Satellite Radiance Assimilation in HWRF

Xiaolei Zou

Department of Earth, Ocean and Atmospheric Science

Florida State University

Collaborators:

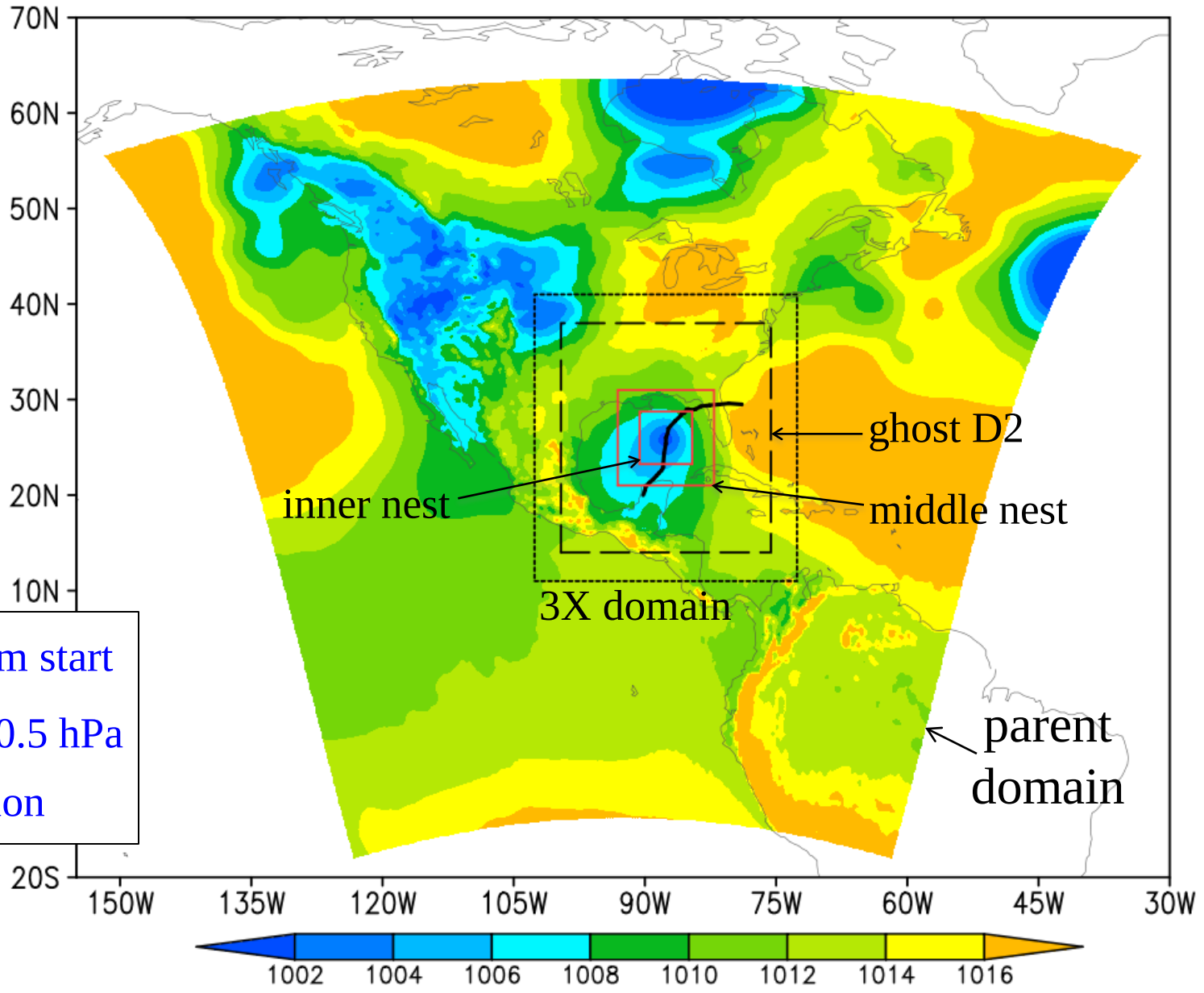
Fuzhong Weng, Banglin Zhang, Lin Lin,

Zhengkun Qin and Vijay Tallapragada

Outline

- A Comparison of Data assimilation and Forecast Results with Two Different Model Top Altitudes
  - ✓ Assimilation of upper-level channels
  - ✓ Differences in storm Debbie's track forecast
- Impact of ATMS radiance assimilation on hurricane track and intensity forecast
  - ✓ A unique feature of ATMS
  - ✓ A consistent positive impacts
- Impact of NOAA-15 AMSU-A Data on QPFs and Its Implications for Three-Orbit Constellation
  - ✓ 11p.02
- Current and Future Plan

HWRF Domain Sizes for Tropical Storm Debby



Three changes made to HWRF:

- Cold start -> warm start
- Model top 50 -> 0.5 hPa
- Vortex initialization

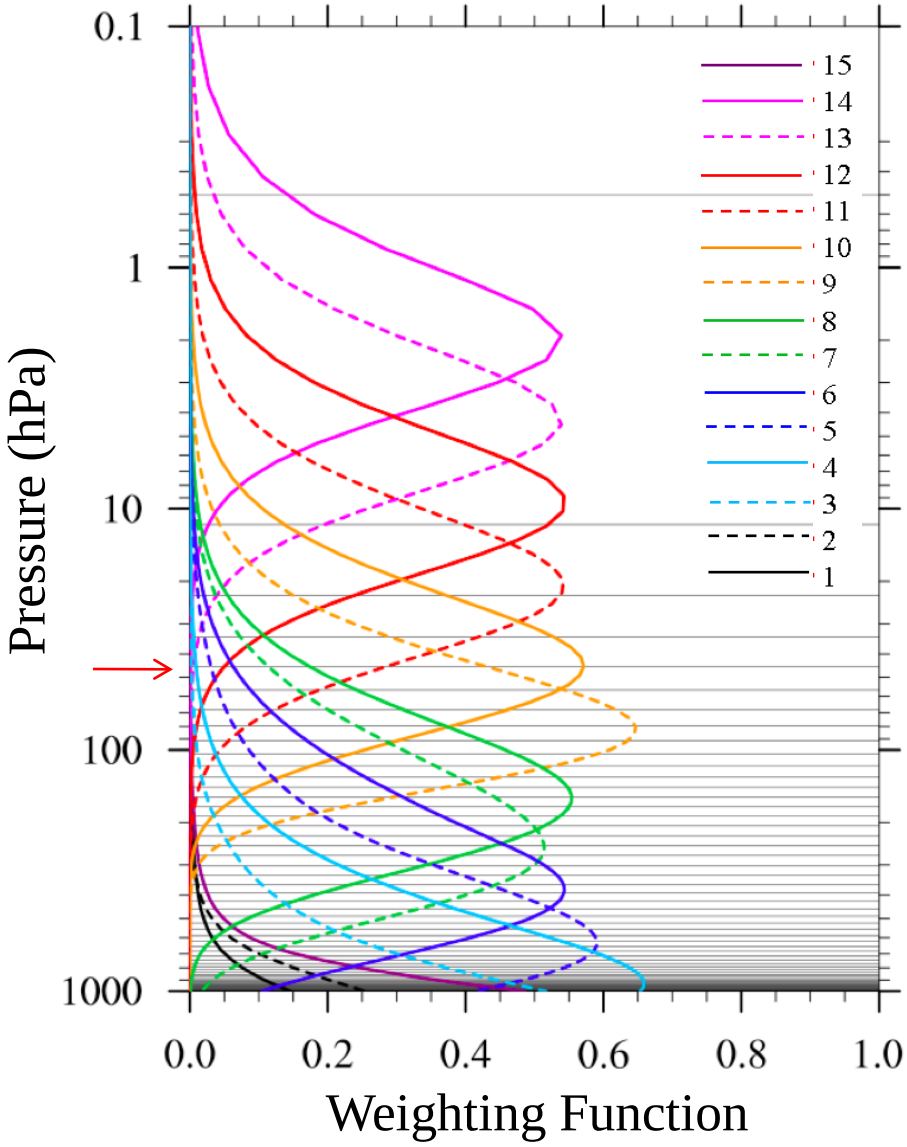
The Importance of Upper Atmosphere on TCs

Environmental factors involve atmospheric conditions in the upper troposphere and the stratosphere:

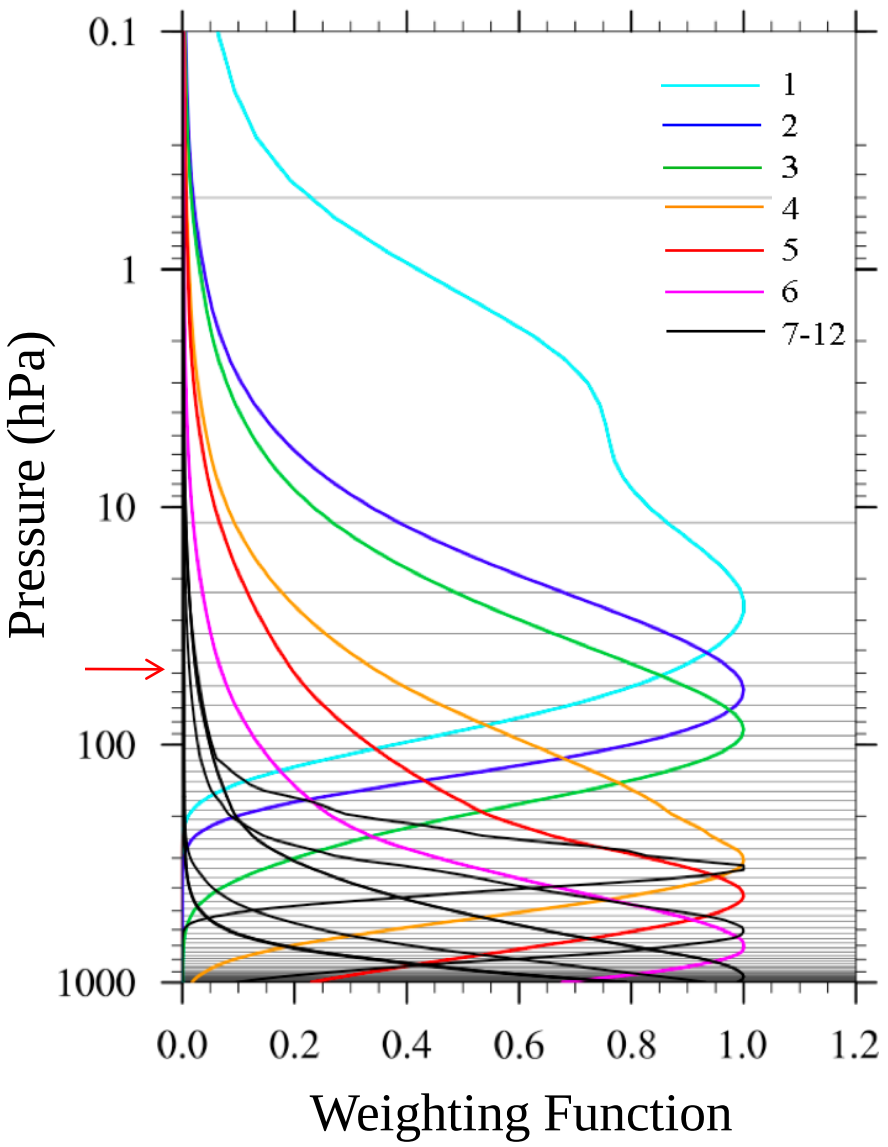
- ✓ Steering flow (Carr and Elsberry, 1990)
- ✓ Vertical wind shear
  (Davis and Bosart, 2006; DeMaria, 1996)
- ✓ Approaching upper-level trough
  (Leroux et al., 2013)
- ✓ Eddy angular momentum flux convergence
  (Pfeffer and Challa, 1981; Bosart et al. 2000)
- ✓ Stratospheric cooling (Ramsay, 2013)
- ✓ Quasi-biennial oscillation in the stratosphere
  (Chan, 1995)

Modeling these environmental factors affecting track and TC intensification requires a sufficiently high model top.

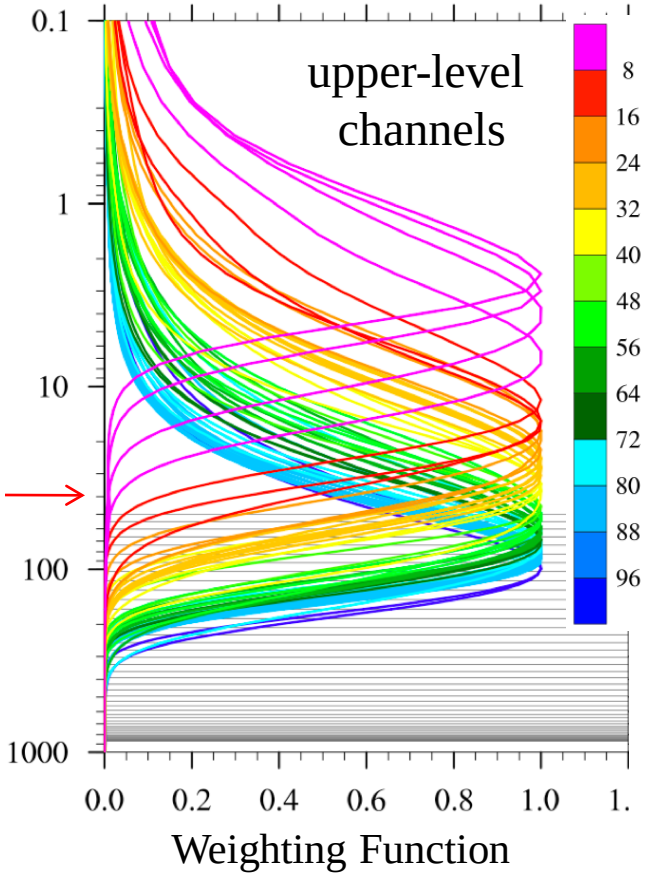
AMSU-A Channels

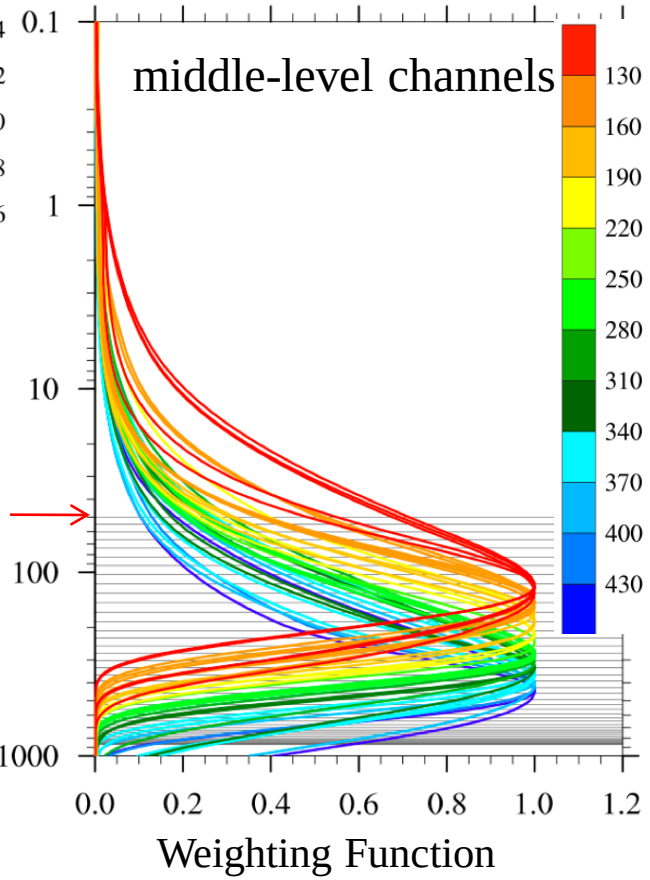


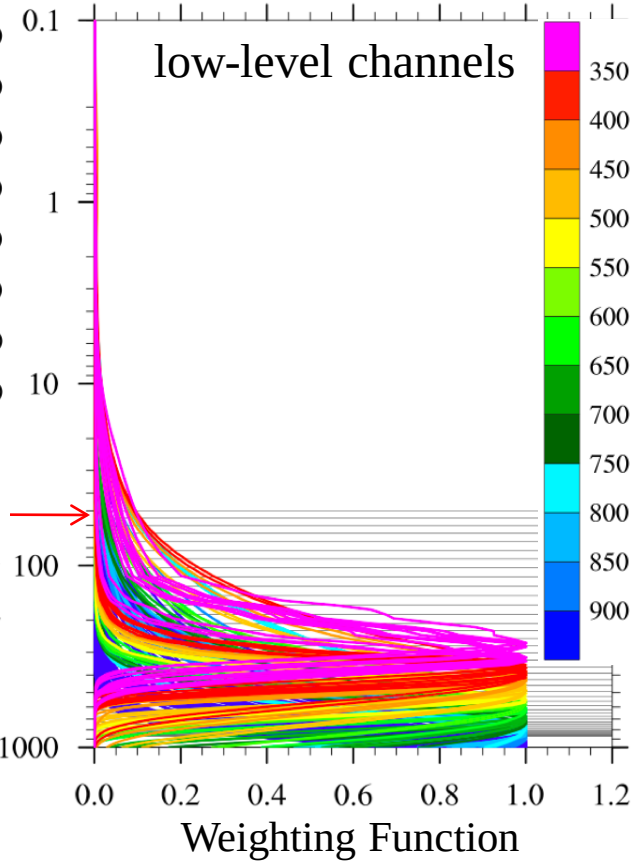
HIRS Channels



AIRS Channels (281)

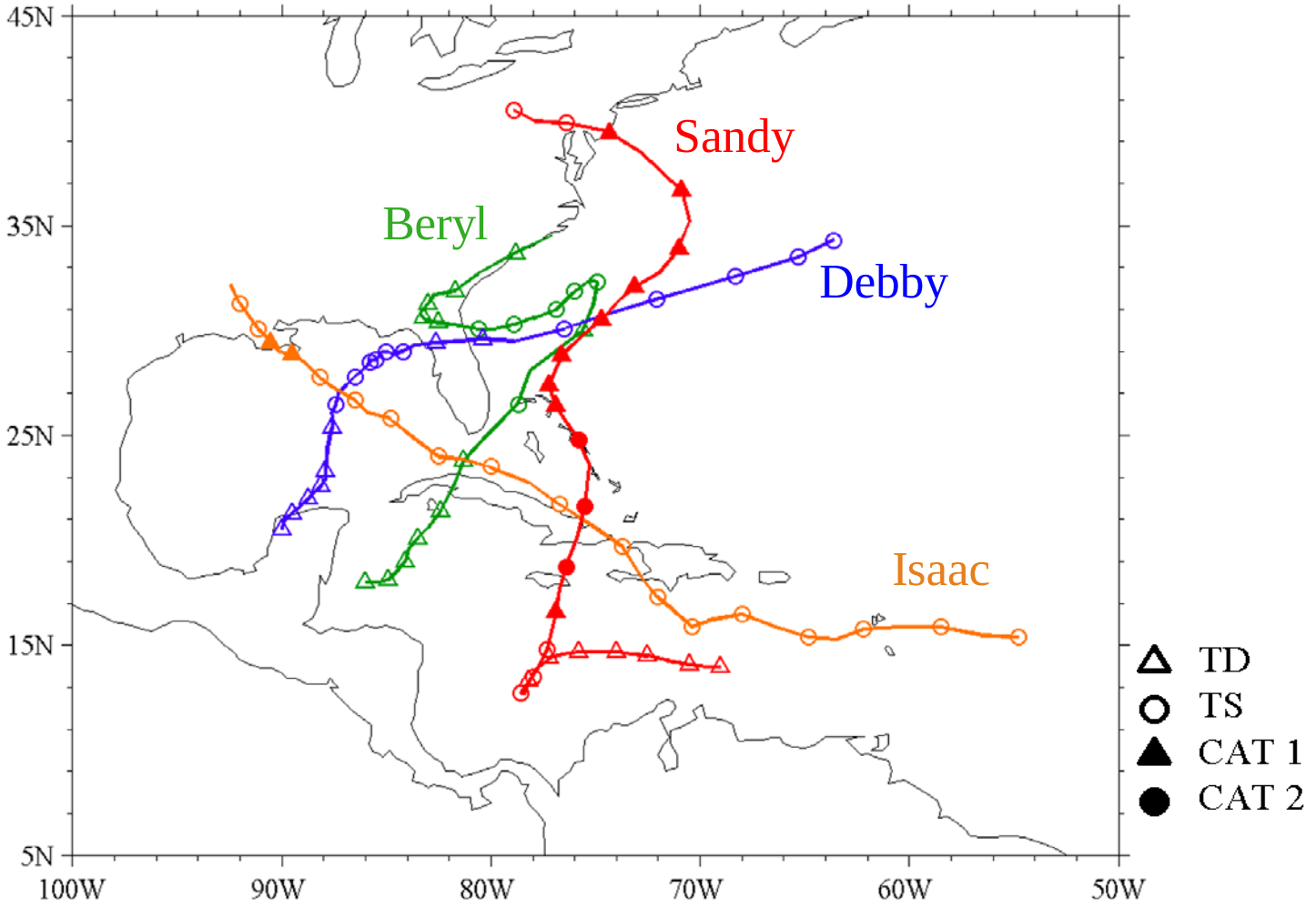




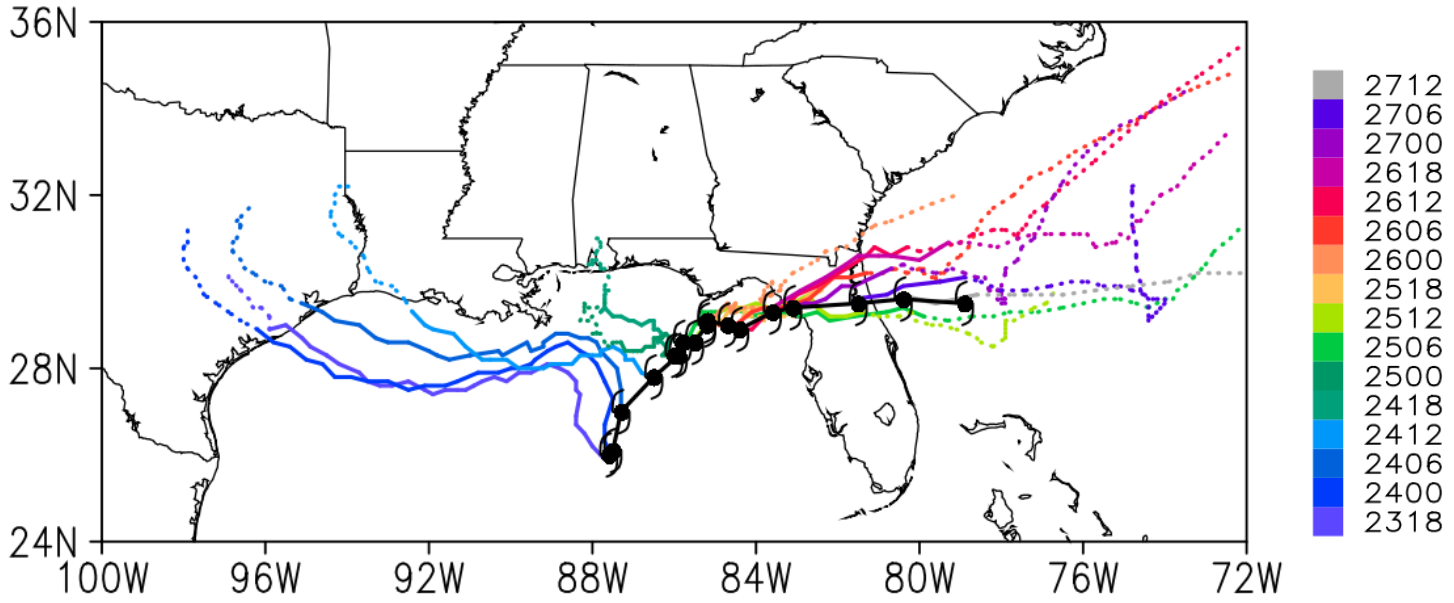


These 281 channels are selected for data assimilation in the GSI/HWRF system. The pressure at which WF reaches a maximum is indicated in color.

The Best Track of Four 2012 Atlantic Landfall Hurricanes Selected for This Study



Track Predictions of the 2012 Operational HWRF

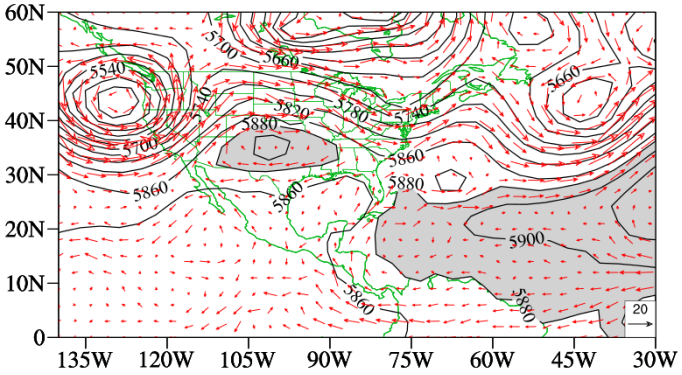


- The operational HWRF model produced an eastward propagating tracks while Debby moved northeastward when model forecasts were initialized before June 25, 2012
- The operational HWRF model produced reasonably good track forecasts after June 25 and afterward.

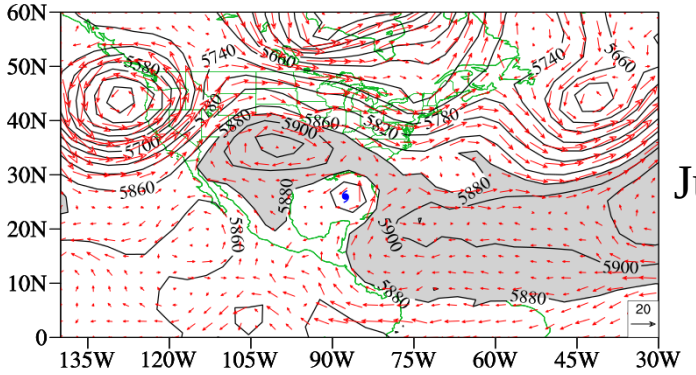
The track prediction of Debby before June 25, 2012 was a major challenge.

500-hPa Geopotential and Wind Vector Distributions

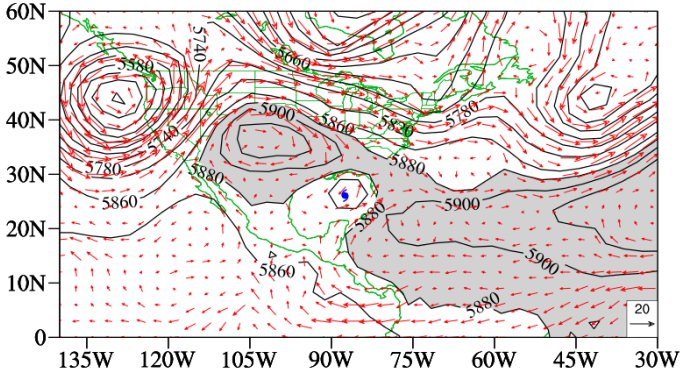
1200 UTC
June 23 ,2012



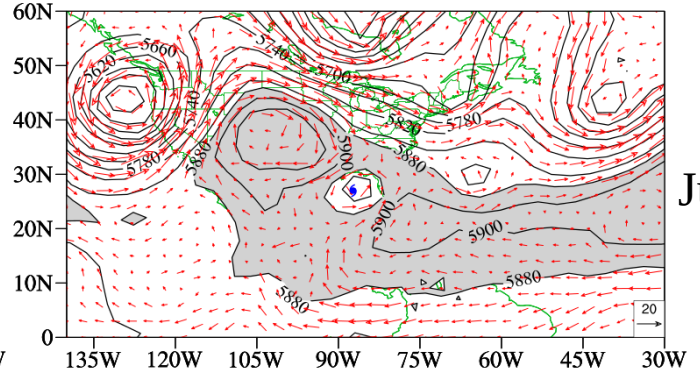
1800 UTC
June 23, 2012



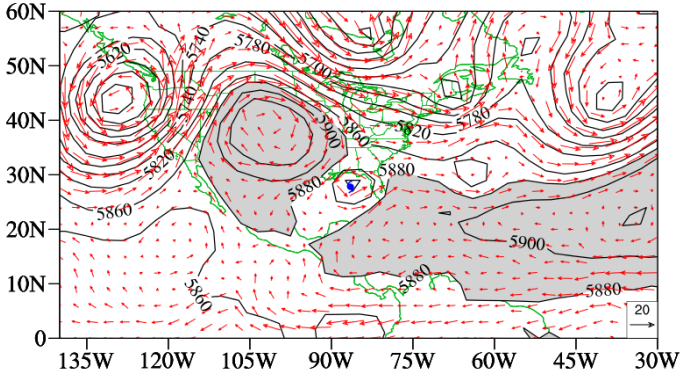
0000 UTC
June 24 ,2012



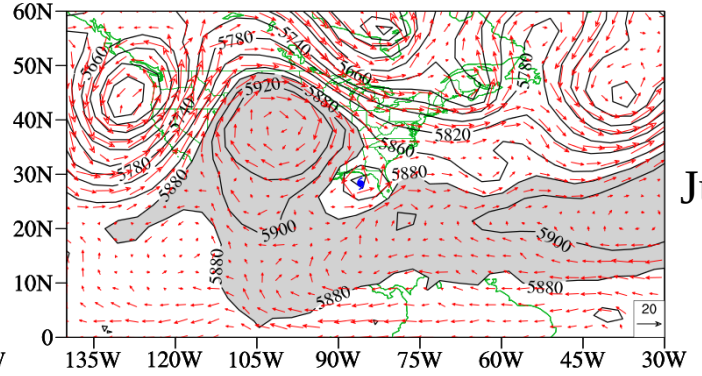
0600 UTC
June 24, 2012

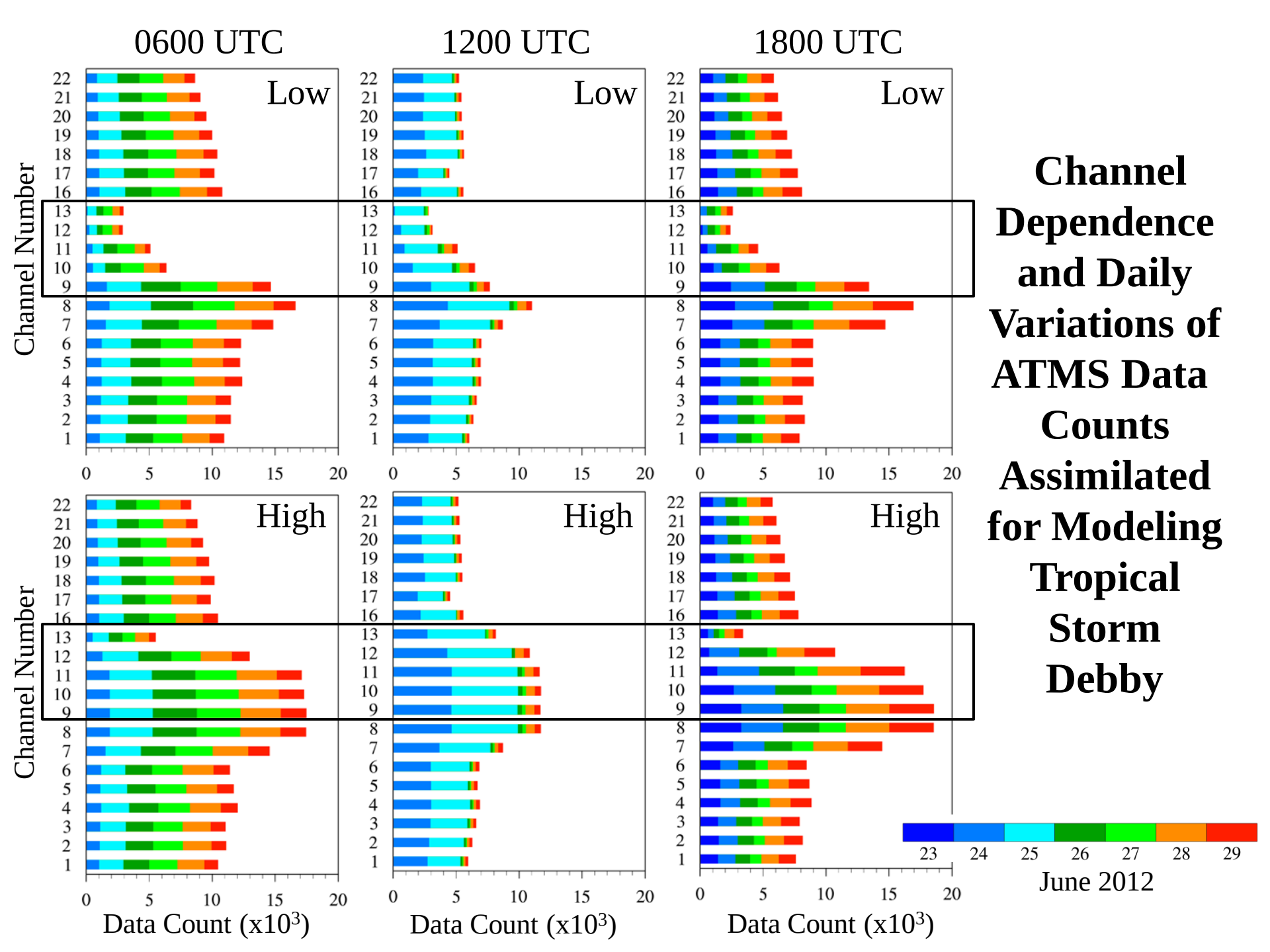


1200 UTC
June 24, 2012

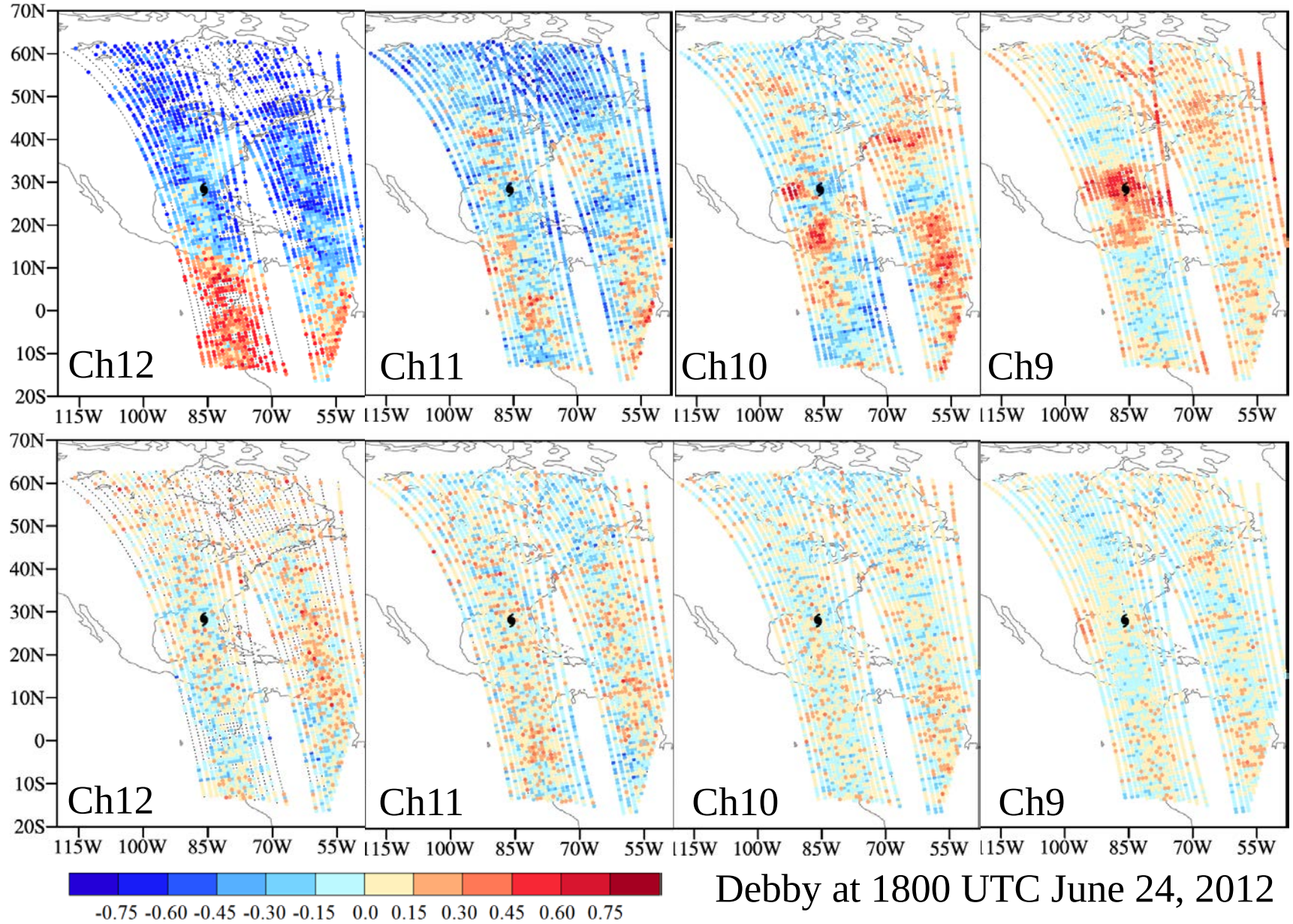


1800 UTC
June 24, 2012

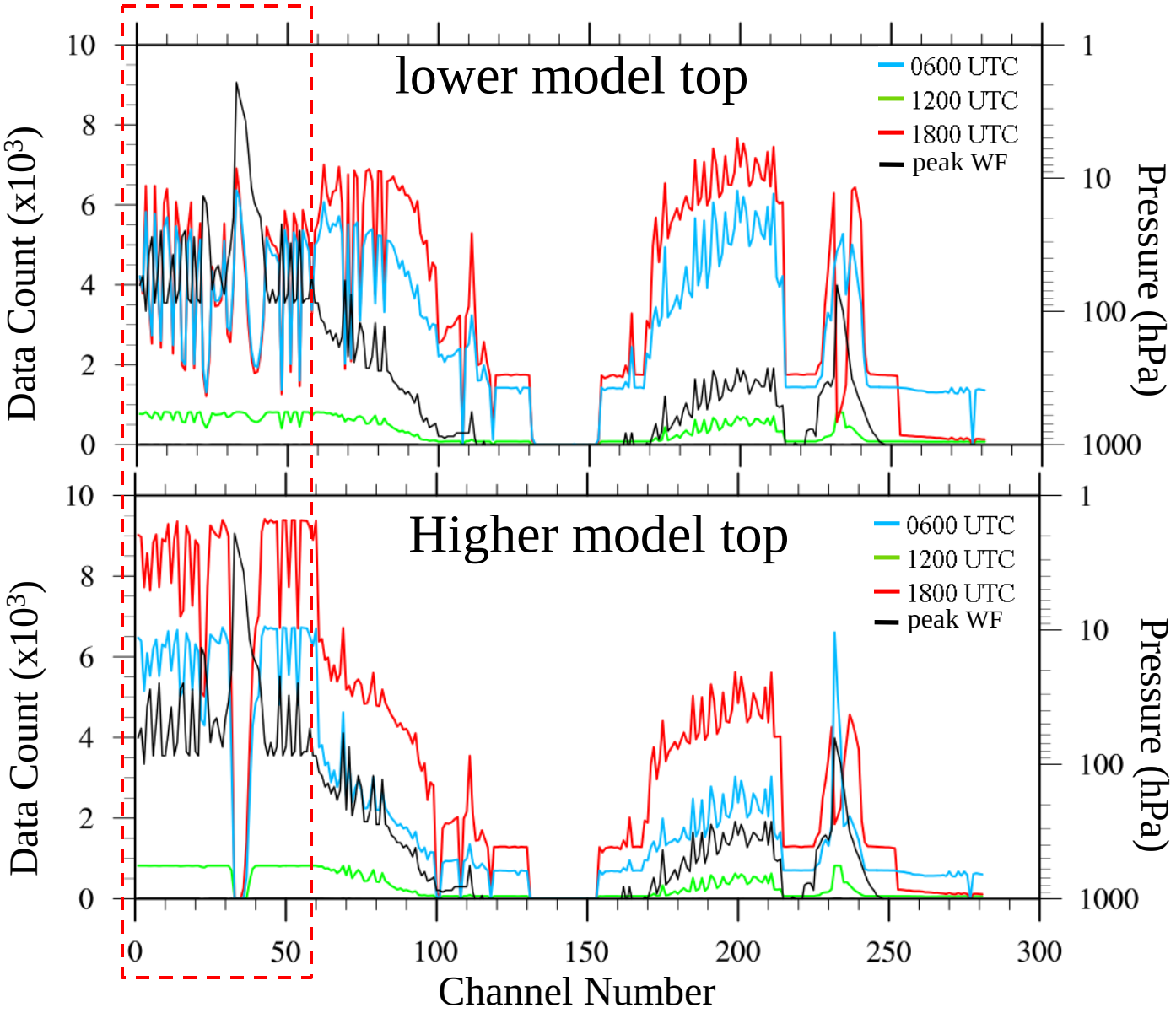



0600 UTC
1200 UTC
1800 UTC
Low
High
Channel Number
Data Count (x10³)
0
5
10
15
20
1
2
3
4
5
6
7
8
9
10
11
12
13
16
17
18
19
20
21
22
23
24
25
26
27
28
29
June 2012
Channel Dependence and Daily Variations of ATMS Data Counts Assimilated for Modeling Tropical Storm Debby

O-B and O-A Distributions of ATMS Upper-Level in L61



AIRS Channel Dependence of Data Count Assimilated During Tropical Storm Debby

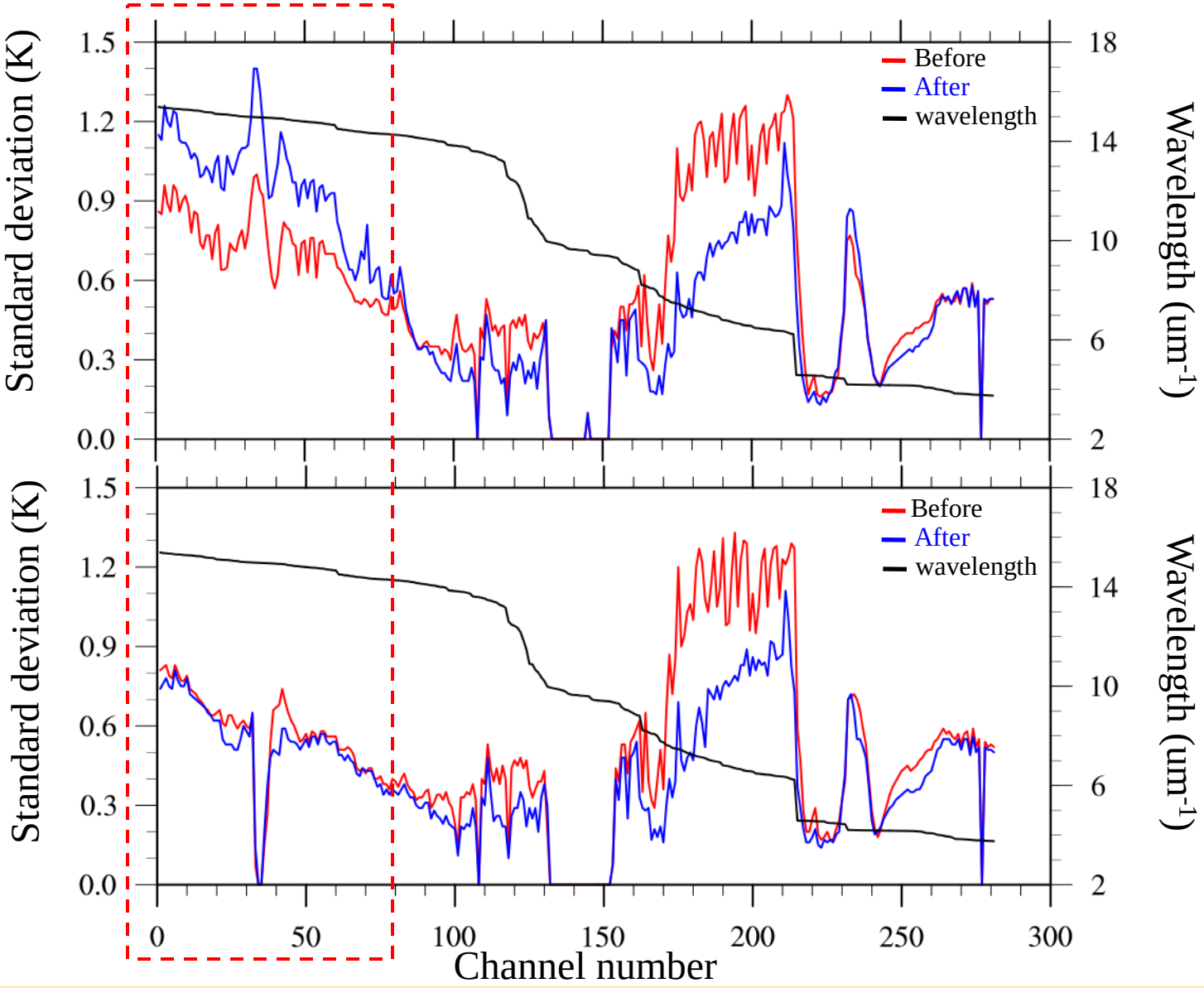


More upper-level channel data are assimilated in L61 with a higher model top (0.5 hPa) than L43 whose model top is located around 50 hPa.

Model Fit to AIRS Observations before and after DA

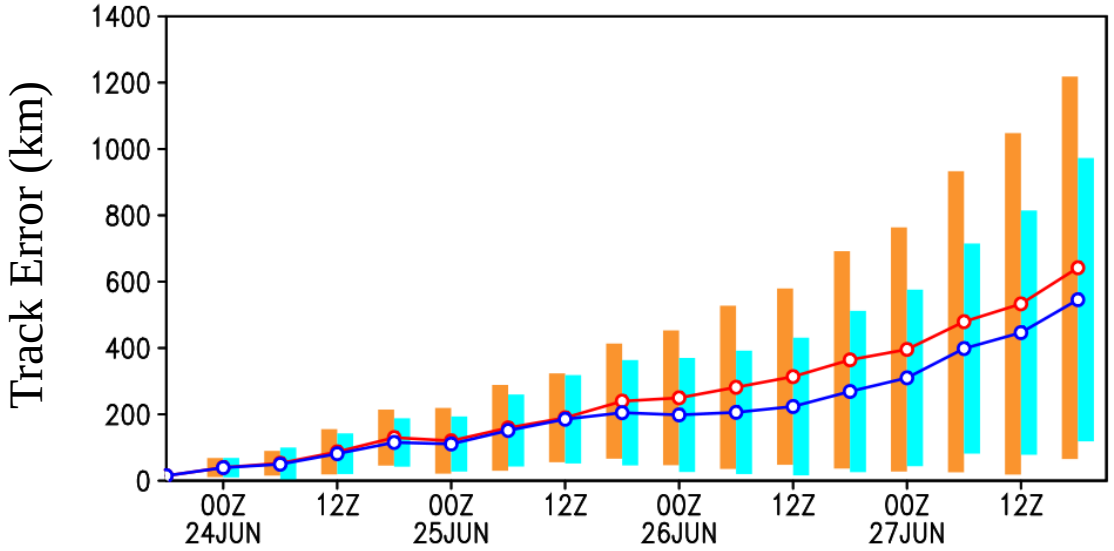
Lower Model top

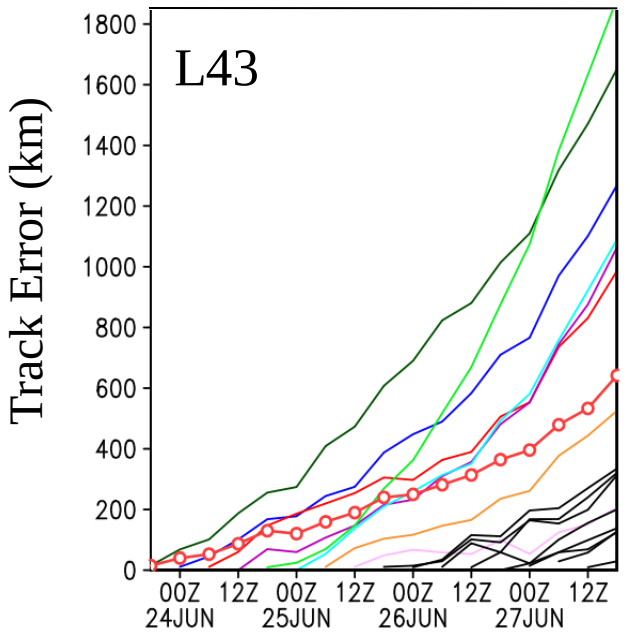
Higher Model top

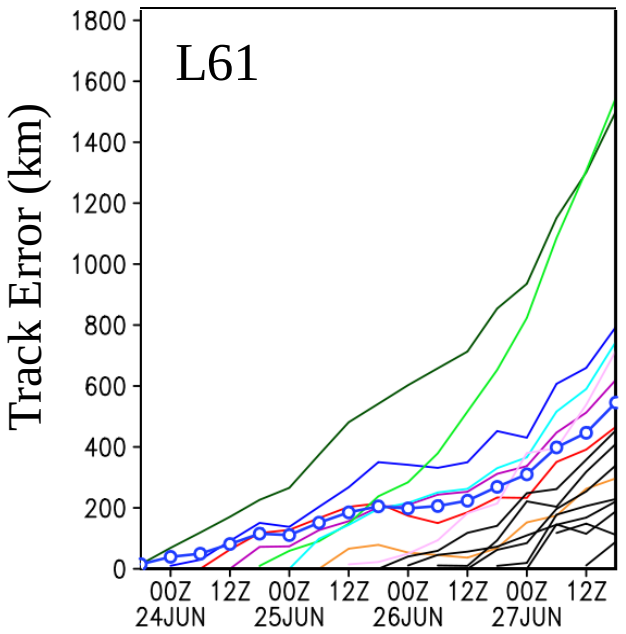


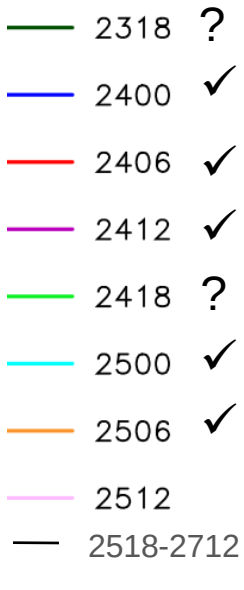
The std. of O-A is greater than that of O-B for upper-level channels in L43.

Comparison of Track Forecasts between L61 and L43





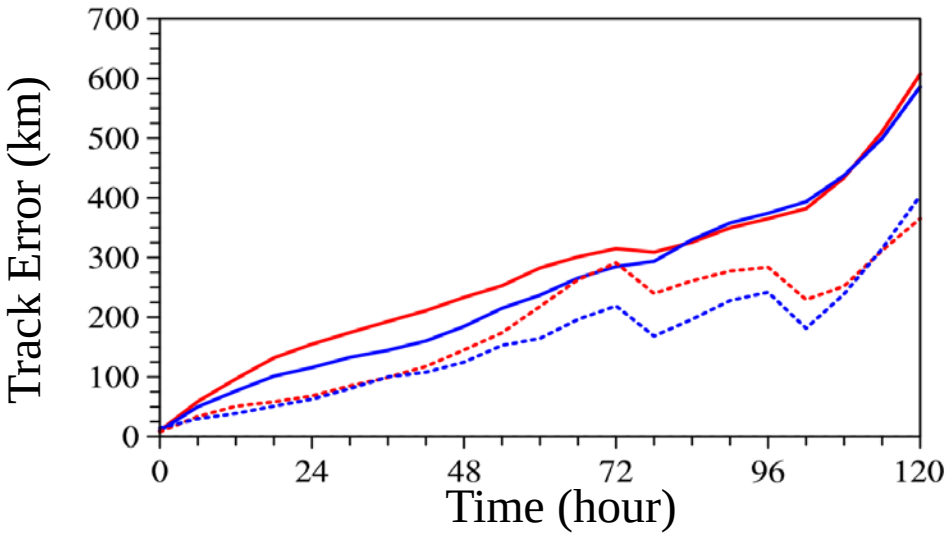


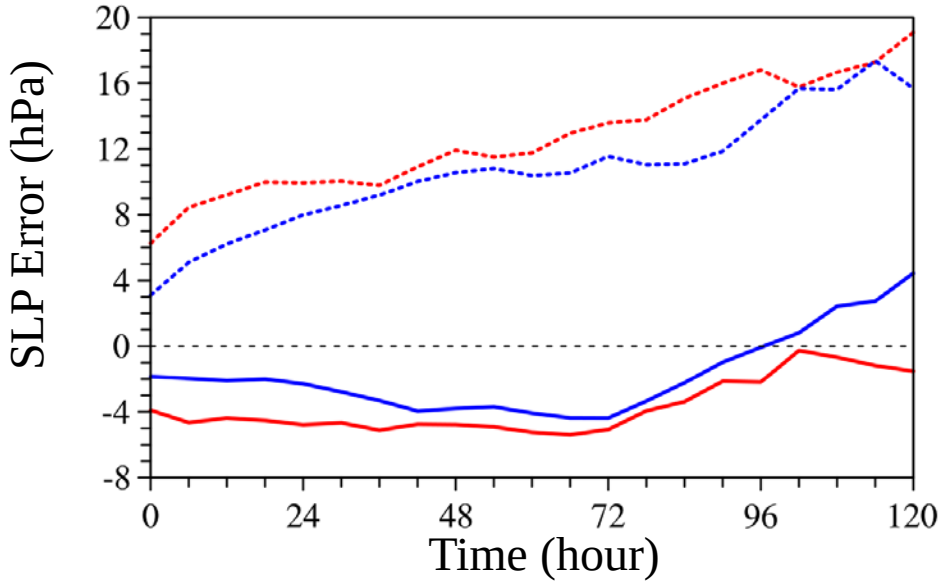


June 2012

Mean Forecast Errors for Four 2012 Atlantic Hurricanes

Impact of Model Top Altitude on Track and Intensity Forecasts





Lower model top:

—— mean

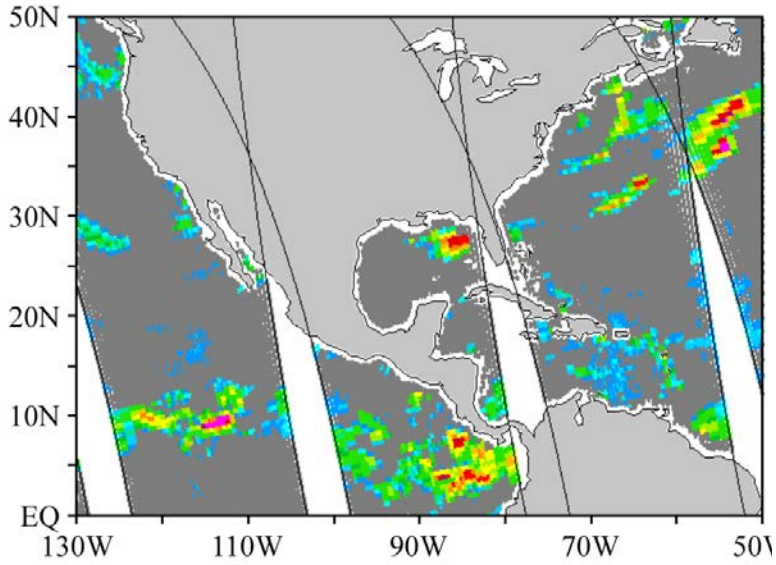
------ std.

Higher model top:

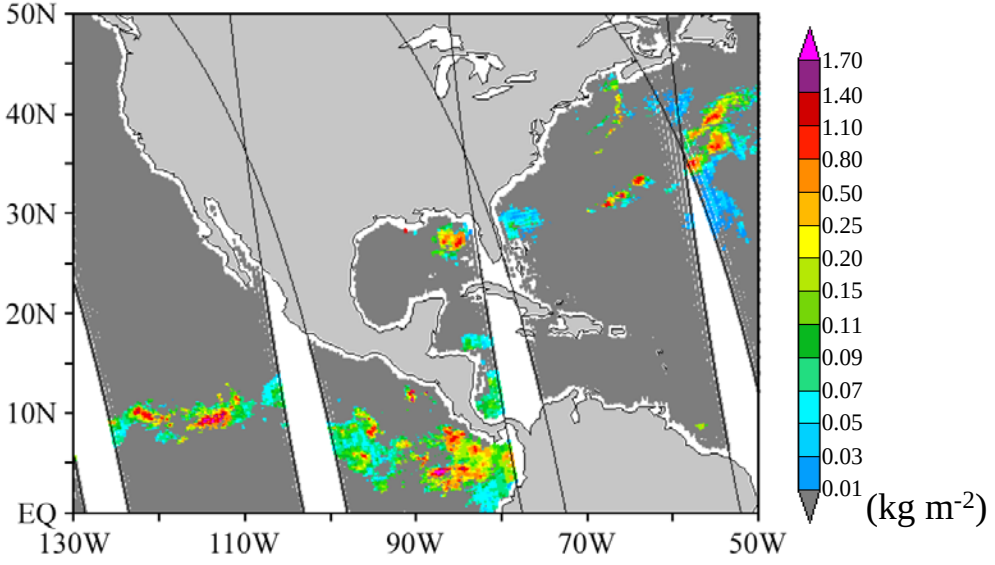
—— mean

------ std.

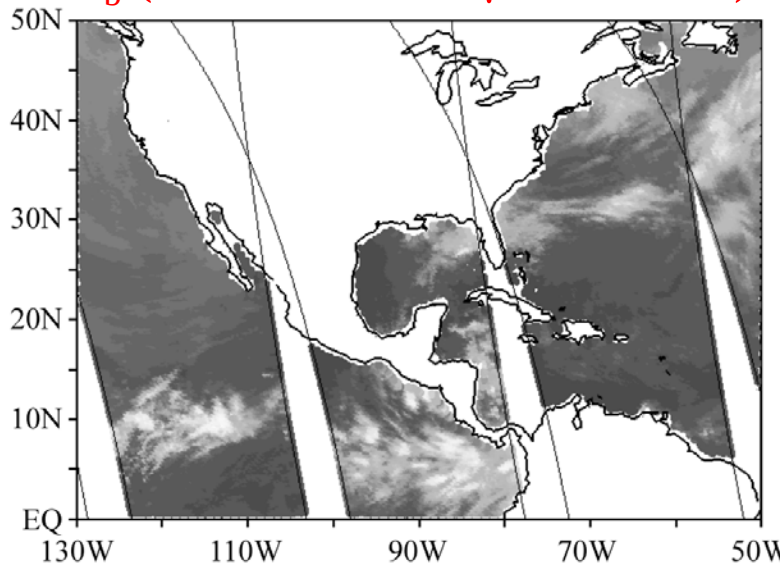
LWP (AMSU-A channels 1-2)



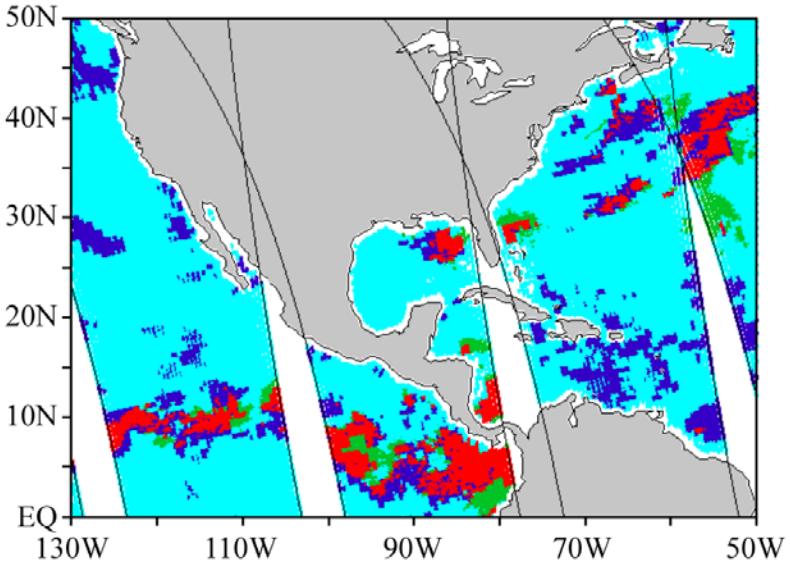
IWP (MHS channels 1-2)



T_b (GOES-12, 10.7μm channel)



LWP/IWP Collocation



clear-sky

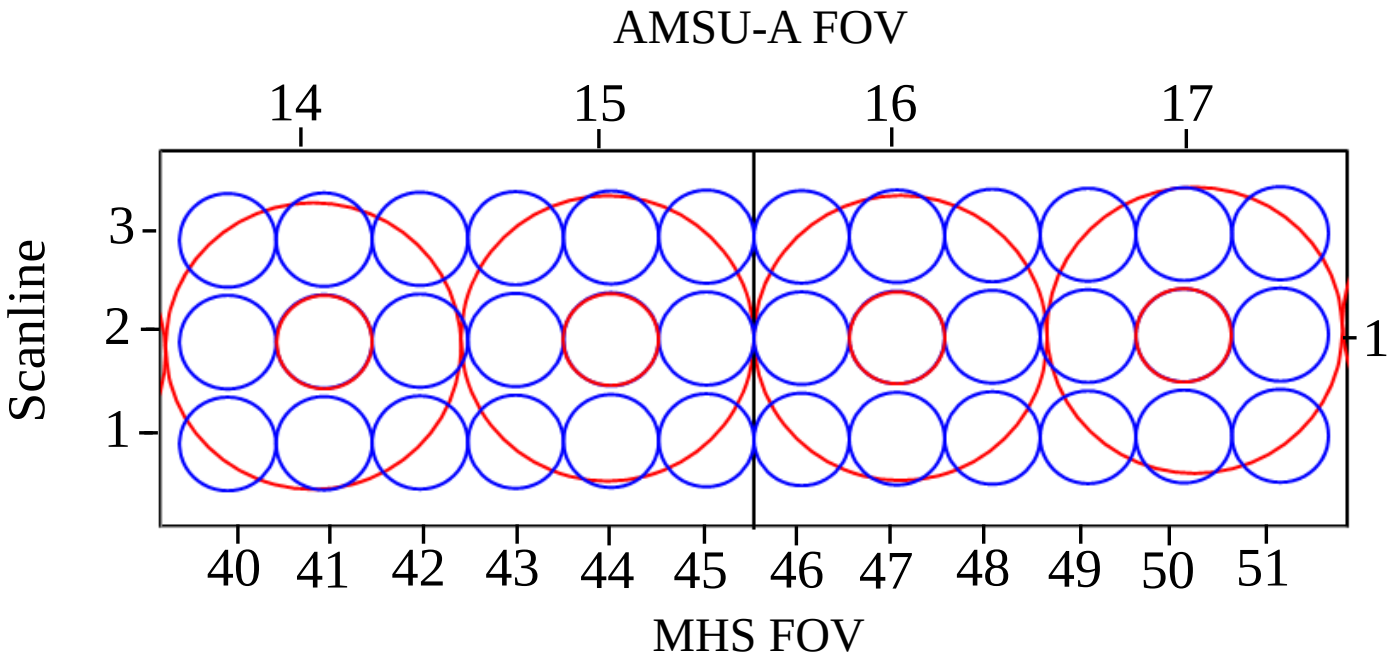
warm cloud

ice cloud

mixed-phase cloud

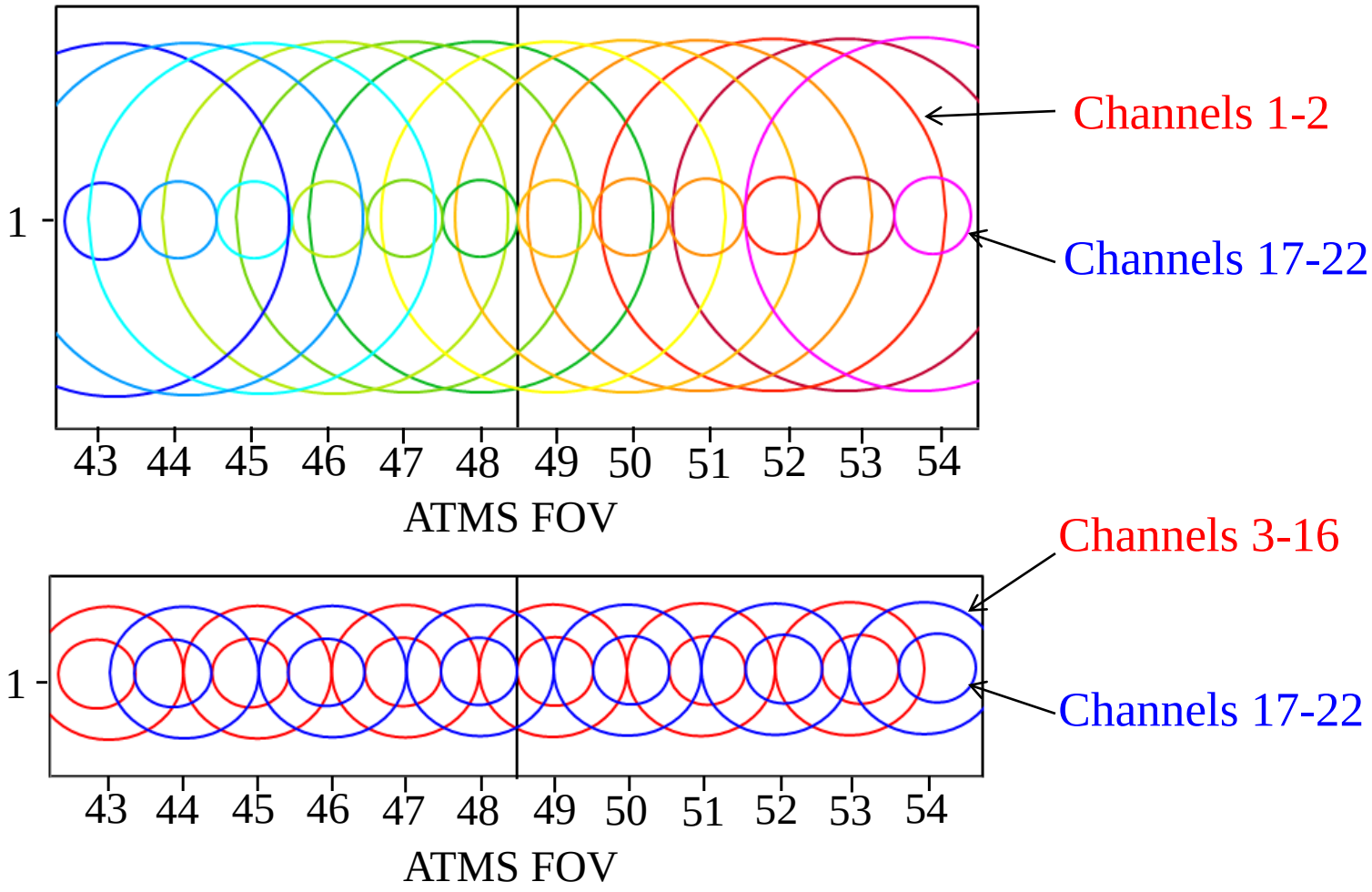
NOAA-18, 1441 UTC to 2303 UTC on May 22, 2008

AMSU-A and MHS FOVs



An inconsistent FOV distribution between AMSU-A and MHS channels makes MHS cloud detection extremely challenging.

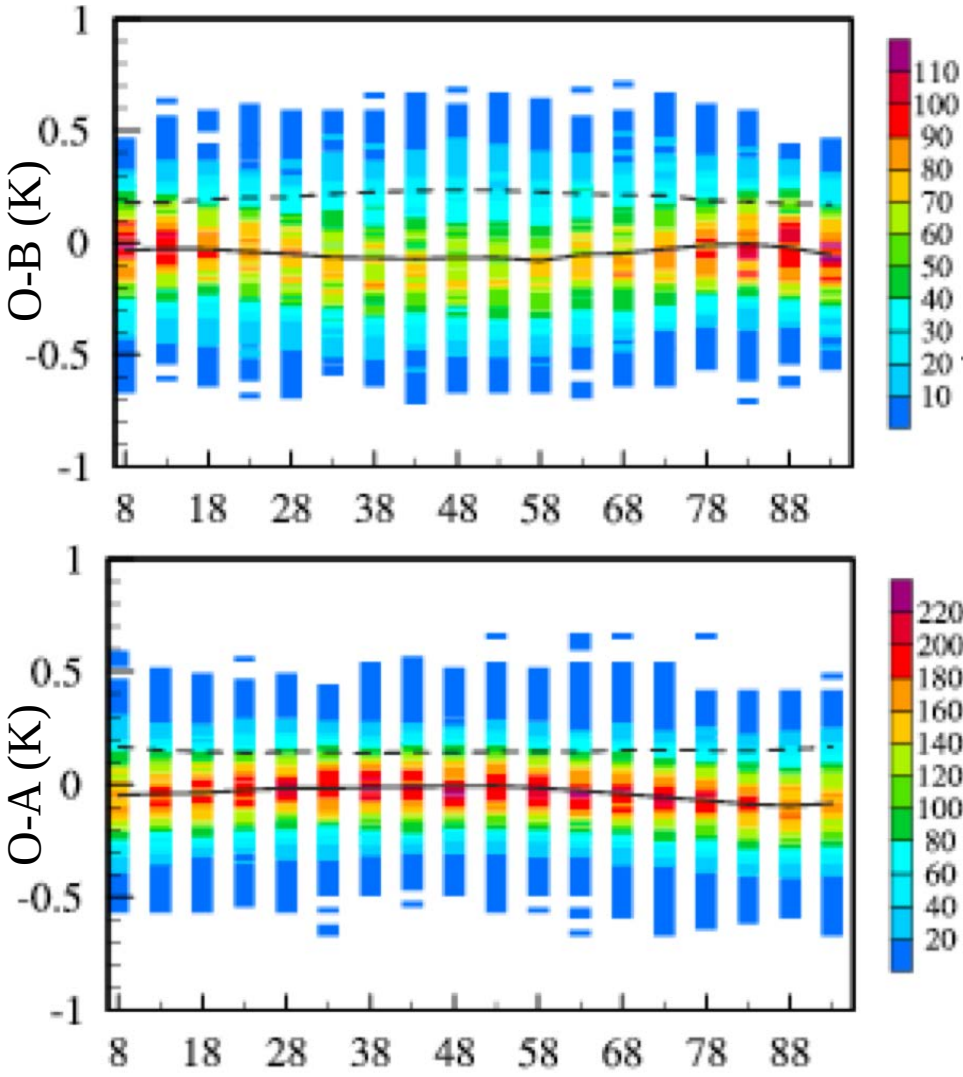
The ATMS FOV Distribution along a Scanline



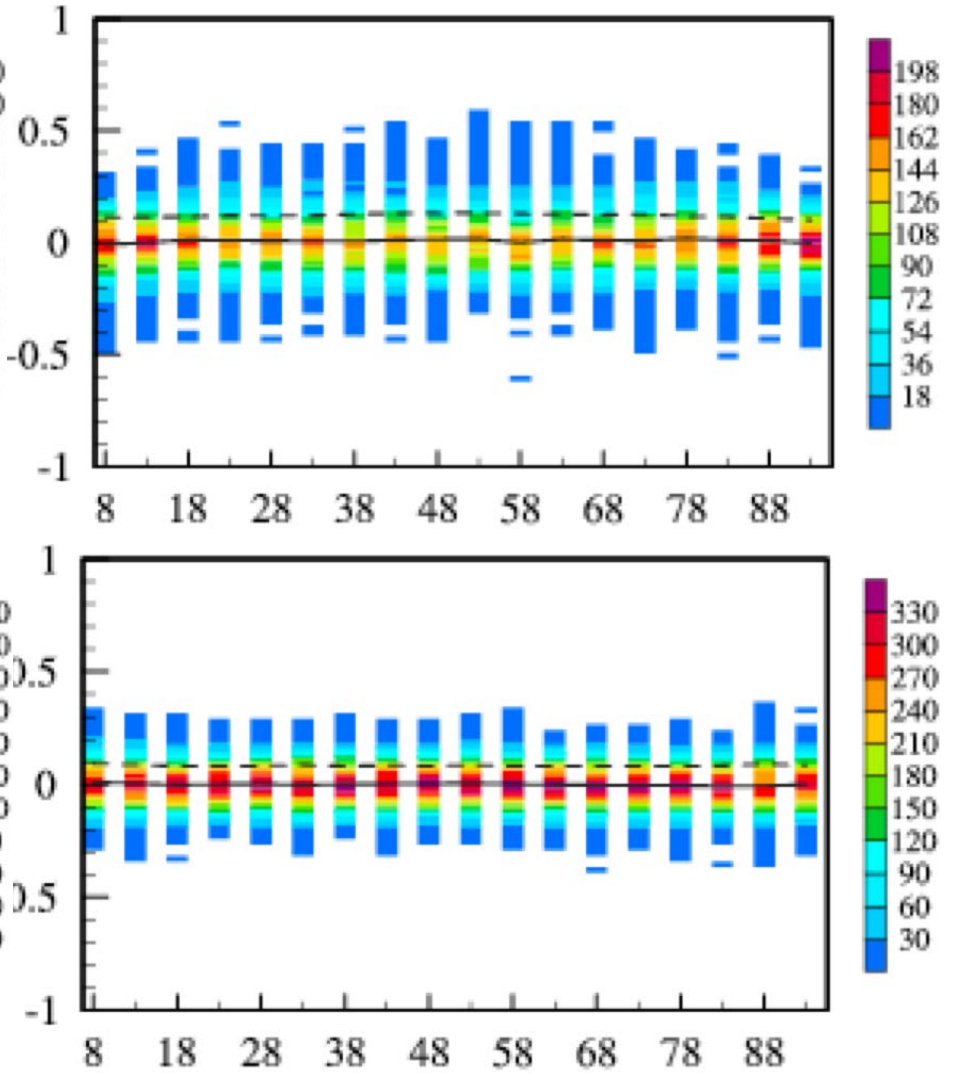
A consistent FOV distribution between temperature and humidity channels on ATMS makes the cloud detection easy to implement.

O-B and O-A Data Counts for Hurricane Isaac

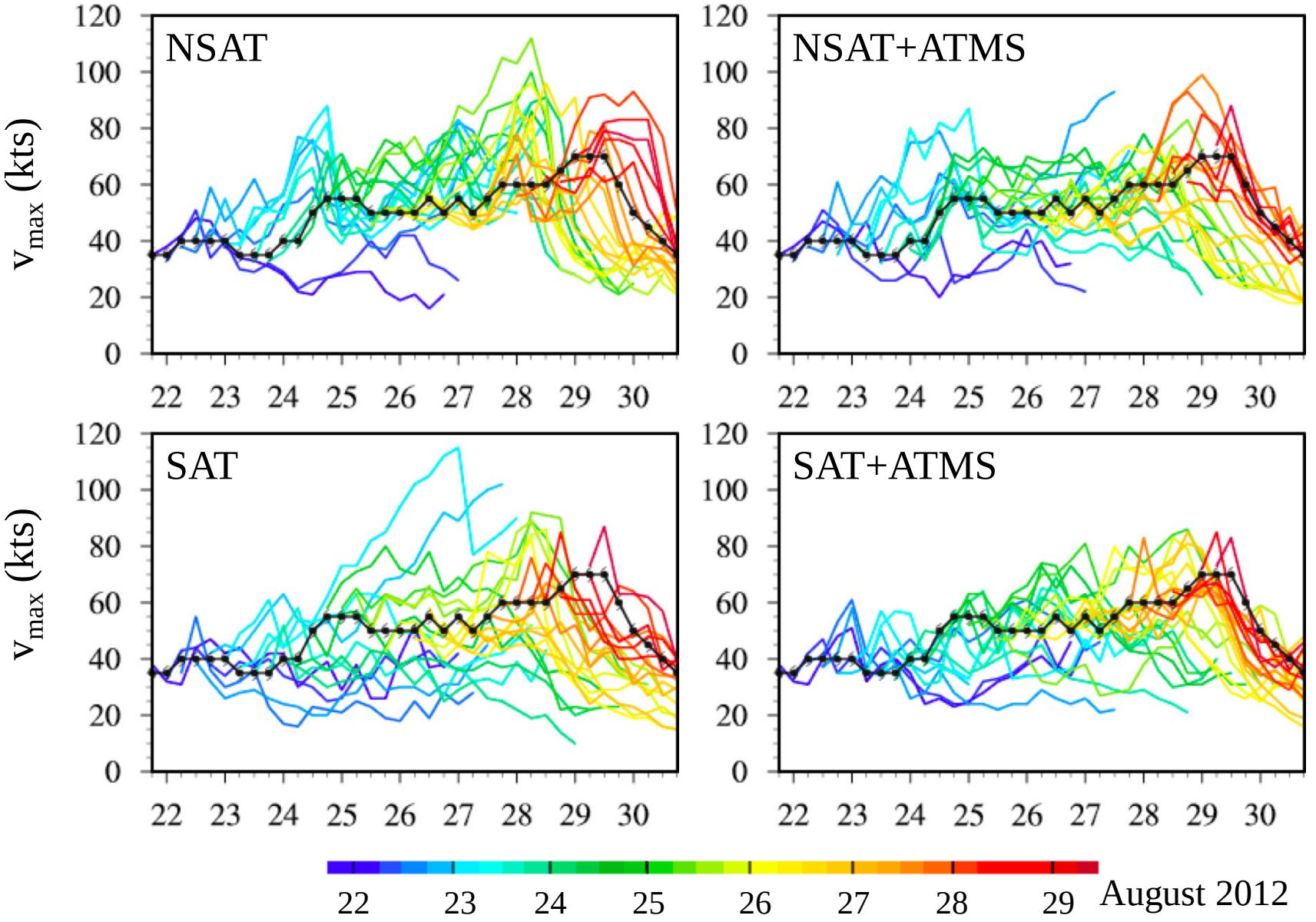
ATMS Channel 6



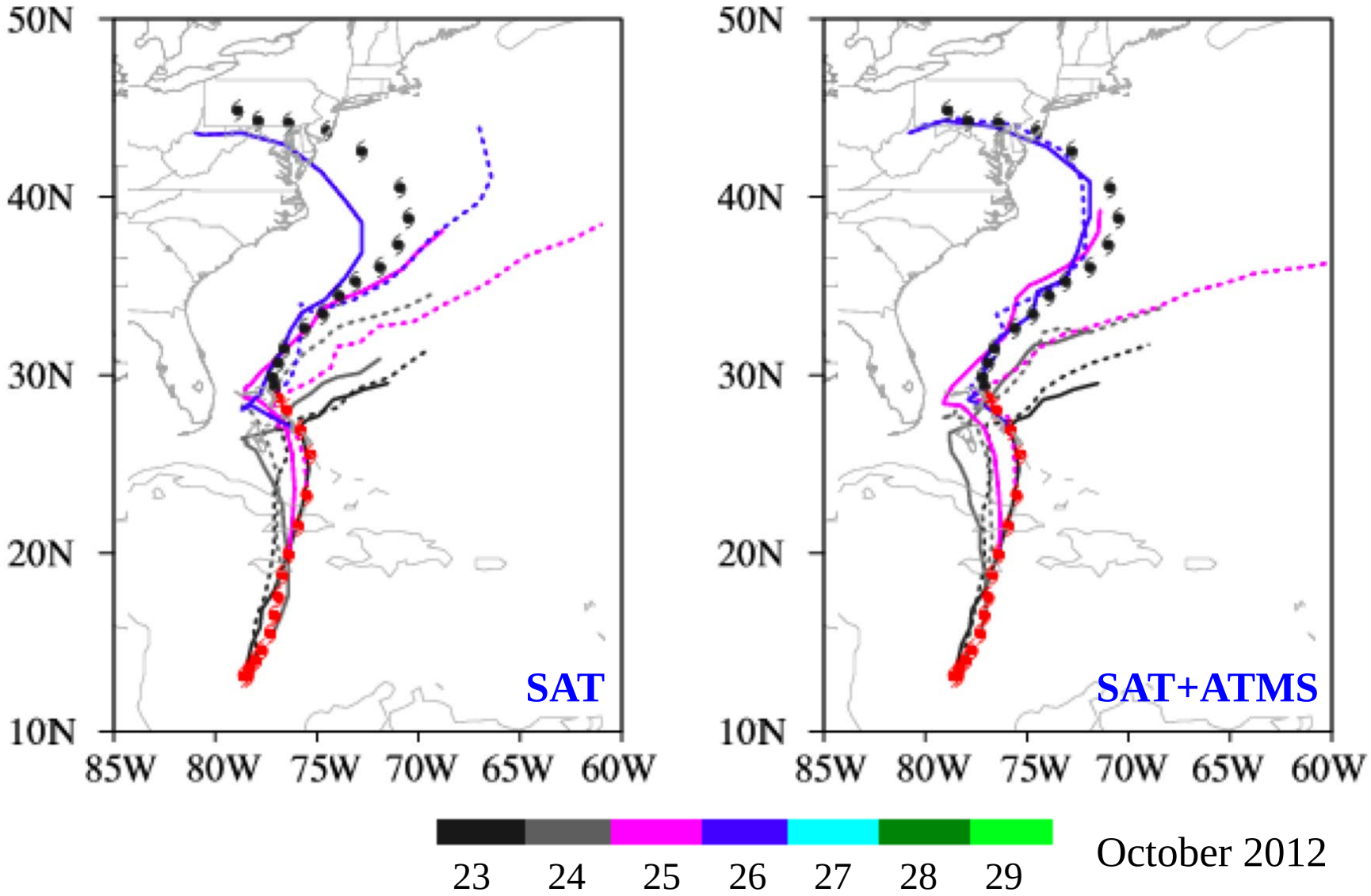
ATMS Channel 9



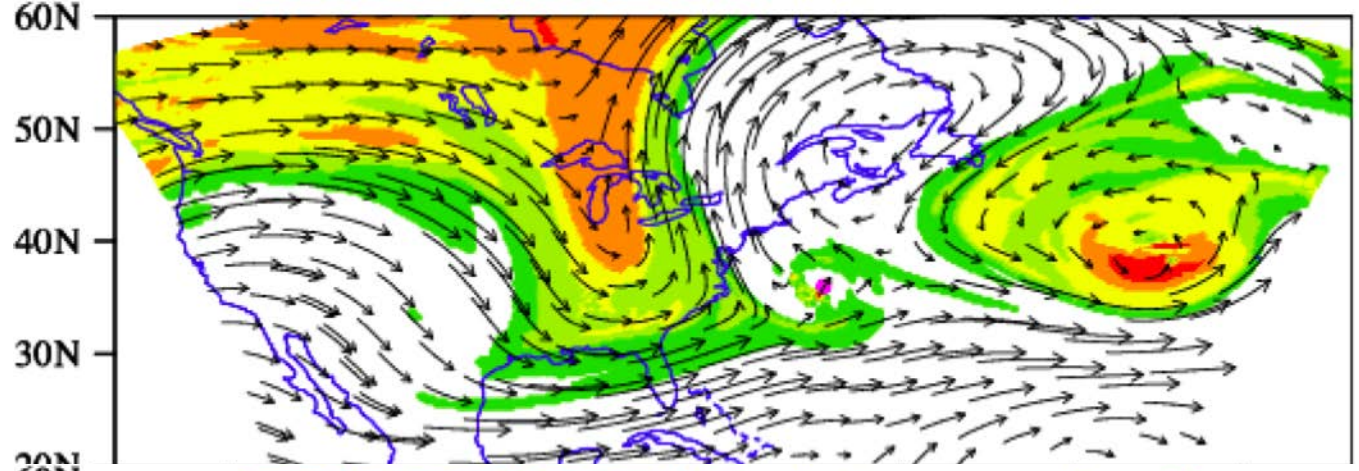
Impacts on Intensity Forecast Hurricane Isaac



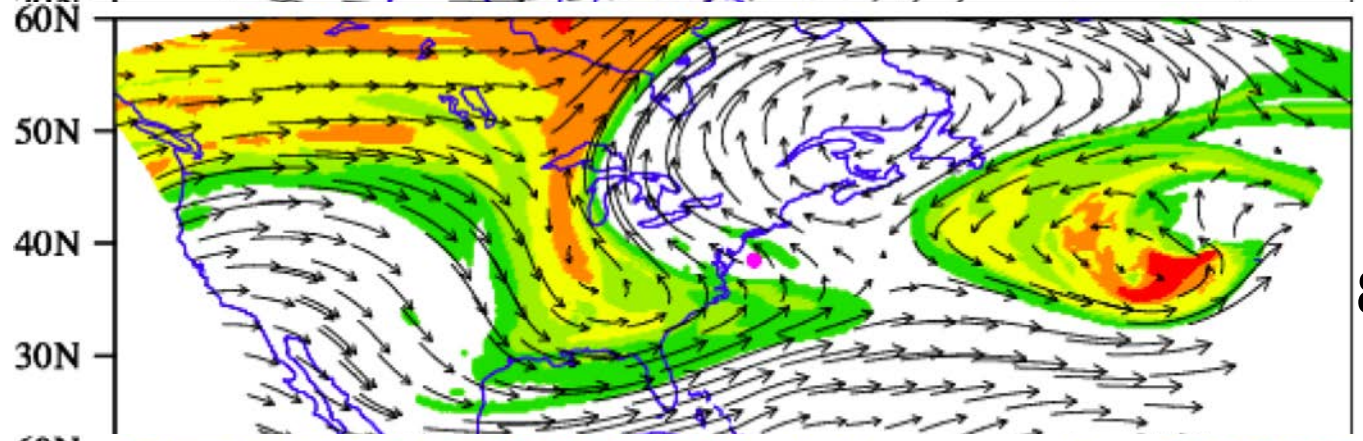
Impacts of ATMS Data Assimilation on Track Forecast of Hurricane Sandy



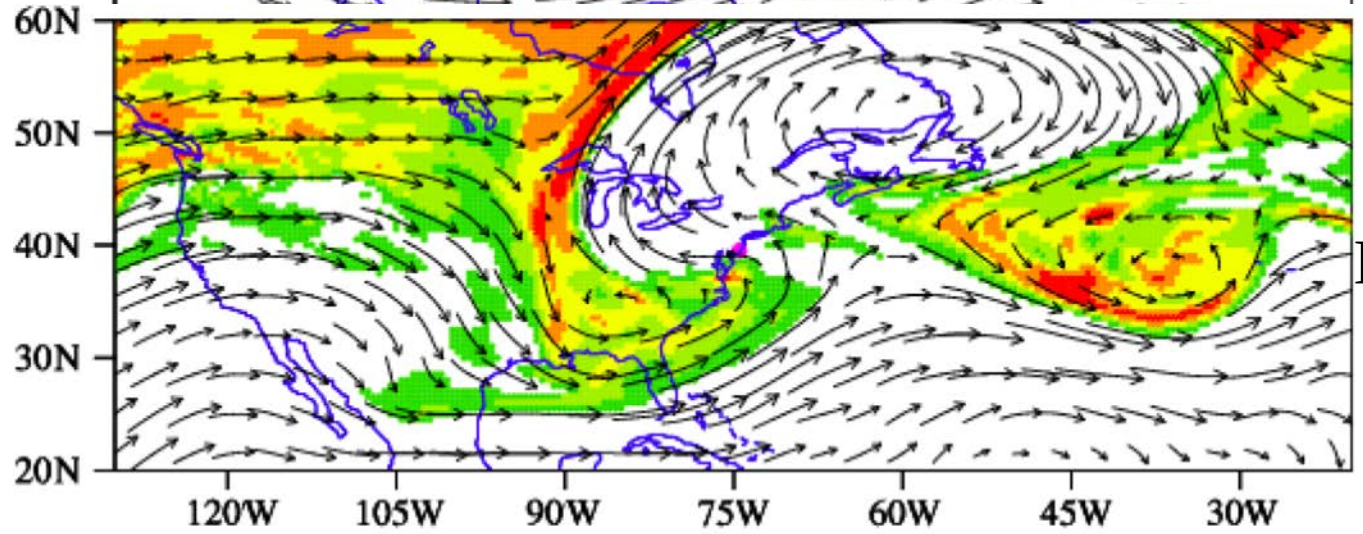
Hurricane Sandy (PV at 200 hPa)



84-h Forecast without ATMS



84-h Forecast with ATMS

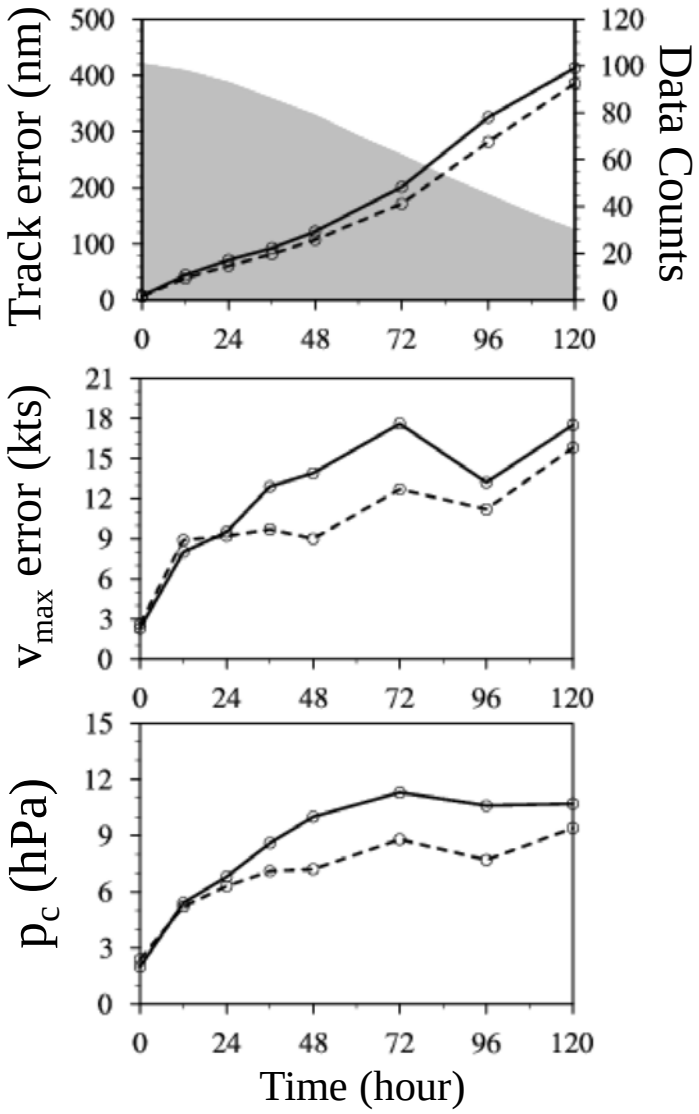


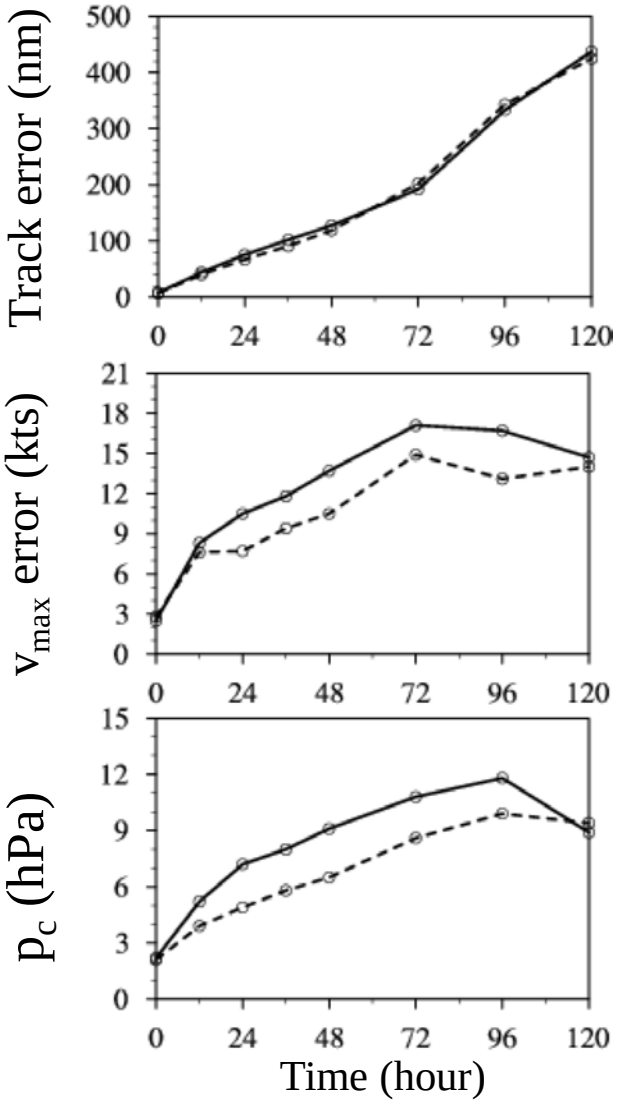
NCEP GFS analysis

0000 UTC October 30

Mean Forecast Errors for Four 2012 Atlantic Hurricanes

Impact of ATMS Data Assimilation





Current and Future Plan

- ATMS radiance assimilation (further refinement)
- Model top&vertical levels (further refinement)
- GOES imager radiance assimilation for TCs (on going)
- AMSU three orbits impact assessment (on going)
- CrIS/VIIRS radiance assimilation (on going)
- SSMIS/AMSR2 imager radiance assimilation (on going)
- Combined AMSU-A/MHS data stream (on going)
- Hurricane initialization using satellite data (on going)

Three Key Components for Satellite Data Assimilation

Bias Correction, Data Thinning, Quality Control

More details can be found in

Zou, X., F. Weng, Q. Shi, B. Zhang, C. Wu and Z. Qin, 2013a: Satellite data assimilation in NWP models. Part III: Impacts of model top on radiance assimilation in HWRF. *J. Atmos. Sci.*, (submitted)

Zou, X., F. Weng, B. Zhang, L. Lin, Z. Qin and V. Tallapragada, 2013b: Impact of ATMS radiance data assimilation on hurricane track and intensity forecasts using HWRF. *J. Geophys. Res.*, **118**, 11,558-11,576.

Weng, F., X. Zou, X. Wang, S. Yang, and M. D. Goldberg, 2012: Introduction to Suomi NPP ATMS for NWP and tropical cyclone applications. *J. Geophy. Res.*, **117**, D19112, 14pp, doi:10.1029/2012JD018144.

Weng, F., X. Zou, and Z. Qin, 2014: Impact of NOAA-15 AMSU-A data on QPFs and its implications for three-orbit constellation. *Mon. Wea. Rev.*, (to be submitted)

Acknowledgement

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