Radiance Assimilation in WRF-Var : Implementation and Initial Results

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NCAR/MMM

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Status of Radiance Assimilation (1)

- NCEP BUFR Data interface for a number of satellite instruments (not pass OBSPROC step, directly read in WRF-Var)
  - HIRS, AMSU-A/B, AIRS
- RTM interface: RTTOV8_5
  - only clear-sky condition
- Interface to NESDIS/NCEP Microwave surface emissivity model
- Quality Control for AMSU-A/B
- Bias Correction (Linear Regression Scheme)

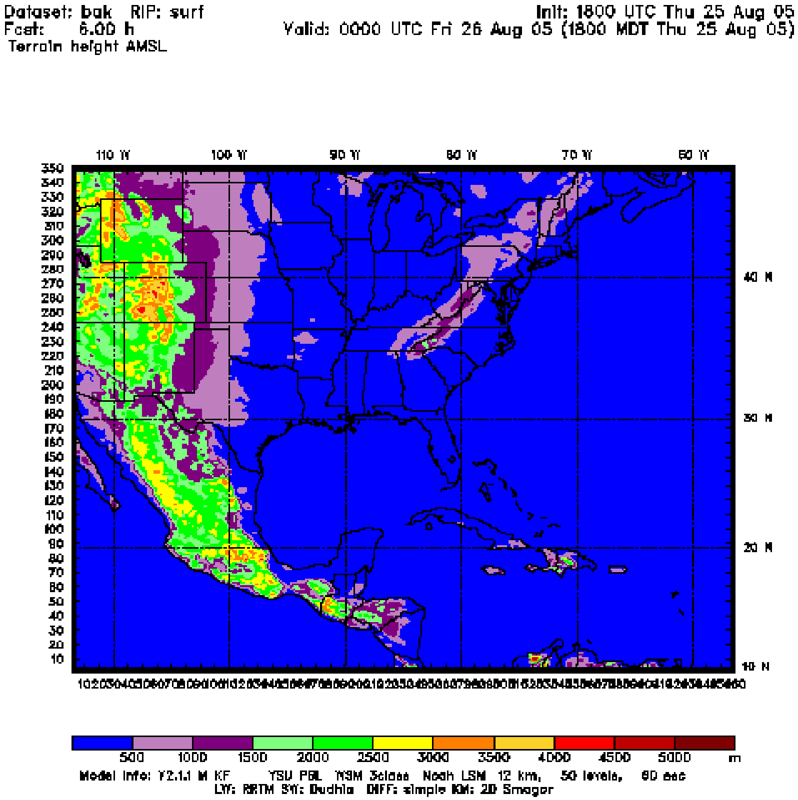
$$BT_{corrected}(X_b)=a+b*BT(X_b)$$

Status of Radiance Assimilation (2)

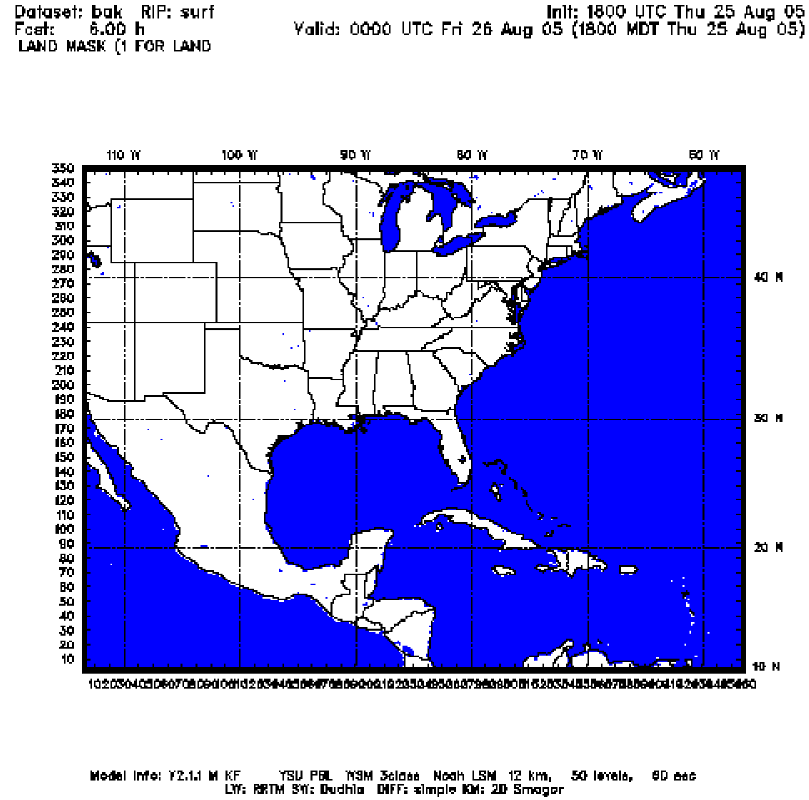
- Observation error tuning (Desroziers & Ivanov, 2001)
- FGAT (First Guess at Appropriate Time)
  - Straightforward to transit to WRF-4DVAR
- Parallel: MPI
- Flexible programming design to reduce additional coding efforts for adding new satellite instruments
  - A general radiance assimilation framework.

Application to Katrina Case with WRF-ARW 12km51L(460*351)

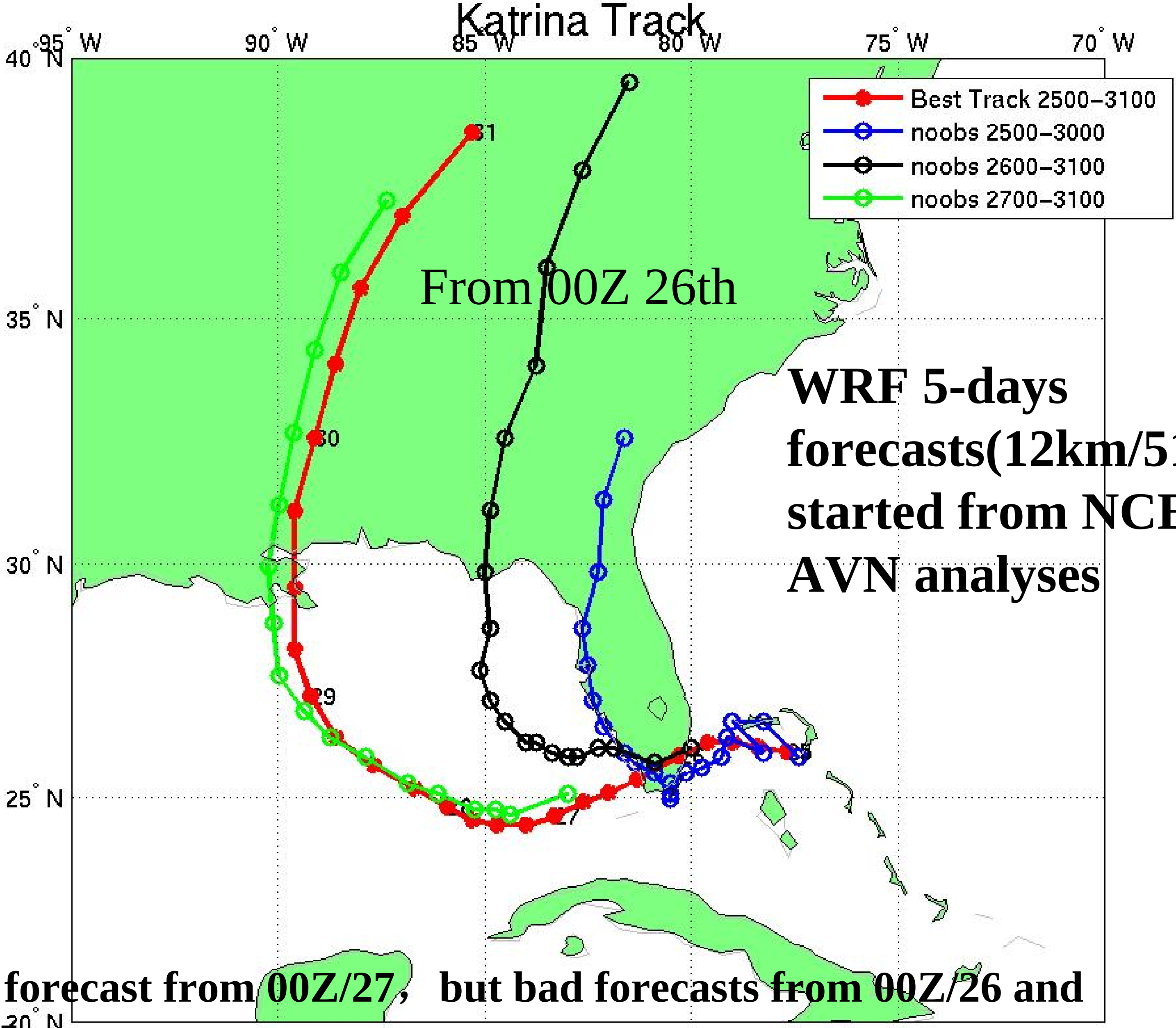
Model Top is at 10hPa (for better using high channels)



Terrain Height



Land Sea Mask



WRF 5-days forecasts(12km/51L）started from NCEP AVN analyses

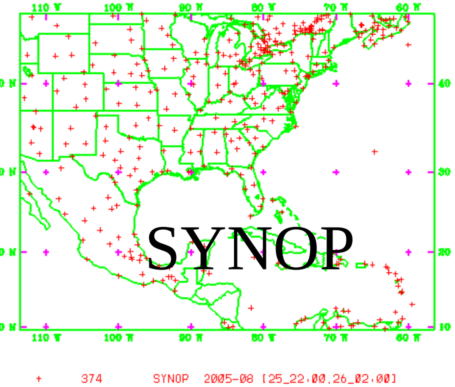
Good forecast from 00Z/27，but bad forecasts from 00Z/26 and 00Z/25，

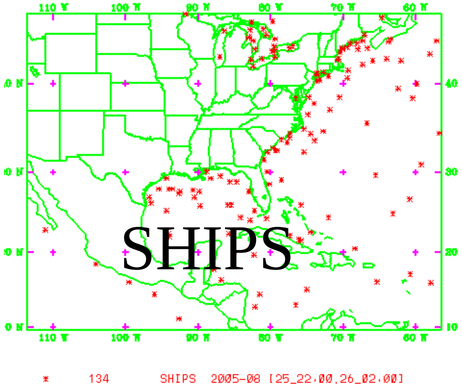
We try to improve the forecast from 00Z/26 by radiance assimilation.

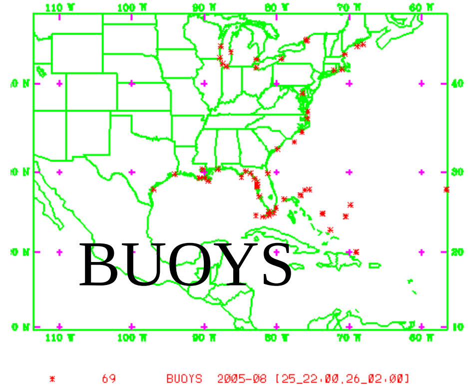
4 Assimilation Experiments at 00Z 26th

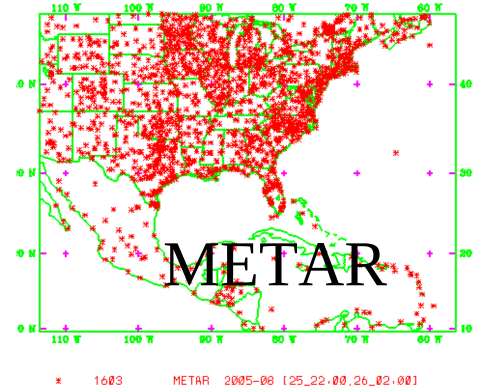
- GTS: only use conventional data
- AMSUA: only use AMSUA radiance
- GTS+AMSUA
- AMSUA+SLP: plus one single SLP located at the center of Hurricane
- The background field is a 6-h WRF forecast from AVN analysis at 18Z 25th.
- All EXPs use a background error statistics **(CV_OPTION=5)** with NMC method using one month WRF forecast from AVN analysis

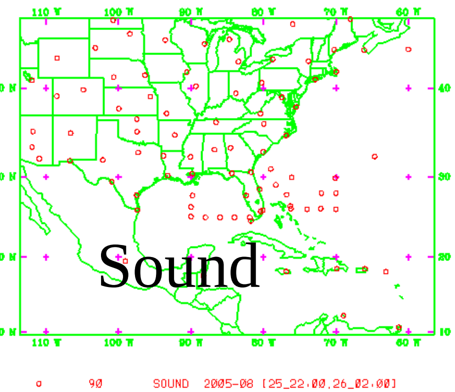
Analyses are followed by a 5-day forecast

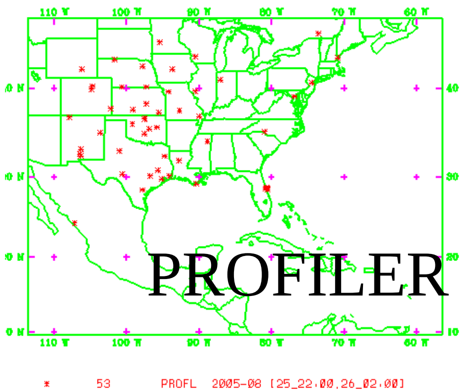


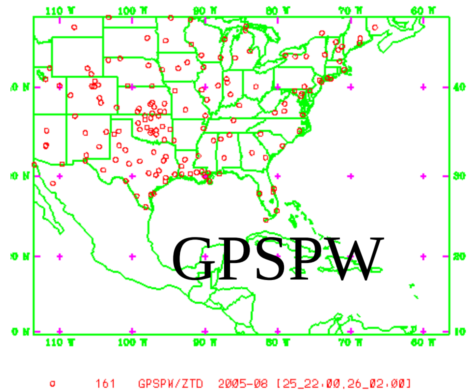


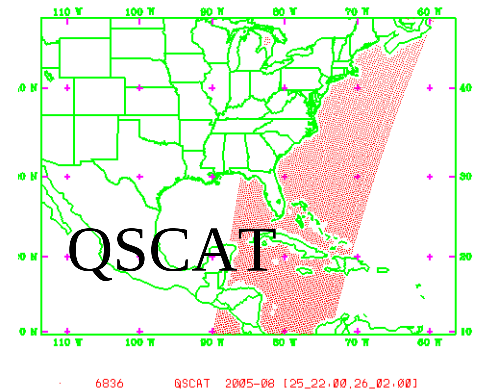




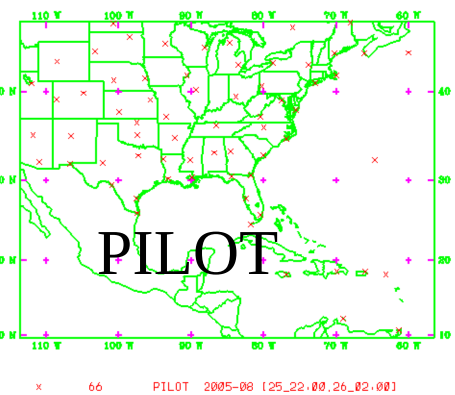


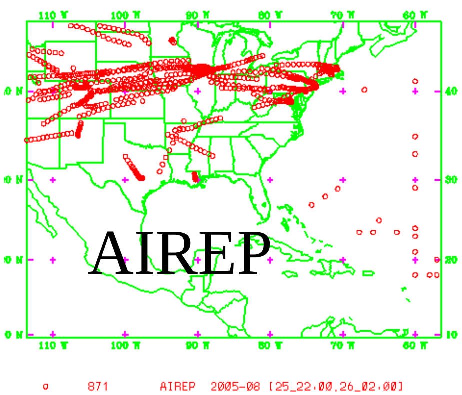






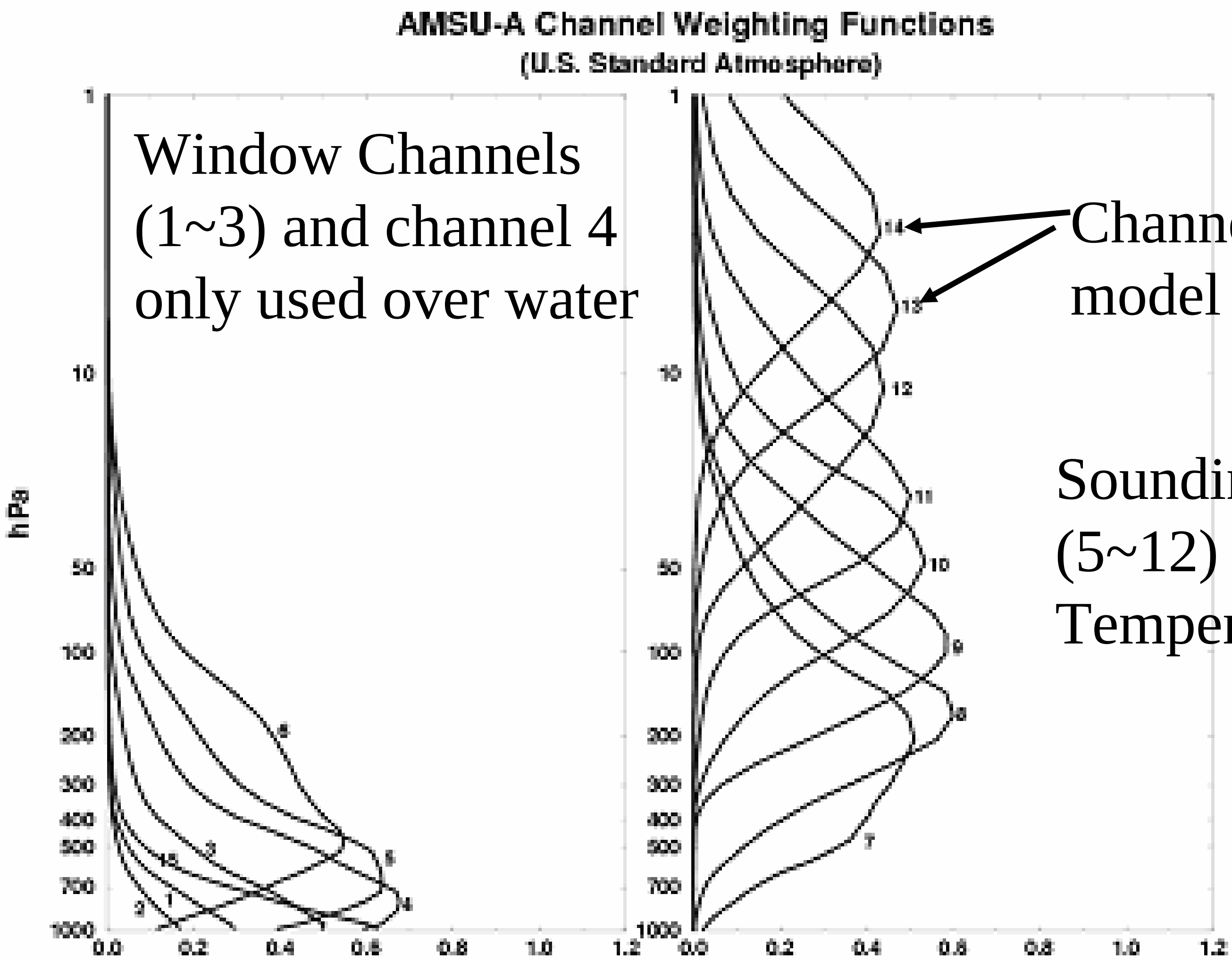
Coverage at 00Z 26th August





NOTE: Satellite winds not available due to decoding error of real-time GTS data at that time.

AMSU-A Weighting functions



Window Channels (1~3) and channel 4 only used over water

Channels above model top removed

Sounding Channels (5~12) sensitive to Temperature.

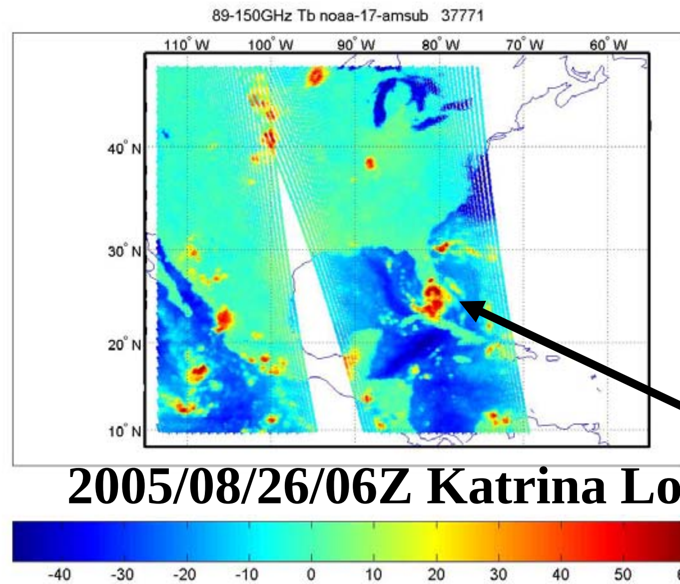
(Courtesy of Jun Li)

Precipitation Detection

Scatter Index

AMSU-B: SI=89GHz-150GHz
AMSU-A: SI=23.4GHz-89GHz

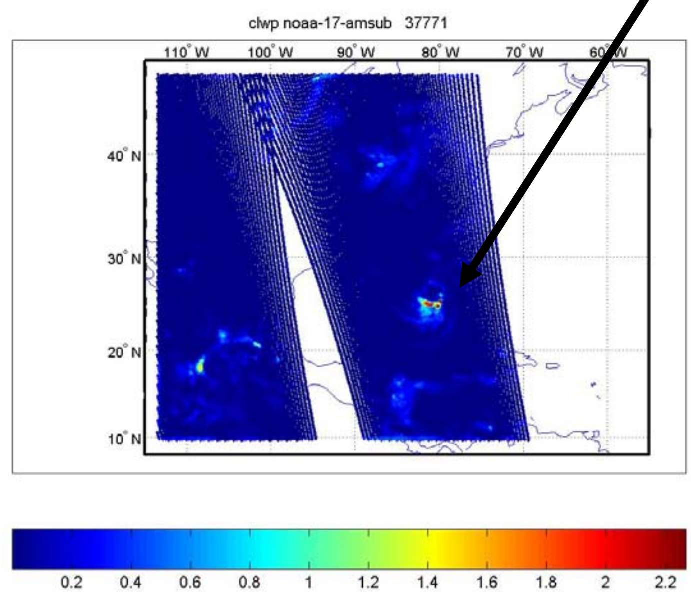
Rejected if SI>3K



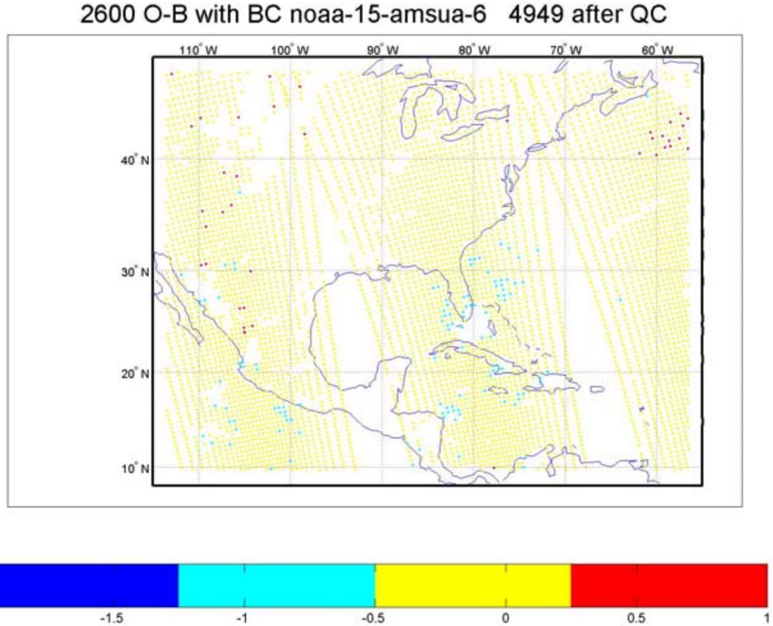
2005/08/26/06Z Katrina Location

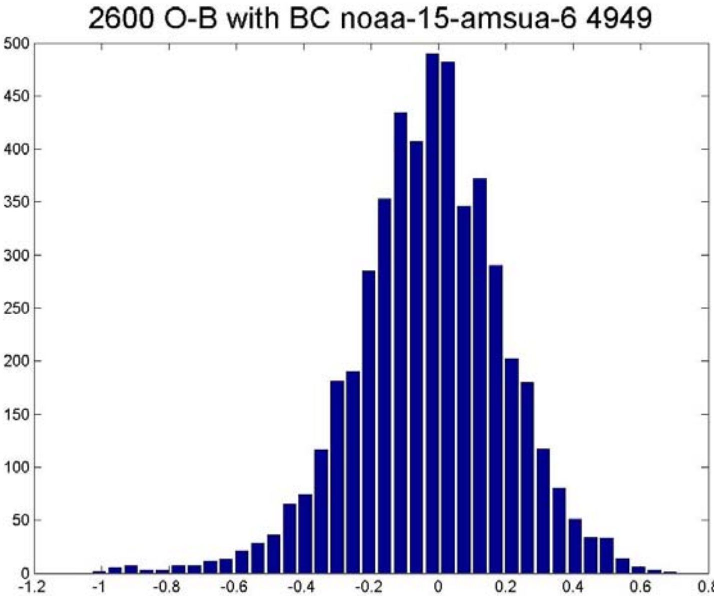
Cloud Liquid Water Path(mm)
From the background field

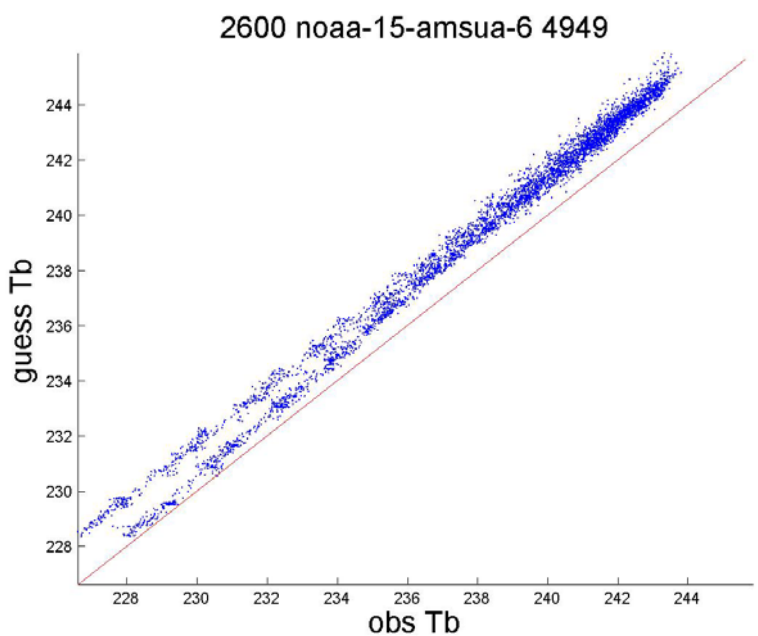
Rejected if CLWP>0.2mm

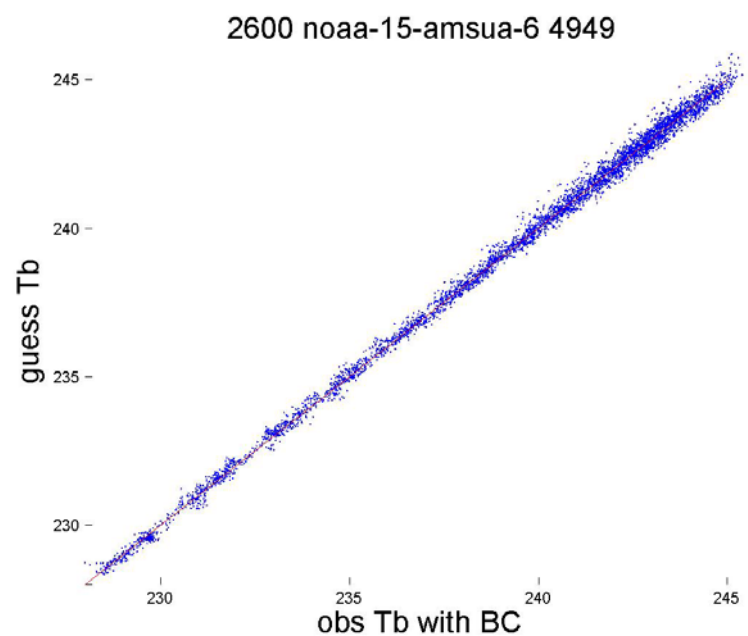


NOAA-15-AMSUA-6

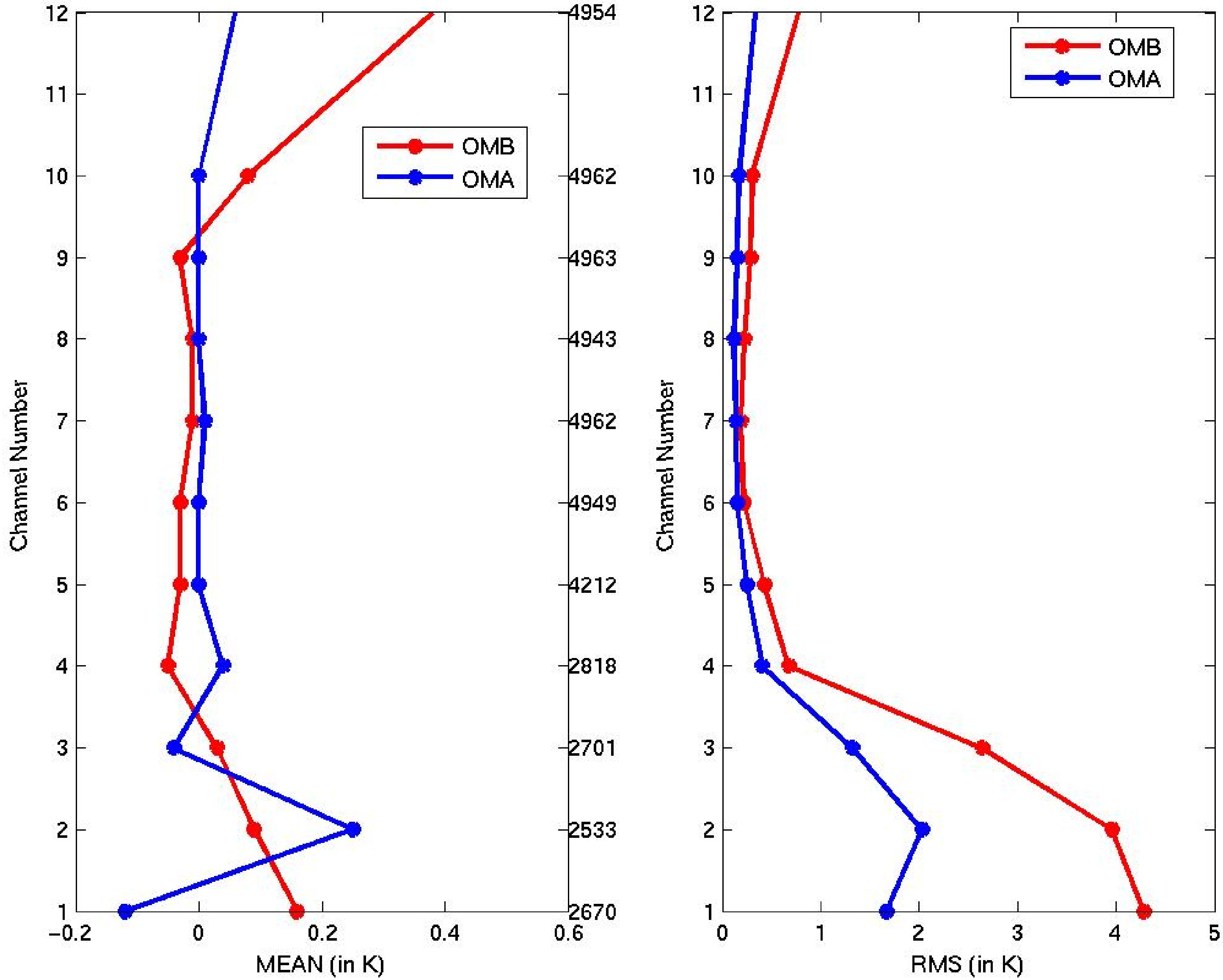








OMB and OMA (NOAA-15-AMSUA)



Information Content of obs

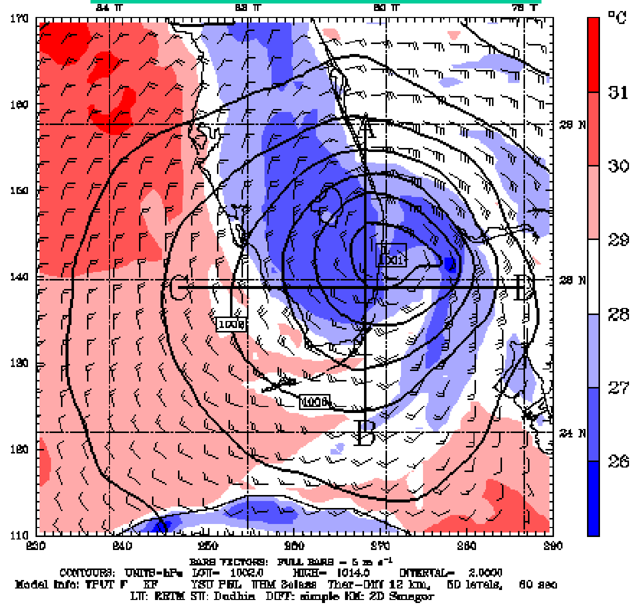
Exp	gts+amsua	gts	amsua
J	43885	19062	23443
J_o	37044	16307	18931
J_b	**6842**	**2756**	**4411**

Degree of Freedom for Signal

Statistically: DFS = $< J_b(\text{min}) >$

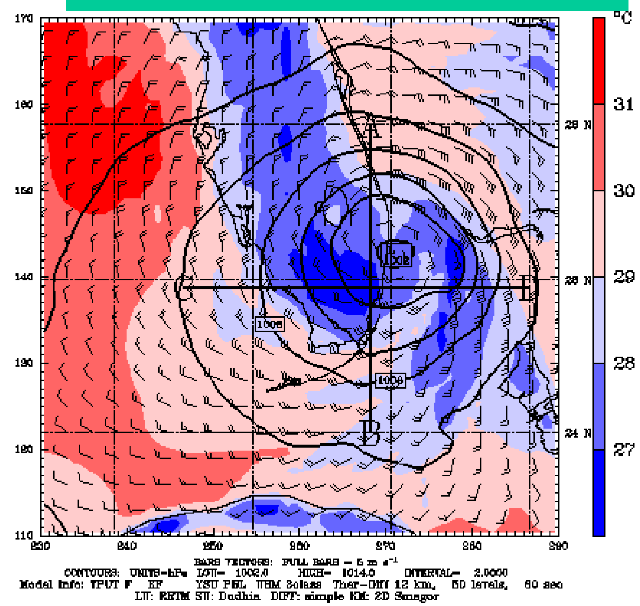
AMSU-A's information content is about 1.5 times than that of conventional data

GTS: 1000.5mb



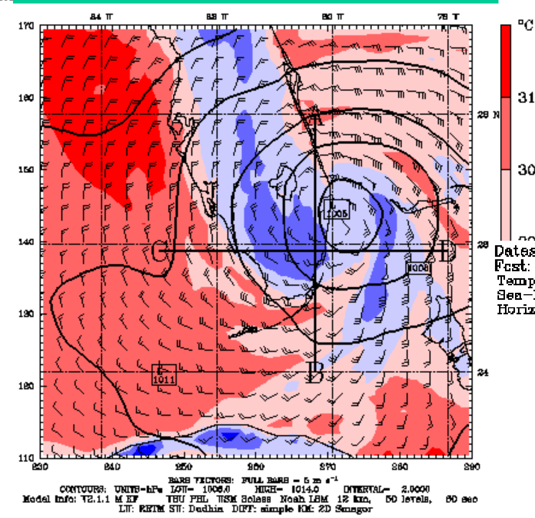
SLP, T, (U,V)

AMSUA: 999.85mb

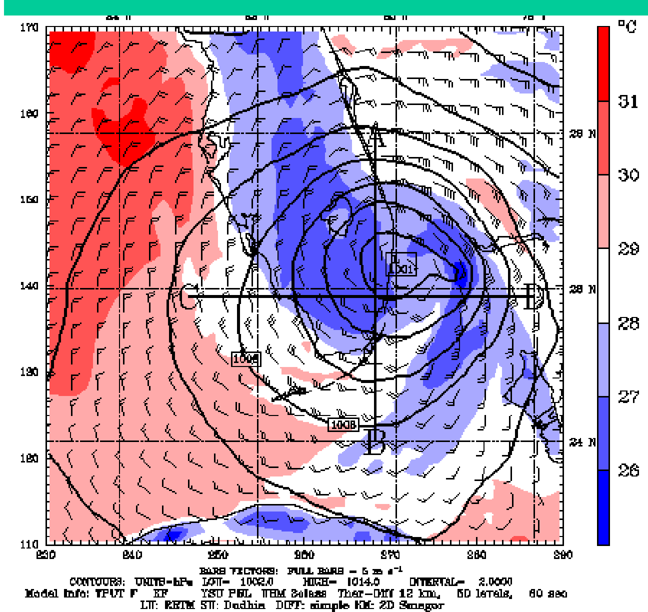


ANV ana: 1000.7mb

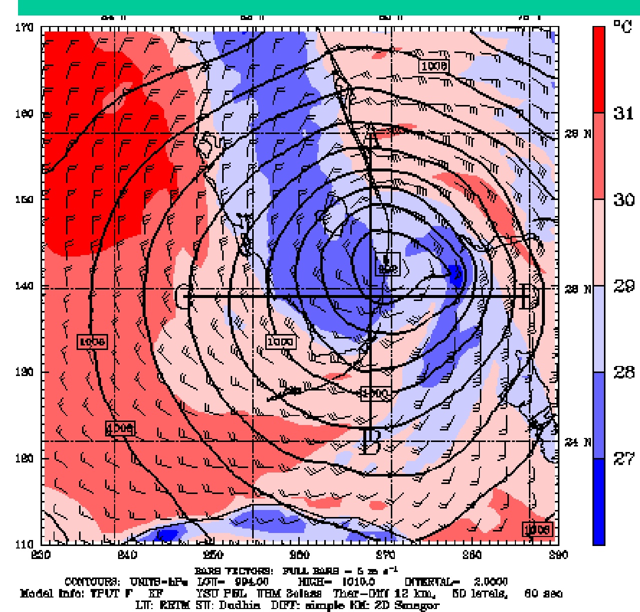
GUESS: 1005mb



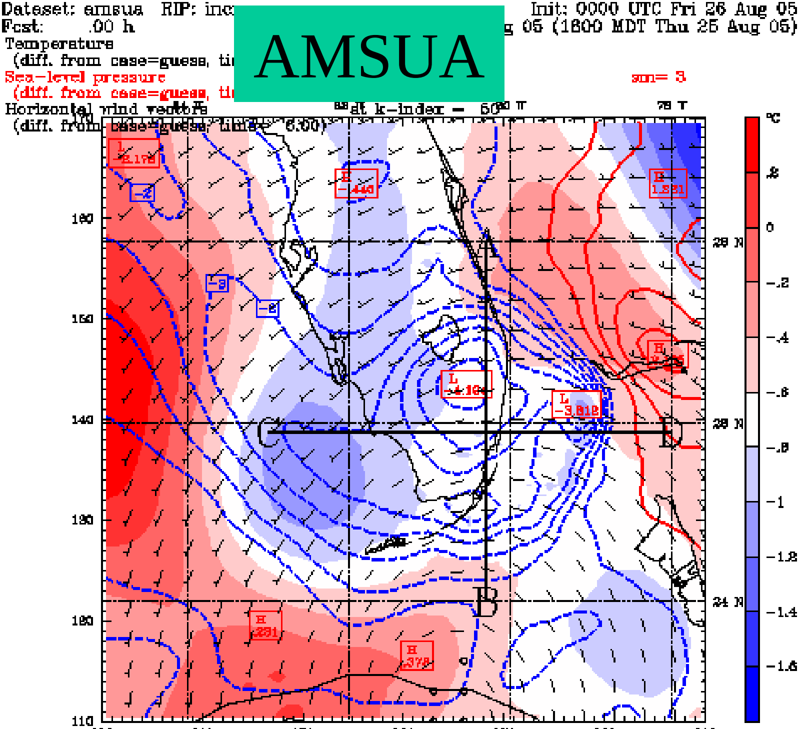
GTS+AMSUA:999.5mb

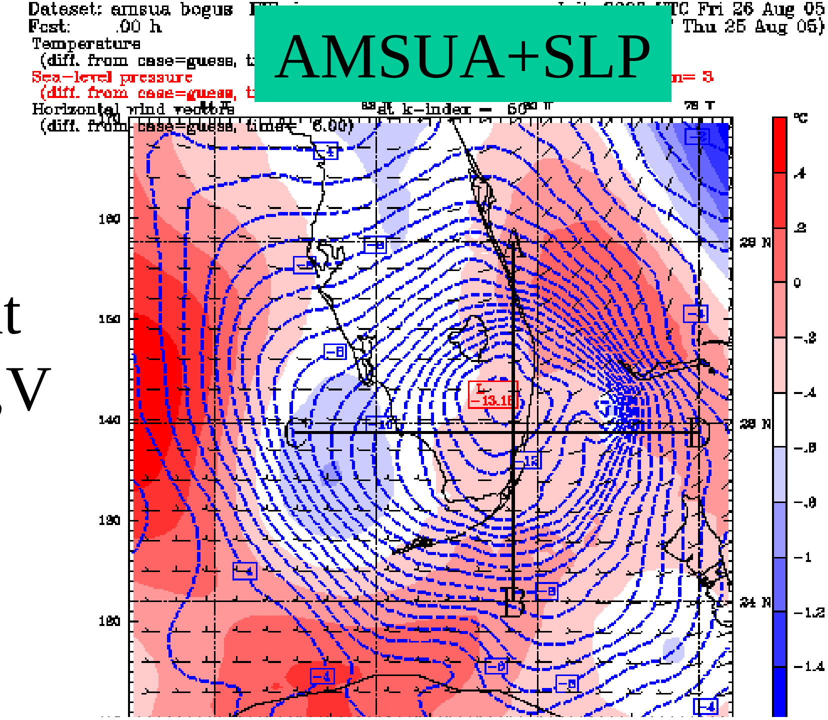


AMSUA+SLP: 992mb

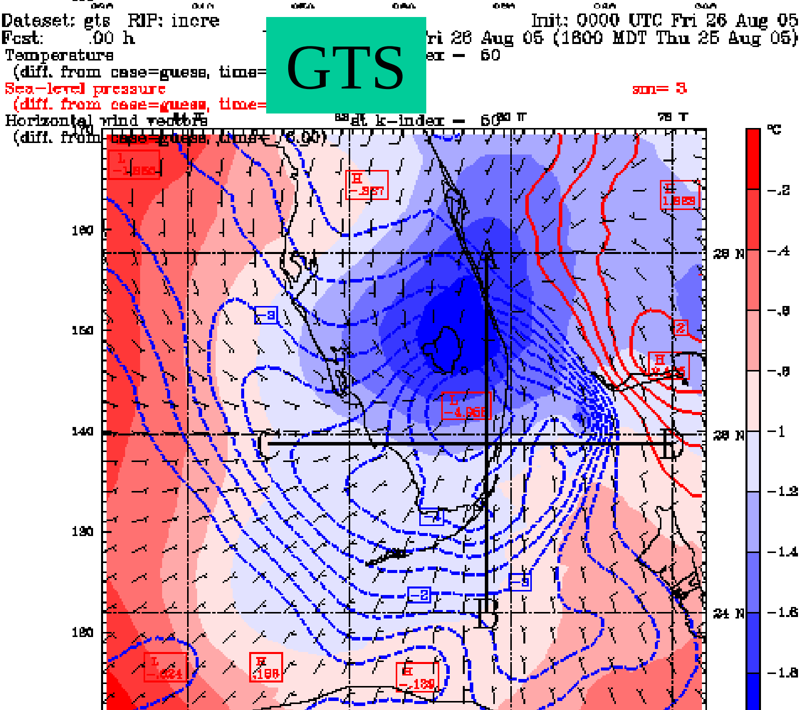


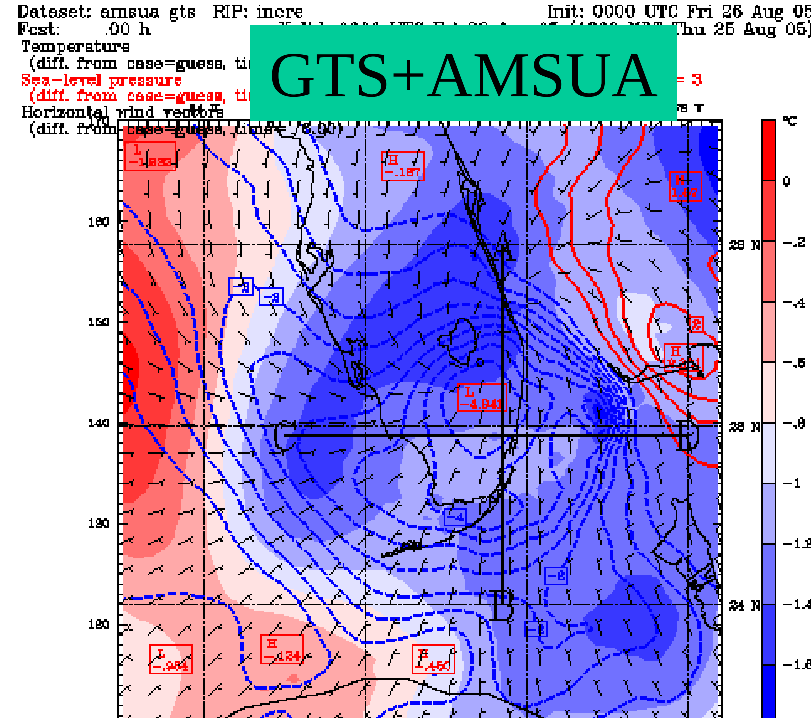
Best track: 983mb

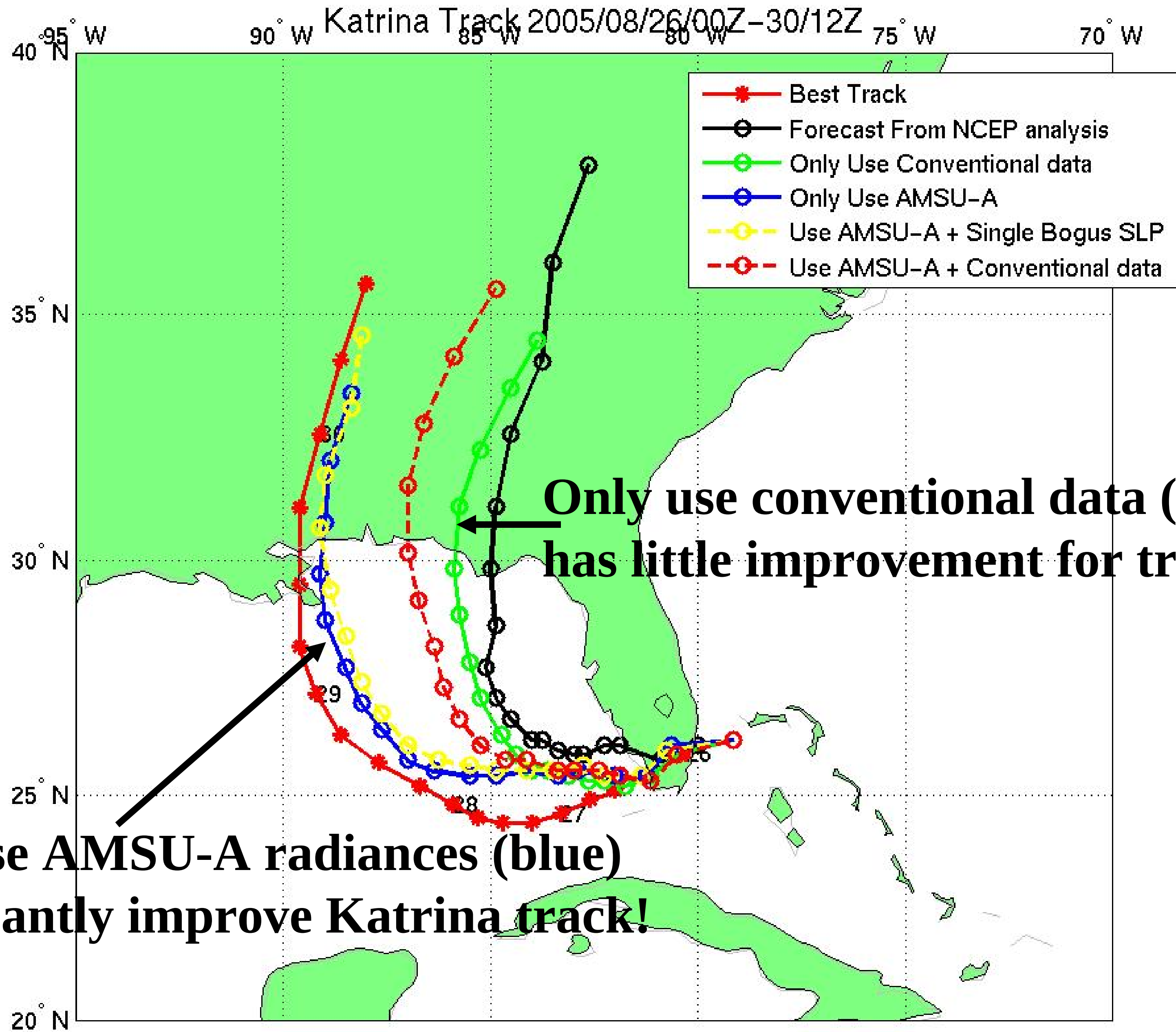




Increment
SLP,T,U,V



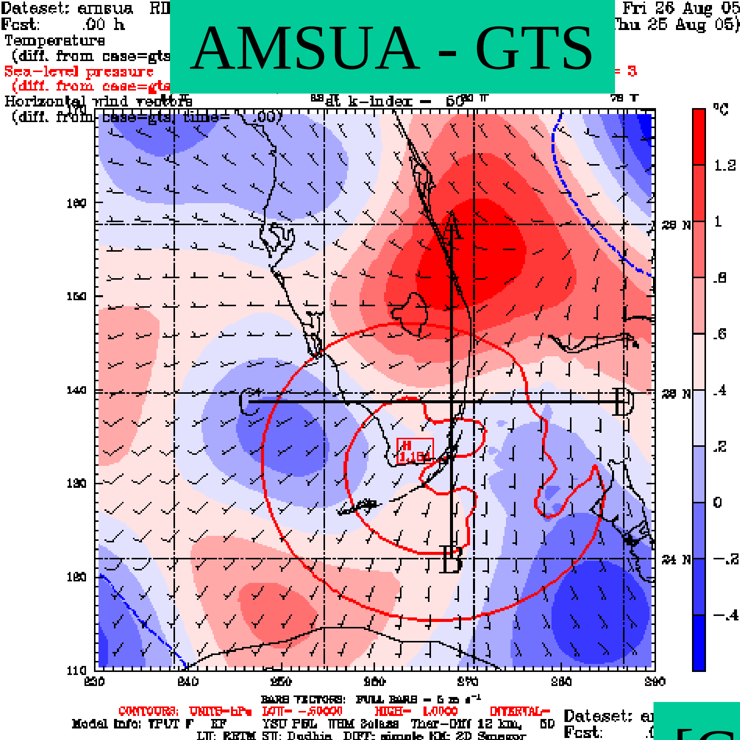




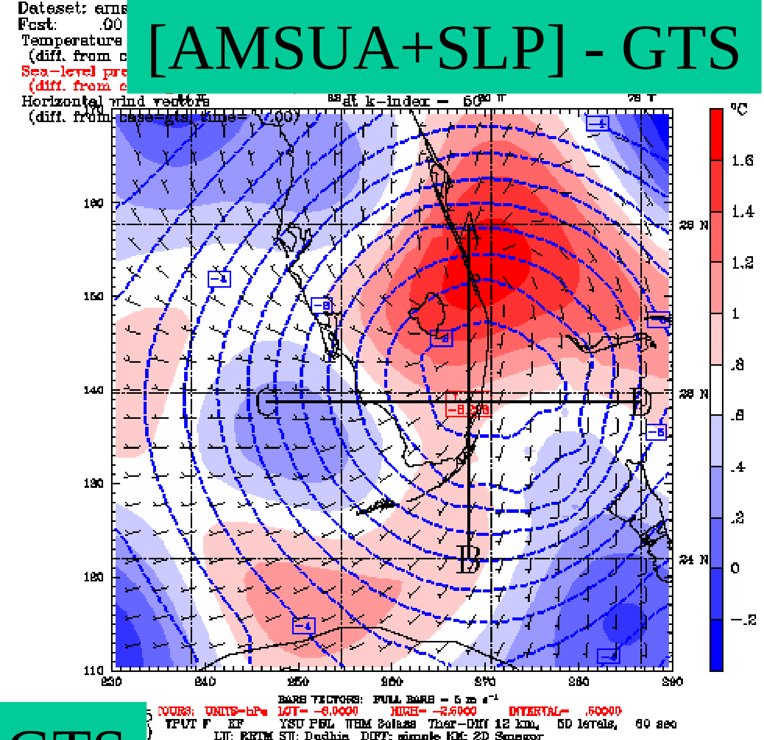
Only use conventional data (green) has little improvement for track.

Only use AMSU-A radiances (blue) Significantly improve Katrina track!

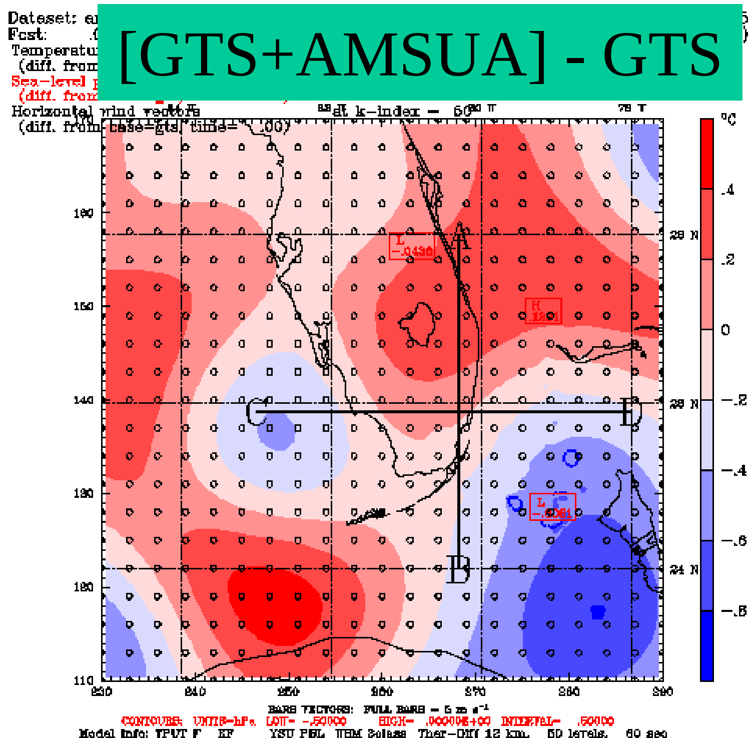
AMSUA - GTS



[AMSUA+SLP] - GTS

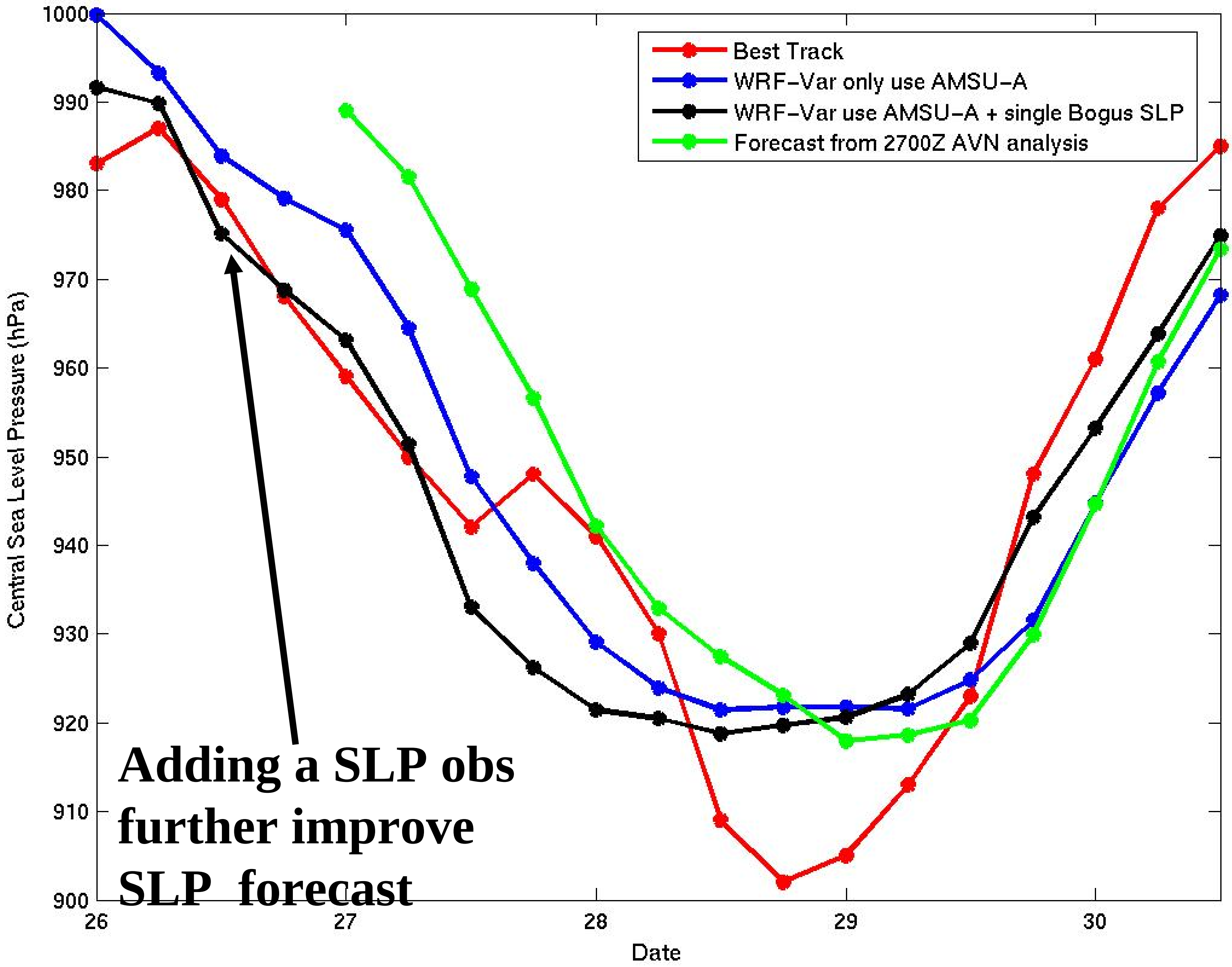


[GTS+AMSUA] - GTS



Almost no difference
For wind and SLP!

Central Sea Level Pressure Forecasts



Summary

- Preliminary radiance assimilation capability has been implemented in WRF-Var.
- First application to Katrina case shows encouraging results.
- Appropriate background error statistics also play a key role
- More case study and statistical impact study for extended period will be performed.

Developing Plan for near term

- Improved bias correction scheme
  - Air-mass dependent, VarBC,
- Observation error tuning for extended period
- Porting CRTM of JCSDA to WRF-Var
- AIRS radiance assimilation
- Improved MW surface emissivity
- Cloud/Precipitation affected radiance simulation
- Assimilate radiance with 4DVAR/EnKF/Hybrid