Advanced Research WRF High Resolution Simulations of Hurricanes Katrina, Rita and Wilma (2005)

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The Advanced Hurricane WRF

• Run in real-time at NCAR since 2004 when a tropical cyclone (TC) threatened to make landfall within 3-5 days

• Two or three domains (12, 4, 1.33 km) with two-way moveable nests that follow the hurricane center

• Initialized from GFDL at 00 UTC and/or 12 UTC

• Kain-Fritsch cumulus (12 km only), WSM3 microphysics, YSU PBL scheme, drag (Donelan) and surface enthalpy coefficients (Carlson-Boland) for TCs

• Available on the web at http://www.wrf-model.org/plots/realtime_main.php
Hurricane Rita
03 UTC 24 September
39 hr forecast

Column maximum reflectivity
4 km
Precipitable water

Hurricane Rita
03 UTC 24 September
39 hr forecast

Column maximum reflectivity
4 km
Precipitable water
Hurricane Wilma

4 km Precipitable water

22 UTC 20 October
22 hr forecast

05 UTC 24 October
77 hr forecast
Hurricane Katrina
Precipitable water
12 km
21 UTC 8/28

1.33 km
00 UTC 8/29

4 km
03 UTC 8/29
Katrina Radar Reflectivity
20 UTC 28 August

Top: WRF 4 km(left), 1.33 km(right)
Right: ELDORA radar

RAINEX JOSS Field Catalog
Katrina

Wind speed

Left:
Dual Doppler
1725-1946 UTC
28 August

Right:
WRF 1.33 km
18 UTC

Top: 700 hPa
Bottom: 900 hPa

HRD/AOML/NOAA
Katrina 1.33 km WRF

900 hPa wind speed

900 hPa relative vorticity
Both the real and WRF vorticity profiles exhibit sharp gradients of vorticity and changes in the sign of $\partial \zeta / \partial r$.

Such profiles satisfy the necessary condition for barotropic instability.
Schubert et al. (1999)
The 1.33 km WRF simulation is most unstable to wavenumber 2, with significant wavenumber 1-4 instability.

The 4 km WRF simulation is most unstable to wavenumbers 1 and 2, with very little instability at higher wavenumbers.

Ring stability analysis

The 1.33 km WRF simulation is most unstable to wavenumber 2, with significant wavenumber 1-4 instability.

The 4 km WRF simulation is most unstable to wavenumbers 1 and 2, with very little instability at higher wavenumbers.

Code provided by M. Montgomery and M. Bell
Questions and Unresolved Issues

• Are model numerics and parameterizations playing a role in the abundance of triangular eyewalls?

• Do tropical cyclones pose a unique problem to WRF with their circular geometry and strong diabatic heating-vorticity generation feedback?

• Will 1.33 km WRF TCs always be too weak due to an abundance of eyewall asymmetries?

• What is the resolution dependence of these eyewall structures?
Vertical motion
(warm up, cool down)
185 m resolution
Idealized WRF hurricane simulation

The eyewall is predominantly circular or elliptical, with transient higher wavenumber structures.
Future Work

• Add another nest to the 1.33 km Katrina run to test resolution dependence

• Decompose the WRF output into its various wavenumber components and compare with observations

• Analyze the results of the 2007 hurricane season WRF 1.33 km runs

We’re not alone!

WRF 2km Wilma
GFS initialization

Brian Etherton
UNC Charlotte