A Near Realtime Regional Satellite Data Assimilation System and Initial Evaluation

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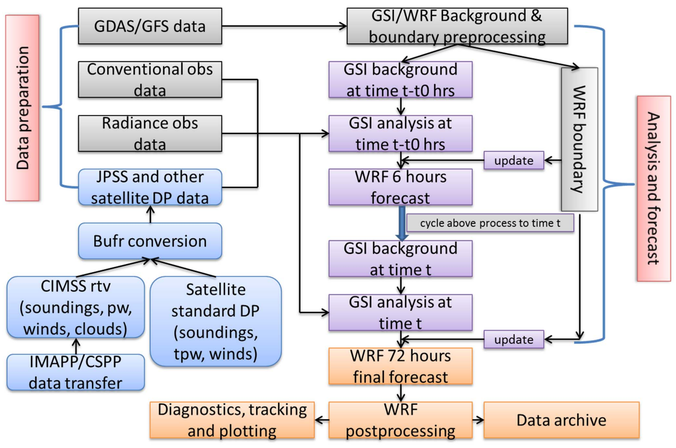
1. Introduction

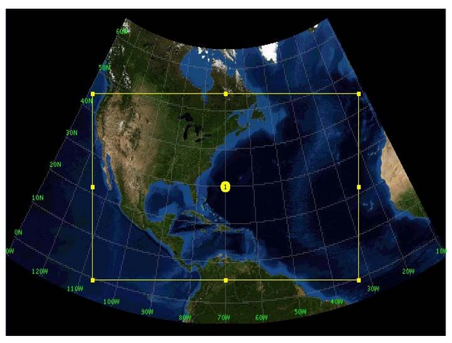
Although satellite data assimilation has made the significant progress in global numerical weather prediction (NWP), challenges remain on satellite data assimilation in regional NWP models. How to better represent the information from satellite observation and how to get value added information from satellite data into the regional NWP model still need investigations. In this research, we have developed a flexible regional satellite data assimilation/forecast system for tropical storm forecast (**SDAT) (see website http://cimss.ssec.wisc.edu/sdat/**). As a research test-bed, SDAT will be used to study the impacts of different satellite information on high impact weather forecast, test new ideas and new methodologies that can be potentially transferred to the operation. SDAT realtime products can also be used directly by users.

2. Assimilation/Forecast System

SDAT System flowchart



WRF model setup



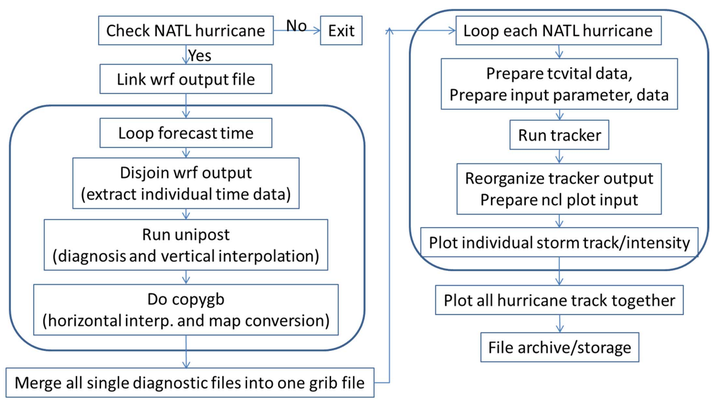
Domain focus: CONUS and North Atlantic Ocean
Horizontal resolution: 36km
Vertical: 51 levels
Model top: 10 mb

Physics schemes:
CU: Kain-Fritsch
MP: WSM 5-class scheme
LW: rrtm
SW: Dudhia
PBL: YSU
SF: Noah land-surface model

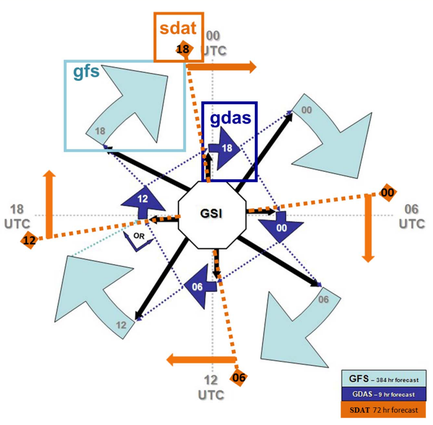
GSI system and data assimilated

- 3D variational assimilation (v3.1)
- 6 hours cycle
- Conventional data assimilated
  - ➢ radiosondes, aircraft reports, surface land/ship/buoy observations, dropsondes, pibal winds, wind profilers, VAD (NEXRAD) winds,
- Satellite data assimilated
  - ➢ AMSUA (N15, N18, N19, metop-a, aqua), ATMS (Suomi-NPP), HIRS4 (N19, metop-a), AIRS (aqua), IASI (metop-a), MHS (N18, N19, metop-a),
- Satellite bias correction
  - ➢ using NCEP GDAS output bias coefficients at initial step, then using model cycle output and calculated mass and angle bias coefficients
- **Optional** CIMSS and other satellite retrieved products
  - ➢ hyperspectral soundings (AIRS/IASI/CrIs), total and layer precipitable water (AIRS/MODIS/GOES etc), satellite winds,

Flowchart to run standard vortex track



Timeline of GFS, GDAS and SDAT in realtime



GFS is initiated approximately 2 hours and 45 minutes after the cycle time, and runs 384 hours forecast..

GDAS is initiated 6 hours after the cycle time and runs 9 hours forecast.

SDAT: is initiated 5 hours and 30 minutes after the cycle time and runs 72 hours forecast; needs both GFS and GDAS as its initial and boundary conditions.

3. Research experiments

Hurricane Irene (2011) – different satellite data impacts

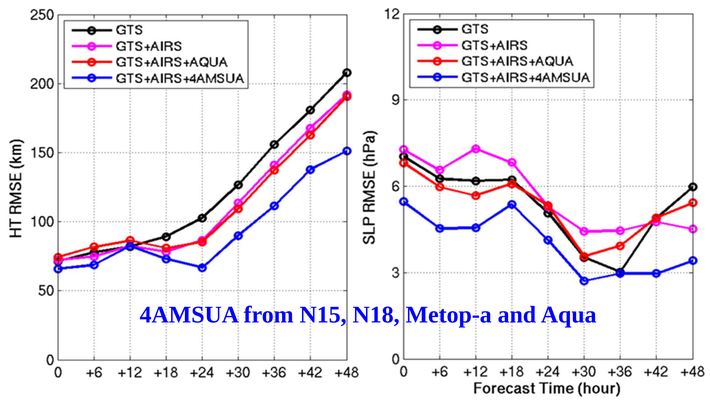
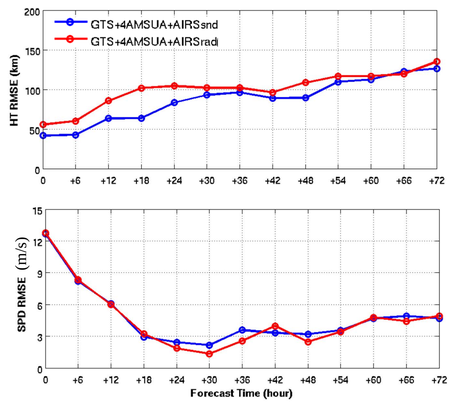


Figure1: Data are assimilated every 6 hours from 06 UTC August 22 to 00 UTC August 24, 2011 followed by 48-hour forecasts. Hurricane track (HT) (left) and central sea level pressure (SLP) root mean square error (RMSE) are calculated.

Hurricane Sandy (2012) – radiance vs sounding

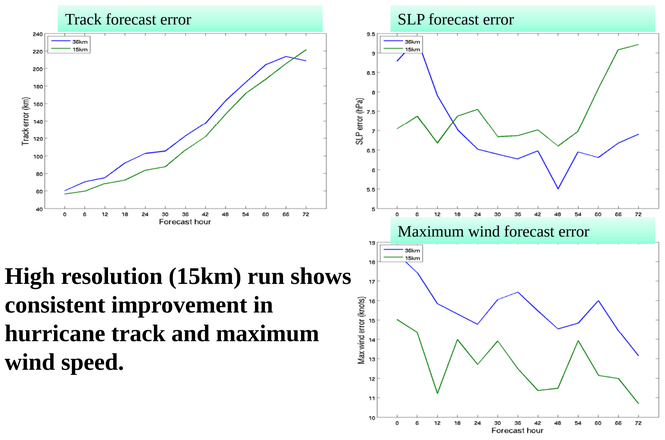


4AMSUA from N15, N18, Metop-a and Aqua

Sounding retrievals use much more channels.

Figure 2: RMSE of hurricane Sandy track (upper) and maximum wind speed (lower) forecasts with AIRS radiance and retrieval assimilation, respectively. Data are assimilated every 6 hours from 06 UTC 25 to 00 UTC 27 October 2012, followed by 72-hour forecasts. The results confirm the equivalence between radiance assimilation and sounding retrieval assimilation suggested by a recent theoretical study (Migliorini 2012, MWR).

Hurricane Sandy (2012) – horizontal resolution impacts

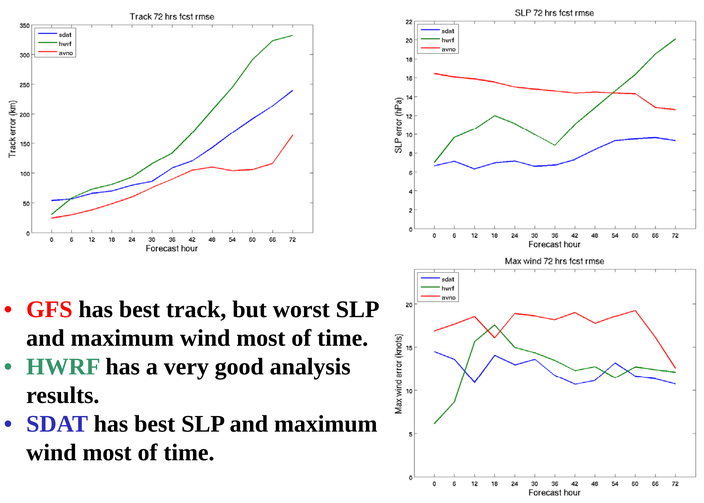


High resolution (15km) run shows consistent improvement in hurricane track and maximum wind speed.

Figure 3: RMSE of hurricane Sandy track (upper left), central sea level pressure (upper right) and maximum wind speed (lower right) forecasts for 36 km and 15 km horizontal resolution respectively. Data are assimilated every 6 hours from 18 UTC 22 to 00 UTC 30 October 2012, followed by 72-hour forecasts.

4. Comparison and validation

Life cycle forecast comparison for hurricane Sandy (2012)



- **GFS has best track, but worst SLP and maximum wind most of time.**
- **HWRF has a very good analysis results.**
- **SDAT has best SLP and maximum wind most of time.**

Figure 4: RMSE of life cycle hurricane Sandy track (upper left), central sea level pressure (upper right) and maximum wind speed (lower right) forecasts from GFS, HWRF and SDAT respectively. Forecasts started every 6 hours from 18 UTC 22 to 18 UTC 28 October 2012.

Hurricane Sandy 72 hours forecast verification

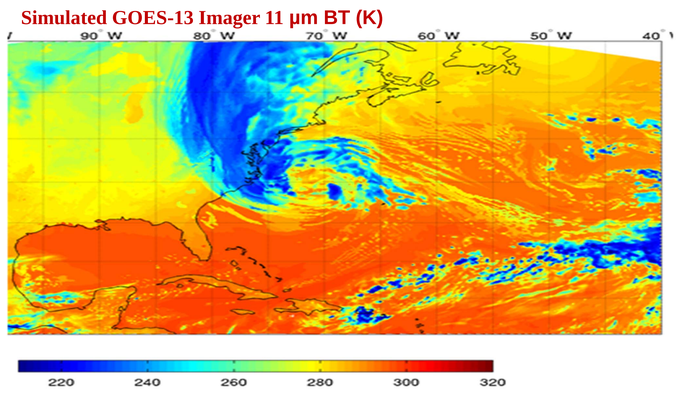


Figure 5: WRF initial field is produced by assimilating both conventional and satellite data. WRF 72 hours forecast starts at 18 UTC 27 October 2012. The top panel is simulated GOES 13 imager 11 μm BT from 36 hours SDAT forecasts, while the lower panel is the corresponding GOES 13 imager 11 μm BT observations.

5. Realtime experiments in 2013

Snapshot of storm Karen (2013) realtime forecast

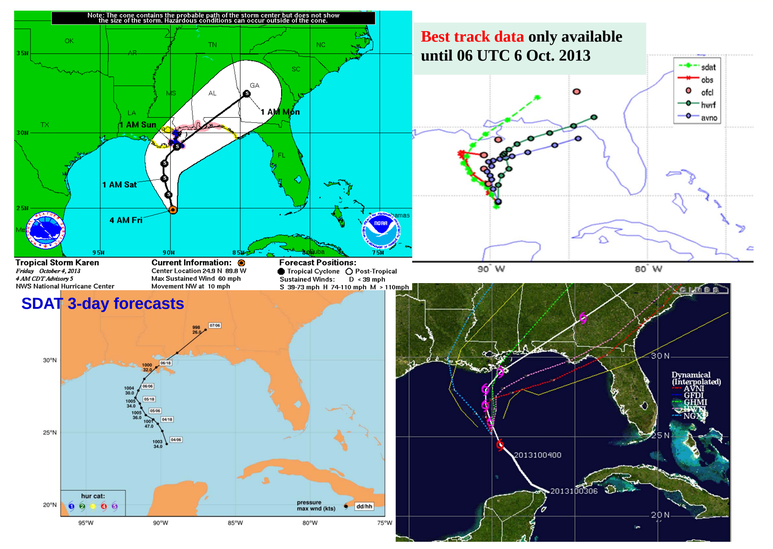


Figure 6: Upper Left: NHC 4 AM CDT (***09 UTC***) Advisory (Friday 04 October 2013); Lower left: SDAT track forecasts started at 06 UTC 04 October valid until 06 UTC 07 October 2013);
Lower right: Other dynamic models; Upper right: GFS, HWRF, SDAT and official forecasts along with best track data.

Hurricane Humberto (2013) life cycle forecasts

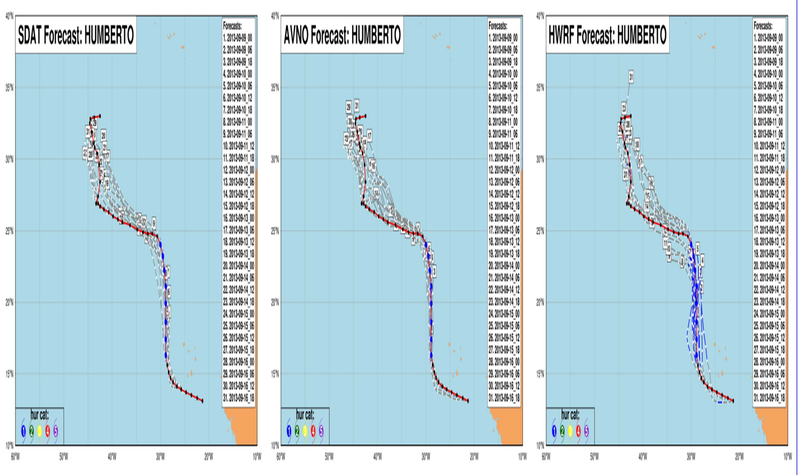


Figure 7: Hurricane Humberto 72 hours track forecasts starting every 6 hours from 00 UTC 9 September to 18 UTC 16 September 2013, SDAT (left), GFS (middle), and HWRF (right).

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