MESOSCALE MODELING INVESTIGATION OF AIR-SEA INTERACTIONS OVER THE GULF OF MEXICO FOR A CASE STUDY OF HURRICANE GORDON

REMATA Praveena, SIMS Jamese, REDDY R.S., Dept. of Physics, Atmospheric Sciences & General Science, Jackson State University, 1400 J. R. Lynch Street, Just Hall of Science, Jackson, Mississippi – 39217. Phone: (601)-979-7012. Fax: (601)-979-3630.

Abstract - Under the NASA/FAR Program, a study has been established to investigate Air-Sea Interactions associated with the formation and development of Hurricane Gordon in the Gulf of Mexico. Hurricane Gordon was a Category 1 storm, which formed in the Gulf of Mexico on September 17th, 2000. We are using the Penn State/NCAR MM5 (version 3) modeling system for diagnostic studies of surface fluxes (sensible heat, latent heat, and momentum) over the Gulf of Mexico relevant to the air-sea interactions in the vicinity of this intense hurricane. The MM5 configuration features two nested domains over the Gulf of Mexico; with horizontal grid spacing of 90 km and 30 km. Nesting between the grids is two ways. Physics options selected include: non-hydrostatic; Grell cumulus parameterization on 90 km grid; explicit microphysics (Reisner) on 30 km grid; modified Mellor-Yamada boundary layer parameterization; and a cloud-resolving radiation scheme. Gridded analysis and rawinsonde data from NCAR were used to construct initial and boundary condition files. The model results will be discussed, along with relation to other theoretical and modeling studies of air-sea interactions in hurricane environments. Potential links between the model surface fluxes and precipitation at landfall will be considered.

I. INTRODUCTION

Air-sea interactions including heat, momentum and moisture fluxes play a vital role in the formation and intensification of the hurricanes/ tropical cyclones. In the present study, PSU/NCAR Mesoscale Modeling system of Version 3 is being used for predicting the formation and structure of the hurricane Gordon, which occurred in the Gulf of Mexico during September 14-17 '2000.

II. HISTORY OF HURRICANE GORDON

Gordon was downgraded to a tropical storm at 1800 UTC 17 September. It continued to track northeastward and eventually made landfall just northwest of Cedar Key, Florida, at 0300 UTC 18 September, as a tropical storm with 55 kt winds. Using with mesoscale model (MM5) such simulations of hurricane Bret Surface fluxes have been pursued by Loren and Reddy, 2001.

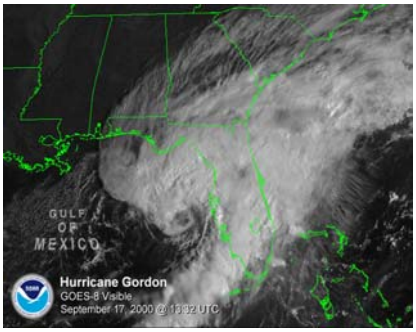

Fig. 1. Represents the satellite Image of hurricane Gordon over the Gulf of Mexico.

III. OVERVIEW

MM5 can be used for a broad spectrum of theoretical and real-time studies, including applications of both predictive simulation and four-dimensional data assimilation to monsoons, hurricanes, and cyclones. The MM5 model consists of five modules: TERRAIN, REGRID, LITTLE_R/RAWINS, INTERPF, MM5, and GRAPH. In this model, the objective module LITTLE_R has been used instead of RAWINS. In its configuration, the model consists of two domains with horizontal resolution of grid 90km and 30km.

A. Terrain

The Program TERRAIN is the first program that needs to be run in the suite of MM5 system programs. This program lets to design the mesoscale model configuration: where the placement of grid, the grid size, what resolution data to use to generate terrain elevation, land-use category, and other datasets will come into if using the MM5 with the land-surface model option. All fields generated by the Terrain program are constant fields for the model.

B. Regrid

The program creates meteorological fields on the mesoscale grid that are designed in TERRAIN. REGRID has two sequential programs: pregrid and regridder. Program pregrid pre-processes gridded, pressure-level meteorological fields from another source (such as the NCAR archive, and NCEP's ftp server or ECMWF) and put the data in an intermediate

format. Program regridder takes the intermediate-format data and output file from TERRAIN, and creates what is called as a "first-guess" for subsequent programs. The output file from REGRID will have 3-dimensional meteorological fields of wind, temperature, relative humidity, geo-potential height, and 2-dimensional fields like sea-level pressure and sea-surface temperature.

C. Little_r

The program reads in output from program REGRID (REGRID_DOMAINx), and observations (radiosonde and surface reports), performs an objective analysis which blends first guess with observations, and outputs data on pressure levels again (just like it is from REGRID). The major advantage of LITTLE_R is that it makes observation input easier to deal with for users who don't have access to NCARs' archived ADP data.

D. Interpf

The program takes pressure-level meteorological fields produced either by REGRID or RAWINS/ LITTLE_R, and the user's definition of model sigma levels, and interpolates pressure level data to sigma levels.

E. MM5

This is the numerical weather prediction part of the Modeling system. In this program, user can specify various physical options and parameterization. MM5 requires output files from INTERPF: MMINPUT_DOMAIN1, BDYOUT_ DOM-AIN1, and LOWBDY_DOMAIN1. To use 4DDA and 3 hourly surface analysis nudging, the output from the file RAWINS: SFCFDDA_DOMAIN1 is needed.

F. Graph

This program generates simple diagnostics and plots for some standard meteorological variables. This program also provides simple vertical interpolation capability, cross-section figures, and skew-T plots. Program GRAPH is the plotting utility program in the suite of the MM5 modeling system that is used to plot output from all MM5 programs (MODULE_DOMAINx).

IV. DISCUSSION

Initially the modeling aspects of air-sea interactions associated with hurricane Gordon has been done by analysis of model –simulated surface heat fluxes in the hurricane environment. Eventually the following issues will be addressed: (a) how do the fluxes vary in time and space? (b) What is the impact of high-resolution sea surface temperatures? (c) what is the sensitivity of the model to physical parameterization options?

The model run is on a doubly nested domain centered over the eastern Gulf of Mexico, with grid spacing of 90km and 30km. To minimize effects of track errors, MM5 is run over several consecutive 12hr periods, from the initial storm development on 17th September through landfall on the Florida west coast on 18th September. A simplistic semi-manual approach to bogus initialization of the storm has been used deriving information from estimated minimum sea level pressure and maximum sustained winds.

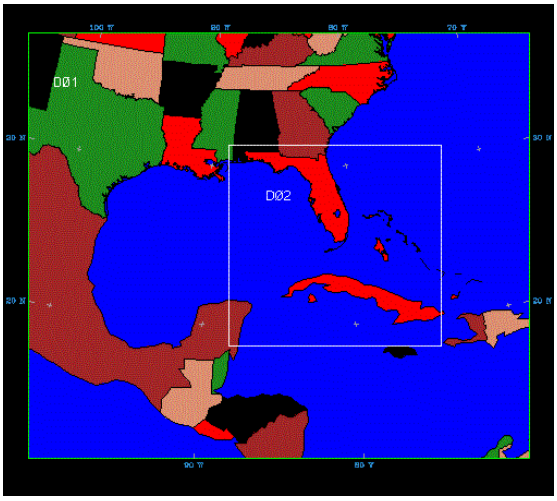

Fig. 2. Represents the two nests with horizontal grid spacing of 90 km and 30 km over the Gulf of Mexico.

V. PRESENTATION OF RESULTS

The model results will be discussed in relation to other theoretical and modeling studies of air-sea interaction in hurricane environments. The results will discuss the surface flux contributions according to three different criteria: time (with regard to stages of the storm's development and movement over the warm pools), quadrant relative to storm motion; and distance from the center. The potential links between the cumulative effect of the modeled surface fluxes and precipitation observed at landfall will also be considered.

ACKNOWLEDGEMENT

The research has been supported by NASAFAR grant under grant-NAS13 –99012.

REFERENCES

[1] Loren D. White and Remata S. Reddy: 2001, Mesoscale modeling investigation of air-sea interactions over Gulf of Mexico for a case study of Hurricane Bret, Procedure of the Symposium on precipitation, Impacts, and Responses, 14-18 January 2001, AlbuQuerque, New Mexico, American Meteorological Society, pp. 398-399.