JHT mid-year project report

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Project title: Validation of HWRF forecasts with satellite observations and potential use in vortex initialization

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Collaborators : V. Tallapragada, EMC/NOAA, and S. G. Goapalakrishnana, AOML/HRD, NOAA

1. Summary of achievements

In the first 6 months of the project the following was accomplished:

1) The satellite simulator module for HWRF model was completed using the latest release of CRTM (Community Radiative Transfer Model, release 2.0.5). The software is described in section 2.
2) The simulator has been tested on single forecast case of hurricane Earl using HWRF_3.X forecast with 3-grid configuration at resolution 27/9/3 km. Results are presented in section 3.

Contributions from staff members working with PI , Co-Pi and collaborators were as follows:

- Significant contribution to the software development was made by James Davies of CIMSS, supervised by Co-PI T. Greenwald
- Significant contribution to visualization/imaging and start-up of diagnostics were made by Kathryn Sellwood of CIMAS, supervised by PI T. Vukicevic.
- T. Quirino of HRD provided forecast for testing, supervised by S. G. Goapalakrishnan

2. Satellite Simulator Module

We developed software to interface HWRF forecast model output with the JCSDA's Community Radiative Transfer Model (CRTM) for generating simulated satellite imagery. The software is called the "Hurricane WRF Satellite Simulator," or HWSS for short. It has been run successfully on jet, the computer used by the HWRF operational forecast system.

HWSS is comprised of two executables, HWRF_Convert and HWRF_CRTM, that work together under the control of main Perl script HWSS.pl (see Figure 1 below). HWRF_CRTM takes atmospheric profile data, surface properties and satellite sensor characteristics, and inputs them to the CRTM (currently at release 2.0.5) for computing 2D fields of sensor radiances. These sensor radiances are converted to units that users are familiar with, such as brightness temperature (thermal infrared and microwave sensors) or reflectance (visible and near-infrared sensors). The observation geometry is expressed by view zenith angle (and additionally, for visible and near-infrared sensors, by view azimuth angle). Table 1 summarizes the platforms and sensors that we currently support. Plans are to include microwave cross-track scanners like AMSU and ATMS in the near future.

HWRF_Convert is preparation for HWRF_CRTM. It transforms the HWRF condensate profile information to hydrometeor type, size and abundance required by the CRTM. There are currently two options for computing hydrometeor radius: 1) assumes fixed particle sizes (operational approach); 2) assumes fixed number concentrations. Also, if the satellite sensor to be simulated is in low earth orbit (LEO), it may cut a limited swath of observations through the HWRF domain; this time and space coincidence information needs to be captured and passed to HWRF_CRTM. This is the second function performed by HWRF_Convert; it is achieved by accessing sensor observation earth location directly from satellite swath files for the satellite sensors and swaths to be simulated. Sensors aboard geostationary (GEO) satellites take their view geometries from user-specified sub-satellite longitude and from an assumed geostationary altitude.

Table 1. Supported platforms/sensors for the satellite simulator.

Platform	Sensor	Bands
GOES-13	Imager	Vis/IR
GOES-13	Sounder	Vis/IR
Aqua	AMSR-E	Microwave
DMSP F-20	SSMIS	Microwave
DMSP F-19	SSMIS	Microwave
DMSP F-18	SSMIS	Microwave
DMSP F-17	SSMIS	Microwave
DMSP F-16	SSMIS	Microwave
DMSP F-15	SSM/I	Microwave
TRMM	TMI	Microwave

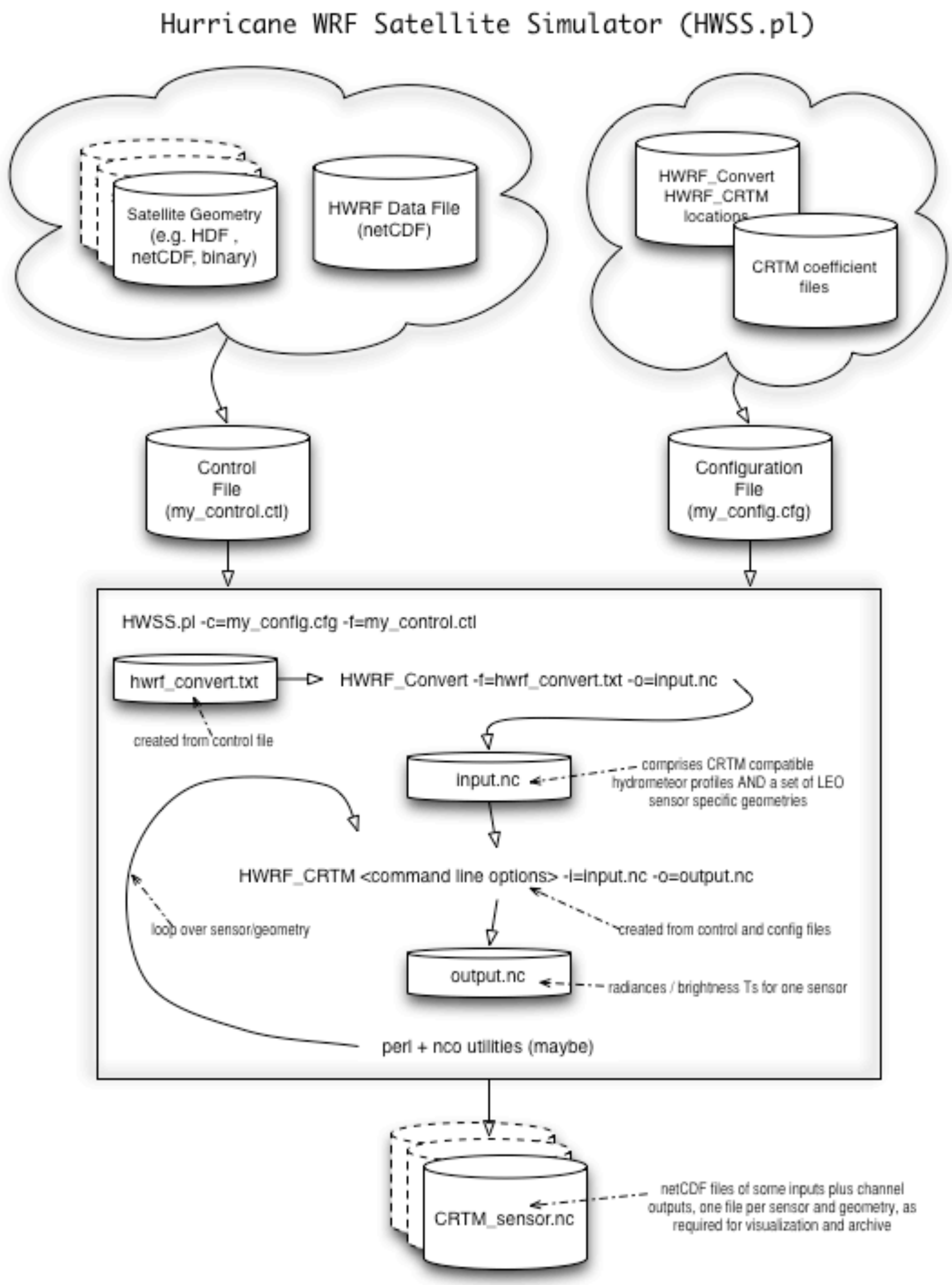

Fig. 1. Processing flow schematic in which the large rectangular box represents the scripted solution, HWSS.pl, operating in its own temporary directory, and the cloud shapes represent "information about...". Typically a single configuration file will be used for all simulations; a different control file is needed for each HWRF domain time-step to be simulated by the CRTM.

HWSS.pl accepts on its command line the names of two files to guide its operation, a control file and a command file. The control file specifies the location of the CRTM sensor coefficient files, some parameters that configure CRTM operation, and the locations of HWRF_Convert and HWRF_CRTM executables. It is likely that only one configuration file will be used per installation. The control file comprises the name of the HWRF domain time-step file, and the names of all of the satellite sensors that one wishes to simulate observing this domain time-step, plus any files that specify the swath for LEO satellite sensors. There will be one control file per HWRF file.

The output of one run of HWSS.pl is a set of netCDF files, one per satellite sensor simulated. Examples of simulated brightness temperature field from HWRF forecast model output are show in the next section:

3. Results

In the following HWSS capabilities are demonstrated on example of single forecast for hurricane Earl for period August 29 00Z – September 3 00Z. For reference, the storm track and intensity forecast are displayed in Figure 2.

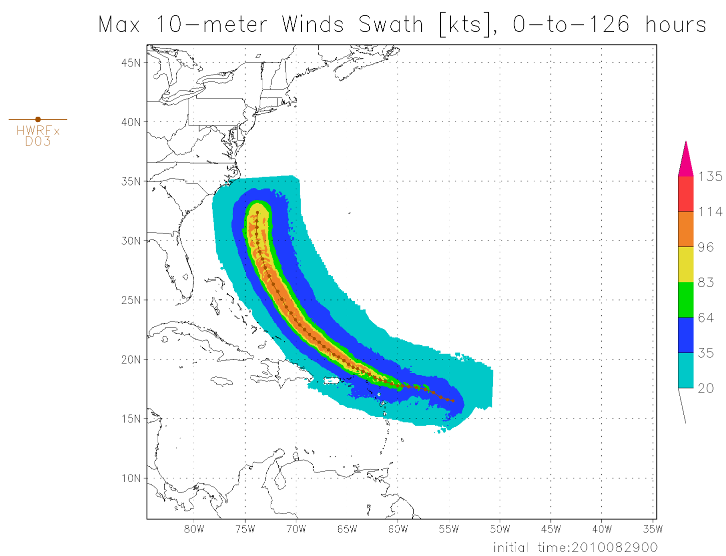

Figure 2: 10 m maximum wind swath from HWRF 27/9/3 forecast, starting on August 29 00Z using the bogus-vortex initialization

To demonstrate capability for direct comparison between the observed and simulated images, the satellite data simulation was applied for LEO sensors which had significant capture of the storm during the forecast period and were within ½ h of the forecast time. The matching forecast and observation instances are presented in Table 2 together with sensor, satellite and frequency specification for each time.
The simulations of GOES13 imager were performed over the entire forecast grid, as expected. A sample of comparison between the simulated (forecast) and observed

images is shown in Figure 3. It is readily observed in this figure that the simulated and observed swats are matching. This illustrates the important feature of HWSS capability to use the observed data files to exactly match the geometry of the observations in the simulations for the forecast evaluation.

Figure 3 displays simulated (top row) and observed (bottom row) 37H and 85H for AMSR-E (panels a-b) and GOES 13 water vapor channel (the channel 3), (panel c) and equivalent observed . Reader should notice that color tables are reversed for the water vapor images between the observed and simulated . The sample in Figure 3 shows consistent forecast fields with the observed. In Figure 4 an example of using the multiple channel images for GOES imager (channels 2-5) is shown for evaluating the spatial variability of water vapor in different regions outside cloud covered core region. The equivalent observed images are not displayed due to current visualization software problem with the observation data files. An illustration of simulated image for the outer domain is shown in Figure 5.

In addition to the 2D images, the diagnostics developed so far include frequency diagrams for each channel using the simulated and observed brightness temperatures over water surface. Comparison of such diagrams would provide quick evaluation of gross biases in the forecasts in terms of cloud presence, height and thickness and also in terms of water vapor gross distribution. The example of frequency diagrams is shown in Figure 6.

Table 1 : Cases of simulated and observed satellite data for direct comparison

Year	Month	Day	Model time	Satellite time	Sensor	Satellite	CRTM key word and channels
2010	Aug	30	1800	1806	AMSR-E	Aqua	amsre_aqua_ 37 and 85 GHz
2010	Aug	21	2100	2107	SSM/I	DMSP F15	ssmi_f15 21, 37 and 85 GHz
2010	Sep	1	0000	2332(Aug 30)	SSMIS	DMSP F18	ssmis -f16 37, 55 and 91 GHz
2010	Sep	1	1200	1151	TMI	TRMM	tmi_trmm all
2010	Sep	1	1800	1756	AMSR-E	Aqua	amsre_aqua
2010	Sep	2	0600	0601	TMI	TRMM	tmi_trmm all
2010	Sep	2	0900	0917	TMI	TRMM	tmi_trmm
2010	Sep	2	1200	1135	SMMIS	DMP F16	ssmis_f16

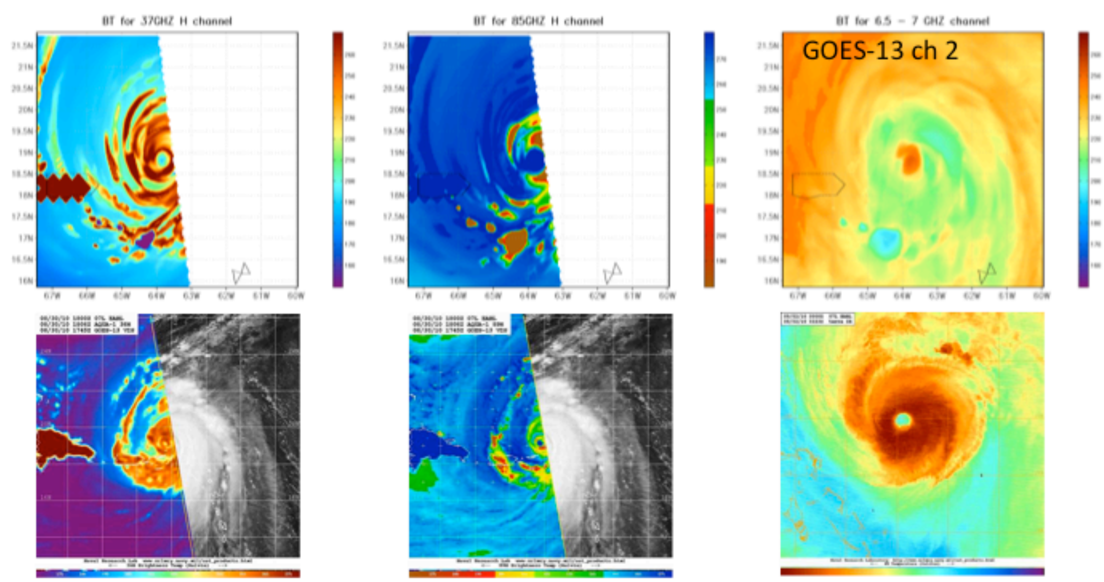

Figure 3 : Simulated (top row) and observed (bottom row) micro wave and infra red brightness temperatures for August 30 1800Z 2010.

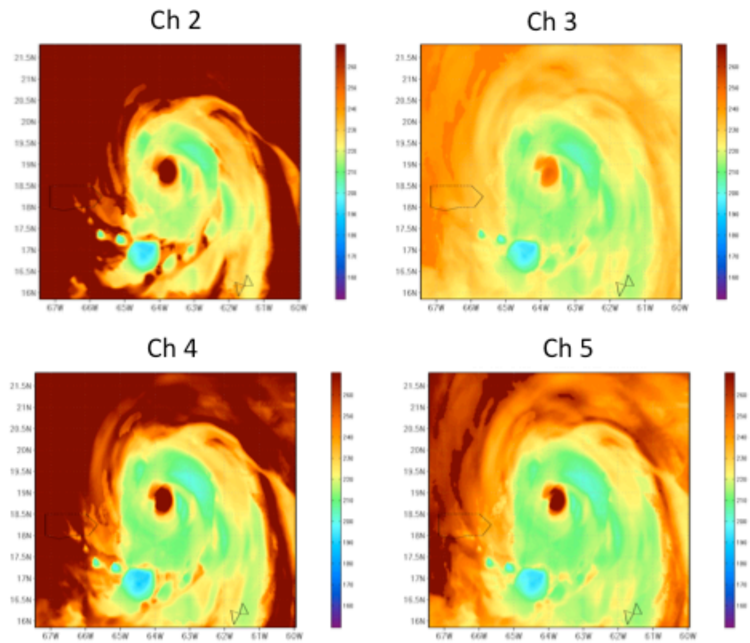

Figure 4 : Simulated different channels for GOES imager for the same time as in Figure 3.

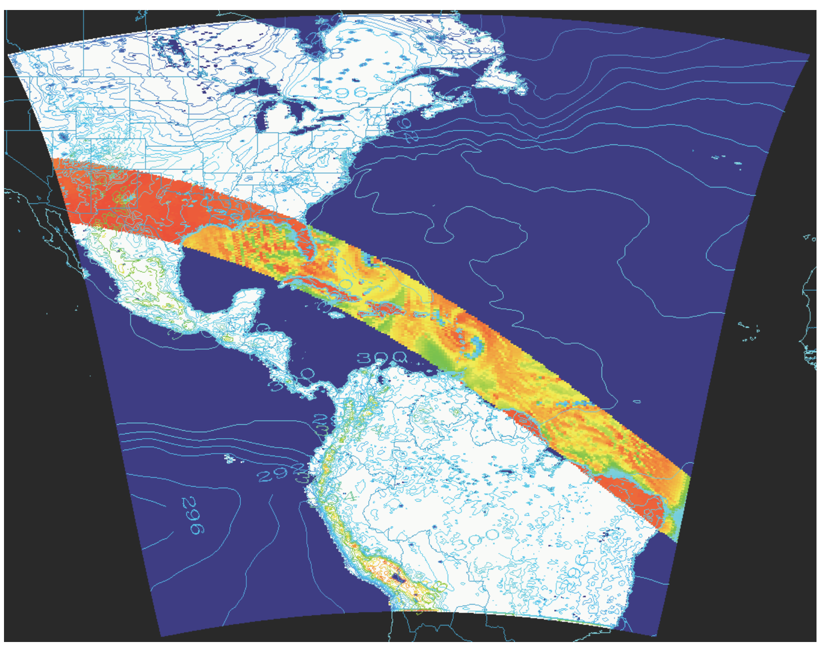

Fig. 5. Simulation of the 85.5H GHz band of the TMI for the outer HWRF model grid on 1200 UTC 2 September, 2010.

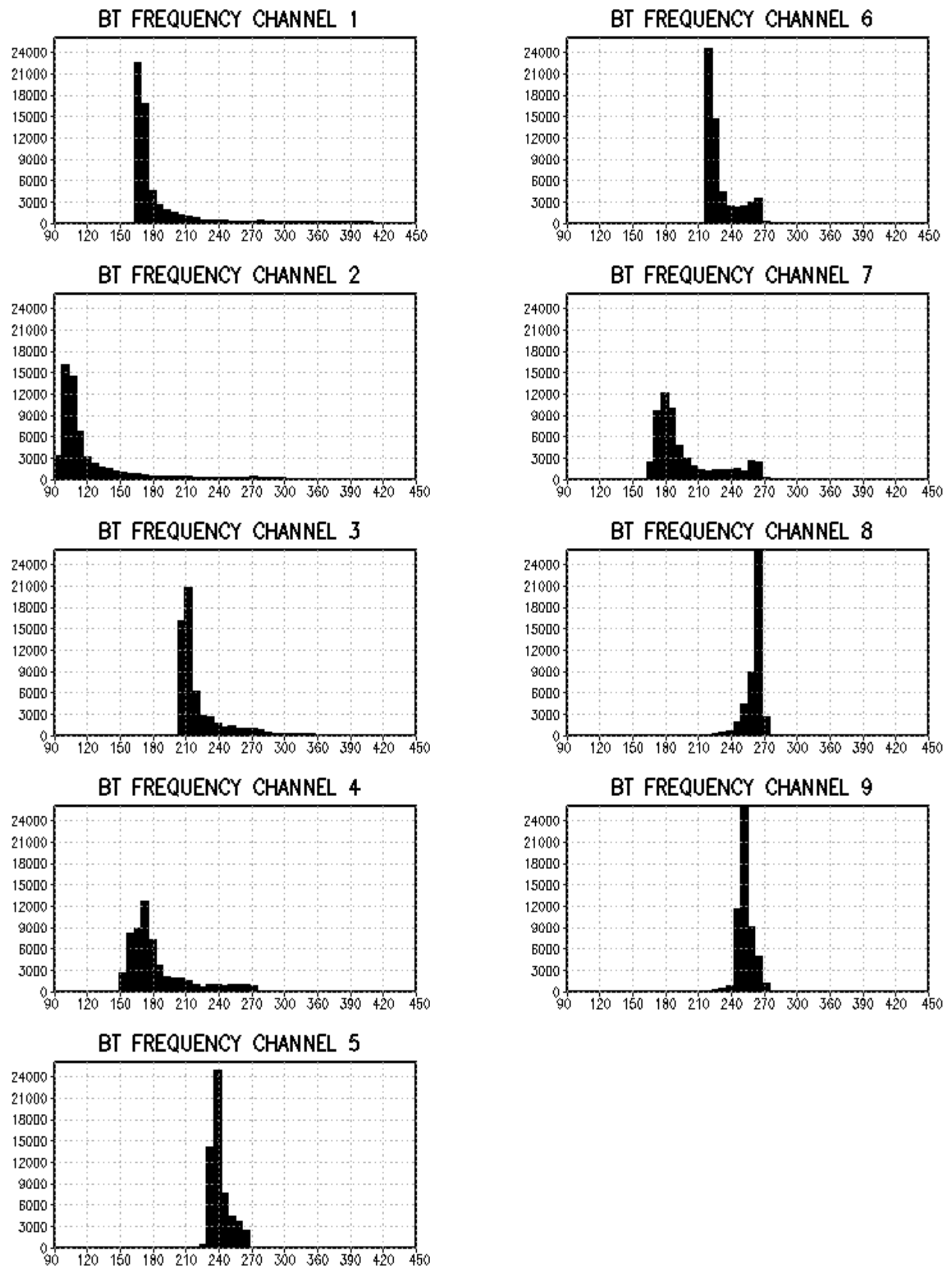

Figure 6: Example of frequency diagrams of simulated brightness temperatures for TMI channels