# Progress on the assimilation of advanced IR sounder radiances in cloudy skies

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The 20th International TOVS Conference (ITSC-20)

28 October – 03 November 2015, Lake Geneva, Wisconsin, U.S.A.

Acknowledgement: This research is partly supported by JPSS PGRR and GOES-R HIW

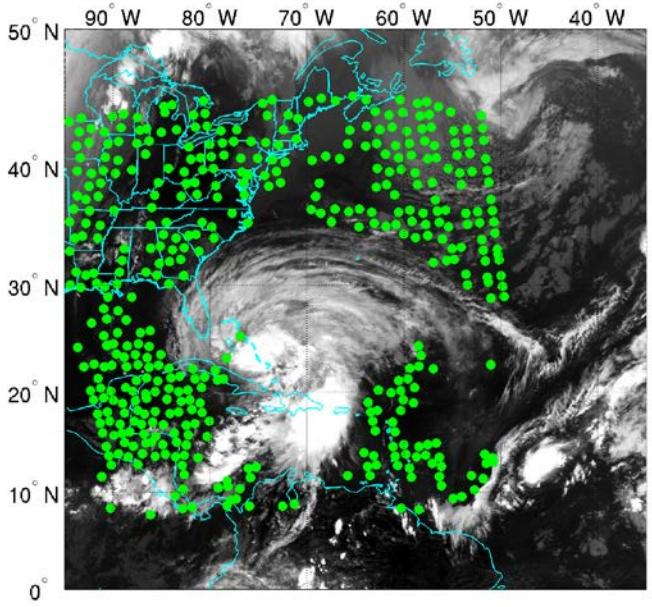
# Motivation

- How does “clear location” detection impact IR radiance assimilation? And
- How to improve clear location detection for IR radiance assimilation?
- Direct assimilation of cloudy IR radiances in NWP is still challenging, any alternative solutions for IR radiance assimilation in cloudy regions?

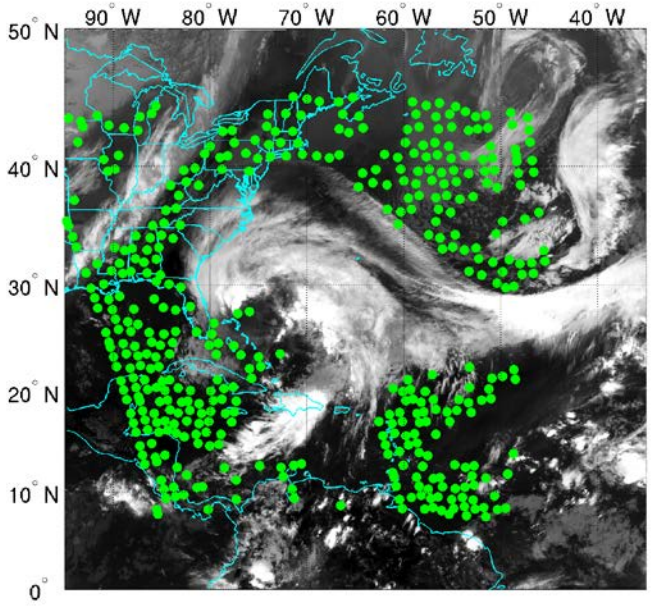
## CrIS clear radiance locations (GSI)

channel 96 (wavelength 709.375cm^-1)

Oct 25 18z



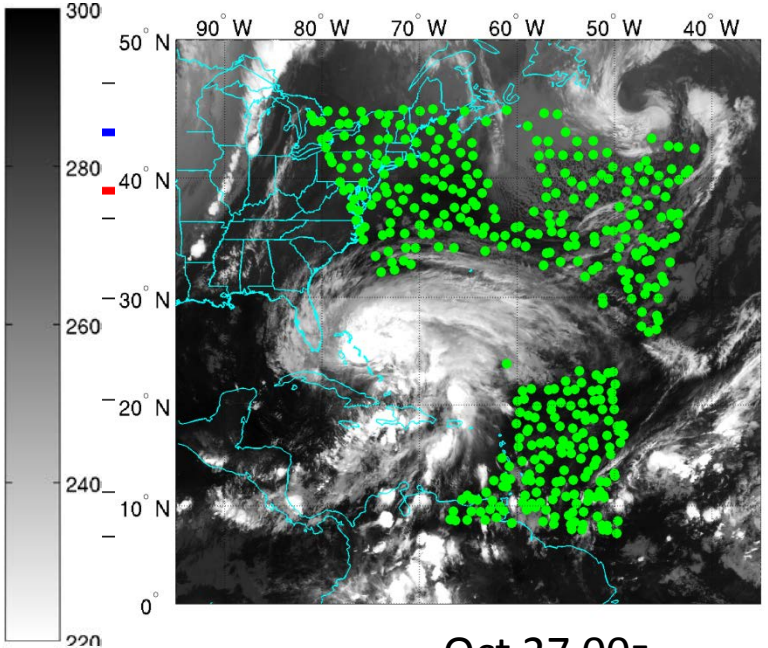

Oct 26 18z



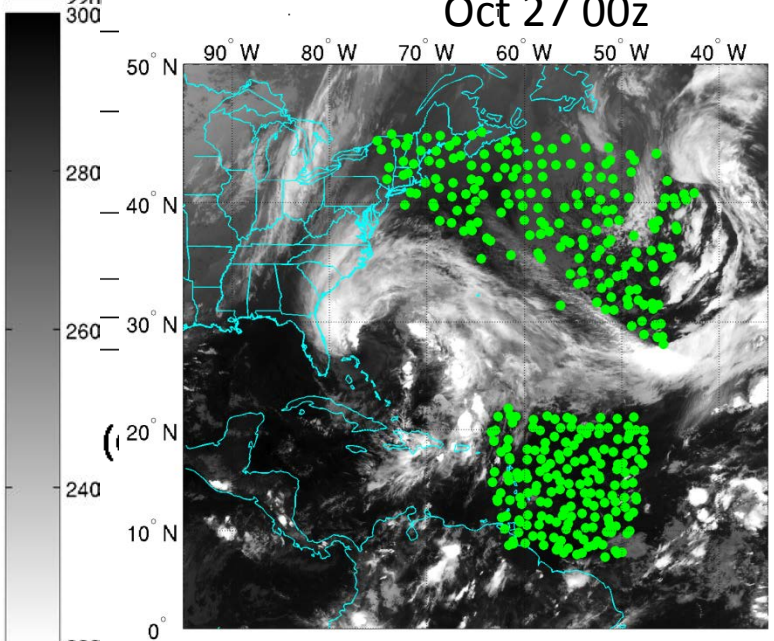

## IASI clear radiance locations (GSI)

channel 259 (wavelength 709.5cm^-1)

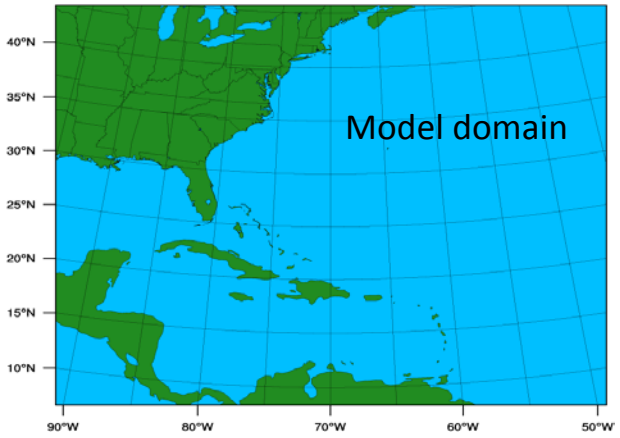
Oct 26 00z




Oct 27 00z



# Near real time Satellite Data Assimilation for Tropical storms (SDAT) (http://cimss.ssec.wisc.edu/sdat) (11P.03 "A near real time regional satellite data assimilation system for high impact weather studies")



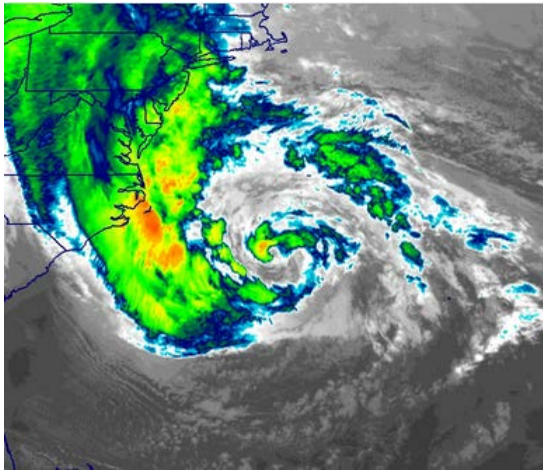

WRF-ARW v3.2.1: 12 km horizontal resolution (400*350) , 52 vertical layers from surface to 10hPa

GSI v3.3: 3D-Var Data Assimilation Method

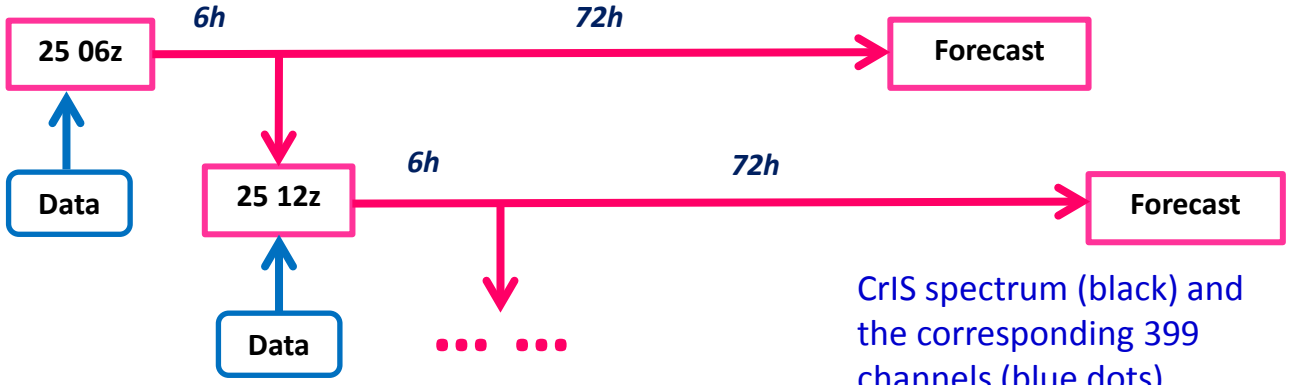
- NAM background error covariance matrix
- Cycled bias correction
- Conventional Data (GTS)
- AMUS-A radiances onboard NOAA-15, NOAA-18, Metop-A, and Aqua
- CrIS radiances onboard Suomi-NPP

Hurricane Sandy

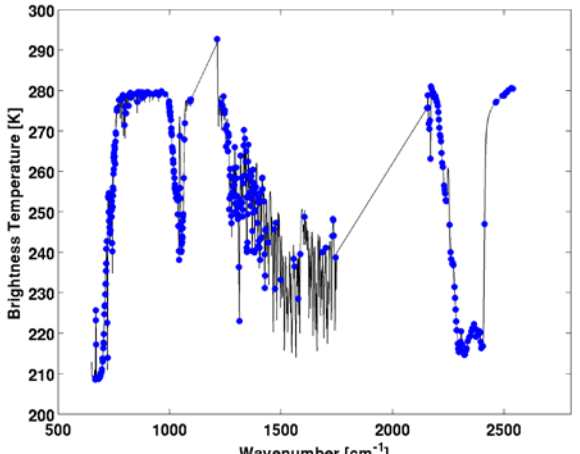
- Assimilation : Oct 25 06z to Oct 27 00z, 2012
- Forecasts: Oct 25 06z to Oct 30 00z, 2012
- Assimilation every 6 hour, 8 groups in statistics



GOES-13 10.7 μm



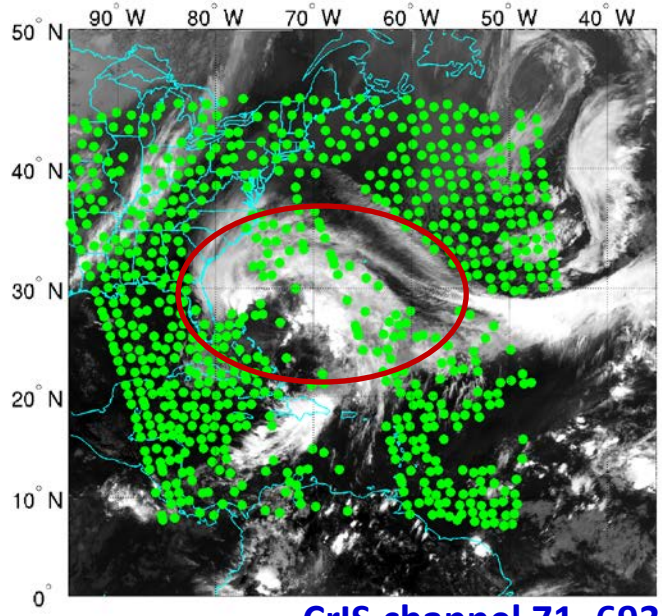

DA experiments on Sandy (2012)

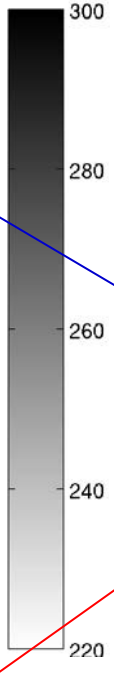



CrIS spectrum (black) and the corresponding 399 channels (blue dots) selected for the NWP center.

2012-10-26 18z

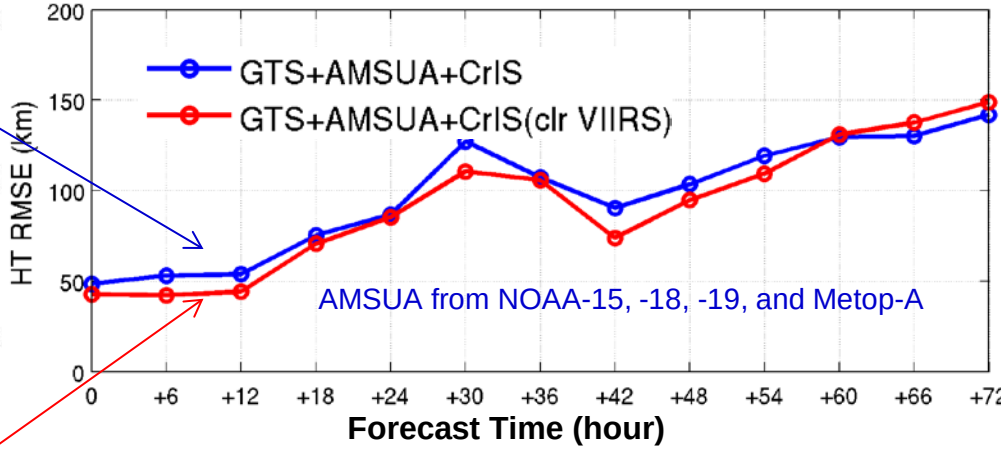
CrIS clear location from GSI



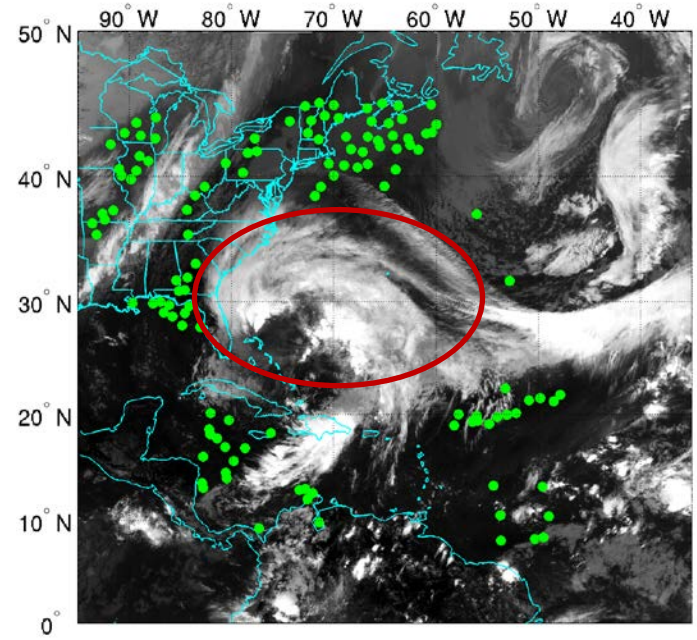




**CrIS channel 71, 693.75 cm$^{-1}$**

# Q1: How does clear location detection affect IR radiance

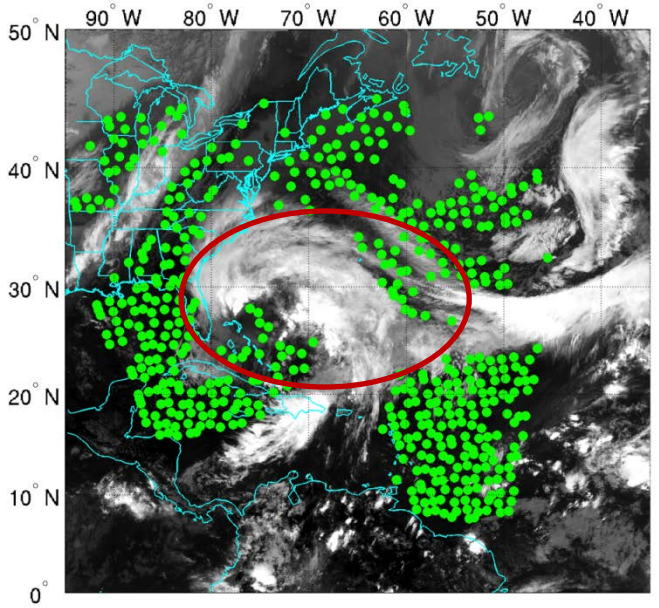



CrIS clear location from VIIRS

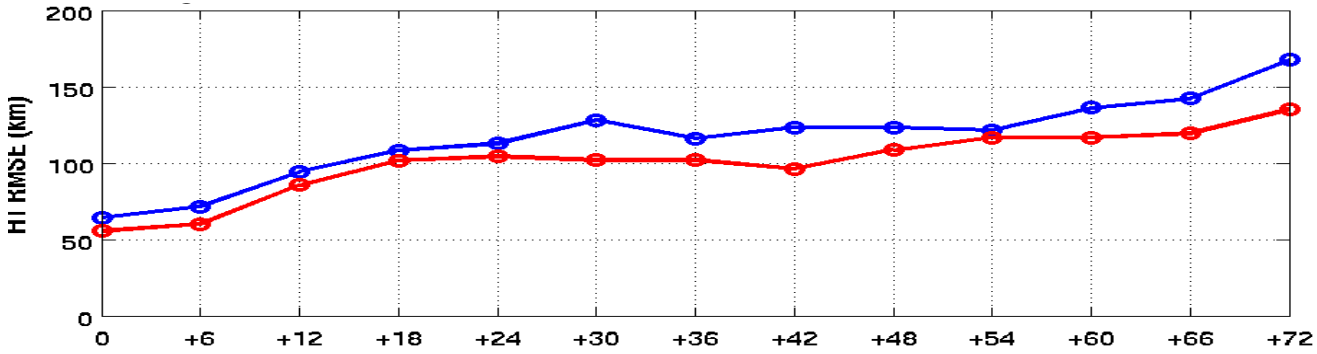



CrIS clear locations (green) overlaying on GOES-13 11 µm BT (B/W)

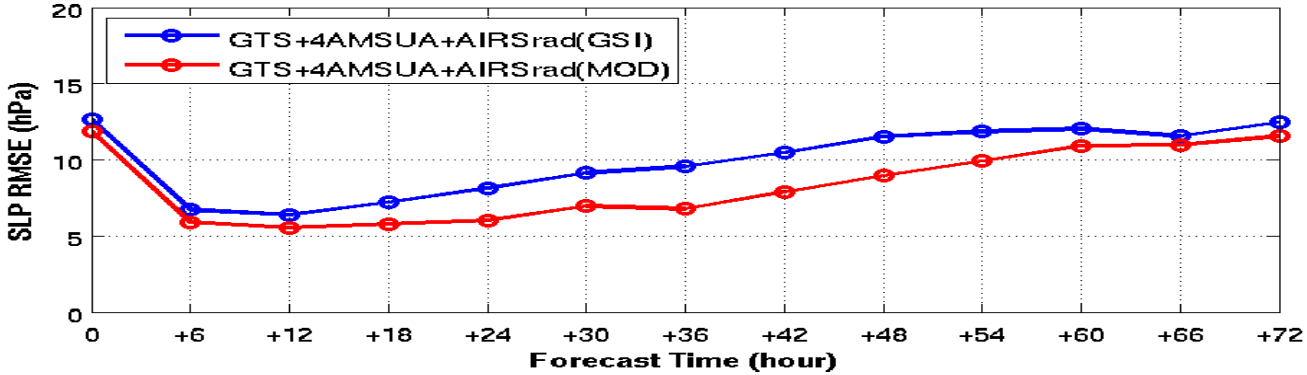
CrIS CCRs from Chris Barnet

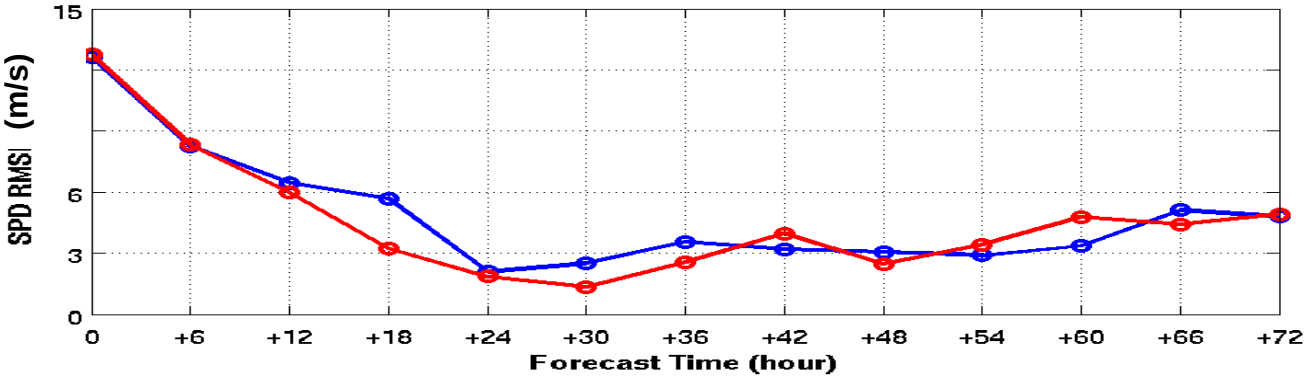


# Hurricane Sandy (2012)




Using AIRS with MODIS for clear location detection shows similar improved impact

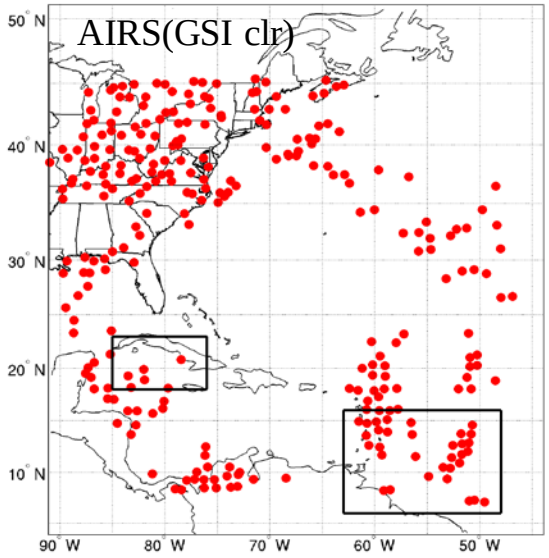


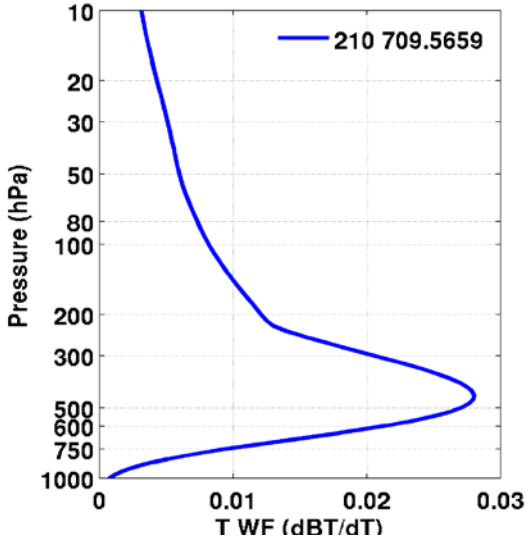



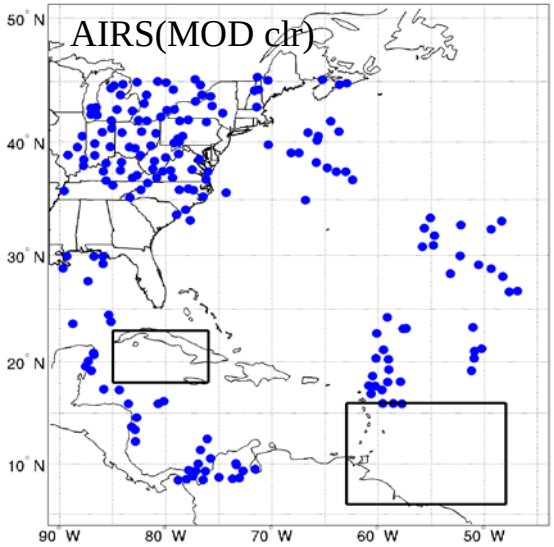

Wang et al. 2014 (GRL)

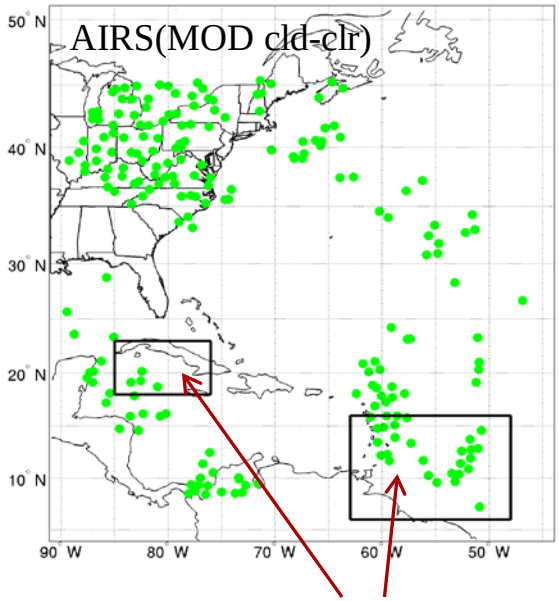
72-hour forecasts of Sandy from 06z 28 to 00z 30 Oct, 2012

# Q3: Direct assimilation of IR cloudy radiances is desired, but quite challenging, any alternative solution on IR radiance assimilation in cloudy region?




Cloud-cleared radiances (CCRs): clear equivalent radiances from partly cloud cover FOV after cloud effect is removed using additional information.

Currently three are types of CCRs:

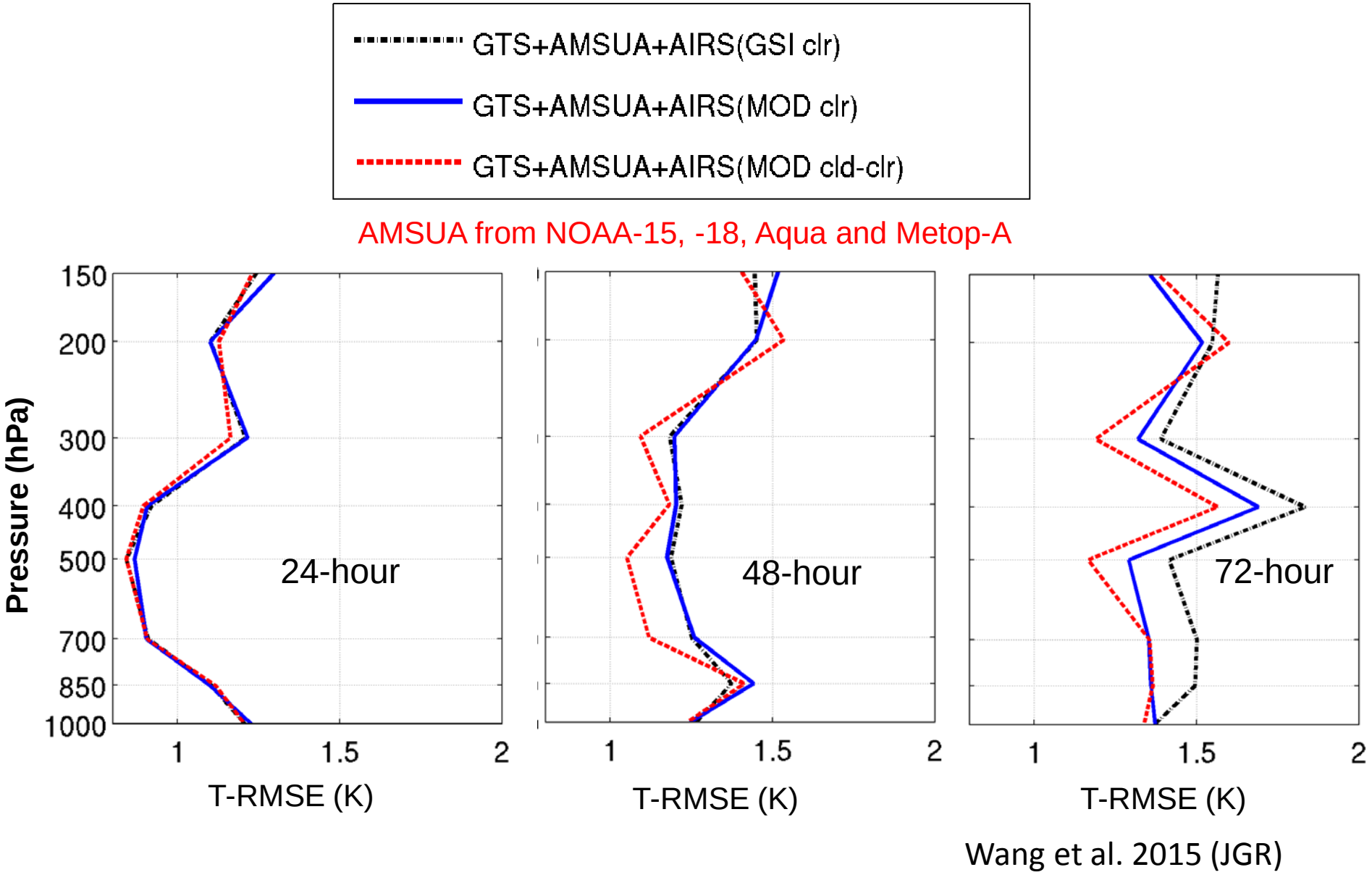
(1) Imager-based
(2) Microwave-based
(3) Background-based

AIRS data locations at 18z 25, Oct 2012

Imager-based CCRs

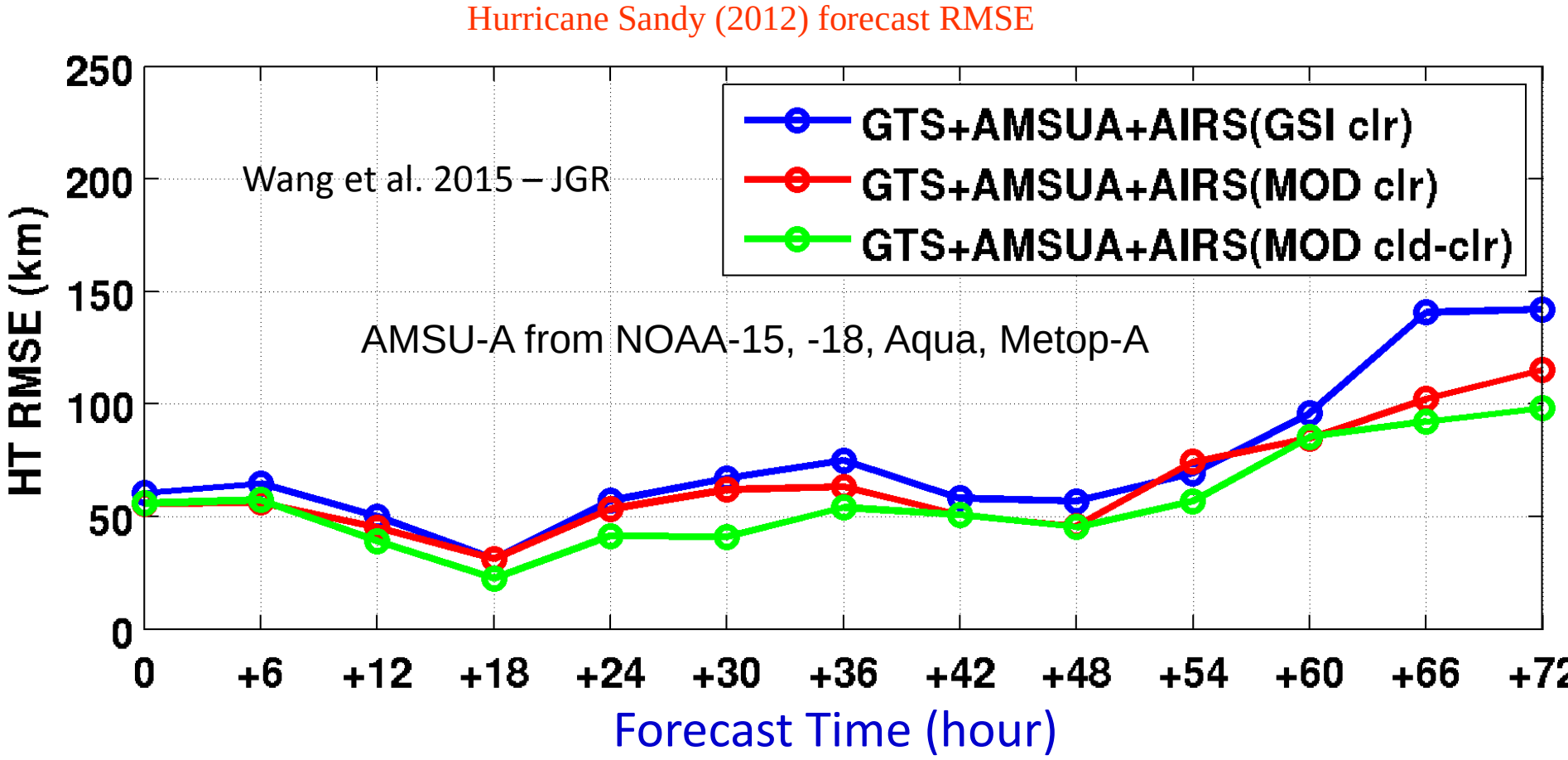
Wang et al. 2015 - JGR

# Impact of assimilating CCRs (imager-based) on temperature forecasts – RMSE against RAOBs

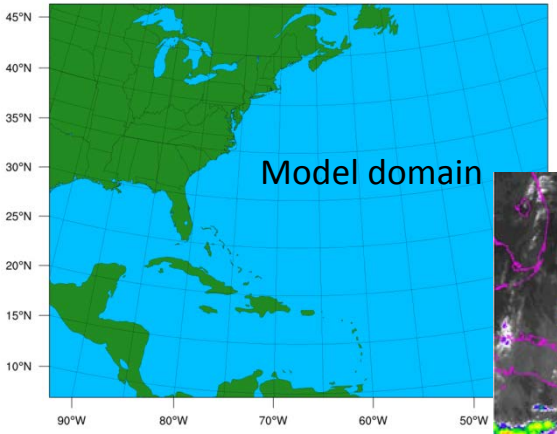



Wang et al. 2015 (JGR)

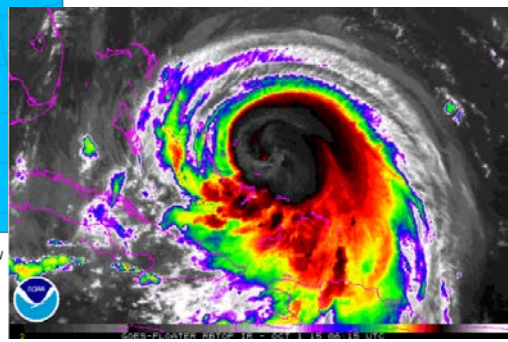
# Impact of assimilating AIRS CCRs (MODIS-based) on hurricane Sandy track forecasts



# DA Experiments on Hurricane Joaquin (2015)




GOES-13



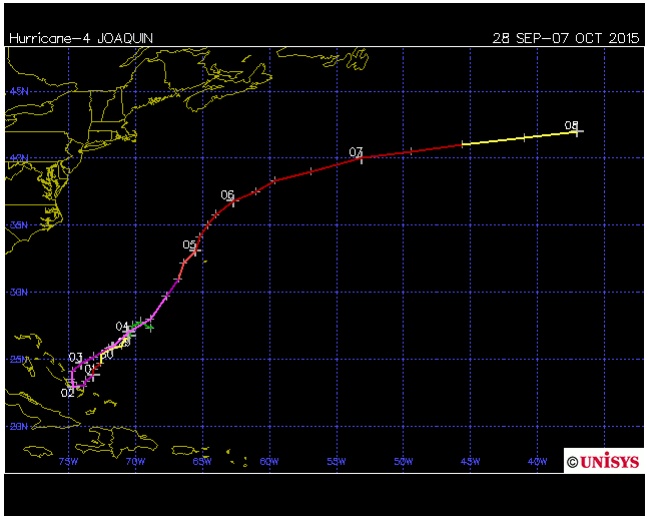
WRF-ARW v3.6.1: 12 km horizontal resolution (480*380) , 52 vertical layers from surface to 10hPa

GSI v3.3: 3D-Var Data Assimilation Method

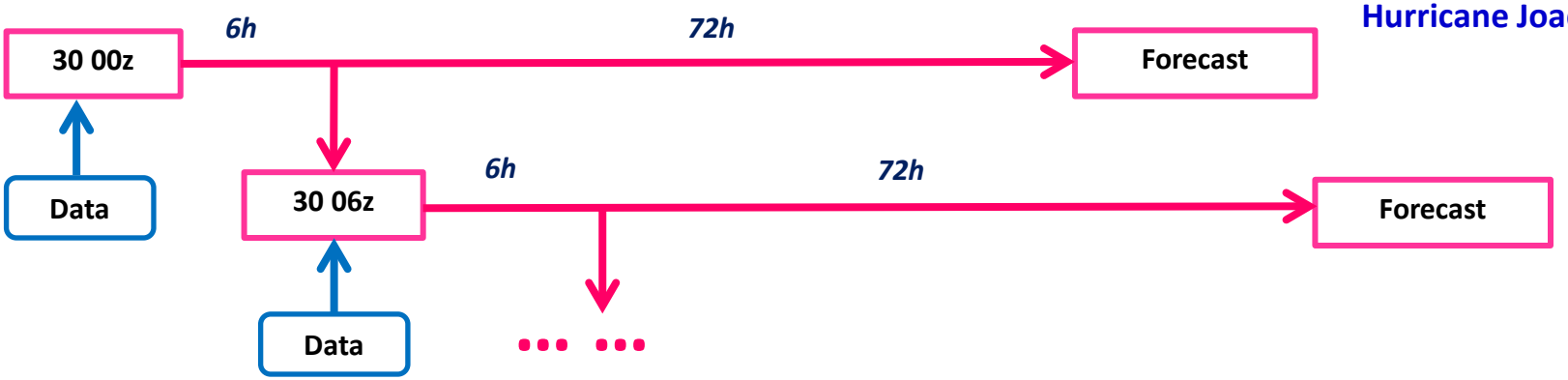
- NAM background error covariance matrix
- Cycled bias correction
- Conventional Data (GTS)
- AMUS-A radiances from NOAA-15, NOAA-18, NOAA-19, and Metop-A
- CrIS radiances from Suomi-NPP

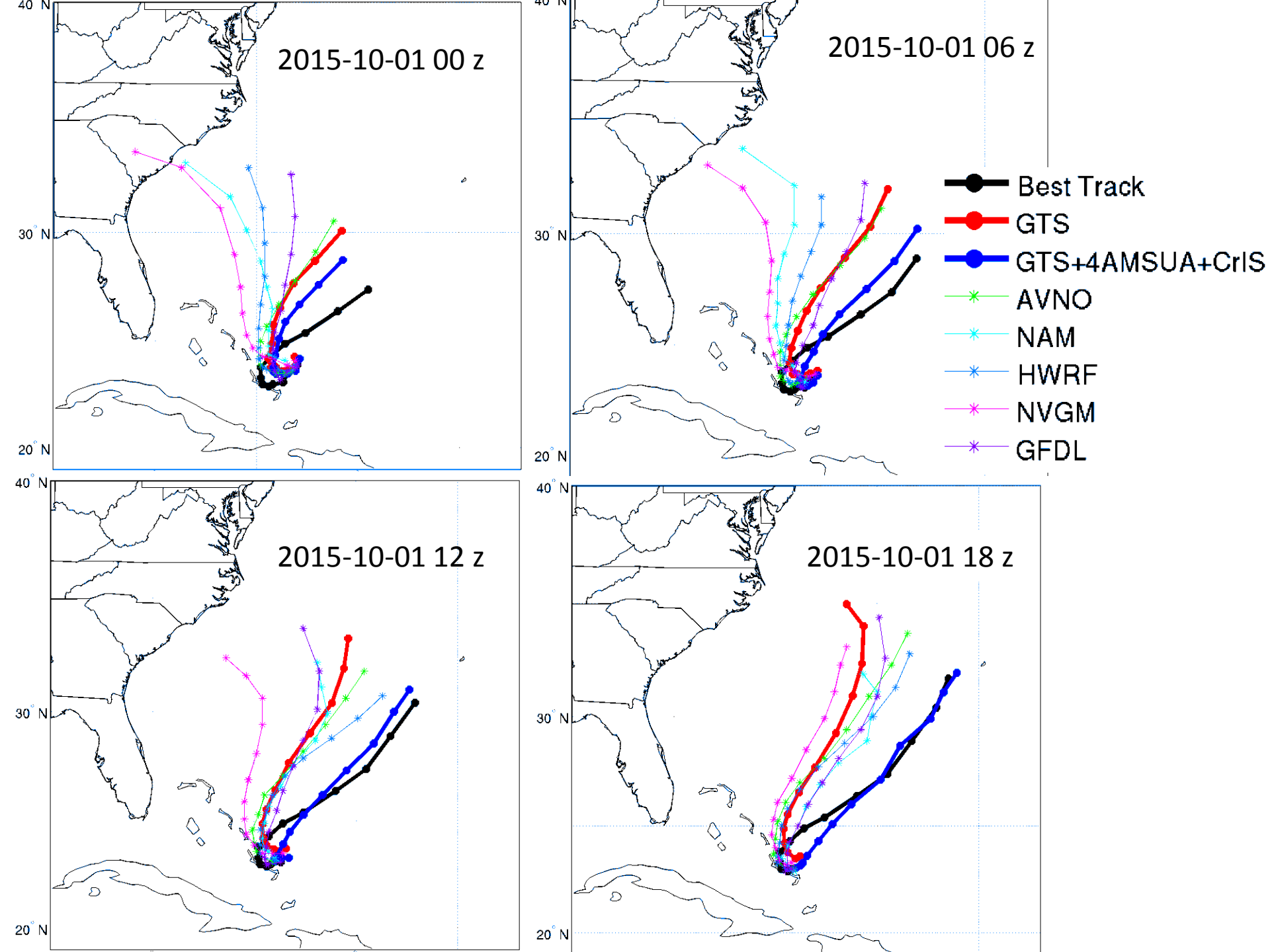
Hurricane Joaquin (2015)

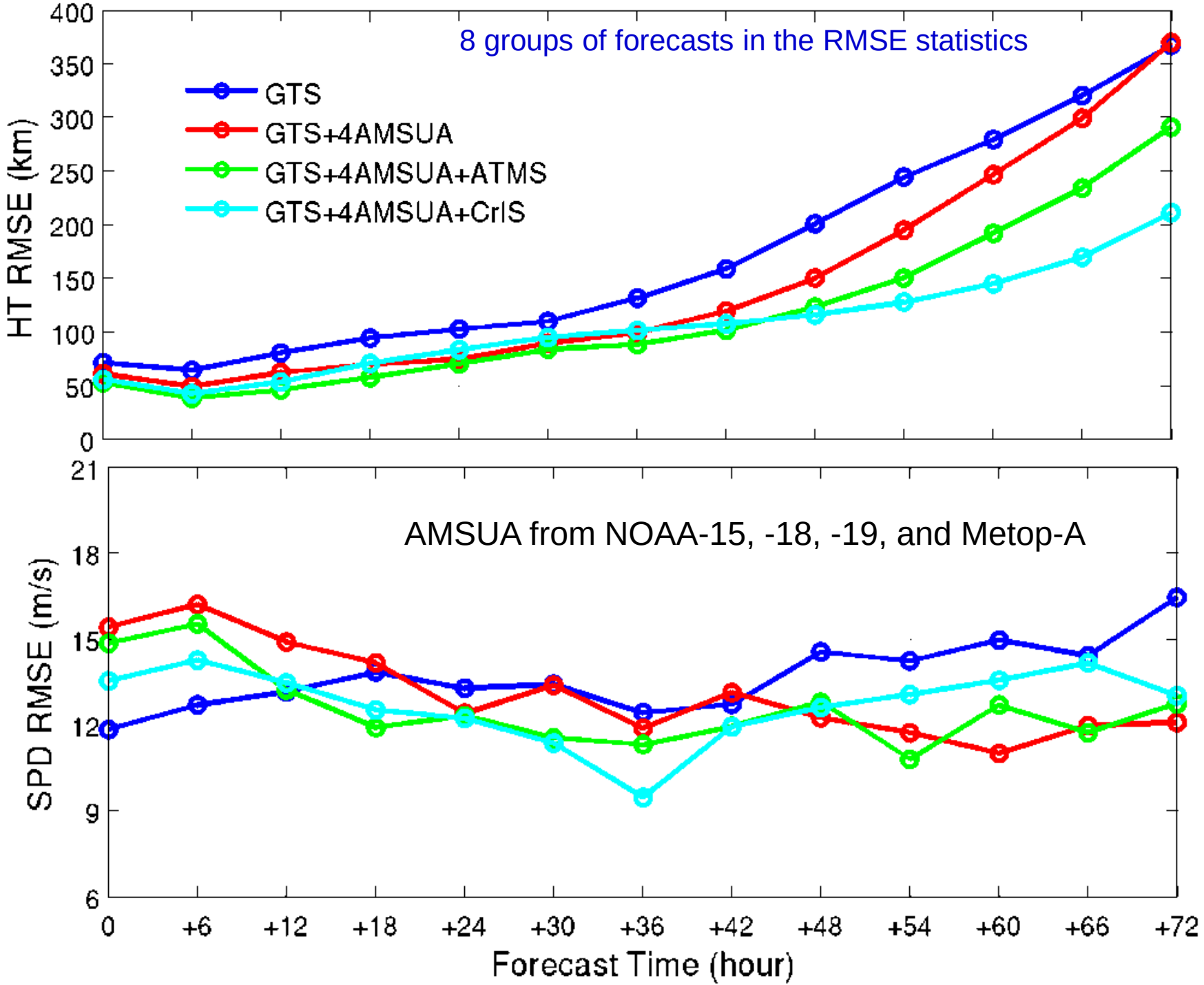
- Assimilation : Sep 30 00z to Oct 01 18z, 2015
- Forecasts: Sep 30 00z to Oct 04 18z, 2015
- Assimilation every 6 hour, 8 groups in statistics




Hurricane Joaquin Best track




2015-10-01 00 z
2015-10-01 06 z
2015-10-01 12 z
2015-10-01 18 z
40° N
30° N
20° N
Best Track
GTS
GTS+4AMSUA+CrIS
AVNO
NAM
HWRF
NVGM
GFDL


8 groups of forecasts in the RMSE statistics
GTS
GTS+4AMSUA
GTS+4AMSUA+ATMS
GTS+4AMSUA+CrIS
HT RMSE (km)
400
350
300
250
200
150
100
50
0
AMSUA from NOAA-15, -18, -19, and Metop-A
SPD RMSE (m/s)
21
18
15
12
9
6
0
+6
+12
+18
+24
+30
+36
+42
+48
+54
+60
+66
+72
Forecast Time (hour)

# Summary

- Clear location detection has substantial impact on IR radiance assimilation, collocated imager cloud mask can improve the detection of clear location for IR radiance assimilation;
- Imager-based clear-cleared radiances (CCRs) provide value-added impact, could be an alternative approach for radiance assimilation in some cloudy skies;
- Future work
  - comparisons among CrIS CCRs (imager-based, BG-based and MW-based), CCR impact studies;
  - clear location from collocated imager plus clear channels in cloudy regions for IR radiance assimilation.