Preliminary studies of SEVIRI and advanced AIRS sounding data assimilation for hurricane model initialization

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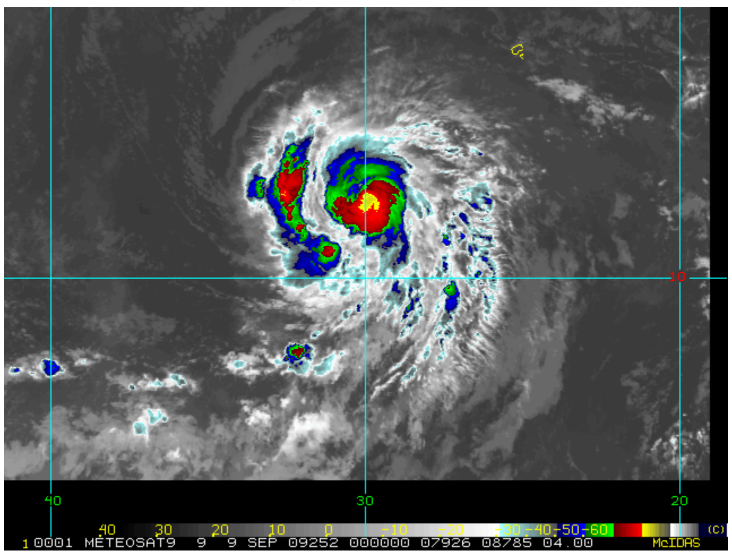
Introduction

Satellite data is critical for improving hurricane forecasts:

- GOES-R ABI will provide real-time monitoring and tracking of severe weather events with a high temporal and spatial resolutions.
- Recent studies indicate that advanced AIRS soundings has the potential to improve the short-term prediction of tropical cyclone.

SEVIRI Ch09 (IR10.8μm) TBs
0000 UTC 09 Sep 2009, Hurricane Fred (2009)



- Onboard: MSG
- Spectral channels: 12
- Sampling Frequency: **15 min**
- Spatial resolution:**3km@nadir**

- SEVIRI matches the typical observation cycle of weather radar.
- An unprecedented starting point for better coping with the short lifetime of cloud targets in TC core region.

A regional HVEDAS for TC core region

❑ Hybrid DA algorithm

Maximum Likelihood Ensemble Filter (Zupanski, 2005)

❑NWP model

The modified ATMOS portion of NOAA operational HWRF (2011)

-The fixed outer domain has a grid spacing of 27 km;

-The fixed inner domain of about 6°×6° has a grid spacing of 9 km

❑ Observation forward operators

Gridpoint Statistical Interpolation （GSI）

- Exclude GSI B.E.s, the adjoint model , and minimization

Community Radiative Transfer Model (CRTM)

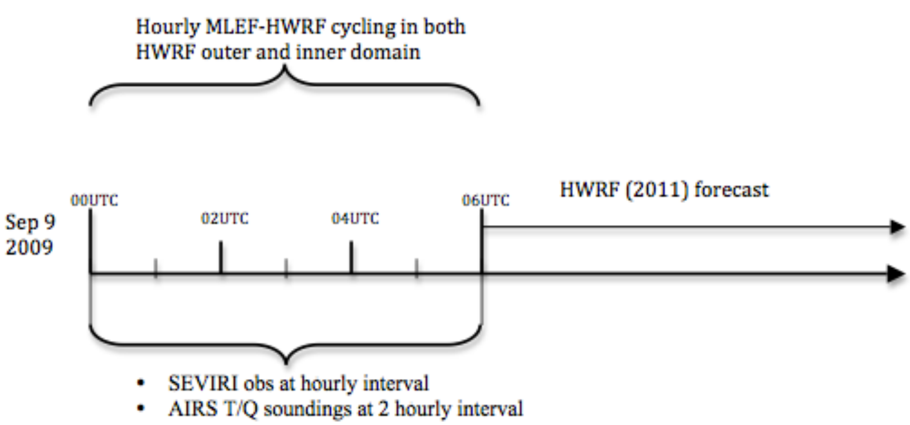


Figure.1. Schematic diagram showing the frequency and types of observations assimilated with each experiment.

TABLE 1. Summary of observations assimilated.

Platform(s)	Type(s)	Source
Advanced AIRS retrievals (clear-sky)	Temperature profiles Water vapor profiles	CIMSS[a]
MSG SEVIRI (all-sky)	channel-9 IR10.8μm radiances	McIDAS[b]

[a] Cooperative Institute for Meteorological Satellite Studies.
[b] Man Computer Interactive Data Access System

Experimental design

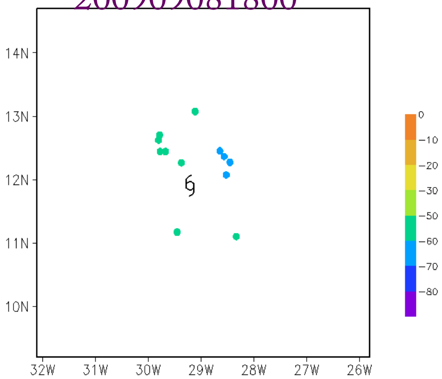
- **Hurricane Fred (2009)**
- **Rapid update MLEF-HWRF cycling system**: produce 9-km resolution analysis in TC core area every 1-h; the outer domain provides the LBCs to the inner domain.
- **Control variables** include the following model variables: wind components (U,V); specific humidity (Q); temperature (T); hydrostatic pressure depth (PD); Total column condensate (CWM-Ferrier microphysics).
- Ensemble size is **32 members**
- Horizontal error covariance localization (Yang et al. 2009)

Sensitivity Experiments

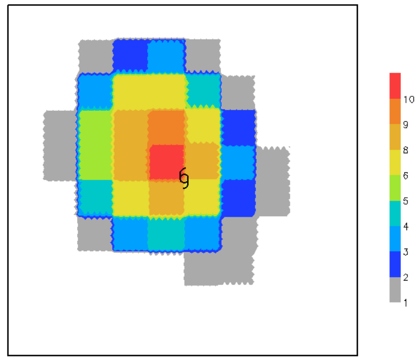
- **CTL**: 60-h forecast following no data assimilation cycles.
- **SEV**: assimilate overcast clouds in the TC core area.
- **AIRS_T**: assimilate overcast clouds in the TC core area and AIRS temperature profiles (200-800hPa) in TC environment.

Information content extraction from SEVIRI IR10.8µm at Fred (2009) core area

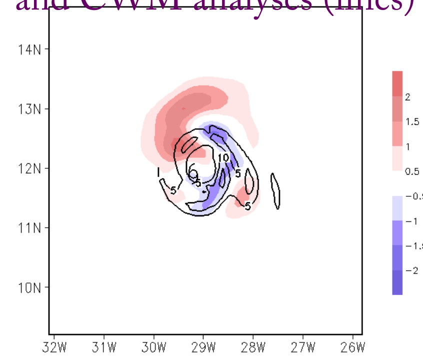
TB_{obs}<-50°C 200909081800



Information content



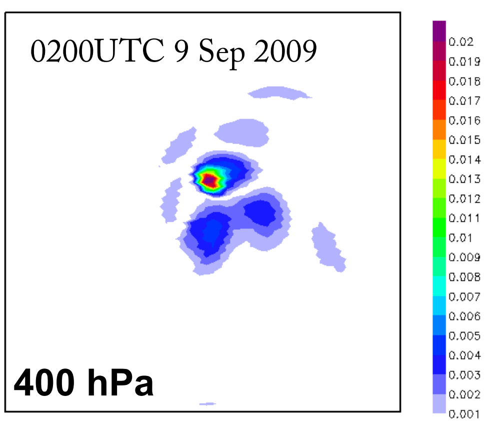
CWM analysis increments (colored), and CWM analyses (lines)

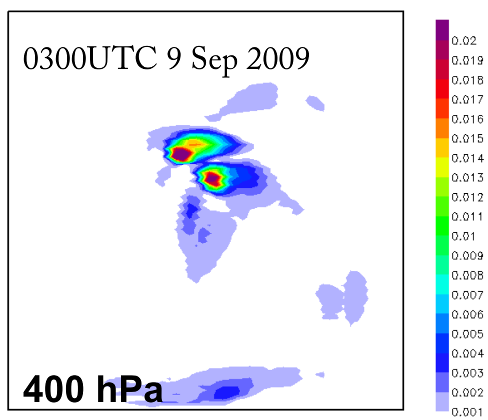


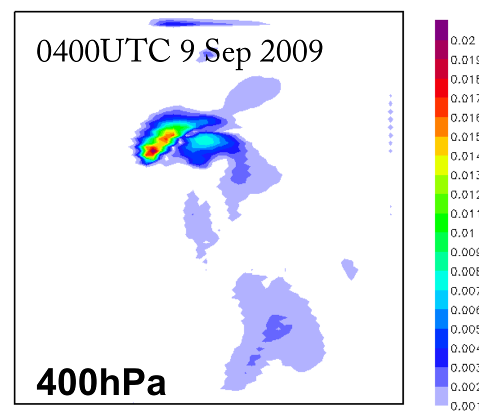
SEVIRI provides integrated information on TC core analysis through a regional HVEDAS.

The time series of the ensemble spread about the control run for total cloud condensate in Fred core area

All plots are shown in a 6°×6° domain





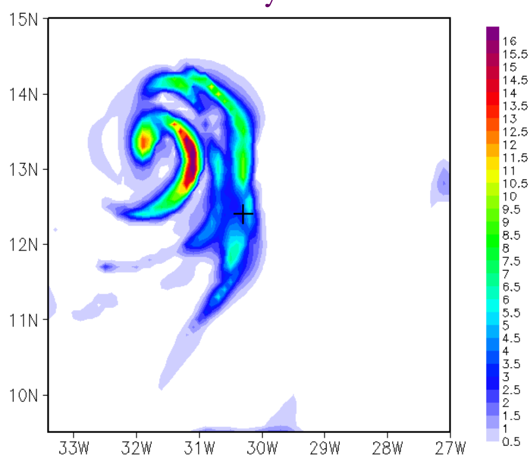


The errors in the background variables are moved along the storm track and are propagated by the flow.

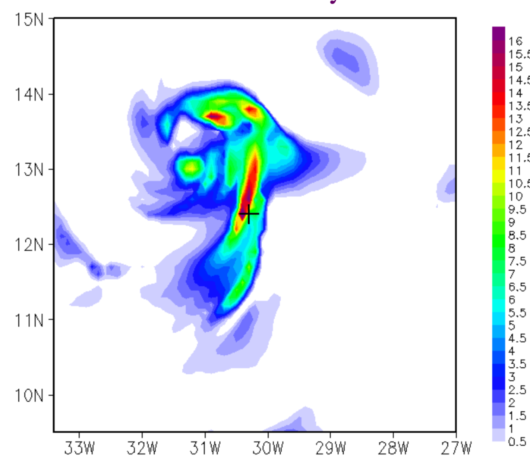
Verification of Cloud analysis

valid at 0600 UTC 9 Sep 2009, analyses at the 6th cycle

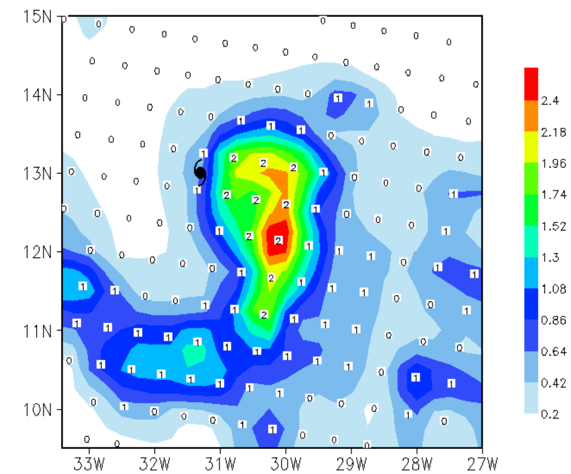
CWM analysis @CTL/cyc6



CWM analysis @SEV/cyc6



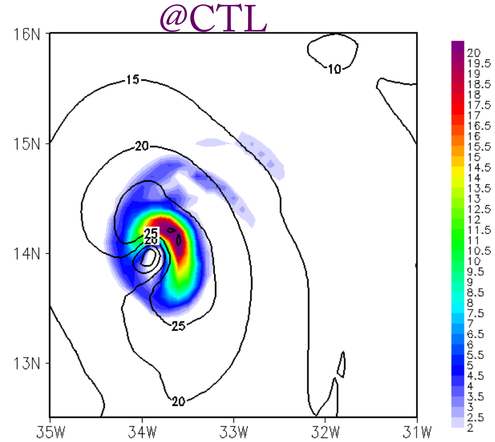
AMSU-retrieved cloud liquid water



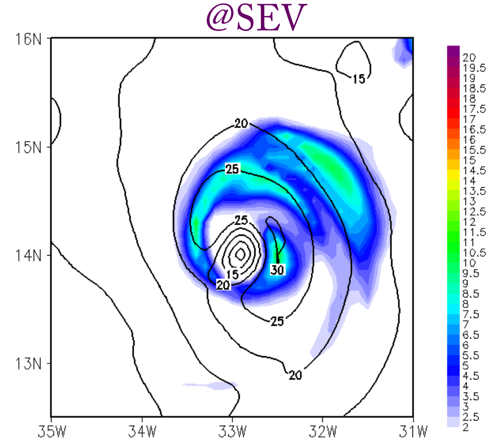
21-h forecast of CWM and max 10-m wind

valid at 0300 UTC 10 Sep 2009

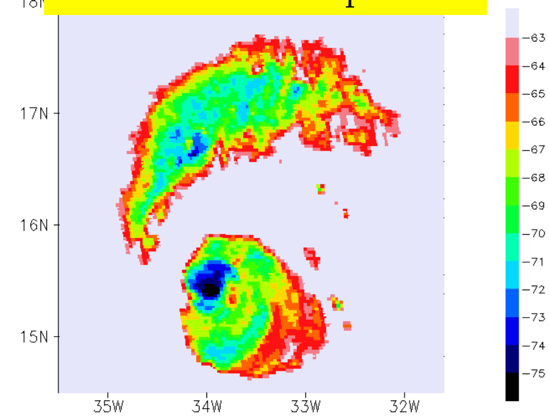
CWM forecast @CTL



CWM forecast @SEV



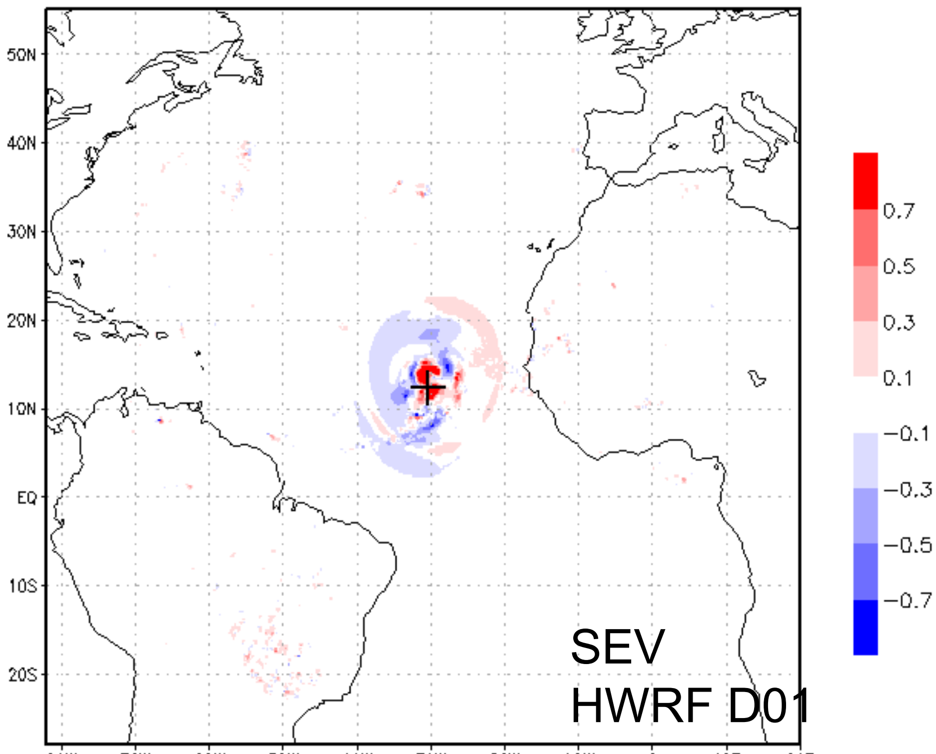
SEVIRI 10.8 μ m obs (K) 0300 UTC 10 Sep 2009



Cloud analysis and forecast is more accurate when IR10.8μm radiances are assimilated

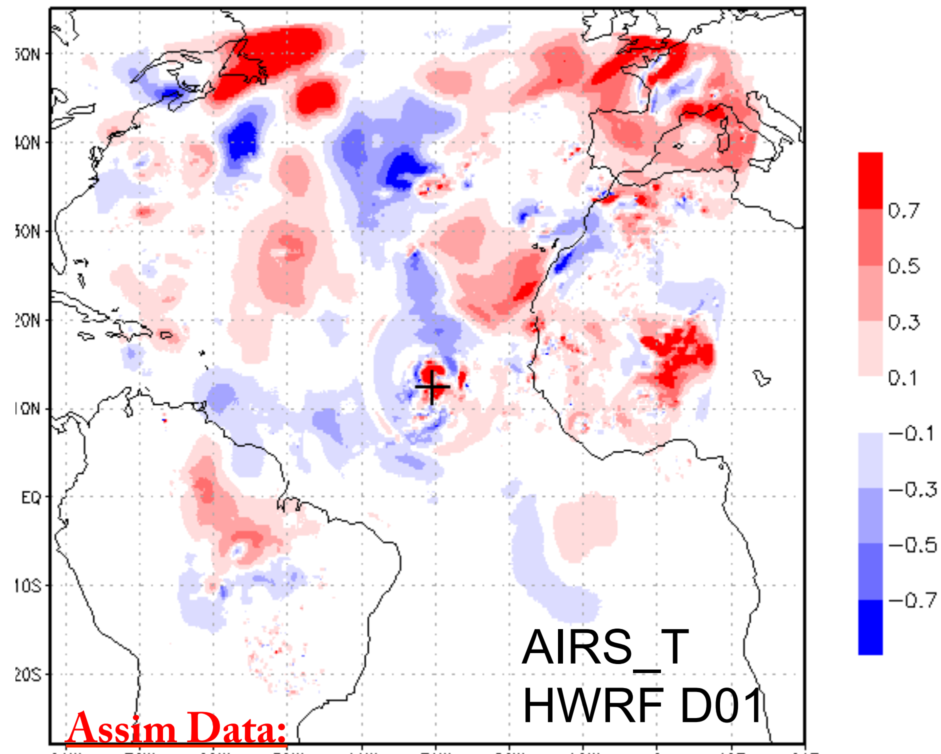
Combine SEVIRI with advanced AIRS T/Q retrievals

500 hPa T analysis increment (K) at
0600 UTC 09 Sep 2009



Assim Data:
SEVIRI IR10.8μm

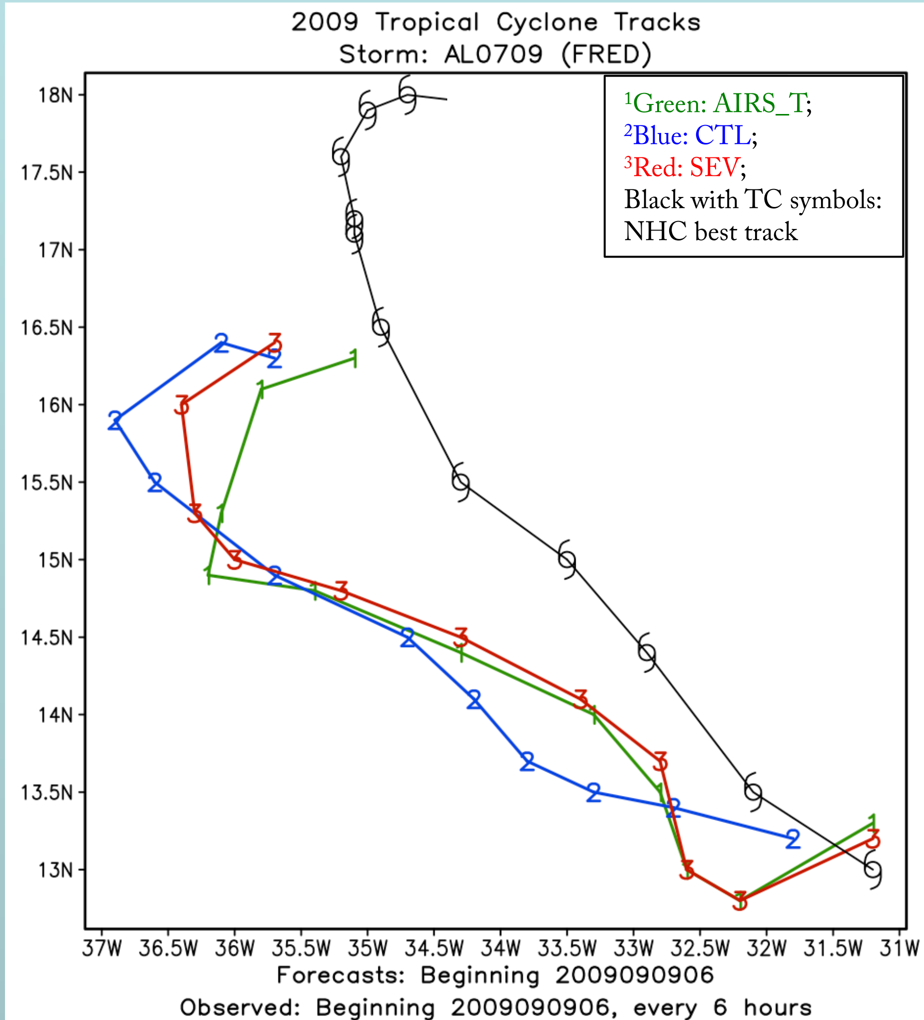
500 hPa T analysis increment (K) at
0600 UTC 09 Sep 2009



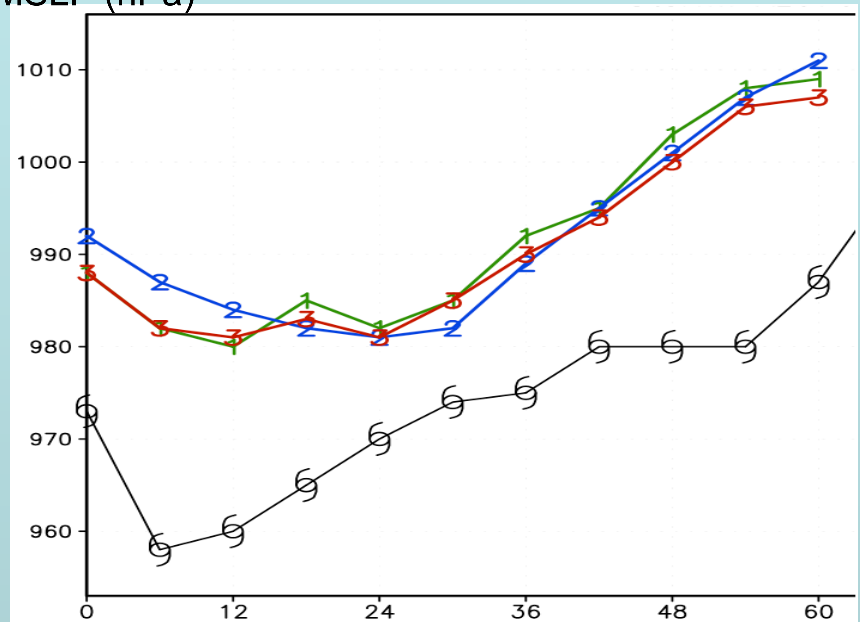
Assim Data:
SEVIRI IR10.8μm
Clear-sky AIRS_T profiles (200-800 hPa)

Verification of HWRF(2011) 60-h forecasts against NHC best track data

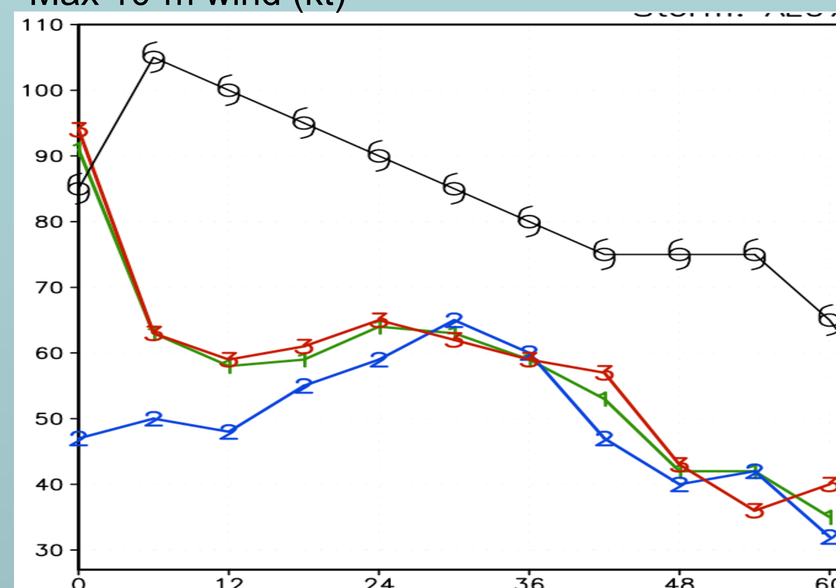
initialized from 0600 UTC 9 SEP 2009



MSLP (hPa)



Max 10-m wind (kt)



Fred track/intensity forecasts were more accurate during the satellite data assimilation cases for the first 0-36 h.

Summary

- Hourly updated MLEF-HWRF cycling system has been implemented and evaluated in a regional hybrid DA system for TC core area using SEVIRI radiances and advanced AIRS profiles.
- Results indicate that the skill of quantitative cloud forecasts can be significantly increased by appropriately assimilating cloud-affected satellite radiances.

Future Plans

- Add 6 hourly conventional observations to assimilation cycling.
- Further quantify the impact of cloudy satellite radiance assimilation.
- Combine MW, IR, and single field-of-view AIRS sounding retrievals into a hybrid DA system.
- It is desirable to run the system for an entire season .

Possible Path to Operations

- In the current operational HWRF model, most of satellite data are not used in HWRF analysis process due to HWRF configuration and its model top setup.

  - In our experiments, we used 15 hPa model top instead of 50 hPa.

  - In order to maximizing the benefits of assimilating cloudy satellite radiances, it is appropriate to use more realistic cloud microphysical scheme in NWP model and include all radiatively sensitive hydrometeors into the control variables.

- Cloudy radiance bias correction for limited-area model without global statistics

- A call to explore quality control procedures of cloudy satellite radiance assimilation from various satellite measurements.

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