Radiance Data Assimilation in ARW WRF Mesoscale System

By Jianjun Xu

1. Work plan

The work in year 2005 -2006 partly funded by the DTC, in cooperation with the Air Force Weather Agency (AFWA), was asked to finish the three tasks of following:

Apply Radiation transfer model into the WRF applications, work with the scientists of NCAR and JCSDA personnel to generate data assimilation system relevant to radiance analysis:

 i) Provide report the performance of WRF-Var and GSI data assimilation system in ARW WRF mesoscale model

 ii) Provide report detailing interfaces of radiance data assimilation code and key issues concerning radiance assimilation.

 iii) Provide initial radiance code/data to NCAR (obs read/write, nonlinear observation operators, bias correction datasets, AMSU-A test data).

2. Motivation

   The radiance data assimilation is an important part in NCAR ARW WRF 3DVAR data assimilation system. To enhance the capability of direct radiance data assimilation in ARW WRF mesoscale forecast system is a necessary task for future research.

   Based on this purpose, during the past one year from 2005 through 2006, I have finished a series of experiments for the ARW WRF system, and working with Dr. Dale Barker and Dr. Zhiquan Liu successfully developed some of algorithms for using AMSU-A , AMSU-B radiance and HIRS/3 in NCEP GSI and NCAR WRF-Var data assimilation System, which include three parts of works: (1) added and modified part codes of radiance data and innovation vector data structures for NCAR WRF 3DVAR system; (2) ATOVS radiance data is being used in GSI/ARW WRF system to successfully simulated the Hurricane Katrina activity. (3) Comparing the performance of two data assimilation real time forecasts over the AFWA Southwestern Asian domain.

3. Results

   I now show you an example of the ATOVS radiance data assimilation in the prediction of Hurricane Katrina in August , 2005
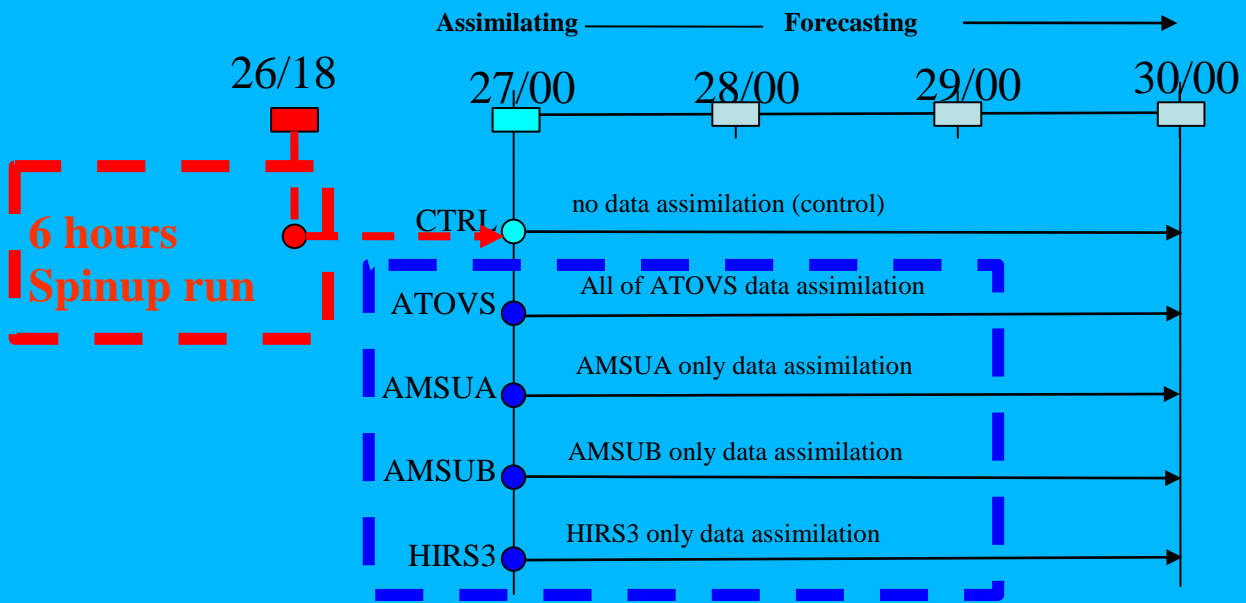
Figure 1, Experiments design for ATOVS radiance data assimilation. The initial time is at 0000 UTC 27 August and make 72 hours forcasting by 0000 UTC 30 August 2005 .
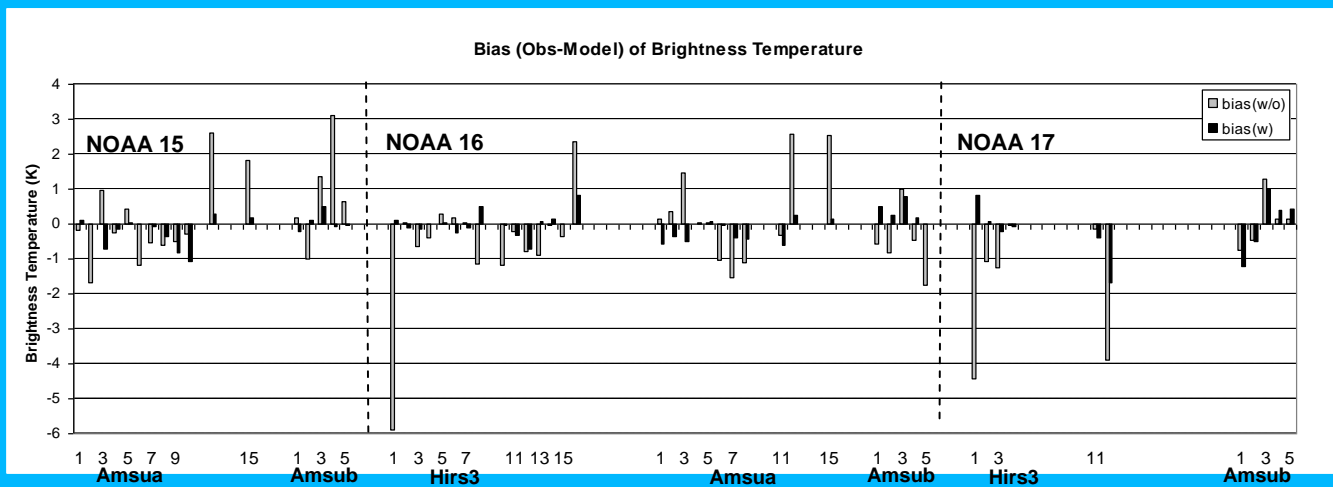

Figure 2, The brightness temperature innovation vector (Observation minus Model difference) varies with channels, instruments and bias or no bias correction.

Track of Hurricane Katrina Simulated
initial at UTC 00 AUGUST 27 2005

**Hurricane Katrina
23-31 August**

——	Hurricane
- - -	Tropical Storm
·····	Tropical Dep.
——	Extratropical
- - -	Subtr. Storm
····	Subtr. Dep.
-·-·-	Low / Wave
●	00 UTC Pos/Date
○	12 UTC Position
← PPP	Min. press (mb)

ATOVS
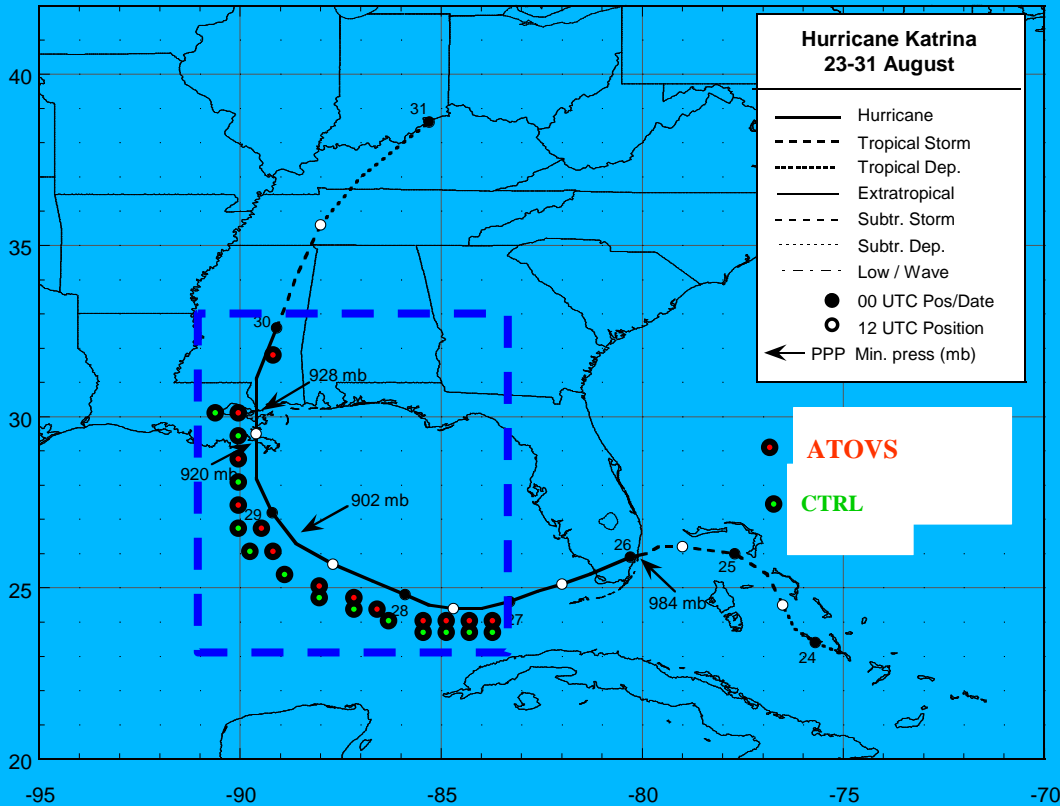
CTRL

928 mb

920 mb

902 mb

984 mb

Figure 3, Track position of hurricane Katrina, the black line is observation, red and blue points shows the location of ATOVS radiance data assimilation (ATOVS) and no data assimilation (CTRL), respectively.

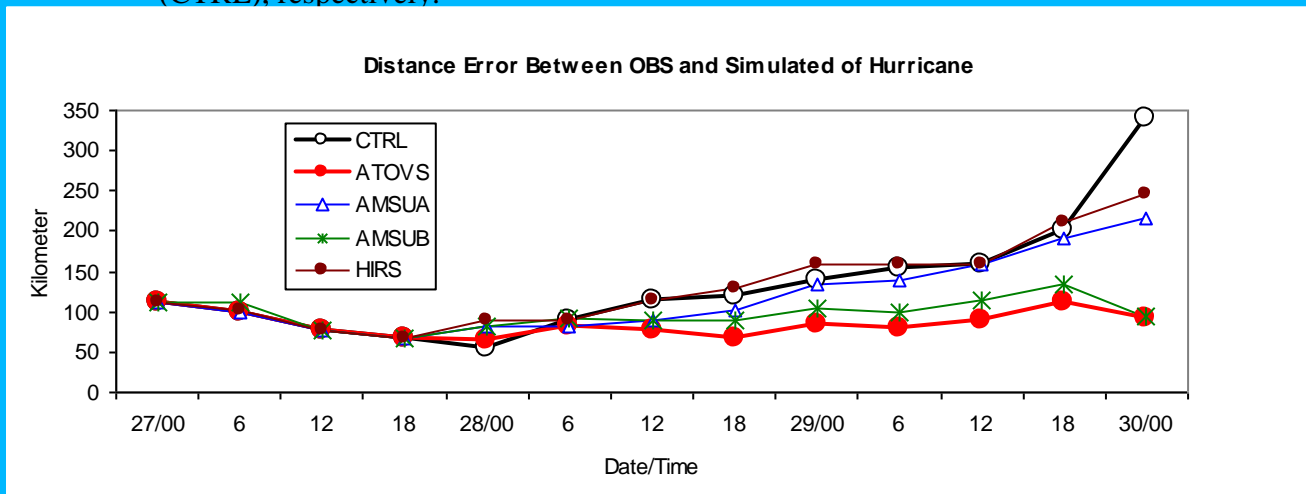**Distance Error Between OBS and Simulated of Hurricane**

Figure 4, The observed and radiance assimilated Hurricane Katrina tracks errors (km) for the entire forecast period from 0000 UTC 27 to 0000 UTC 30 August 2005

In this study, we evaluate the impact of ATOVS radiance direct assimilation through the JCSDA's Community Radiative Transfer Model (CRTM) on the forecasts of hurricane Katrina over the tropical Atlantic in the southeastern United States in August 2005. The NESDIS's ATOVS radiance data, NCEP's Gridpoint Statistical Interpolation (GSI) three-dimensional variational analysis (3DVAR) system and NCAR's ARW WRF mesoscale system are employed in the study.

A series of experiments (ATOVS, AMSUA, AMSUB and HIRS3) for this case is conducted. The results show that the assimilation of radiance can produce a better track and intensity of hurricane center for a 72 hours forecasting. However, the performance is different for those multi channel instruments and the significant impact from the microwave sensors (AMSU-A and AMSU-B) has been identified. It is indicated that a great amount of satellite data has been assimilated and the initial winds, moisture and temperature fields has been corrected. Therefore, the forecast of hurricane is closer to observations in both intensity and pattern.

Comparing the WRF-Var data assimilation system, the JCSDA's GSI data assimilation system shows a better result.

4. Research plan

Apply JCSDA new Community Radiation Transfer Model (CRTM) into the NCAR's ARW WRF model, work with the scientists of JCSDA and NCAR personnel to testing, tuning and improving the radiance assimilation in regional model system:

i) Work with NCAR's scientist to provide report detailing the performance of the radiance data assimilation in the ARW WRF model.
ii) Work with JCSDA's scientist to test the quality control and bias correction algorithm in the WRF-Var system to improve the capability of satellite data assimilation in ARW WRF system.

5. publication

I have done one paper and prepare to write another paper. Those papers concerned the ATOVS radiance data assimilation in JCSDA's GSI analysis system:

Xu, J. et al., 2006: Application of ATOVS Radiance with ARW WRF/GSI Data Assimilation System in the Prediction of Hurricane Katrina. To be submitted soon.

6. Announcements

The data assimilation system is under the testing, which could not yet become a completed software offered by the DTC to WRF users.