Numerical Simulation of Hurricane Emily (2005): Sensitivity to Cloud Microphysical Schemes and Model Initialization

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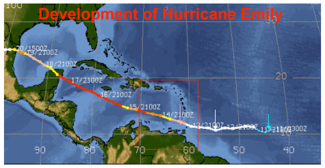
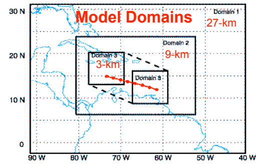
WRF Simulation: Rapid Intensification of Hurricane Emily (2005)





Objectives: To understand hurricane intensification

1. Investigate how cloud microphysical processes influence hurricane rapid intensification.
2. Examine the impact of model initialization (data assimilation) on hurricane intensity forecast.

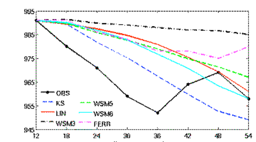
Simulation period:
27 and 9 km domains: 1800 UTC 13 to 0000 UTC 16 July 2005
3 km domain: 0600 UTC 14 to 0000 UTC 16 July 2005

Experimental Design

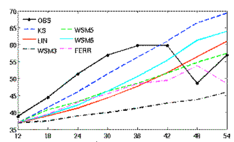
Microphysical Schemes (Exp.)	Hydrometeors Included	Other Physics Processes
Kessler (KS)	Cloud water and rain	RRTM longwave radiation
Lin (LIN)	Cloud water, rain, cloud ice, snow and graupel	Dudhia shortwave radiation
WRF Single Moment 3-class (WSM3)	Cloud water/ice, rain/snow	
WRF Single Moment 5-class (WSM5)	Cloud water, rain, cloud ice, and snow	27-km and 9-km grid domains: Grell-Devenyi ensemble cumulus scheme.
WRF Single Moment 6-class (WSM6)	WSM5 + graupel	
Ferrier (FERR)	Cloud water, rain, cloud ice, snow, and graupel	3 km grid: no cumulus scheme.

Sensitivity of Numerical Simulations of Emily's Intensification to Cloud Microphysics Schemes

Intensity of Hurricane Emily from 0600 UTC 14 to 0000 UTC 16 July 2005

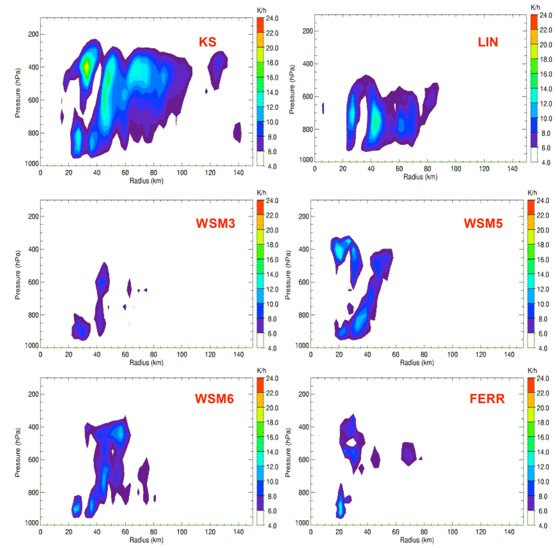


Minimum SLP (hPa)

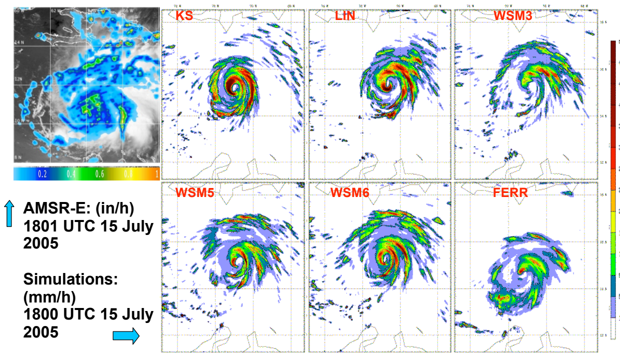


Maximum Surface Wind (m/s)

Inner-Core Convective Heating Rate at 0600 UTC 15 July



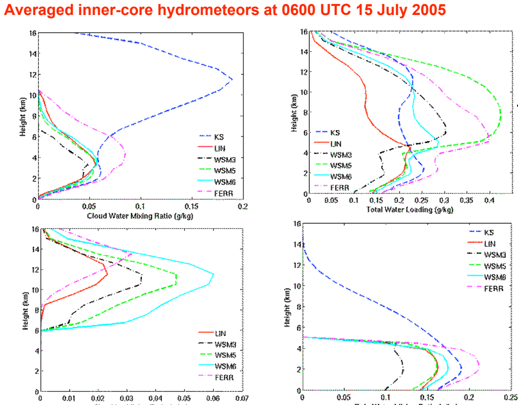
Precipitation Structure at 1800 UTC 15 July 2005



AMSR-E: (in/h)
1801 UTC 15 July 2005

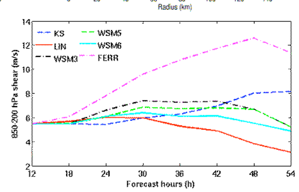
Simulations: (mm/h)
1800 UTC 15 July 2005

Averaged inner-core hydrometeors at 0600 UTC 15 July 2005



Total water: cloud water + cloud ice + rain + snow + graupel

Time series of 850-200 hPa Environmental Vertical Wind Shear (m/s)



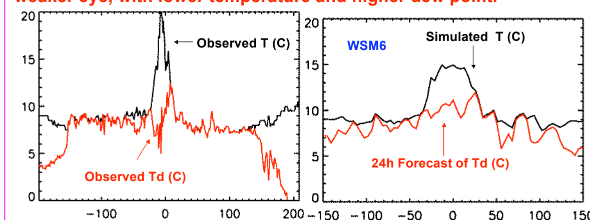
Summary

- Hurricane Emily's intensity forecast is very sensitive to varying cloud microphysics schemes in the WRF model.
- Environment vertical wind shear is not very sensitive to varying microphysics schemes in most of the cases.
- Convective heating rates produced by various microphysics schemes are closely related with the intensity of simulated storms.
- Compared with the observations, numerical simulation produces a larger, weaker, colder, moister eye with weaker vertical motion in the eyewall region.
- Data assimilation shows strong potential to improve the intensity forecast.

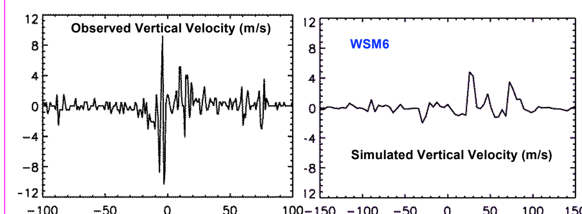
Acknowledgements: The authors appreciate Dr. Edward Zipser's comments and encouragement. This research is funded through a NASA TCSP grant and Program Manager Dr. Ramesh Kakar.

Flight Level Observations vs. Model Simulations:

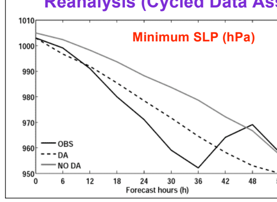
Compared with observations at 700 hPa: Model has larger diameter, weaker eye, with lower temperature and higher dew point.



Vertical velocity at 700 hPa: Model has weaker vertical motion than observed in the eyewall region in 24 h forecast



Reanalysis (Cycled Data Assimilation) Results



When GOES-11 atmpspheric motion vectors, QuikSCAT surface winds and dropsonde data were assimilated into model simulation every 6-h from 1800 UTC 13 to 0000 UTC 16 July 2005, *the result is a far more accurate rate of intensification of Emily starting in the model almost immediately.*

Questions for future work:

- Why do different cloud microphysics schemes produce significant differences in precipitation and heating rates?
- What is the major physical mechanism though which cloud microphysical processes influence hurricane intensification?
- To what extent can data assimilation improve the forecast of hurricane rapid intensification in other cases?