Influence of Environmental Shear on the Rapid Intensification Problem

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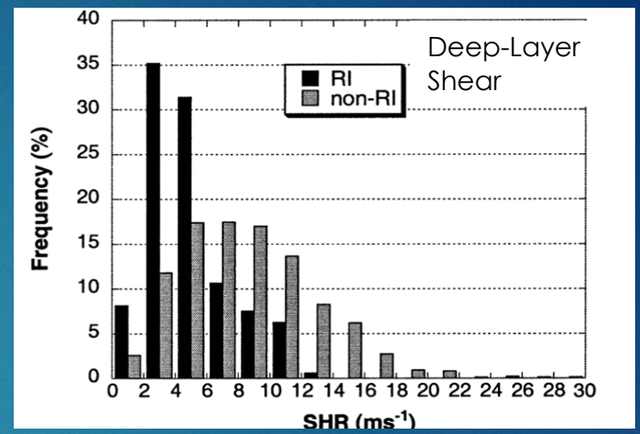
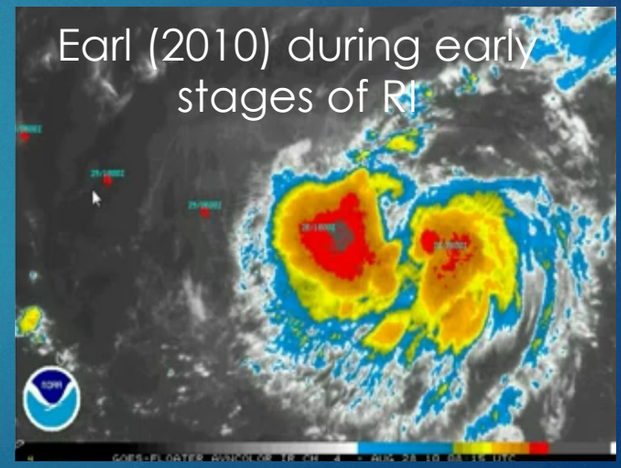
Factors that influence TC Rapid Intensification

Adopted from Kaplan and DeMaria, 2003, Weather and Forecasting

Variable	Units	RI (N = 159, N_e = 92)	Non-RI (N = 2462, N_e = 705)	D = RI − non-RI
VMX	m s^{-1}	28.9	30.1	−1.2
LAT	°N	19.7	23.4	−3.7 (***)
LON	°W	63.2	57.2	6.0 (*)
SPD	m s^{-1}	5.2	5.3	−0.1
DVMX	m s^{-1}	4.6	1.0	3.6 (***)
USTM	m s^{-1}	−3.1	−1.8	−1.3 (**)
JDAY		22.5	25.0	−2.5
SST	°C	28.4	27.5	0.9 (***)
POT	m s^{-1}	47.6	40.3	7.3 (***)
SHR	m s^{-1}	4.9	8.5	−3.6 (***)
U200	m s^{-1}	−0.6	3.8	−4.4 (***)
T200	°C	−53.3	−53.4	0.1
RHLO	%	69.7	65.4	4.3 (***)
Z850	10^{-7} s^{-1}	32	22	10.0
REFC	m s^{-1} day^{-1}	0.9	2.4	−1.5 (**)
SLYR	hPa	583.4	613.2	−29.8 (**)





Factors interact in a non-linear manner. HWRF may be for conducting control experiments and for understanding modeled intensification process [Gopal et al, 2011 (MWR), Bao et al., 2012 (MWR), Gopal et al, 2013 (MWR), Kieu et al, 2014 (GRL), Halliwell et al, 2014 (MWR), D.-L. Zhang et al. ,2014 (MWR)

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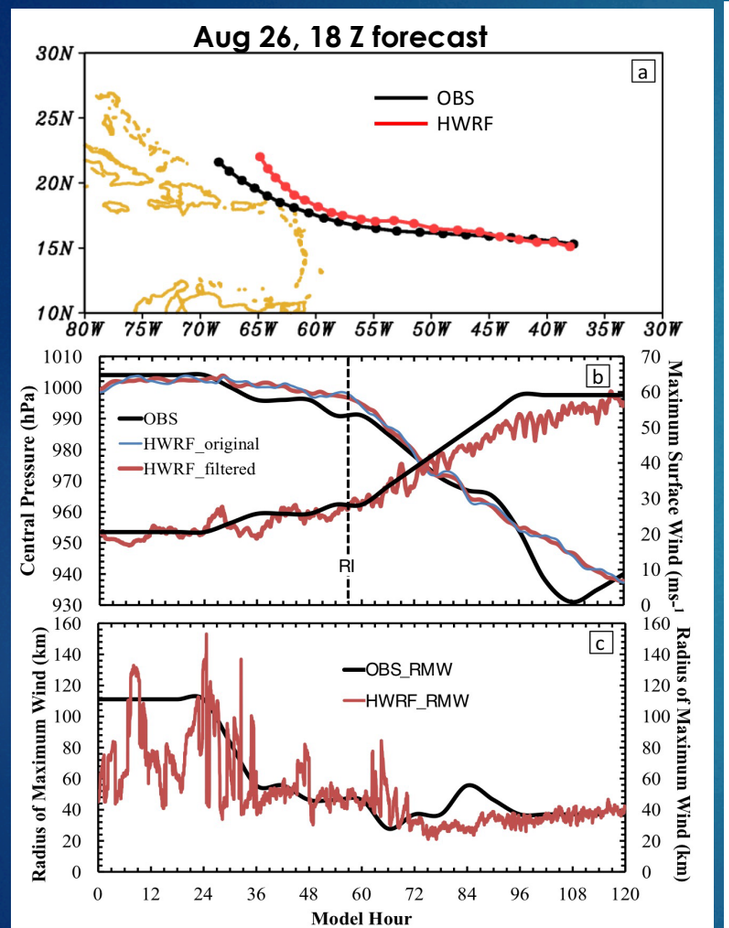
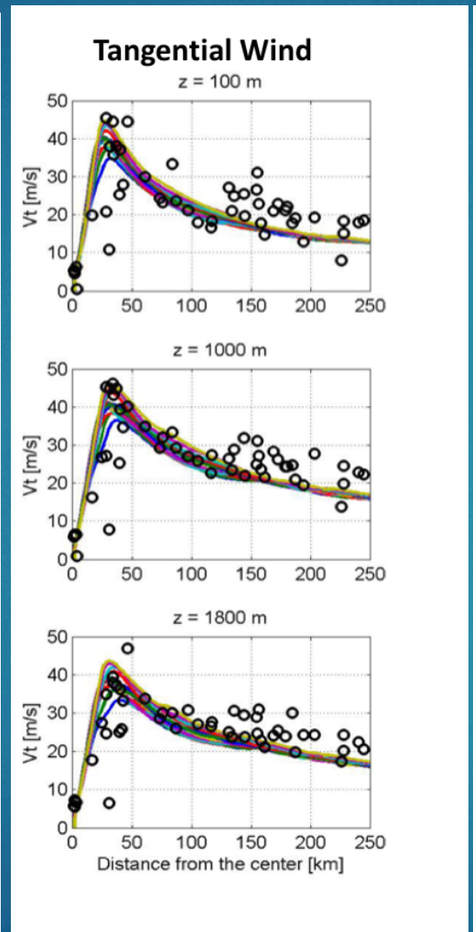
A Study on the Asymmetric Rapid Intensification of Hurricane Earl (2010) using the HWRF System

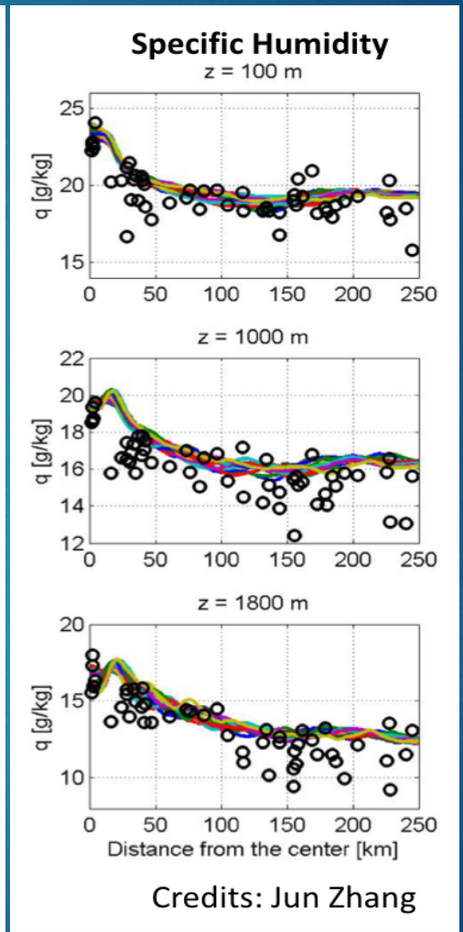
Hua Chen and Sundararaman G. Gopalakrishnan

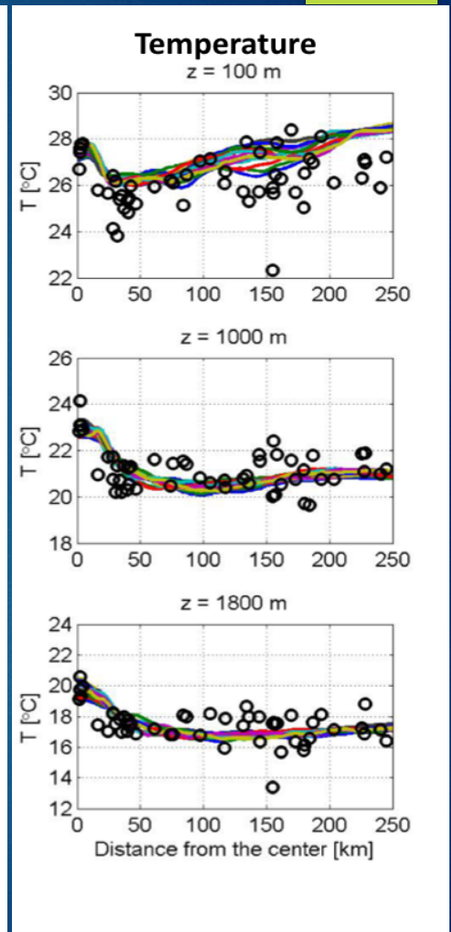
For the first time NOAA's HWRF hurricane track and intensity forecast model was used to help understand the complex processes of asymmetric Rapid Intensification (RI) in tropical cyclones. An important key to understanding the RI process was the availability of detailed aircraft observations in the inner core of the hurricane with which to compare the model results. The model was able to reproduce the evolution of the hurricane structure that caused the RI process similar to what was seen in the actual detailed observations. During the times and in the regions of the hurricane where detailed aircraft observations were not available, the model was able to used as a proxy to gain even more understanding of the four-dimensional intensification process.

Hurricane Earl (2010): How close are we to reality?





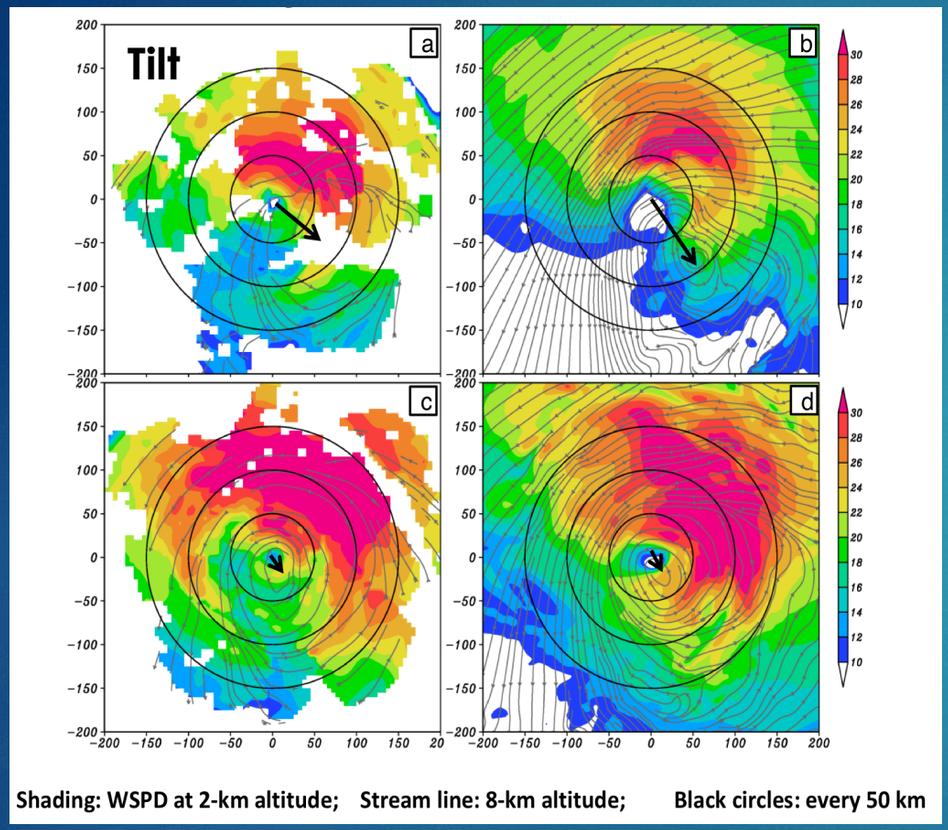




Apart from the standard verification metrics (track and peak winds), HWRF reproduced the storm structure extremely well making this an unique data set

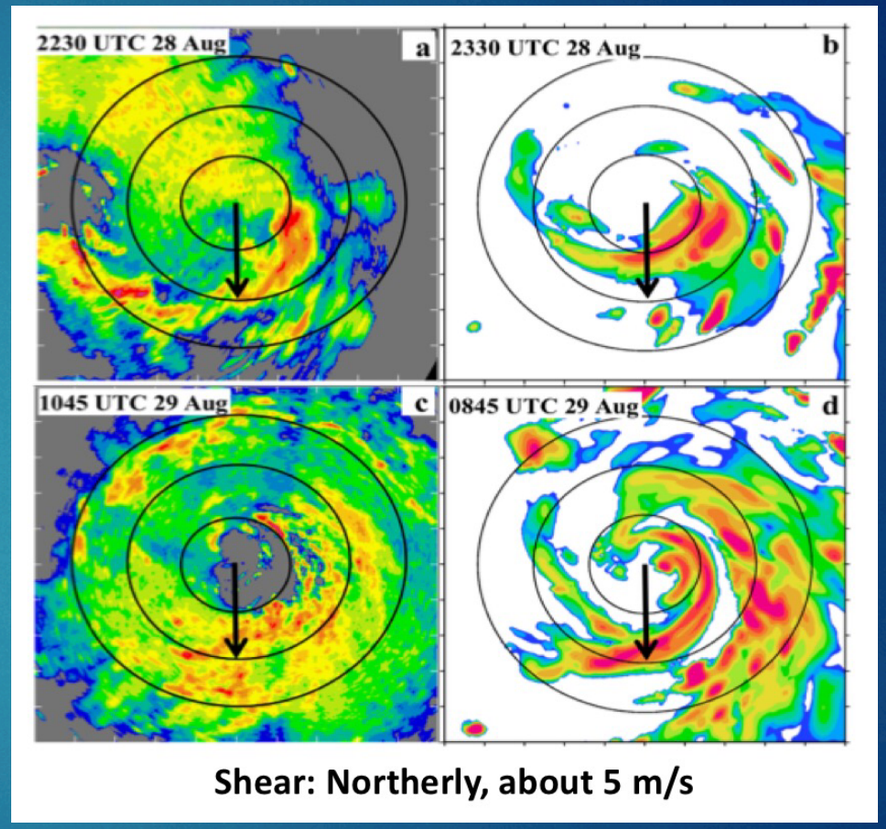
Hurricane Earl (2010): Vortex Tilt and Convection

P-3 Winds | HWRF simulated



Well defined vortex below 5 km and weakly defined circulation aloft, pre-RI. Tilt decreased with improved alignment.

P-3 Lower fuselage | HWRF simulated

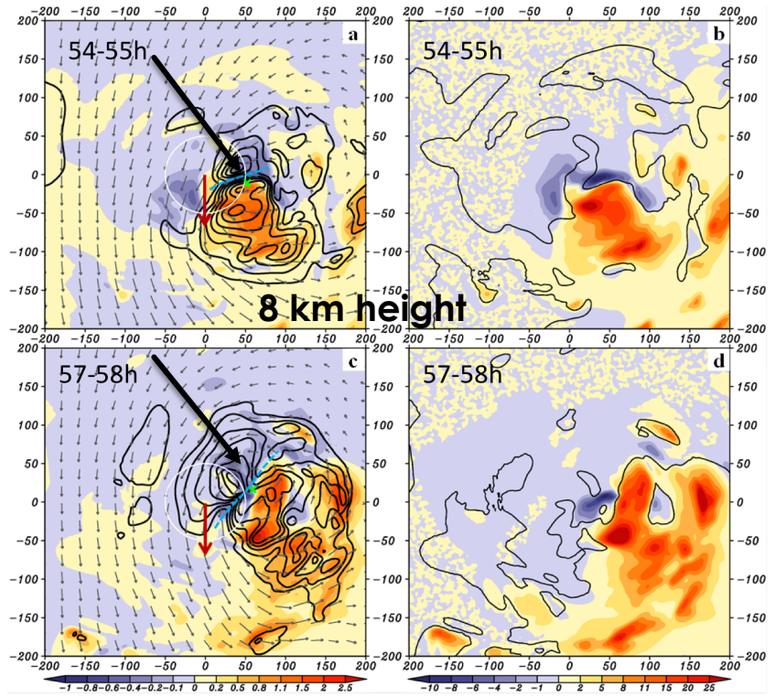


Persistent convection down shear left, pre-RI; Down shear left and up shear left during RI. Convection was asymmetric during RI

Hurricane Earl (2010): Modeled Rapid Intensification

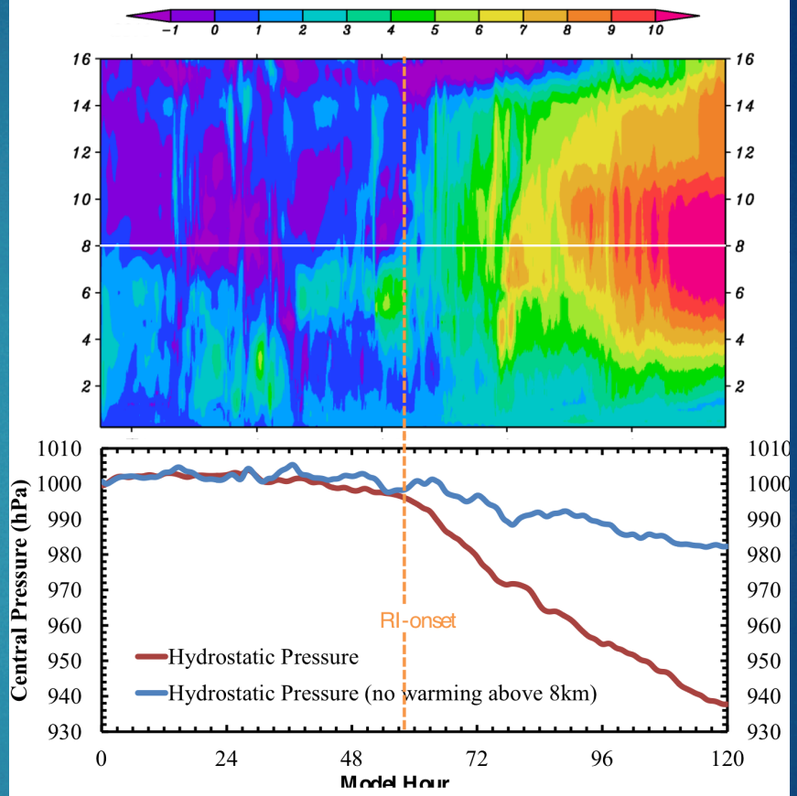
Pre-RI

RI



Shading: vertical motion
Contour: θ’

Shading: dibatic heating k/h
Contour: zero vertical motion

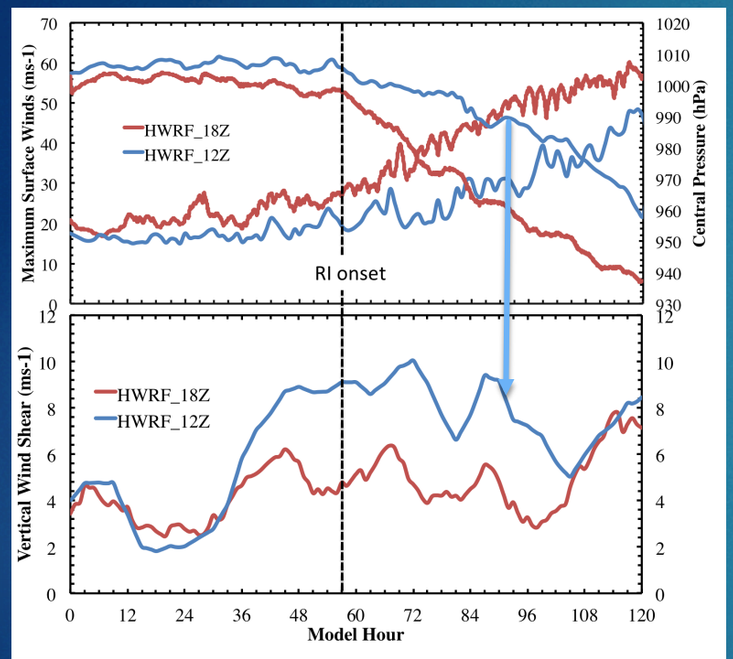


Horizontal advection of potential temperature perturbations associated with downdrafts/subsiding motion in a region of large scale descent. This configuration supports intensification

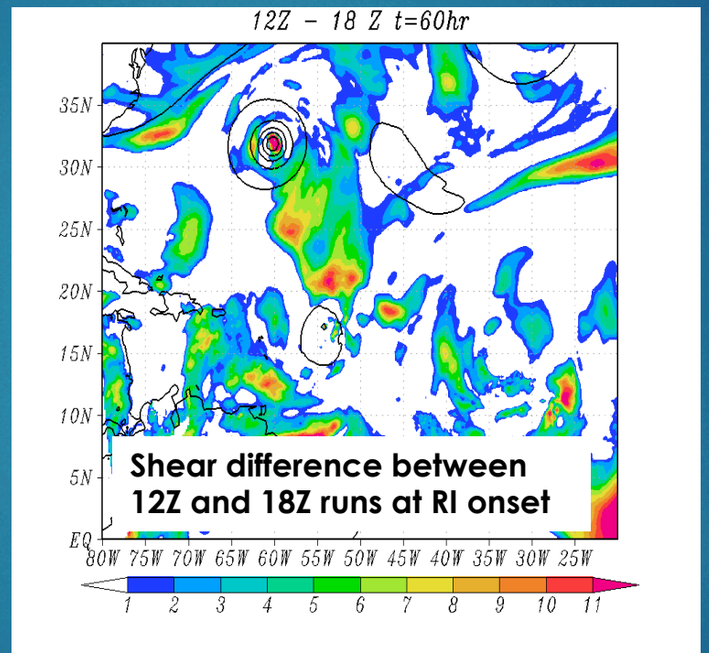
Development of upper level warm core and the associated deepening

RI problem: Importance of Multi-Scale interactions

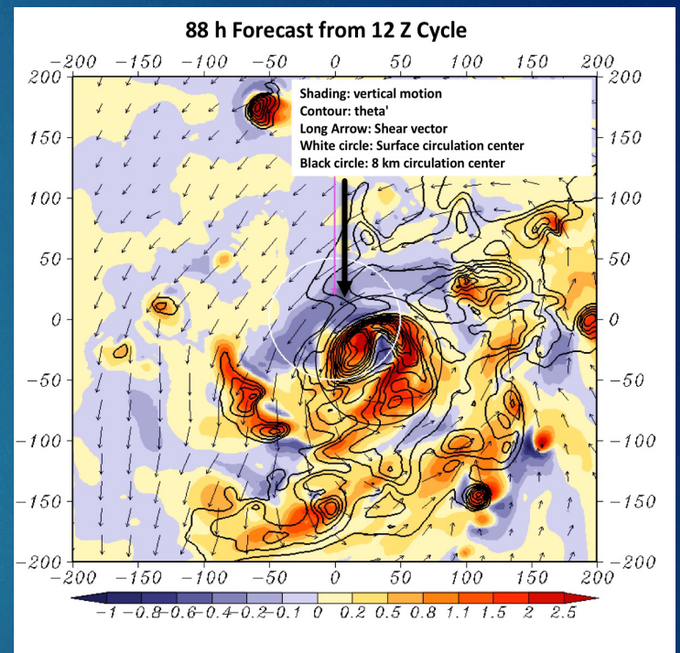
Shear vortex interactions during RI in Hurricane Earl (2010)



Not all forecasts are as good as the 18Z run! The 12Z forecast was not impressive!



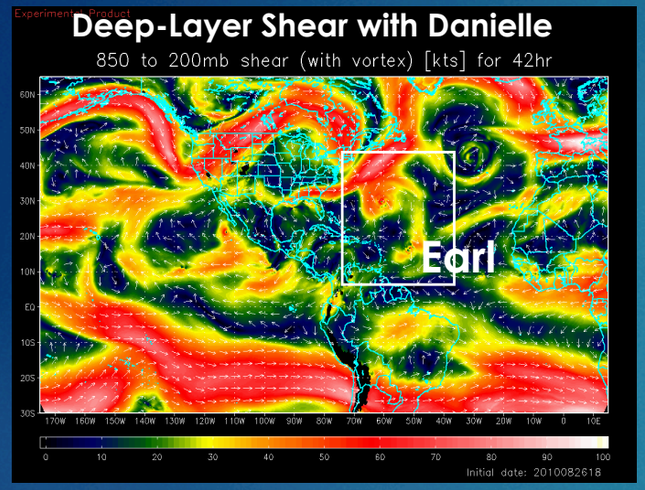
Larger Scale: Higher Shear mostly driven by outflow from Dannielle

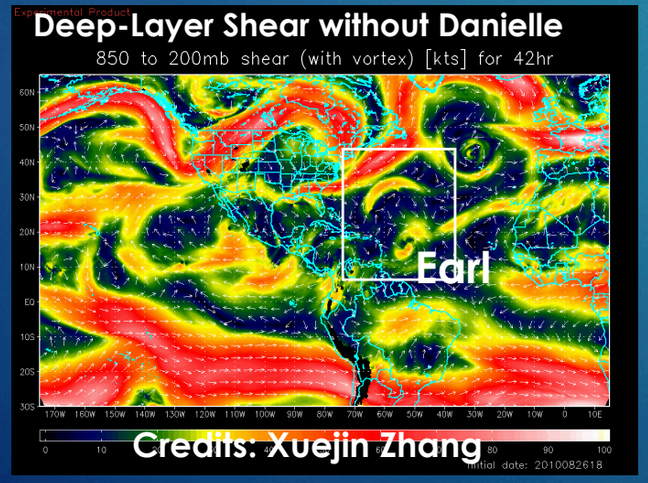


Delayed RI with efficiency reduced due to larger shear. But the favorable configuration for RI still holds good!

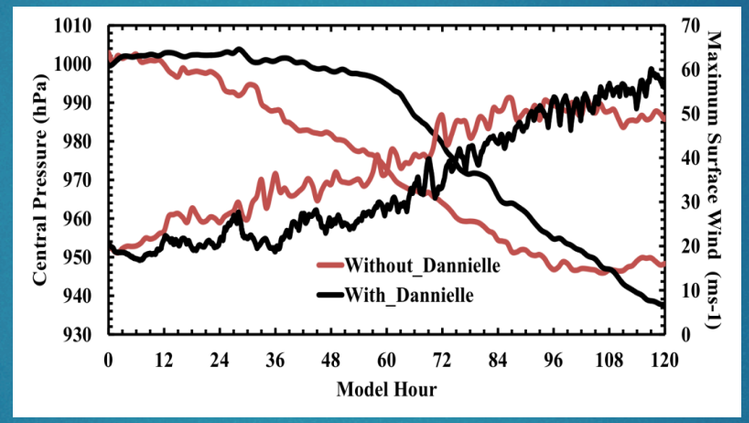
Basin Scale HWRF: Environmental Interactions

Shear vortex interactions during RI in Hurricane Earl (2010)

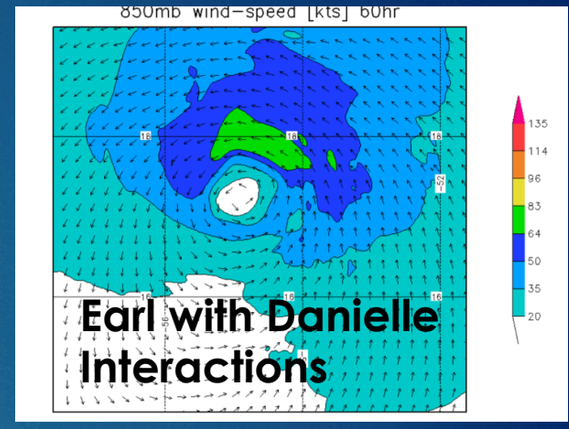


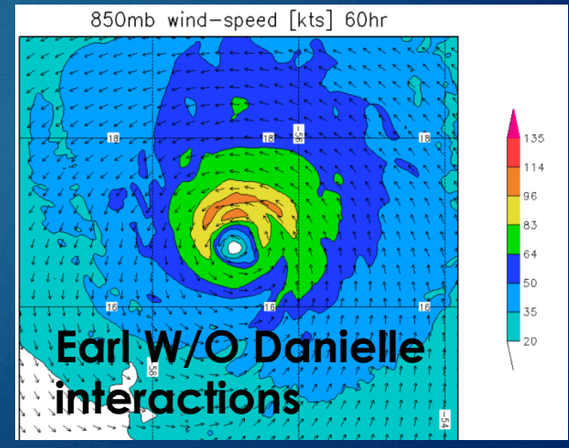


Credits: Xuejin Zhang



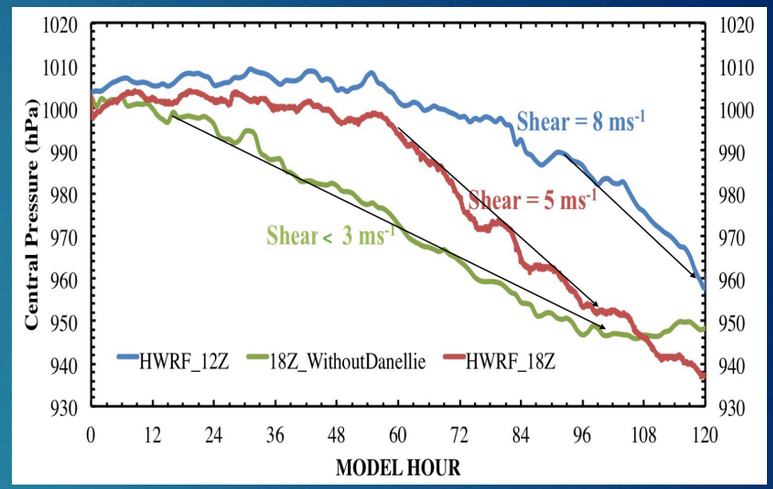
Both large and vortex scale processes are critical for forecasting RI events





Summary & Talking Points

- HWRF reproduces some of the key features observed in sheared storms
- Tracks of all forecasts were consistent.
- Inner core size was nearly the same in all simulations
- All Earl forecasts intensified – less diversity
- Similar analysis for more challenging forecasts is recommended
- Role of moisture vs shear ?
- Observations are key to improve HWRF system
- Is shear an essential ingredient for RI ?



Questions