Evaluation and application of JPSS products through assimilation in regional NWP models

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AMS 92nd Annual Meeting, 22-26 January 2012, New Orleans, LA

STAR Center for Satellite Applications and Research
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CIMSS

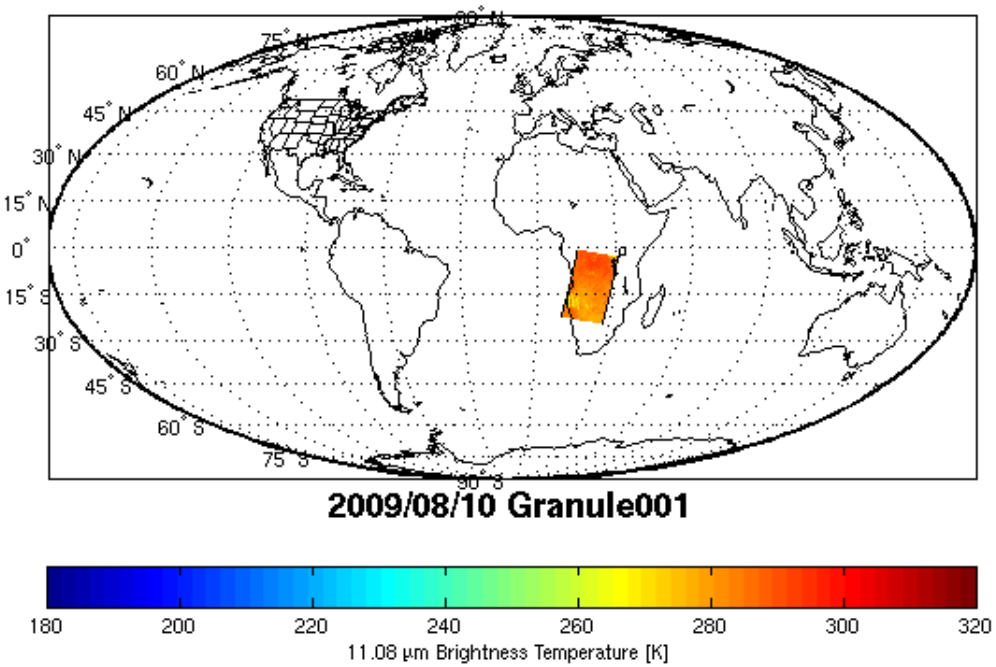
Outlines

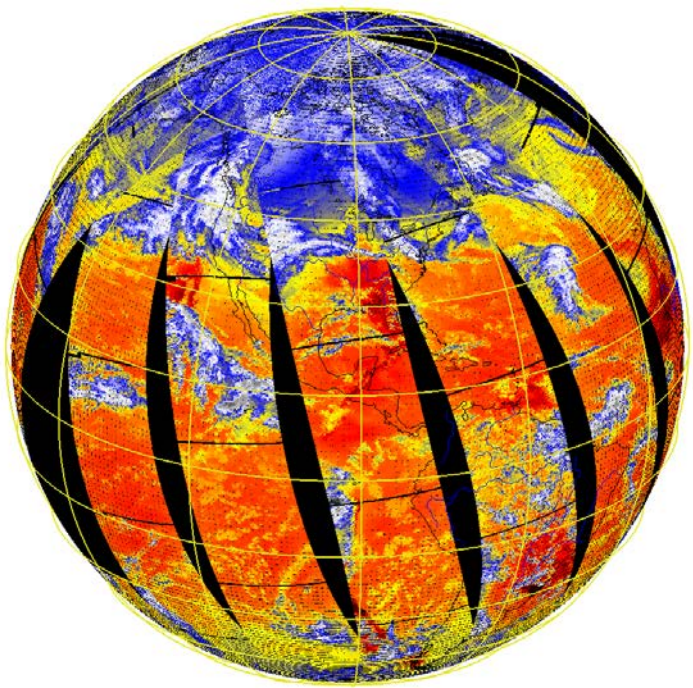
- Why use regional numerical weather prediction (NWP) for JPSS sounding evaluation?

- How to do JPSS sounding evaluation with regional NWP model?

- Initial findings with AIRS (as proxy) soundings;

- Application of soundings on tropical cyclone forecasting and next plans.





AIRS (10 August 2009)

CrIS (20 January 2012) global coverage

(provided by Dave Tobin – CIMSS/SSEC)

Why use regional NWP for sounding evaluation?

- There are drawbacks on traditional evaluation with radiosondes:
  - Radiosondes provide less spatial/temporal information for validation purpose;
  - It is difficult to validate the soundings over ocean where in-situ measurements are rare.

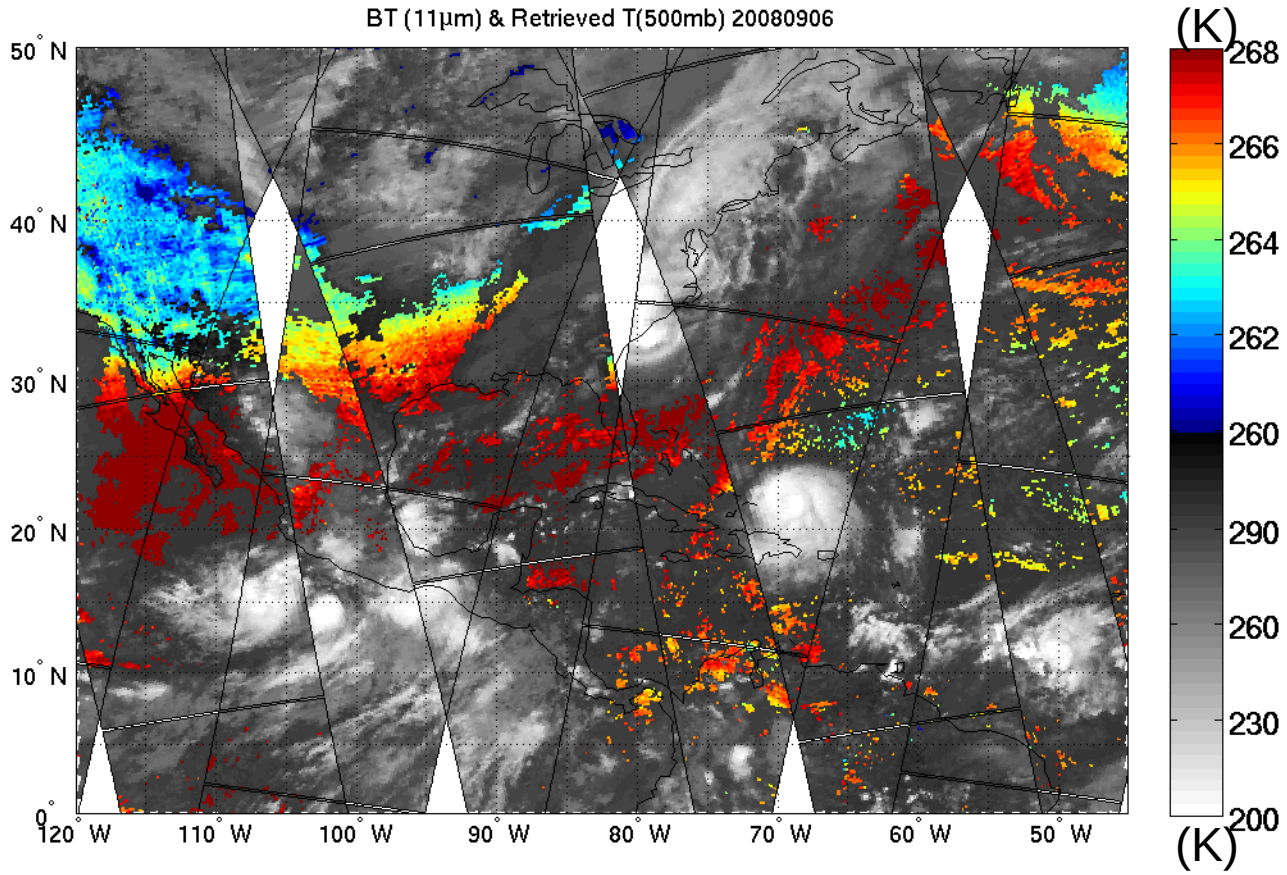
- Sounding assimilation in regional NWP models provide an effective way for algorithm and product evaluation:
  - Evaluate spatial/temporal information through impact verification;
  - Evaluate algorithm and products over ocean.

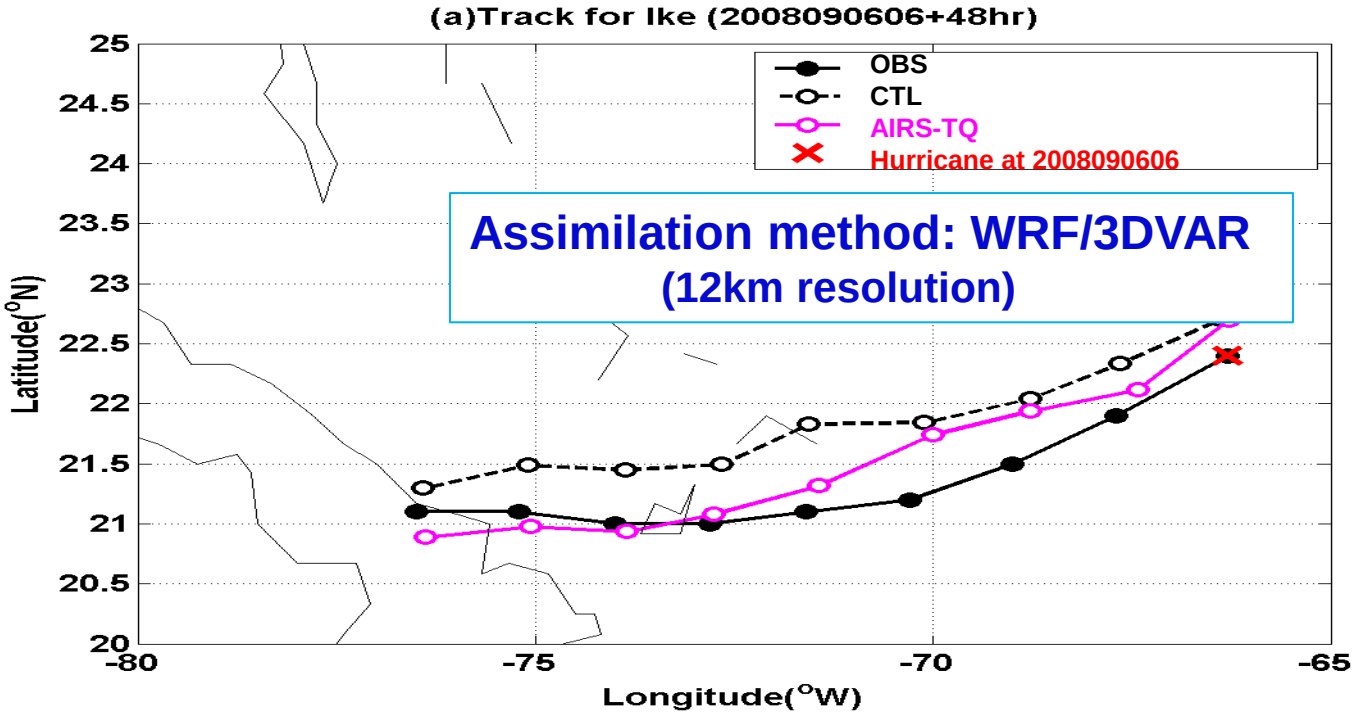
How to do JPSS sounding evaluation with regional NWP models?

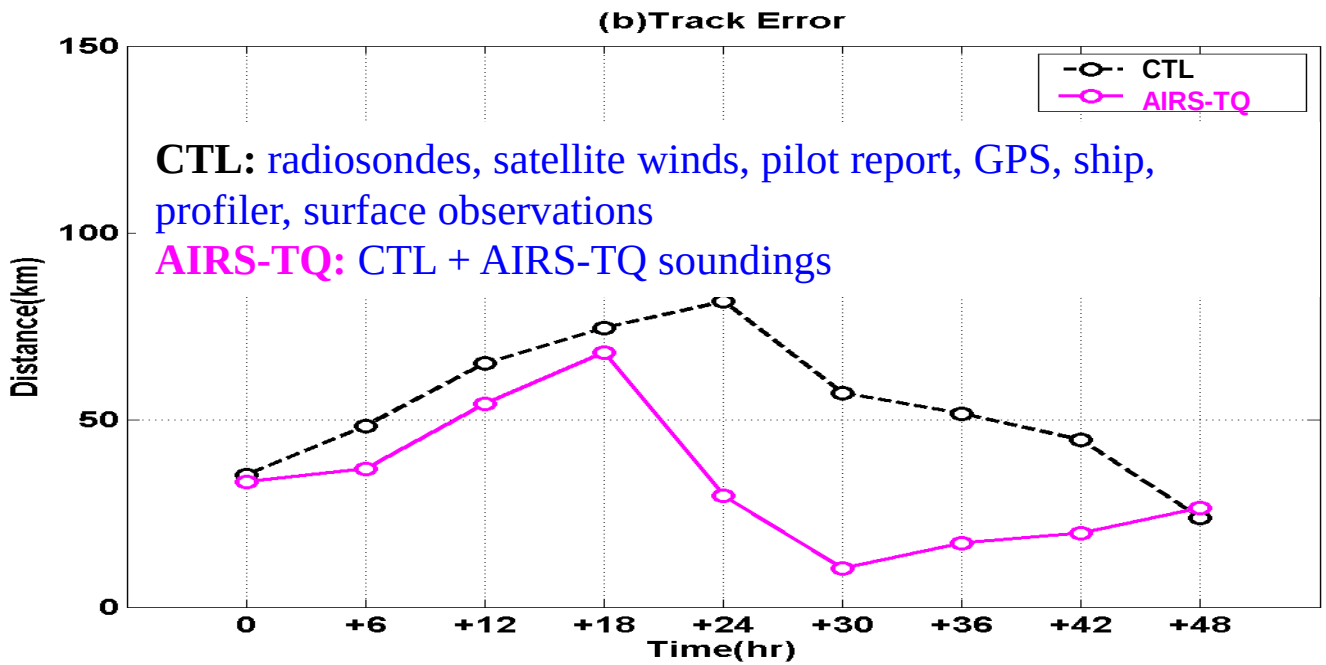
- Assimilate soundings in regional NWP models for tropical cyclone (TC) forecasting using DART, 3DVAR, 4DVAR;

- Verify impact with hurricane track and intensity observations, GOES Imager brightness temperature, AMSR-E TPW (total precipitable water) over ocean.

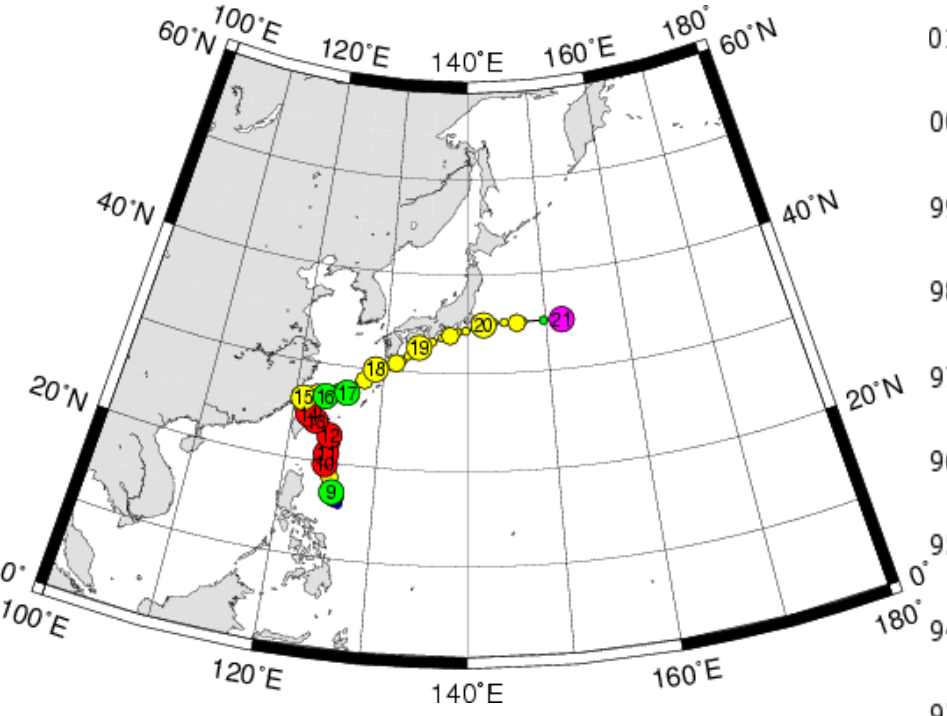
AIRS 500 hPa atmospheric temperatures in clear skies (06 September 2008) for hurricane Ike



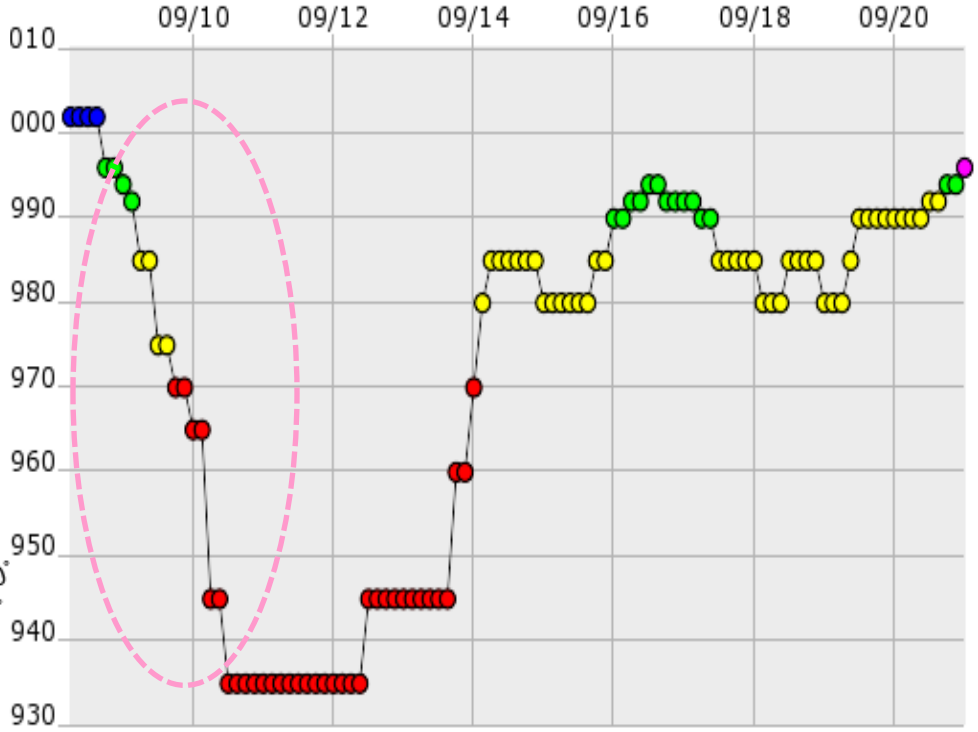

(a)Track for Ike (2008090606+48hr)
OBS
CTL
AIRS-TQ
Hurricane at 2008090606
Assimilation method: WRF/3DVAR
(12km resolution)
Latitude(°N)
Longitude(°W)
25
24.5
24
23.5
23
22.5
22
21.5
21
20.5
20
-80
-75
-70
-65


(b)Track Error
CTL
AIRS-TQ
CTL: radiosondes, satellite winds, pilot report, GPS, ship, profiler, surface observations
AIRS-TQ: CTL + AIRS-TQ soundings
Distance(km)
Time(hr)
150
100
50
0
0
+6
+12
+18
+24
+30
+36
+42
+48

Typhoon Sinlaku (2008) Fact

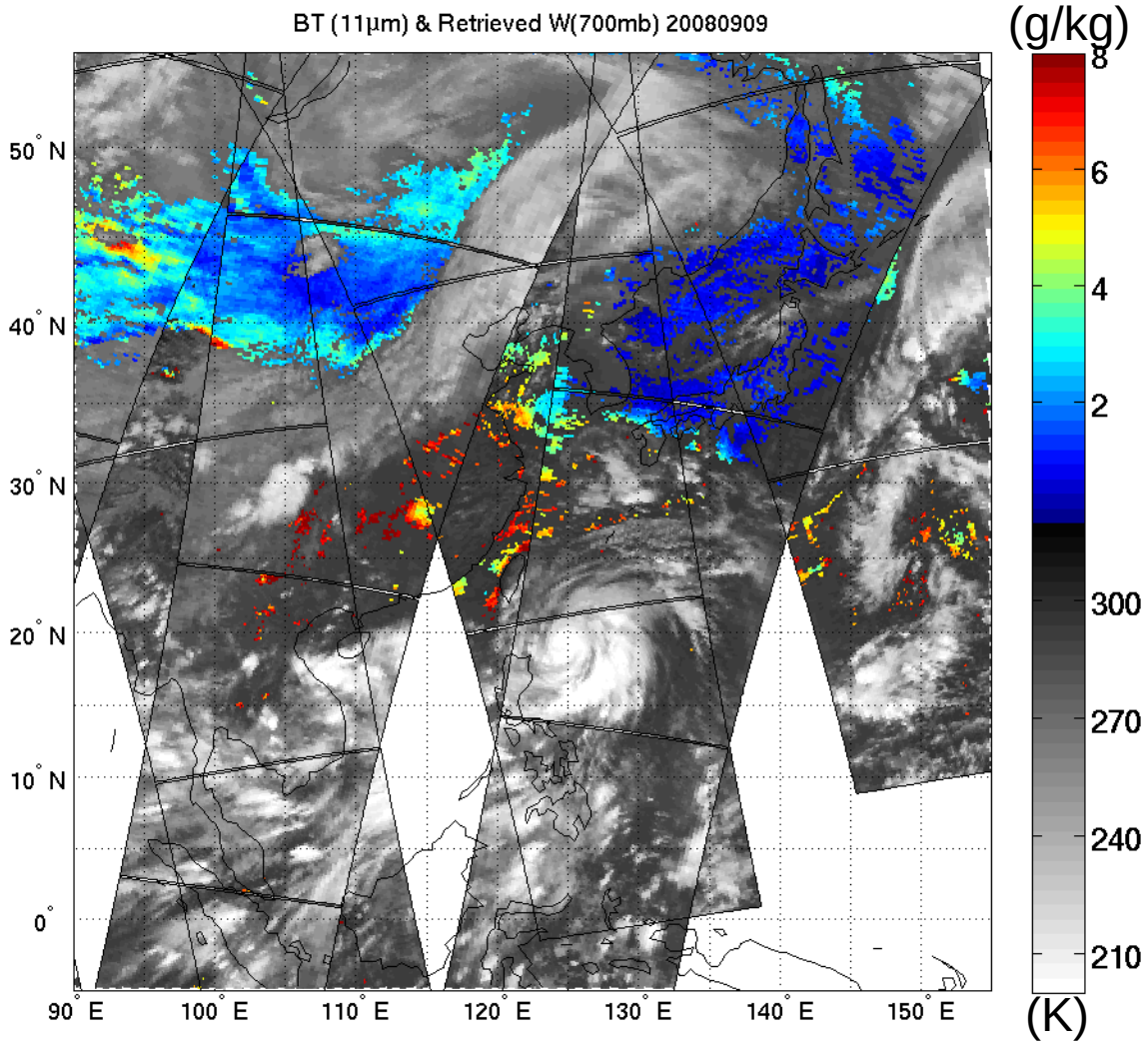


Sinlaku Path

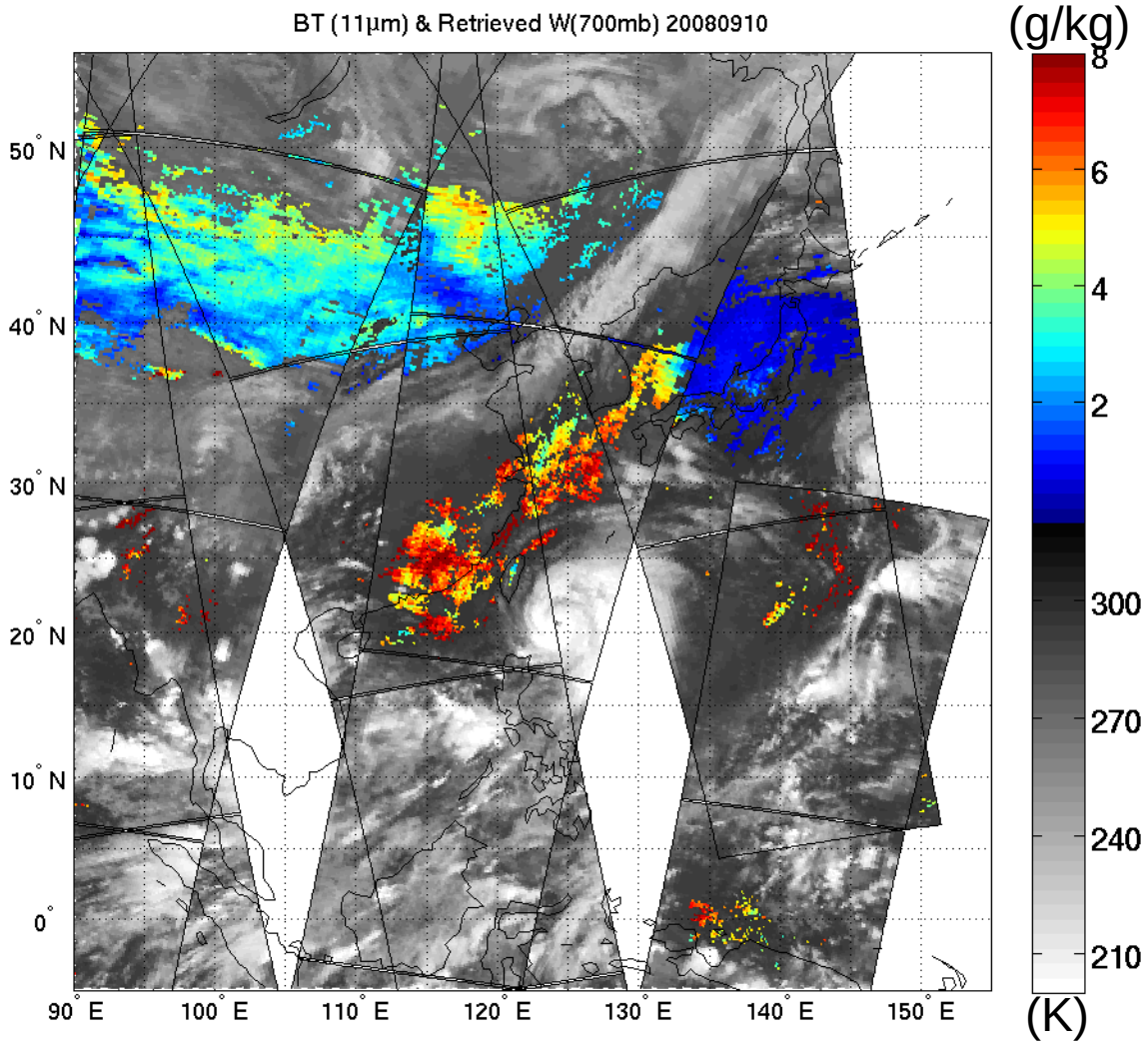


Sinlaku rapid intensification (9 – 10 September 2008) observed

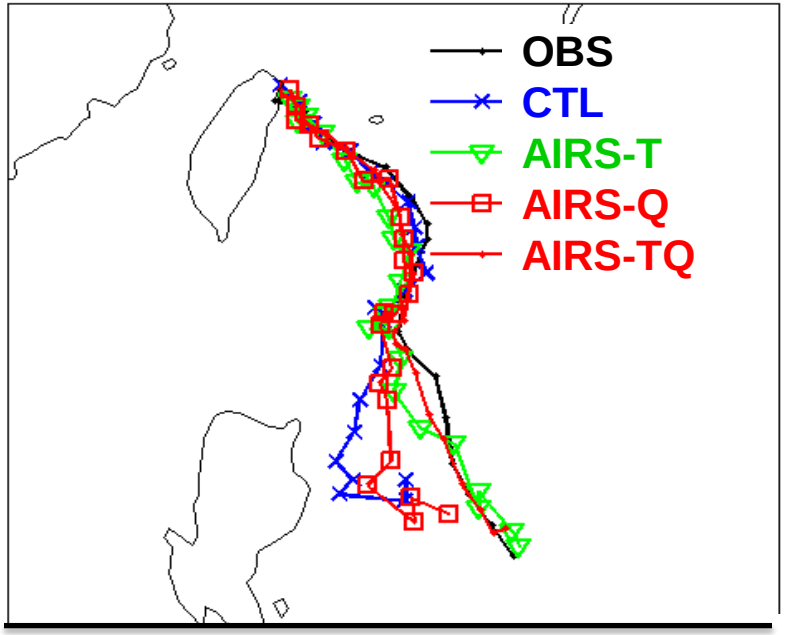
AIRS 700 hPa water vapor mixing ratio (g/kg)（09 September 2008) in clear skies



AIRS 700 hPa water vapor mixing ratio (g/kg)（10 September 2008) in clear skies

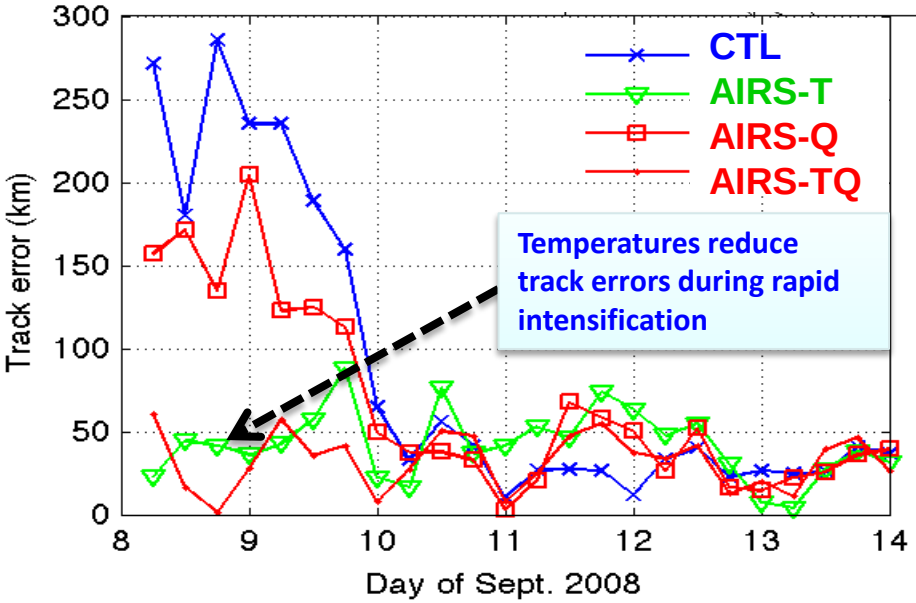


Sinlaku path and intensity analysis with AIRS soundings (WRF/DART)

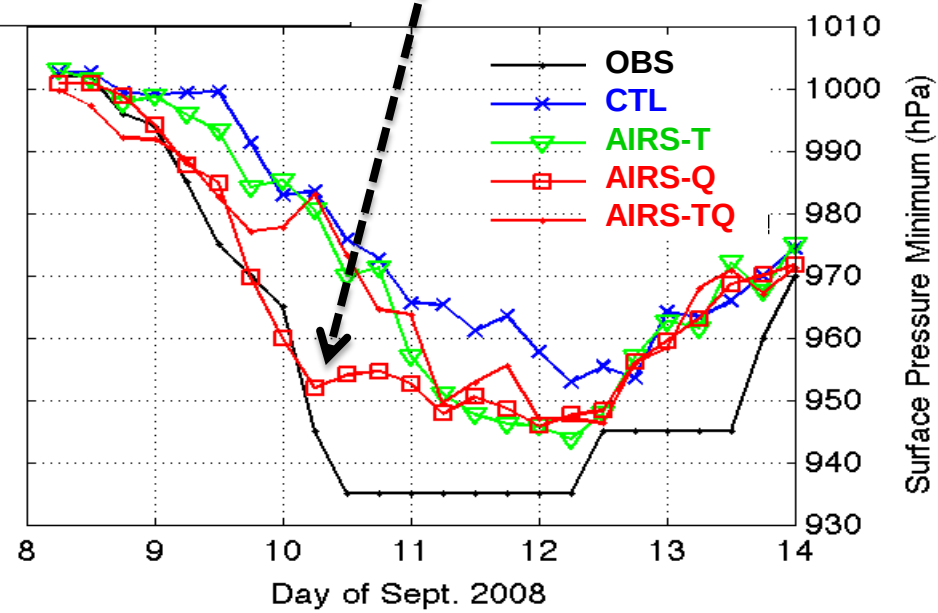


CTL run: assimilate radiosonde, satellite cloud winds, QuikSCAT winds, aircraft data, COSMIC GPS refractivity, ship, and land surface data.

Rapid intensification from 9 to 10 September 2008 captured with water vapor soundings assimilated



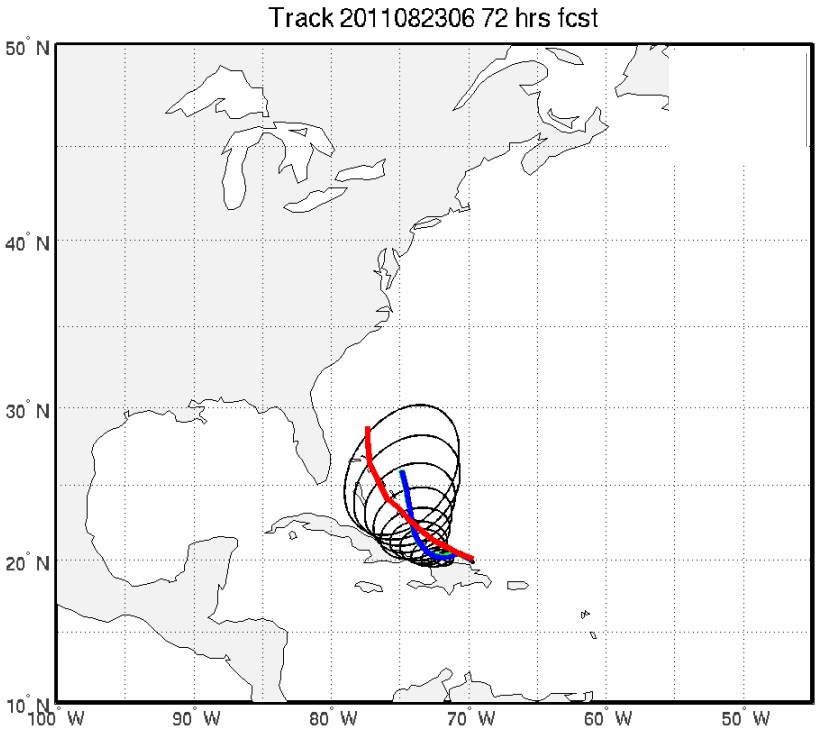
Temperatures reduce track errors during rapid intensification



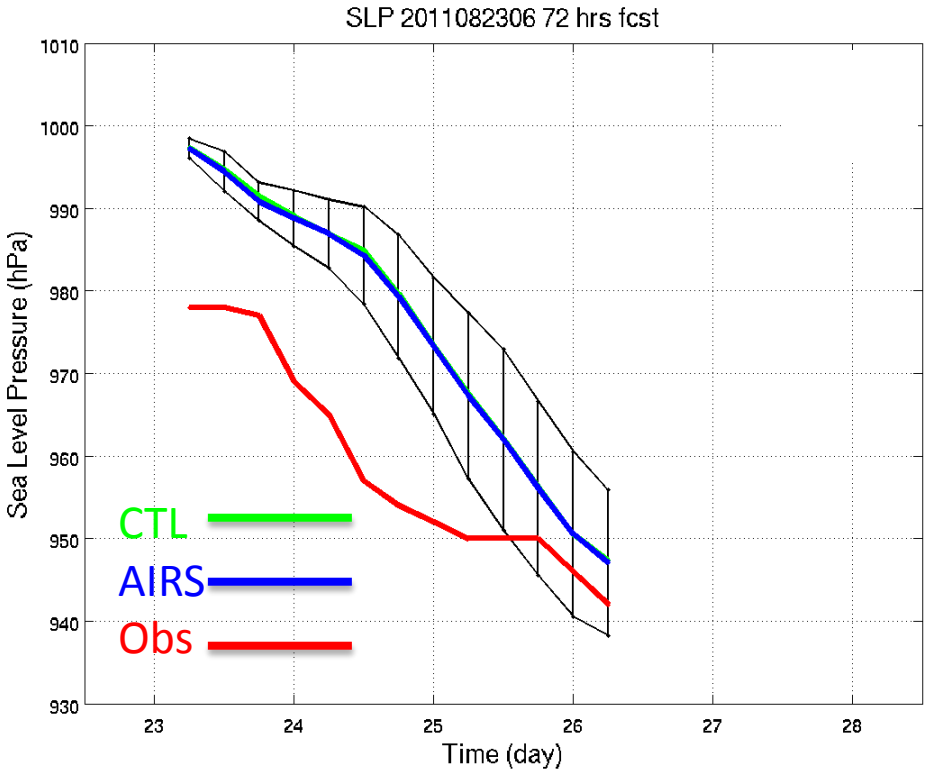
72-hour ensemble forecasts – Hurricane Irene (2011)

(from 06 UTC 23 to 00 UTC 25 August 2011)

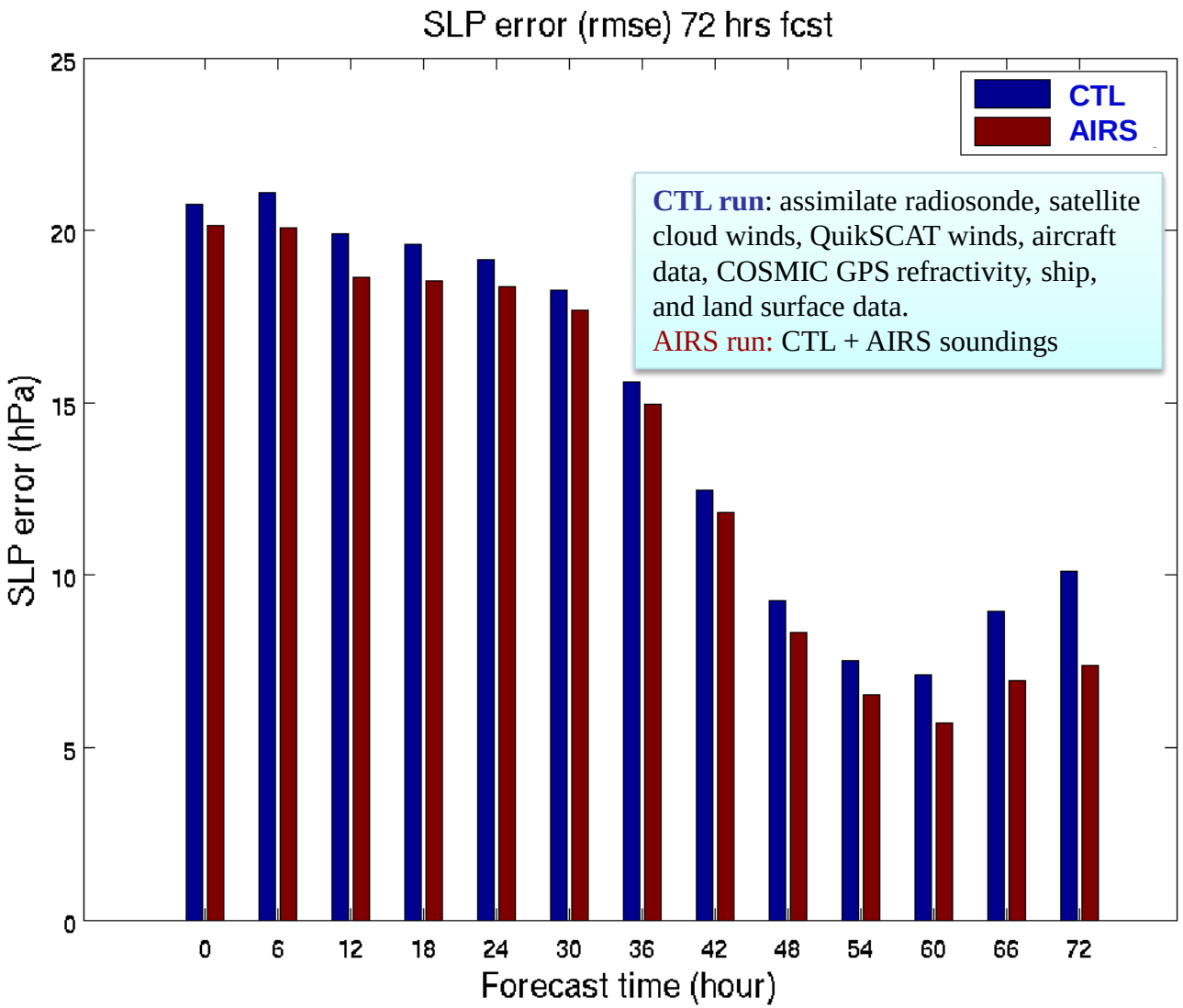
Assimilation method: **WRF/DART** with 36 km resolution
Control (CTL) – includes convectional and aircraft measurements
AIRS – CTL + AIRS soundings



Irene (2011) track forecasts



Irene (2011) sea level pressure forecasts



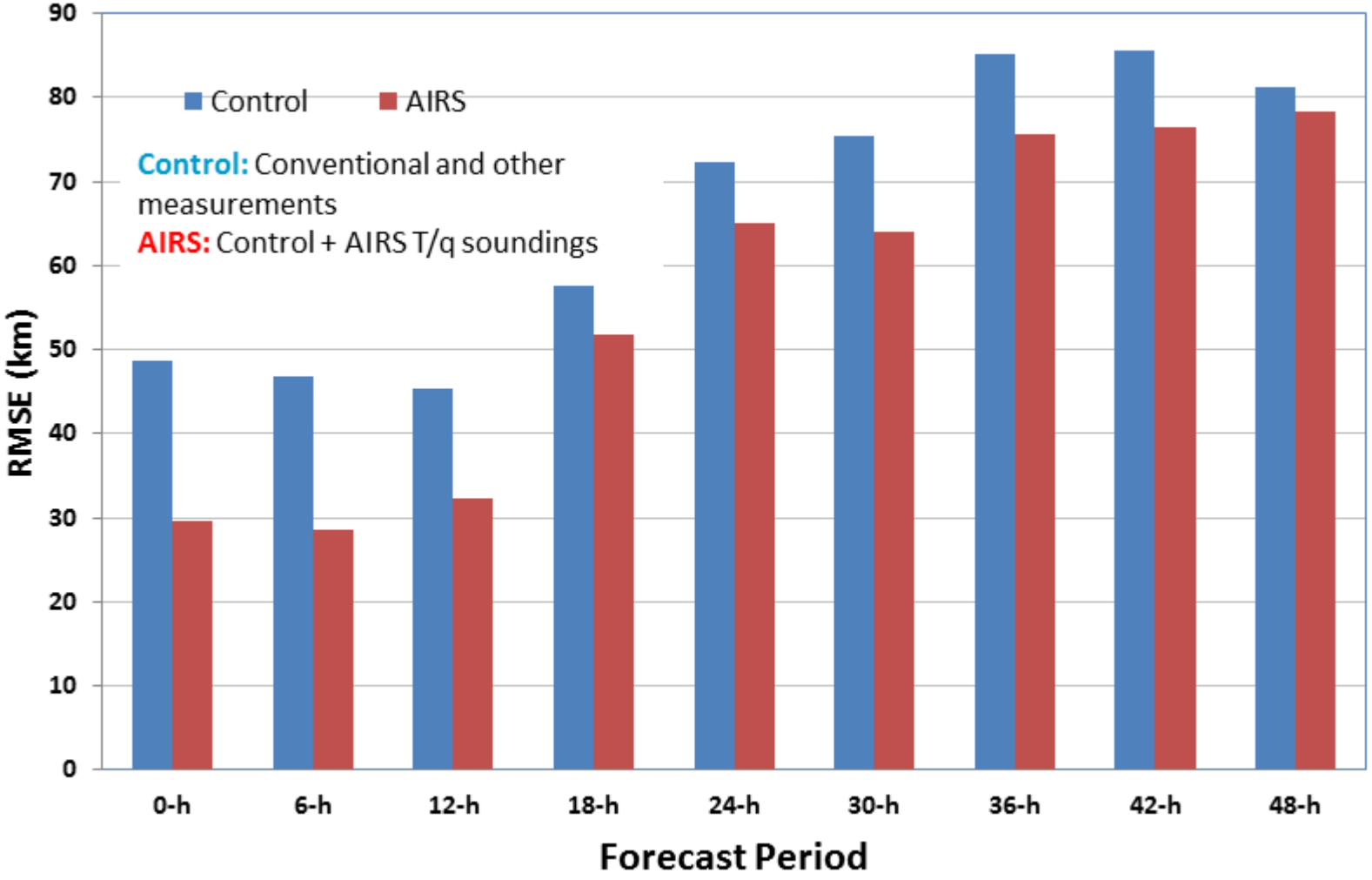
Central sea level pressure forecast RMSE - Hurricane Irene (2011)
(06 UTC 23 to 00 UTC 25 August 2011)

Initial findings with AIRS (proxy for CrIS) soundings

- AIRS soundings provide value-added information to conventional observations;
- Evaluation on sounding vertical information for TC applications;
- Evaluation on spatial information for TC applications;
- Evaluation on soundings from different algorithms;
- Evaluation on sounding bias correction for TC applications.

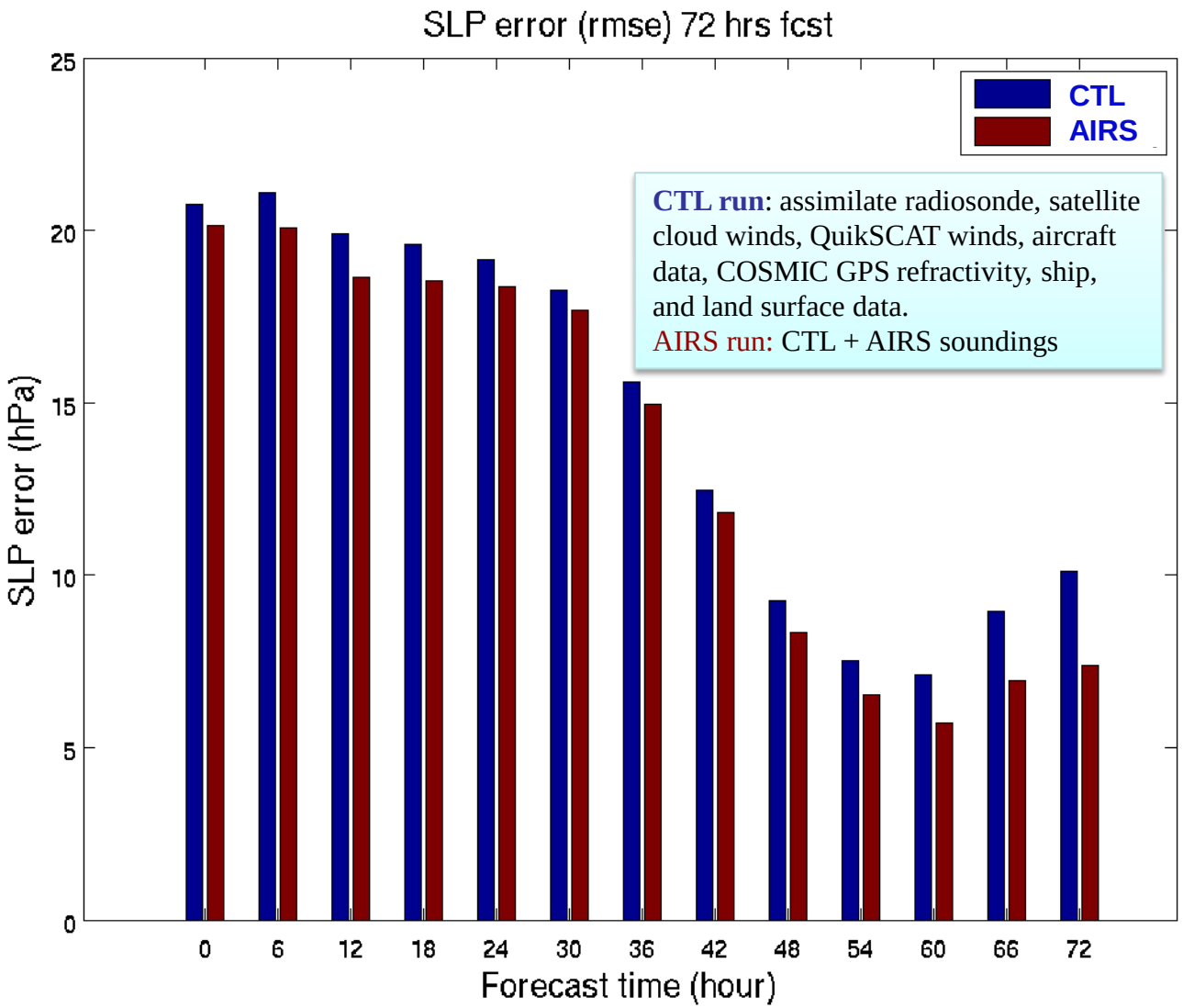
AIRS soundings provide value-added information to conventional observations

(Track forecast RMSE for hurricane Ike - 2008)



AIRS single FOV soundings in clear skies are used. WRF/3DVAR (12 km resolution) forecasting and assimilation system is used. Assimilation is done every 6 hours. 0-h is from analysis, others are forecasts (06 UTC 06 September 2008 – 00 UTC 10 September 2008).

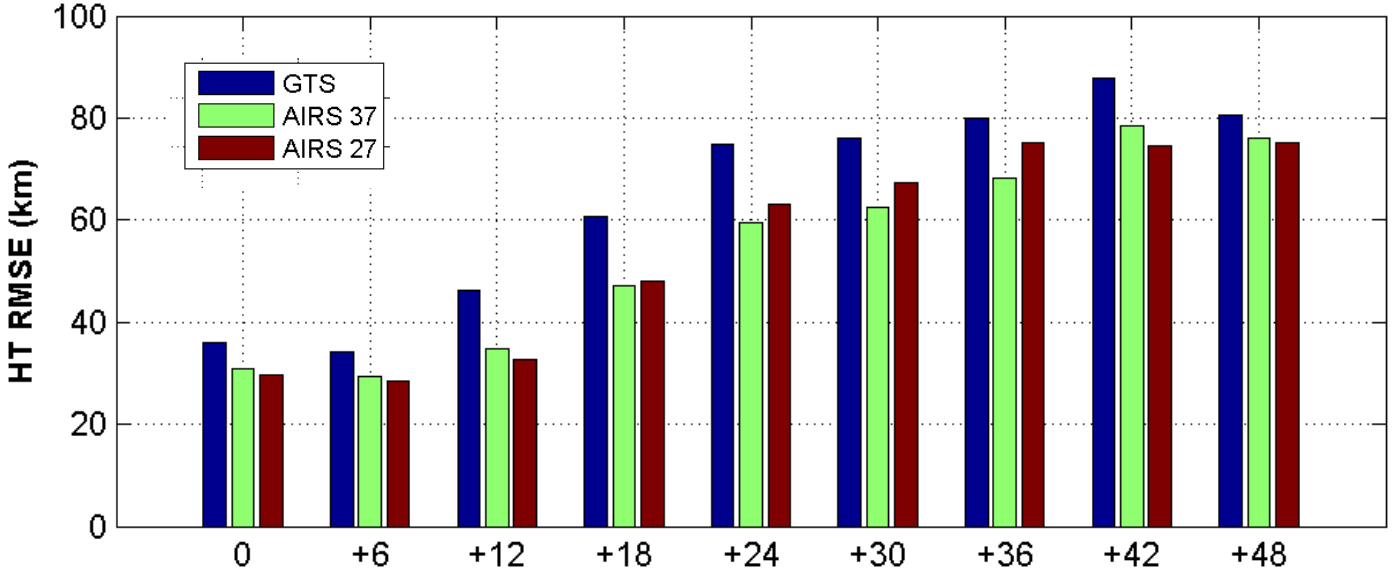
Central sea level pressure forecast RMSE - Hurricane Irene (2011) (06 UTC 23 to 00 UTC 25 August 2011)



AIRS single FOV soundings in clear skies are used. WRF/DART (36 km resolution) forecasting and assimilation system is used. Assimilation is done every 6 hours followed by 72-hour forecasting. 0-h is from analysis, others are forecasts .

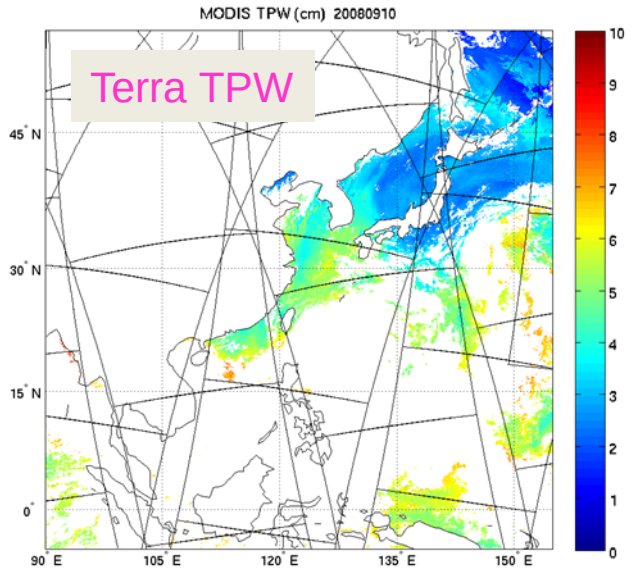
Evaluation with hurricane track observations on sounding vertical information

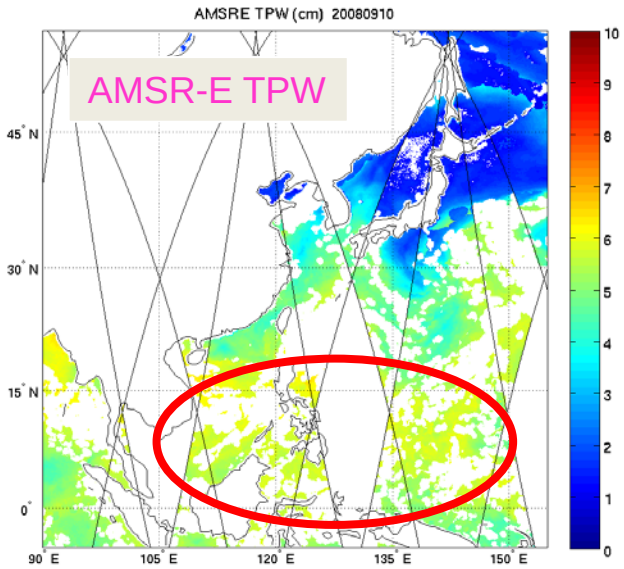
1. Conventional data used: GTS
2. Convectional plus temperature and moisture soundings between 300 – 700 hPa: AIRS 37
3. Convectional plus temperature and moisture soundings between 200 – 700 hPa: AIRS 27

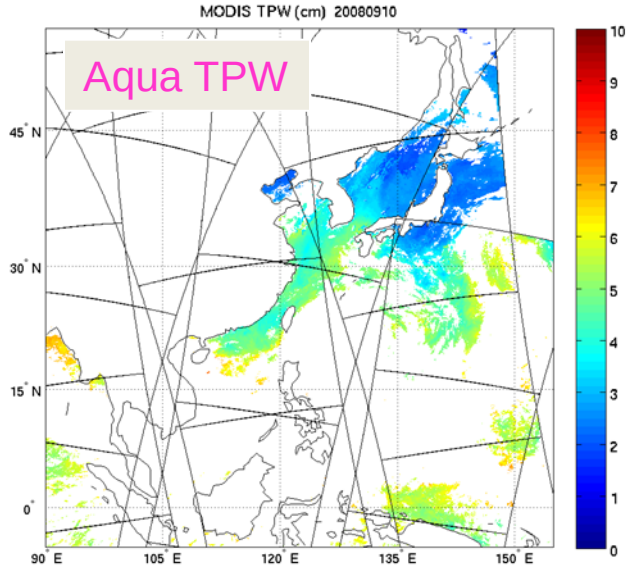


Track forecast RMSE for hurricane Ike – 2008

(06 UTC 06 September – 00 UTC 10 September)

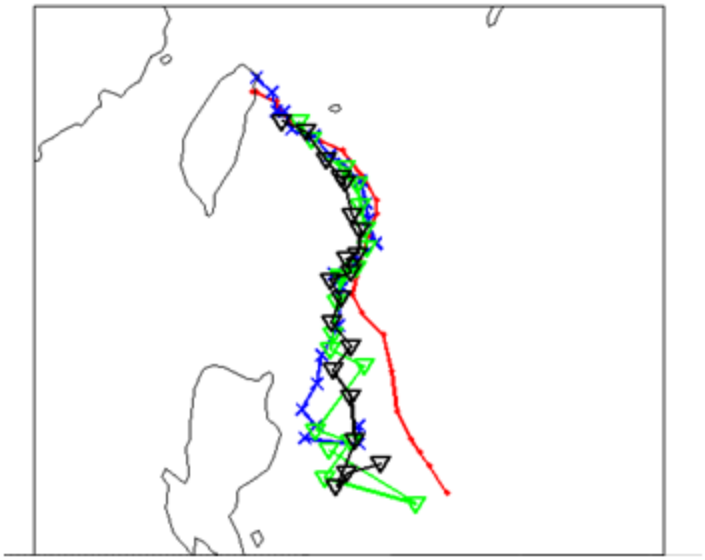






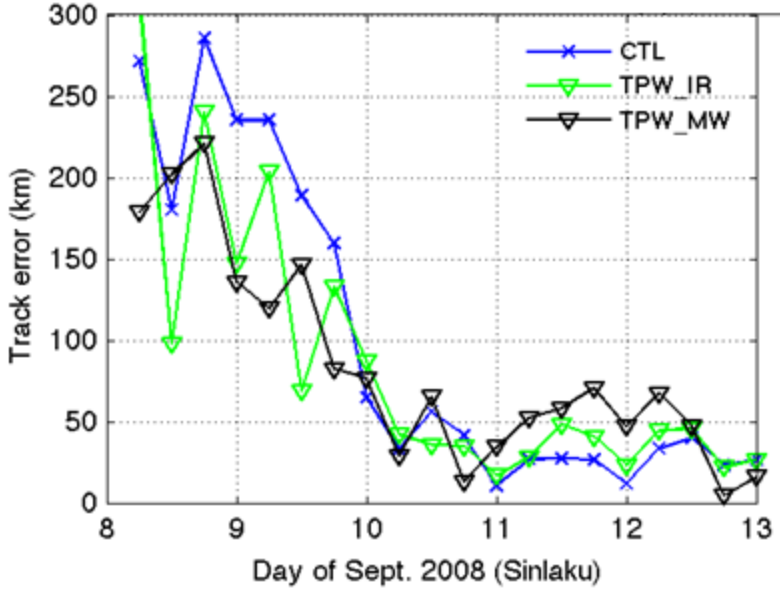
Terra MODIS (upper left), Aqua MODIS (lower left) and AMSR-E (upper right) TPW images over ocean for 10 September 2008. The spatial resolution is 5 km for MODIS TPW and 17 km for AMSR-E TPW.

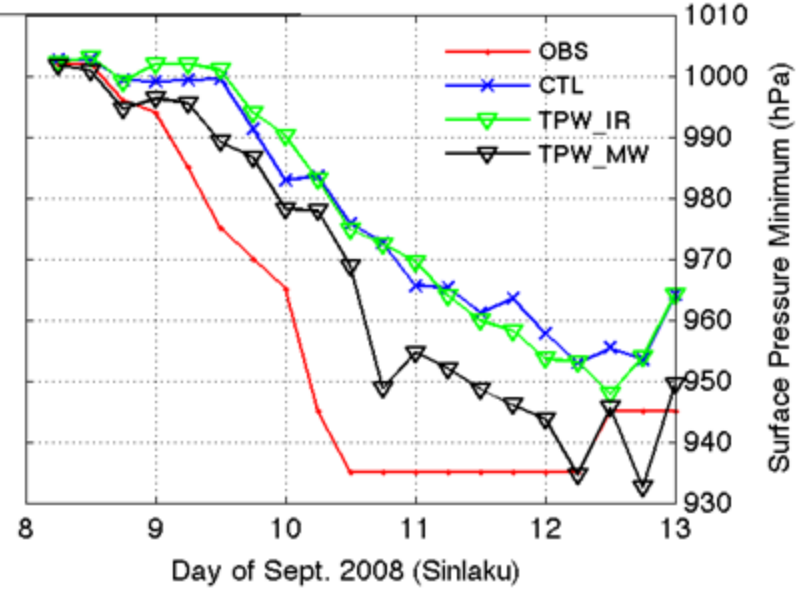
6-hour analysis on track and intensity for Typhoon Sinlaku (2008)

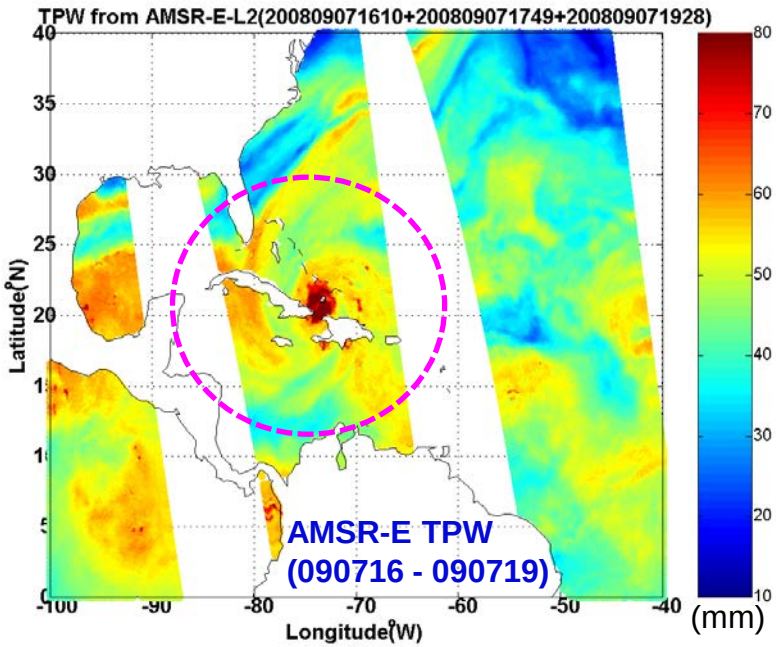


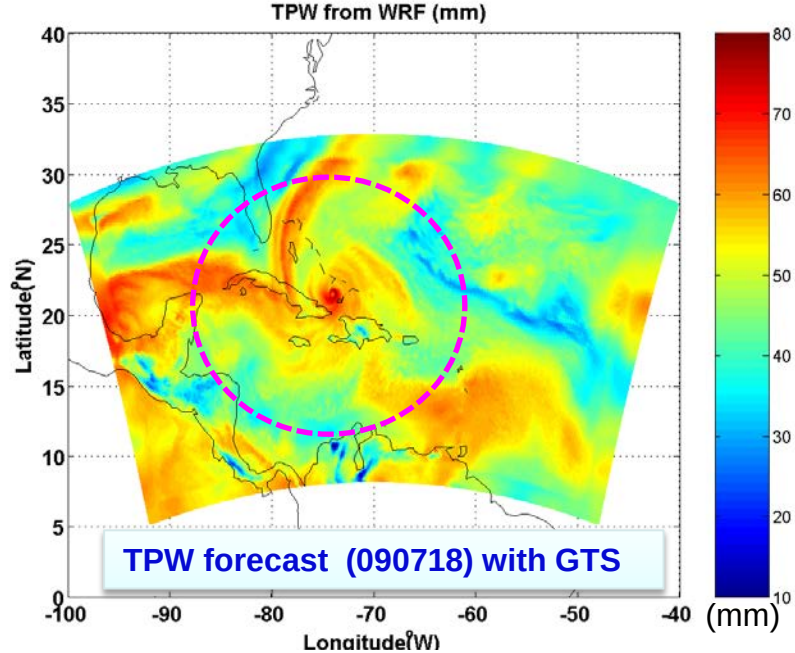
CTL run: assimilate radiosonde, satellite cloud winds, QuikSCAT winds, aircraft data, COSMIC GPS refractivity, ship, and land surface data.

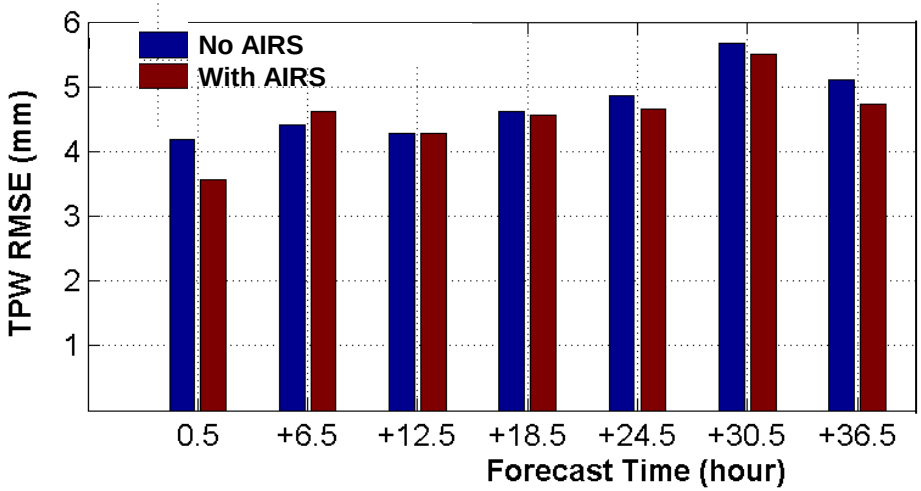
Rapid intensification from 9 to 10 September 2008 captured with water vapor assimilated:
IR: MODIS
MW: AMSR-E

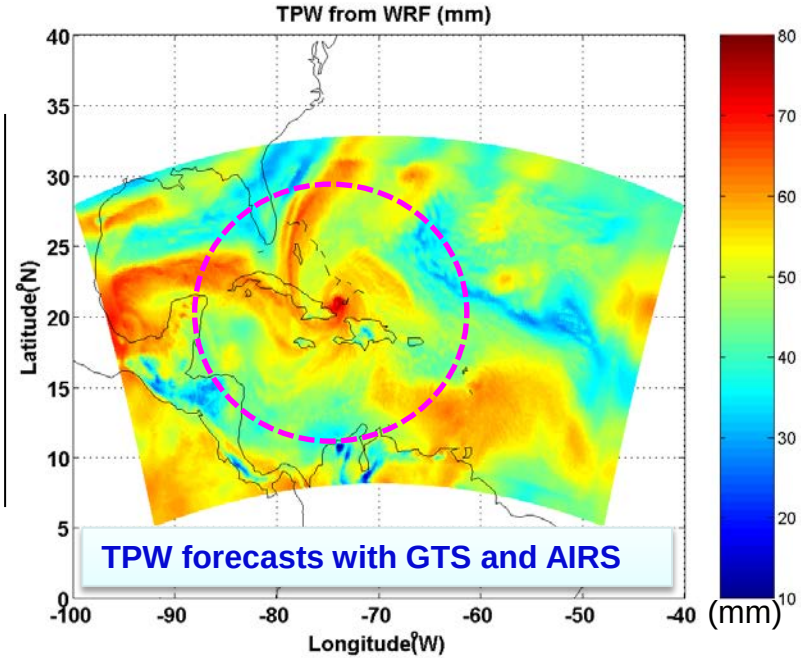








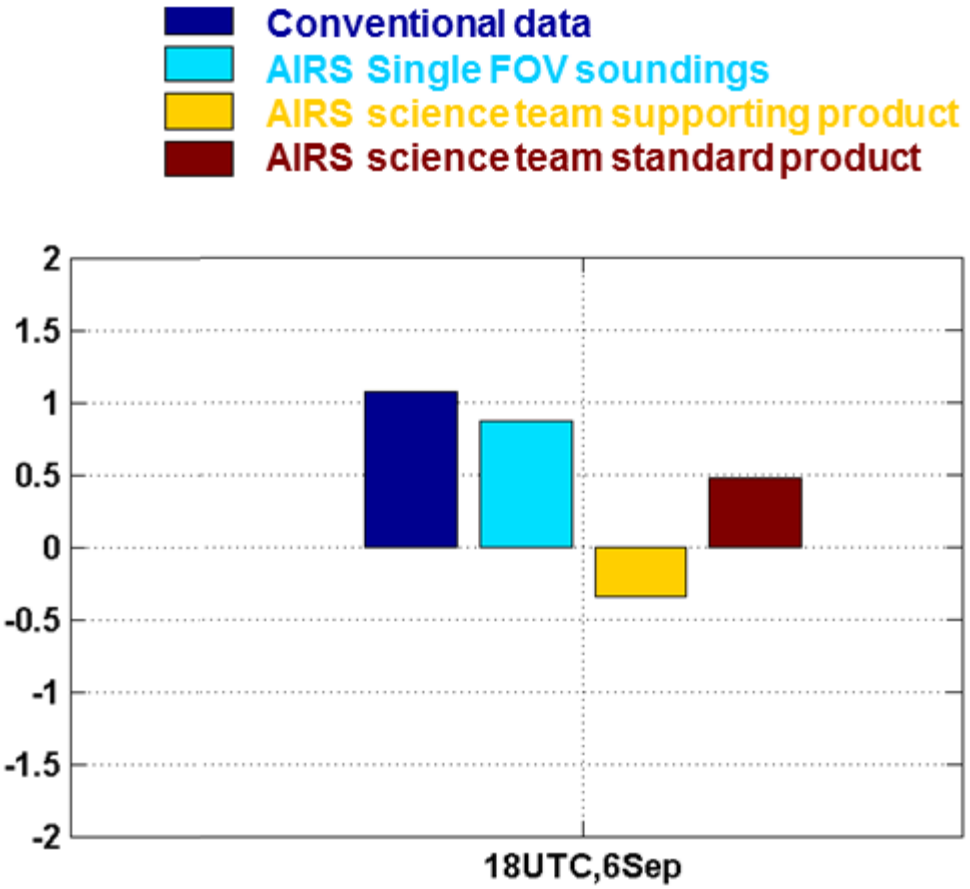




TPW forecast RMSE using collocated AMSR-E as reference
((06 UTC 06 September – 00 UTC 10 September))

Evaluation on soundings from different algorithms

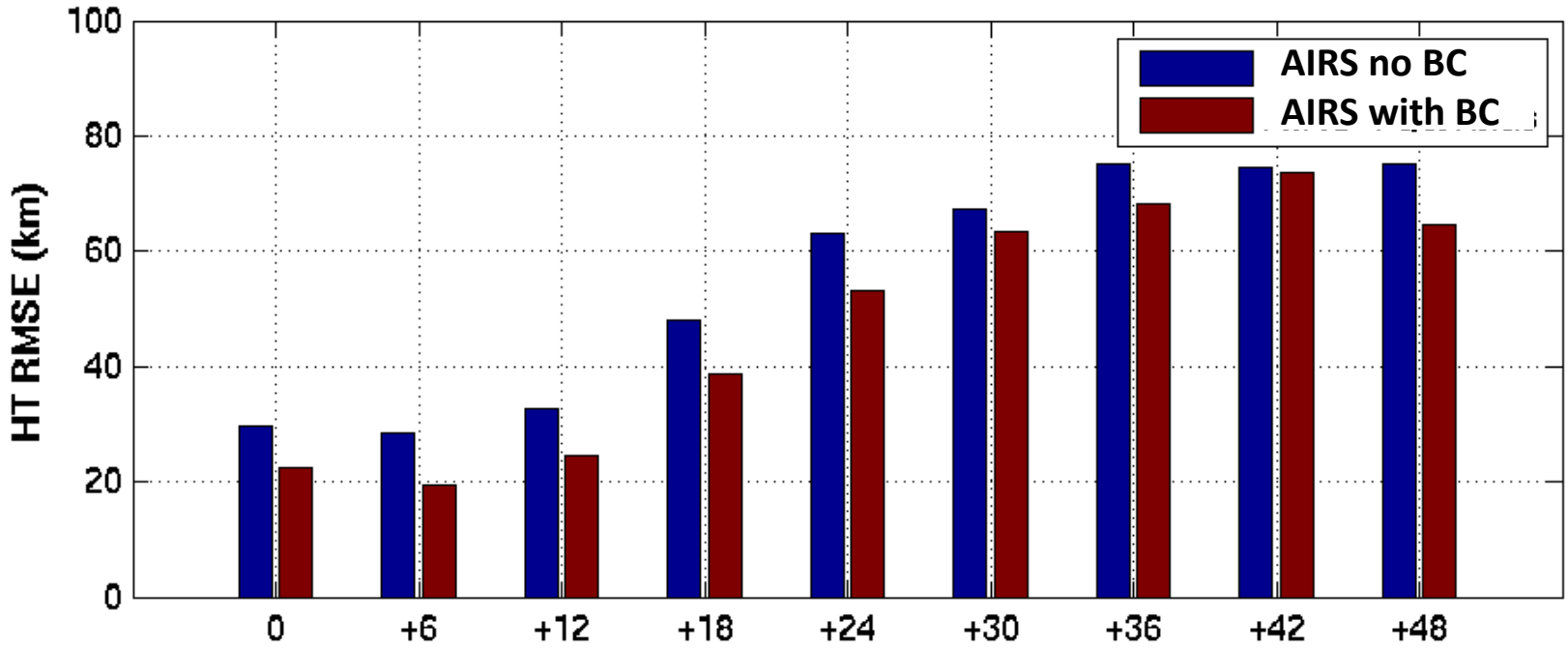
(with collocated AMSR-E TPW)



TPW forecast mean error (mm) with AIRS soundings assimilated

Evaluation on sounding bias correction (BC)

for TC applications



Track forecast RMSE for hurricane Ike (2008)

(06 UTC 06 September – 00 UTC 10 September)

Summary and future work

- Using NWP models provides an effective evaluation method for JPSS soundings, especially over ocean when conventional data are rare;

- Vertical, spatial and temporal information from soundings can be evaluated for TC applications;

- Future work includes impact comparison between CrIS and AIRS (CrIMSS and AIRS/ATMS), more cases for experiments, sounding evaluation in cloudy skies, impact verification with GOES Imager and TRMM precipitation, etc.