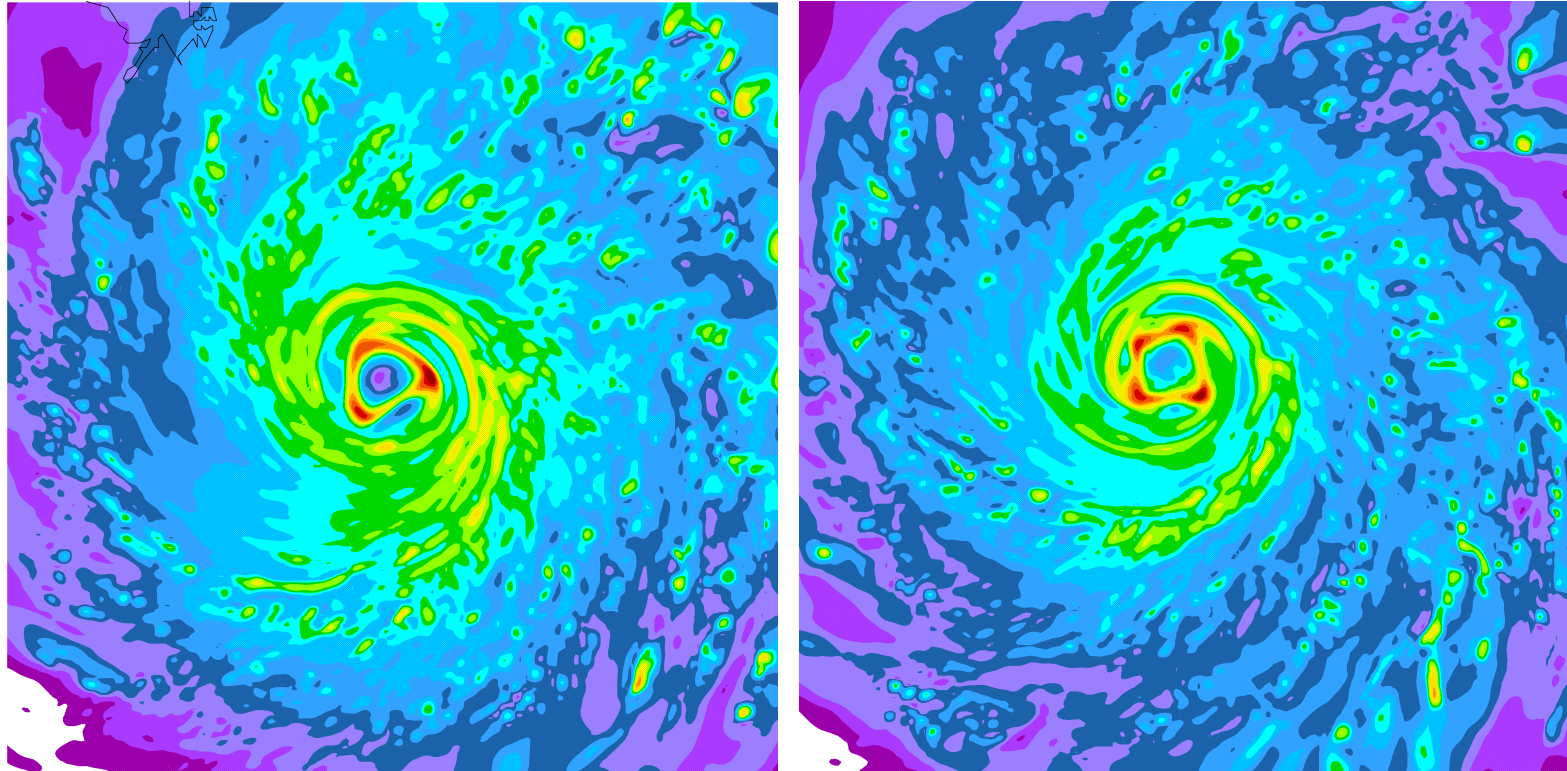


# Advanced Research WRF High Resolution Simulations of Hurricanes Katrina, Rita and Wilma (2005)



Kristen L. Corbosiero, Wei Wang, Yongsheng Chen,  
Jimmy Dudhia and Christopher Davis

National Center for Atmospheric Research

# 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](http://www.wrf-model.org/plots/realtime_main.php)

# 2005 performance Seven tropical cyclone forecast systems

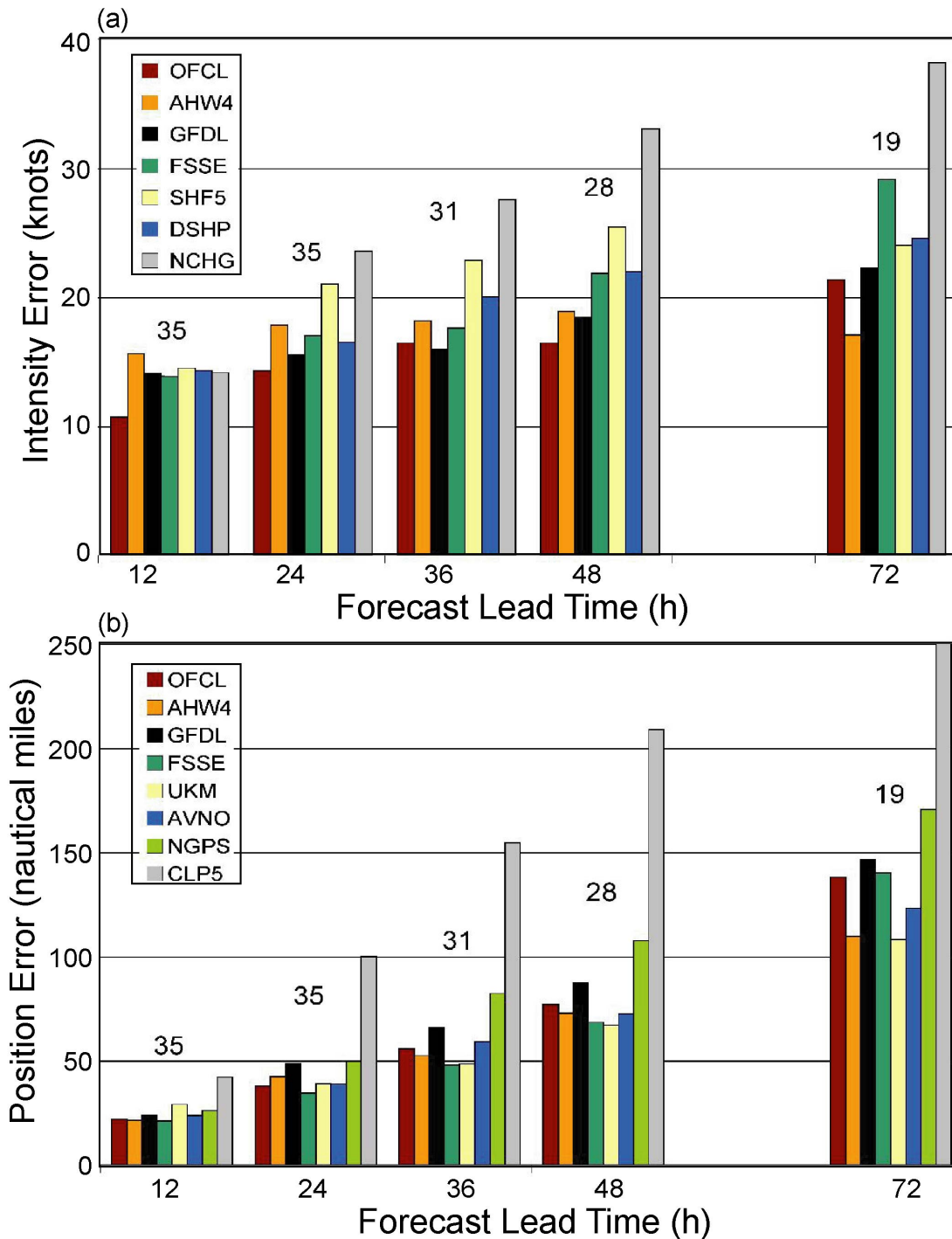
**AHW4**  
**WRF 4 km**

**OFCL**  
**National Hurricane  
Center official**

**GFDL**  
**Geophysical Fluid  
Dynamics Laboratory**

**FSSE**  
**Florida State  
Super Ensemble**

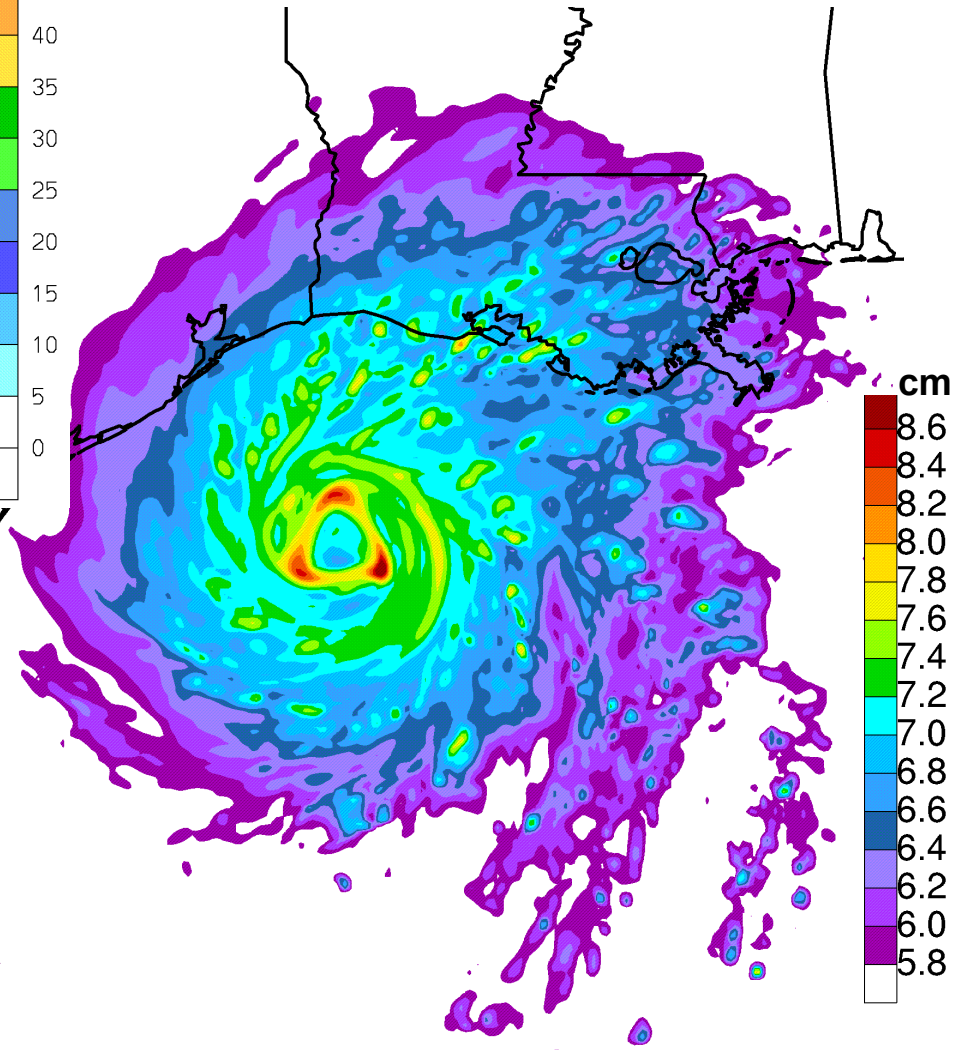
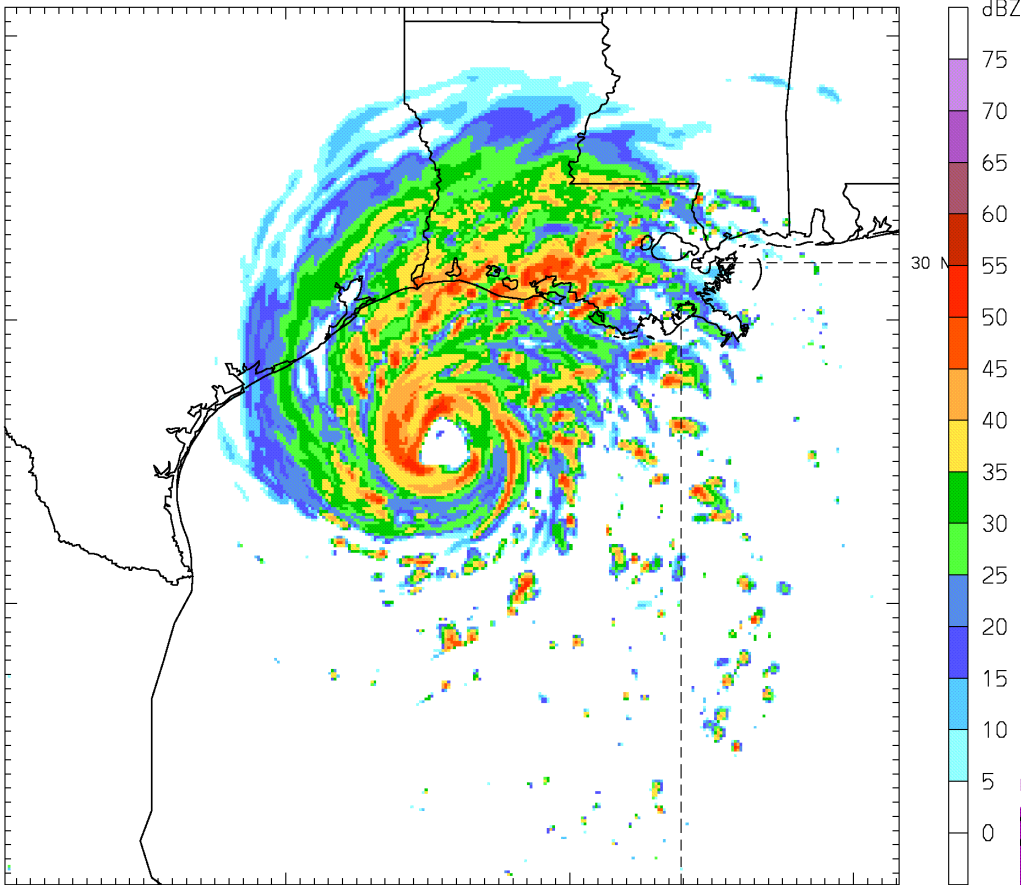
Davis et al. (2007)



# Hurricane Rita

03 UTC 24 September

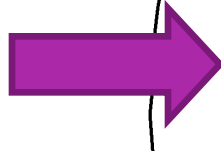
39 hr forecast



**Column maximum  
reflectivity**

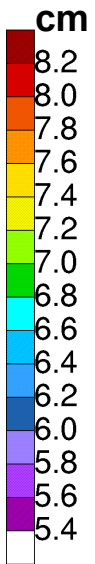
**4 km**

**Precipitable water**



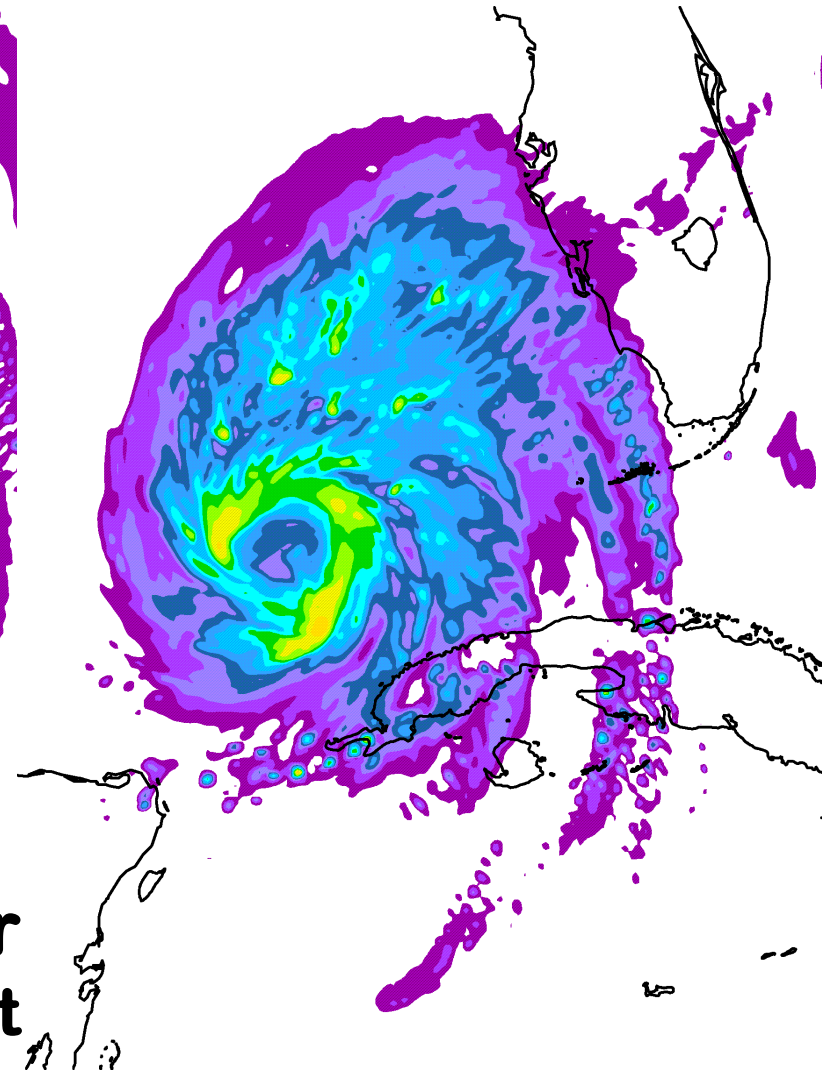
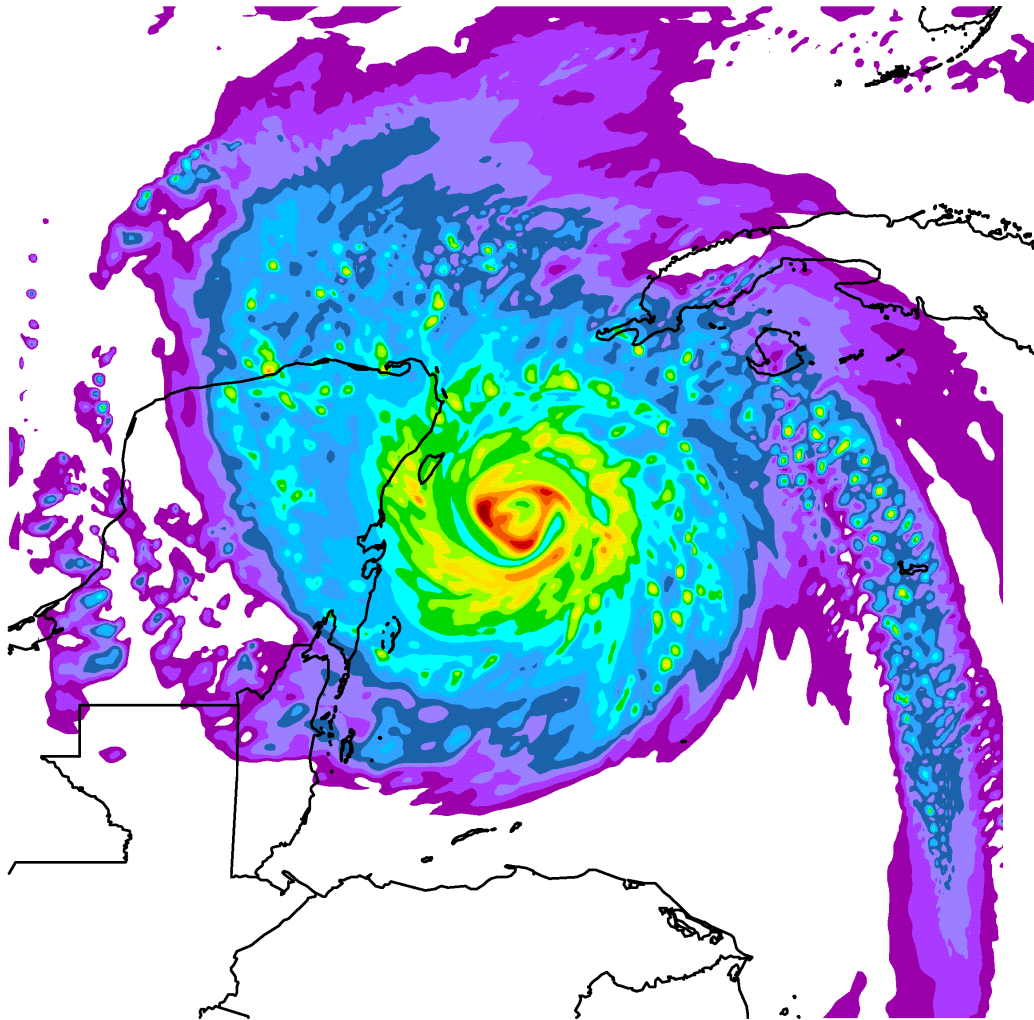
# Hurricane Wilma

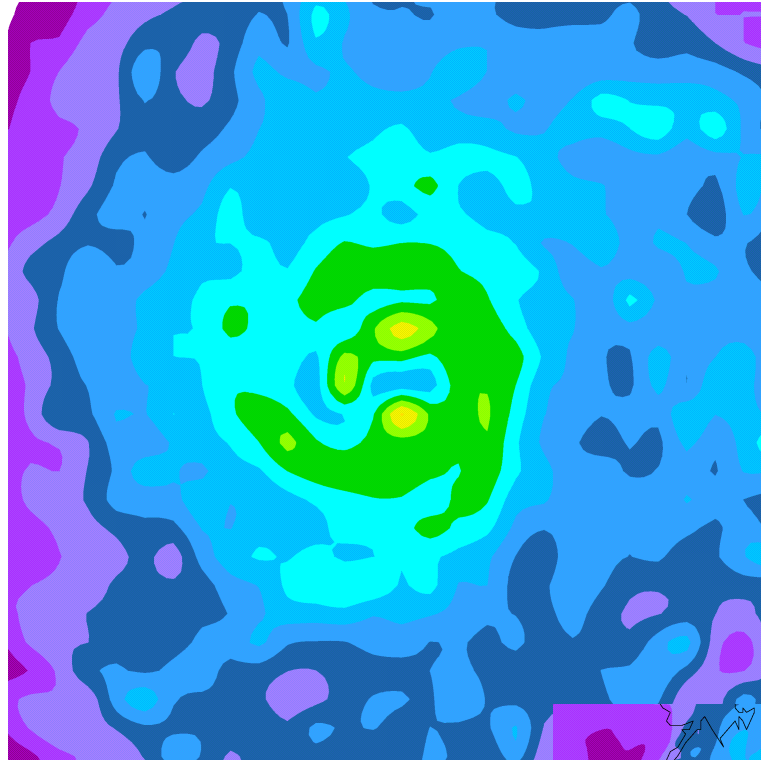
4 km Precipitable water



**22 UTC 20 October**  
**22 hr forecast**

**05 UTC 24 October**  
**77 hr forecast**

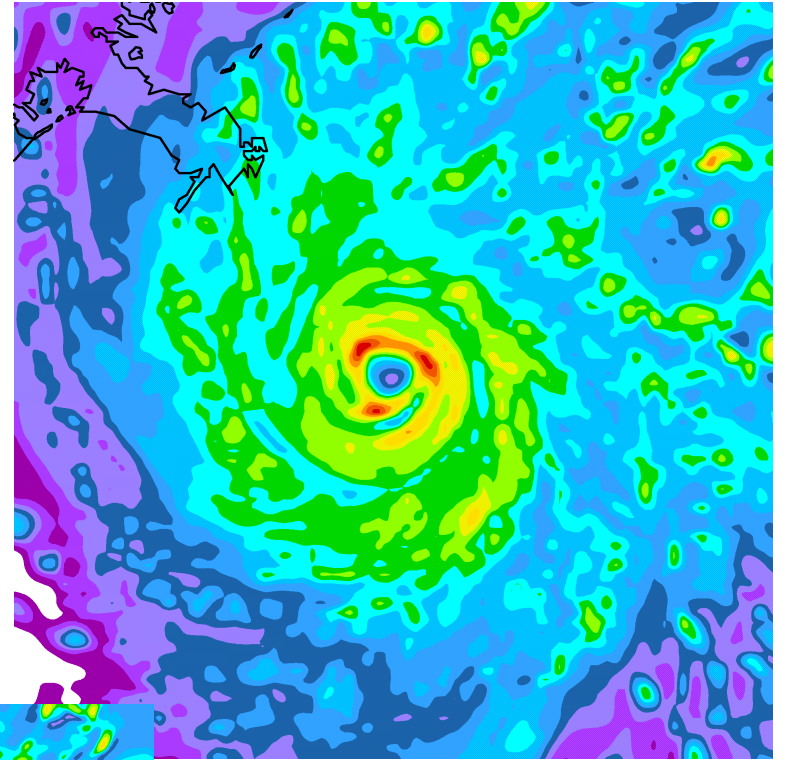
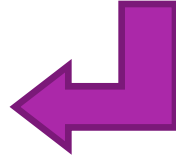




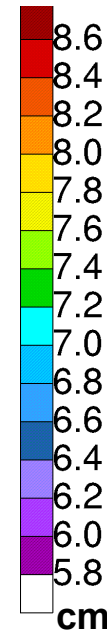
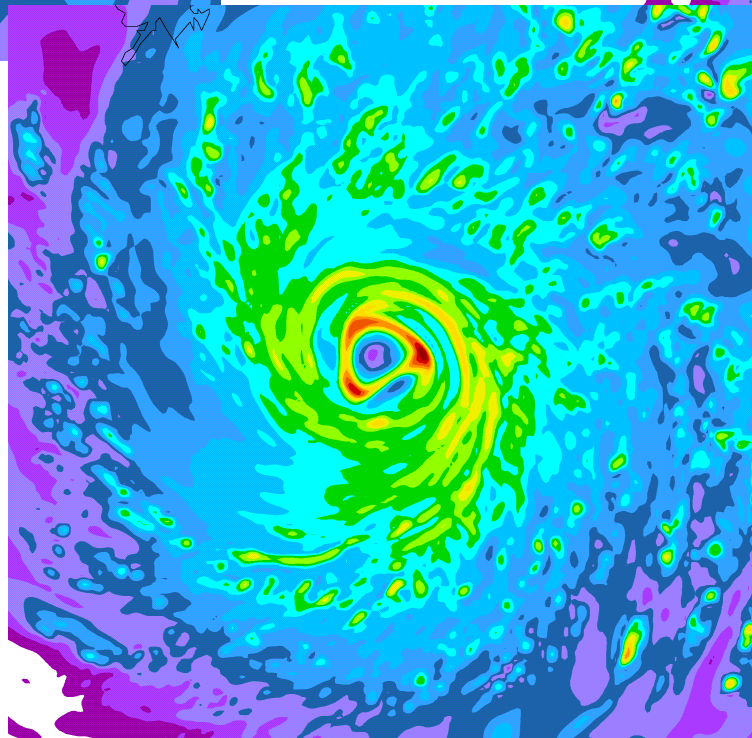
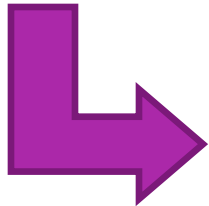
**Hurricane Katrina**

**Precipitable water**

**12 km  
21 UTC 8/28**

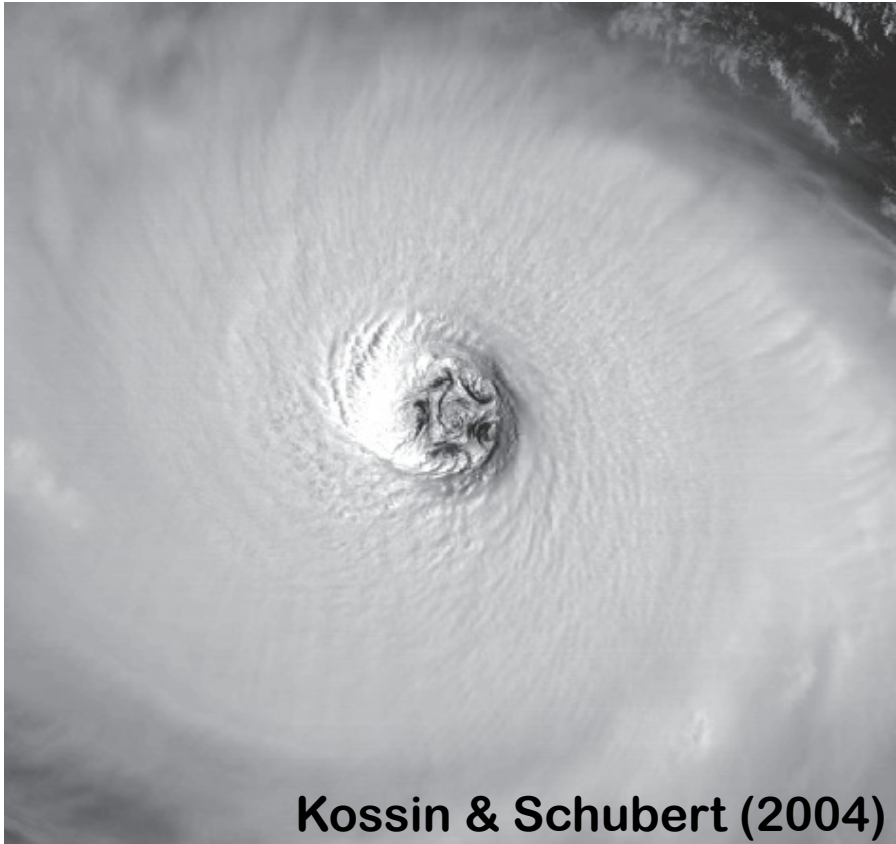


**1.33 km  
00 UTC 8/29**

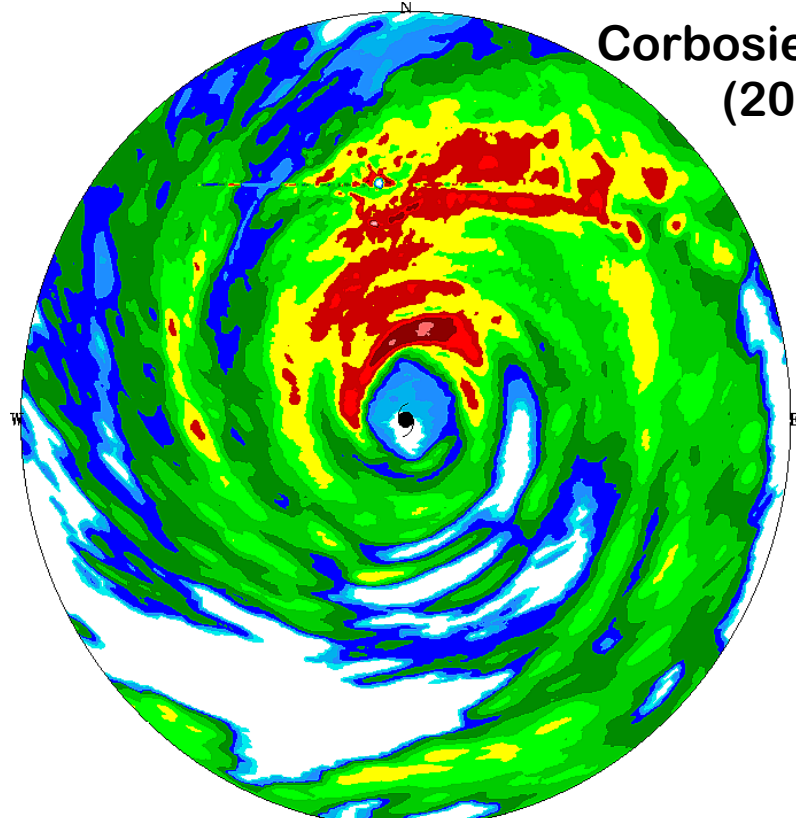


**4 km  
03 UTC 8/29**

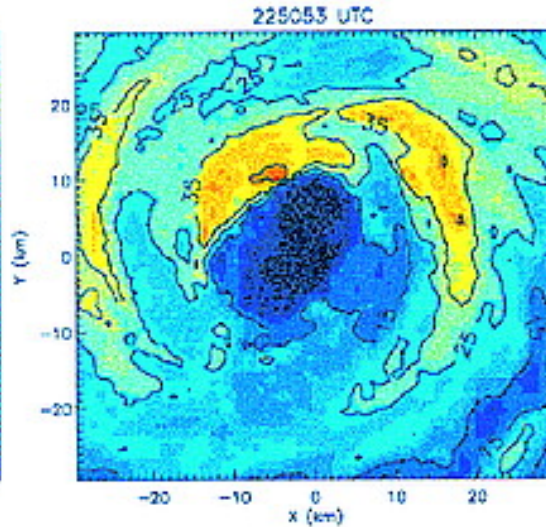
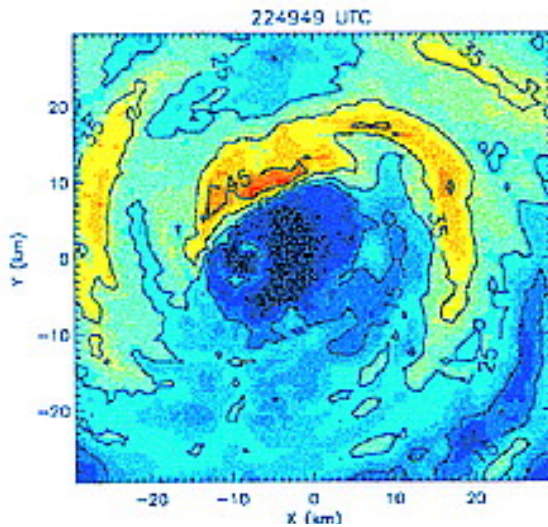




Kossin & Schubert (2004)



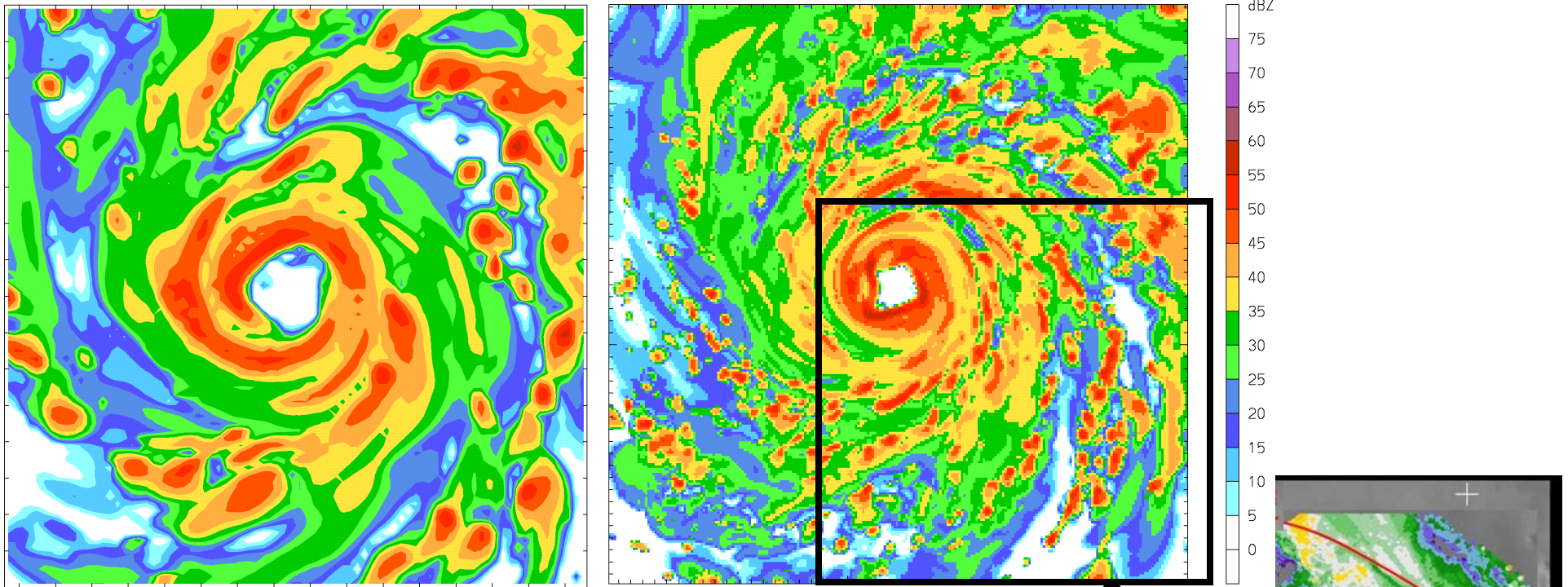
Corbosiero et al. (2006)



Lewis & Hawkins (1982)

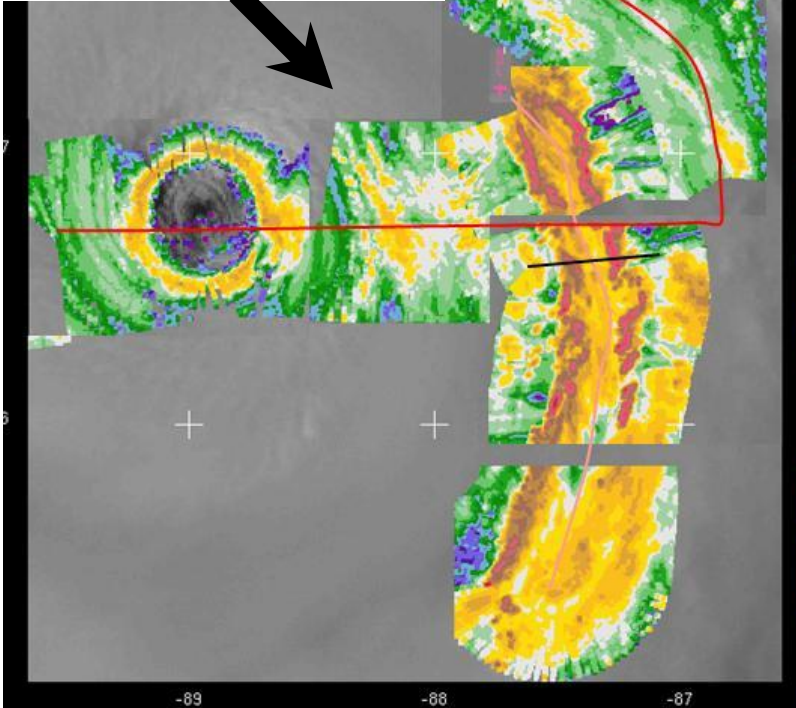


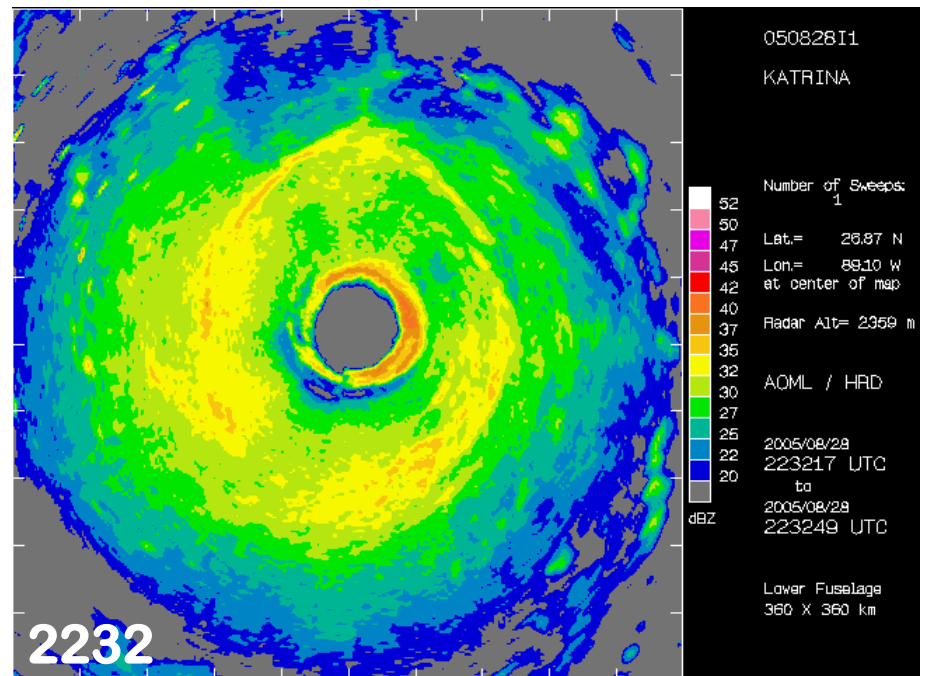
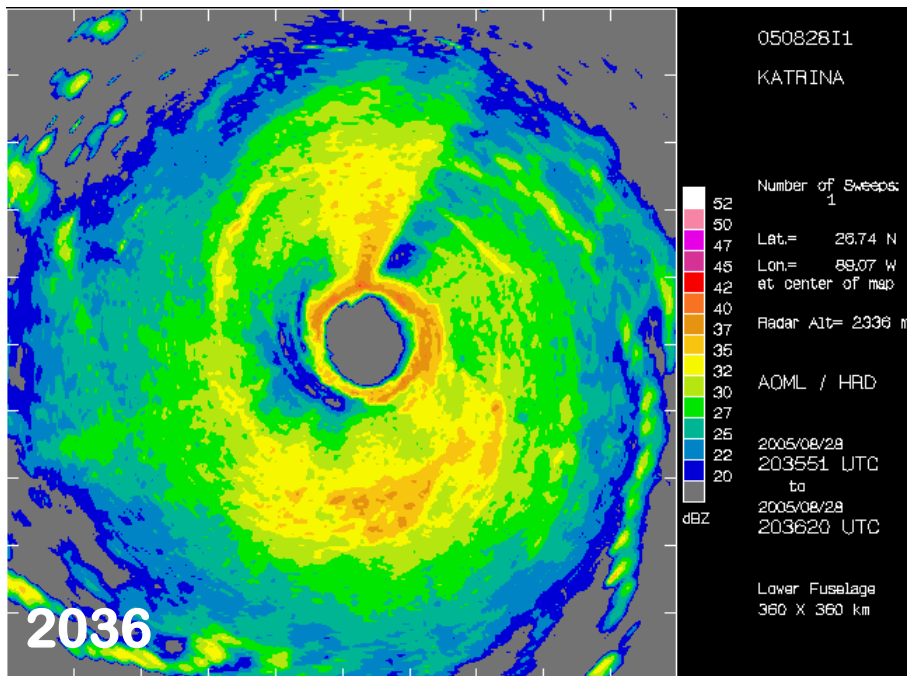
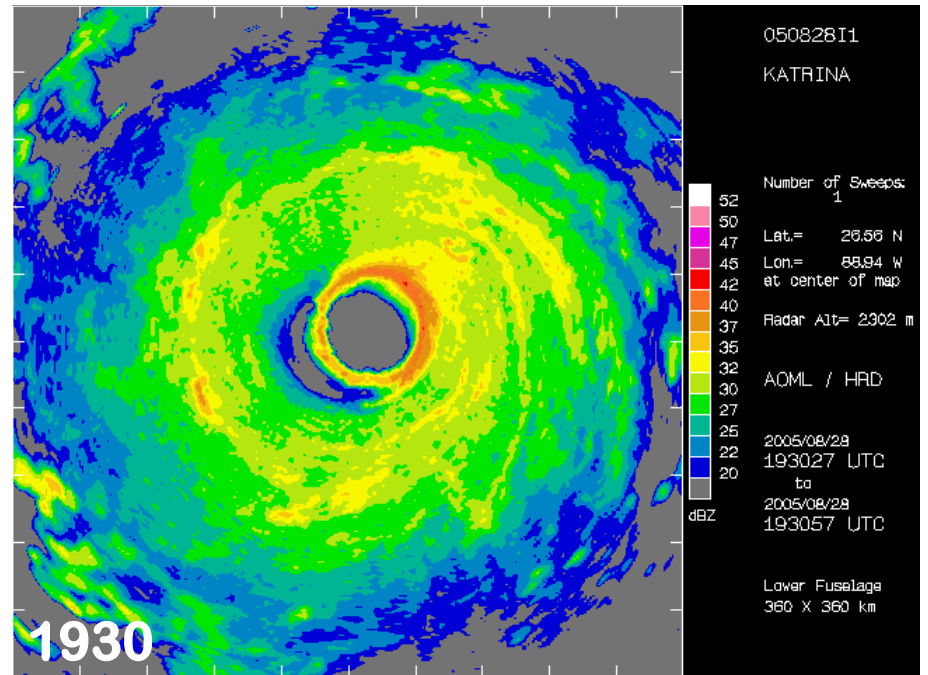
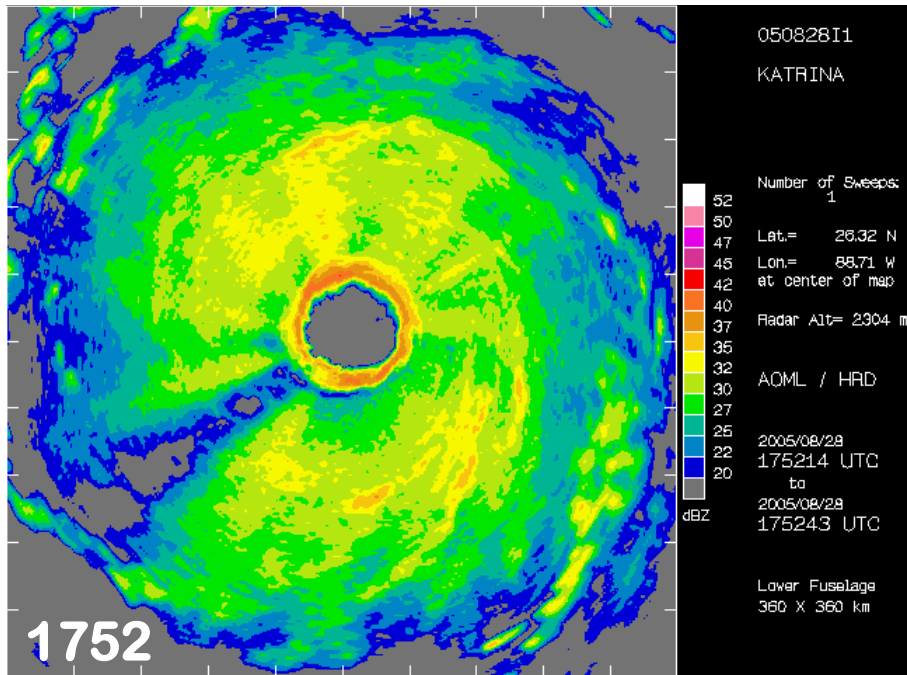
Reasor et al. (2000)



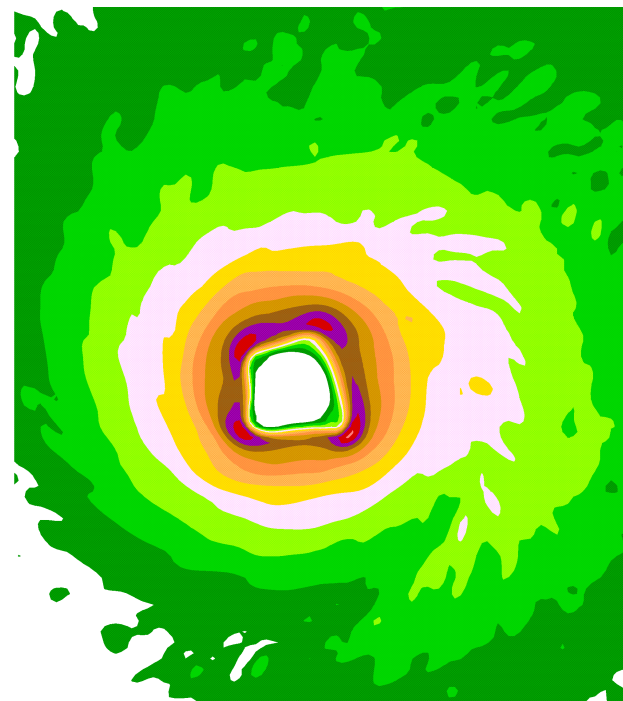
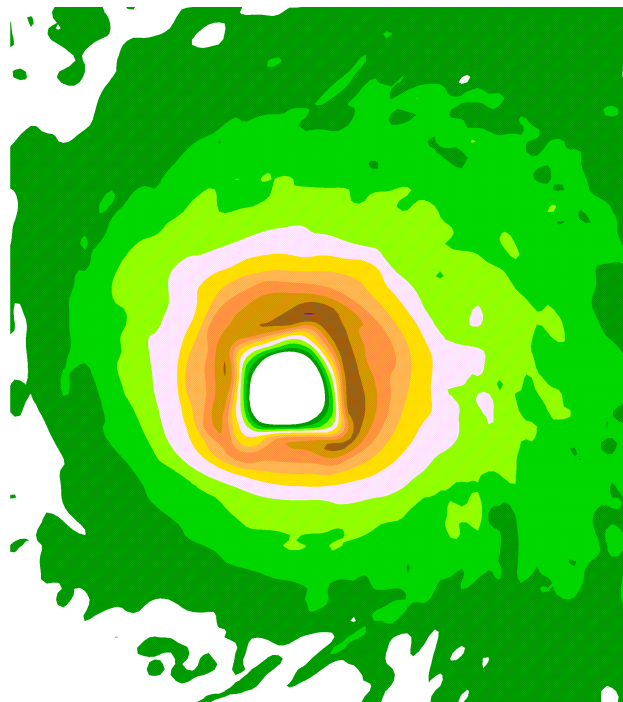
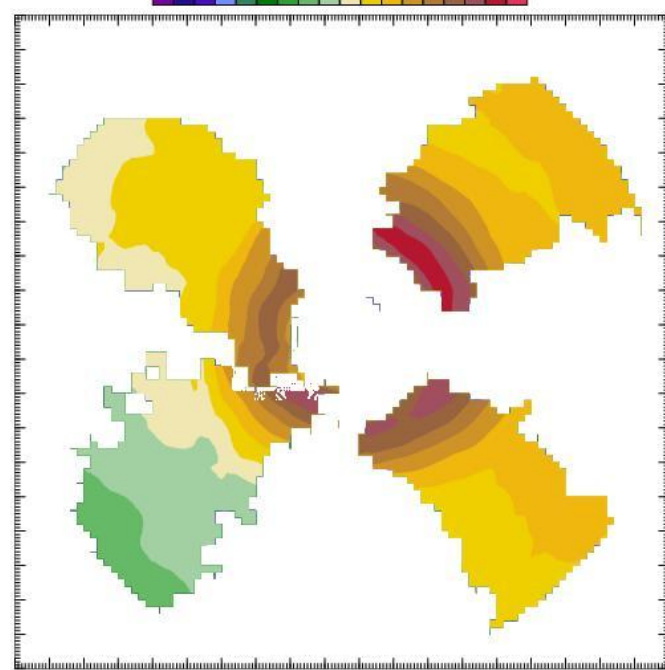
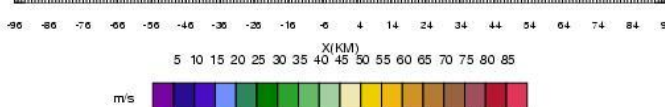
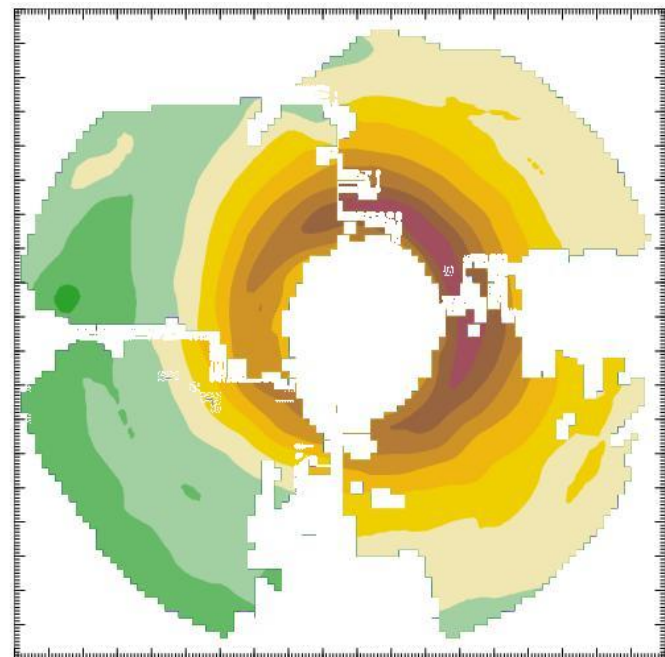
**Katrina Radar Reflectivity**  
**20 UTC 28 August**

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





HRD/AOML/NOAA

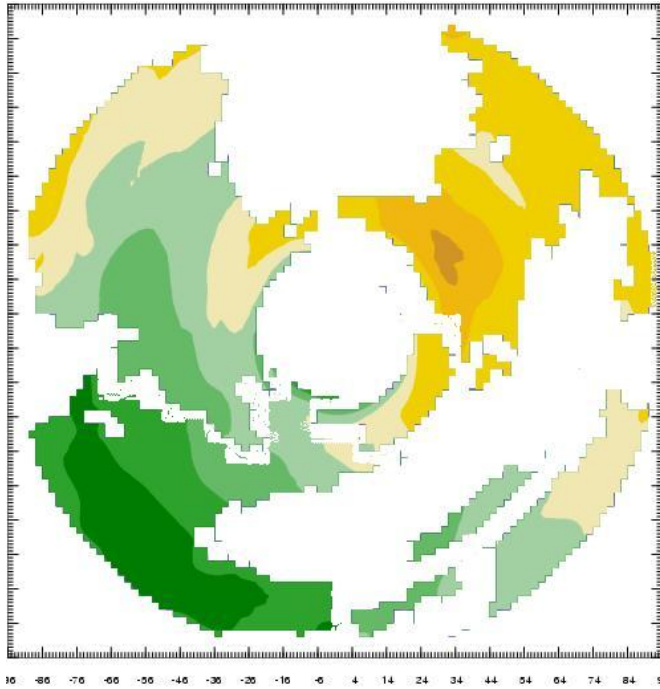


# Katrina Wind speed

Left:  
Dual Doppler  
1725-1946 UTC  
28 August

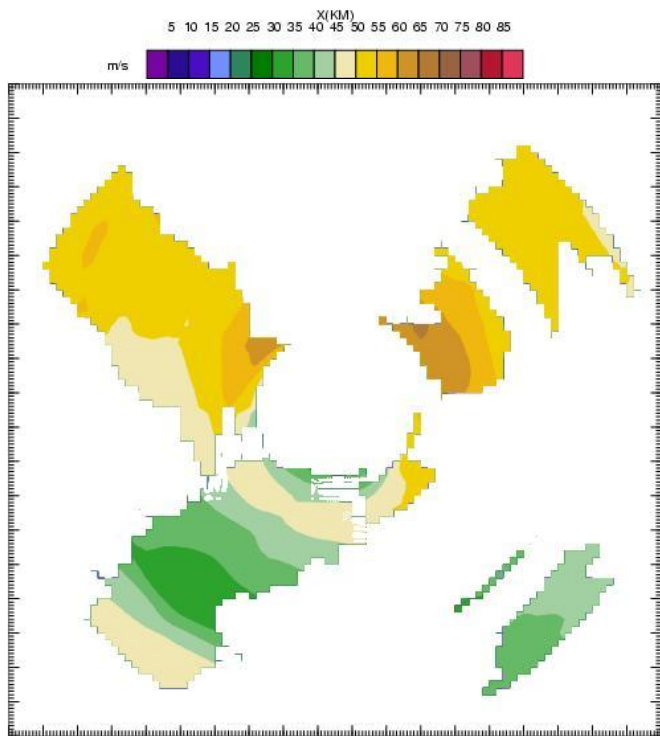
Right:  
WRF 1.33 km  
18 UTC

Top: 700 hPa  
Bottom: 900 hPa



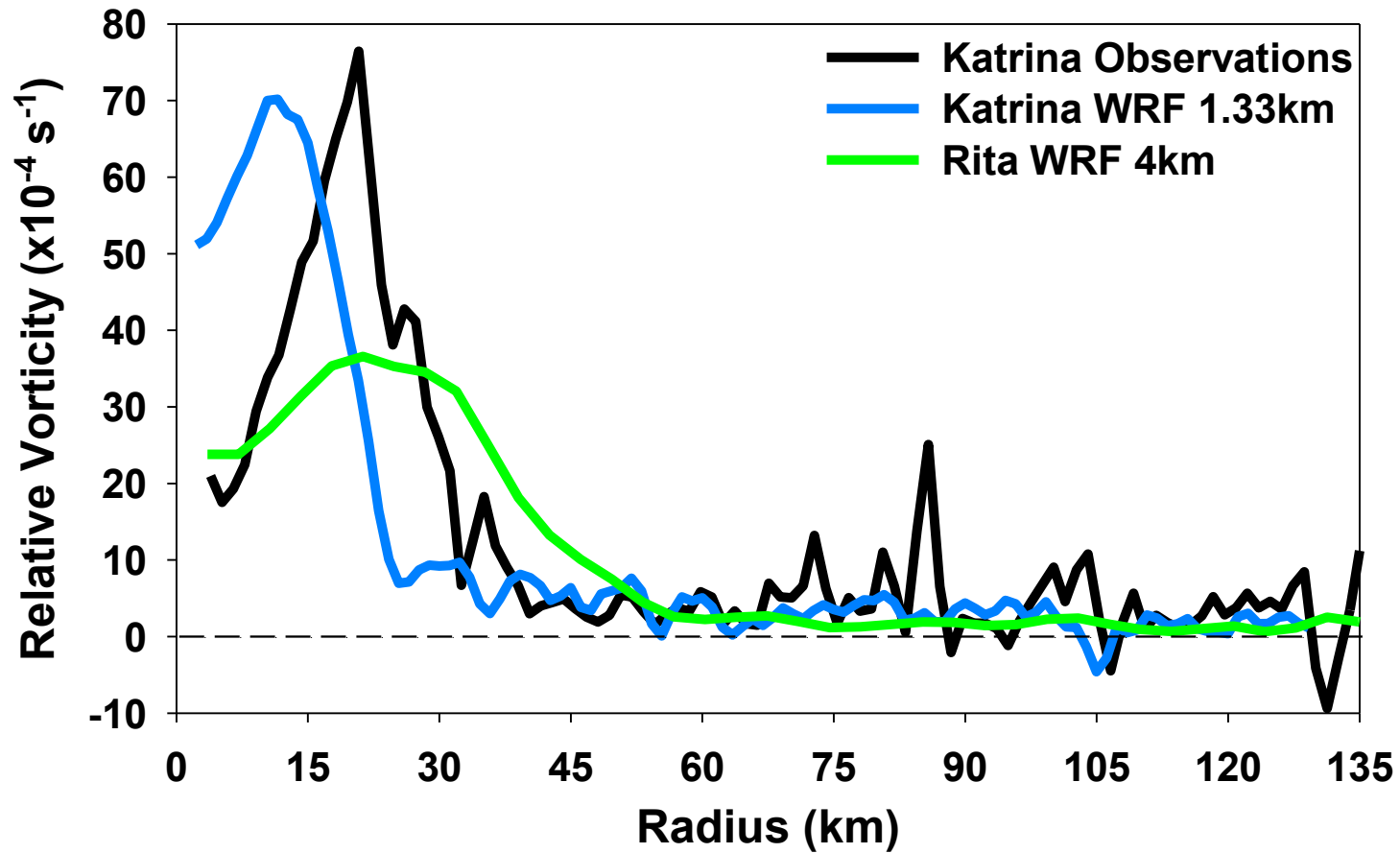
**Rita**  
**Wind speed**

**Left:**  
**Dual Doppler**  
**2015-2208 UTC**  
**23 September**



**Right:**  
**WRF 4 km**  
**01 UTC**  
**24 September**

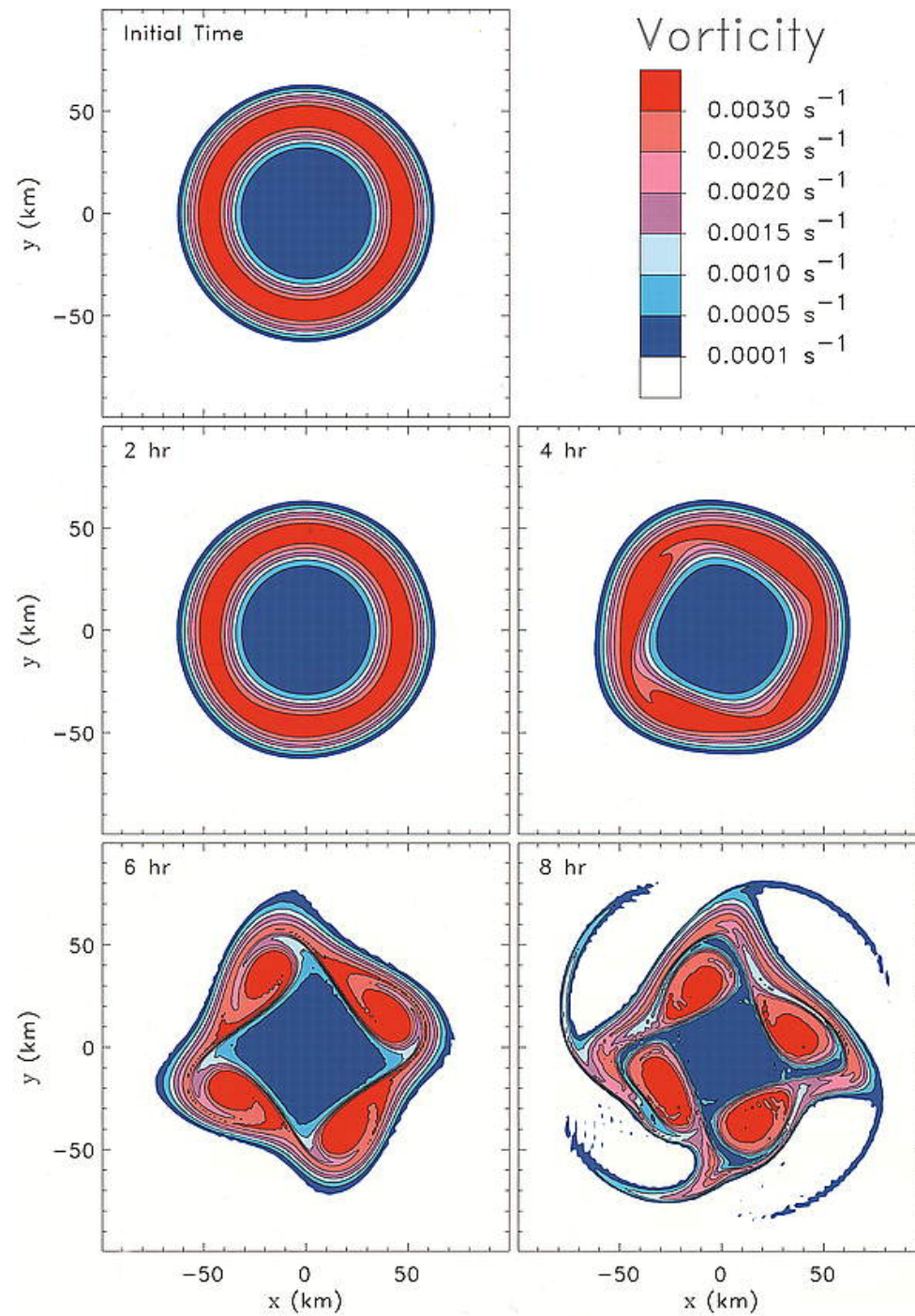
**Top: 700 hPa**  
**Bottom: 900 hPa**



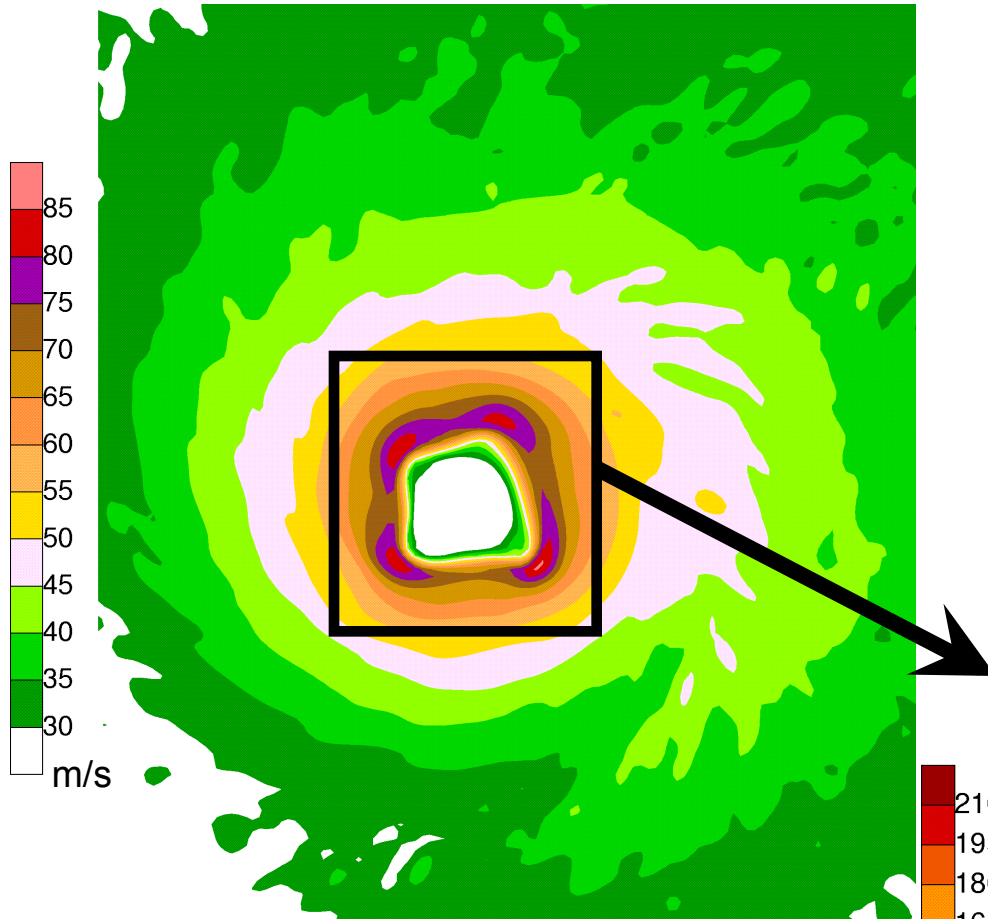
**Both the real and WRF vorticity profiles exhibit sharp gradients of vorticity and changes in the sign of  $\partial\zeta/\partial r$ .**

**Such profiles satisfy the necessary condition for barotropic instability.**

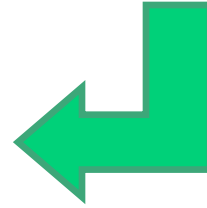
# Schubert et al. (1999)



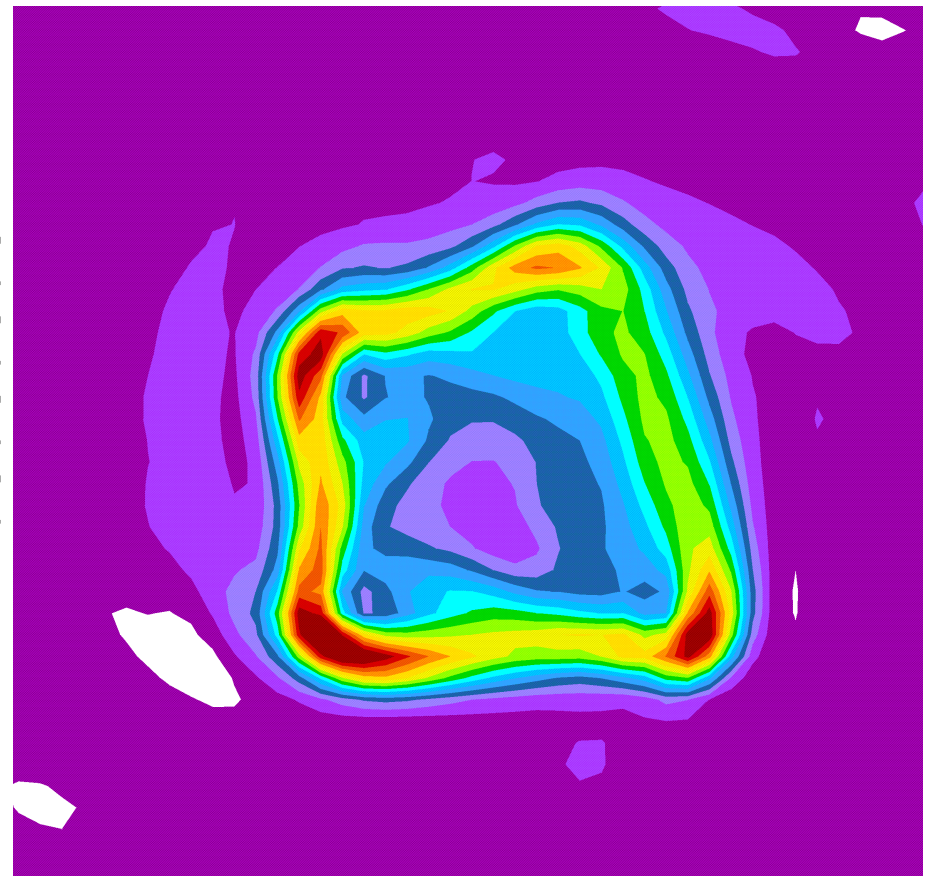
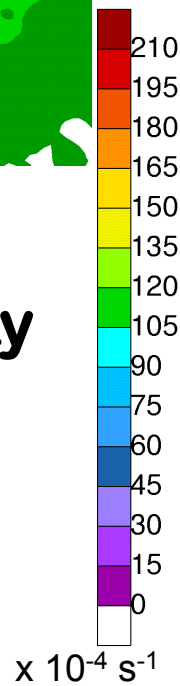
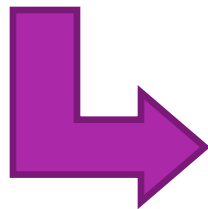
# Katrina 1.33 km WRF

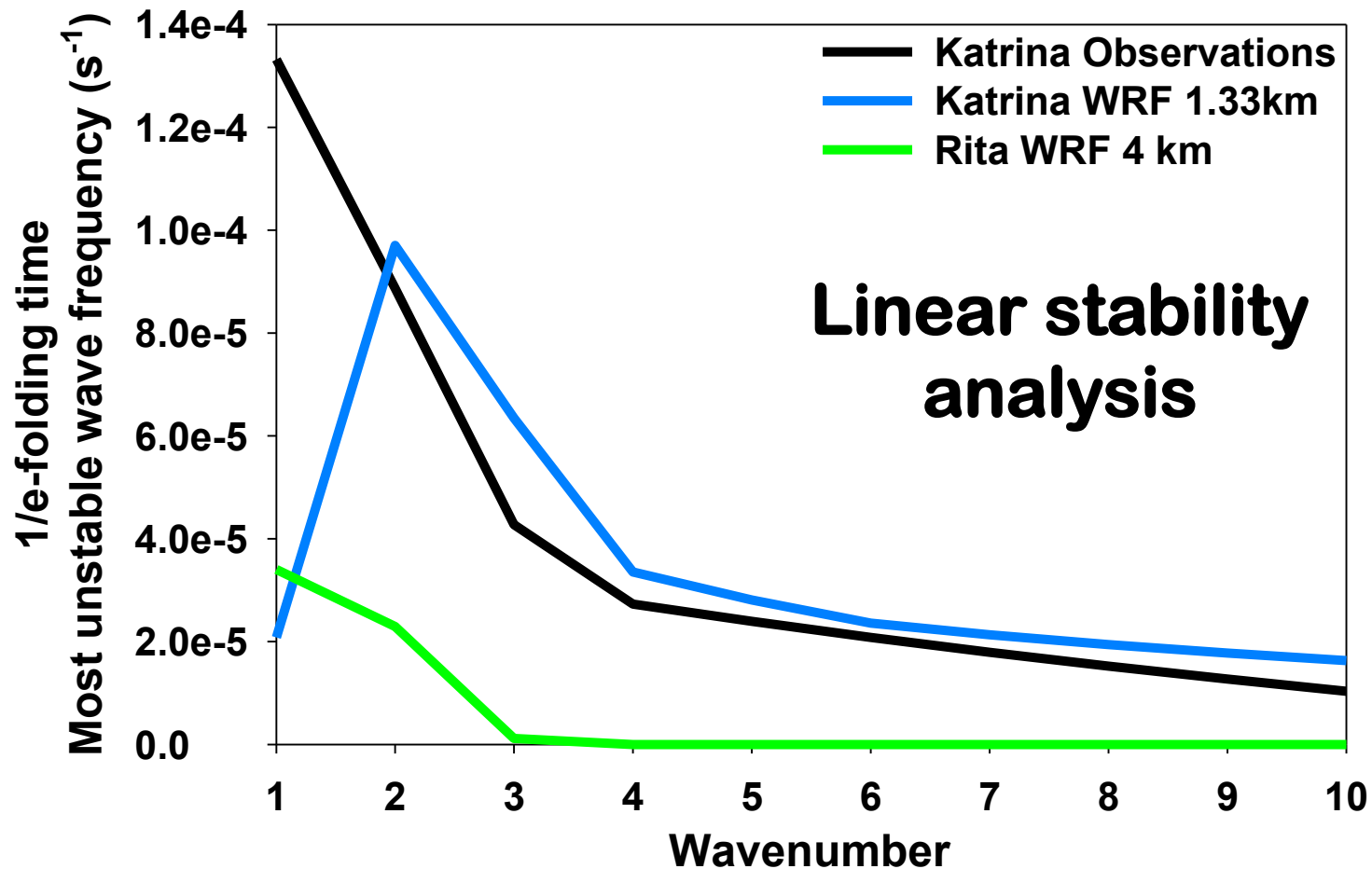


900 hPa wind speed



900 hPa relative vorticity



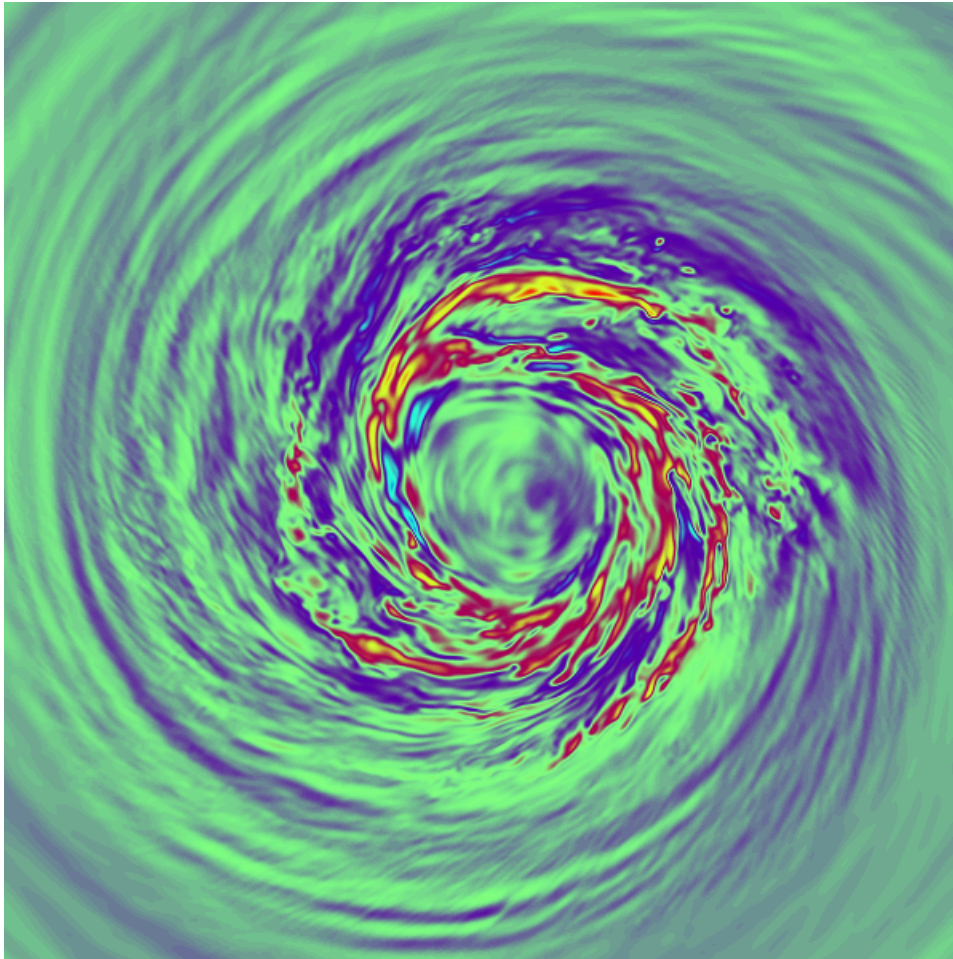


**The 1.33 km WRF simulation is most unstable to wavenumber 2, with significant wavenumber 1-4 instability.**

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

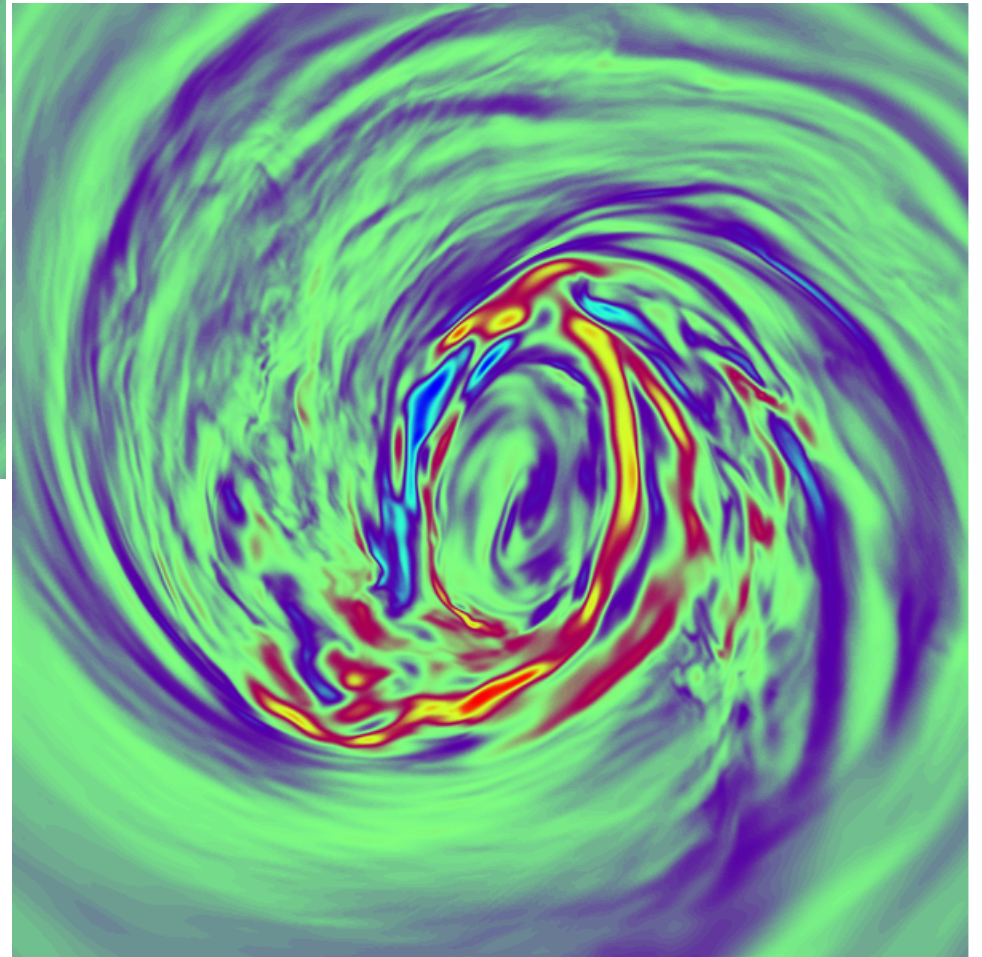
## Questions and Unresolved Issues

- **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?**



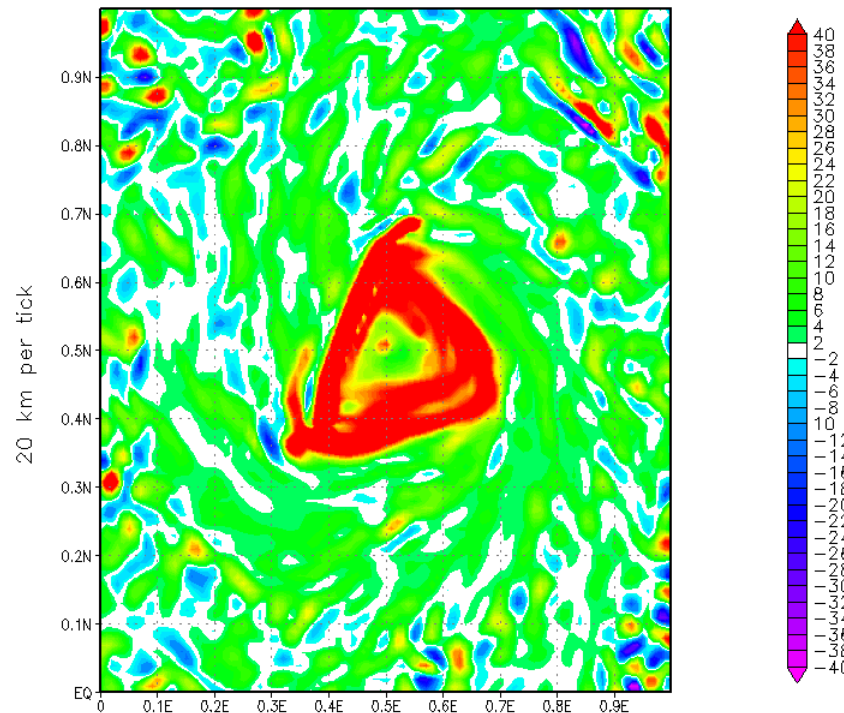
**Vertical motion  
(warm up, cool down)  
185 m resolution  
Idealized WRF hurricane  
simulation**

**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**