High-Res Physics Tiger Team Report

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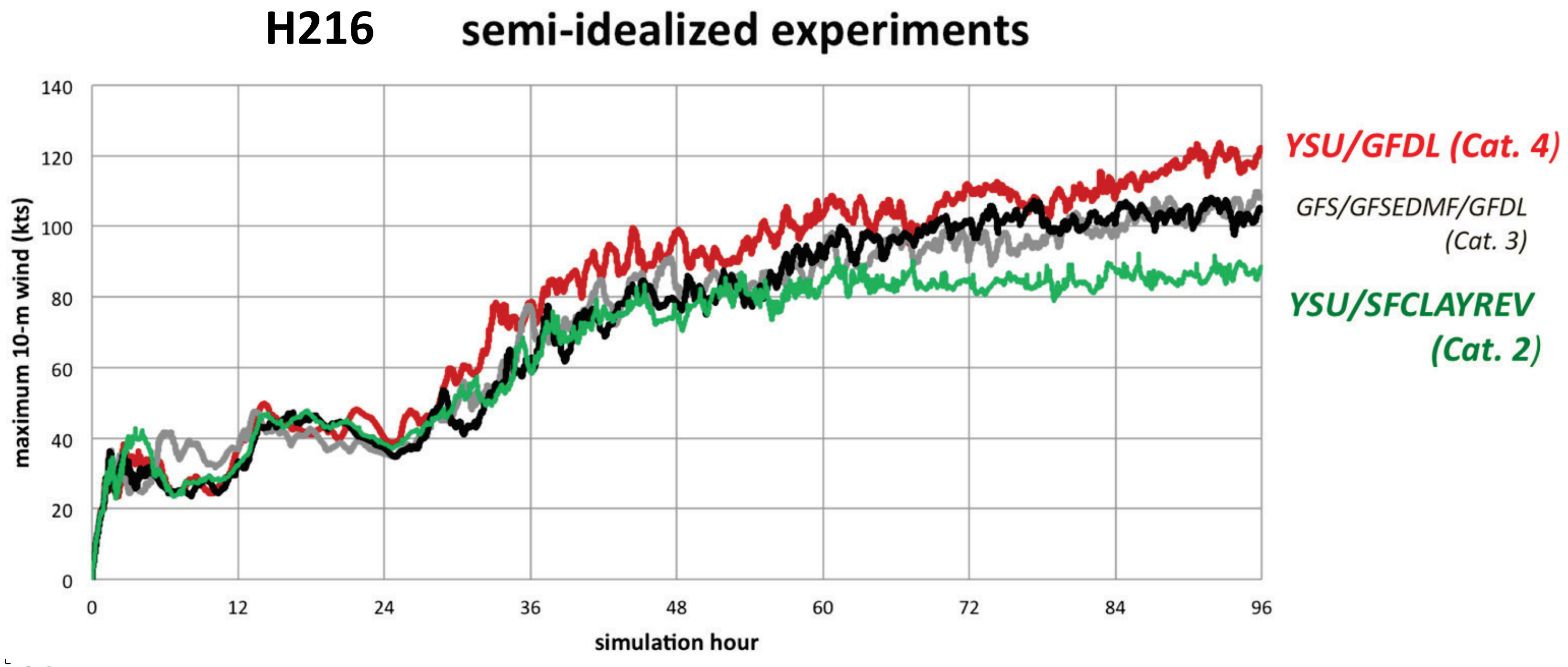
Goal of Physics Tiger Team

To improve forecast performance through betterment of parameterizations

- Impact on model performance is one of the criteria to decide whether a change in a parameterization will become part of the model

- Evaluate parameterization changes with other basis on
  - Physical representation merit
  - Model output of related parameters
  - Improvement on basic storm structure
  - Computational constraints (e.g. FY2018 increased resolution)

PBL parameterization – YSU



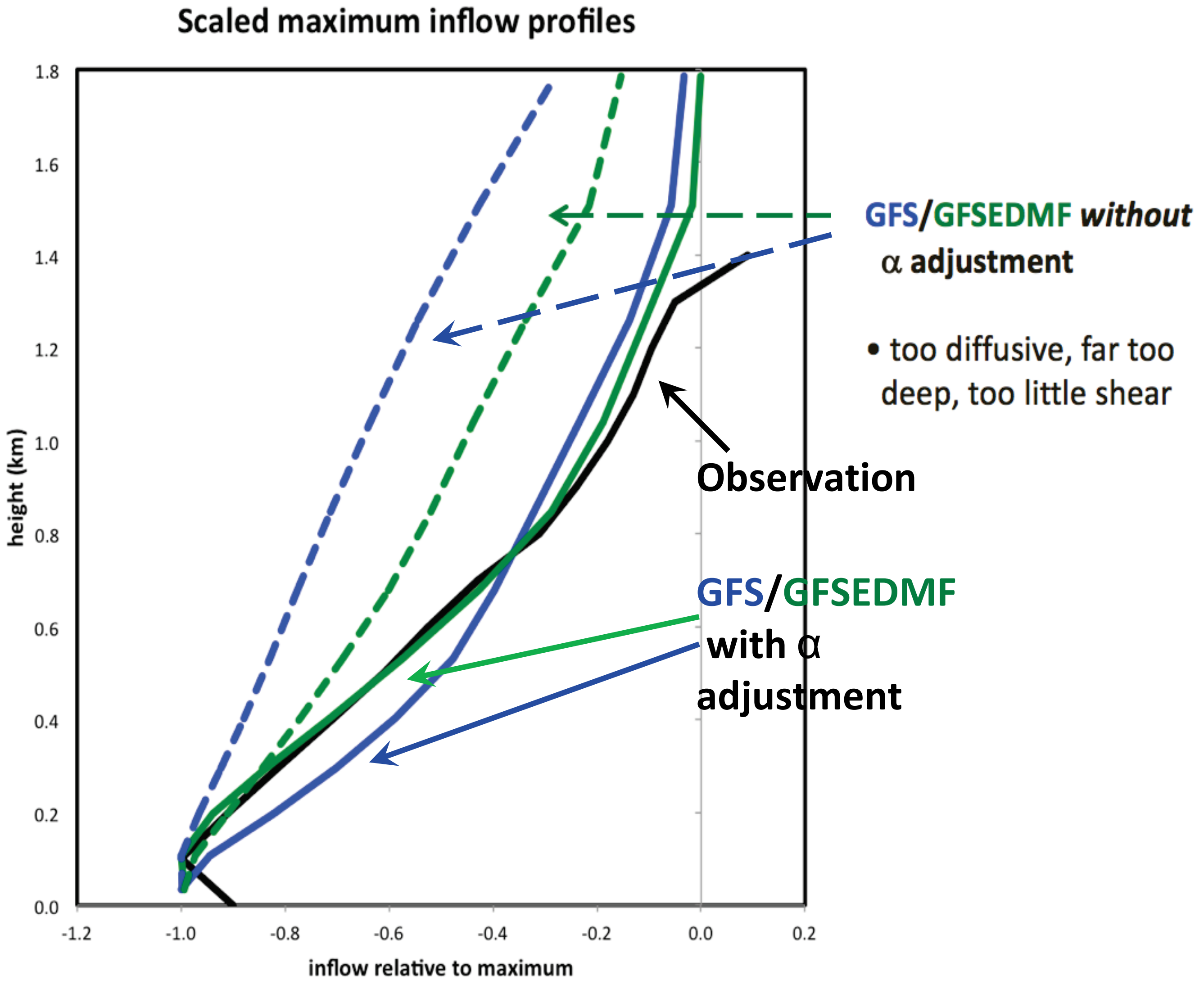
GFS-non-local scheme

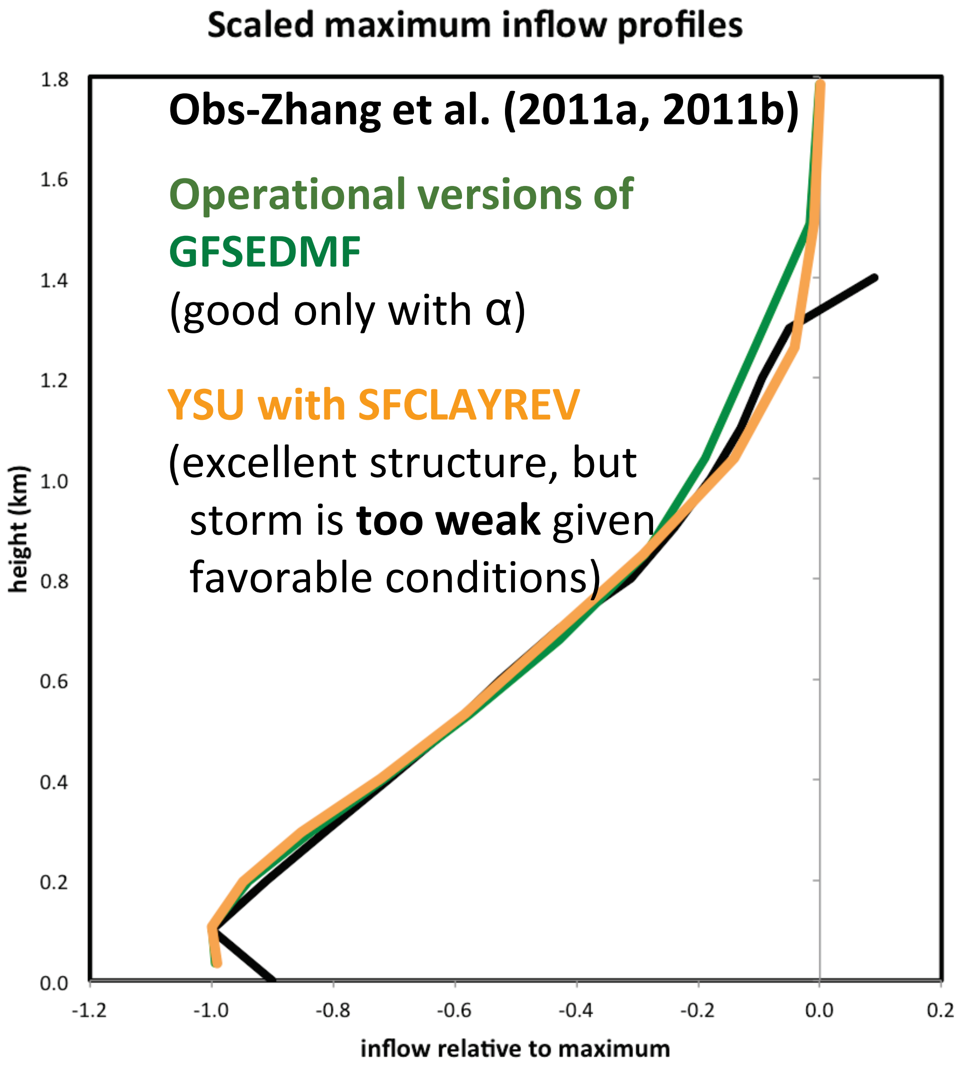
- **Too much mixing**
- **Too deep and weak inflow layer**
- **Fixed with**
  - **PBL height function of Rossby number (derived for stable PBL)**
  - **α < 1 parameter (*ad hoc* modification)**

YSU, includes cloud-top entrainment

Led by Robert Fovell

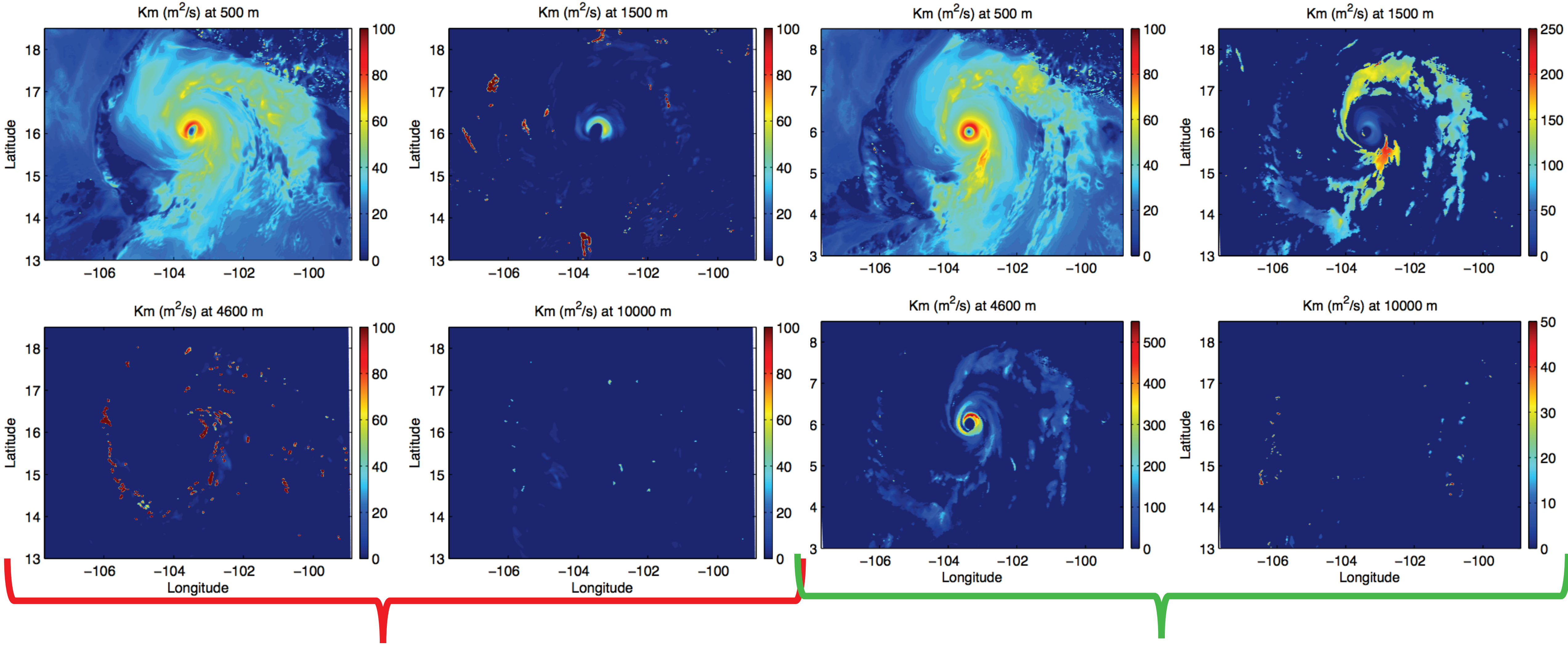
PBL parameterization – YSU





PBL Parameterization – turbulence layer

In-cloud turbulent mixing above the boundary layer in the eyewall and rainbands



HWRF 2017

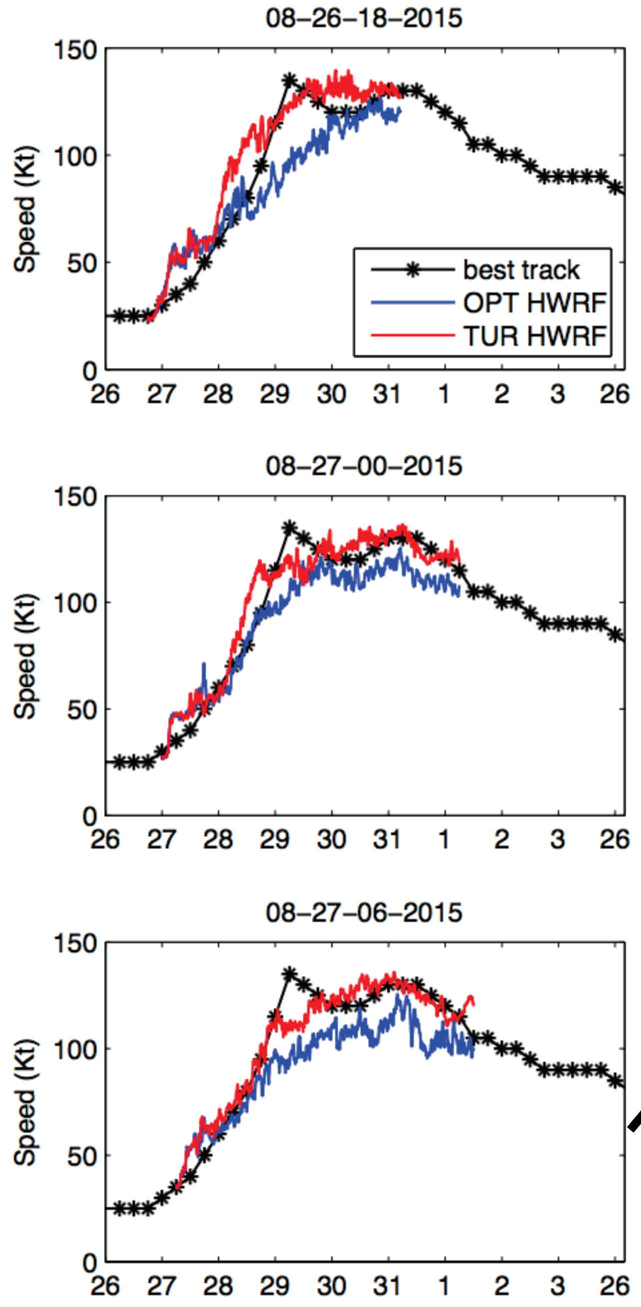
HWRF 2017 with new scheme

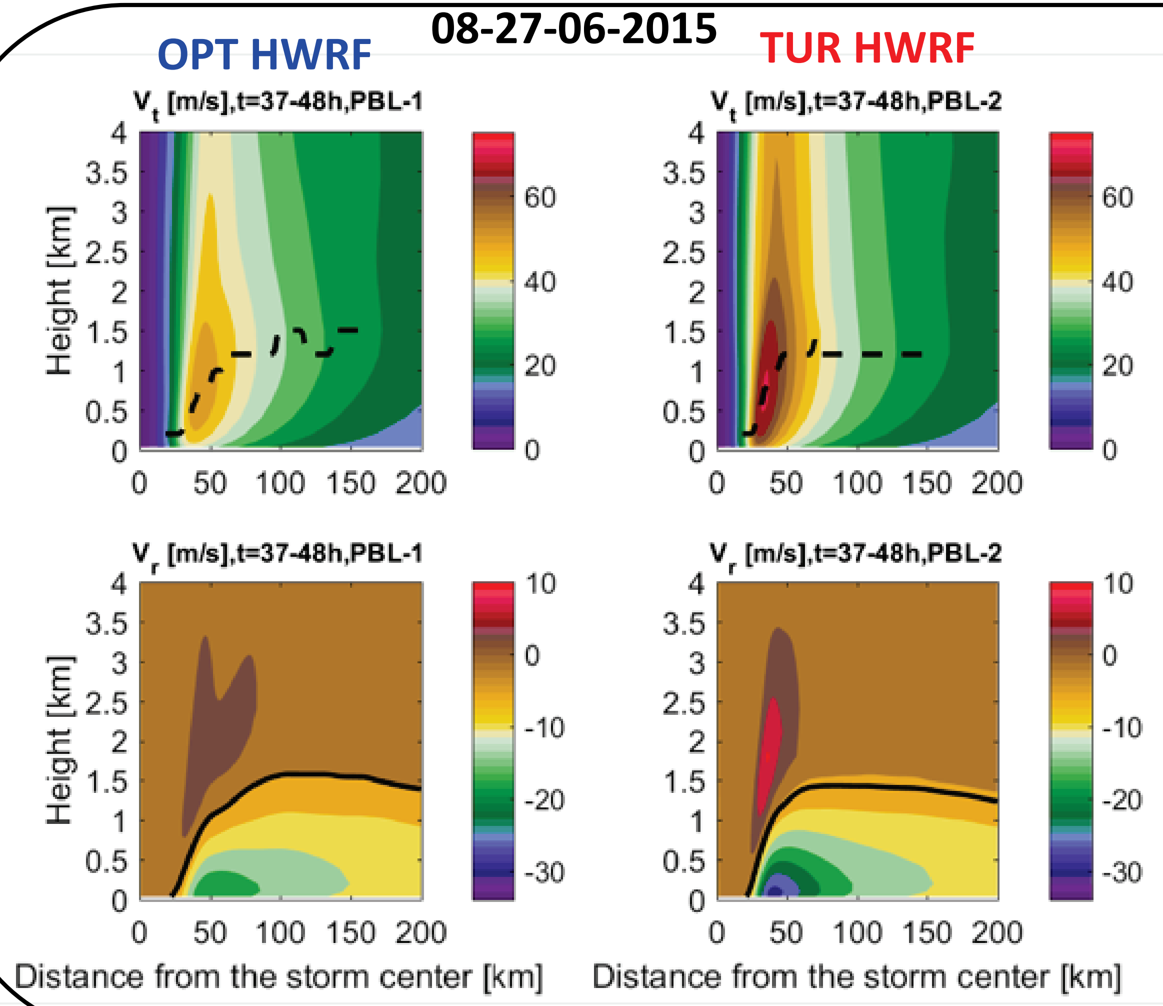
Eddy exchange coefficients for momentum from the HWRF simulation of Hurricane Patricia

Led by Ping Zhu

PBL Parameterization – turbulence layer

Jimena (2015)





- TUR experiment exhibits larger radial inflow and maximum tangential flow
- TUR experiment Does not modify the PBL height much

Led by Ping Zhu

Impact of boundary layer parameterization on HWRF RI forecasts

RI - Contingency Table

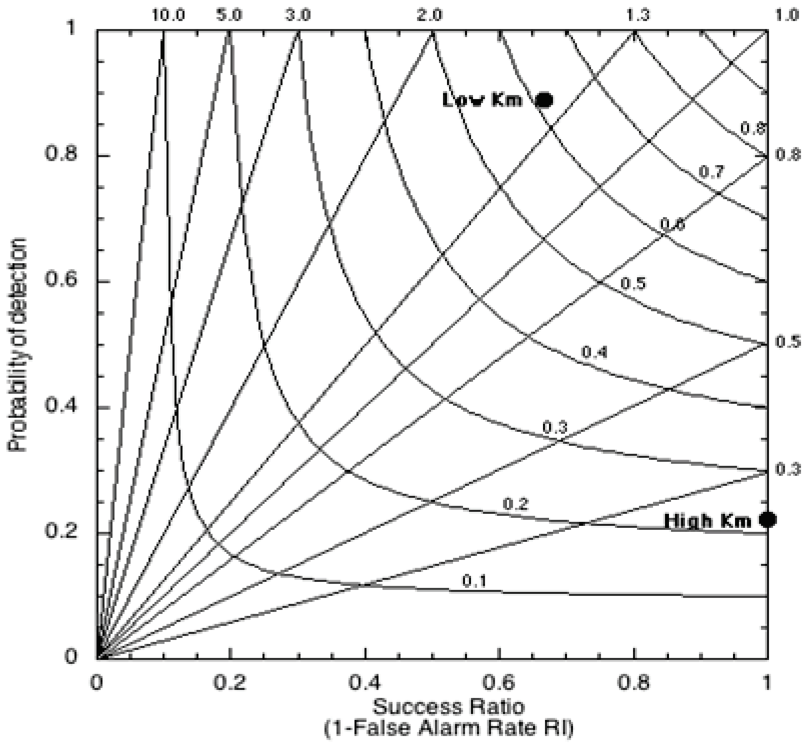
Observed

lowKm		Yes	No
	Yes	Hit 16	False Alarm 8
	No	Miss 2	---

Observed

highKm		Yes	No
	Yes	Hit 4	False Alarm 0
	No	Miss 14	---

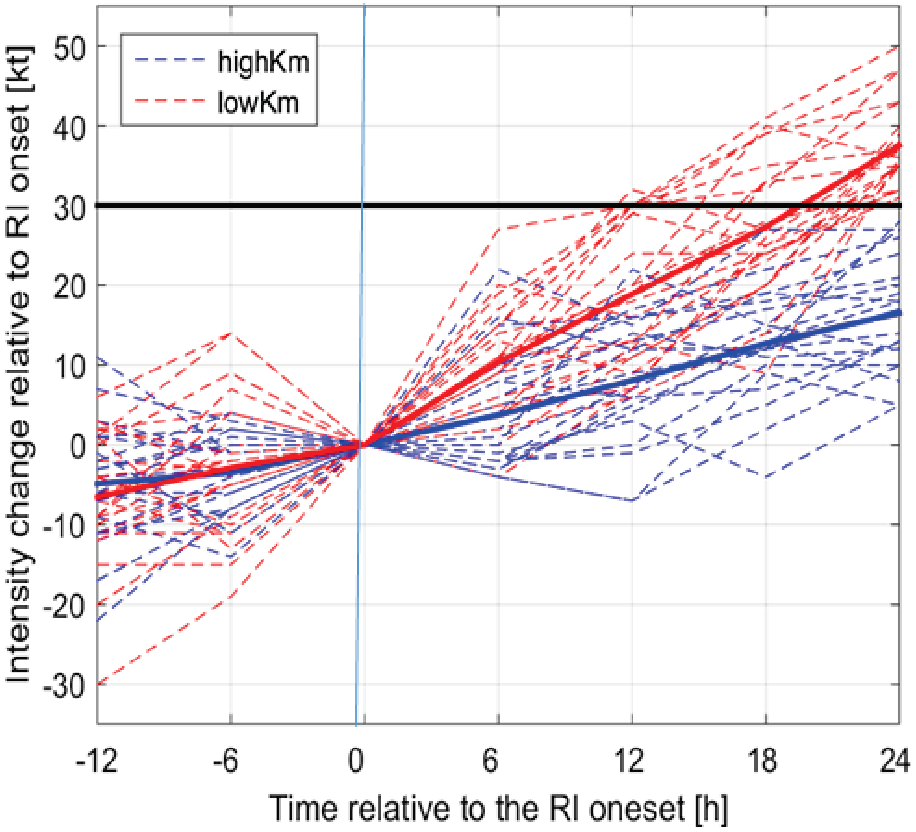
Categorical Performance Diagram

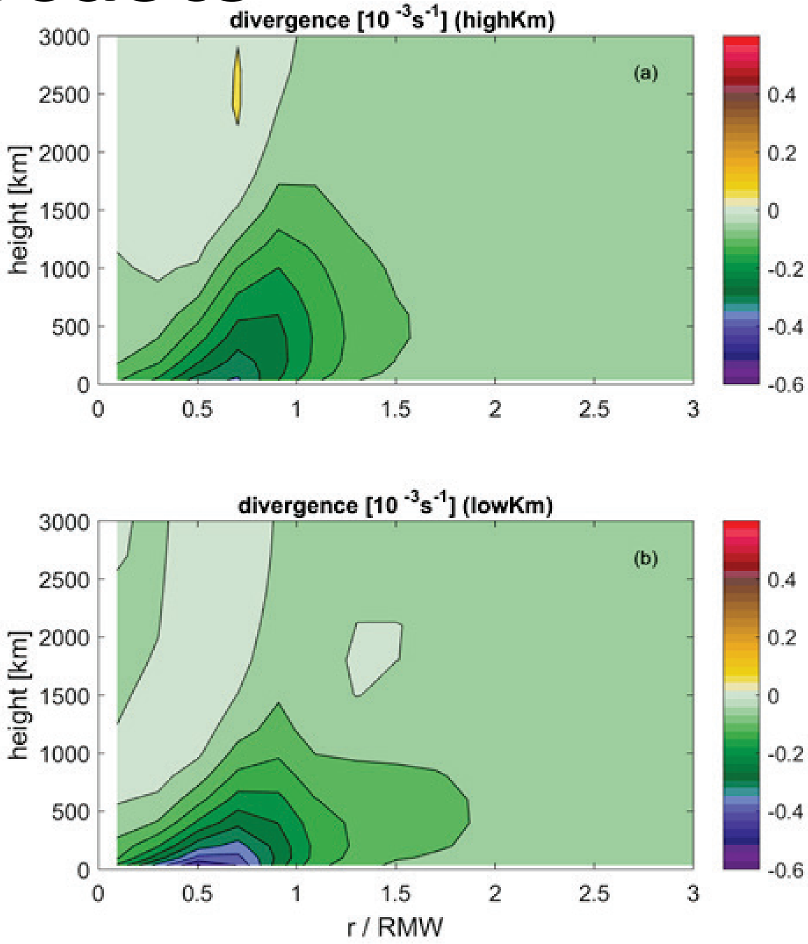


- Lowering Km in the PBL scheme of HWRF based on observations has positive impact on RI forecast.

Jun Zhang et al. (2017 MWR)

Impact of boundary layer parameterization on HWRF RI forecasts

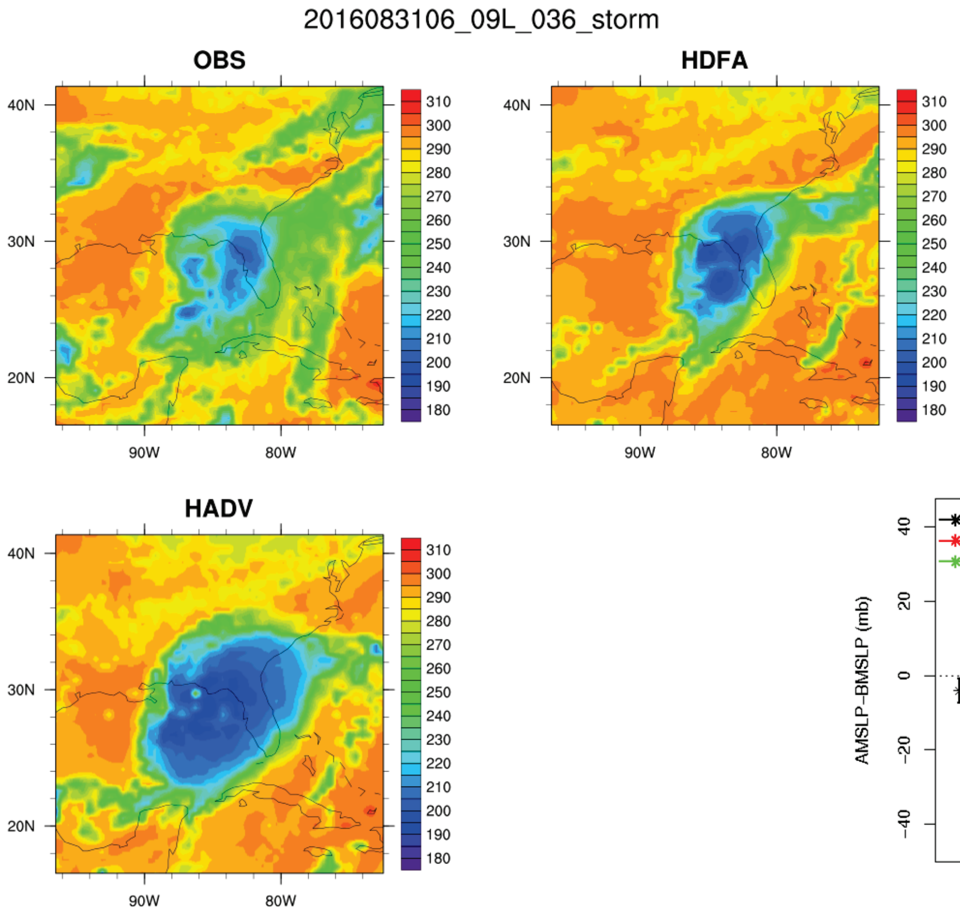




- The boundary layer convergence is stronger and closer to the storm center in the low Km composite than in the high Km composite at the RI onset.

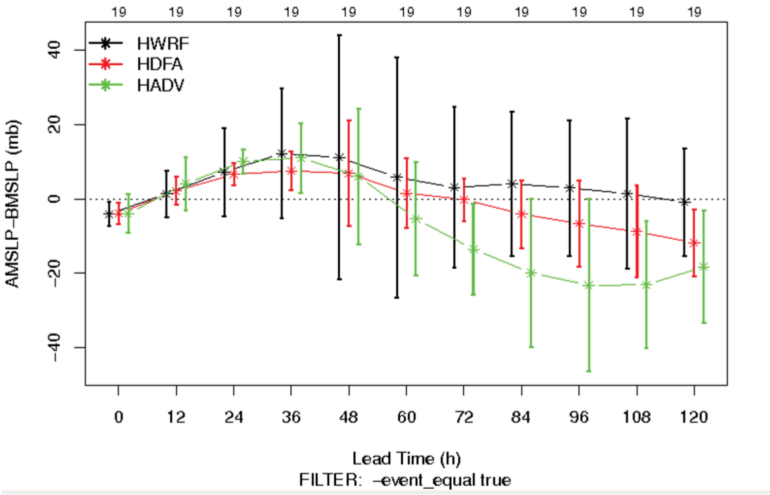
Jun Zhang et al. (2017 MWR)

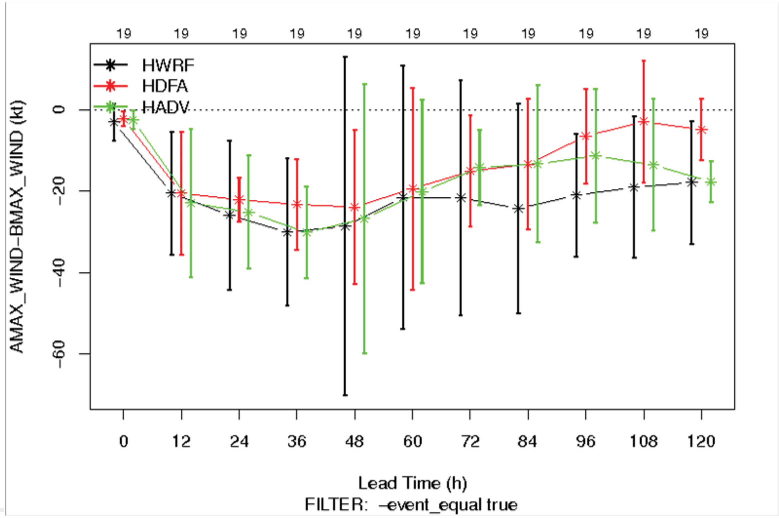
Microphysics - advection of species



Include advection of species "FA-ADV" generates:

- **Lower P_{min} and larger low MSLP coverage**
- **Larger 34kt 10m wind contour area**
- **Weaker Vmax**
- **Heavier rainfall**
- **Unfavorable wind/pressure relationship**



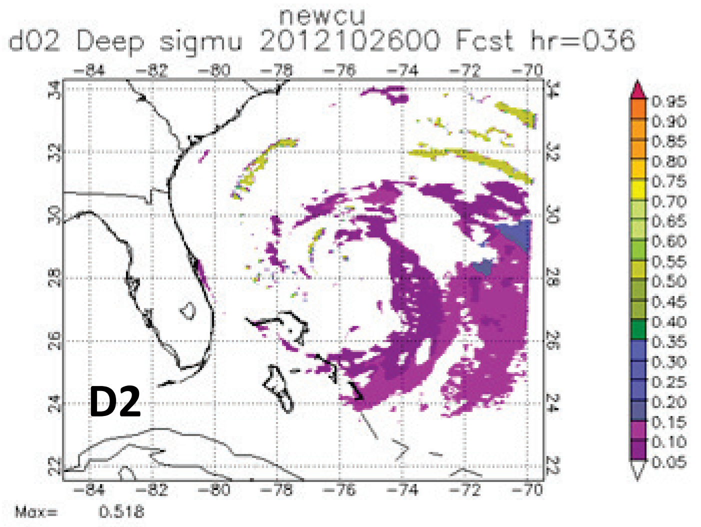


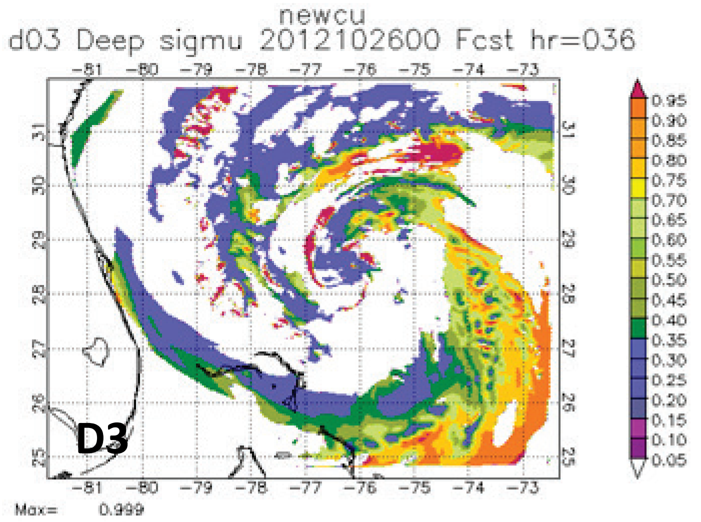
This, more physical approach is not giving promising enough results to consider for H218, where we need to prioritize computationally cheaper advances

Led by Shaowu Bao

Scale-Aware SAS Convection

Updraft area fraction

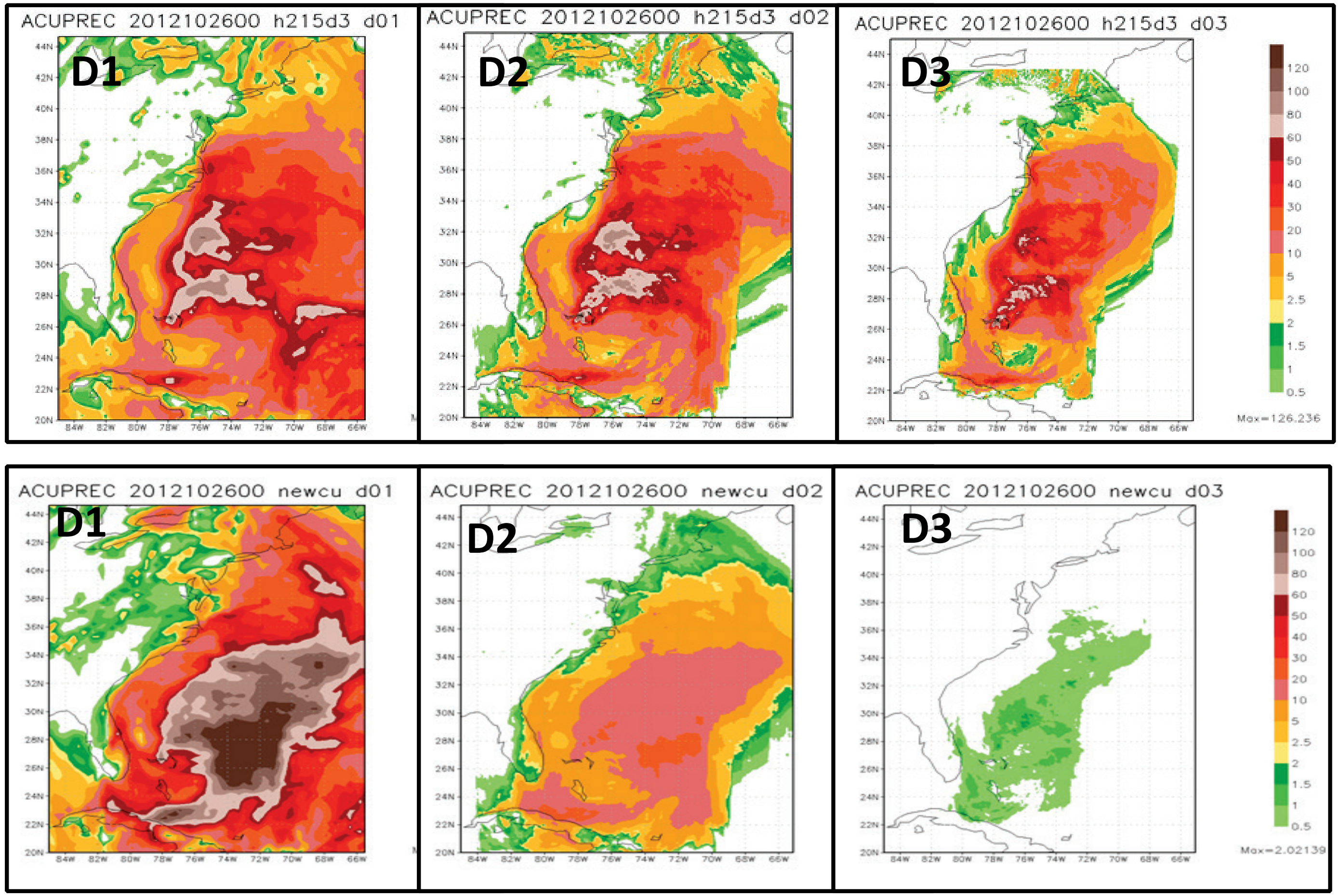




120-hr accumulated convective precip (mm)

SAS

Scale-Aware SAS

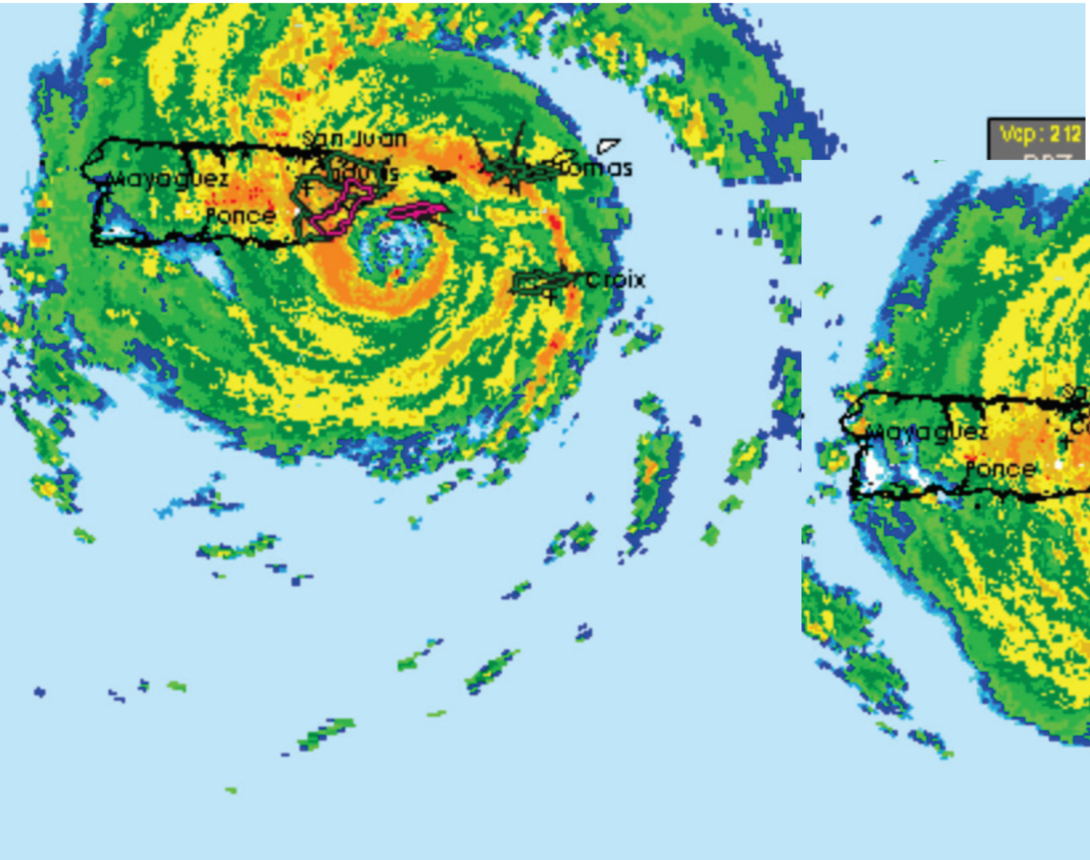


SAS Vs Scale-Aware SAS:

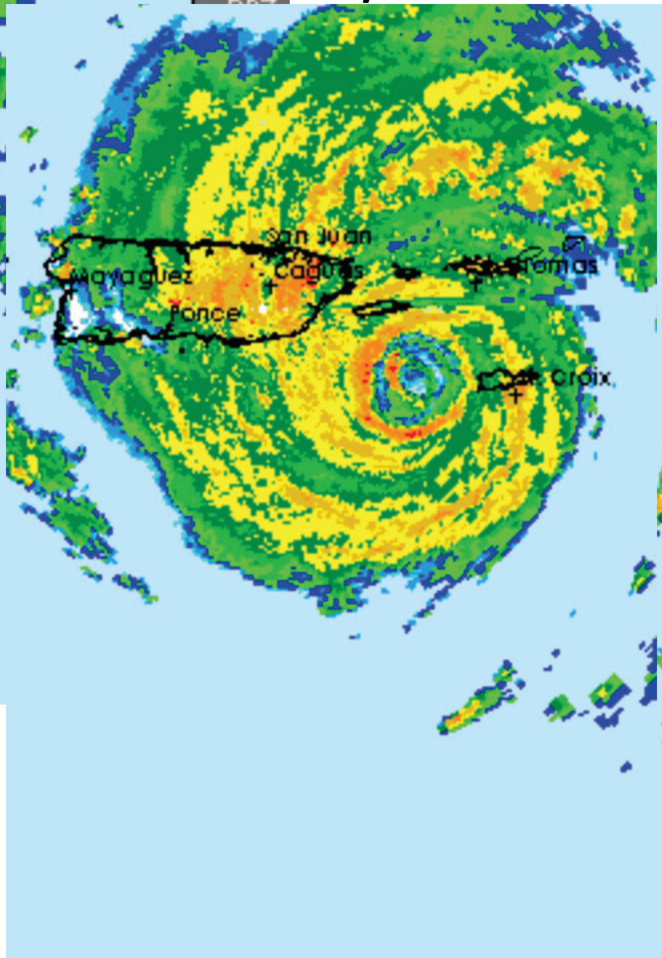
- **SAS produces similar convective precip in all 3 domains;**
- **Scale-Aware SAS produces more CU precip in domain 1 (coarse resolution), while much less in domain 3 (high resolution).**

Canonical ERC observed Maria 15L

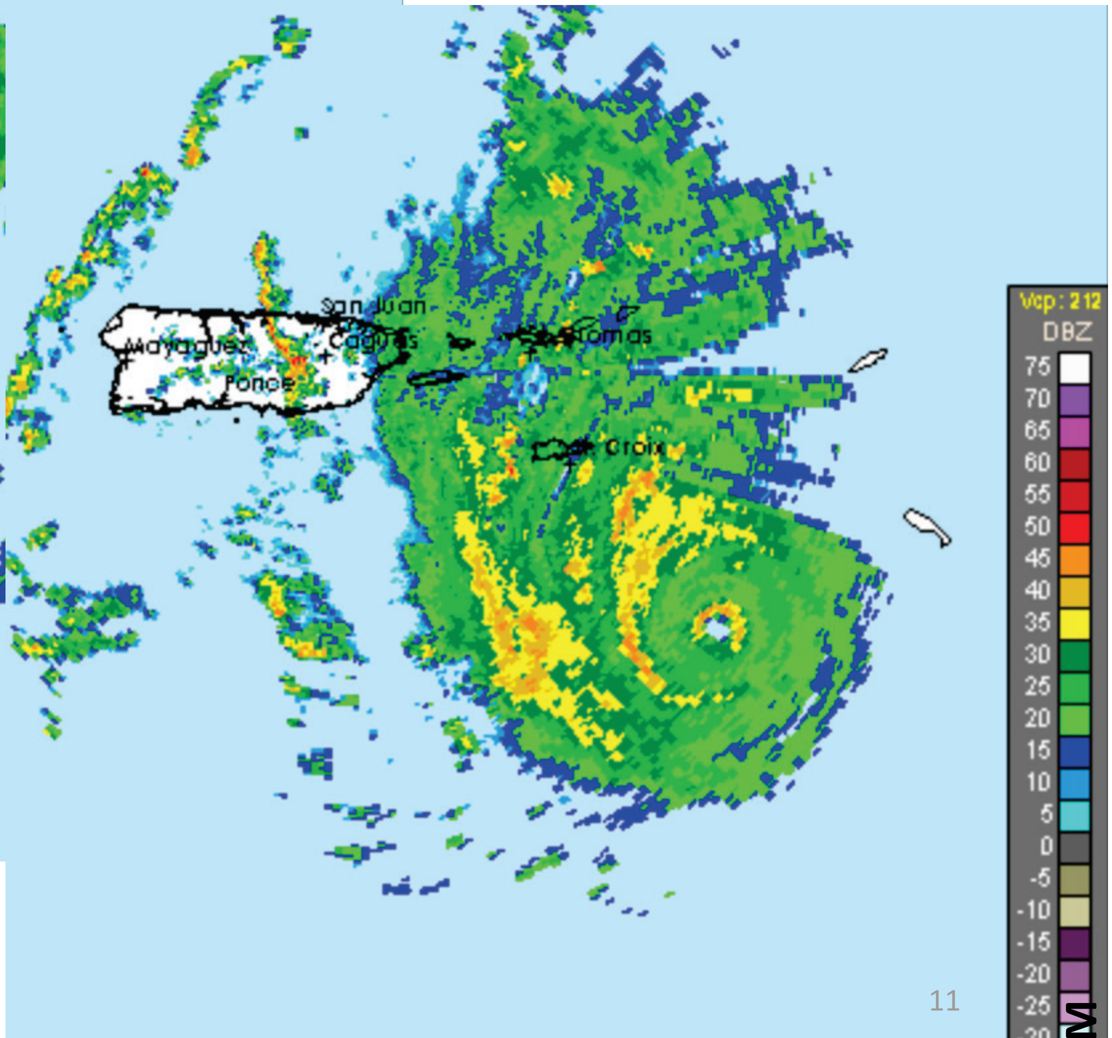
09/20 08Z



09/20 00Z



09/19 18Z



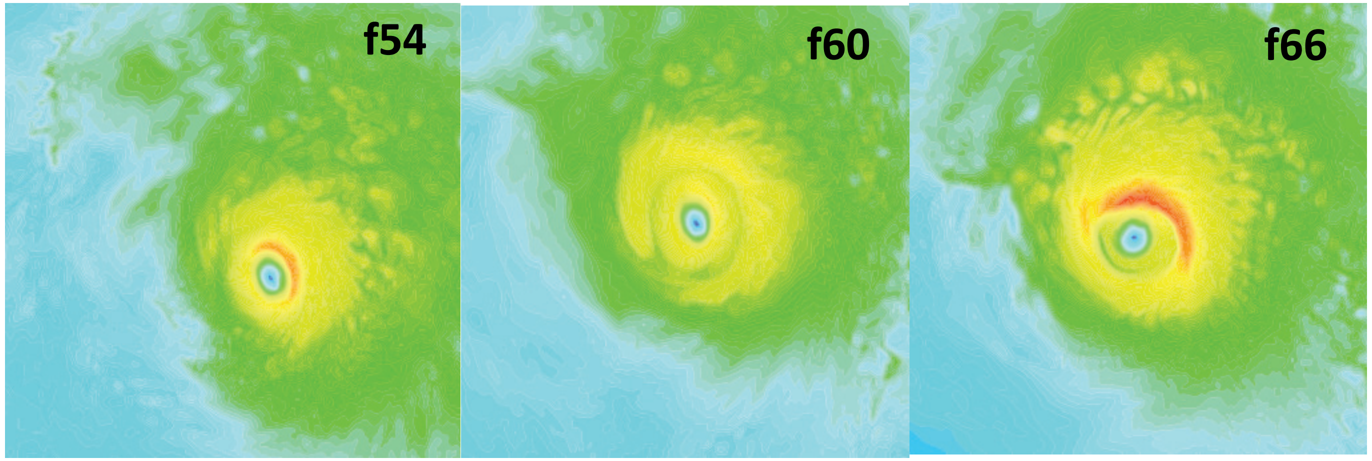
16 HWRF and HMON cycles :

From 091700 (when it was first a named storm)

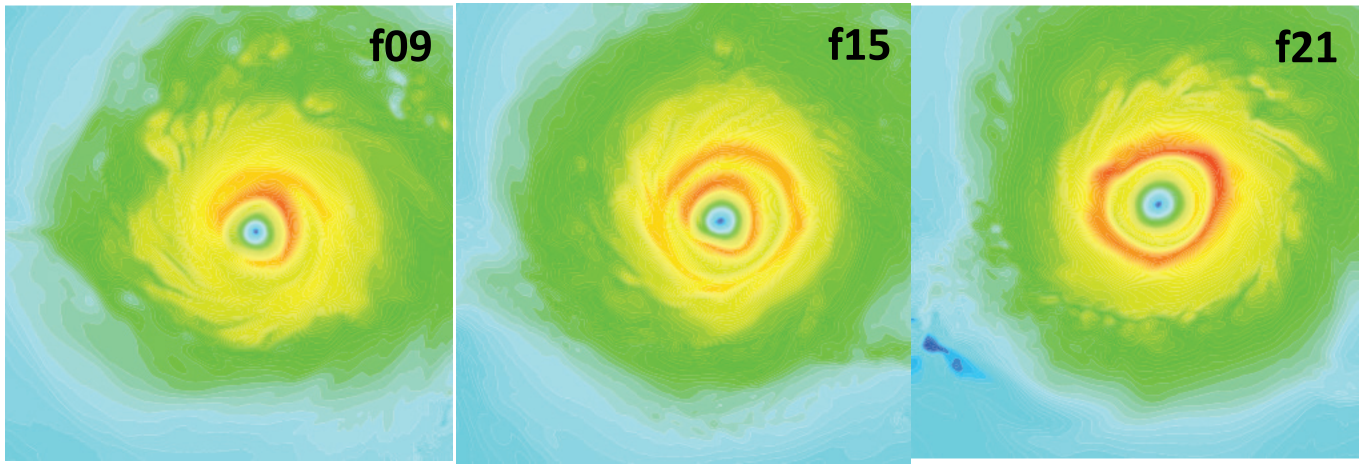
To 092018 (soon after the secondary eyewall observation)

Example of canonical ERC in about 15 hours

HMON initialized on 09/17 12Z



HWRF initialized on 09/20 12Z

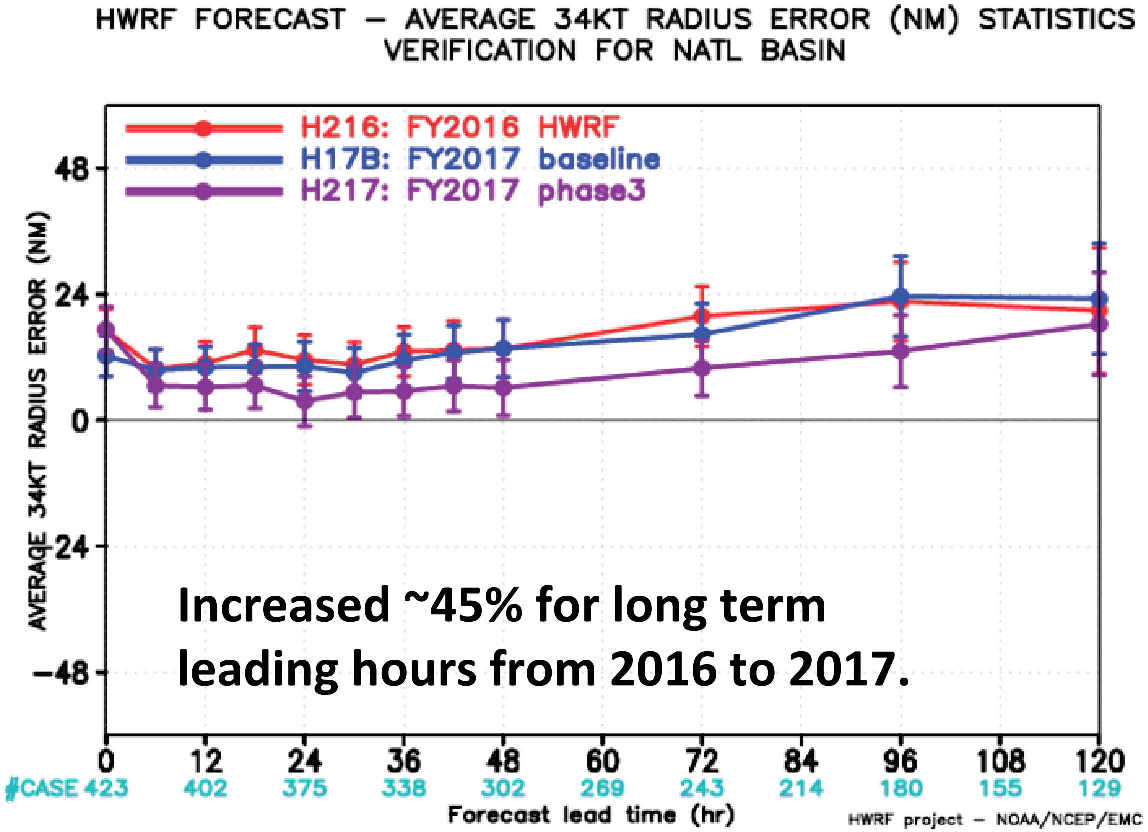


ERC summary for HWRF/HMON

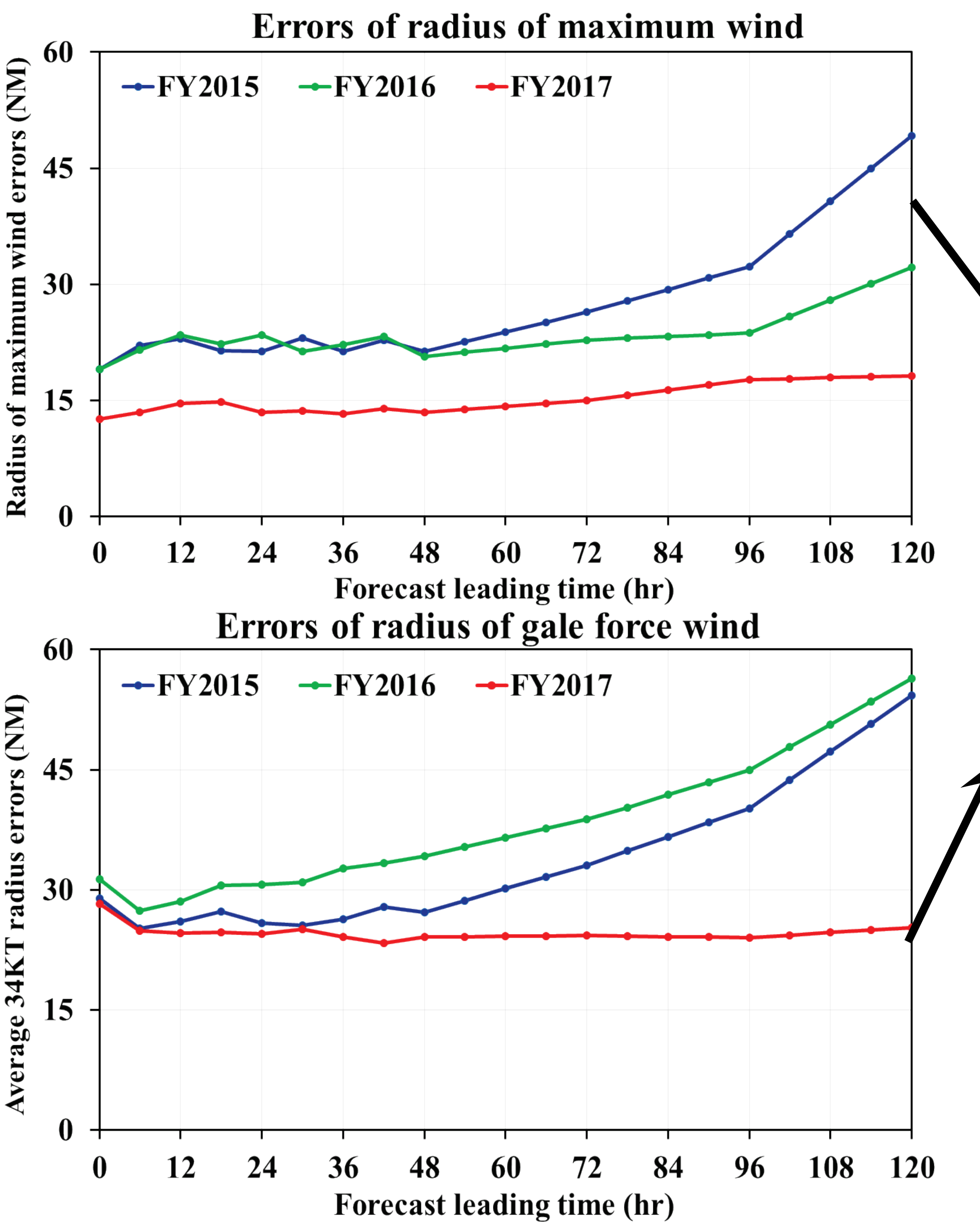
- **In featured hurricanes, Maria, Harvey and Irma, several analyzed HWRF and HMON cycles have captured secondary eyewalls.**
- **Timing is an issues in both models**
  - Secondary eyewalls emerge at different times in different cycles. Generally towards the end of the simulation in earlier cycles and towards the beginning of it in later cycles, but not always
  - Some cycles generated Eyewall Replacement Cycles completed within 15 hours (as in nature), but most Secondary Eyewall are long lasting (one day or more)

HWRF storm size improvement

Retrospective results for Atlantic Basin



Operational results for Atlantic Basin



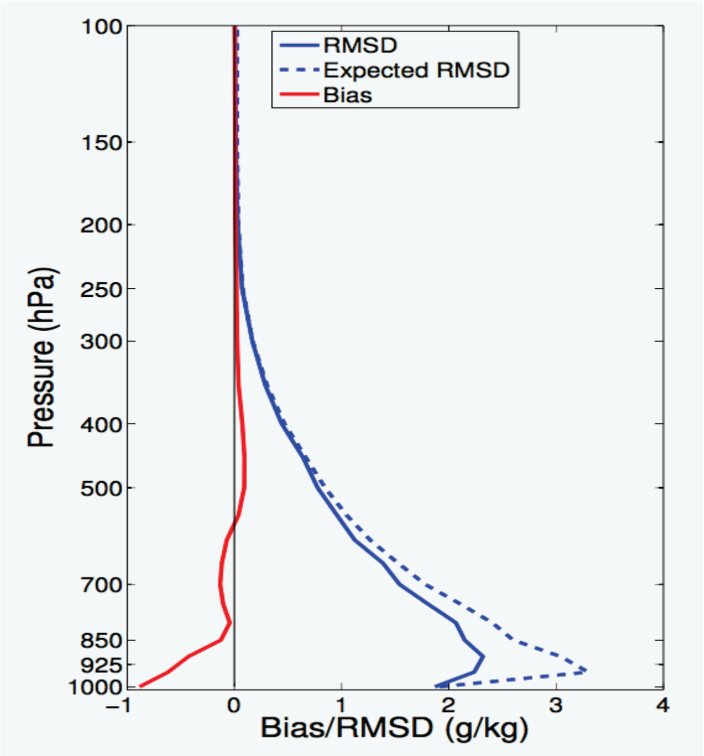
Increased ~50% for long term leading hours from 2016 to 2017.

Other physics work

- Convection, Grell-Freitas –DTC

- Radiation, RRTMG- cloud overlap

- Bias in dry troposphere
  – HRD Basin-scale HWRF



Summary

- Proposed YSU PBL has explicit cloud top entrainment, it has better inflow profile, but it produces weaker storm when it comes with its own surface layer.
- Proposed "In-cloud turbulent mixing" above the boundary layer in GFSEDMF PBL helps storm intensity.
- Lowering Km in the PBL has positive impact on RI.
- Adevected F-A mircophysics produces more heating for species, leading to larger storm with unfavorable pressure-wind relationship.
- Scale-Aware SAS is more skillful for higher resolution hurricane model.
- The operation forecast about secondary eyewall has been improved a lot, but timing is still an issue.
- Physics improve leads to storm structure improvement, especially storm size improvement which is important for storm surge.