Improving high impact weather forecasts with combined GOES-R measurements and advanced infrared soundings from JPSS

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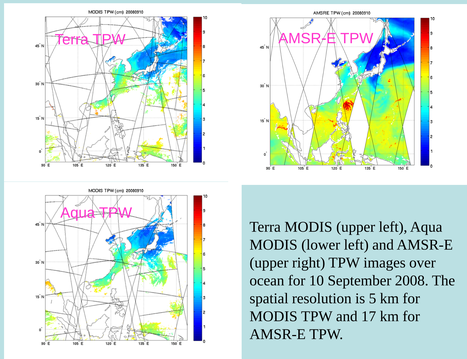
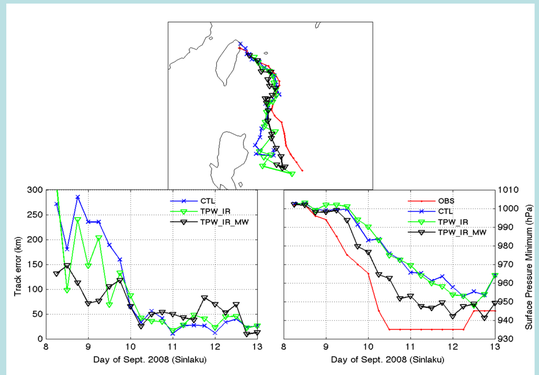
Objectives

(1) To improve the high impact weather (HIW) (tropical cyclones, severe storms) forecasts by assimilating the high spectral resolution advanced IR soundings (AIRS, IASI, CrIS) in regional numerical weather prediction (NWP) models.
(2) To combine GOES-R and advanced IR soundings for HIW forecasts through data assimilation. AIRS/IASI/CrIS and MODIS/GOES Sounder are used to emulate the LEO and GEO observations.
(3) To use different assimilation techniques (3DVAR, 4DVAR and EnKF) for LEO/GEO data assimilation to assure consistent conclusions.

1. GOES-R total precipitable water (using MODIS as proxy) impact on hurricane forecast with WRF/DART



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.



Upper panel shows the Typhoon Sinlaku track observation (red), analysis from assimilating MODIS TPW (green), analysis from assimilating both MODIS and AMSER-E TPW (black). The lower left panel shows the track error, the lower right panel shows the intensity (seal level pressure) analysis . Time period is from 08 to 13 September 2008.

ABI water vapor product should be better than MODIs because:
(1) ABI has one more water vapor absorption band;
(2) MODIS TPW is from regression, ABI TPW is from physical retrieval;
(3) ABI has three layer precipitable water
(4) ABI has high temporal resolution.

(1) Control (CTL): Radiosondes, cloud winds (AMVs from JMA) extracted from NCEP/GFS dataset, aircraft data, station and ship surface pressure data, JTWC advisory TC positions, 6-hourly analysis cycle.
(2) TPW-IR: Add CIMSS processed MODIS IR TPW data (both Terra and Aqua).
(3) TPW-IR-MW: Add CIMSS processed MODIS and AMSR TPW data.
(4) Assimilations started Sep. 1, 2008. 9 km moving nest grid with feedback to 27 km grid in the forecasts when TC is present.
(5) The results show that MODIS TPW data has slight impact on TC Sinlaku analyses. When the AMSR TPW data is used together with MODIS, the initial track error is reduced evidently and the rapid intensification forecast is improved.

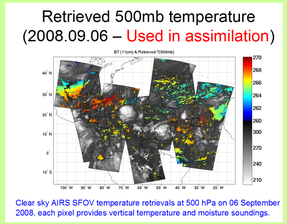
Abstract

(1) Full spatial resolution temperature and moisture profiles (12 ~ 14 km at nadir) from AIRS radiance measurements with CIMSS hyperspectral IR Sounding Retrieval algorithm (CHISR) have been used to study the hurricane track and intensity forecasts. Both WRF/DART and WRF/3DVAR are used for Typhoon (Sinlaku) and Hurricane (Ike) assimilation, positive impact is found on tropical cyclone intensity and track forecast. Both temperature and water vapor profiles are important for hurricane forecast.

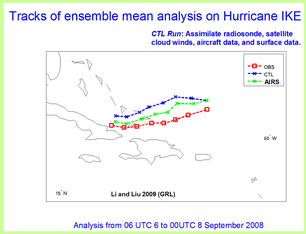
(2) The MODIS total precipitable water (TPW) and GOES Sounder profiles are used as proxy for GOES-R ABI, WRF/DART is used to assimilate MODIS TPW in Typhoon (Sinlaku) forecast, positive impact is also found on both track and intensity analysis.

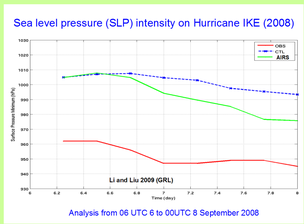
(3) The next work is to assimilate the GOES Sounder high temporal resolution precipitable water (PW) between 300 and 700 hPa which provides good quality, into the regional NWP for hurricane forecast; also to combined AIRS and MODIS/GOES Sounder for hurricane forecast in order to prepare the application of combined GOES-R/JPSS atmospheric profiles in high impact weather applications.

2. Regional assimilation of advanced IR soundings for hurricane/typhoon forecast with WRF/DART

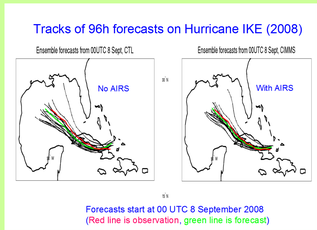


AIRS full spatial resolution sounding data used in assimilation

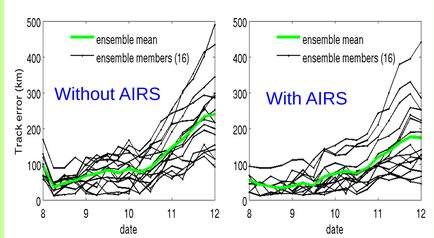




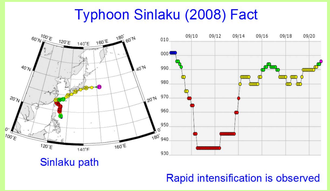
Track (left) and sea level pressure (right) analysis during assimilation period (two days) with AIRS full spatial resolution soundings. Control run already contains radiosonde, satellite cloud winds, aircraft data, and surface data.

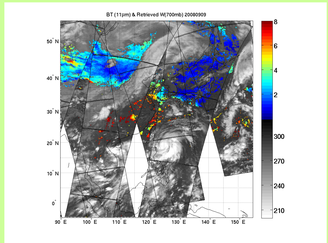


Track forecast without (left) and with (right) AIRS full spatial resolution sounding data

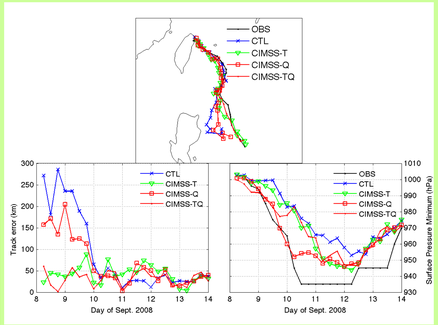


96-hour track forecast error without (left) and with (right) AIRS full spatial resolution soundings.



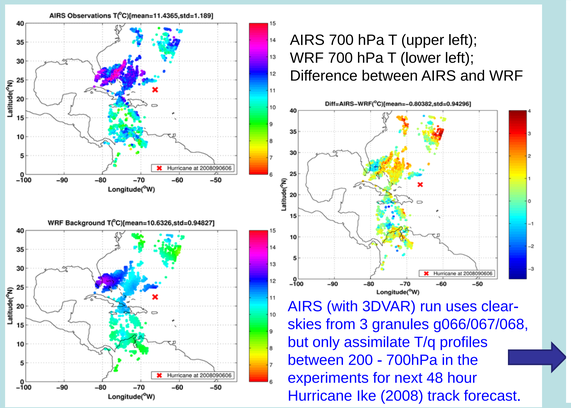


AIRS used in Typhoon assimilation



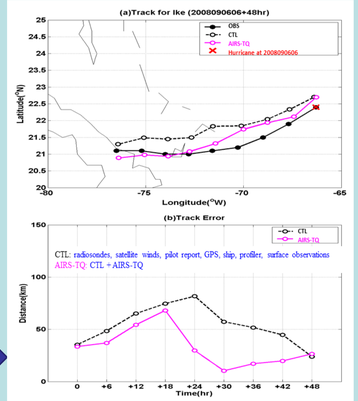
Same as section 2 - WRF/DART ensemble assimilation system with 32 ensembles and 27 km resolution. AIRS single field-of-view (SFOV) temperature (CIMSS-T) and moisture (CIMSS-Q) are assimilated, analysis is generated every six hours from 08 to 14 September 2008. The rapid intensification is captured when AIRS soundings are assimilated.

3. Assimilation of AIRS soundings for hurricane forecast with WRF/3DVAR

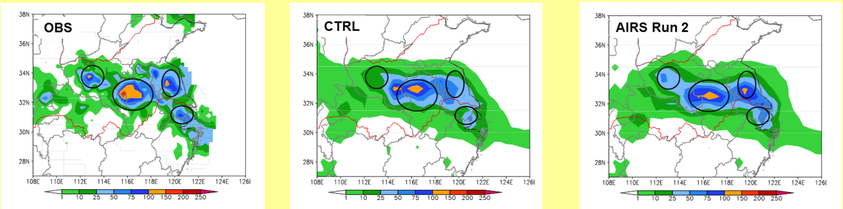


AIRS 700 hPa T (upper left);
WRF 700 hPa T (lower left);
Difference between AIRS and WRF

AIRS (with 3DVAR) run uses clear-skies from 3 granules g066/067/068, but only assimilate T/q profiles between 200 - 700hPa in the experiments for next 48 hour Hurricane Ike (2008) track forecast.



4. Assimilation of AIRS soundings for precipitation forecast with AREM/4DVAR



24-hour precipitation (00 UTC 22 – 00 UTC 23 July 2009) forecast was improved when AIRS full spatial resolution soundings are assimilated. Two AIRS overpass times: 06 UTC and 18 UTC 21 July 2009. CTRL run uses the NCEP analysis as initial, and AIRS Run 2 uses soundings of both 06 UTC and 18 UTC. The regional NWP model is Advanced Regional Eta-coordinate Model (AREM) with 37 km resolution. This is a collaborative work between CIMSS and the Institute of Atmospheric Physics, Chinese Academy of Sciences.

5. References

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