An Evaluation of Alternative Species-Advecting Microphyiscs Schemes in Hurricane WRF

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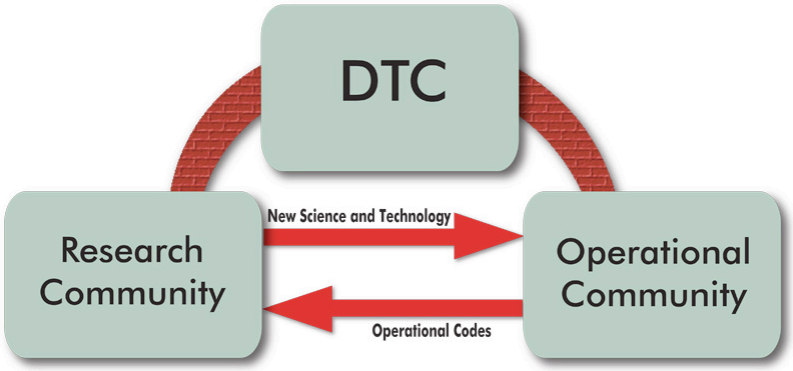
HWRF Development and DTC

DTC (Developmental Testbed Center)

- Works with development community to promote efficient R2O process
- Perform diagnostics on and test and evaluate promising NWP innovations for possible operational implementation
- Provides community support to promote O2R through yearly code release, documentation, help desk,workshops, tutorials, etc.
- Visitor Program funds complimentary projects

DTC is a collaborative effort between NOAA/ESRL/GSD & NCAR



HFIP (Hurricane Forecast Improvement Project)

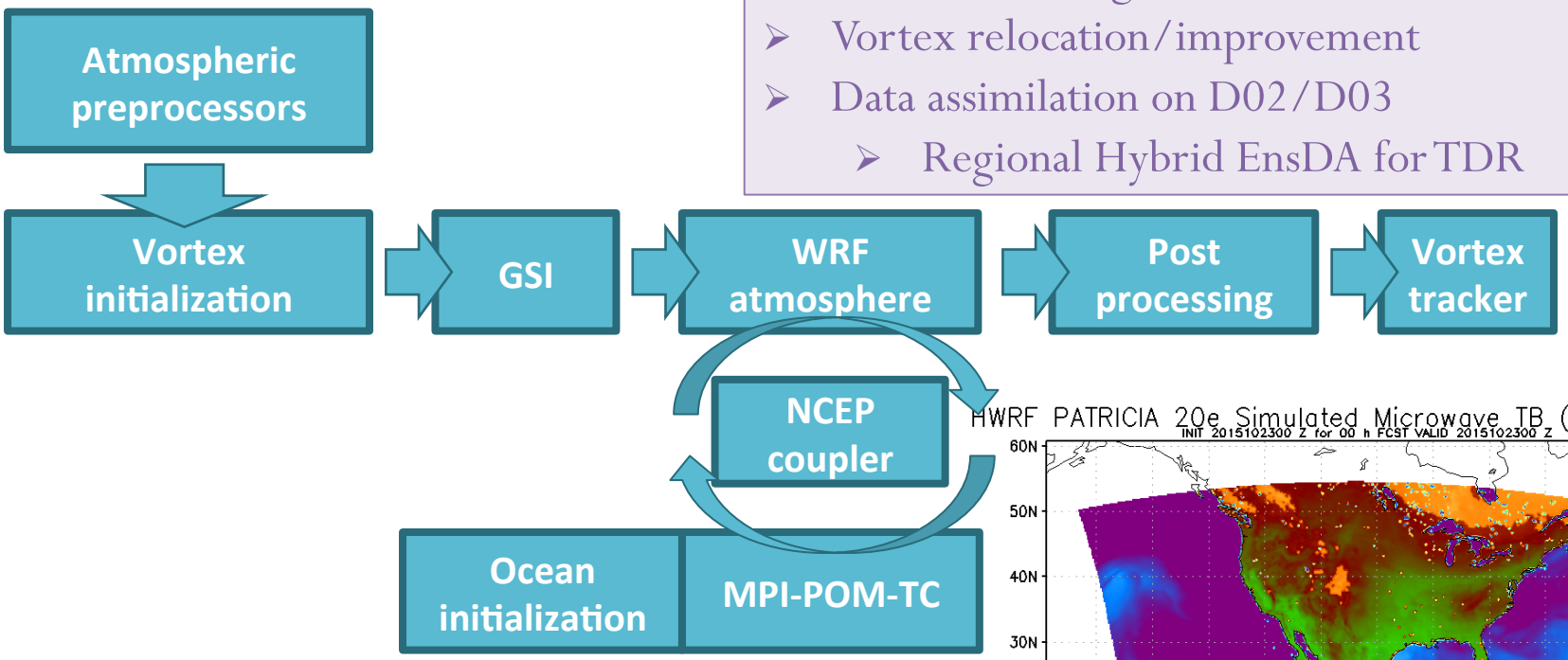
- 10 year project aimed at improving accuracy and reliability of hurricane forecasts (currently in second half)
- Funds scientific community and DTC to work towards R2O

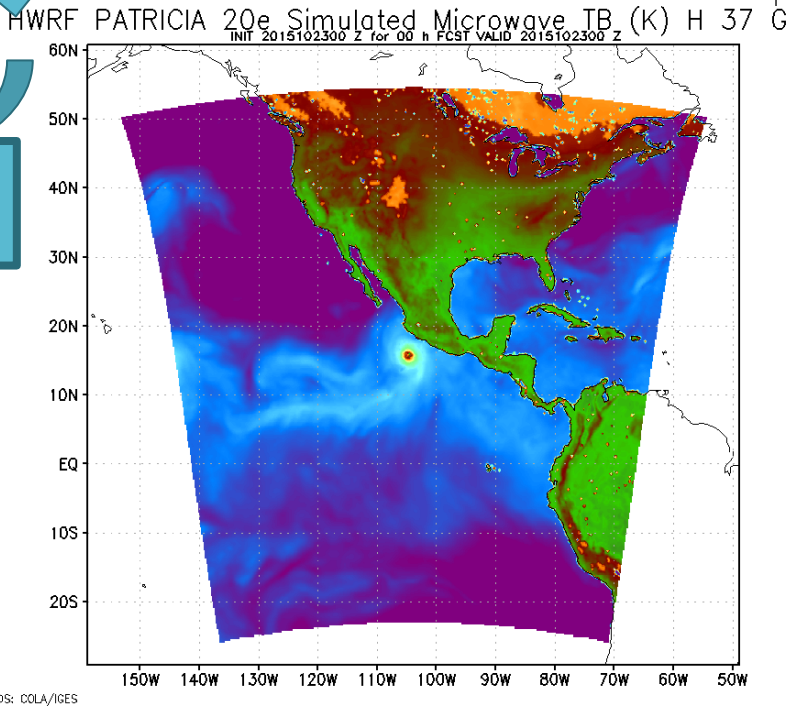
T&E Goals

- Work with community (DTC staff, DTC VP, HFIP PIs) to identify potential upgrades for HWRF
- Communicate with EMC to isolate an area of focus for potential operational upgrade
  - Proposed topics: ocean fluxes, microphysics, radiation, PBL, eddy mixing
- Perform controlled tests during EMC's pre-implementation testing window to provide feedback for operational model
- Pass along information, or even an operational upgrade, based on test results

2015 HWRF

- WRF NMM dynamical core
- Outer domain position based on storm location and projected path
- Storm-following inner nests
- Vortex relocation/improvement
- Data assimilation on D02/D03
  - Regional Hybrid EnsDA for TDR





- **Operational** at NOAA for 5-day forecasting
- Used by **NHC for AL and EP,** available for all basins
- A **community** model

2015 Operational Configuration

- Physics Suite
  - RRTMG radiation
  - Partial cloudiness
  - Ferrier-Aligo microphysics
  - SAS deep and shallow convection
  - GFDL surface layer
  - Noah LSM
  - GFS PBL scheme
- Grid spacing: 18/6/2 km
- Time step: 38 4/7 sec

Microphysics Comparisons

Ferrier-Aligo	Thompson	Advected F-A
Single moment + rime factor	Partial double moment	Single moment + rime factor
Cloud, rain, and snow	Cloud, rain, ice, snow, and graupel	Cloud, rain, and snow
Advects total condensate	Advects individual species	Advects individual species
Supplies only mass to radiation scheme, which independently diagnoses concentration	Coupled with RRTMG (mass & concentration are consistent between microphysics and radiation)	Supplies only mass to radiation scheme, which independently diagnoses concentration
Used in Operational HWRF	Tested for HWRF: red. int. bias at long lead times in ATL	First-time to be tested for HWRF

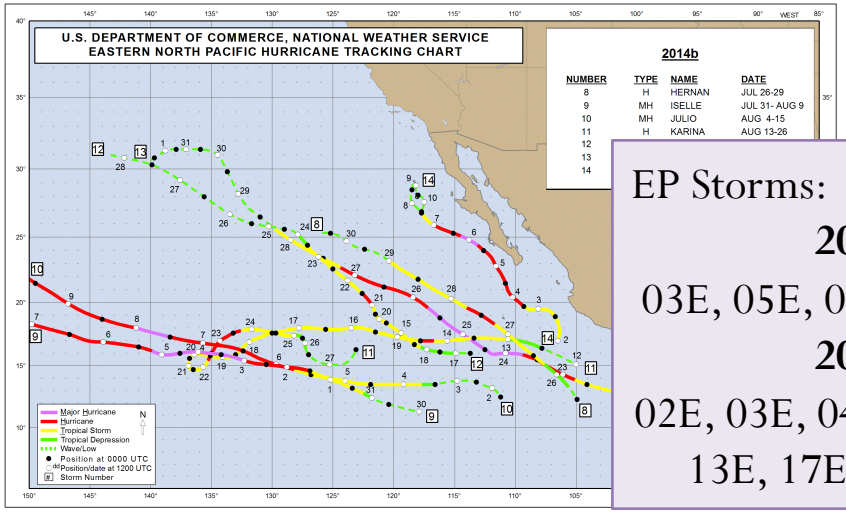
Experiments

Baseline

DTC Test

Code base:
H215 with bug fixes for icloud=3 and non-hydrostatic state retained with nest move

	H16A	HDT6	H16H
Microphysics	Ferrier-Aligo	Thompson	Advected F-A
GFS Version	2015	2015	2015
Dyn. Δt	30 s	30 s	30 s
Partial Clouds	yes	yes	yes
Physics Calls	$6\,\Delta t$	$2\,\Delta t$	$6\,\Delta t$



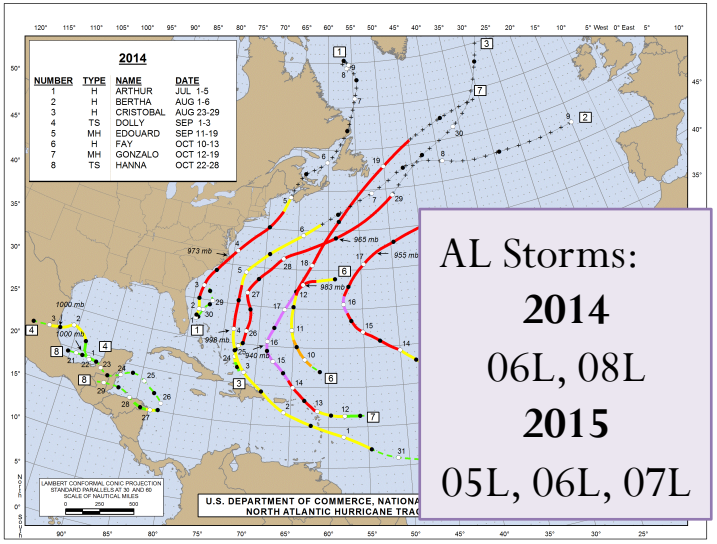
EP Storms:

2014

03E, 05E, 07E, 09E, 11E

2015

02E, 03E, 04E, 10E, 12E, 13E, 17E, 19E, 20E



AL Storms:

2014

06L, 08L

2015

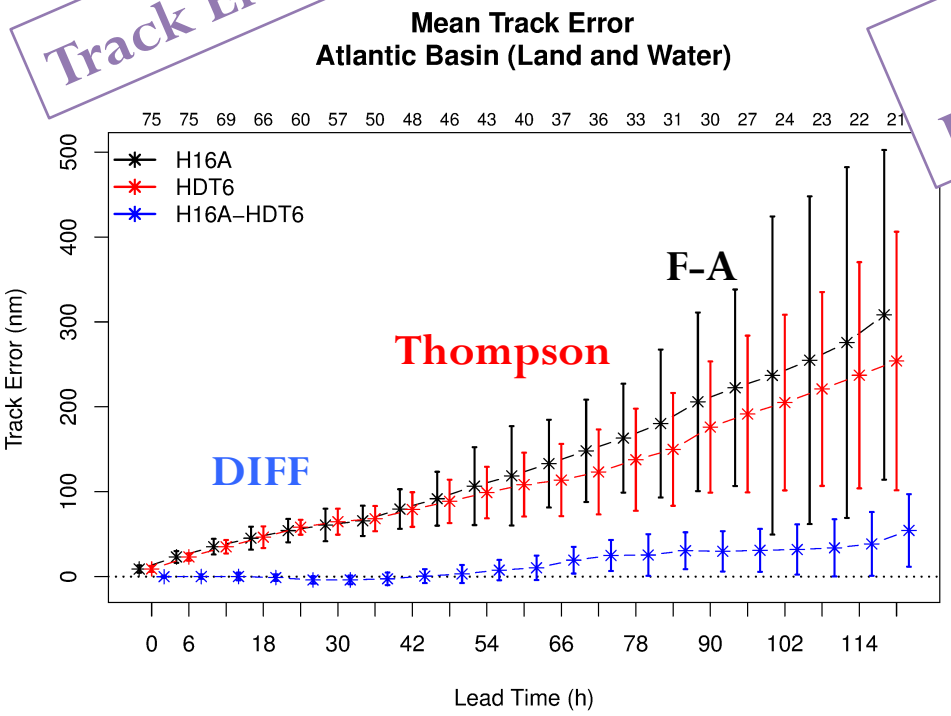
05L, 06L, 07L

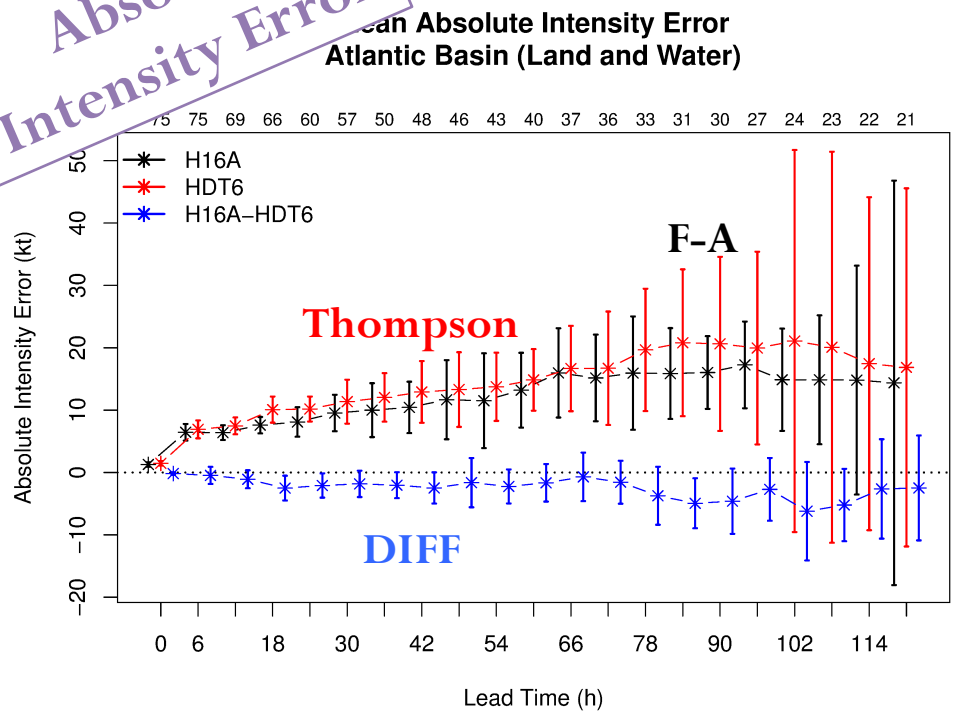
Caution: Very limited sample size!

Track and intensity: AL basin

Track Error

Absolute Intensity Error



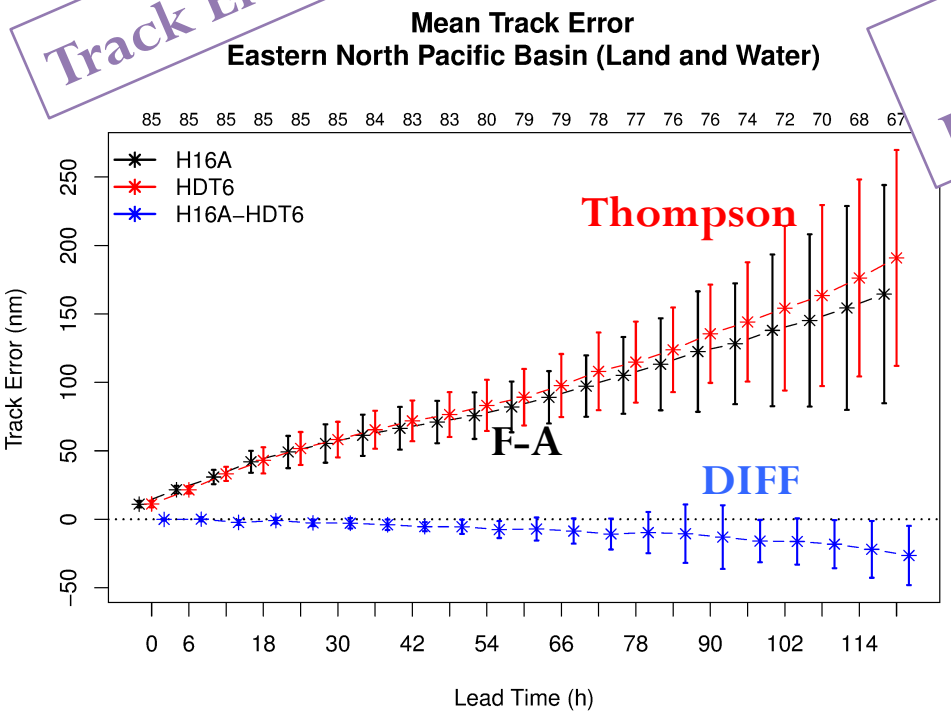


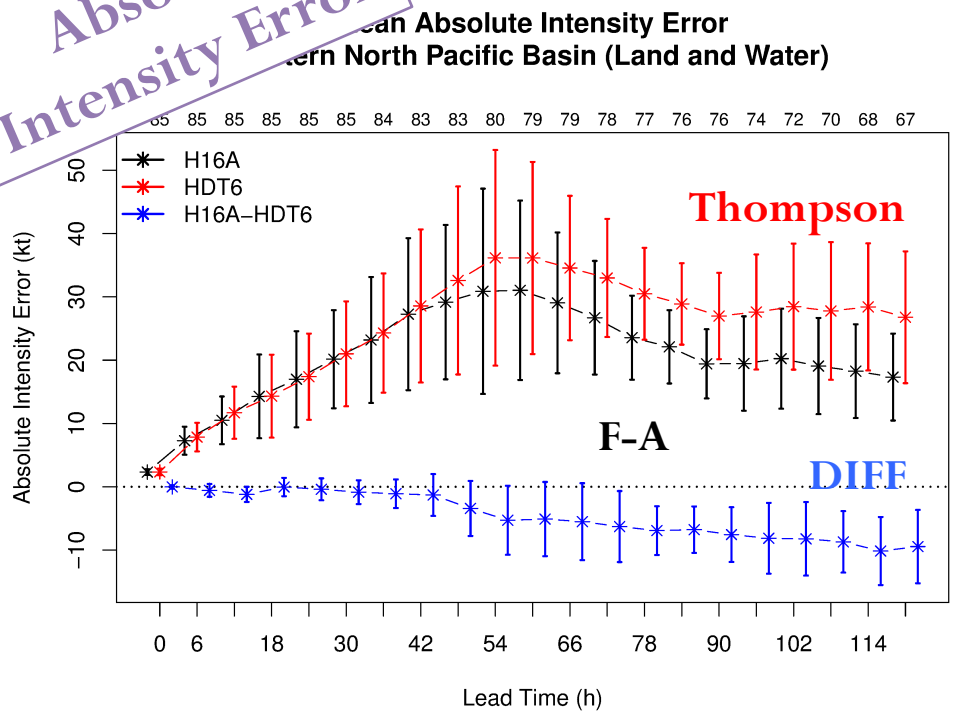
Track improvement for HDT6 beyond 48 hrs
Neutral intensity differences; slight degradation HDT6 after 72 h

Track and intensity: EP basin

Track Error

Absolute Intensity Error

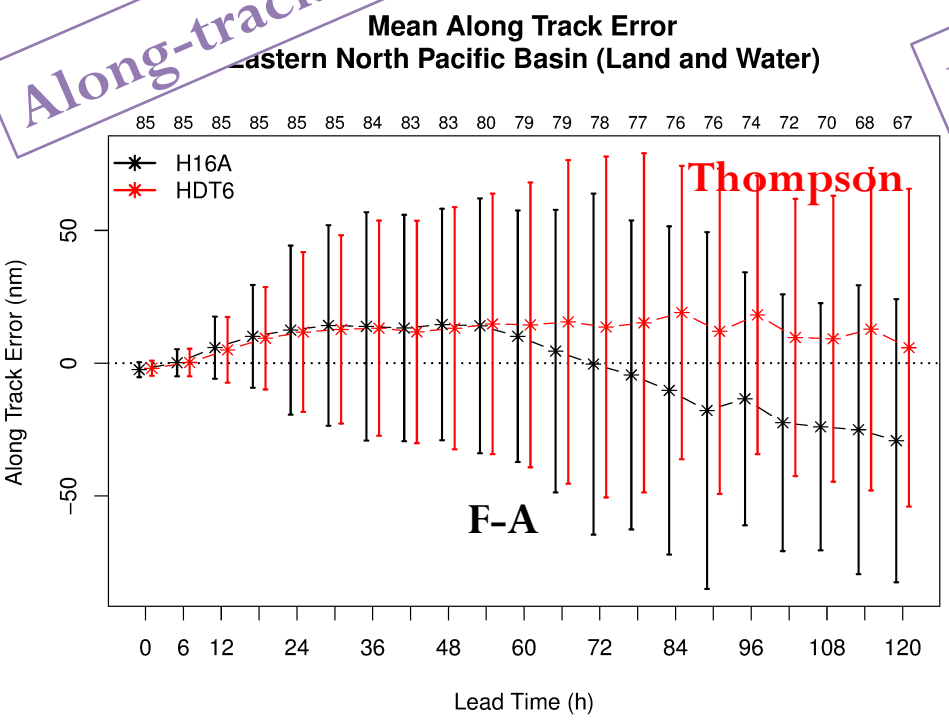




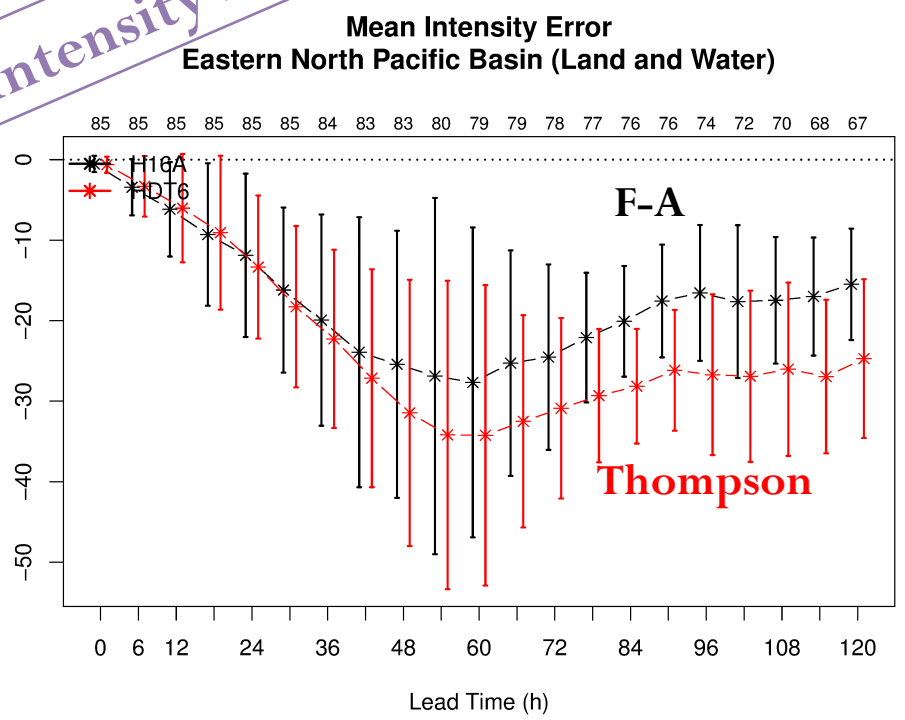
Slight track degradation at long lead times for HTD6
Larger intensity errors beyond 54 hours

Intensity and along track bias: EP Basin

Along-track Bias



Intensity Bias

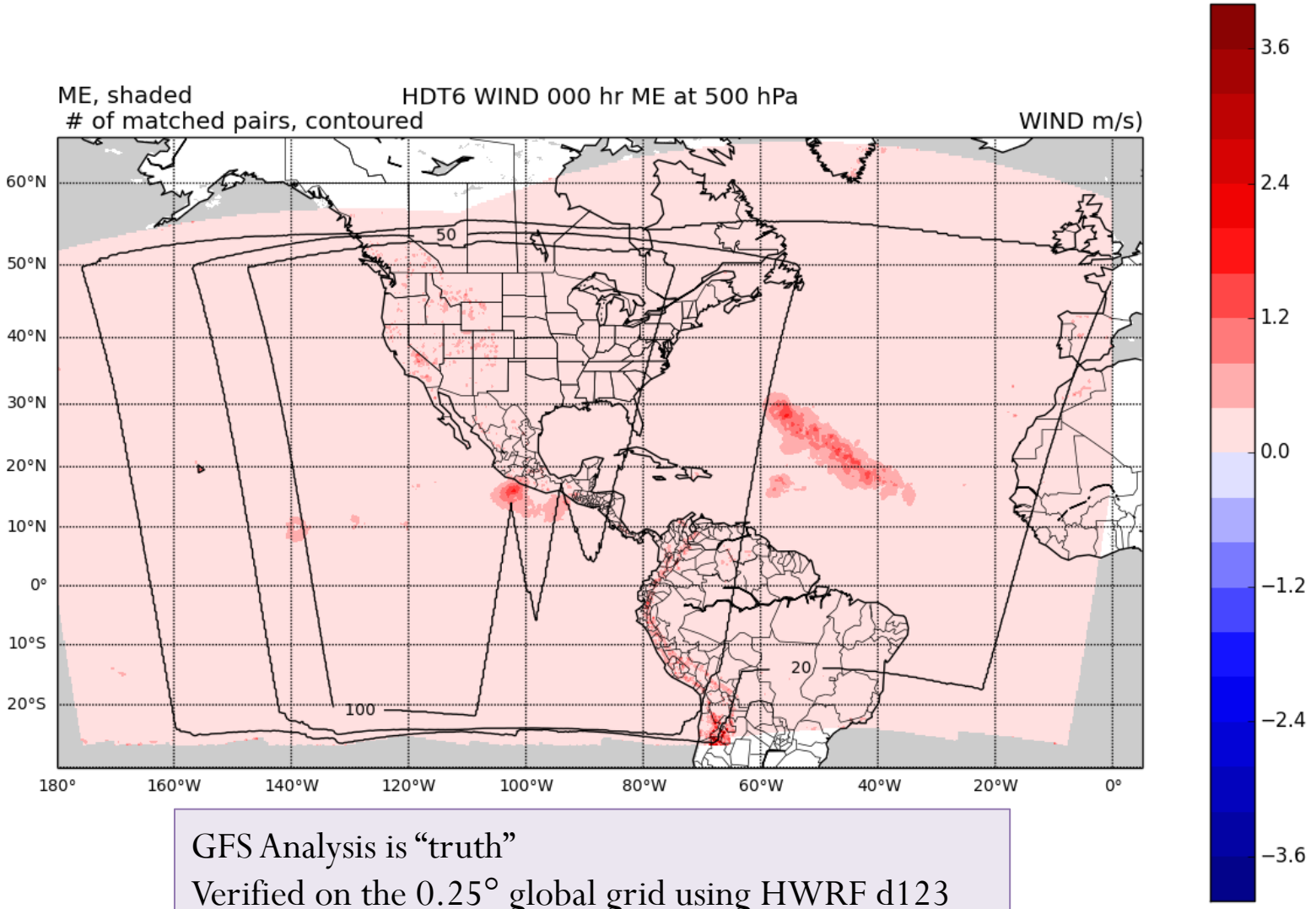


Large negative intensity bias for both, greater for HTD6
Positive along track error for HDT6 (storms moving faster)

Sample includes several RI events that provided an abnormally large negative bias.

Vars: Height, Relative Humidity, Wind speed, Wind components, Temperature
Stats: ME, RMSE

Large scale verification

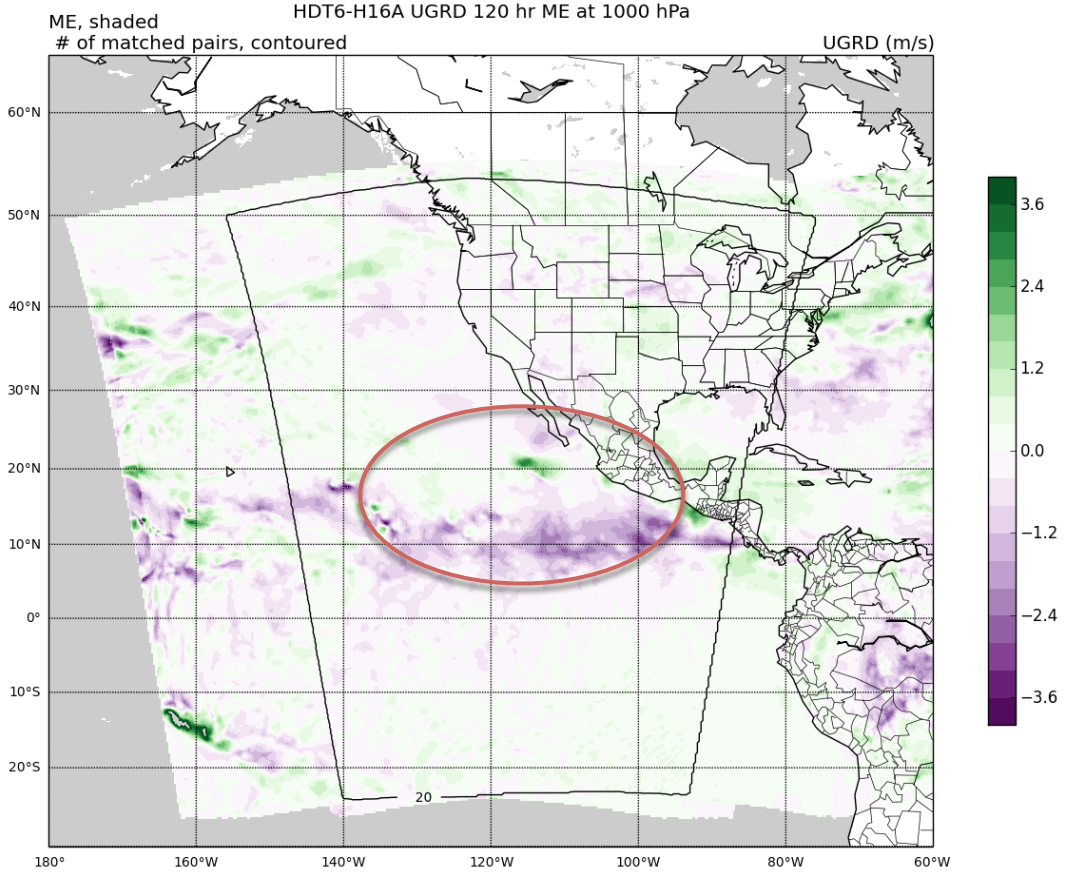


GFS Analysis is "truth"
Verified on the 0.25° global grid using HWRF d123

Zonal Wind

HDT6 – H16A ME

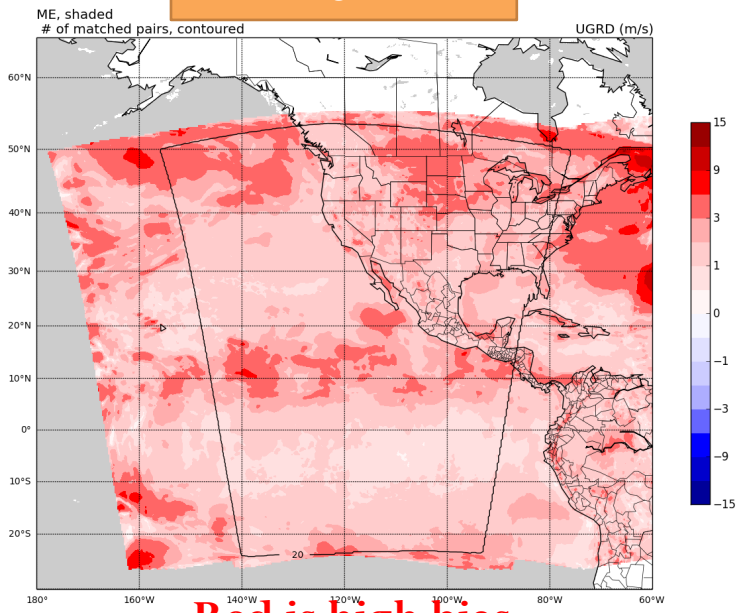
1000 hPa



Green is more westerly

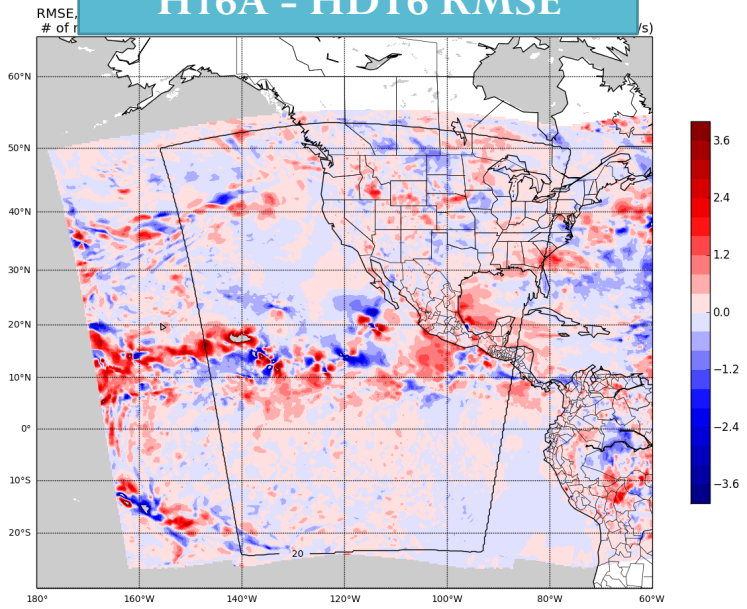
Purple is less westerly

HDT6 MAE



Red is high bias

H16A – HDT6 RMSE

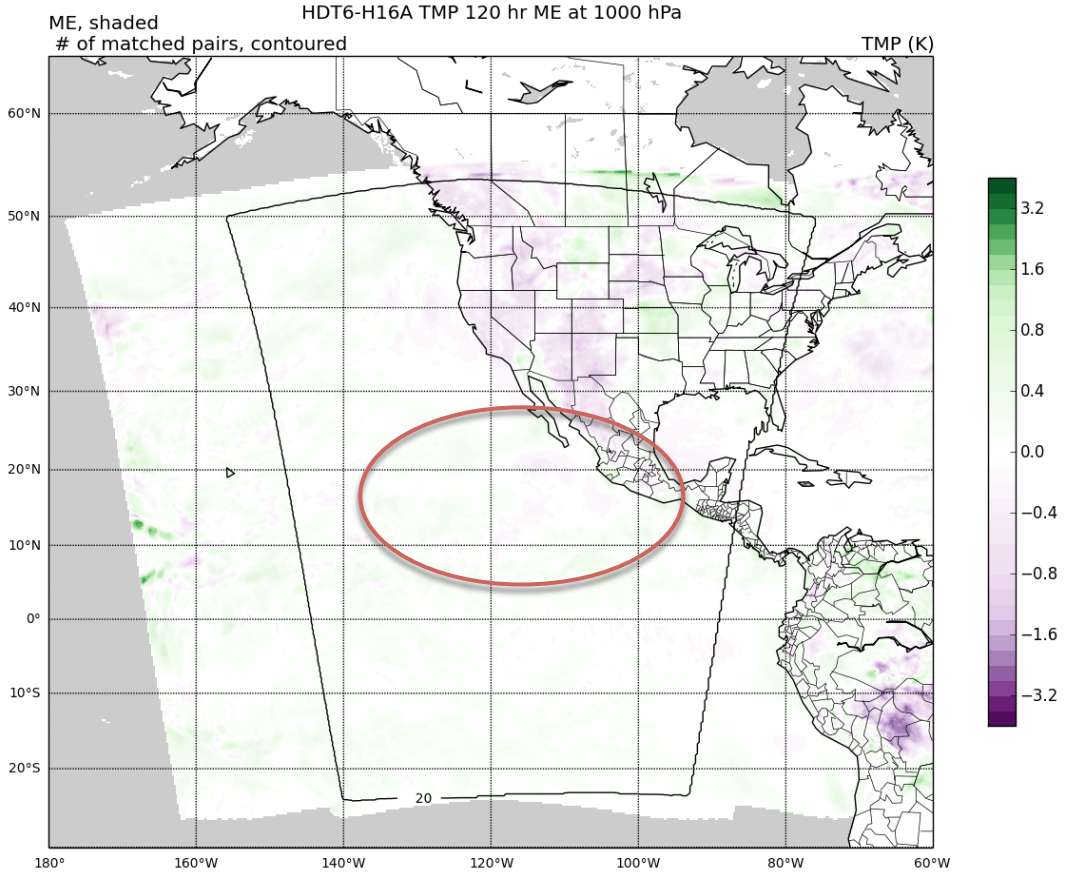


Red is better HDT6

Temperature

HDT6 – H16A ME

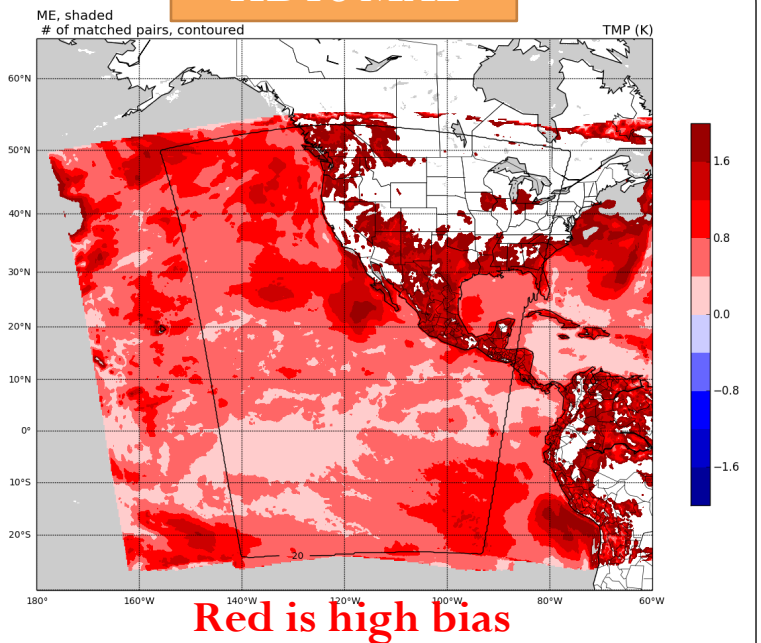
1000 hPa



Green is WARMER

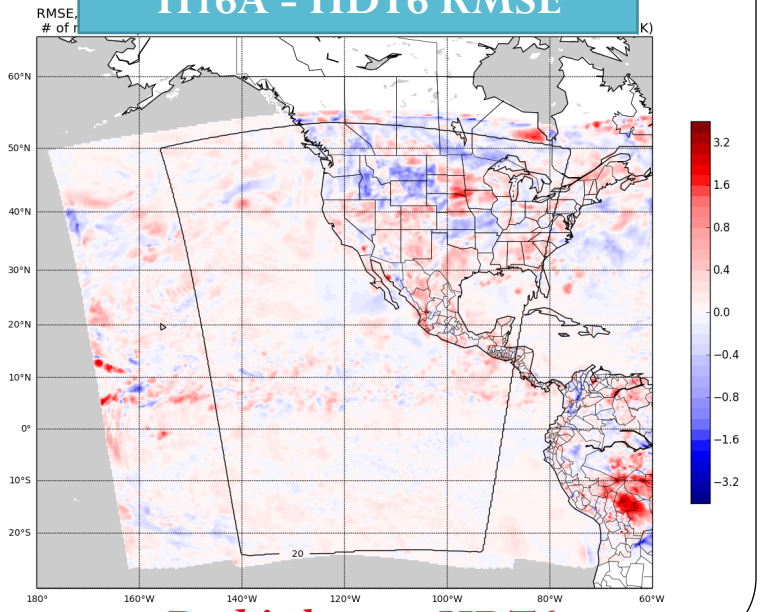
Purple is COOLER

HDT6 MAE



Red is high bias

H16A – HDT6 RMSE

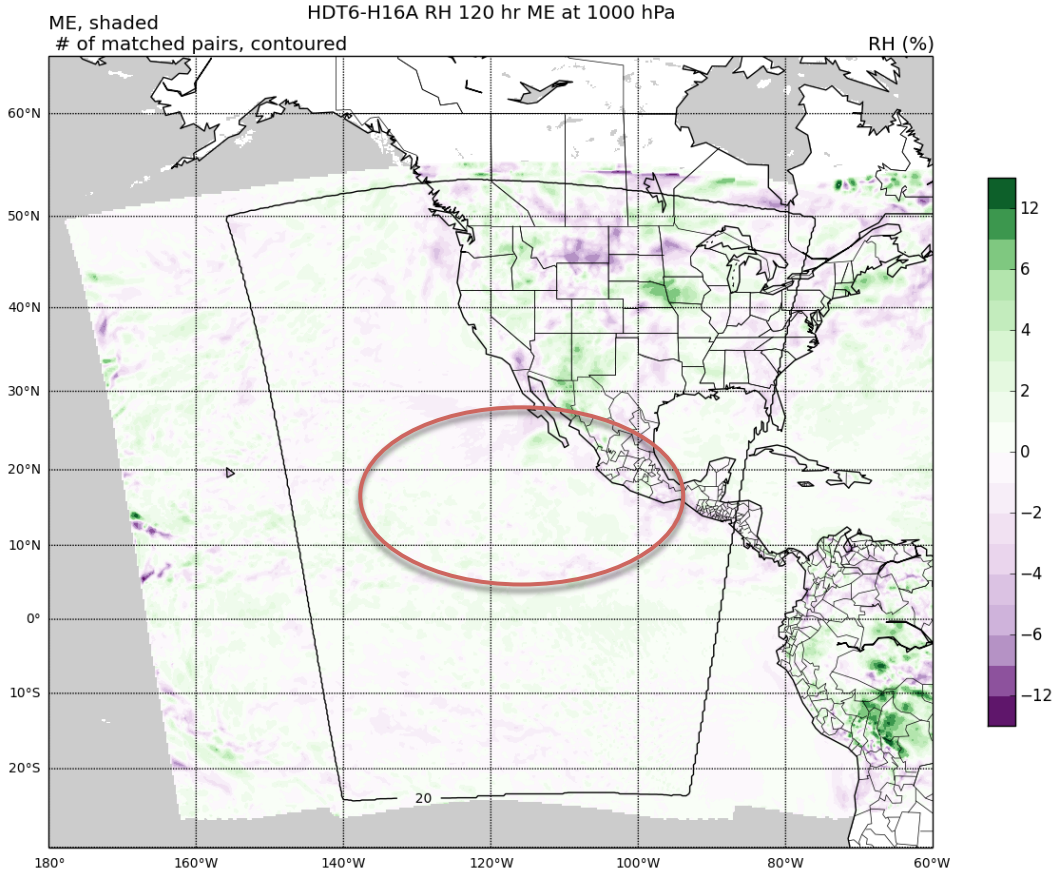


Red is better HDT6

Relative Humidity

HDT6 – H16A ME

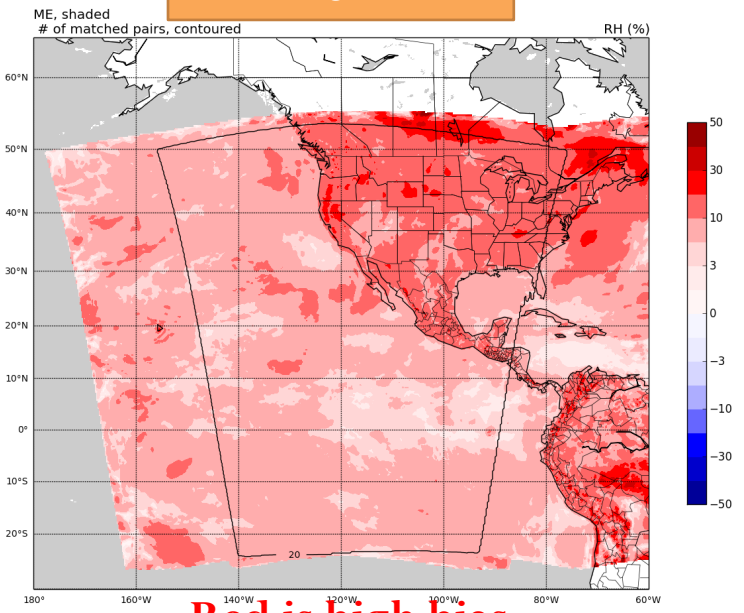
1000 hPa



Green is more humid

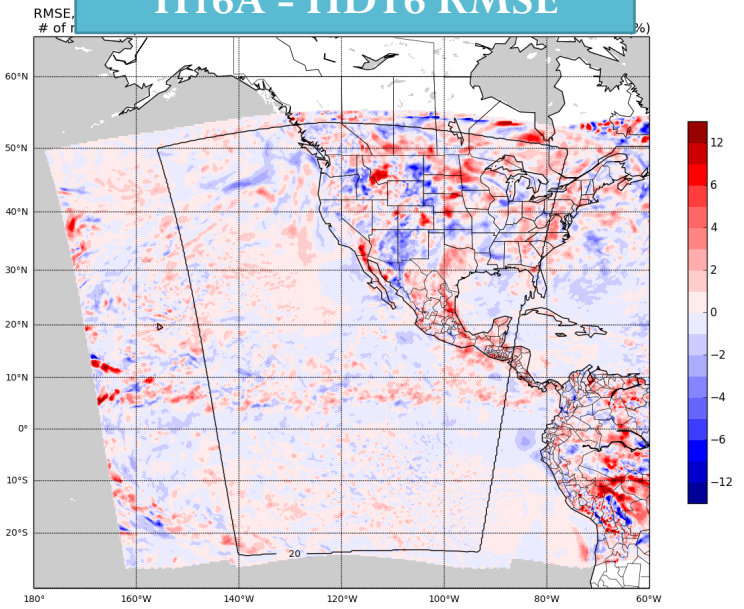
Purple is drier

HDT6 MAE



Red is high bias

H16A – HDT6 RMSE



Red is better HDT6

Summary

- The **Thompson microphysics scheme**, a partial double-moment scheme that includes advection of 6 individual species, was tested at DTC to provide feedback to EMC for potential operational implementation, and was compared against their H16A baseline
- **AL tracks were improved after 48 h**, while the intensity of AL storms was slightly degraded after 72 h in our limited sample (experimentation was stopped for AL storms, while verification of EP storms continued).
- EP tracks were degraded slightly at long lead times, but those storms showed an even **larger negative intensity bias** than the control
- Further investigation indicated that **increased large-scale shear**, combined with cooler, drier mid-levels could be a source of EP intensity degradation.
- EMC used the results of this study to decide to **retain the F-A microphysics scheme** as a component of the operational HWRF physics suite for 2016. Testing for microphysics with advected species will likely continue for future operational implementation.