EMC activities on improving intensity forecast of HWRF via physics improvements

HWRF team at EMC

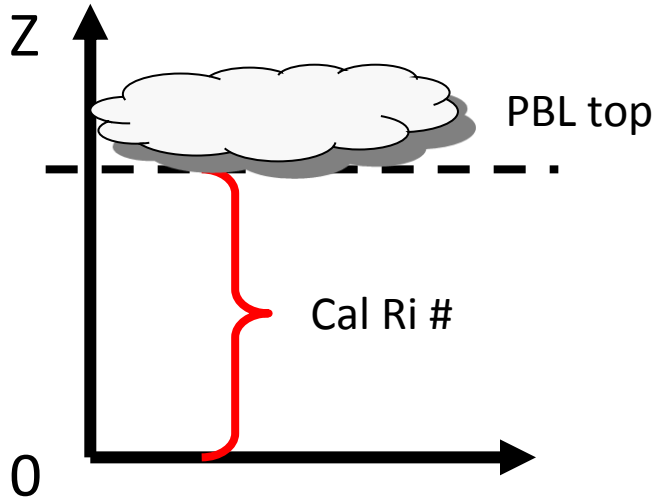
Contents

- **PBL parameterization**
  - revise PBL height in the current HWRF PBL scheme
  - Attempt of incorporating roll vortices effect
- **Radiation**
  - RRTMG
- **Convection**
  - SAS scheme for finer resolution
- **Idealized experiments**
  - Sensitivity tests on convection at d03, H. diffusion & NPHY

Revise PBL Height calculation in GFS PBL scheme

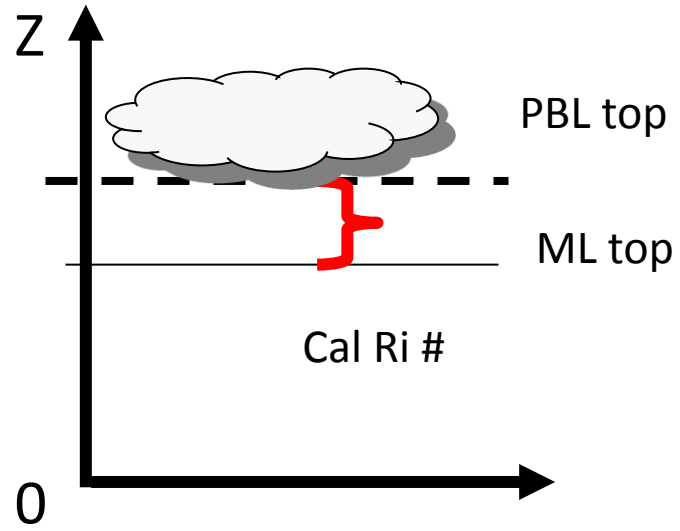
Current scheme

$$pblh = Ric\ \frac{\theta_{va}\,|U(h) - U(0)|}{g(\theta_v(h) - \theta_s)}$$

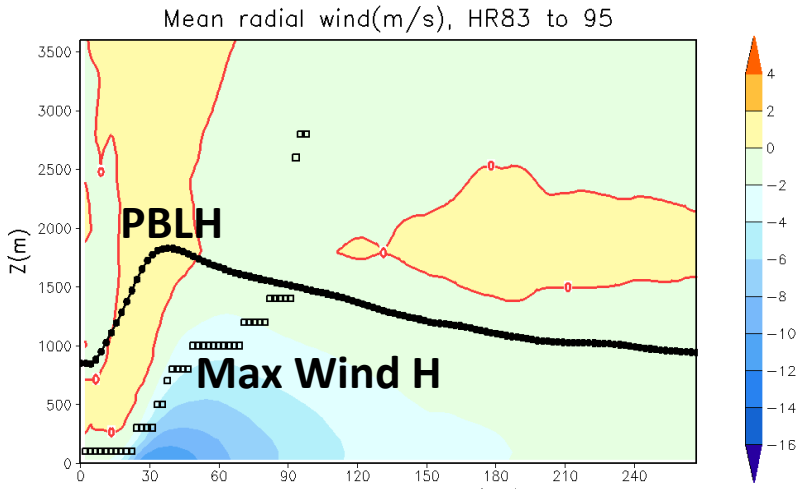


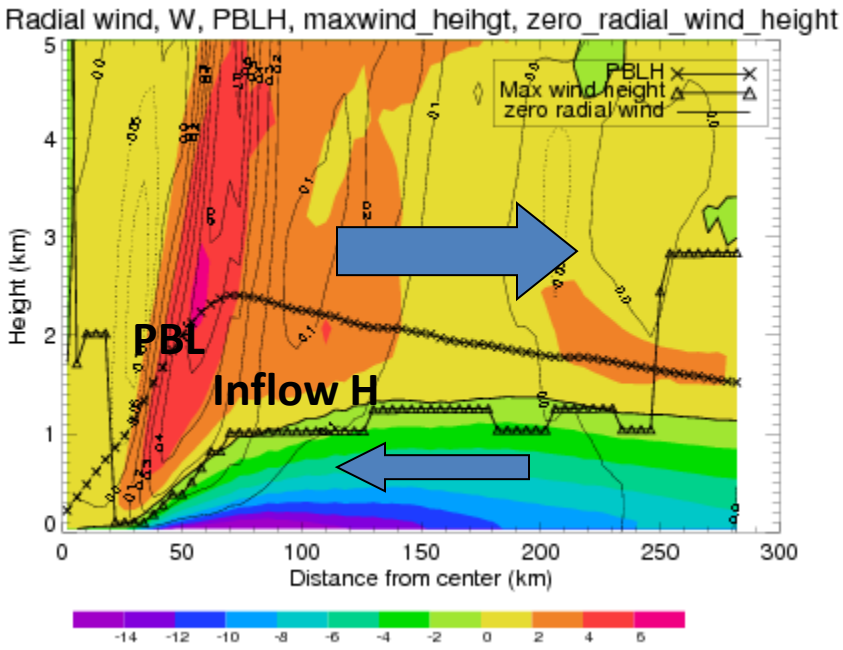
Revised method

$$pblh = Ric\ \frac{\theta_{va}\,|U(h) - U(m)|}{g(\theta_v(h) - \theta_m)}$$

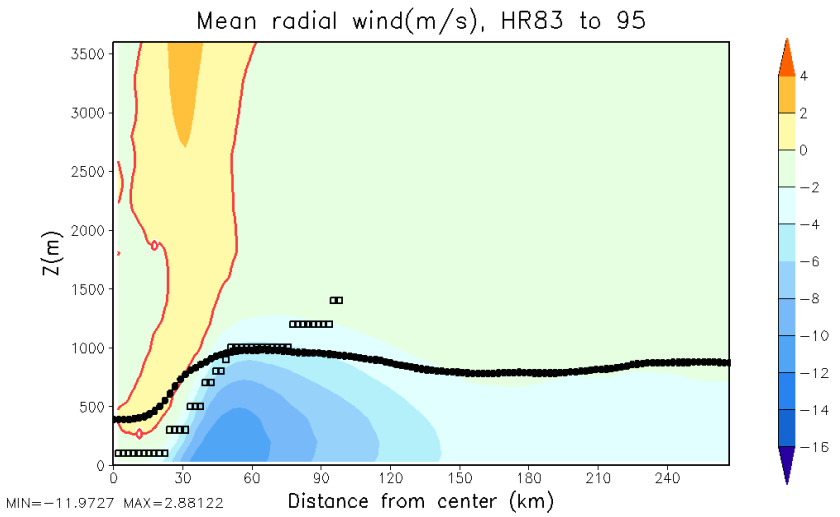


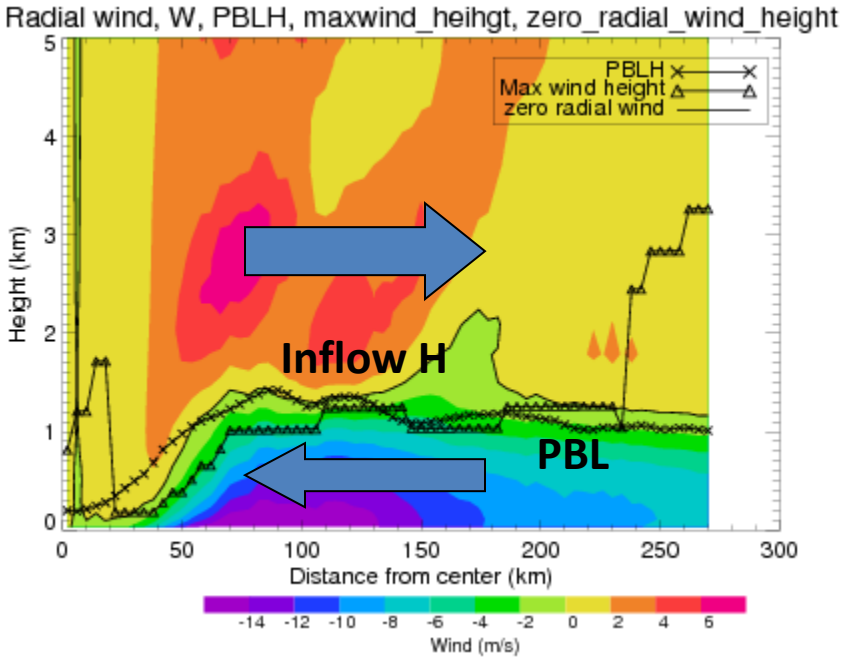
Original PBL h





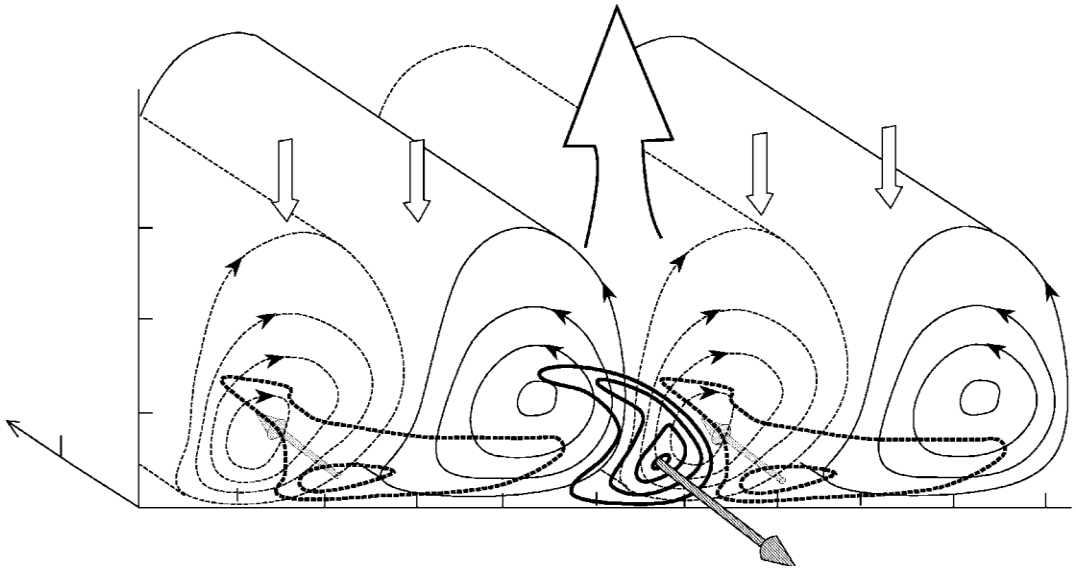
Revised PBL h





Incorporation of roll effects in hurricane boundary layer

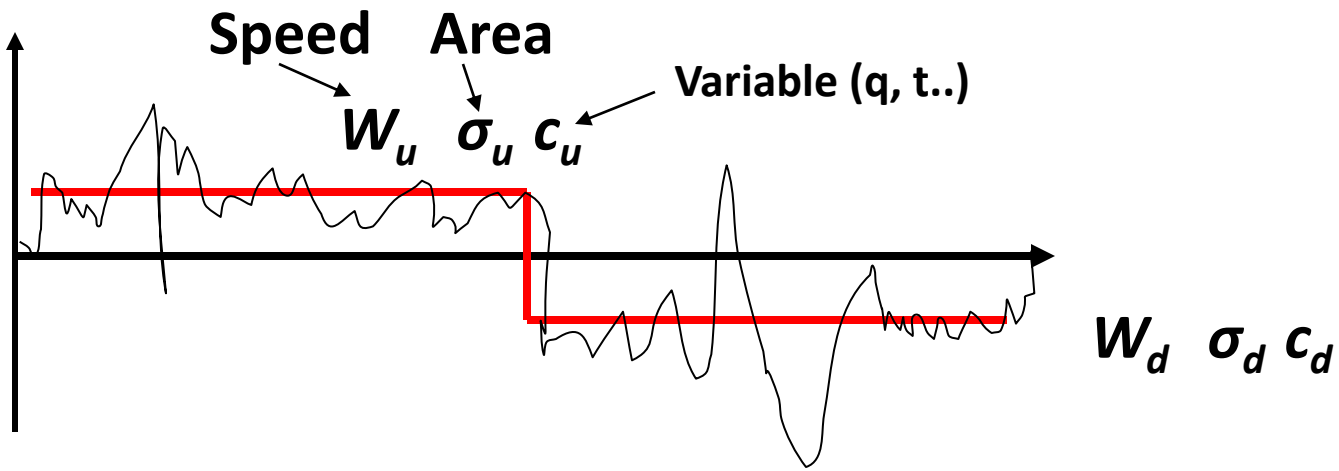
Local schemes, like MYJ, seems appropriate in highly sheared hurricane PBL but need to add roll to accommodate strong mixing



Wavelength: Larger-scale structures ~ 700 to 5000 m
Smaller-scale structures ~ 300 to 700 m
Velocity Perturbations: +/- 7 m/s typical
Orientation: Typically along-mean TCBL wind, wide variability Prevalence: Roll-scale structures ~ unknown

From Ralph Foster's slides

A conceptual model for roll-mixing flux



$$[w'c']_{ROLL} = \sigma_u(w_u - \overline{w})(c_u - \overline{c}) + \sigma_d(w_d - \overline{w})(c_d - \overline{c})$$

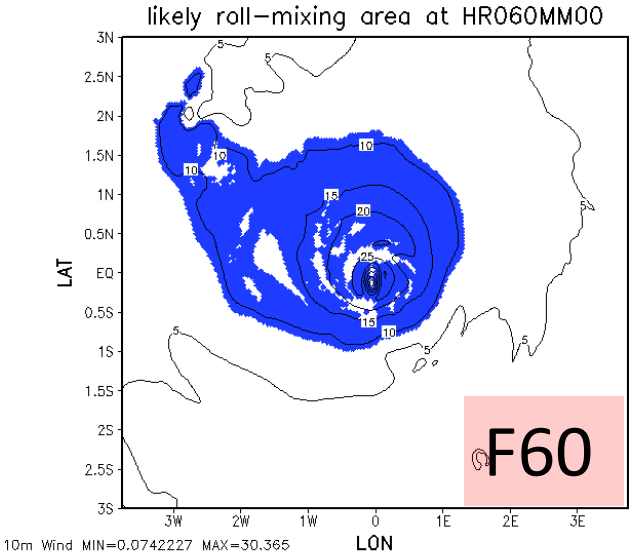
Assume no mass lost $\longrightarrow$ $\sigma_u(w_u - \overline{w}) + \sigma_d(w_d - \overline{w}) = 0$

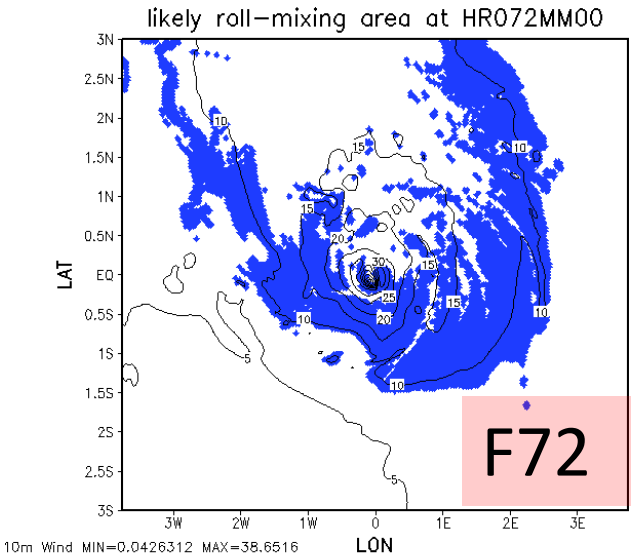
$$\sigma_u + \sigma_d = 1$$

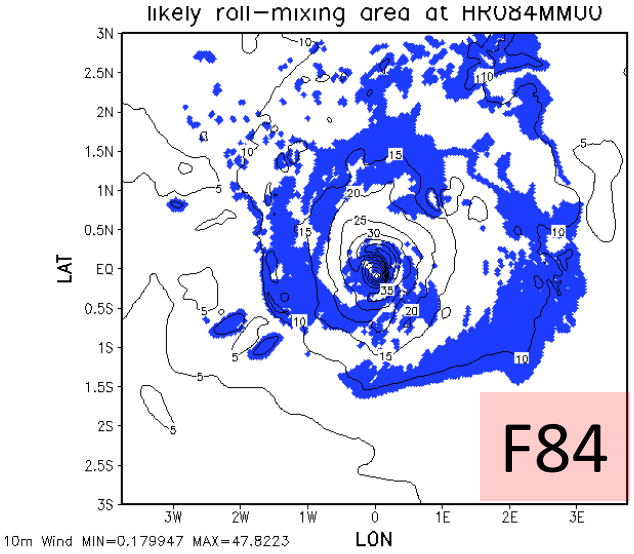
$$[w'c']_{ROLL} = \sigma_u(w_u - \overline{w})(c_u - c_d)$$

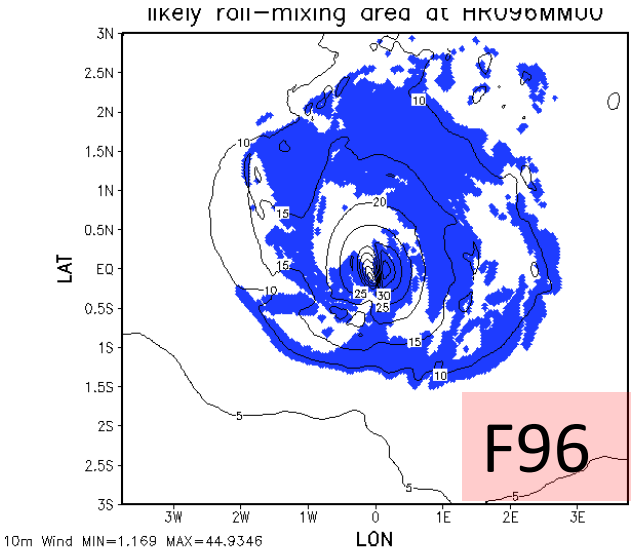
References: Lappen 2005, Siebesma2007, Zhu 2008 etc.

Likely Roll-mixing areas (shaded) based on Z/L, U(10m)
(Etling and Brown, 1993)









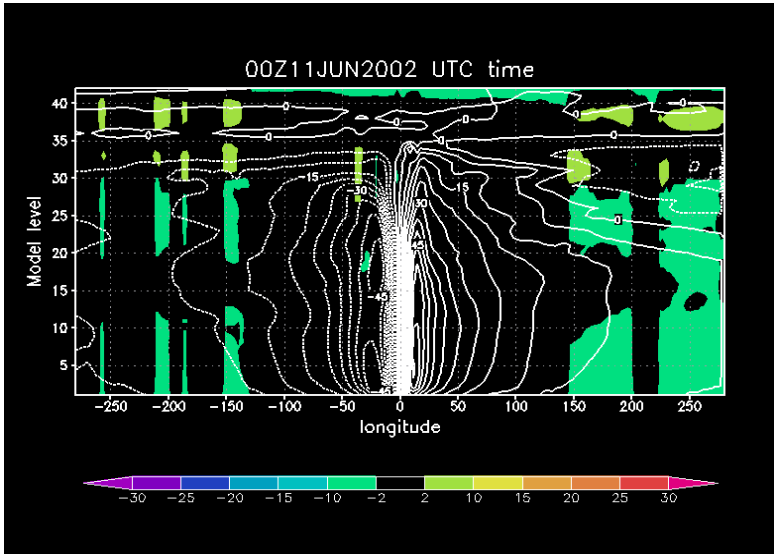
Ongoing work

1. 1D HWRF PBL test, GFSPBL, MYJPBL
   test roll effects, and HPBL height

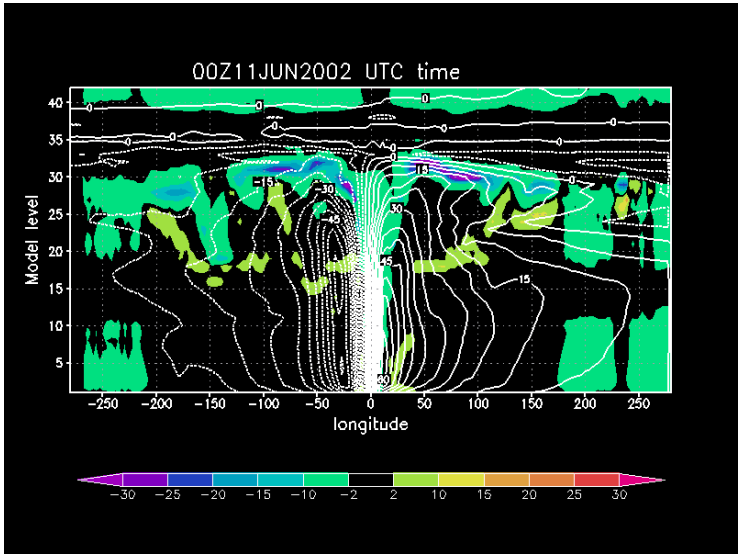
2. 3D test, MYJPBL + roll

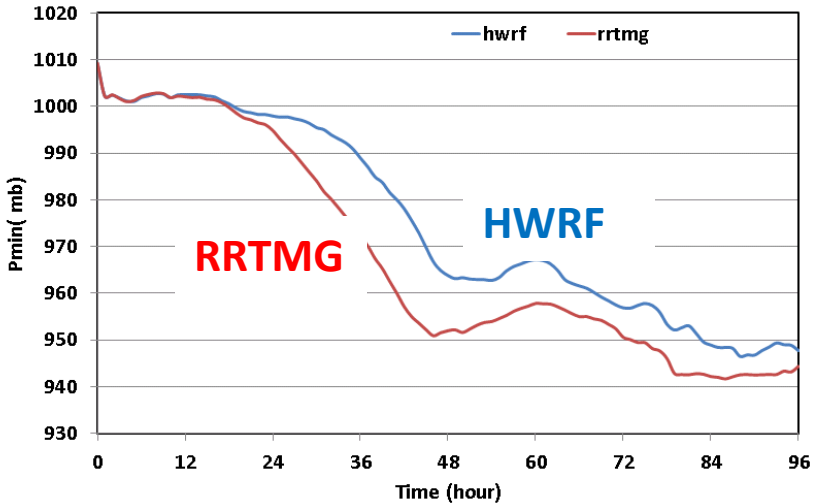
RRTMG radiation

HWRF radiation package

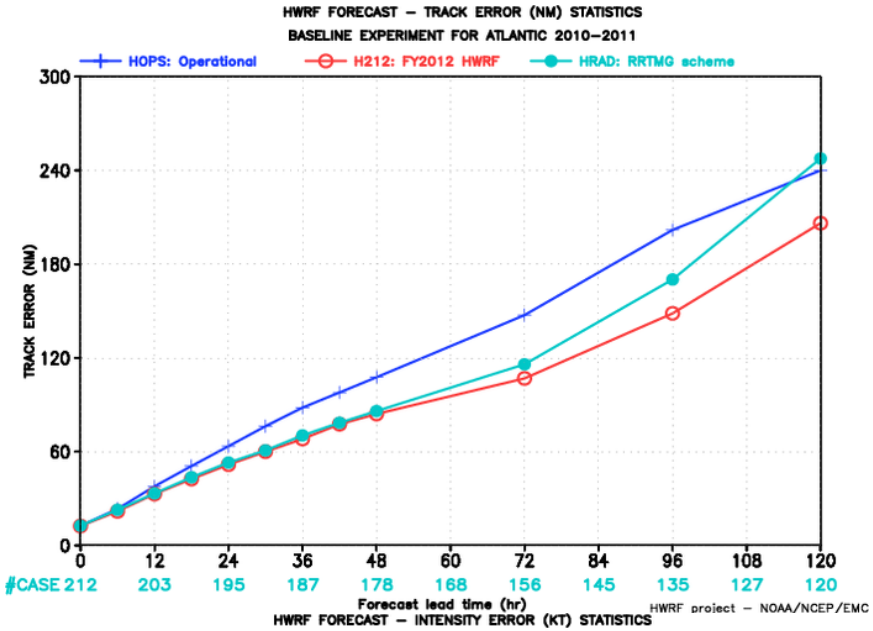


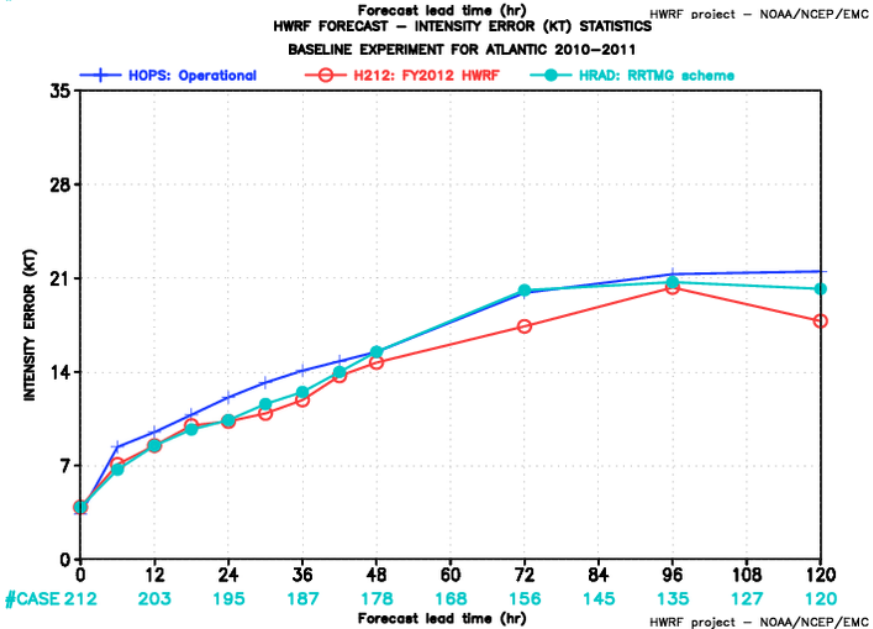
RRTMG radiation package

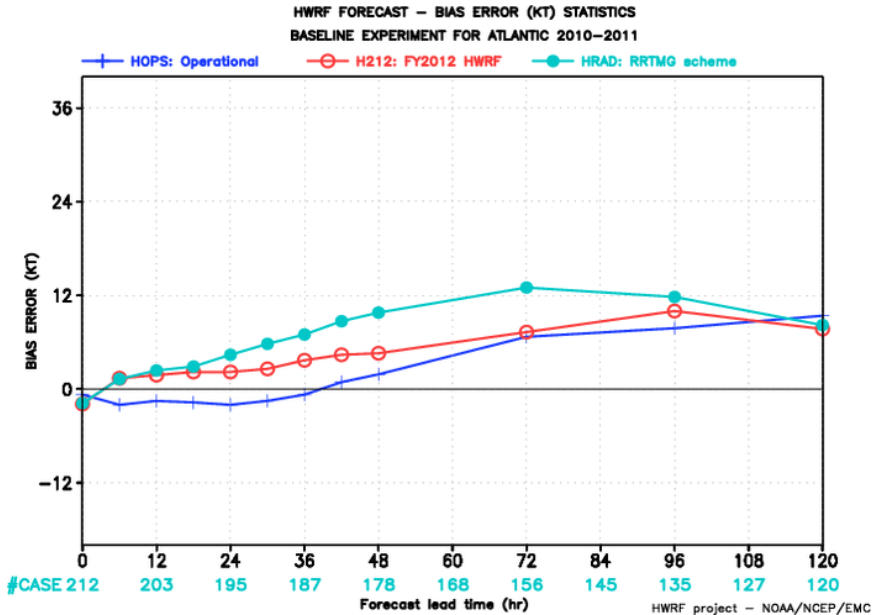




Initial results: track/intensity

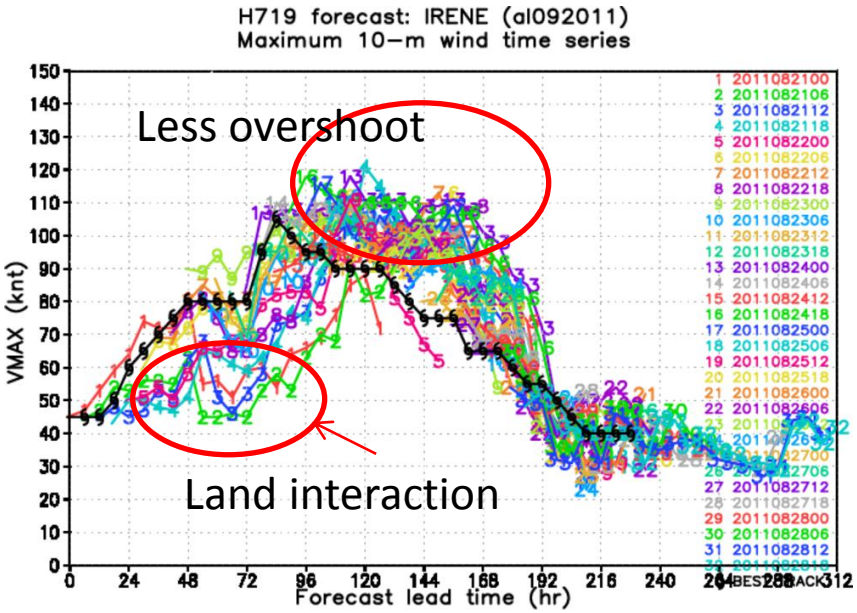




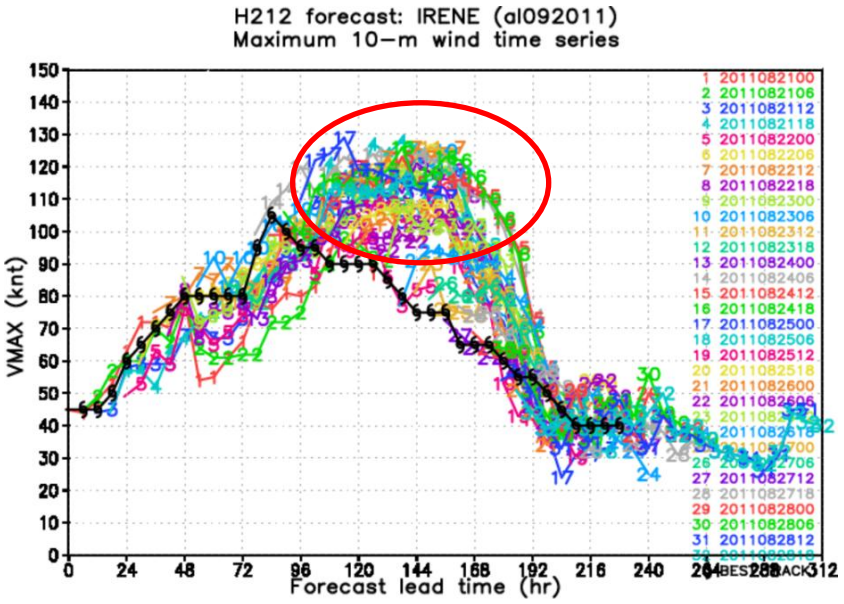


Preliminary results of SAS convection scheme for high resolution

Revised SAS

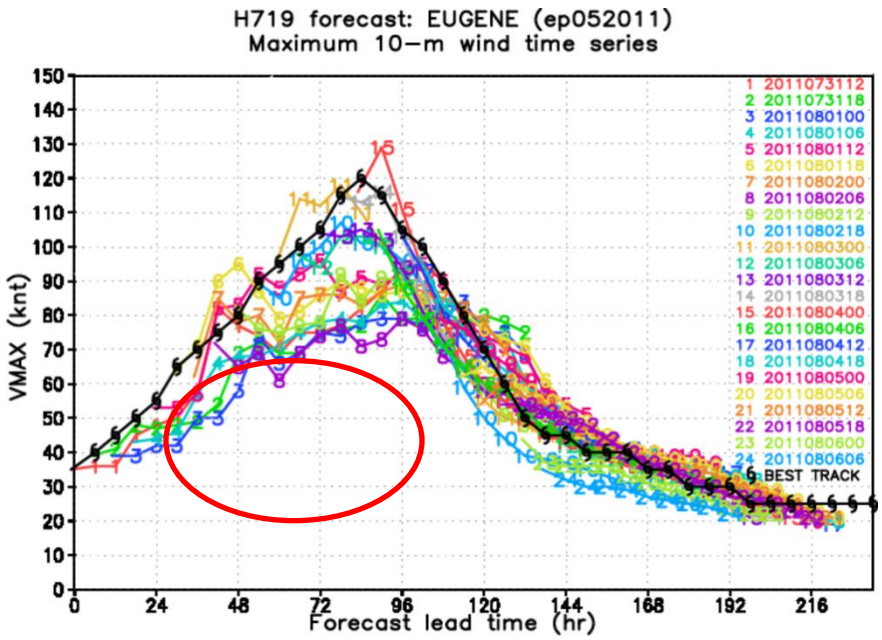


OPR HWRF

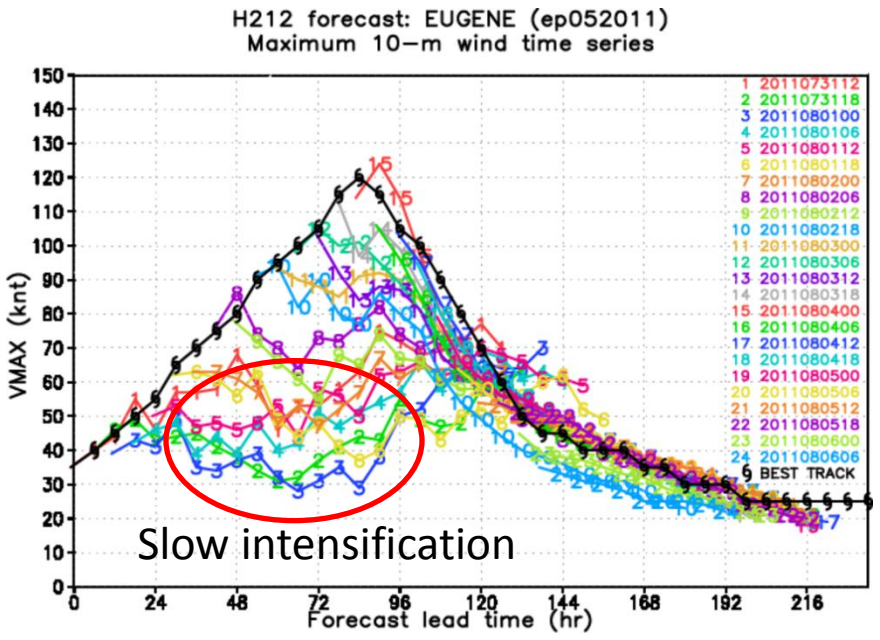


Hurricane Irene (2011)

Revised SAS



OPR HWRF

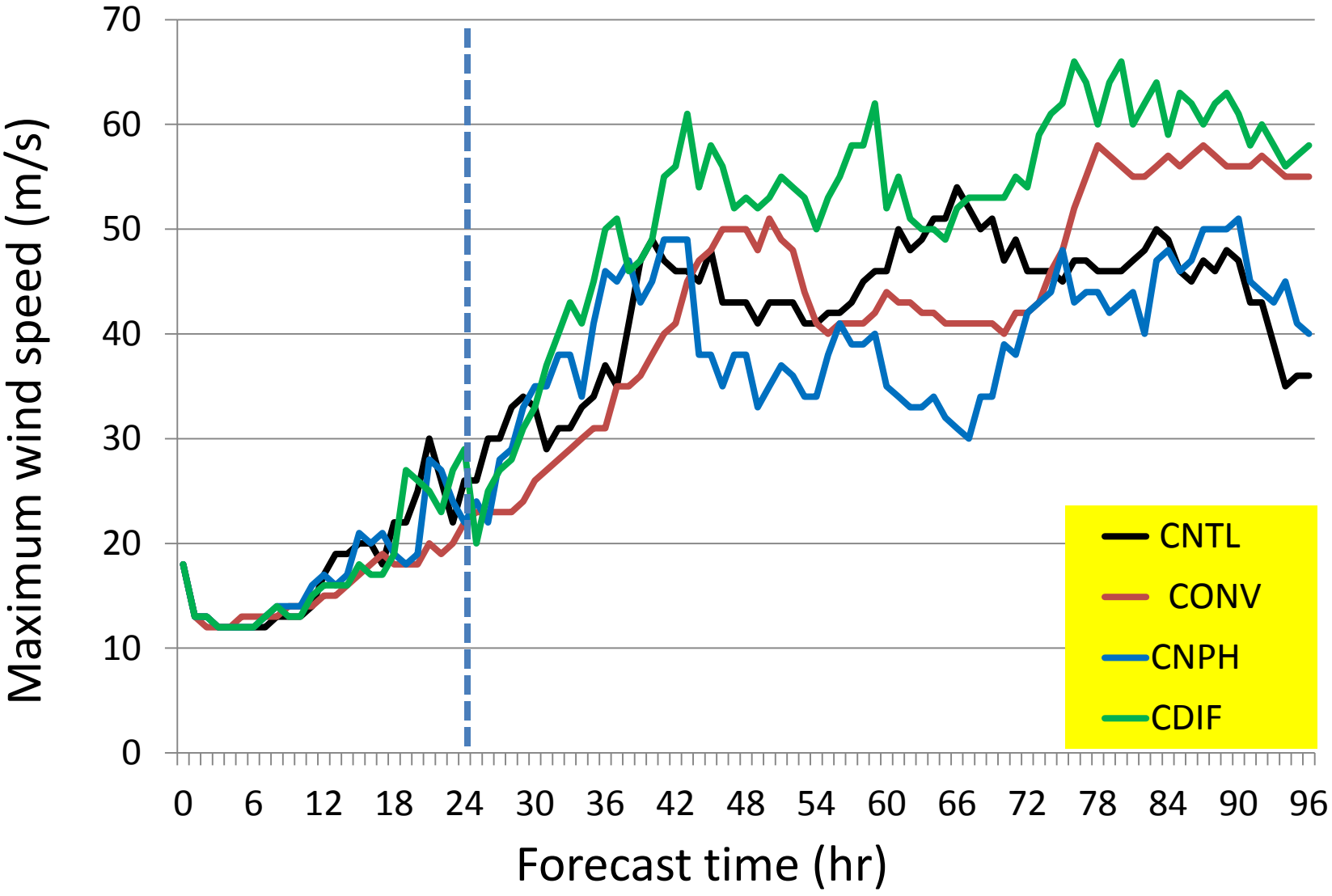


Hurricane Eugene (2011)

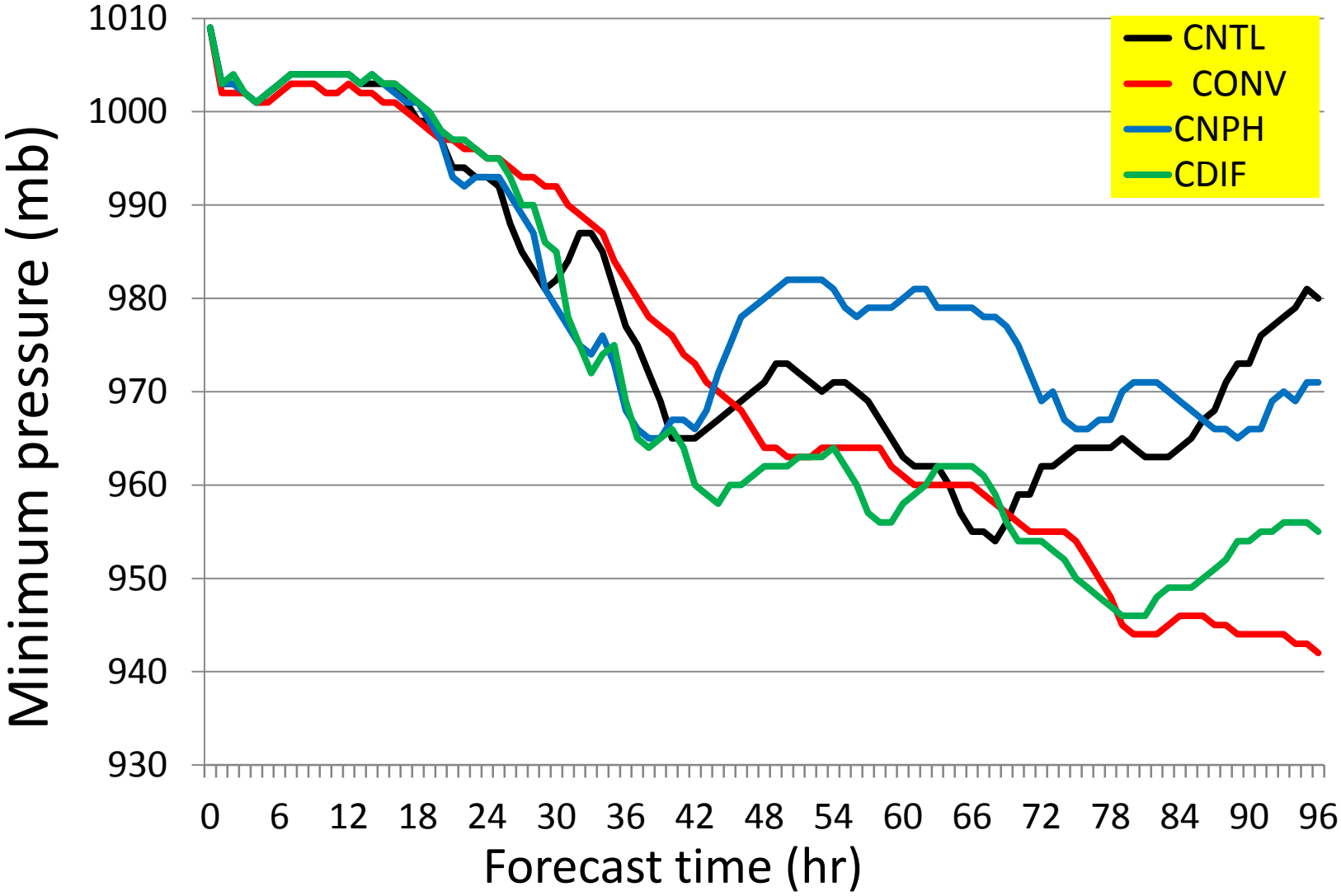
Sensitivity tests on convection at d03, physics calling frequency and horizontal diffusion

	Convection in D03	Physics calling frequency	Horizontal diffusion (COAC)
CNTL	OFF	3 mins	0.75, 3, 4
CONV	***ON***	3 min	0.75, 3, 4
CNPH	OFF	***45 sec***	0.75, 3, 4
CDIF	OFF	3min	***0.75, 0.75, 0.75***
CONP	***ON***	***45sec***	0.75, 3, 4
CODF	***ON***	3min	***0.75, 0.75, 0.75***
NPDF	OFF	***45sec***	***0.75, 0.75, 0.75***
CNDF	***ON***	***45sec***	***0.75, 0.75, 0.75***

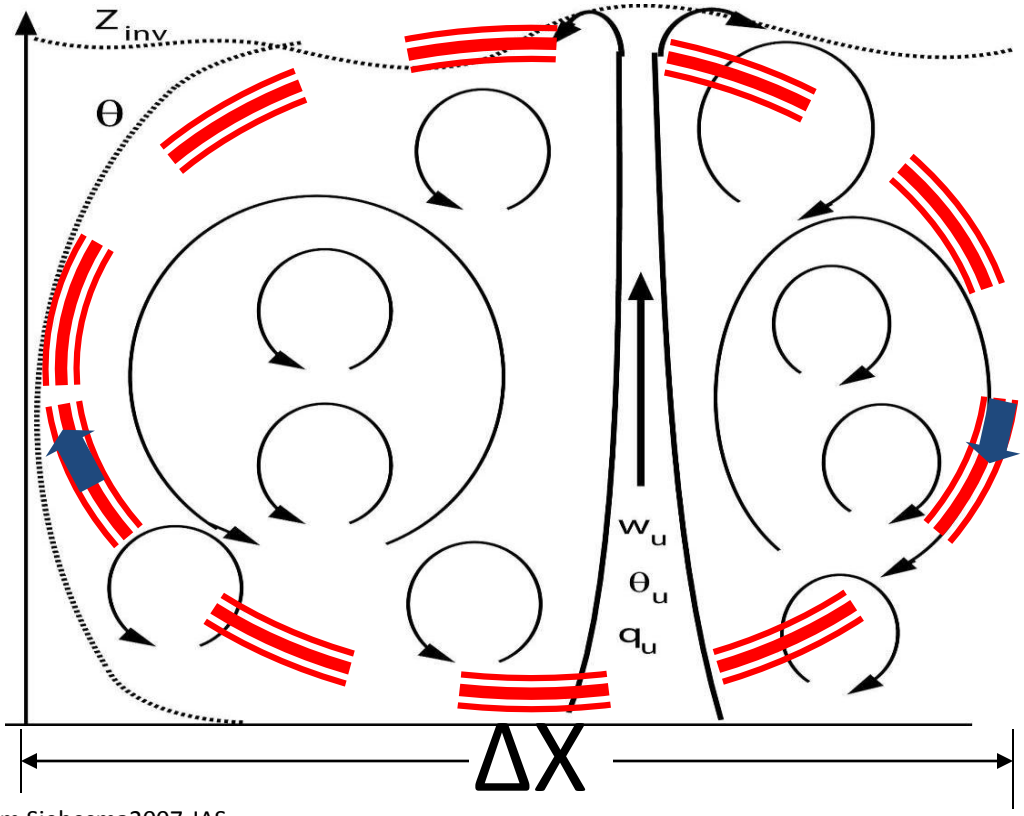
HWRF idealized vortex experiments



HWRF idealized vortex experiments



Sub-grid flux treatment



Modified from Siebesma2007 JAS

Small eddies:

Local scale, Random

Strong-convection:

highly skewed *w*,
strong/narrow updraft
weak/large downdraft
heat-flux

Roll- organized

less skewed,
similar area/strength up- and down-draft.

$$FLUX = [w'c']_{Small} + [w'c']_{Strong-conv} + [w'c']_{ROLL}$$

Mixing/transport by different sub-grid eddies

Eddies	w-skewness	Updraft	Downdraft	Treatment
Small	No	Random	Random	Local
Strong convection	Highly skewed	Strong + Small area	Weak + large area	Updraft nonlocal
Roll organized Weak conv	Less skewed	Similar strength & area	Similar strength & area	Down- & up-draft nonlocal

$$FLUX = [w'c']_{Small} + [w'c']_{Strong-conv} + [w'c']_{ROLL}$$