Assimilation of ATMS Radiances in HWRF

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Abstract

The Advanced Technology Microwave Sounder (ATMS) is a cross-track scanning radiometer that combines all the channels of AMSU-A/B modules into a single payload and has additional channels. With its new design in scanning geometry and more channels in temperature and water absorption lines, ATMS provides better atmospheric temperature profiles under all weather conditions. Compared to AMSU-A, ATMS has an additional 51.75 GHz channel which is sensitive to the temperature at 900-850 hPa. Its scan width of 2503 km is wider than the 2200-km width of AMSU-A which results in nearly no gap between two neighboring orbits at equator. Its continuous scanning along- and cross-rack may result in 1) about a 31.6 km resolution at the nadir, and 2) significant oversampling in the atmosphere off the nadir that can be optimally used to enhance the spatial resolution and reduce the instrument noise.

In this study, the quality control and bias correction schemes for ATMS in NCEP GSI under hurricane conditions are evaluated firstly, then the assimilation experiments of ATMS are conducted for hurricane Sandy with different bias correction schemes. The impacts of different bias correction schemes on the use of ATMS data are diagnosed. The westward bias of Sandy track forecast with the operational bias correction scheme was reduced with a scheme that corrects a scan-angle position bias. Thus, it is recommended that the bias correction scheme in GSI for ATMS need further investigation for regional hurricane analysis and forecast.

HWRF Channel Characteristics

Channel		Frequency (GHz)		NE Δ T (K)		Beam width (°)		Peak WF (hPa)	
ATMS	AMSU	ATMS	AMSU	ATMS	AMSU	ATMS	AMSU	ATMS	AMSU
1		23.8		0.50	0.30	5.2	3.3	Surface	
2		31.4	31.399	0.60	0.30	5.2	3.3	Surface	
3		50.3	50.299	0.70	0.40	2.2	3.3	Surface	
4		51.76		0.50		2.2		Surface	
5	4	52.8		0.50	0.25	2.2	3.3	1000	
6	5	53.596±0.115		0.50	0.25	2.2	3.3	700	
7	6	54.4		0.50	0.25	2.2	3.3	400	
8	7	54.94		0.50	0.25	2.2	3.3	270	
9	8	55.5		0.50	0.25	2.2	3.3	180	
10	9	57.29		0.75	0.25	2.2	3.3	90	
11	10	57.29± 0.217		1.00	0.40	2.2	3.3	50	
12	11	57.29± 0.322± 0.048		1.00	0.40	2.2	3.3	25	
13	12	57.29± 0.322 ± 0.022		1.25	0.60	2.2	3.3	12	
14	13	57.29± 0.322 ± 0.010		2.20	0.80	2.2	3.3	5	
15	14	57.29± 0.322± 0.0045		3.60	1.20	2.2	3.3	2	
16	15	88.2	89.0	0.30	0.50	2.2	3.3	Surface	
17	16	165.5	89.0	0.60	0.84	1.1	1.1	1000	Surface
18	17	183.31±7.0	157.0	0.80	0.84	1.1	1.1	800	Surface
19	18	183.31±4.5	183.31±1.0	0.80	0.60	1.1	1.1	700	400
20	19	183.31±3.0		0.80	0.70	1.1	1.1	600	
21	20	183.31±1.8	183.31±7.0	0.80	1.06	1.1	1.1	500	800
22		183.31±1.0		0.90		1.1		400	

* Channel not used in HWRF, monitoring

ATMS Quality control and Bias correction

Quality control

- -CLW and window channel check
- -Gross check
- -Topography check
- -VarQC

$$b = b^{scan} + b^{air}$$

$$b^{scan} = b^{scan}(\text{global fixed in GSI})$$

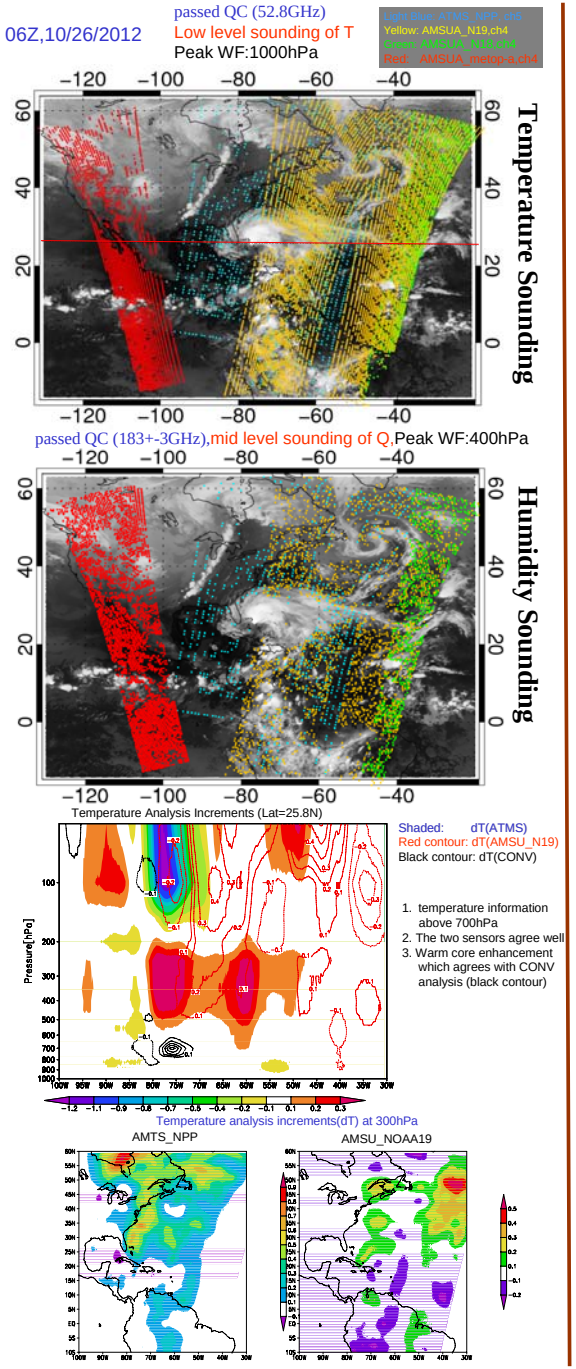
$$b^{air} = \beta_0 + \sum_{i=1}^{N} \beta_i \, p_i(x)$$

Bias correction

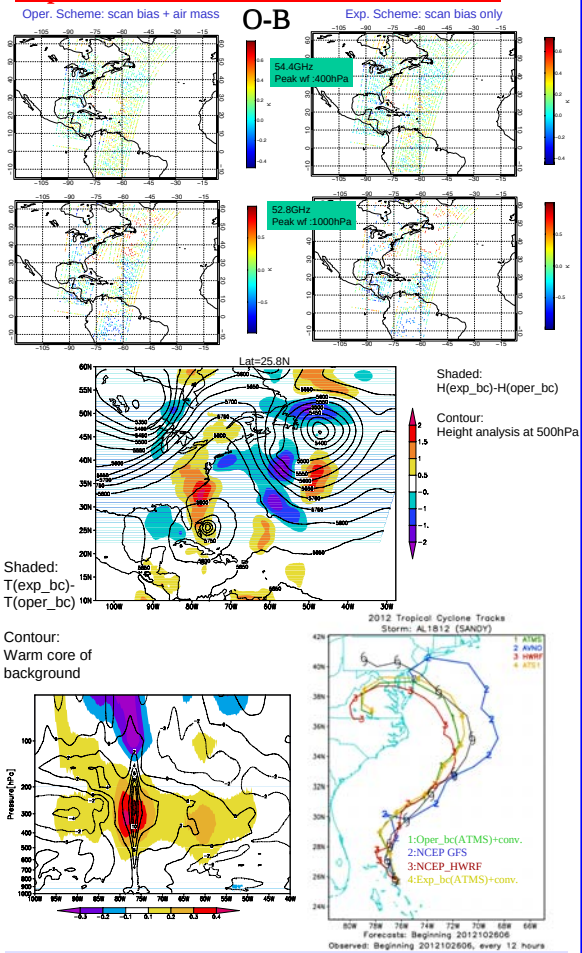
- -Scan bias correction
  - --Offline, based on previous O-B statistics
- -Air mass bias correction, VarBC
  - --CLW
  - --scan angle
  - --LAPS rate
  - --Square of LAPS rate

$$J(x,\beta) = (x_b - x)^T B_x^{-1}(x_b - x) + (\beta_b - \beta)^T B_\beta^{-1}(\beta_b - \beta) + [y - \tilde{H}(x,y,\beta)]^T R^{-1}[y - \tilde{H}(x,y,\beta)]$$

HWRF: 2 domains (dx=27km,9km), Top=1hPa,64 levels



Impact of different bias correction schemes



Summary:

This preliminary results from assimilation of ATMS radiances in HWRF are follows:

1) The use of ATMS data is complementary to the previous microwave sounding instruments for regional hurricane analyses. The analysis increments by NPP ATMS agree well with that by NOAA-19 AMSU which indicates the good calibration accuracy of ATMS indirectly;
2) In Hurricane Sandy forecast experiments, the westward bias of Sandy forecast track with the operational bias correction scheme by scan bias correction only scheme is reduced;
3) Bias correction plays a very important role in the use of ATMS data for hurricane analyses and forecasts and there are potential improvements of the current bias correction scheme in GSI for regional satellite radiance assimilation.
4) It could not be concluded that bias correction by air mass term should be removed in the current bias correction scheme from this case study. However it is clearly demonstrated that satellite observation information may be damaged by improper bias correction. Further study on quality control and bias correction of ATMS in HWRF is an-ongoing.