ATMS and AMSU-A Derived Hurricane Warm Core Structures Using a Modified Retrieval Algorithm

Xiaoxu Tian

Research Advisor: Dr. Xiaolei Zou

December 1, 2016

Outline

- Introduction to Microwave Temperature Sounders
- Warm Core Retrieval Algorithm Description
- Hurricane Sandy's Warm Core Evolution
- Summary and Conclusions

ATMS and AMSU-A Instrument Characteristics

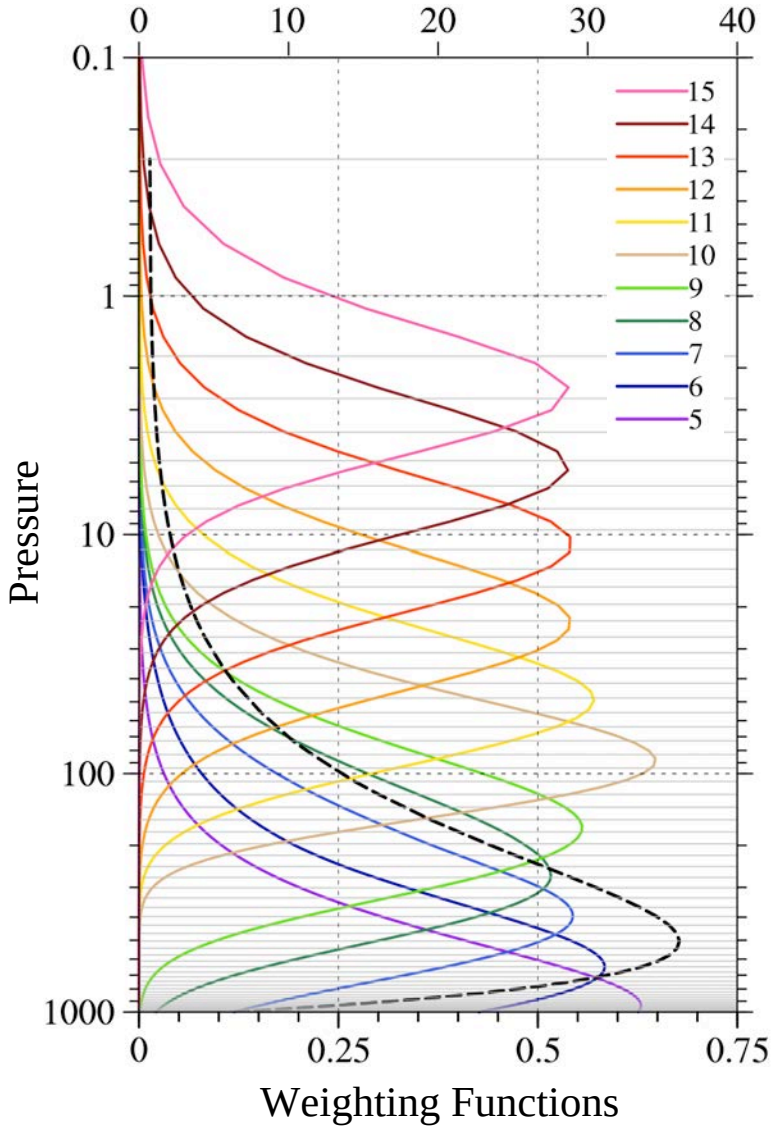
Channel No.		Frequency (GHz)		NEDT (K)		Peak WF (hPa)
ATMS	AMSU	ATMS	AMSU	ATMS	AMSU	
1		23.8		0.5		Window
2		31.4		0.6		Window
3		50.3		0.7		Window
4		51.76		0.5		950
5	4	52.8		0.5	0.25	850
6	5	53.596 ± 0.115		0.5	0.25	700
7	6	54.4		0.5	0.25	400
8	7	54.94		0.5	0.25	250
9	8	55.5		0.5	0.25	200
10	9	57.29		0.75	0.25	100
11	10	57.29 ± 0.217		1	0.4	50
12	11	57.29 ± 0.322 ± 0.048		1	0.4	25
13	12	57.29 ± 0.322 ± 0.022		1.25	0.6	10
14	13	57.29 ± 0.322 ± 0.010		2.2	0.8	5
15	14	57.29 ± 0.322 ± 0.0045		3.6	1.2	2
16	15	88.2	89	0.3	0.5	Window
	16		89		0.84	Window
17	17	165.5	157	0.6	0.84	Window
18	20	183.31 ± 7.0	190.31	0.8	0.6	800
19		183.31 ± 4.5		0.8		700
20	19	183.31 ± 3.0		0.8	0.7	500
21		183.31 ± 1.8		0.8		400
22	18	183.31 ± 1.0		0.9	1.06	300

Temperature sounding channels

Suomi National Polar-orbiting Partnership (NPP) carrying the crsoss-track scanner ATMS was successfully launched onto a sun-synchronous orbit on 28 October 2012.

ATMS is the successor of AMSU-A and MHS, to provide measurements from Earth surface to stratosphere.

ATMS Channel Weighting Functions



Channels 5-15 are temperature sounding channels with weighting functions peaking from 850 to 2 hPa.

Atmospheric temperatures can be expressed as linear combinations of brightness temperatures at these channels (Zhu et al, 2002; Zhu and Weng, 2013).

Temperature Retrieval Algorithm

A traditional regression equation for atmospheric temperature retrieval using AMSU-A and ATMS:

$$T(p) = C_0(p) + \sum_{i=5}^{15} C_i(p) T_b(v_i) + C_{sz}(p) \frac{1}{\cos(\theta)}$$

(Zhu, Zhang and Weng, 2002, AMSU-A)

(Zhu and Weng, 2013, ATMS)

A modified regression equation:

$$T_\theta(p) = C_0(p,\theta) + \sum_{i}^{n} C_i(p,\theta) T_{b,\theta}(v_i)$$

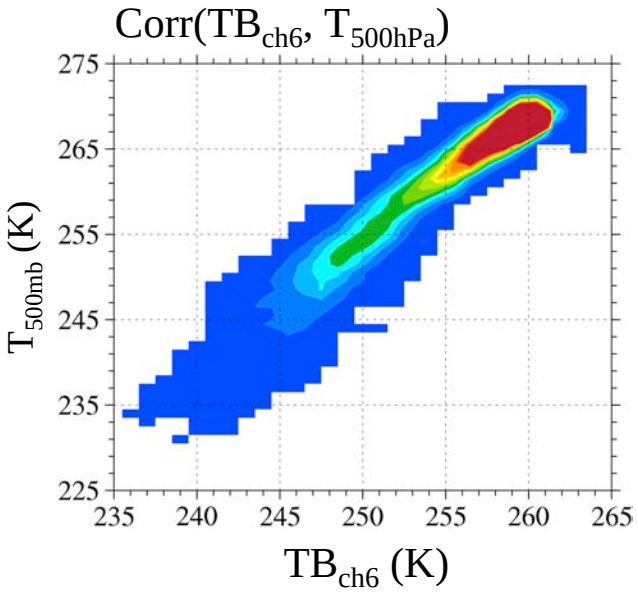
$T(p)$ or $T_\theta(p)$ – atmospheric temperatures

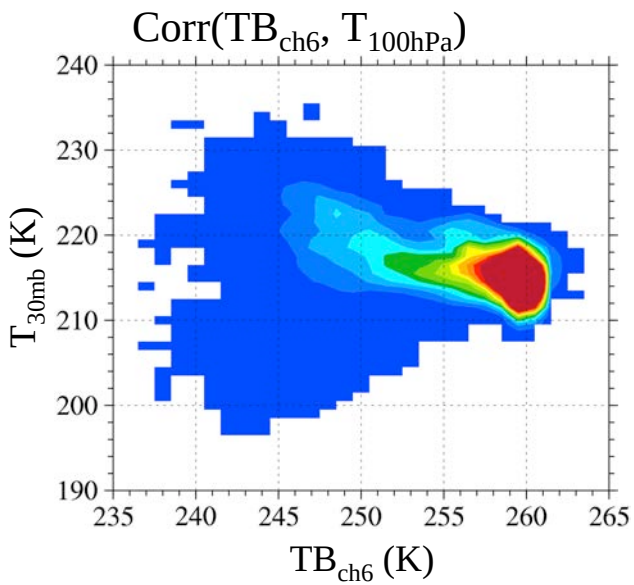
$C(p)$ or $C_0(p, \theta)$ – regression coefficients trained with GFS temperatures

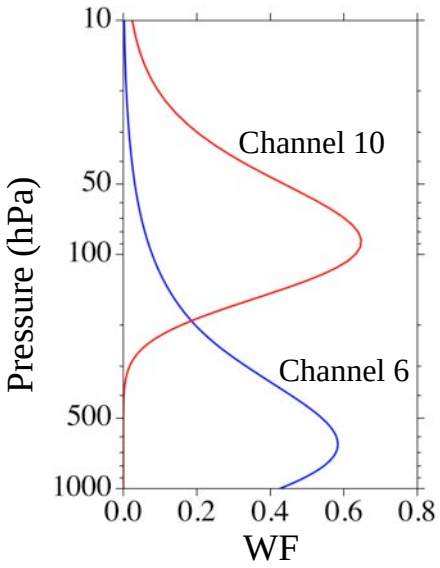
$T_b(v_i)$ or $T_{b,\theta}(v_i)$ – observed brightness temperatures at channels 5-15

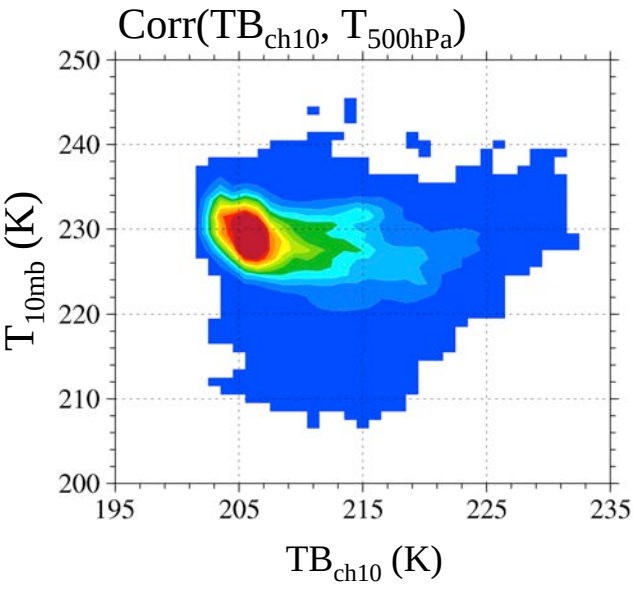
θ – local zenith angles.

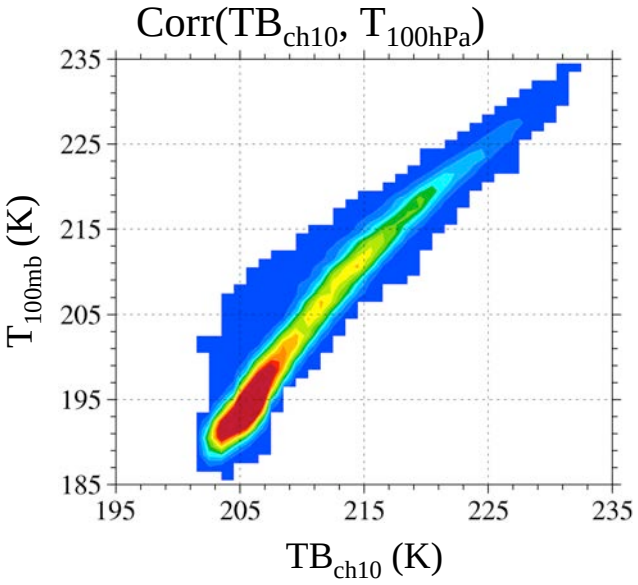
Correlations between T^{GFS} and TB^{ATMS}





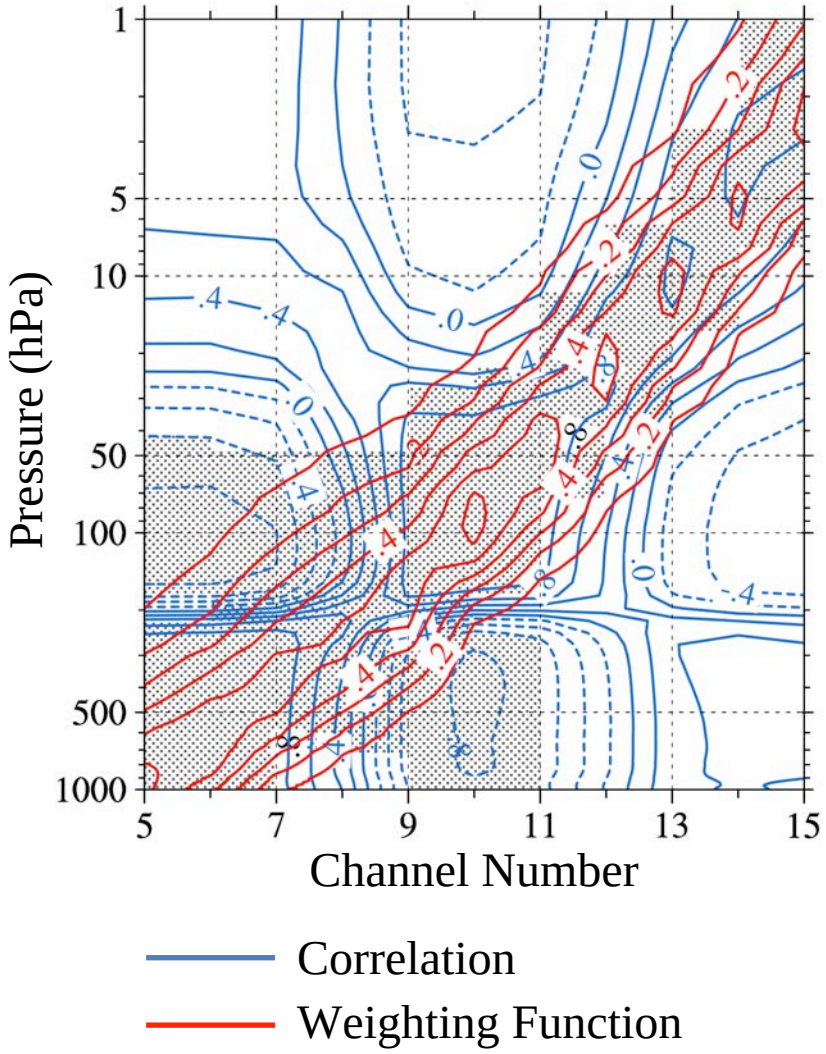






*TB*s are correlated with temperatures at pressure levels where the channel's weighting functions (WF) peaks.

Channel Selection for the Revised Algorithm

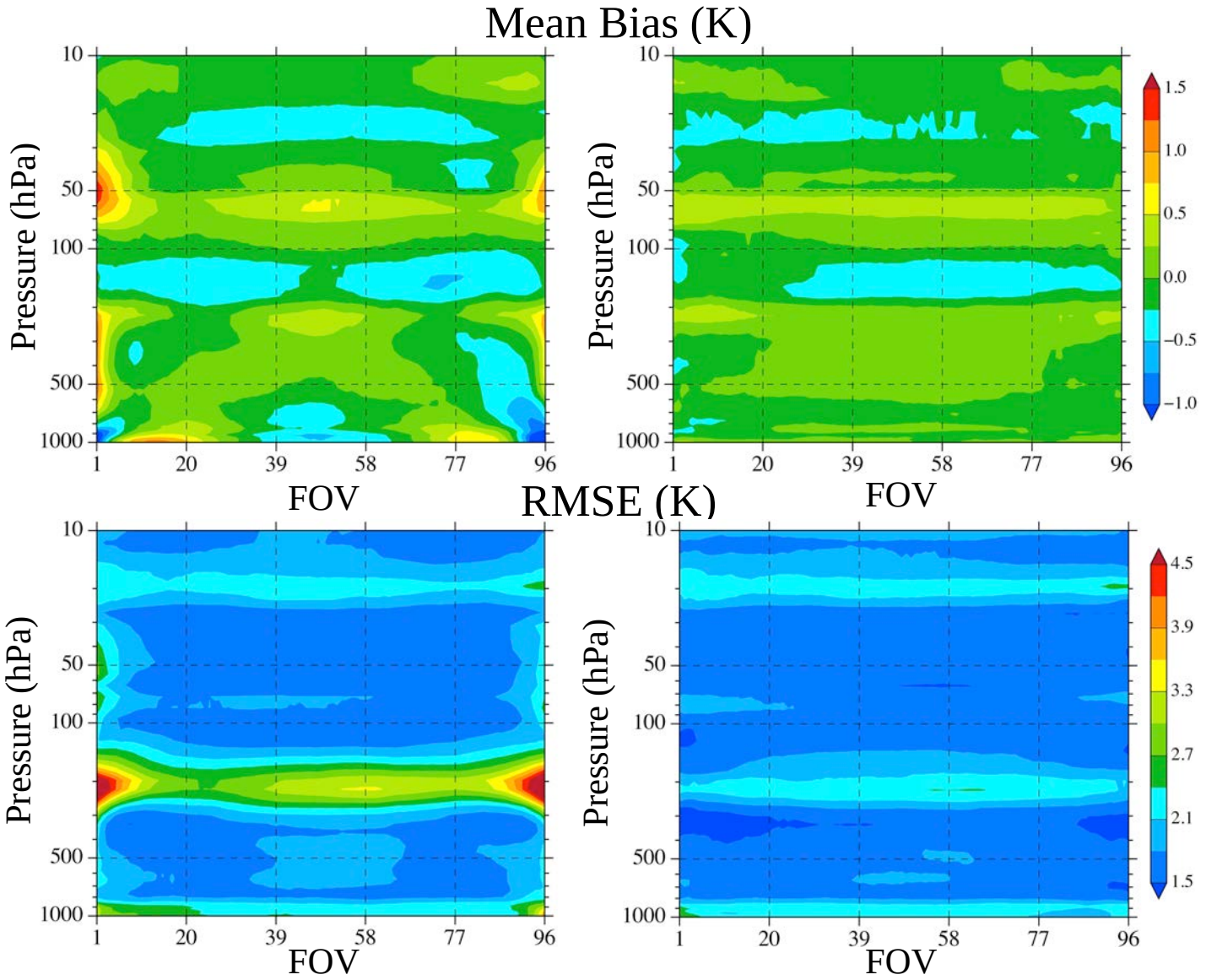


The atmospheric temperatures at a specified pressure level will be retrieved with TB at those channels that satisfy the following conditions (shaded in grey):

(i) Weighting function > 0.1, or

(ii) |correlation| > 0.5

Biases and RMSE of Retrieved Temperatures

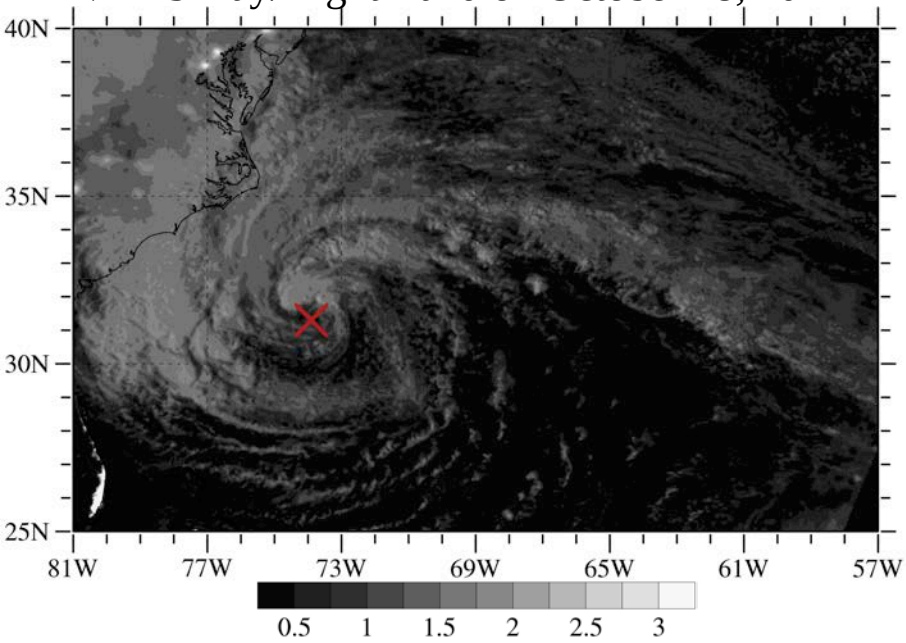


The mean scan biases have been reduced to below 0.5K.

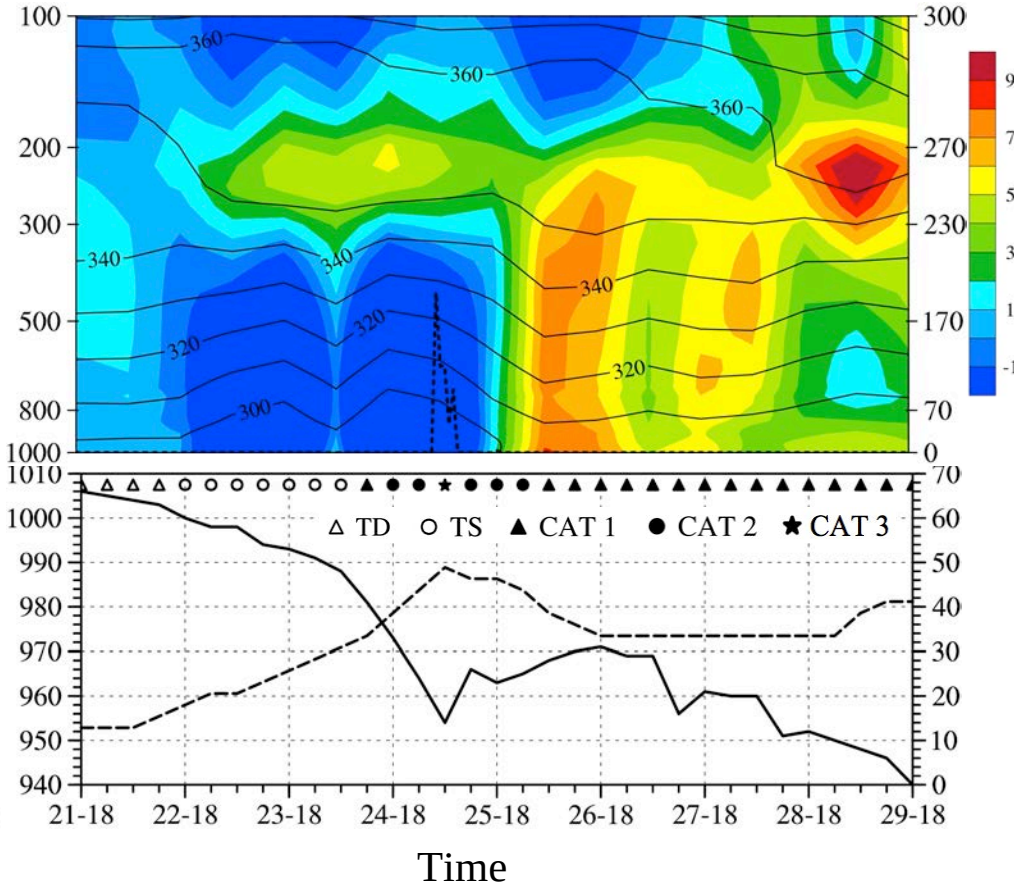
RMSE is greatly reduced compared with the traditional algorithm.

A Case Study — Hurricane Sandy

VIIRS Day/Night Band on October 28, 2012

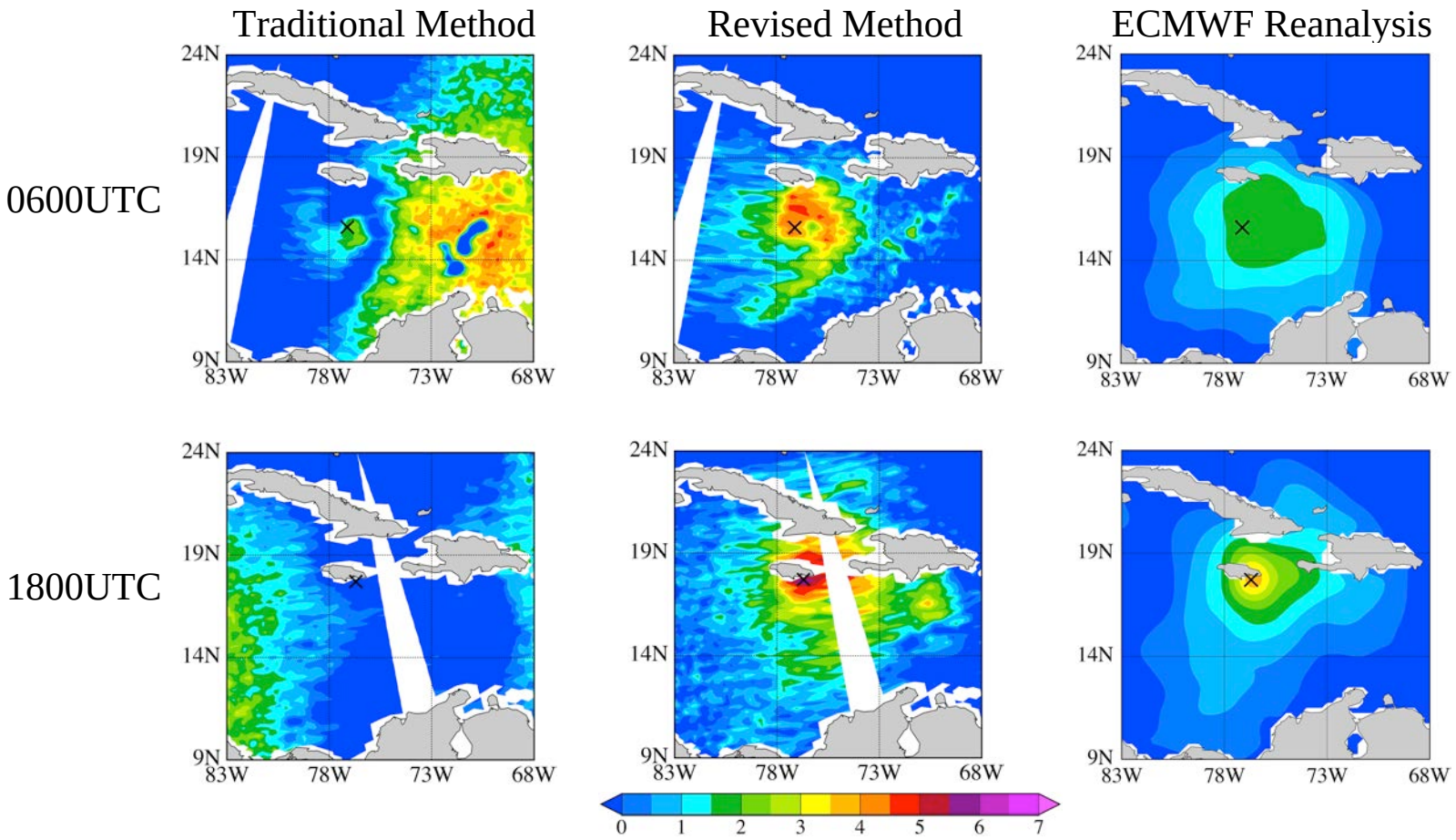


Time evolution of the temperature anomalies at the center from 1800 UTC October 21 to 1800 UTC October 29, 2012.



- Atmospheric temperatures during the period from Hurricane Sandy's genesis to its landfall were retrieved from ATMS observations.
- The temperature anomalies are obtained by subtracting an environmental temperature taken as the mean temperature within the 15˚ latitude/longitude box surrounding the hurricane eye excluding the storm's perturbation.

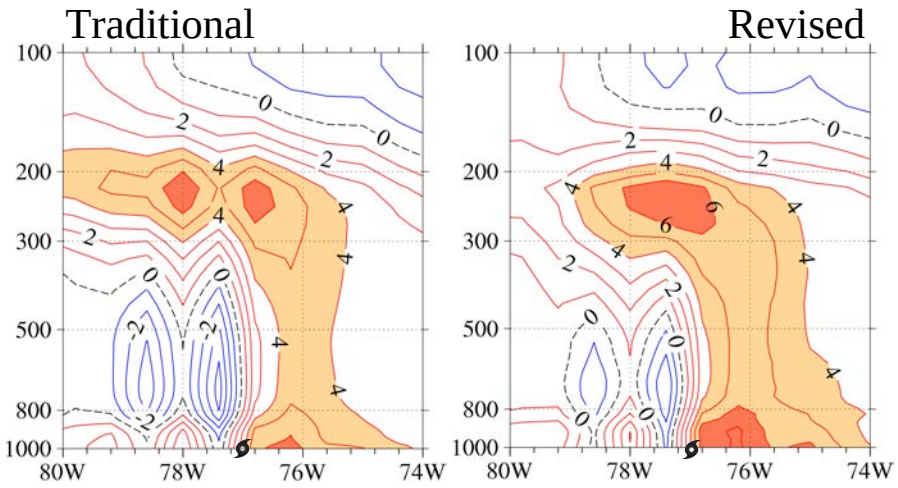
Warm Core at 250 hPa on October 24, 2012



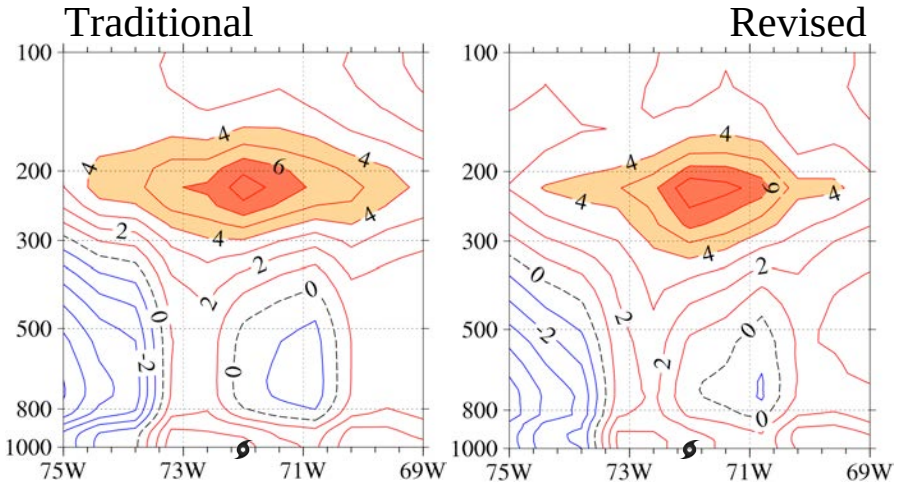
The warm core happened to be covered near the swath edges. Due to the strong biases near the edges, the traditional method didn't capture the warm core well.

Cross Sections of the Warm Core at 3 Selected Times

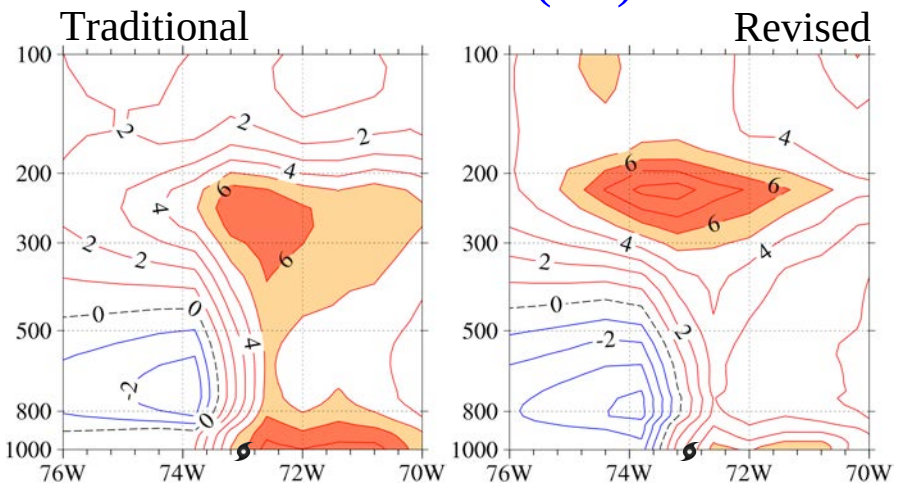
October 26 (H2)



October 28 (H1)

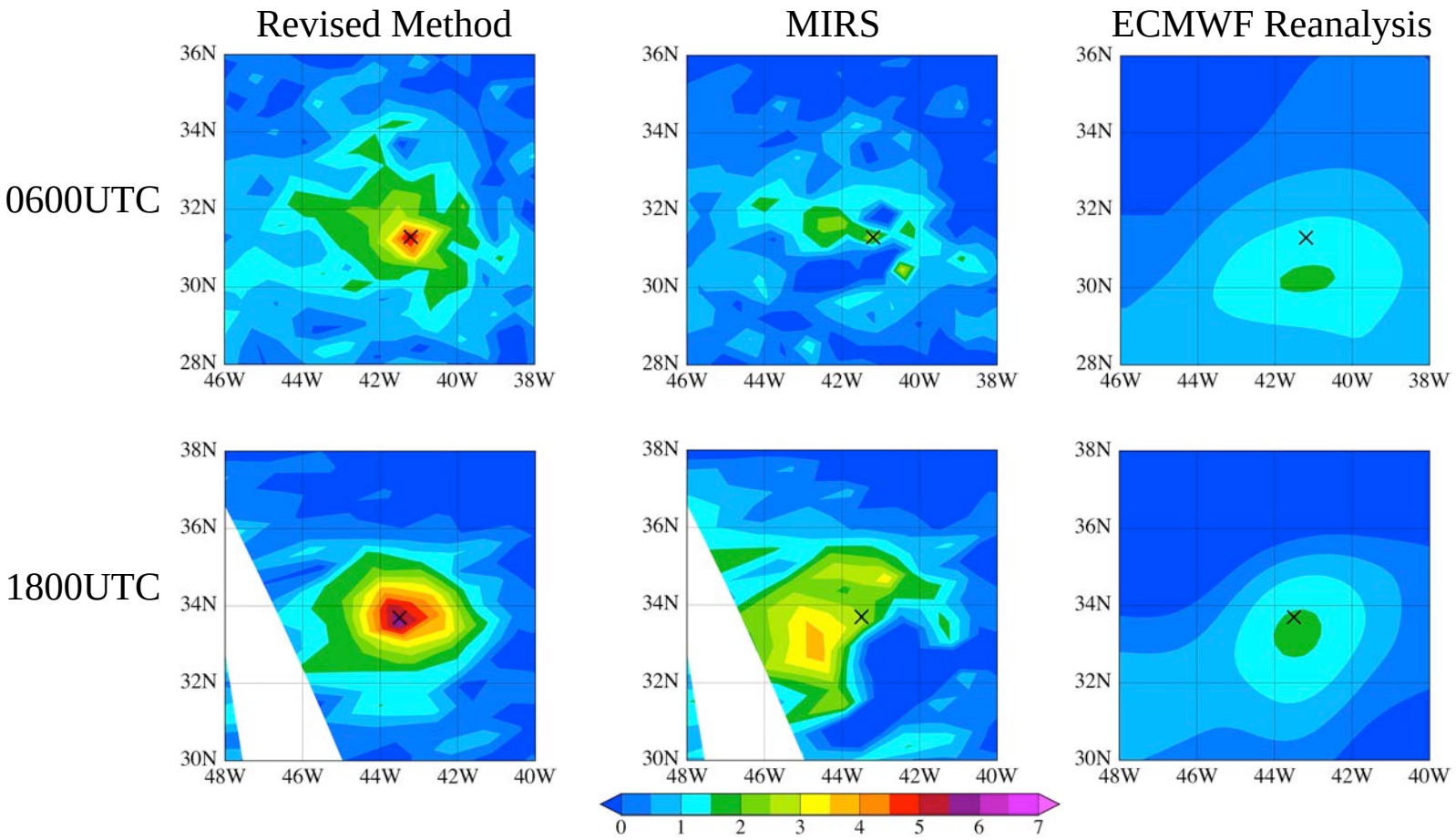


October 29 (H1)



- On 26 October, Sandy left Cuba and passed the Tropic of Cancer. The warm core was located to the east of the storm center.
- On 28 and 29, the warm core became more dominant in the upper troposphere.

Warm Core at 250 hPa on September 7, 2012



The retrieval algorithm is applied to AMSU-A on board NOAA-18, the results from which are compared with warm cores from MIRS output in the case of Hurricane Michael (2012).

Summary and Conclusions

- The atmospheric temperatures retrieved with the revised algorithm proposed in this research prove to be unbiased with respect to the temperature fields in GFS.

- The revised algorithm can capture the asymmetric warm core structures despite the storm's position with respect to the swath.

- The warm core structures from the revised algorithm are more realistic than MIRS retrievals in the cases of Hurricanes Sandy and Michael (2012).

Tian, X. and X. Zou, 2016: ATMS- and AMSU-A-derived hurricane warm core structures using a modified retrieval algorithm. *J. Geophy. Res.*, (in press)