Testing Hurricane WRF with Alternate Radiation and Partial Cloudiness Schemes

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Outline

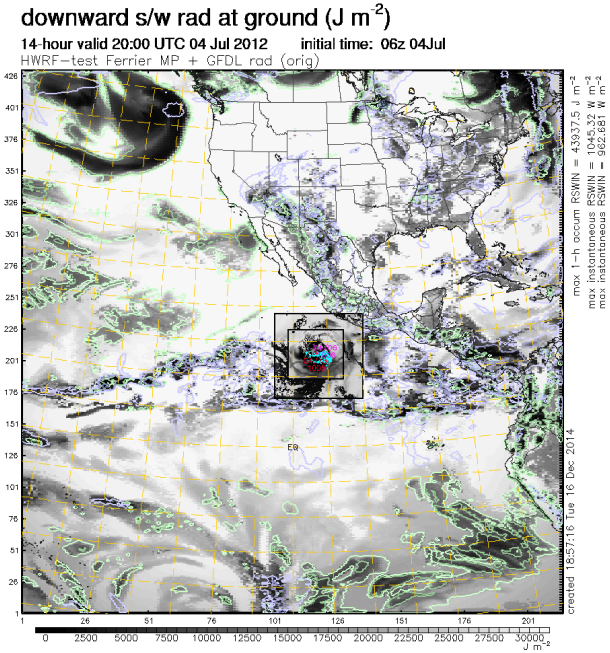
- Background
- Experiment configuration
- Verification of track and intensity
- Results for large-scale fields
- Conclusions

Background

- Fovell diagnosed problems with longwave tendencies in HWRF's operational GFDL radiation parameterization
- Previous DTC tests implementing RRTMG instead of operational GFDL revealed two important deficiencies of the configuration of the RRTMG radiation scheme used in those experiments
  - Only explicit clouds from the mp scheme are visible to the RRTMG – subgrid cumulus clouds (from SAS) are transparent
  - Under representation of stratus clouds in coarse resolution (horizontal and vertical) outer domain
- DTC implemented a scale-aware partial cloudiness scheme for RRTMG

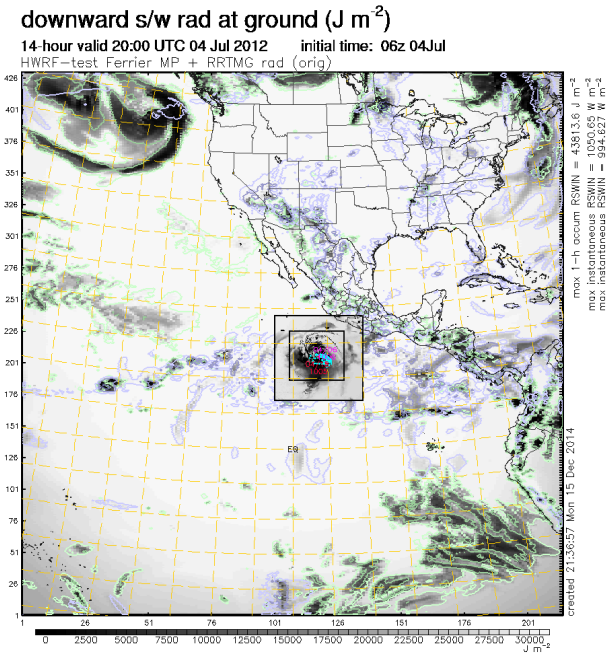
Addressing issues in RRTMG-cloud connection

Ferrier/GFDL radiation



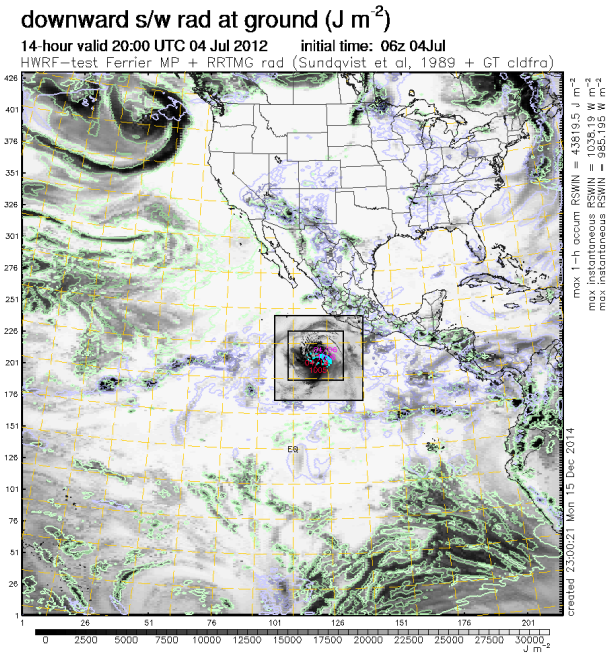
Control: Reasonable SW attenuation but documented problems in LW

Ferrier/RRTMG radiation



Excessive SW radiation reaching surface: SAS clouds transparent to RRTMG radiation and lack of stratus representation

Ferrier/RRTMG/part cloud

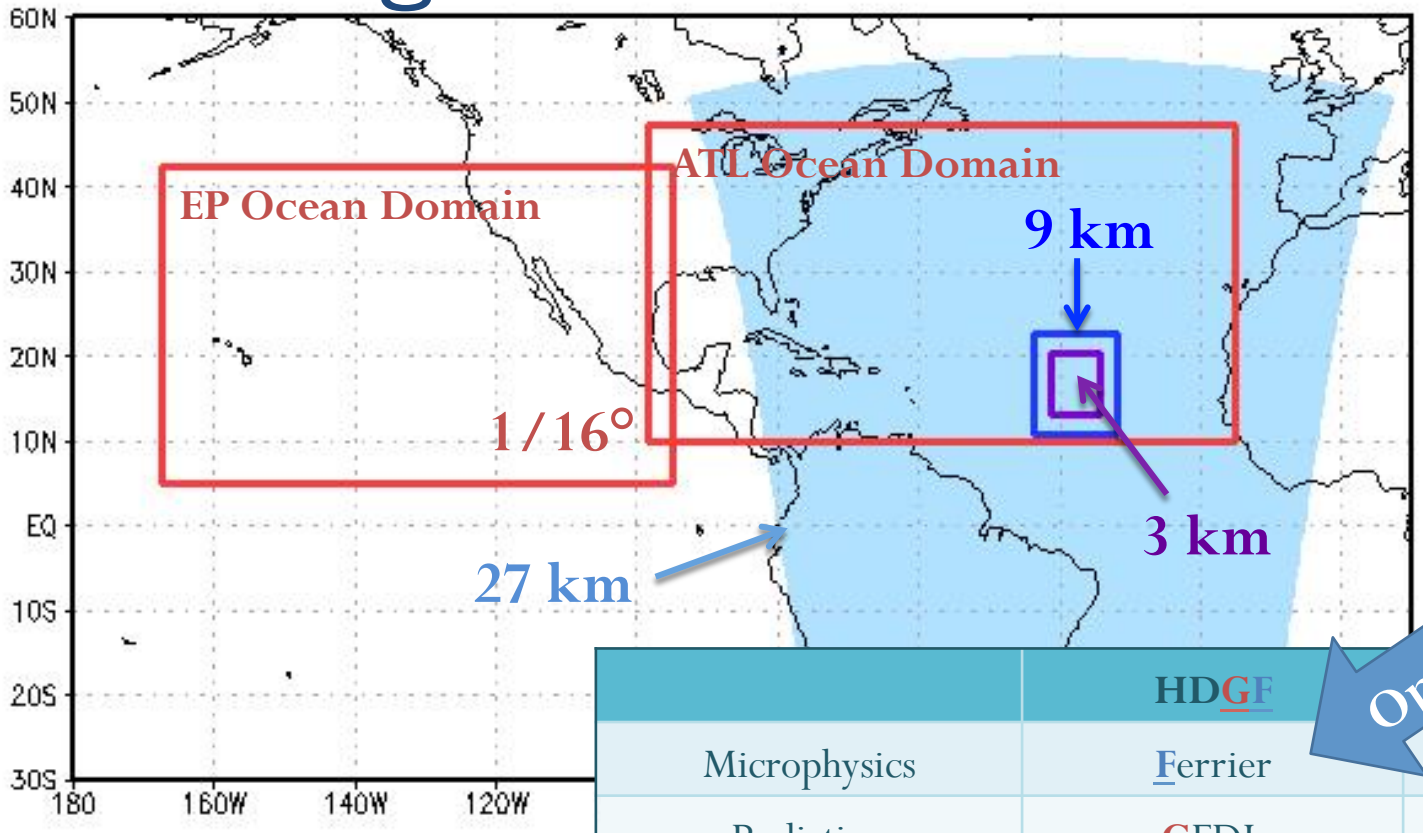


Reasonable SW attenuation with partial cloudiness scheme implemented by DTC

Partial Cloudiness for RRTMG

- Existing RRTMG radiation parameterization assigned a binary (0% or 100%) cloud fraction based on existence of cloud condensate of mp scheme
  - No cloud if the mp didn't create one
- Now, namelist parameter ICLOUD=3 invokes the Sundqvist et. al (1989) cloud fraction scheme (available for all WRF v3.7 users)
  - Simulates liquid- and ice-water content based on humidity and temperature to represent a "cloud" with radiative properties
  - LWC & IWC are used only by radiation and in the absence of mp condensate
- Subgrid clouds are now "visible" by RRTMG

Configuration



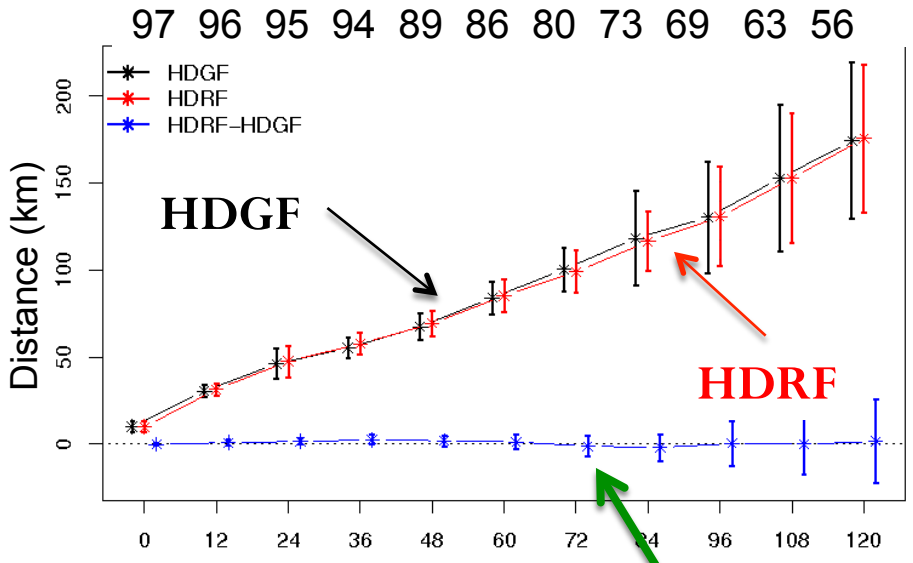
9 ATL Storms
101 Cases

9 EP Storms
97 Cases

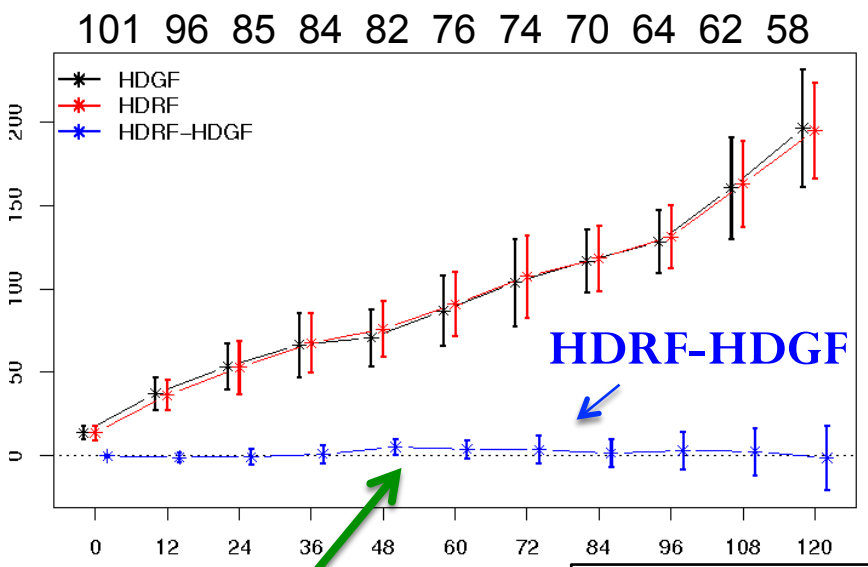
Ops Suite

	HDGF	HDRF
Microphysics	Ferrier	Ferrier
Radiation	GFDL	RRTMG
Rad. Δt	1 hour	15 mins
SAS/Rad. Connection	yes	no
Partial Clouds	no	yes
Convection	SAS	SAS
PBL/Sfc Layer Phys	GFS/GFDL	GFS/GFDL

EP Track Error



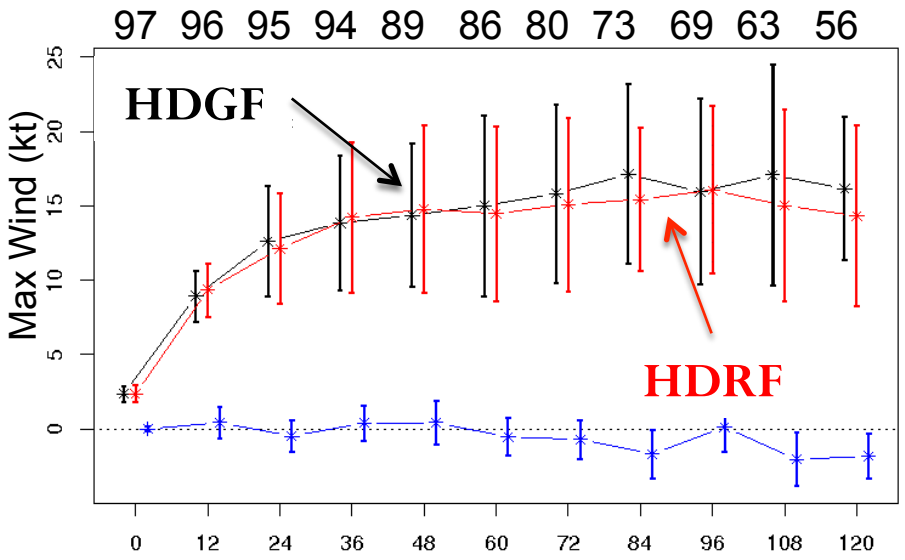
AL Track Error



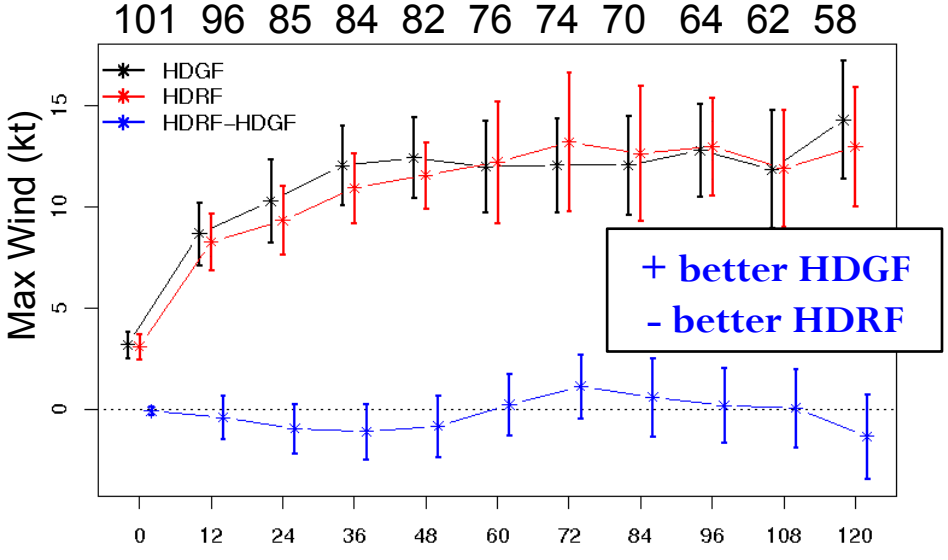
+ better HDGF
- better HDRF

Neutral track impact for both basins

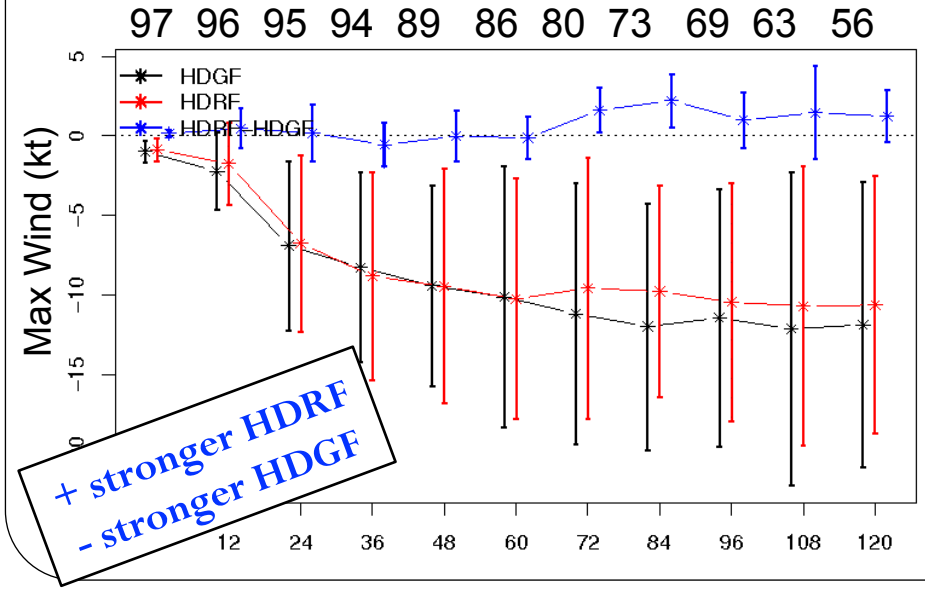
EP Intensity Error



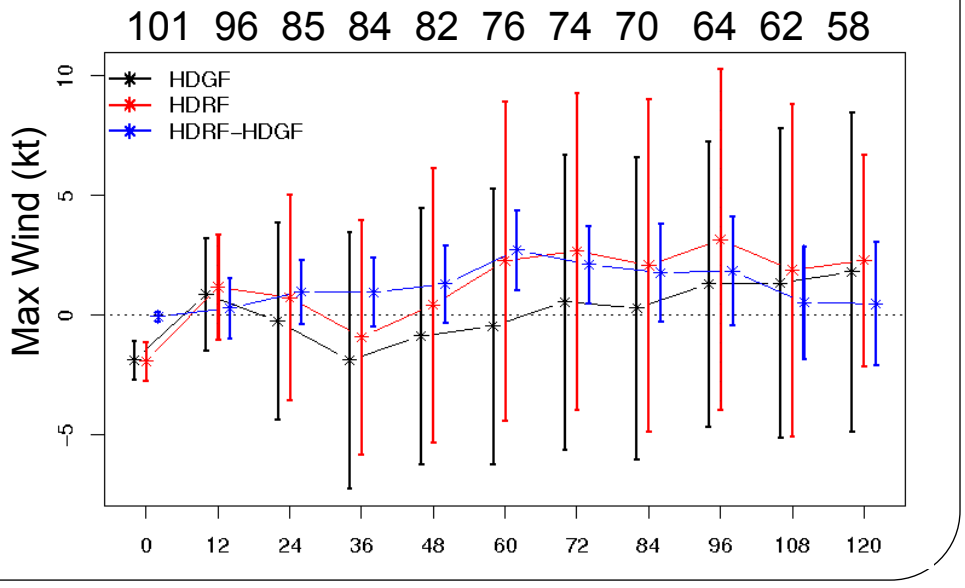
AL Intensity Error



EP Intensity Bias

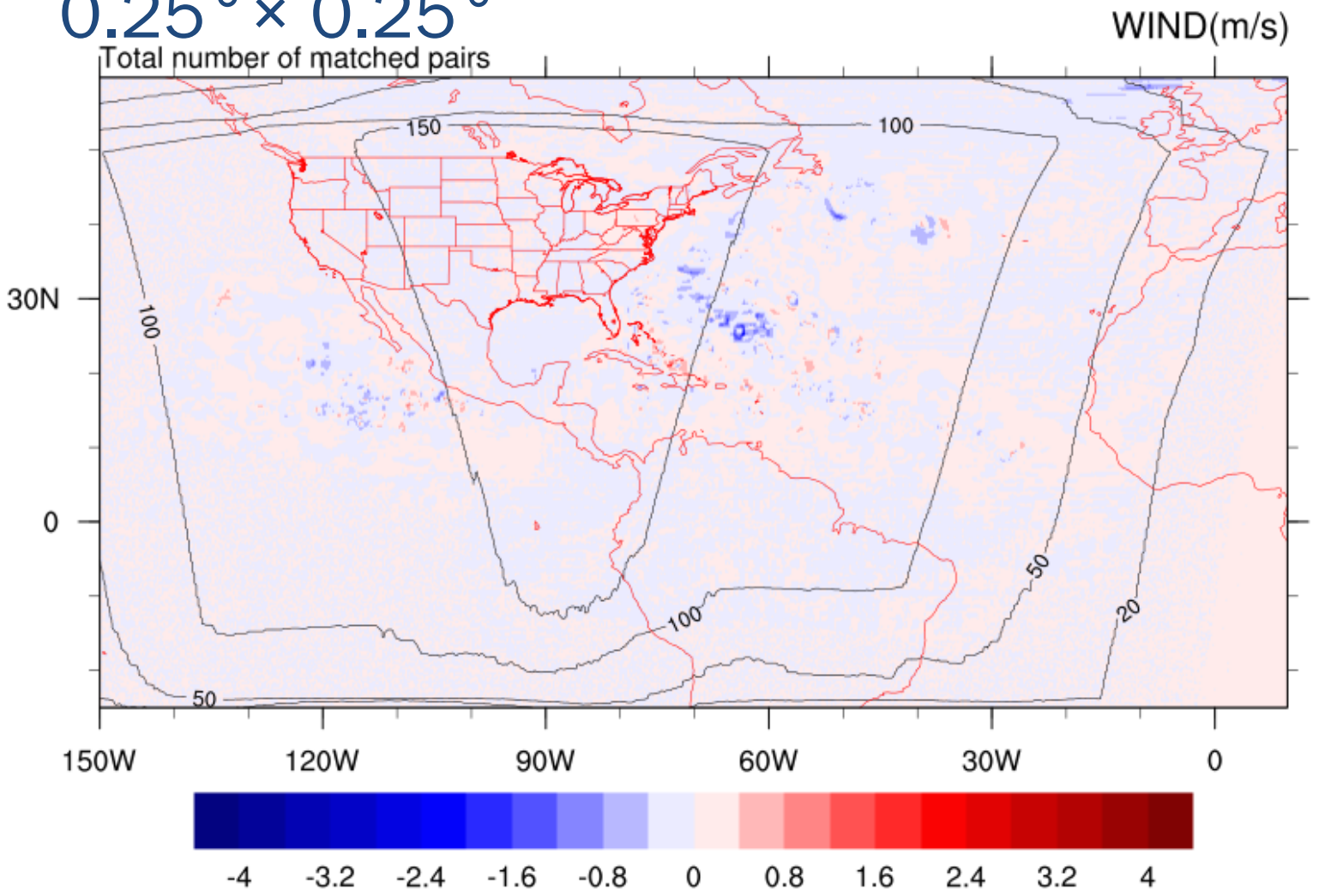


AL Intensity Bias



Mega Domain Verification against GFS Analysis

0.25° × 0.25°



HDGF BIAS

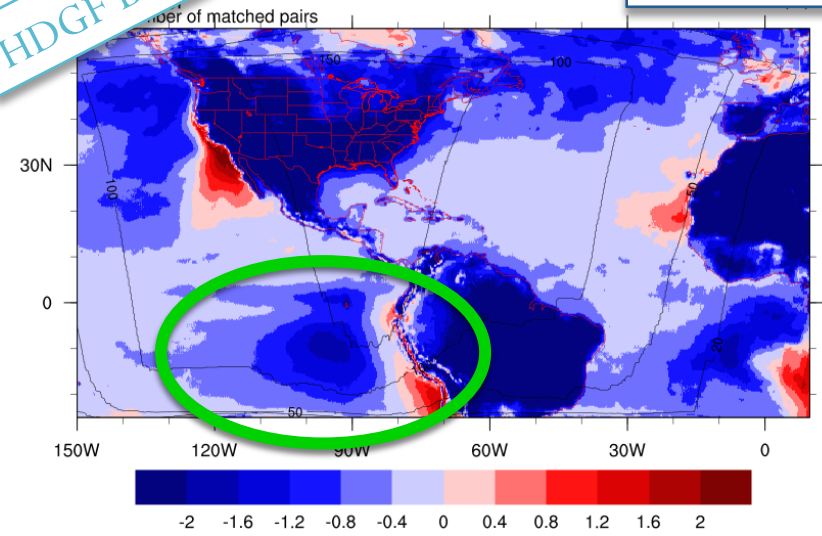
HDRF BIAS

HDGF RMSE

DIFF RMSE
(HDGF-HDRF)

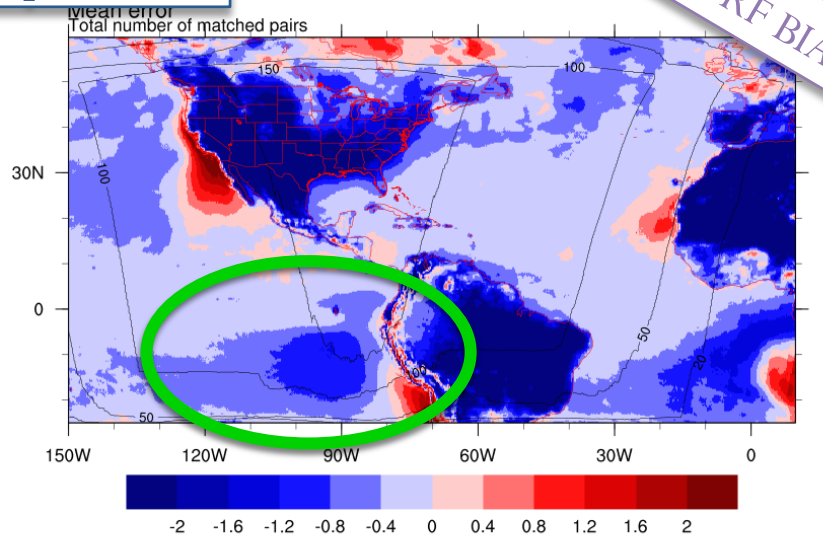
1000 hPa Temp (K)

HDGF BIAS



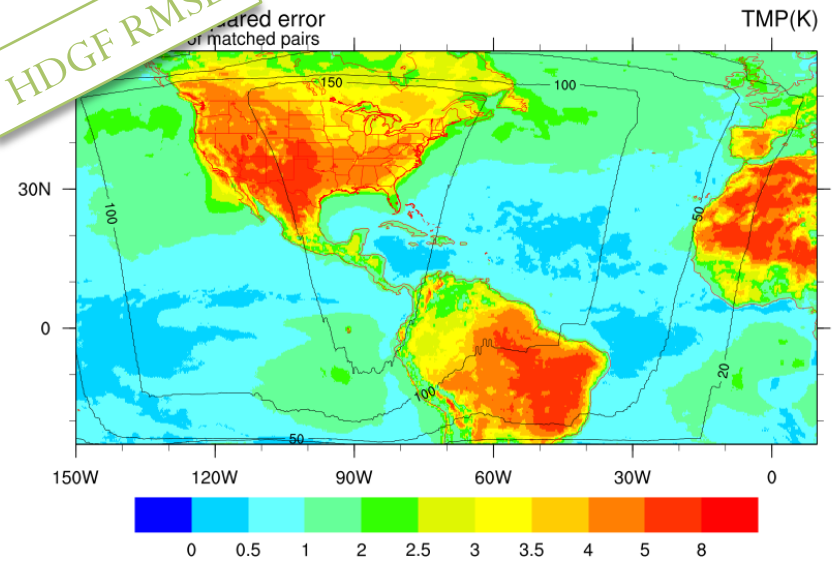
EP AVE: -0.979769 Tot. AVE: -1.0105 AL AVE: -0.927435

HDRF BIAS



EP AVE: -0.65933 Tot. AVE: -0.72074 AL AVE: -0.58924

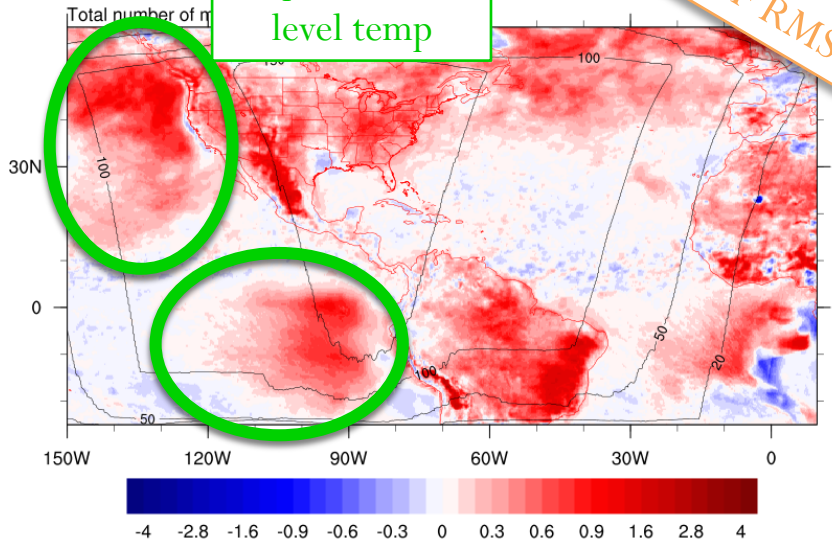
HDGF RMSE



EP AVE: 1.88855 Tot. AVE: 1.81233 AL AVE: 1.83459

HDRF improves low-level temp

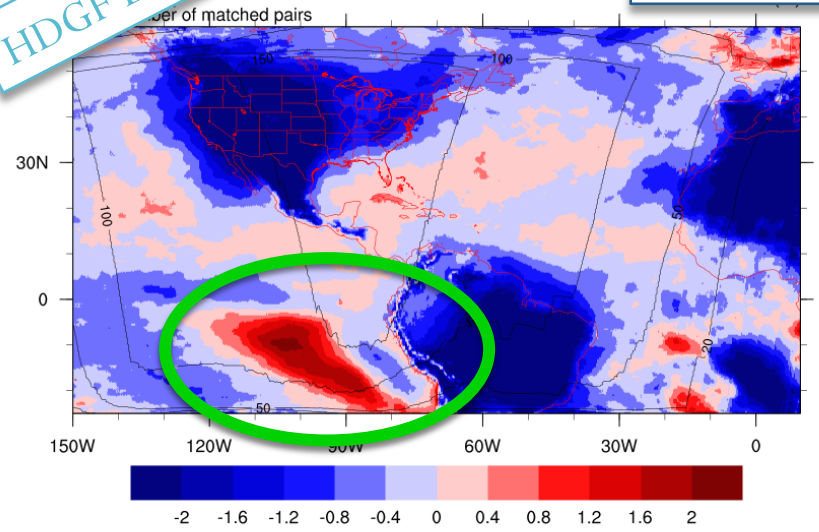
DIFF RMSE



HDRF Degrades HDRF Improves

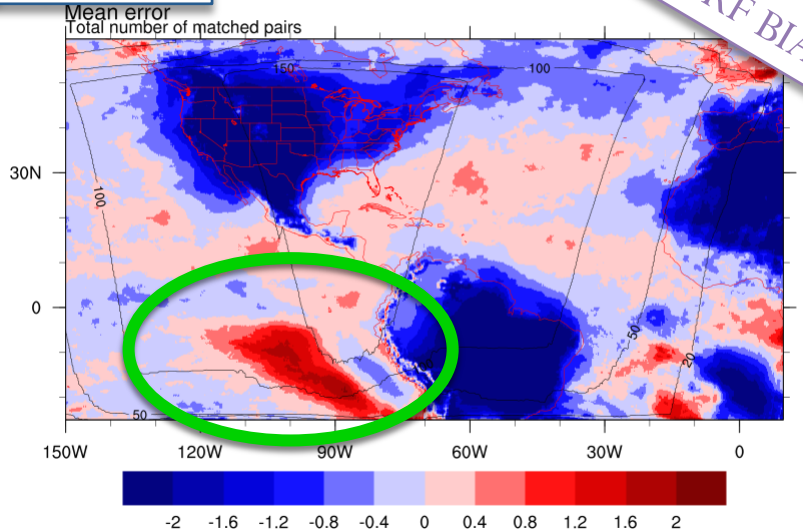
850 hPa Temp (K)

HDGF BIAS



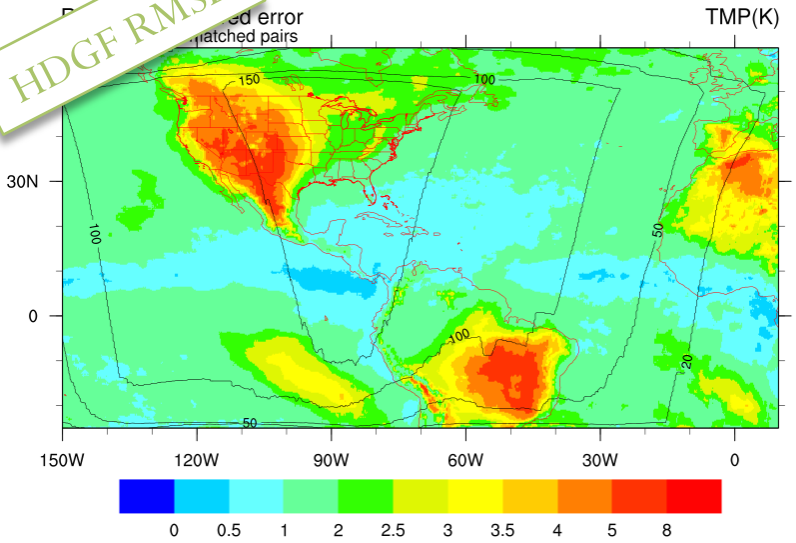
EP AVE: -0.780543 Tot. AVE: -0.714818 AL AVE: -0.544793

HDRF BIAS



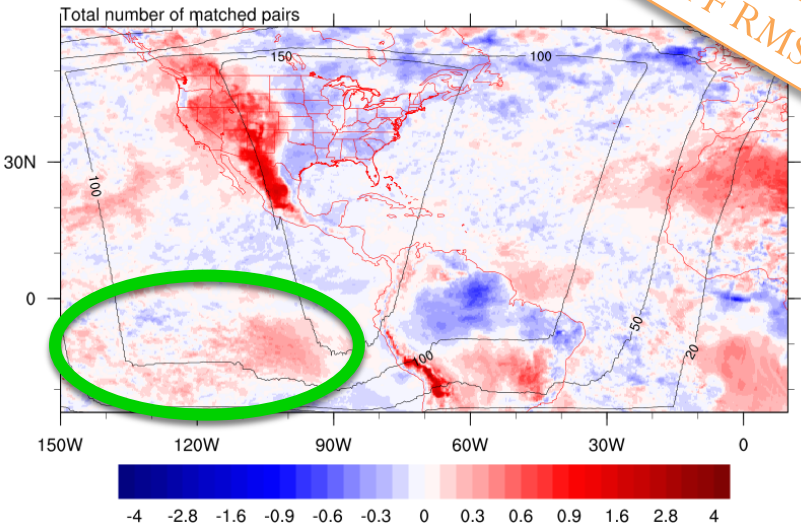
EP AVE: -0.628531 Tot. AVE: -0.590104 AL AVE: -0.507183

HDGF RMSE



EP AVE: 1.94896 Tot. AVE: 1.78585 AL AVE: 1.49908

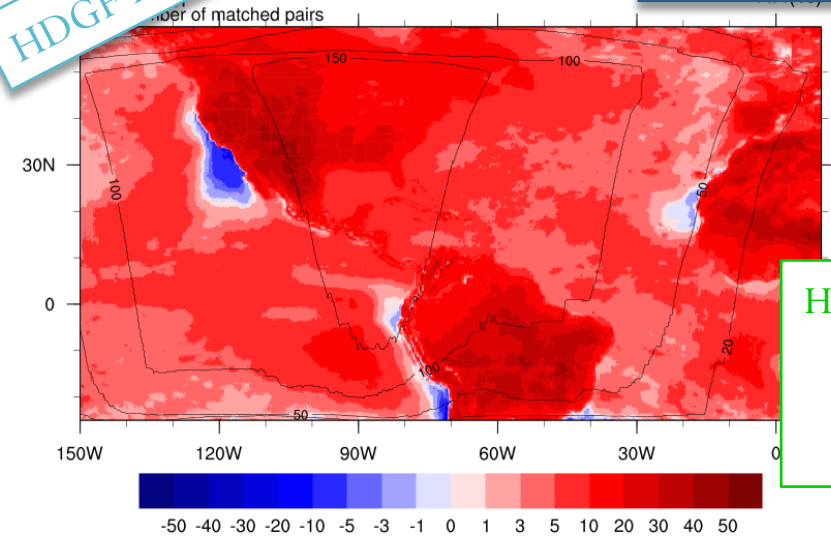
DIFF RMSE



HDRF Degrades HDRF Improves

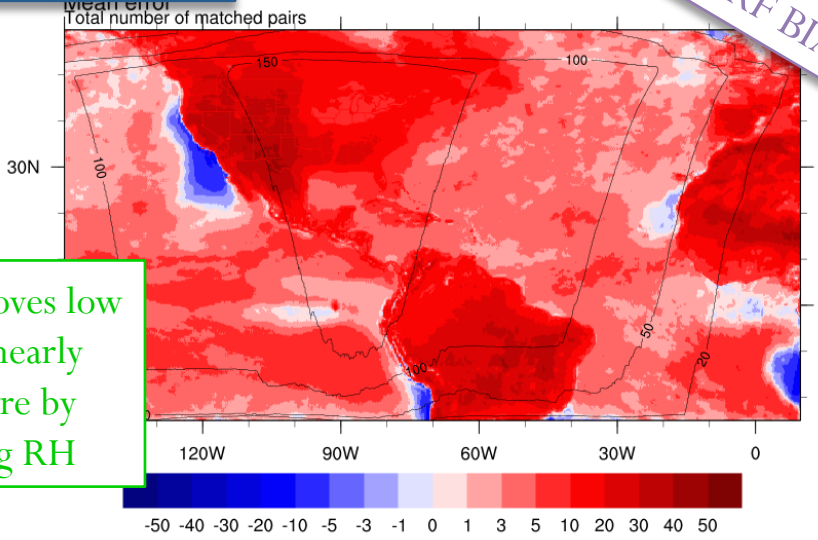
1000 hPa RH (%)

HDGF BIAS



EP AVE: 10.3413 Tot. AVE: 9.61764 AL AVE: 9.57451

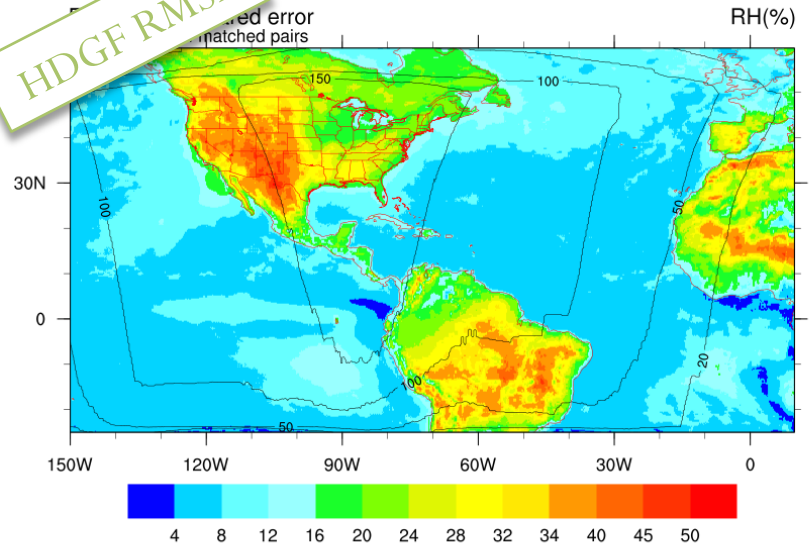
HDRF BIAS



EP AVE: 8.90547 Tot. AVE: 8.30299 AL AVE: 7.9842

HDRF improves low level RH nearly everywhere by decreasing RH

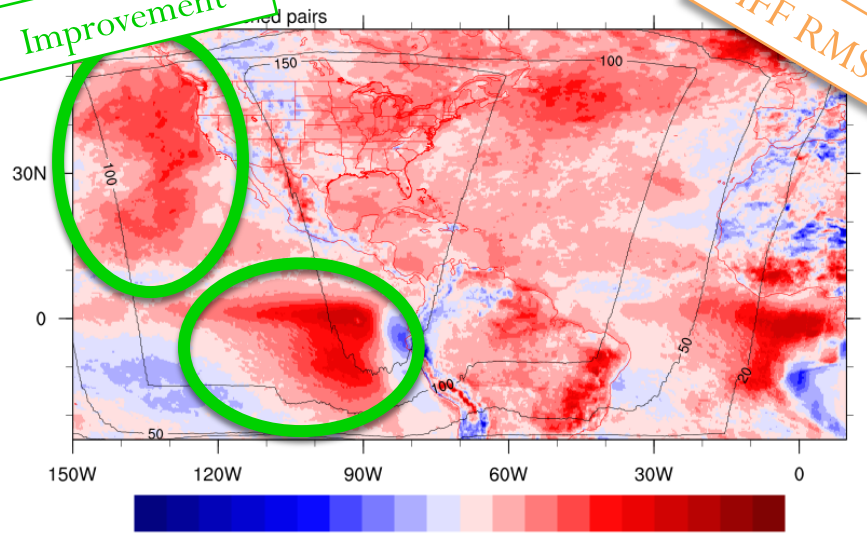
HDGF RMSE



EP AVE: 14.2047 Tot. AVE: 13.1538 AL AVE: 13.0006

Improvement

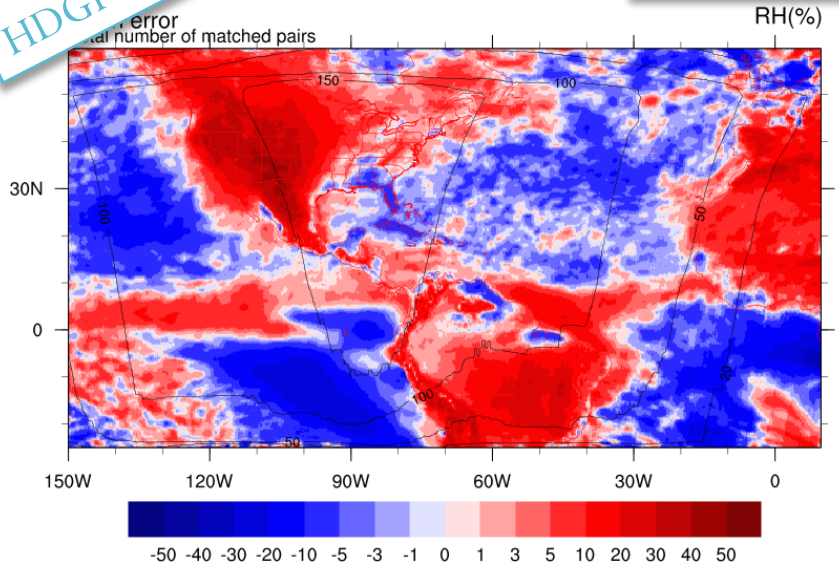
DIFF RMSE



HDRF Degrades HDRF Improves

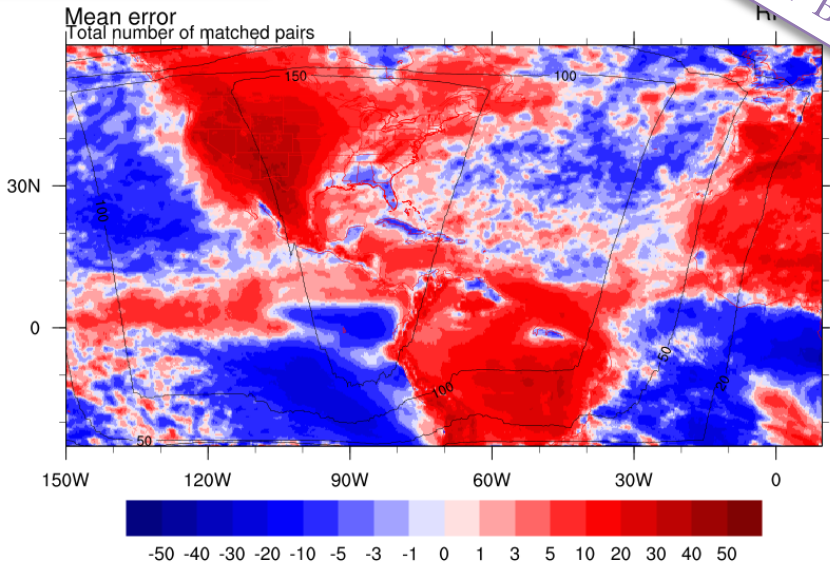
850 hPa RH (%)

HDGF BIAS



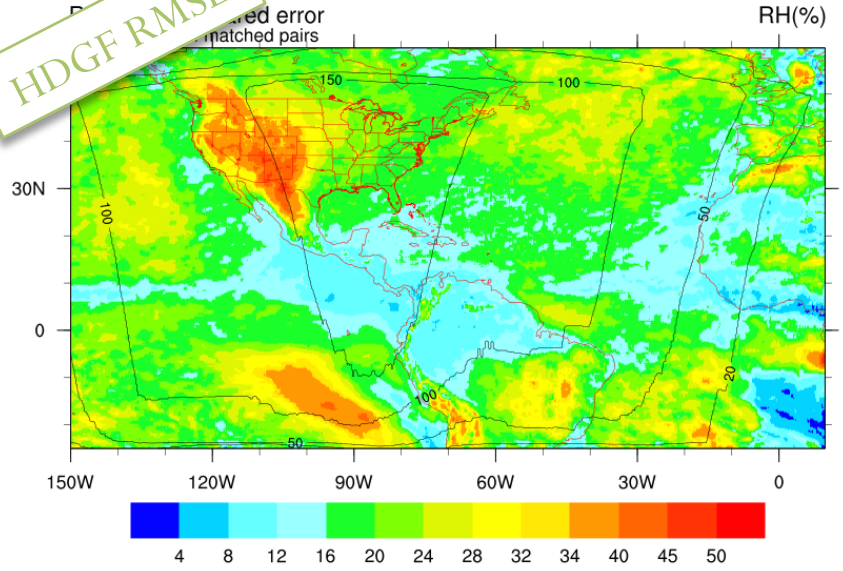
EP AVE: 3.70319 Tot. AVE: 1.43107 AL AVE: 0.747427

HDRF BIAS



EP AVE: 3.97913 Tot. AVE: 2.05938 AL AVE: 2.60121

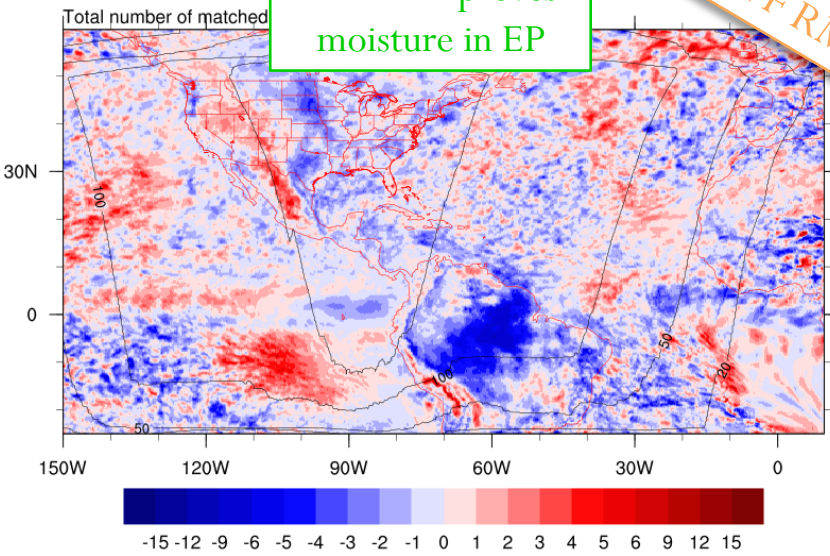
HDGF RMSE



EP AVE: 21.8456 Tot. AVE: 20.0103 AL AVE: 18.1723

HDRF Improves moisture in EP

DIFF RMSE



HDRF Degrades HDRF Improves

Conclusions

- HWRF was tested with an alternate radiation package, exchanging the GFDL radiation scheme for the RRTMG scheme, partial cloudiness, and a more frequent physics time step
- TC intensity forecasts improved very slightly in HDRF at longer lead times in the EP, and had mixed results for ATL storms
- TC track forecasts were left virtually unchanged from the control experiment

Conclusions

- The experimental configuration had small impact in most metrics of large scale verification
- Low level heat and moisture fields were the most sensitive and were improved in the experimental configuration. This may explain the improved intensity forecasts
- Some fields, such as geopotential height, were better in the control configuration
- We expect that the HDRF cloud structure is more realistic and will perform further diagnostics

RRTMG with partial cloudiness was delivered to EMC and has been implemented in the Operational HWRF for 2015