High-Res Physics Tiger Team Report

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[1]IMSG/EMC
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3 driving agents

Realism

- Better portray the physical processes that parameterizations represent
- Attribution (idealized simulations)

Model biases/problems

Identify/understand/eliminate

- Positive intensity bias of weak storms & negative intensity bias of strong storms
- Secondary eyewalls
- Too large Radius of Maximum Winds
- Heat flux bias as reported by Joe Cione

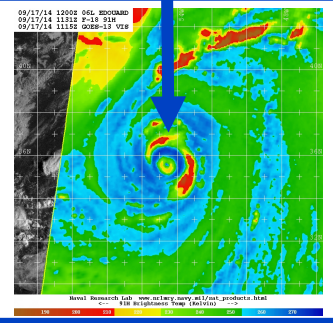
Modeling interests

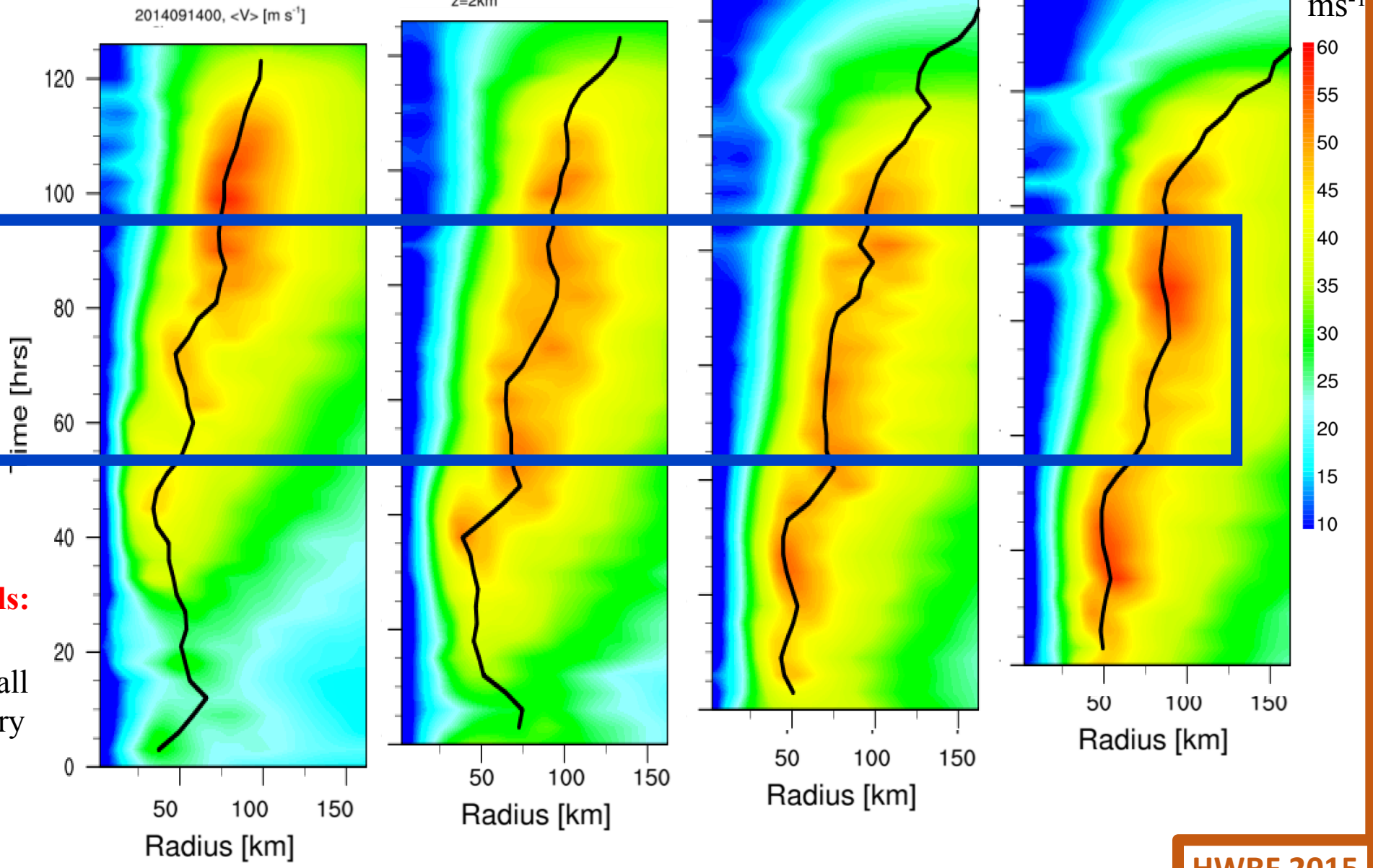
- Consistency with large scale models

  Tuning imported parameterizations
- Scale aware physics
- Stochastic parameterizations

Edouard (2014), 09/14

Evidence of Secondary Eyewall in nature





HWRF 2015 Secondary eyewalls:

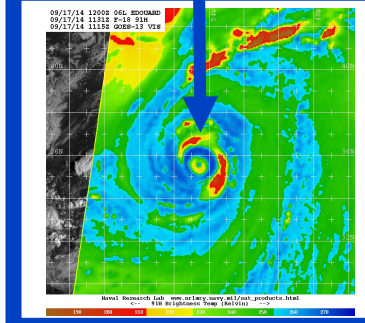
a) Rare

b) Too close to the primary eyewall

c) Too quick to replace the primary eyewall

Edouard (2014), 09/14

Evidence of Secondary Eyewall in nature



2014091400, <V> [m s^{-1}]
z=2km

2014091406, <V> [m s^{-1}]
z=2km

2014091412, <V> [m s^{-1}]
z=2km

2014091418, <V> [m s^{-1}]
z=2km

Time [hrs]

0 20 40 60 80 100 120

50 100 150
Radius [km]

ms^{-1}

10 15 20 25 30 35 40 45 50 55 60

HWRF 2016 Secondary eyewalls:

a) Common in storms that exhibit them in nature e.g. Edouard 2014, Blanca 2015, Matthew 2016

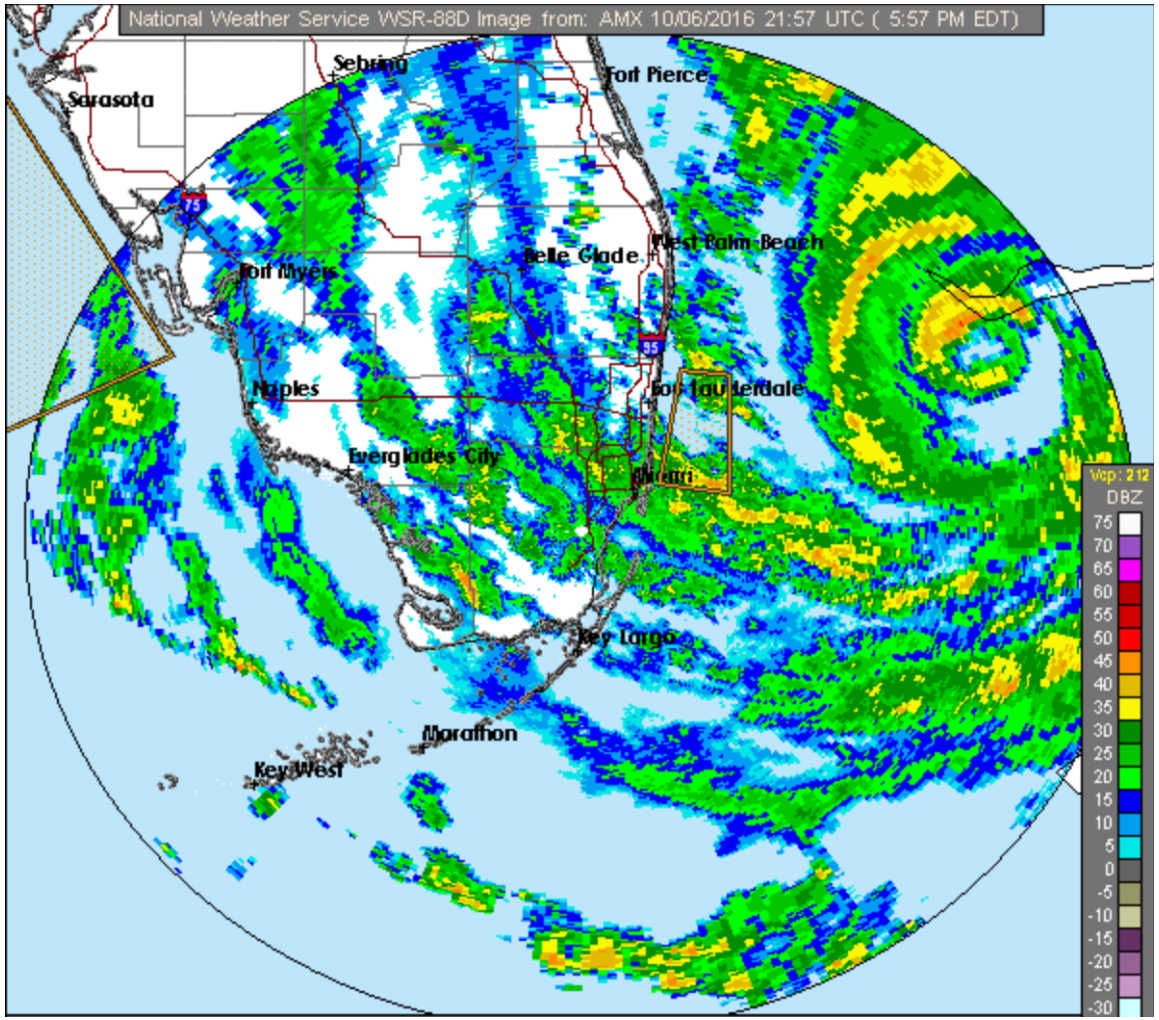
b) Often with realistic radius and evolution

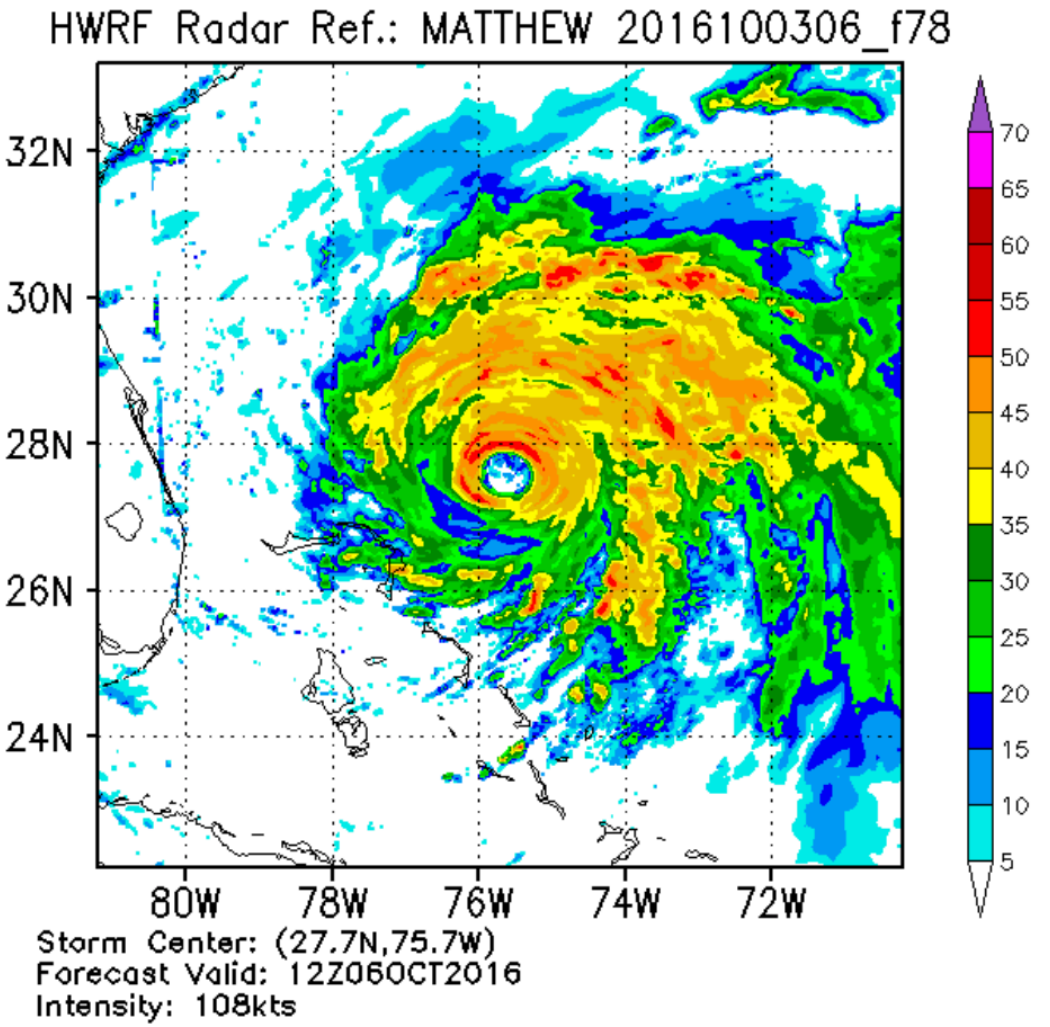
Matthew (2016)

Operational cycles:

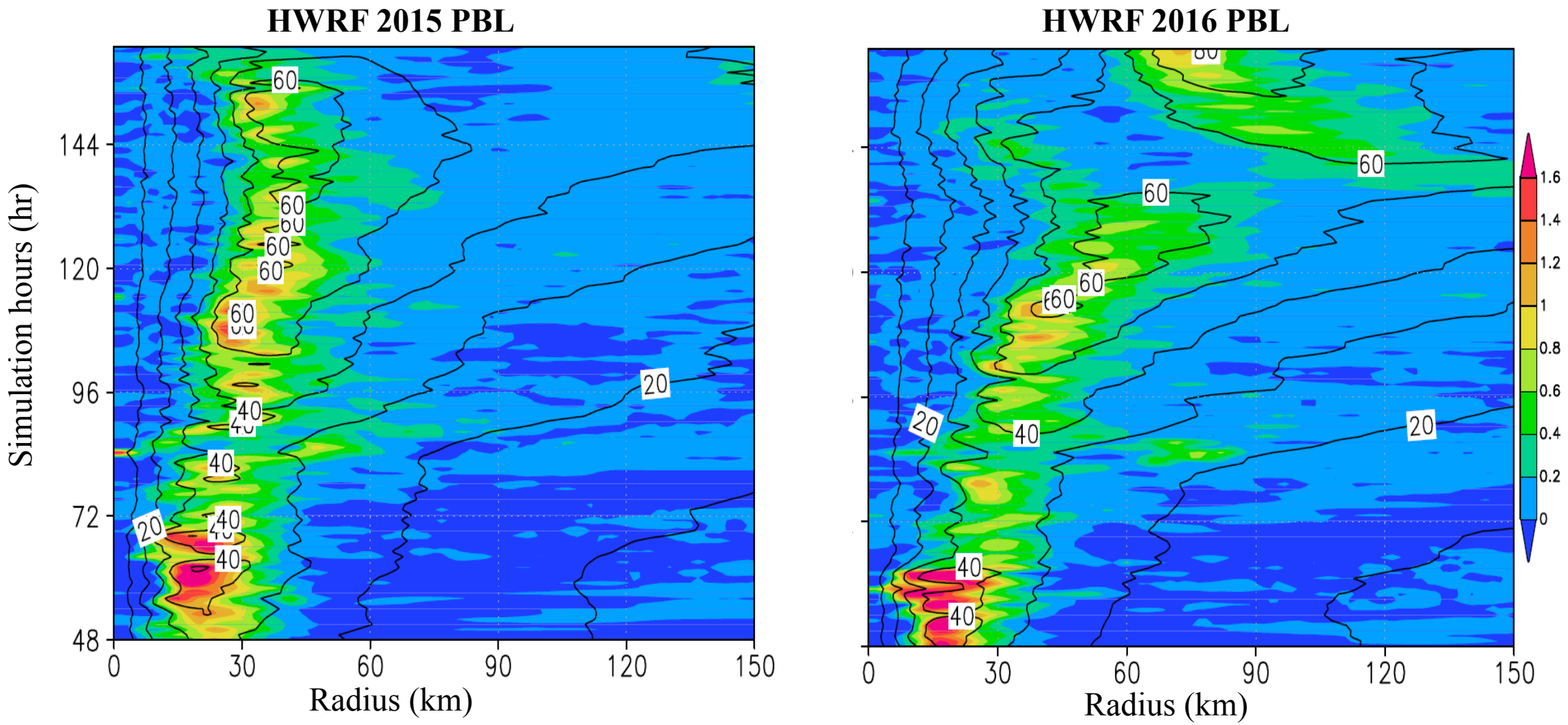
-September 28-31, **~30% of the cycles show a SE** towards the end of the integration

-October 01-05, **~80% cycles show SE & ERC**





Identical idealized simulations except for the PBL parameterization



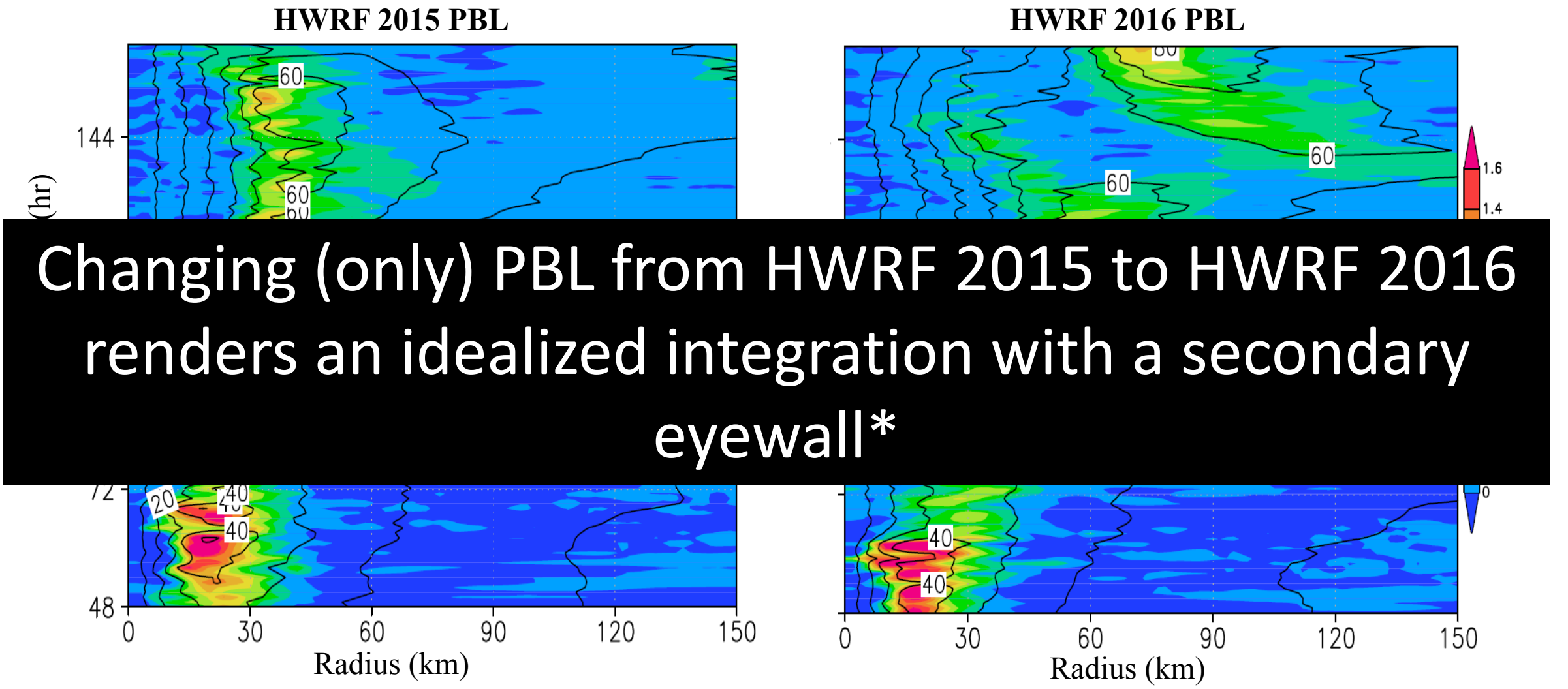
Vertical velocity- color, m s^{-1}

Tangential velocity-contours, m s^{-1}

z=1km

Lin et al

Identical idealized simulations except for the PBL parameterization



Changing (only) PBL from HWRF 2015 to HWRF 2016 renders an idealized integration with a secondary eyewall*

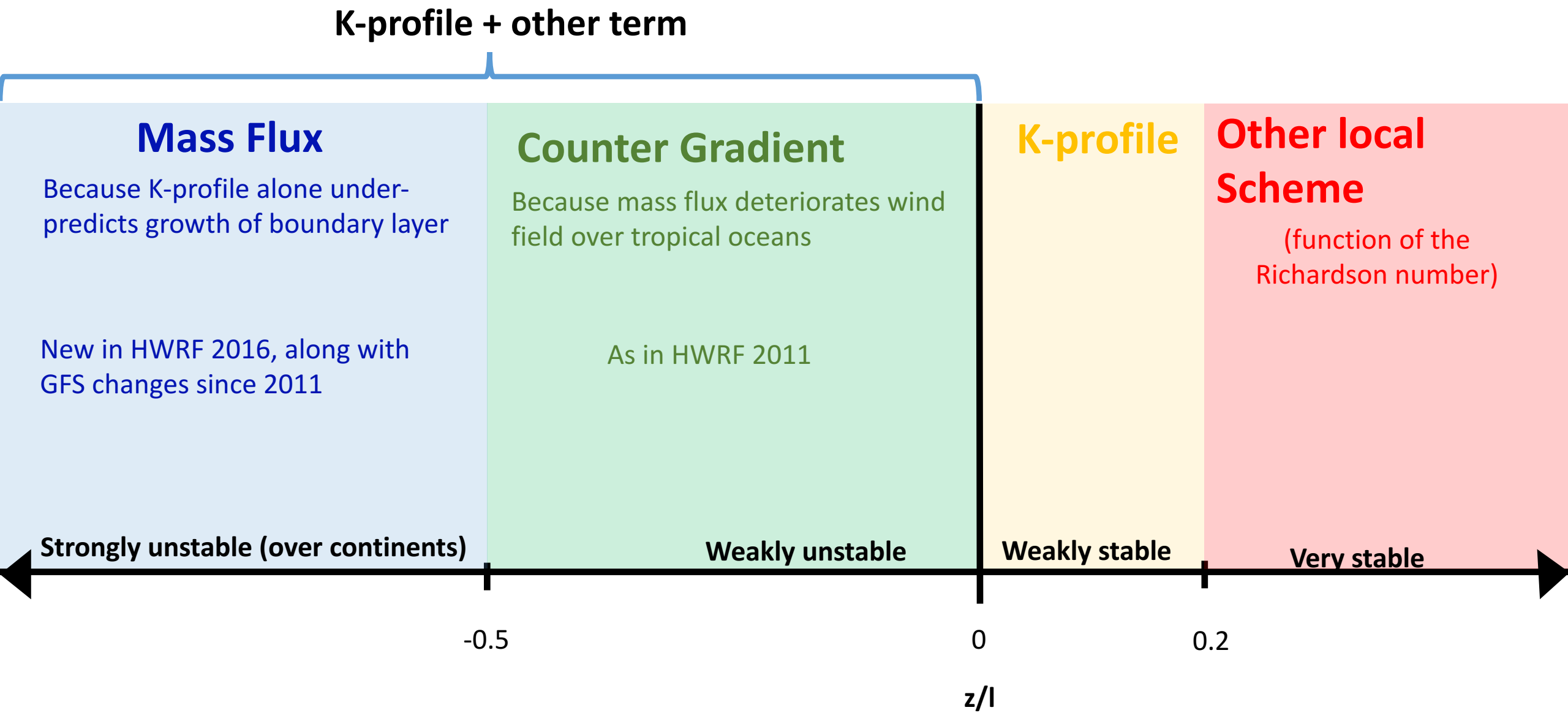
Vertical velocity- color, m s^{-1}

Tangential velocity-contours, m s^{-1}

z=1km

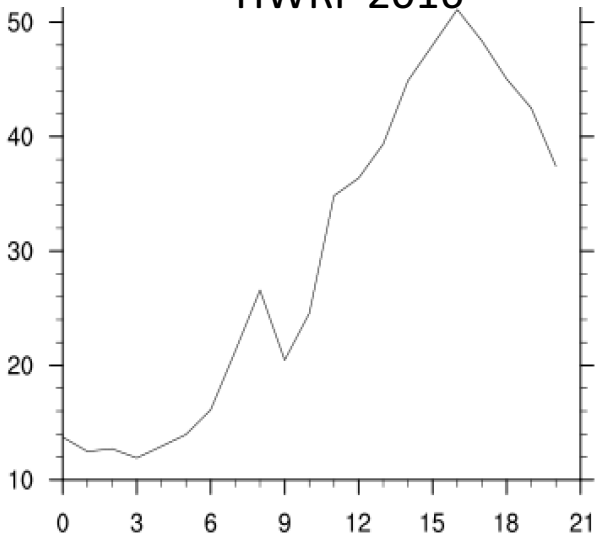
Lin et al

HWRF 2016, “Hybrid” PBL

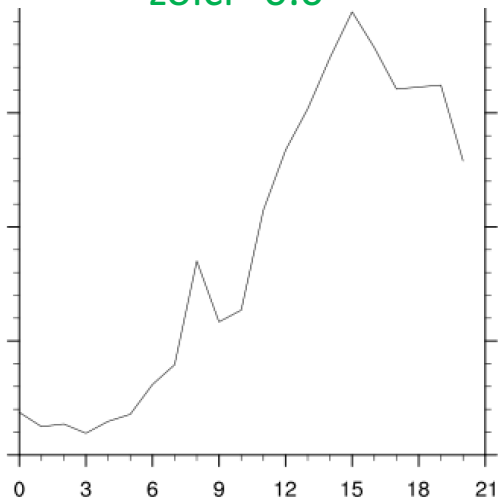


Experiment initialized on 2016072912

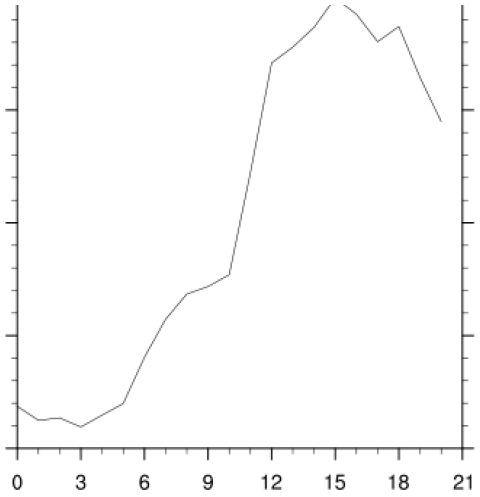
HWRF 2016



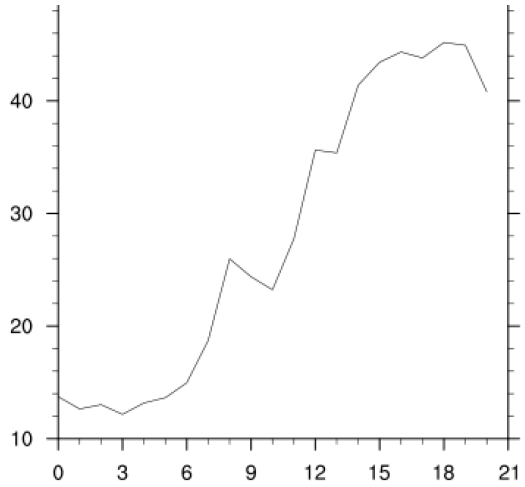
zolcr=0.0



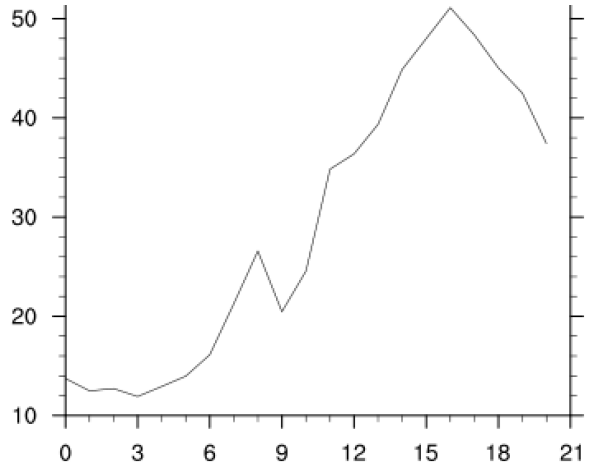
zolcru=-100.0



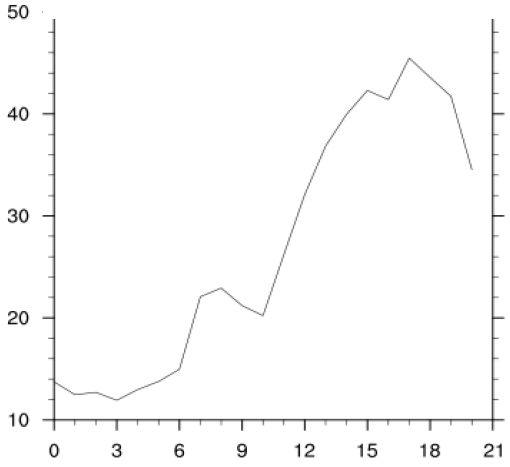
zolcru=0.0



THRATEN=0



disheat=False



Vmax @ 10m height, ms^{-1}

Time, 6-hourly output

Sensitivity to:

zolcru=0/100, make all/non unstable grid points EDMF

zolcr =0, make all stable atmosphere K-profile

THRATEN=0, disable radiative feedback with PBL clouds

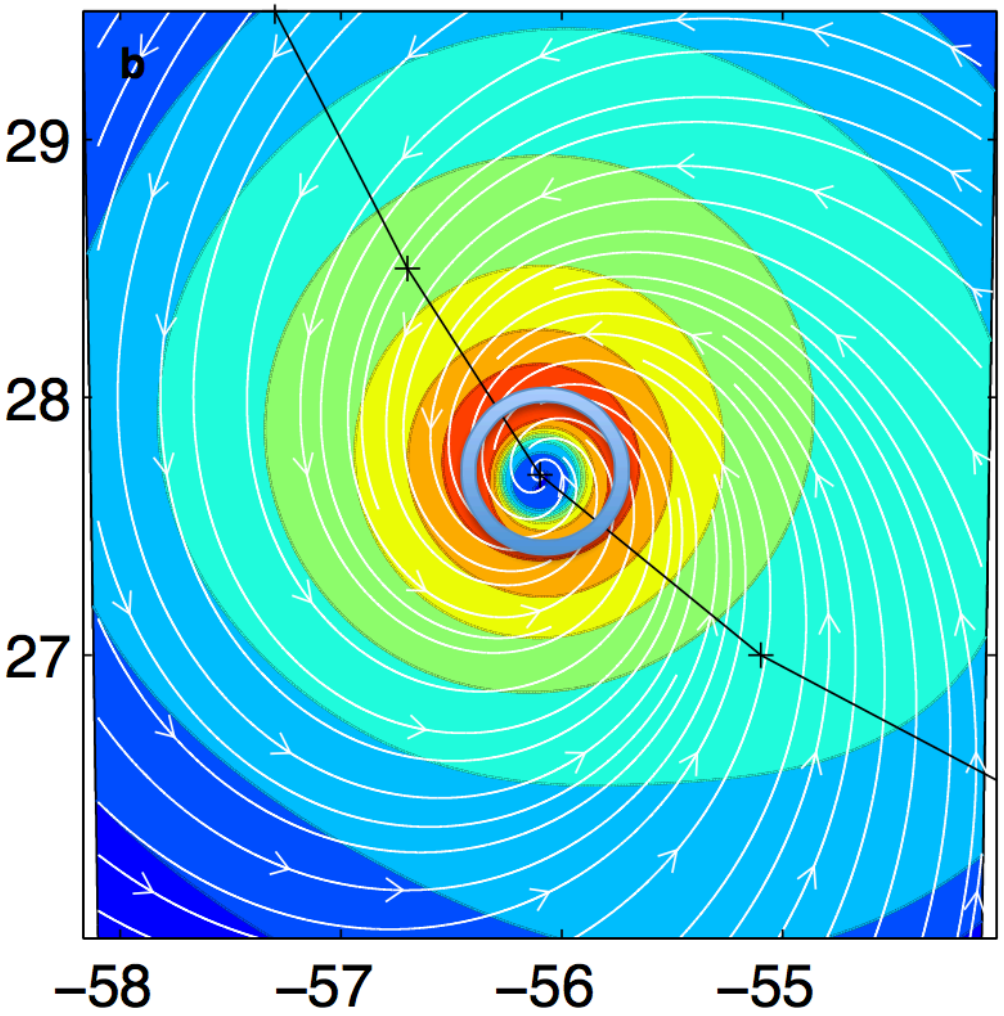
disheat =False, disable dissipational heating

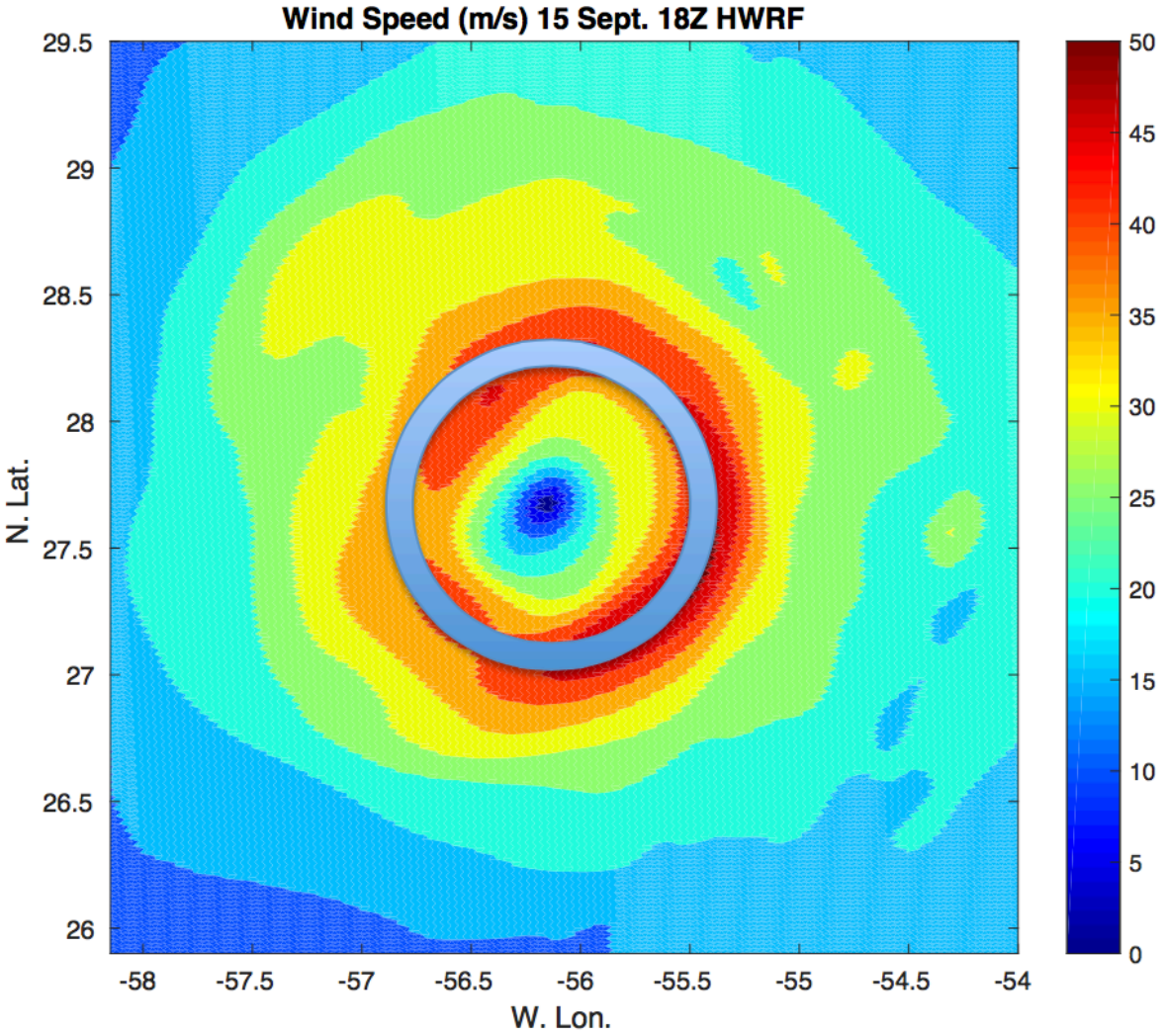
zolcru=0, reduced Vmax ~10Kts

Hurricane Edouard: 10m Wind Speed (ms^{-1})

RMW~2x

Valid: September 15th 18Z





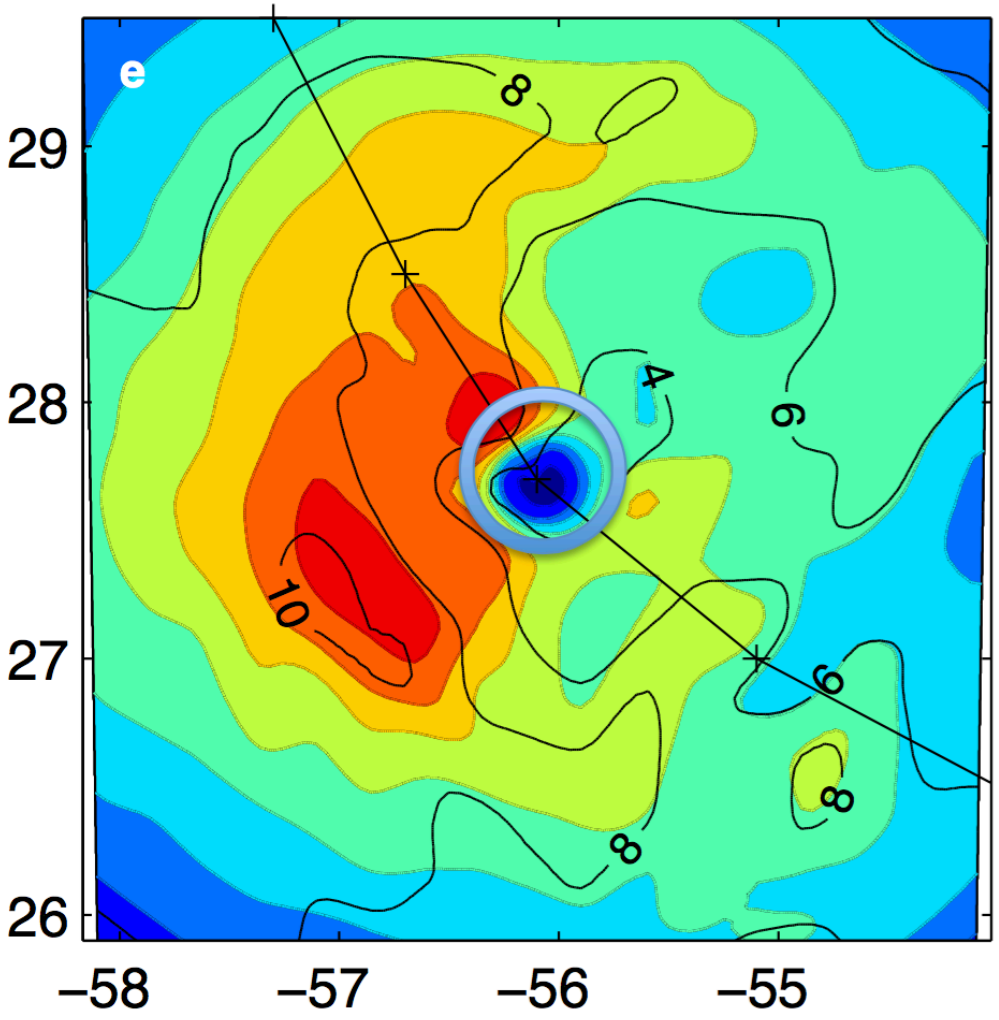
OBSERVATIONS

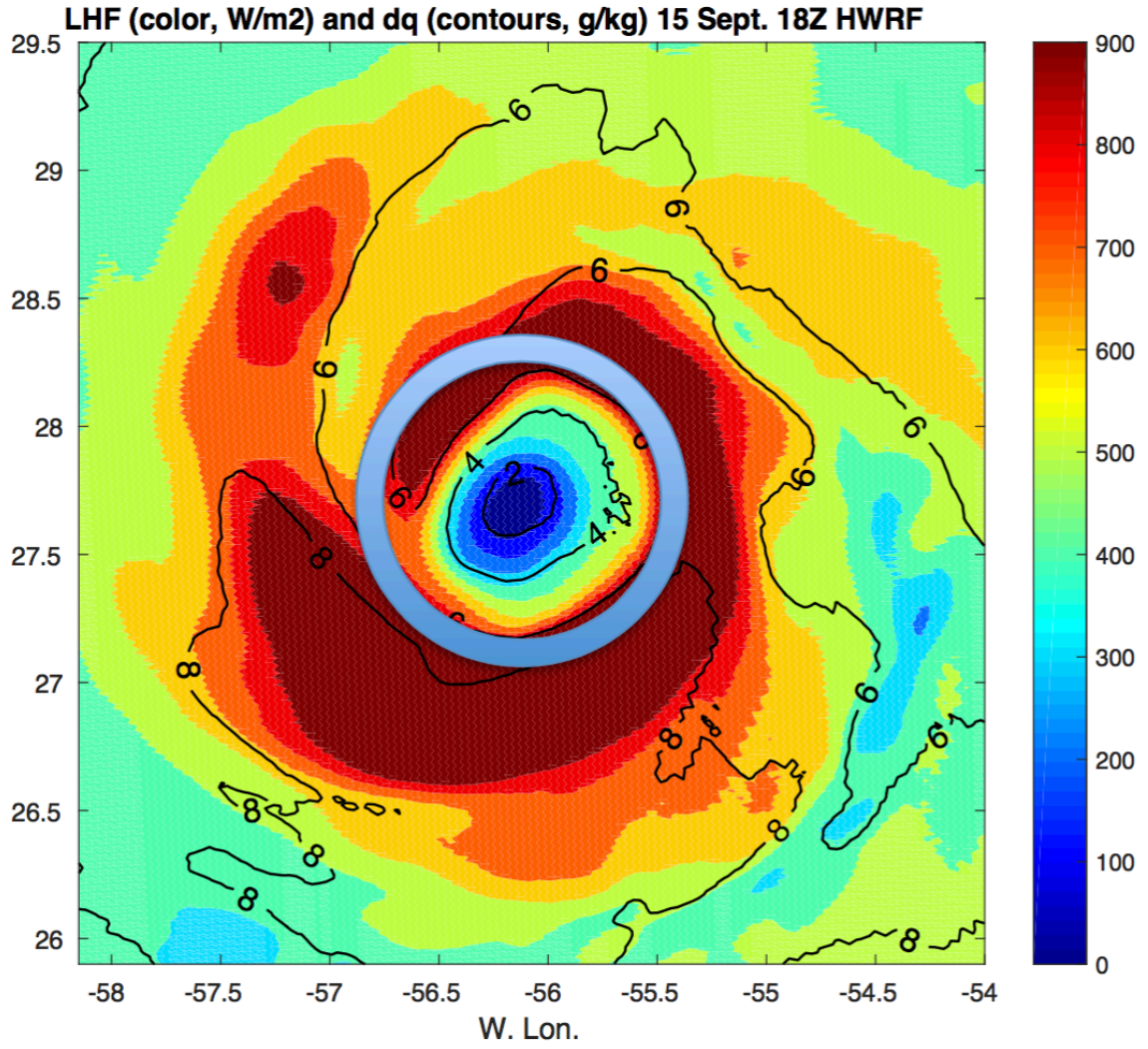
HWRF (t=0)

Courtesy of Joe Cione

Hurricane Edouard: Surface Latent Heat Flux (Wm^{-2})

Valid: September 15th 18Z





OBSERVATIONS

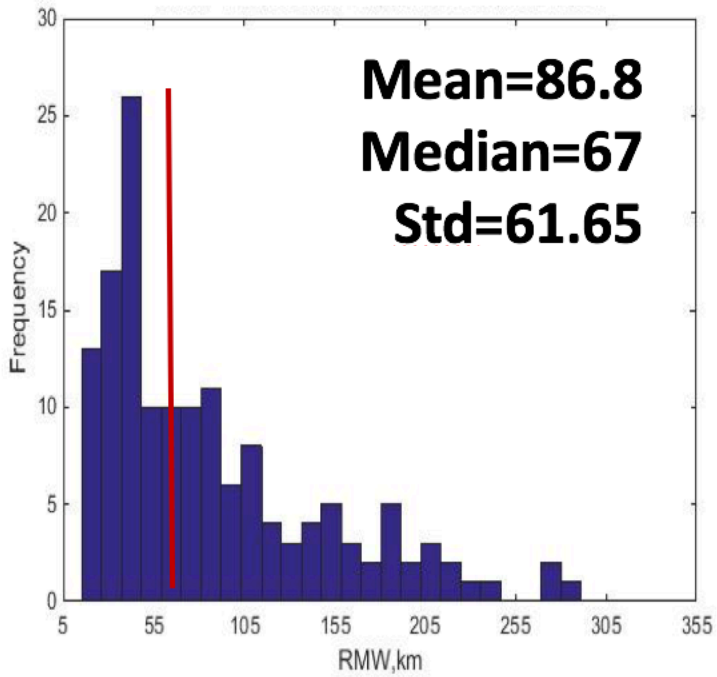
HWRF (t=0)

2 km RMW

2008-2015

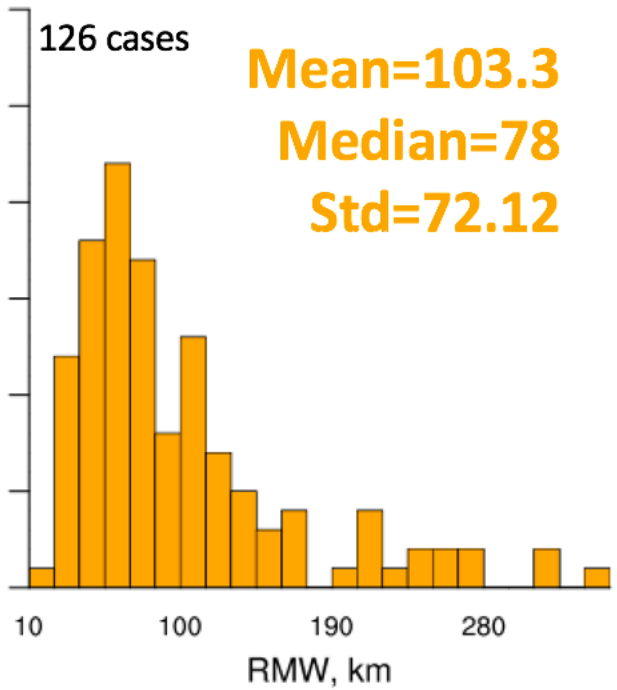
Radar

126 cases

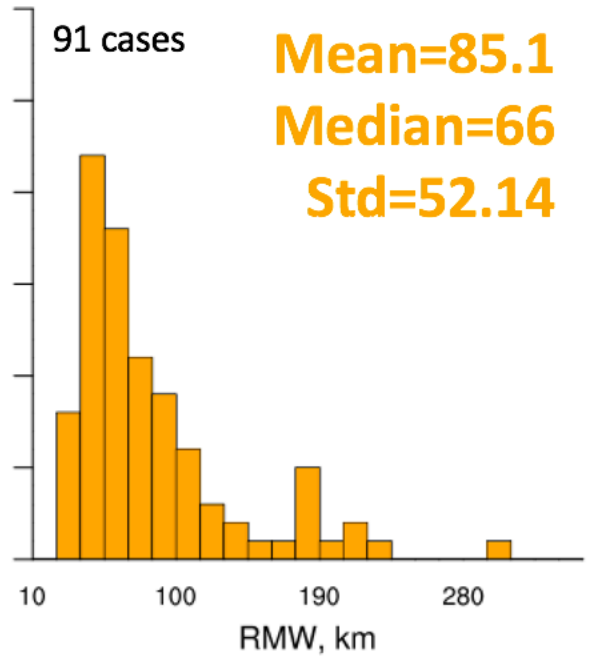


HWRF

Initial conditions

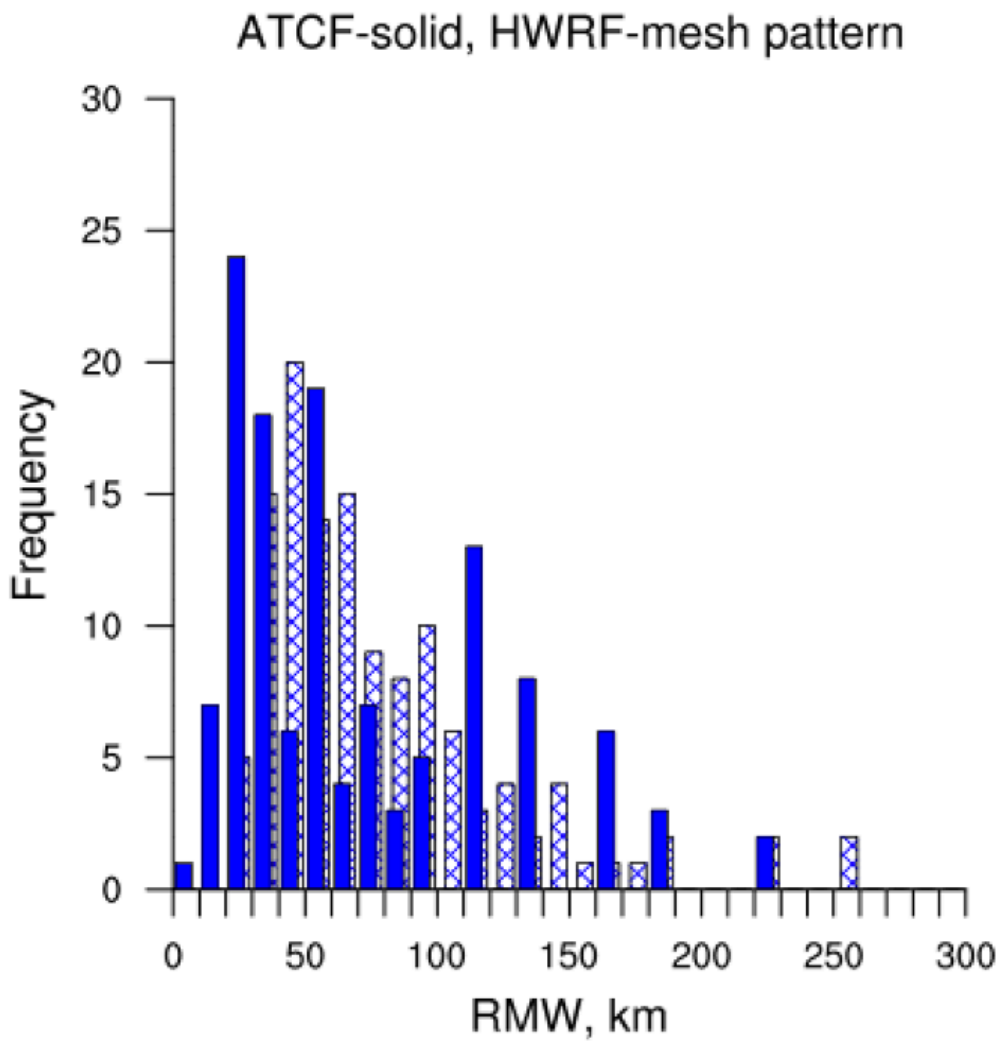


Hr 48

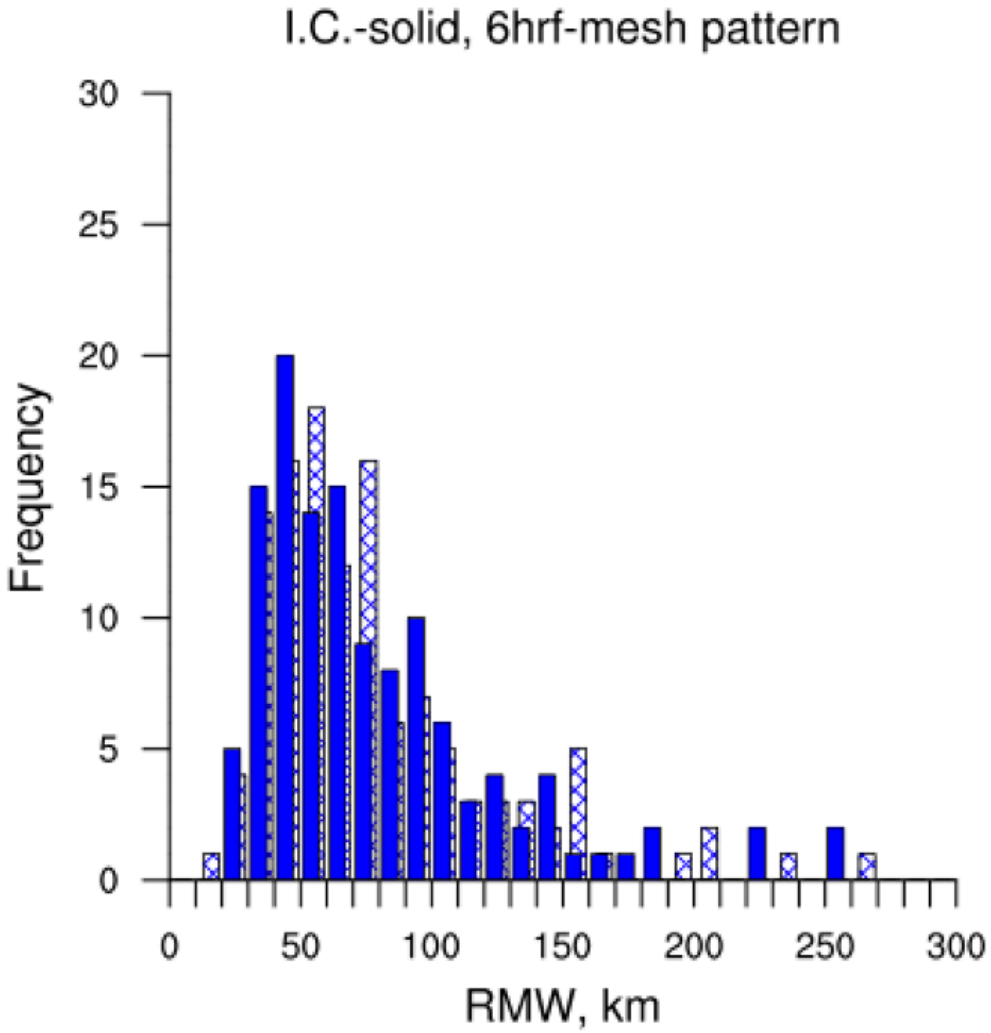


“Large” bias in initial conditions

Marks, Sellwood and Abarca



ATCF vs. HWRF 0-h



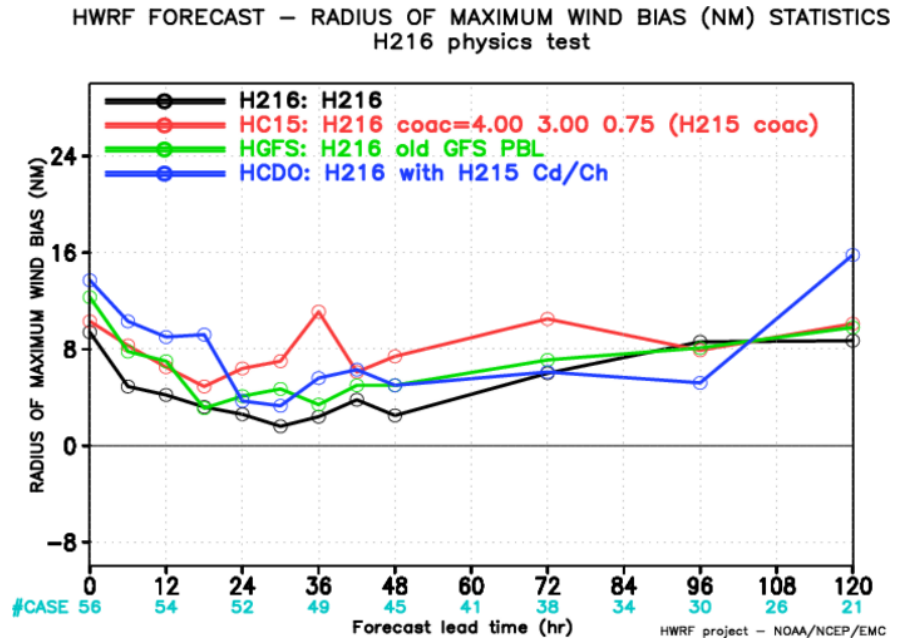
HWRF 0-h vs. HWRF 6-h

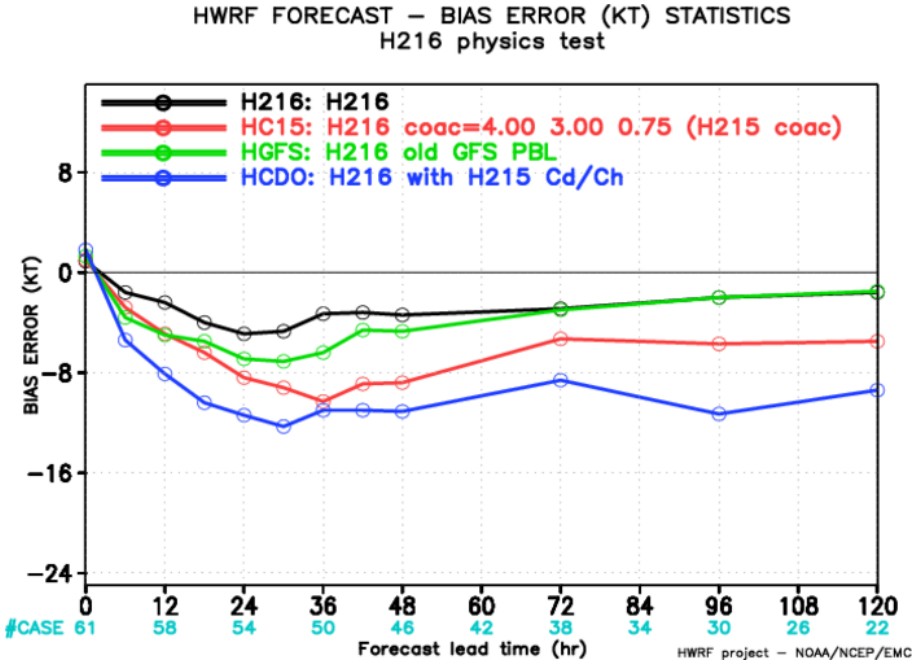
RMW bias larger at initialization than at 6-h forecast!

Physics test – RMW bias

- HWRF 2016 PBL, COAC, and Cd/Ch change all reduced Vmax and RMW bias

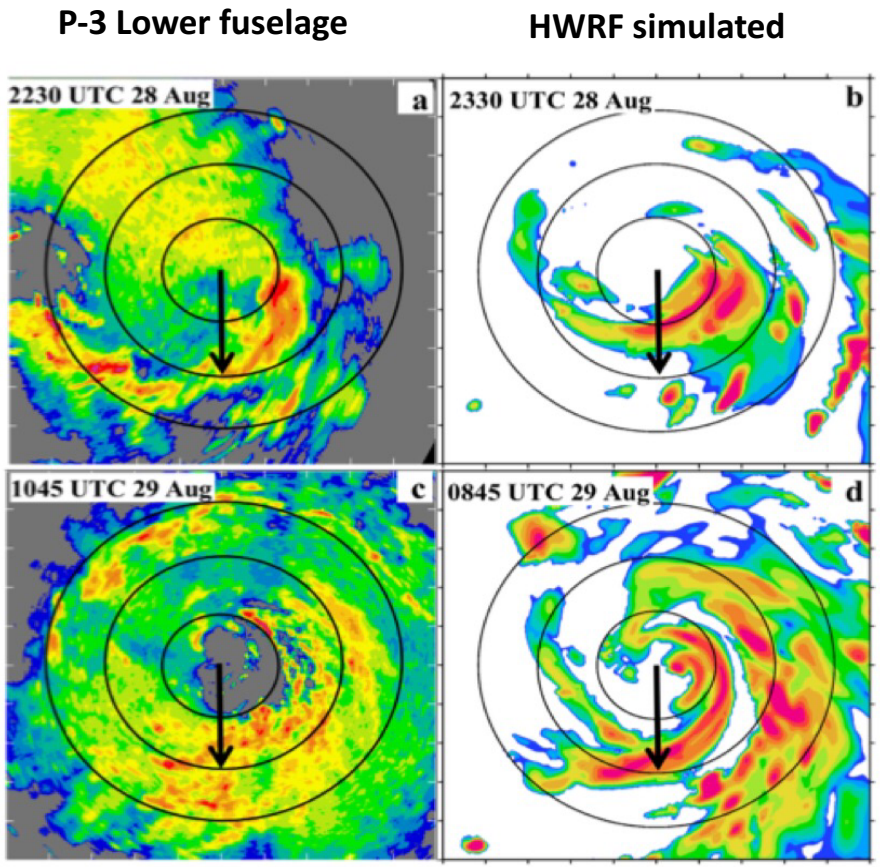
- RMW bias still larger at analysis time than at 6h for all tests & remains positive throughout forecast



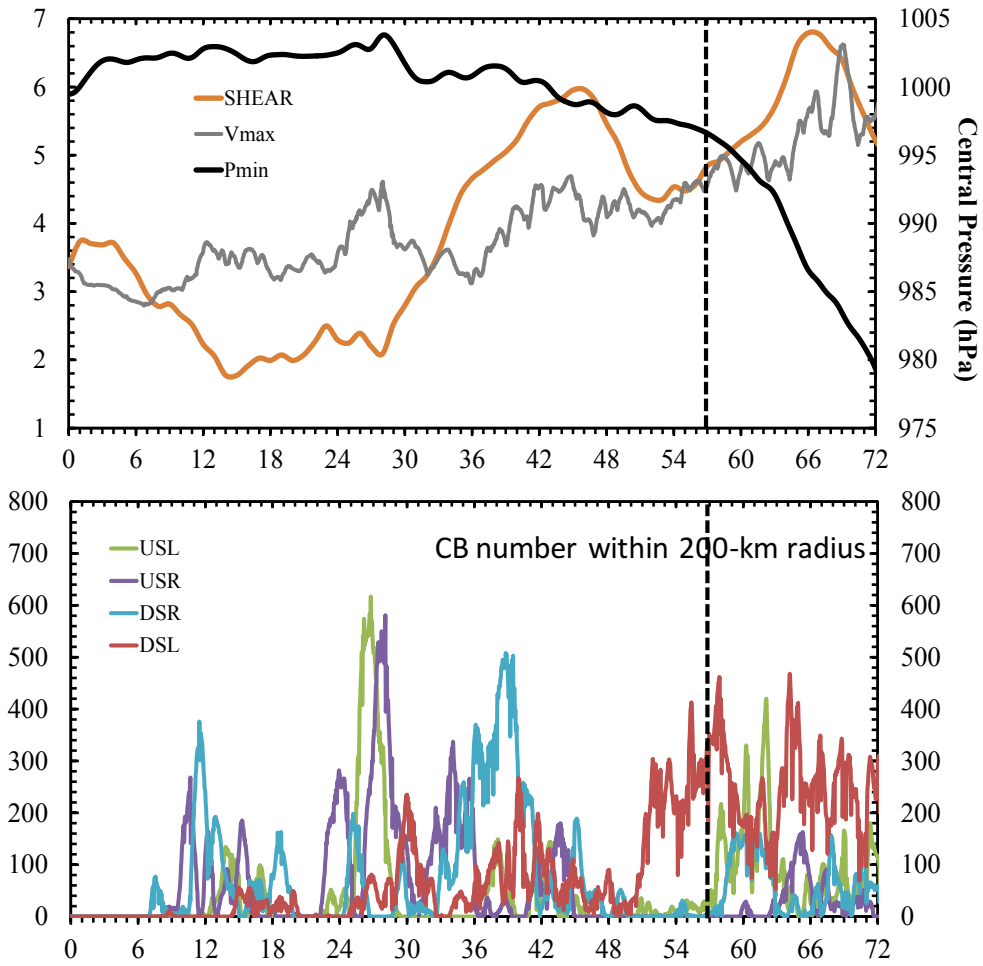


From Jason Sippel

Hurricane Earl (2010): Convection



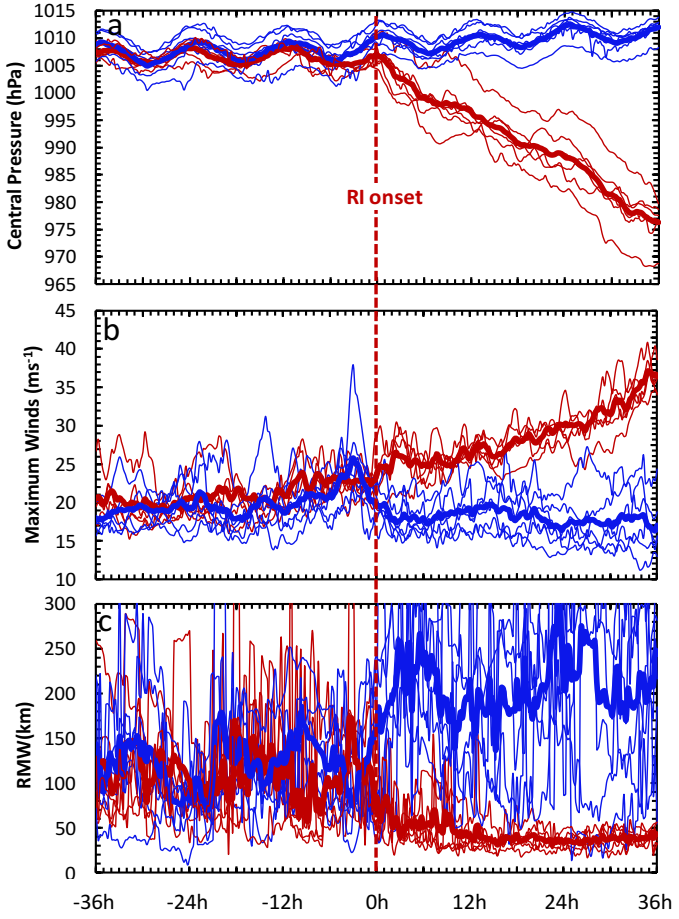
Shear: Northerly, about 5 m/s



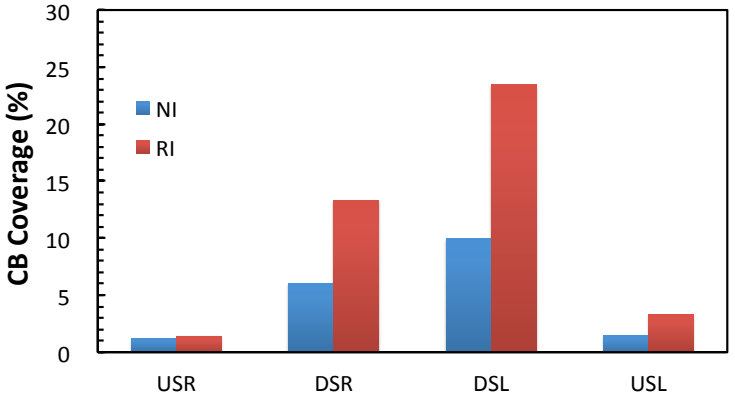
RI occurs after persistent deep convection taking place inside RMW in downshear-left quadrant

Q: Will storms always intensify after convection takes place persistently in downshear-left quadrant inside RMW?

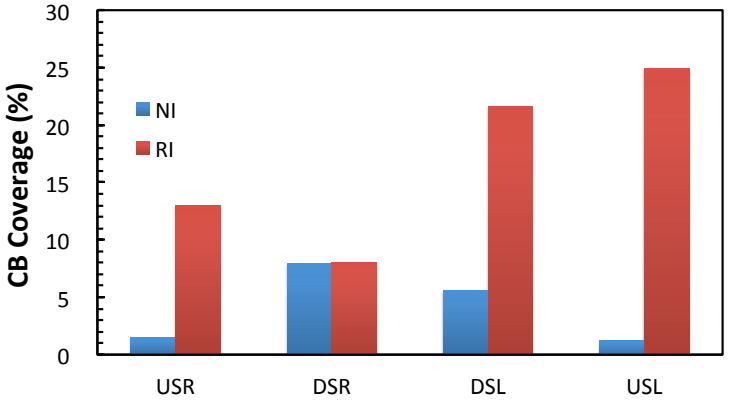
HWRF Ensemble forecast of Hurricane Edouard (2014)



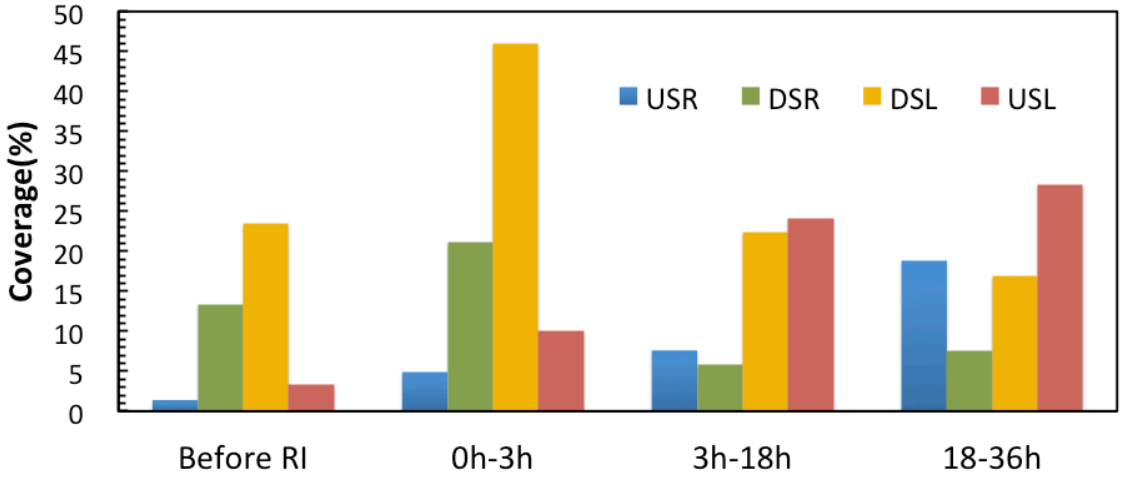
CB coverage averaged between -36h —0h



CB coverage averaged between 0h—36h



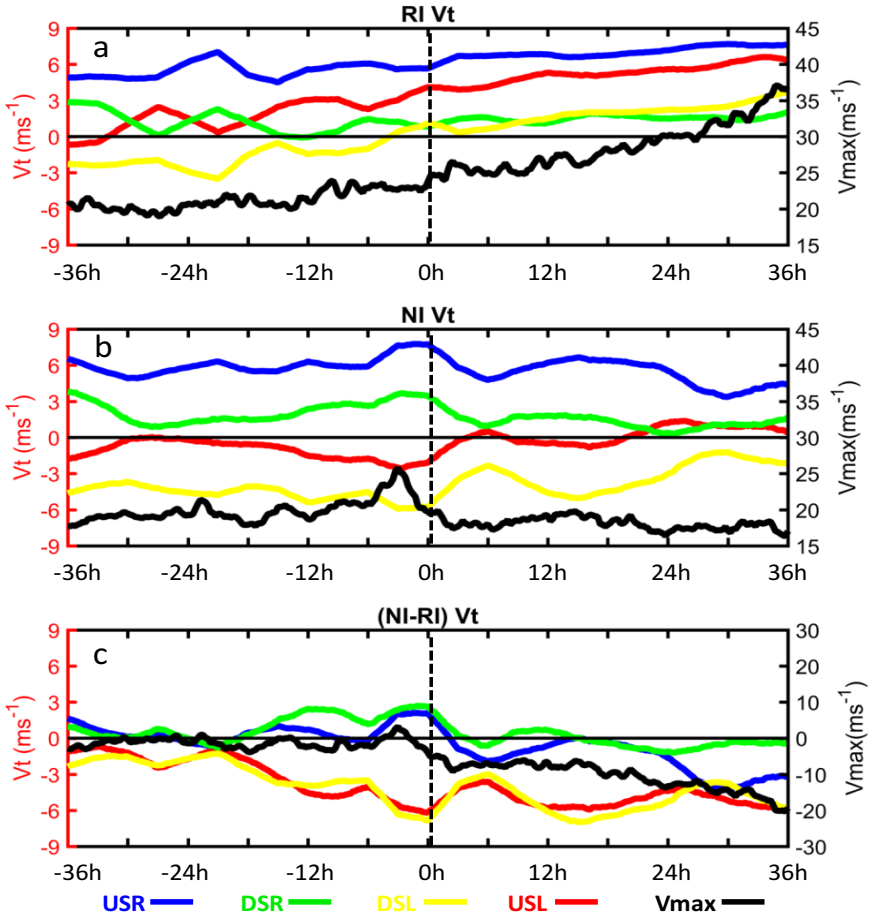
Histogram of CBs Evolution in RI Scenario

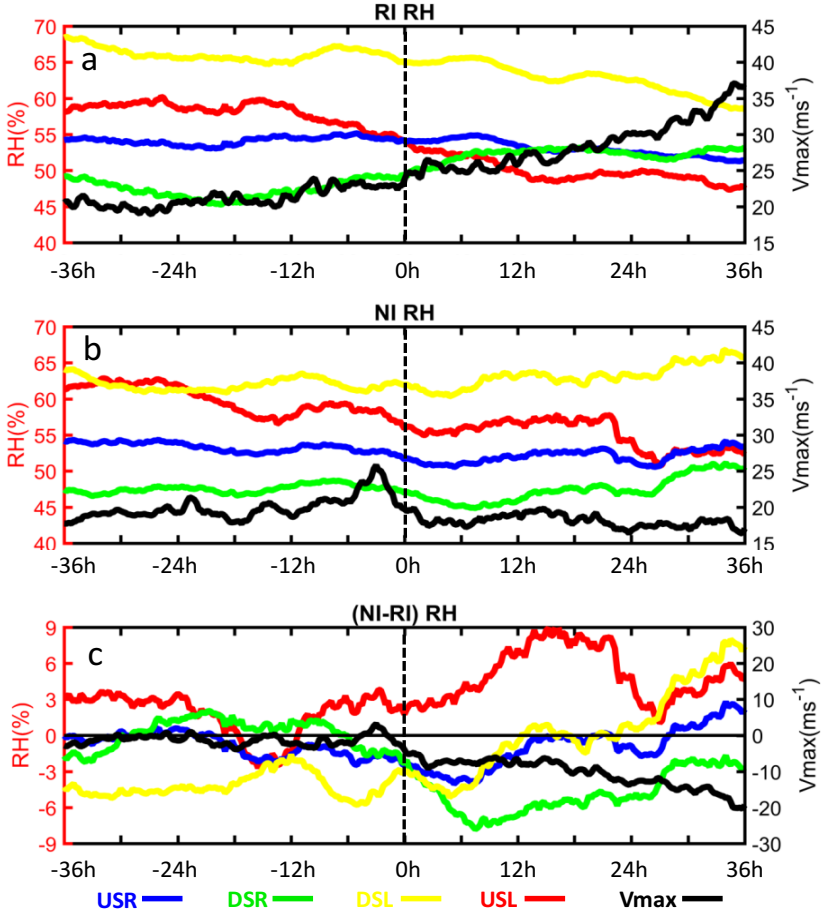


A: Only storms with convection rotating into USL quadrant intensify!

Q: Why deep convection can rotate into USL quadrant in RI members but can't in NI members?

Composite tangential component of storm-relative environment flow averaged within 500km and z=6-10km





Composite environmental moisture averaged within 500km radius and z=2-6km layer

A: Environmental flow in left-shear quadrants determines if deep convection can propagate into USL after deep convection takes place; moisture field in DSR quadrant is important in the initiation of deep convection.

Ferrier-Aligo Microphysics Changes

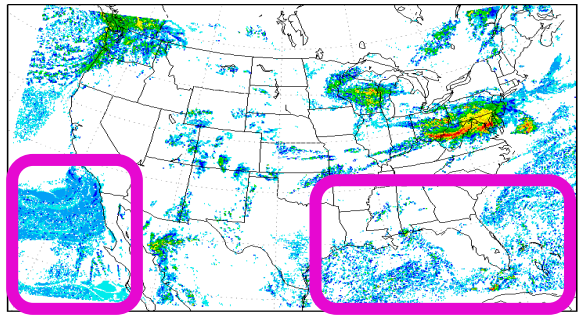
Problem / Solution

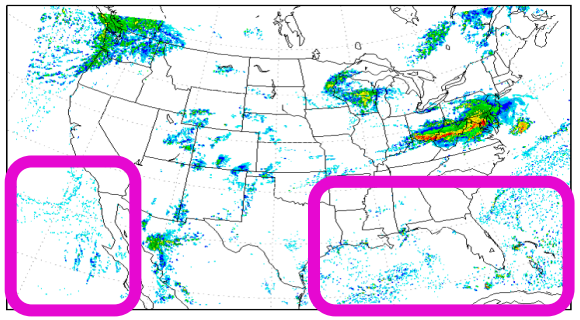
High reflectivity bias in PBL clouds — **Added a drizzle parameterization (allows larger number of droplets)**

High reflectivity bias at anvil — **Increased largest possible number concentration of snow**

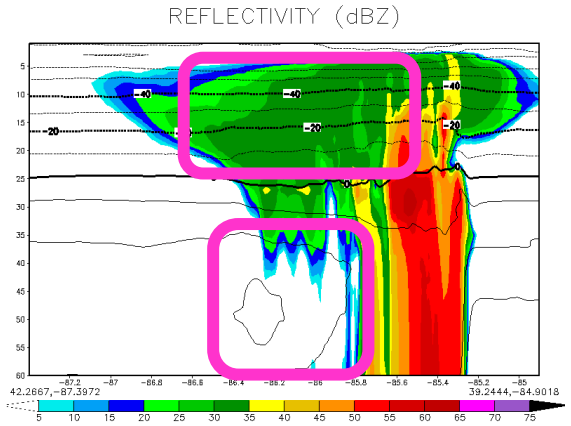
Lack of stratiform precipitation — **Constant rain drop size during rain evaporation (reduces evaporation)**

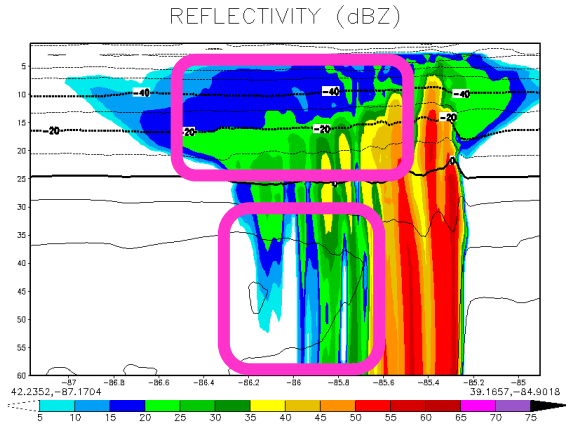
Old | **New**





12Z 23 June 2016





21Z 29 June 2012

DTC physics testing: Grell-Freitas

- Grell-Freitas convective scheme implemented in HWRF by G. Grell and J.-W. Bao (NGGPS project)
  - Scale-aware/Aerosol-aware (Grell and Freitas, 2014)
- DTC is undergoing testing of the G-F scheme in HWRF
  - Provided developer support to bring code and subsequent bug fixes into centralized HWRF repository
  - Tests are against baseline 2016 operational HWRF configuration.
  - Initial results in AL basin show promising results in both track and intensity

DTC physics testing: clouds and radiation

- Funded DTC Visitor Program PIs M. Iacono & J. Henderson (AER) implemented alternate cloud overlap methodology (Exponential-Random) with RRTMG in HWRF
  - DTC provided support for bringing code into HWRF
- Modified partial cloudiness (icloud=3) updates provided by G. Thompson (NCAR)
  - Modifications reduce solar radiation biases

➢Tests are underway for both cloud-radiation modifications using 2016 operational HWRF configuration

High Priority Areas for Physics betterment

- Continue to incorporate scale aware physics
- Continue maintaining alignment with global models
- Microphysics higher moment (or species advection?)
- Adopt stochastic approaches

- Address identified model biases
  - RI/RW
  - Positive intensity bias of weak (<50kt) storms and negative intensity bias of strong (>50kt) storms
  - Air sea interaction (Joe Cione)
  - Storm structure
    - Secondary eyewalls
    - RMW

Successes!:

- Wavenumber 1 asymmetries!
- Progress on secondary eyewalls!
- Mean intensity bias is close to zero!
- Intensity performance in Atlantic improved systematically since 2011!
- Improvement in storm size!