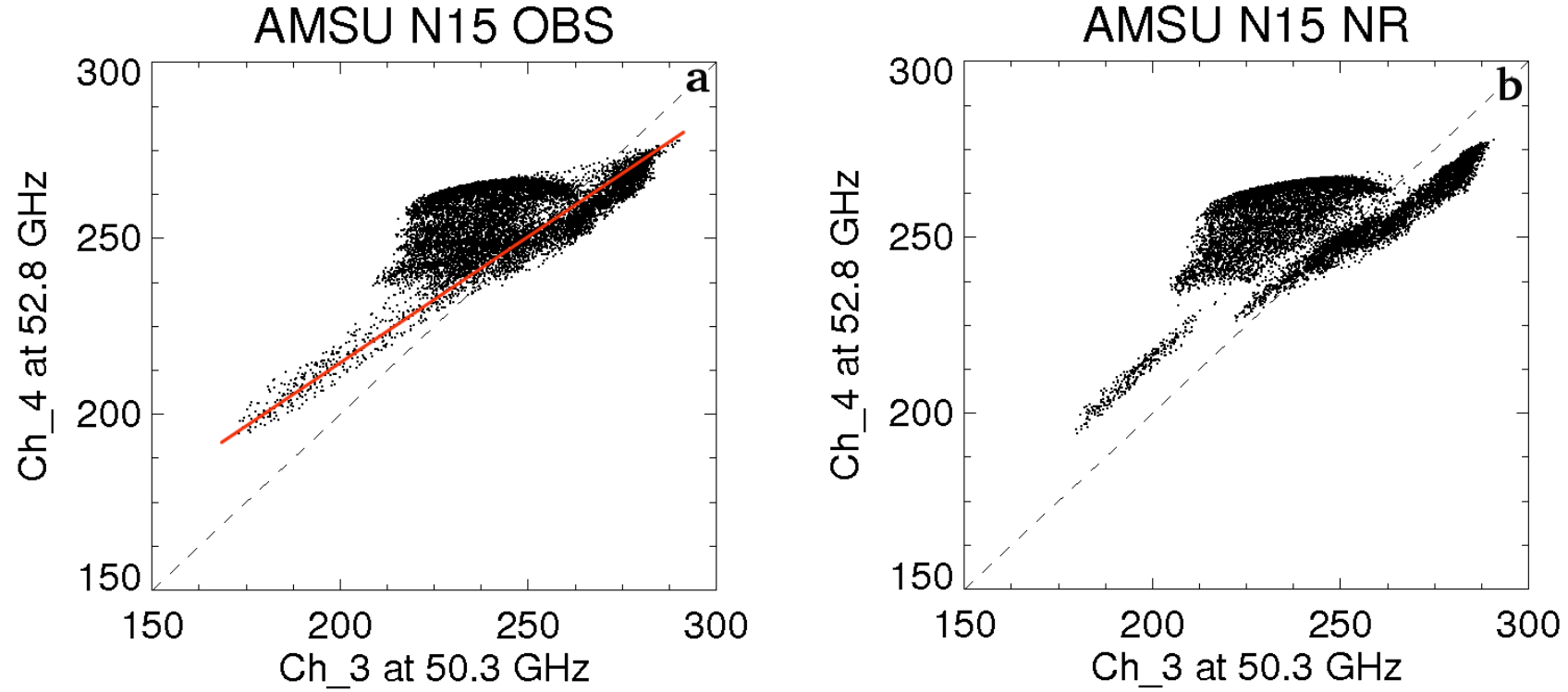
NOAA-15 AMSU-A Simulation Standard Deviations



•The STDs for the OBS-NR and OBS-GSI have similar magnitudes (see Fig. 2b) for all channels.

•The STDs are below 1 K at channels 5 - 13, and bigger than 1 K for all of the other surface sensitive channels.

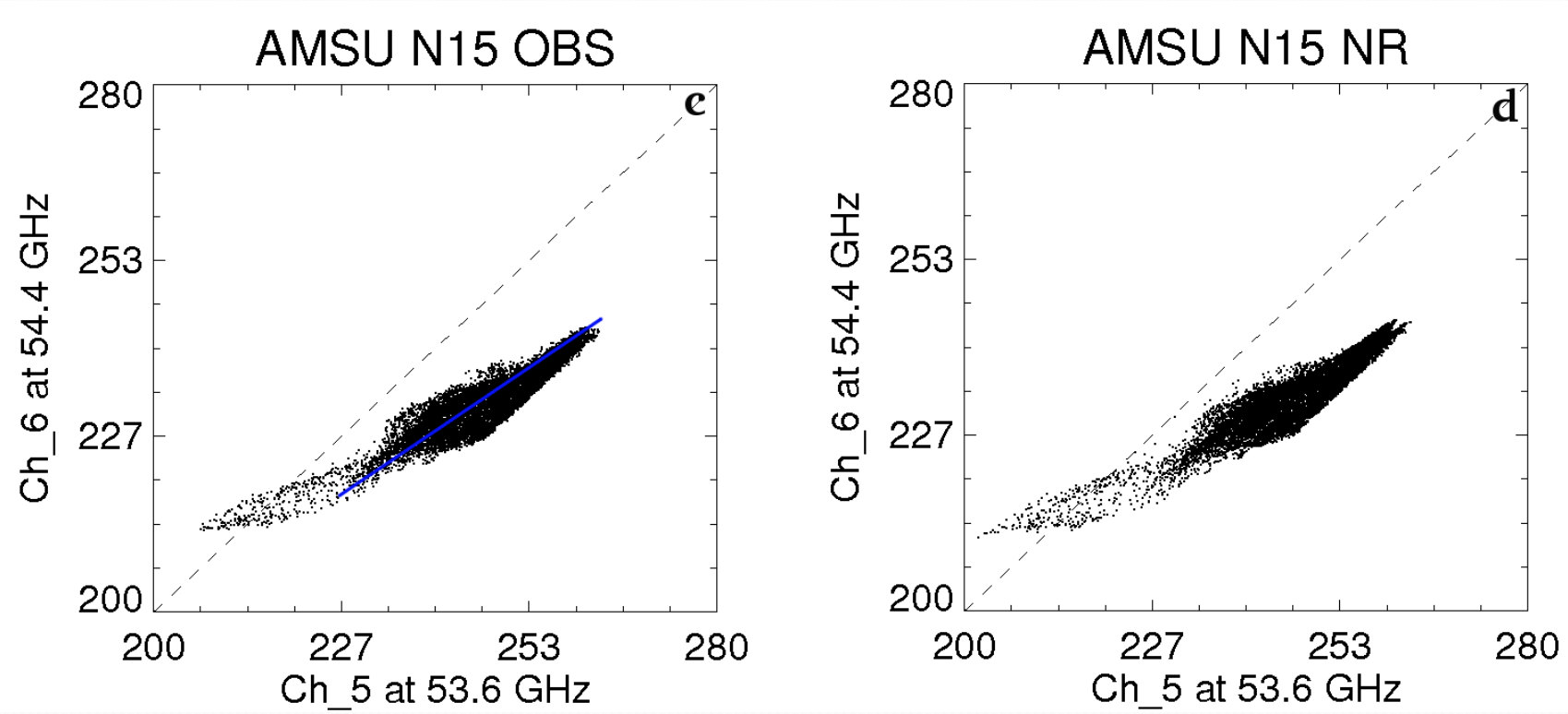
AMSU-A Inter-Channel Correlation: Ch-3 vs. Ch-4



•Over land, Channel 3 and 4 observations have a strong linear correlation, and Tb3 > Tb4 over most landmass, except Antarctica.

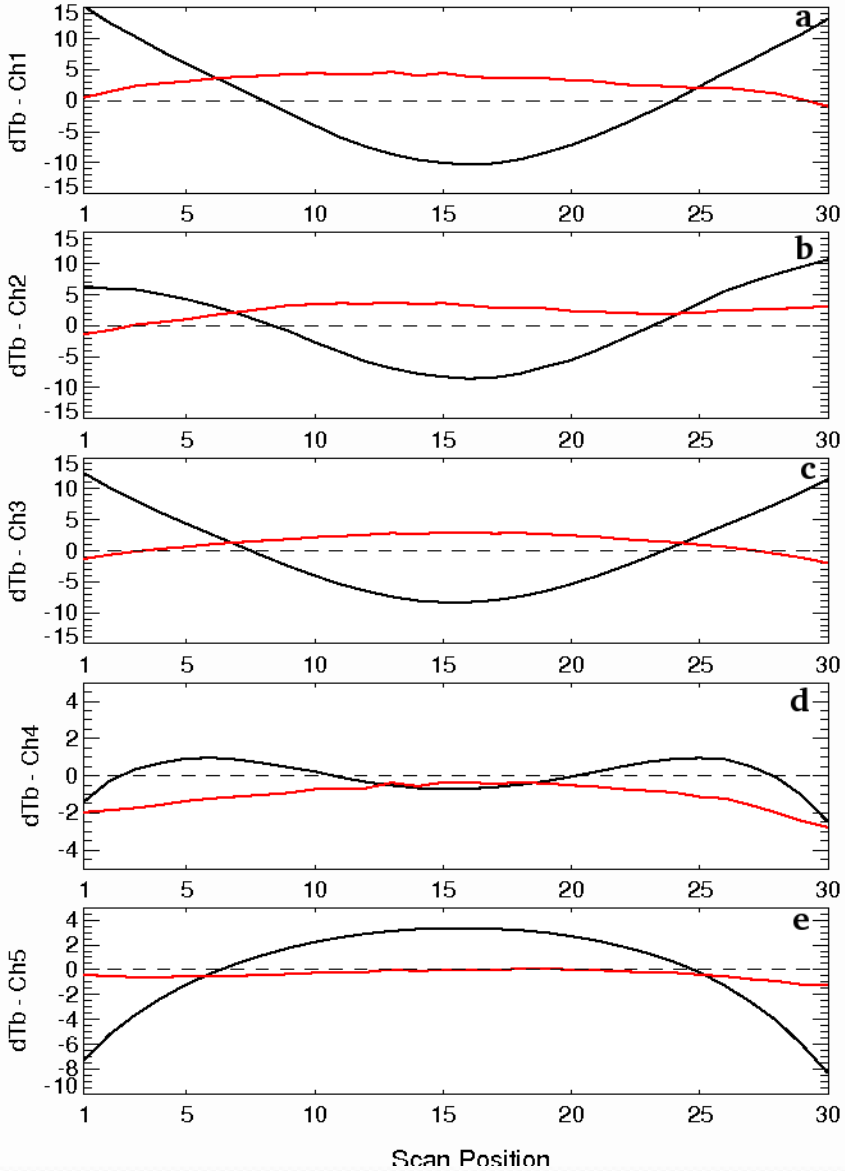
•Over ocean, Tbs at channel 3 are lower than those of channel 4 due to the lower ocean surface emissivity.

AMSU-A Inter-Channel Correlation: Ch-5 vs. Ch-6



- Tbs at Ch-5 and 6 have a linear correlation in most areas over land and ocean, and the Tb at Ch-5 is higher than that of Ch-6,
- Over Antarctica, the Tb at Ch-5 is very cold and close to the temperature of Ch-6.

AMSU-A Scan Angular Dependent Biases



One month averaged bias for May 2005

OBS angular dependent bias: T_{abias}(OBS)

$dT_{abias} = T_{abias}$(OBS) – T_{abias}(NR)

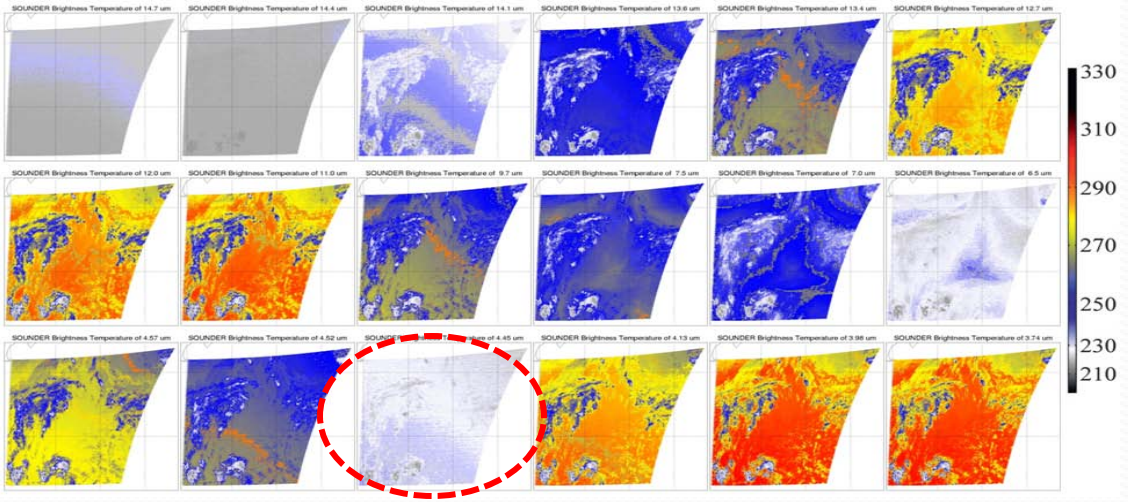
- Because of the difference in peak WF, the observed Tb at each channel shows unique symmetric angular bias,
- The synthetic radiances can simulate these symmetric biases,
- However, the asymmetric bias for surface sensitive channels cannot be reproduced.

GOES-12 Sounder 18 IR Bands

Band No.	Central Wavelength (μm)	Primary usage	GSI assimilation
1	14.7	stratosphere temperature	Y
2	14.3	tropopause temperature	Y
3	14.0	upper-level temperature	Y
4	13.6	midlevel temperature	Y
5	13.3	low-level temperature	Y
6	12.6	total precipitable water	Y
7	12.0	surface temperature and moisture	Y
8	11.0	surface temperature	Y
9	9.71	total ozone	Y
10	7.43	low-level moisture	Y
11	7.02	midlevel moisture	Y
12	6.51	upper-level moisture	Y
13	4.57	low-level temperature	Y
14	4.52	midlevel temperature	Y
15	4.46	upper-level temperature	Y
16	4.13	boundary-layer temperature	N
17	3.98	surface temperature	N
18	3.74	surface temperature and moisture	N

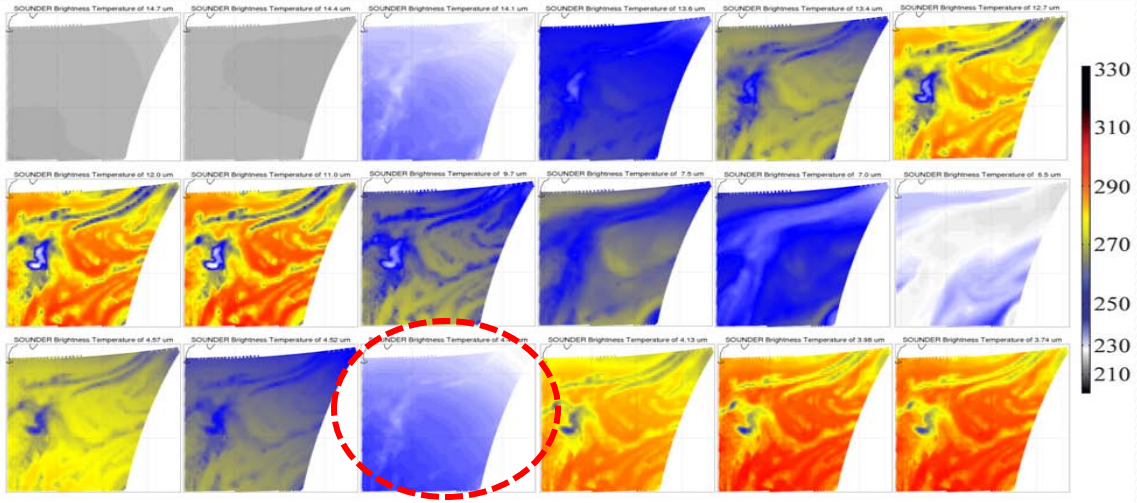
GOES-12 Sounder 18 IR channels over North Atlantic region

Observation
1200 UTC October 1, 2005



NR Simulation
1200 UTC October 1, 2005

- Less fine moisture and cloud structures;
- Large difference at Ch-15, due largely to the shifting of SRF for about +8.4 cm^{-1}.



Time series of GOES12 Sounders radiance simulation and observation

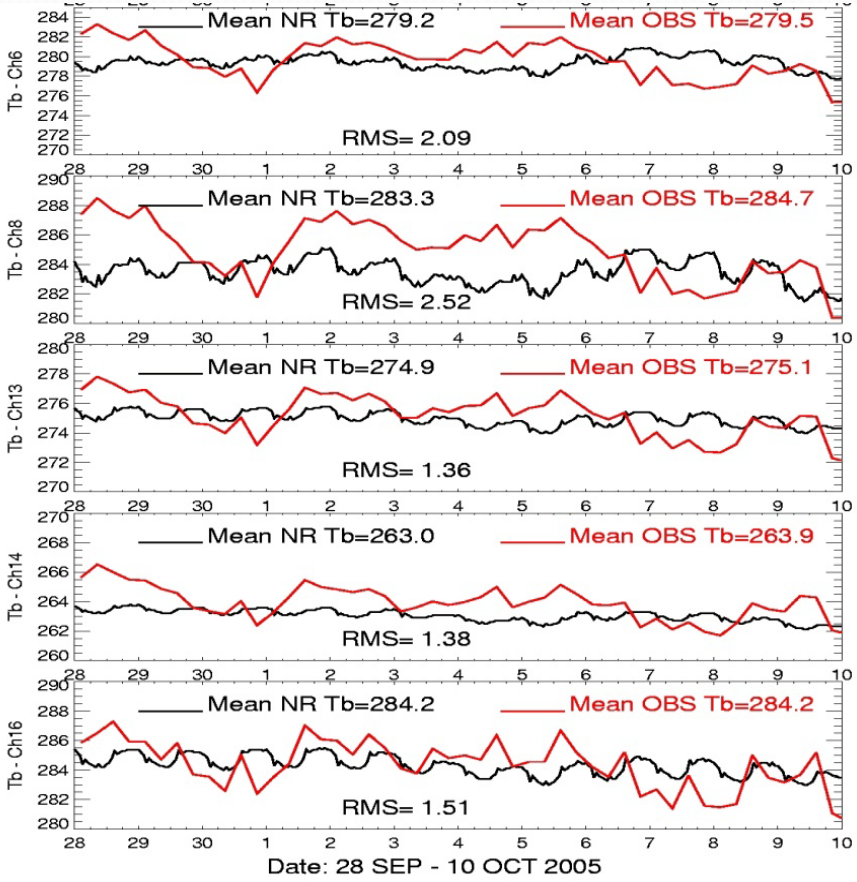
Ch-6 12.6 μm

Ch-8 11.0 μm

Ch-13 4.75 μm

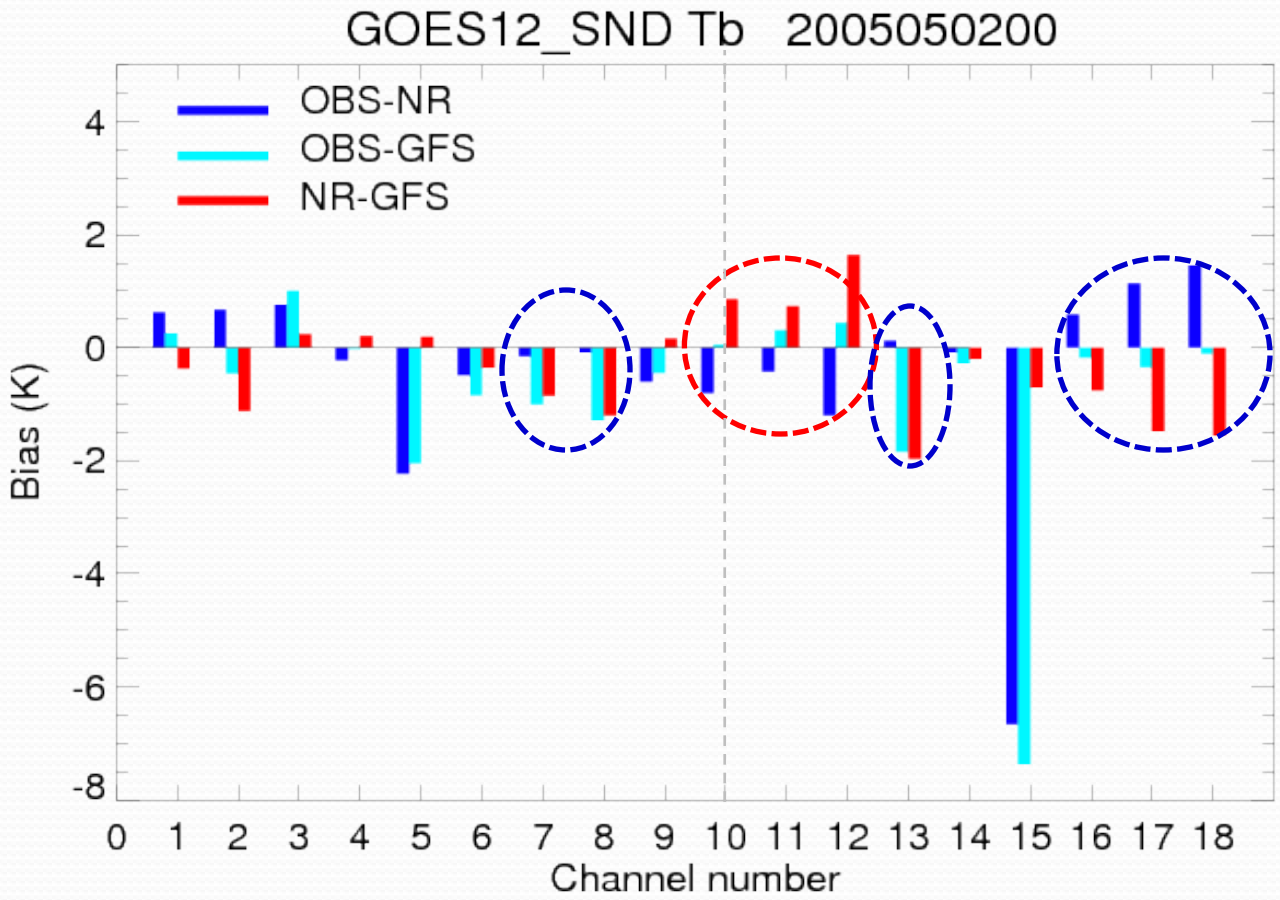
Ch-14 4.52 μm

Ch-16 4.13 μm



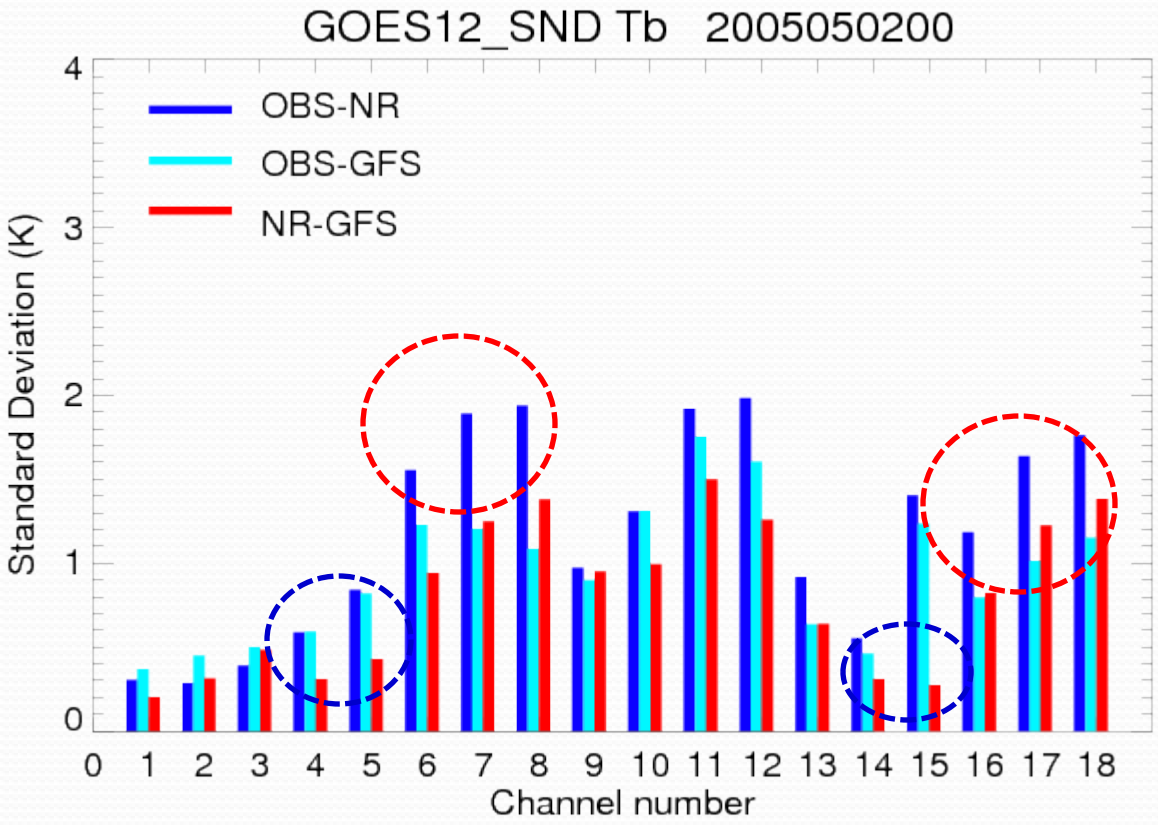
- Averaged over the North Atlantic Ocean scan sector, for the time period over 09/28 - 10/10, 2005.
- Surface temperature sensitive channels (Ch8, 13, 16) show strong diurnal cycle variation.
- RMS errors are small for atmospheric sounding channels, and larger than 2 K for surface and moisture channels.

Comparison of GOES-12 Sounder Simulation Biases



- Biases of OBS-NR and OBS-GFS have similar sign and magnitude at most channels, except following bands.
- O-B large differences can be found at Ch10-12, atmospheric moisture bands. NR field is more moist than GFS field.
- Compared with GFS Tb, there is about 1 K – 2 K cold bias of NR simulated Tb at Ch7-8, ch13, Ch16-18, which are PBL and surface temperature bands. At short wave window bands, NR Tb is close to OBS, while GFS Tb is close to OBS at longwave window.

GOES-12 Sounder Simulation Standard Deviations

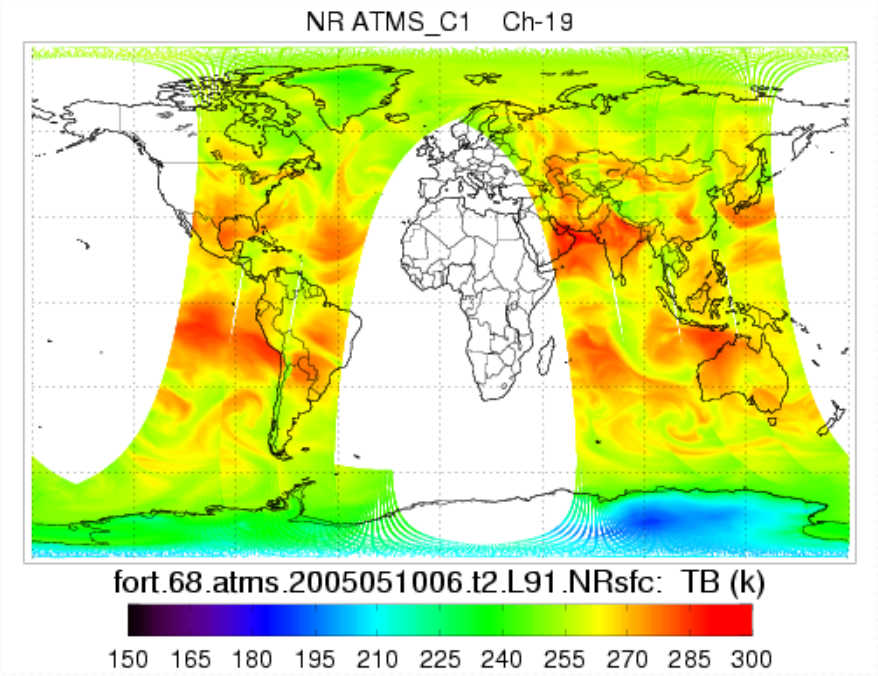


- STDs of OBS-NR and OBS-GFS are similar, except Ch6-8 and Ch16-18, which are surface sensitive temperature and moisture bands.
- At a few channels, like Ch4, 5, 15, NR-GFS STDs are smaller than that of OBS-GFS.

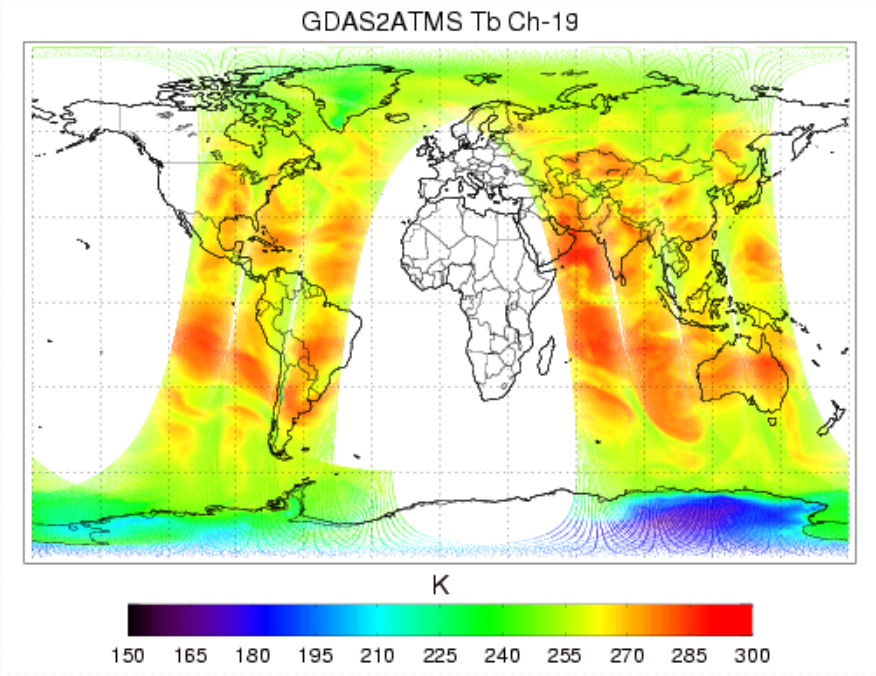
Simulation of ATMS with OSSE NR vs. simulation with GFS

ATMS Ch-19

Using OSSE NR data
0600 UTC 10 May 2005

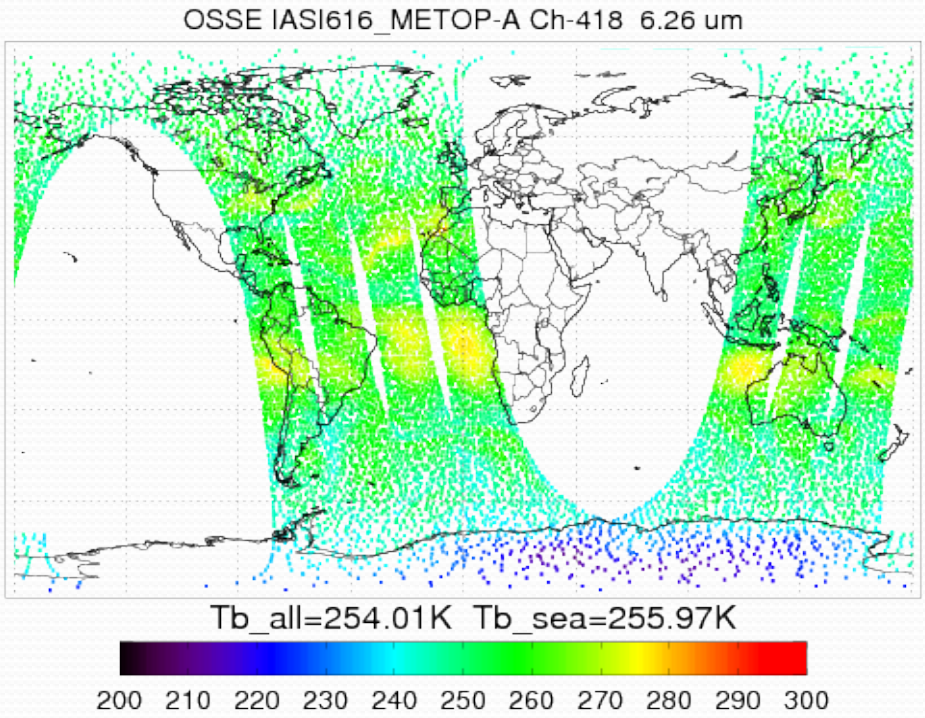


Using GFS analysis
0600 UTC 10 May 2011

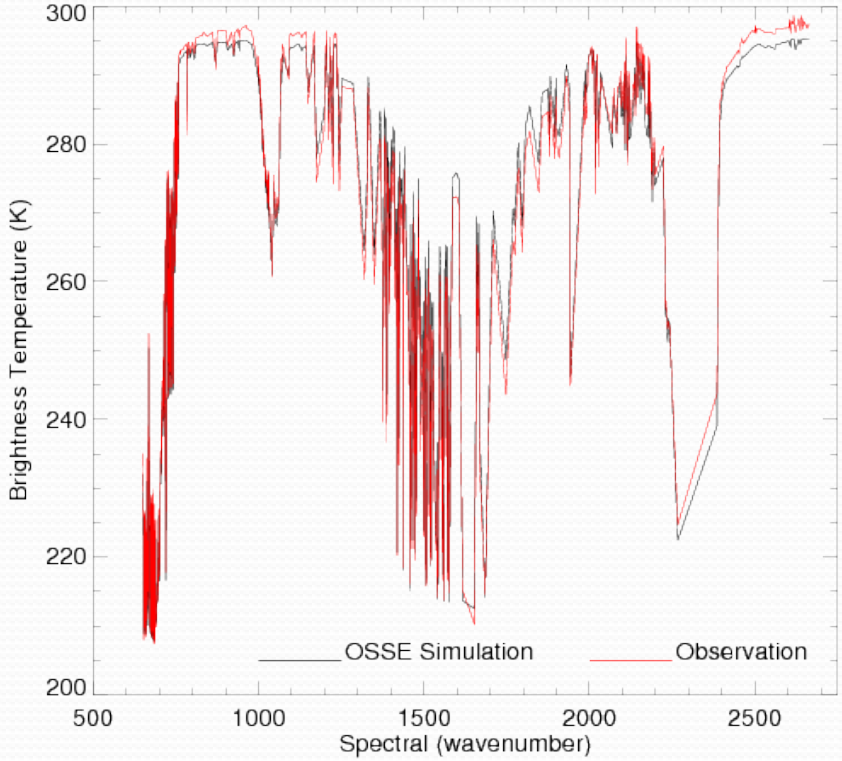


OSSE IASI Simulation vs. Observation

Ch-418 6.25 μm WV band
for 0000 UTC 02 May 2012 GSI ingest time



Point at: lon= 4.32E, lat= 10.19S
Ocean Clear_sky_amt=98%



Summary and Future Plan

- In general, the simulated radiances display similar statistical characteristics (bias & STD) as those derived from the operational GSI analysis for AMSU-A.
- The AMSU-A synthetic radiances can reproduce inter-channel correlation features, and symmetric angular dependent features. The asymmetric angular dependent bias cannot be simulated.
- The error characteristics of simulated GOES-12 temperature sounding channels are similar to those from operational GFS analysis; while those biases of moisture and surface channels are approximately 2K.
- Using the ECMWF T511 NR data, we are simulating all satellite radiances data for 2012 in order to include the sensors used in GSI after 2006.
- Simulate future instruments, such as GOES-R ABI.
- Simulate synthetic radiance with ECMWF T799 NR data.