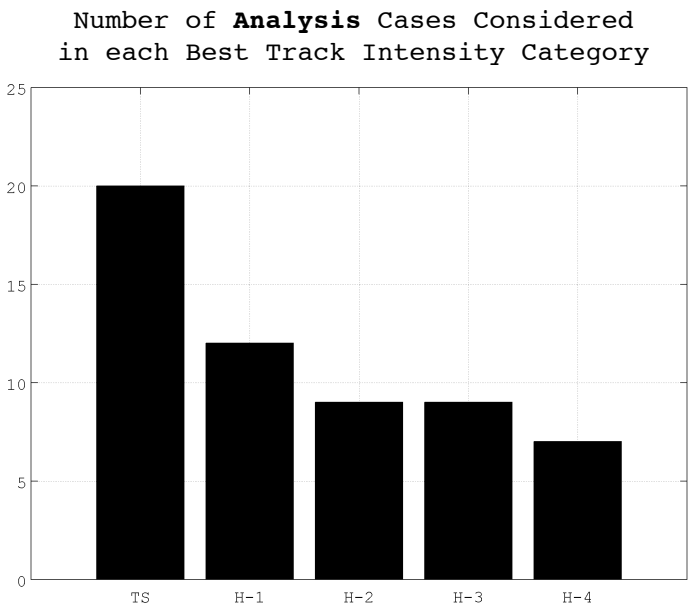
DA Team report

Jeff Whitaker with input from

Tom Hamill, Phil Pegion, Ryan Torn, Fuqing Zhang, Altug Aksoy, Jim Doyle, Mingjing Tong, Milija Zupanski

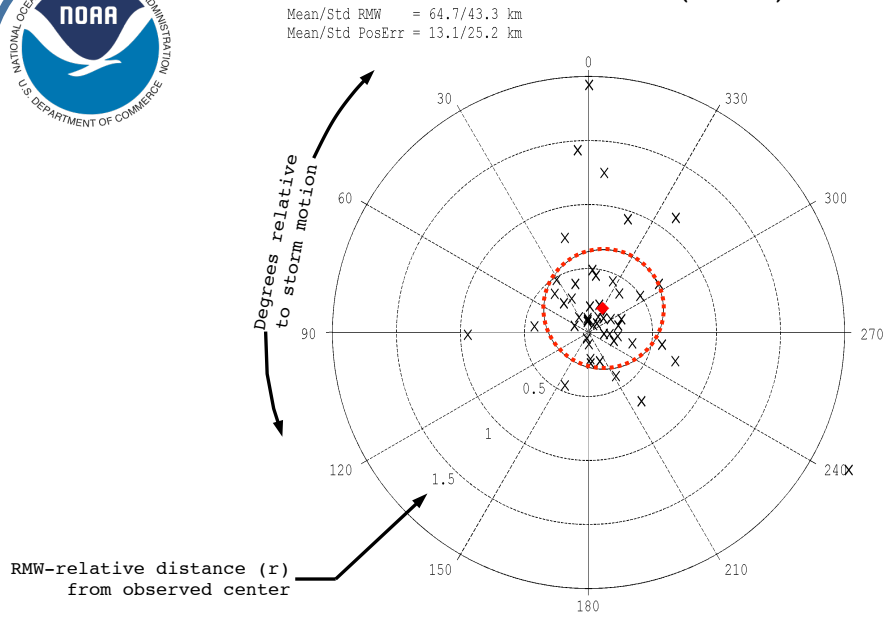
VORTEX-SCALE DA WITH NOAA/AOML/HRD's HEDAS: 2008-2011 REAL-TIME & RETRO RUNS

- HEDAS = HWRF Ensemble Data Assimilation System:
  - EnKF-based DA system to assimilate airborne hurricane inner-core observations
  - Assimilates Doppler wind speed, flight-level, SFMR, and dropsonde data
  - 30 ensemble members
  - HWRF 3.1 at 9/3-km resolution
  - Ensemble mean vortex analysis is used as the initial condition for deterministic HWRFx
- Retrospective (2008 & 2009) and real-time (2010 & 2011) analyses and forecasts have been performed
- **Diagnosis of analyses**: Only cases that were Tropical Storm intensity or greater in the Best Track database are considered: ***52 cases***
- **Diagnosis of forecasts**: All tropical cyclone cases considered: ***72 cases***

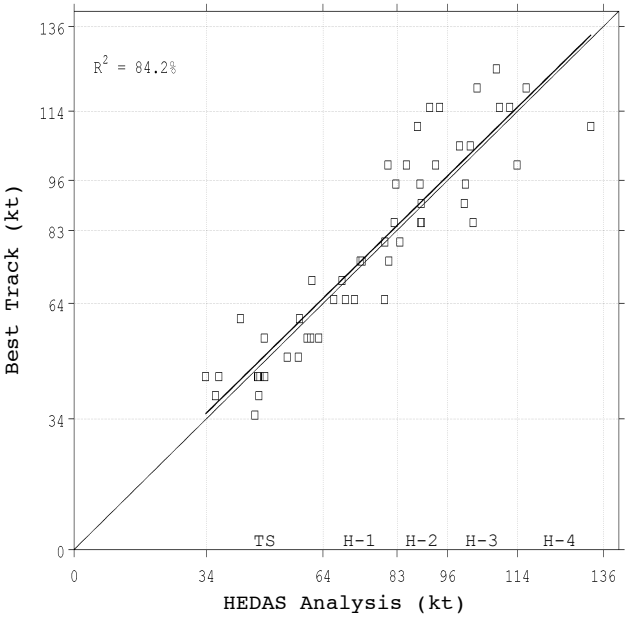


Altug Aksoy, Sim Aberson, Tomi Vukicevic HRD

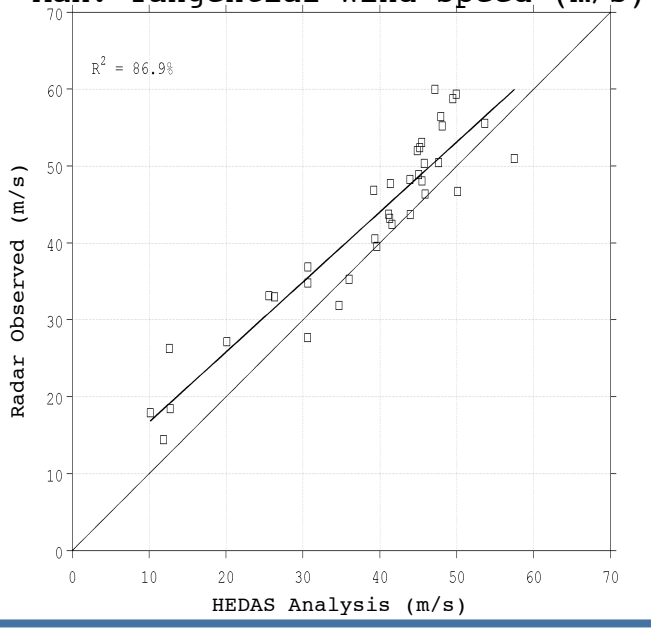
Position Error (xRMW)



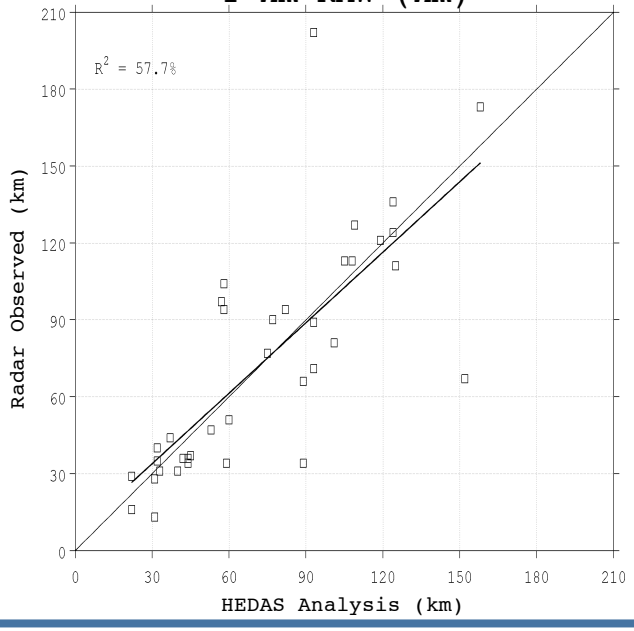
Intensity (kt)



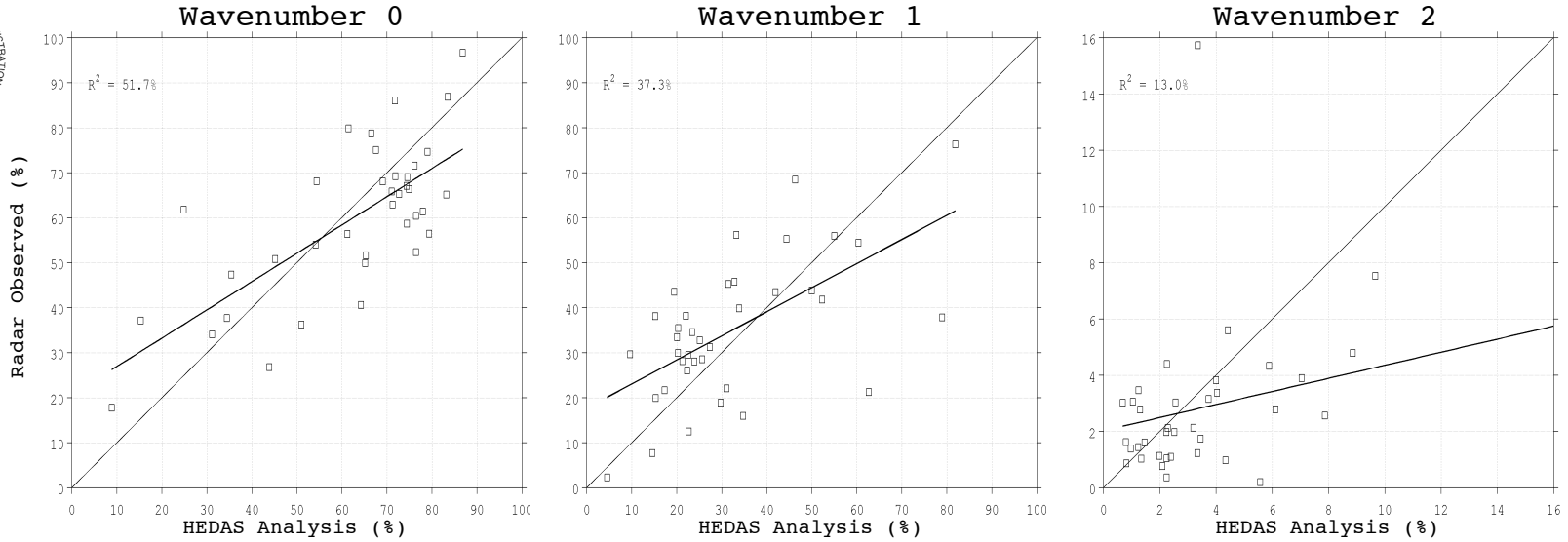
Max. Tangential Wind Speed (m/s)



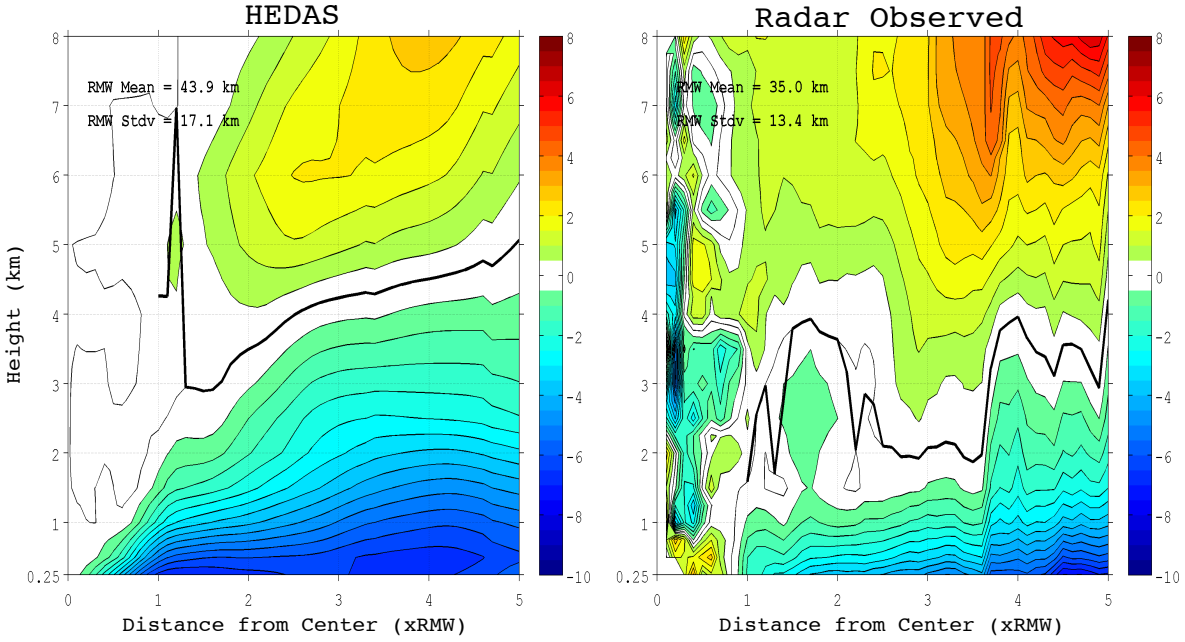
1-km RMW (km)



Variance Explained (%) by Wavenumber Components of 1-km Tangential Wind Speed



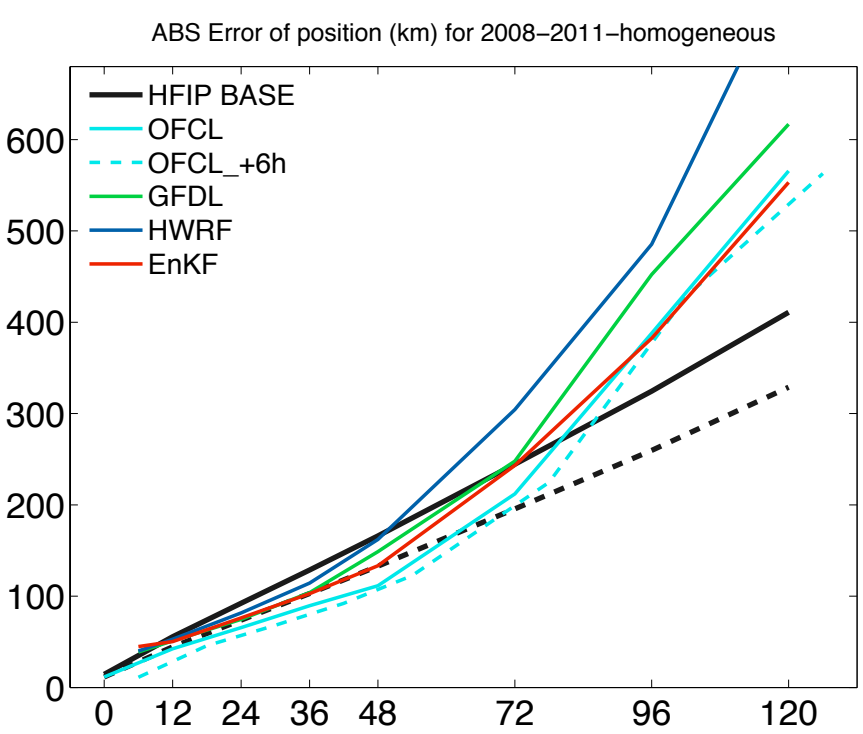
RZ-Mean Radial Wind Speed (Inflow=negative) (m/s)
Composited for 13 Major Hurricane Cases



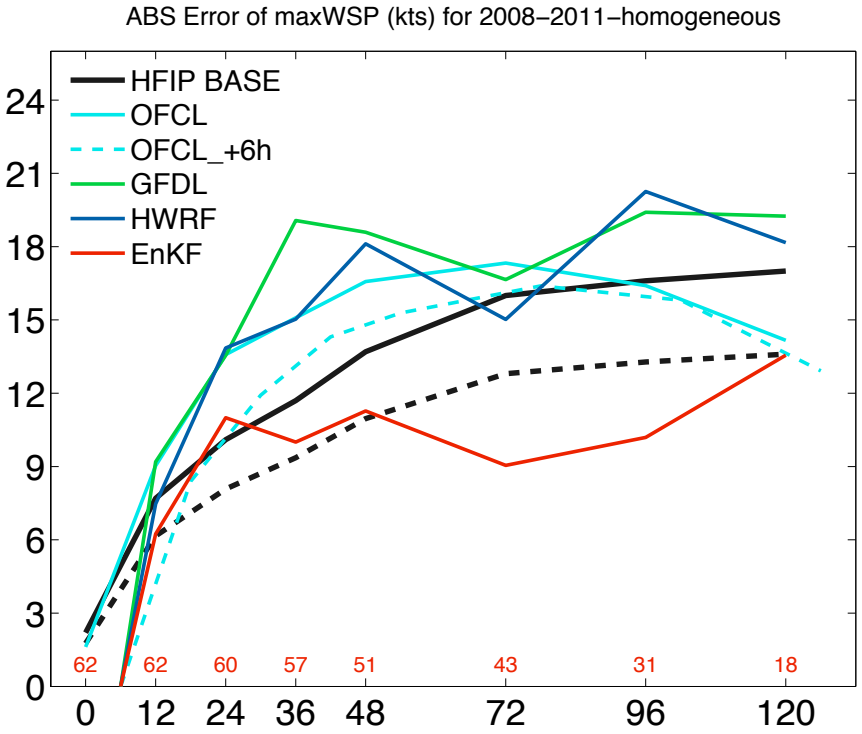
- **The good:**
  - Position error to within 0.2 RMW
  - Good fit of analysis intensity to best track intensity
  - RMW captured to within 10 km
  - Wavenumbers 0 and 1 captured well
- **Where research is needed:**
  - Importance of higher-wavenumber structure
  - Boundary layer structure
  - Vertical correlations and localization
  - How well does the radar sample the radial wind?

Updated Performance of the PSU WRF-EnKF during 2008-2011 with assimilation of P3 airborne radar

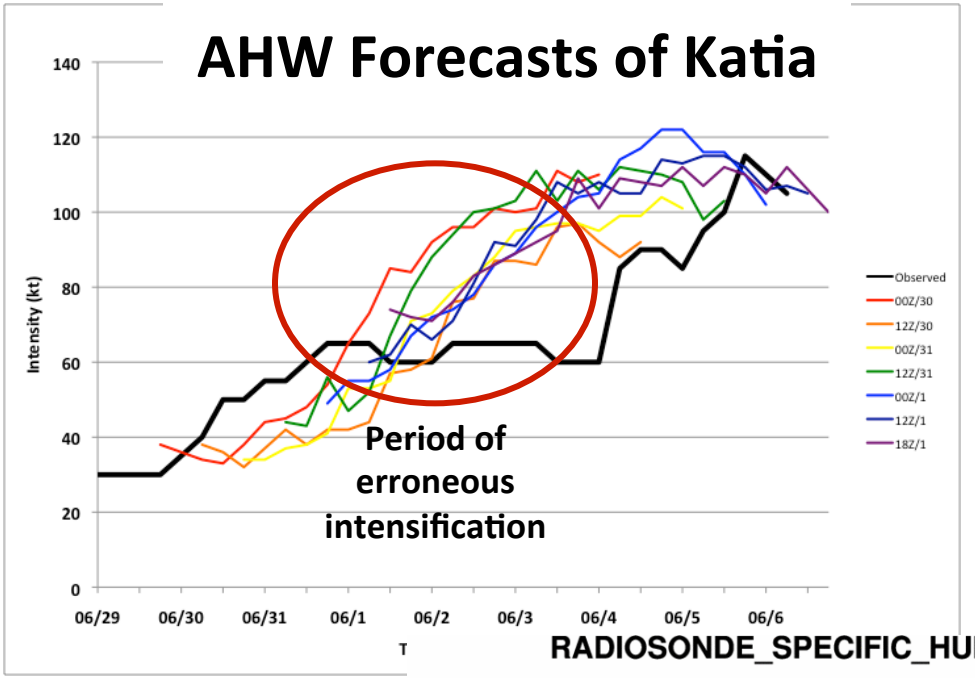
Position Error (km)



Intensity Error (kt)

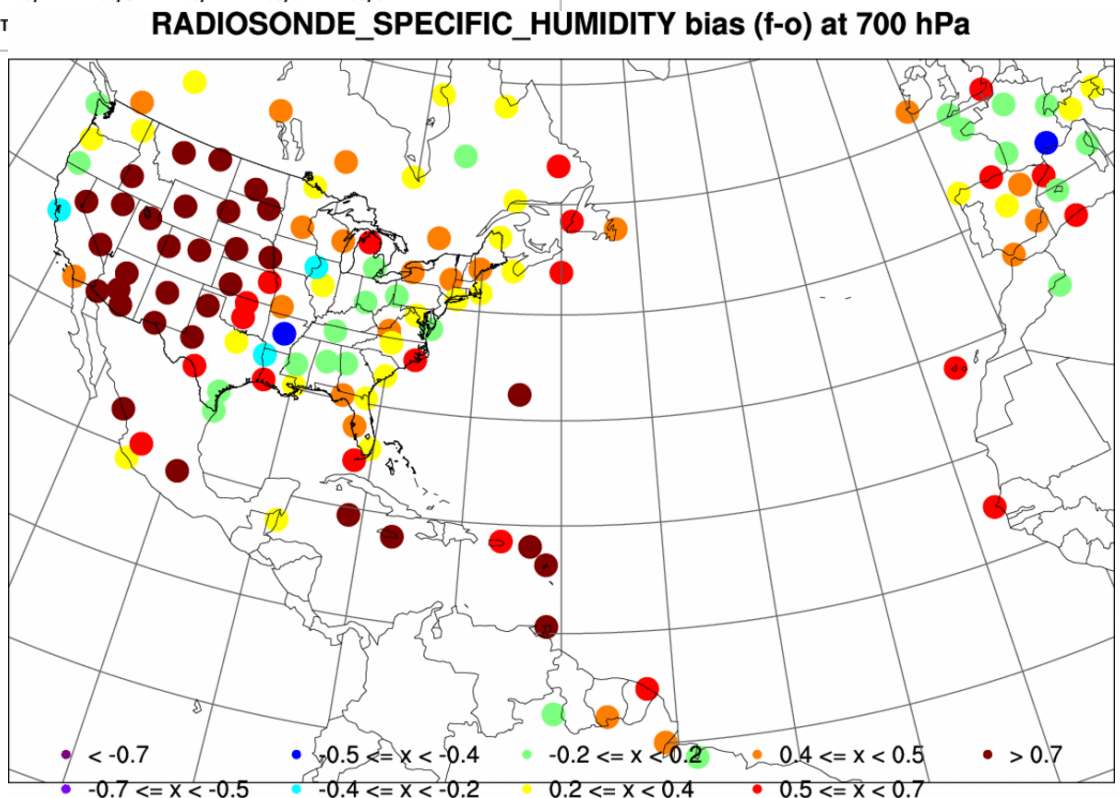


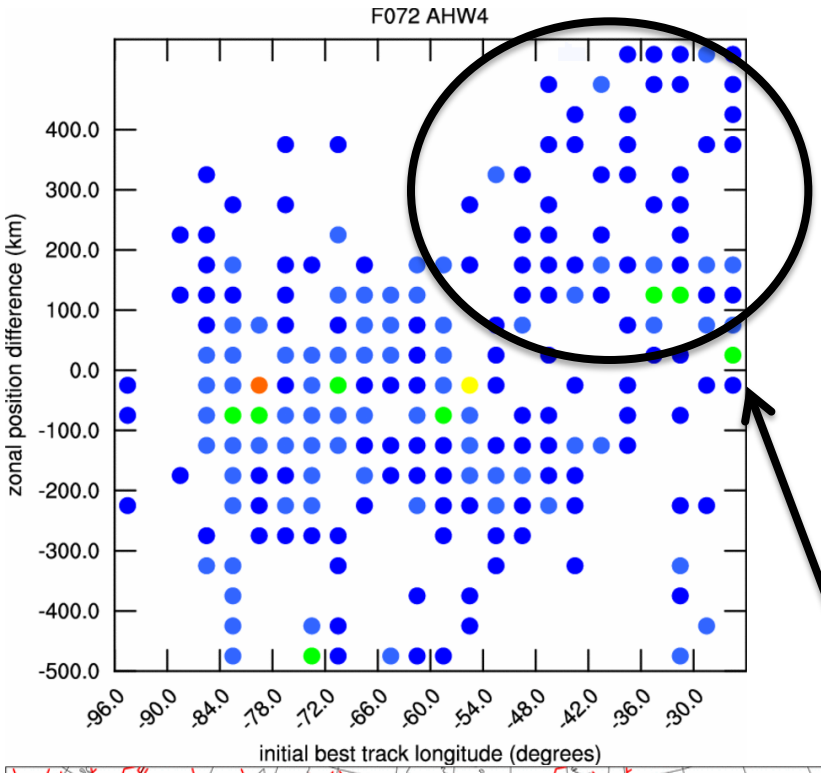
Fuquing Zhang and collaborators, PSU

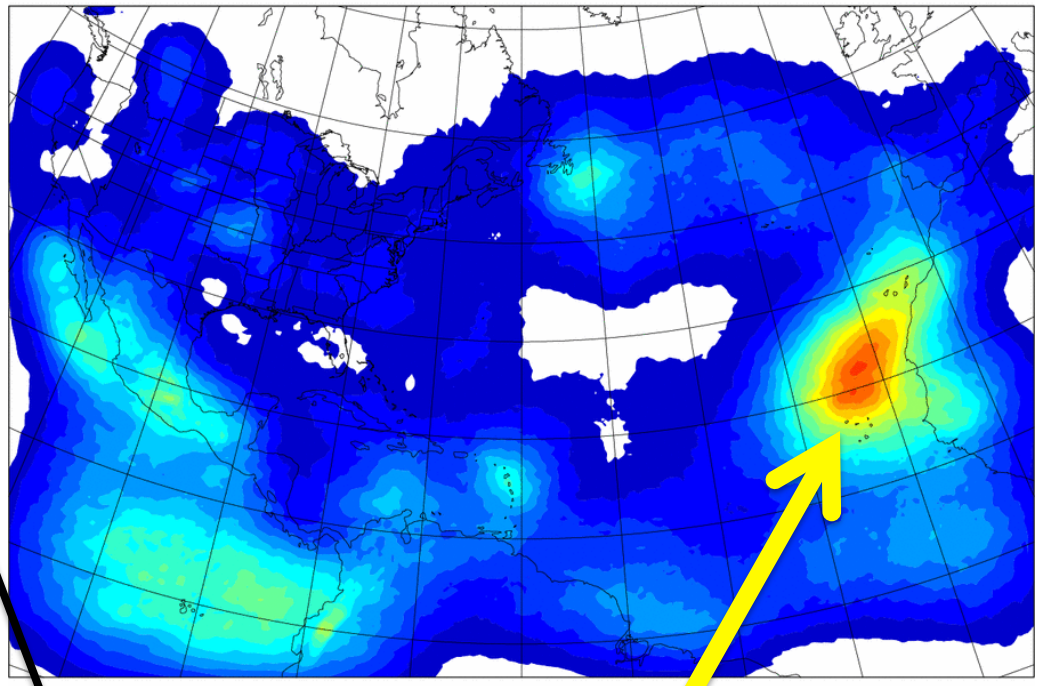


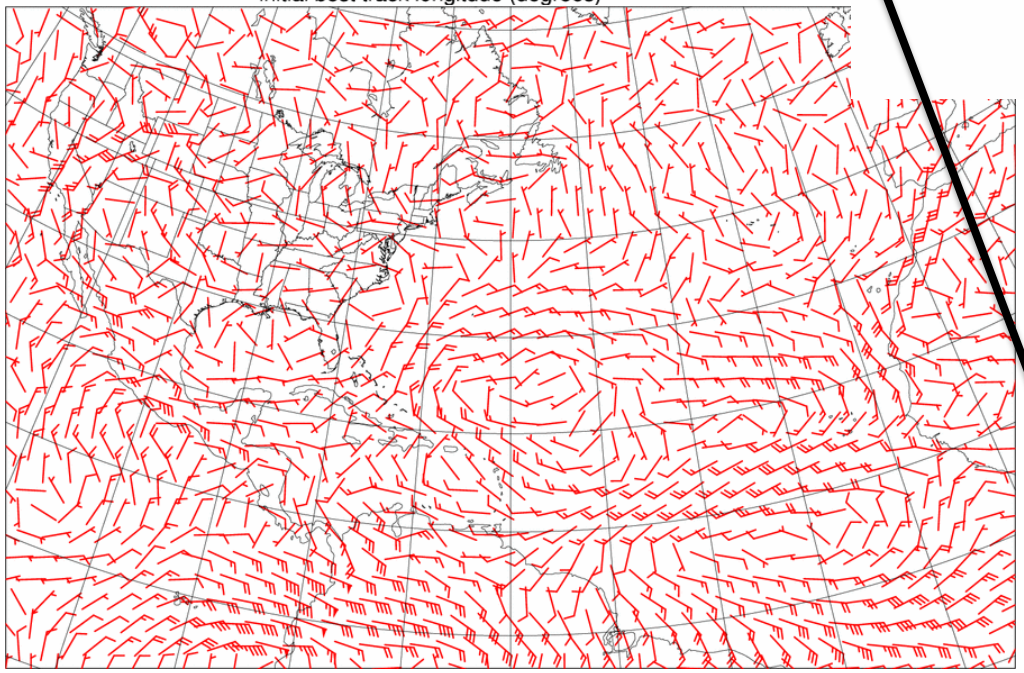
Ryan Torn U of Albany

During 2011, AHW shows tendency to over-intensity moderate sheared systems (Katia, Maria in particular). Comparisons of 6 h forecasts against observations suggest atmosphere is too moist (leads to too much convection)









Data assimilation system detecting an issue; adaptive inflation system trying to add variance to match observations

Hypothesis: Lack of aerosol leads to weakening of subtropical ridge

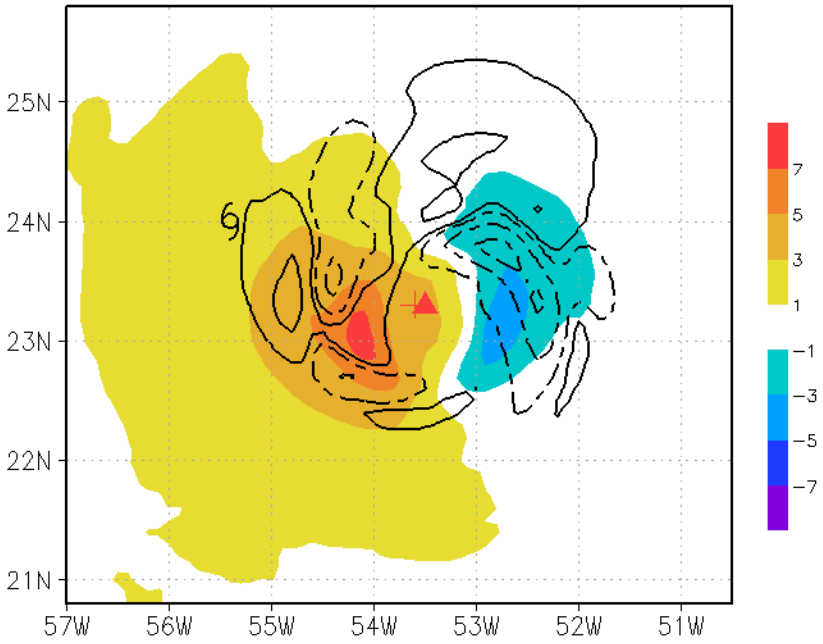
Regional Ensemble Data Assimilation Research for Hurricane Forecasting (*CIRA collaboration with EMC/NCEP*)

Milija Zupanski and Man Zhang
(in collaboration with Min-Jeong Kim)

- *Research focus:*

1- Assimilation of all-sky microwave radiances in inner-core of the hurricane

2- Use of EMC infrastructure (HWRF, GSI, CRTM) with hybrid variational-ensemble data assimilation algorithm developed at Colorado State University



6-hour HWRF forecast difference:

- **MSLP (shaded) and total cloud condensate (contours)**

Real Time COAMPS-TC Data Assimilation Ensemble

Serial EnKF (DART)

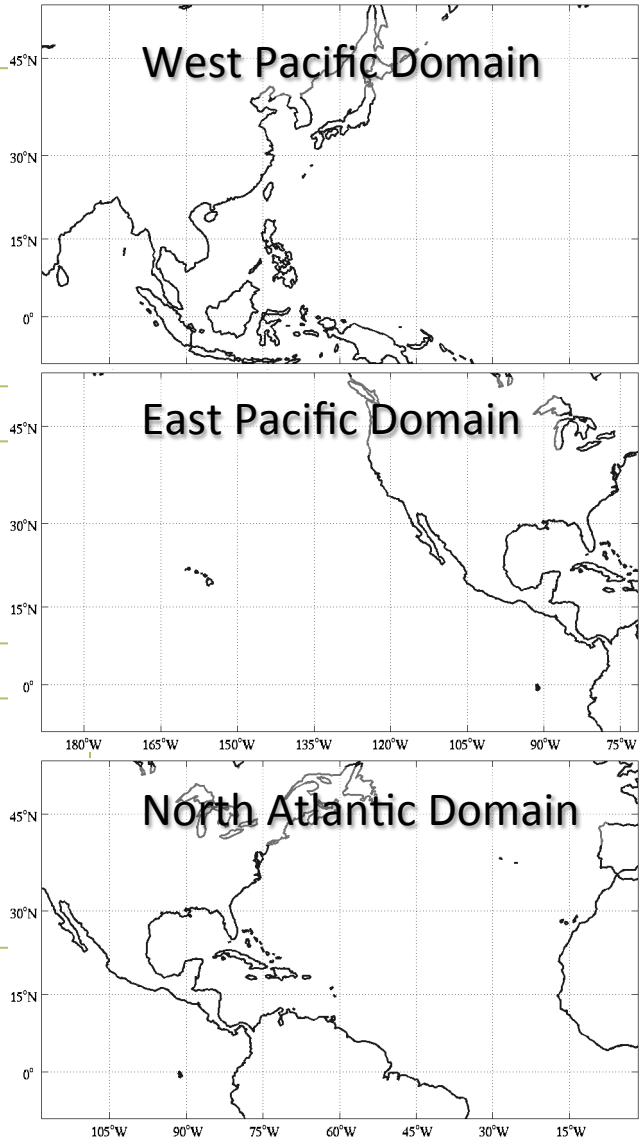
- Two-way interactive DA – highest resolution nest defines the innovation
- Observations: Surface/ship stations, cloud-track winds, aircraft data, dropsondes, radiosondes, synthetic tropical cyclone observations, storm position.
- Distance based localization, multiplicative based adaptive inflation

80-member ensemble for Data Assimilation

- 6-hr update cycle
- GFS-EnKF fields interpolated to COAMPS grid for the initial ensemble
- GFS-EnKF lateral boundary conditions.

DA and forecast for Atlantic, EastPac, and WestPac basins

- Fixed 45-km mesh for each basin
- Imbedded 15- and 5-km moving nests
- Only one set of high resolution nests per basin
- For each storm mesh is initialized with GFS-EnKF fields



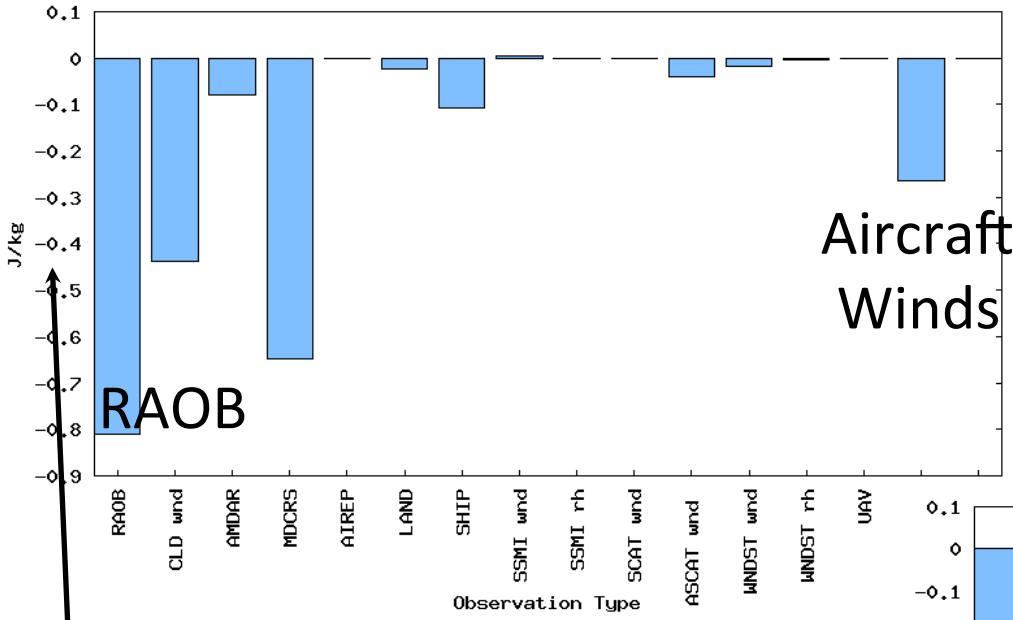
Jim Doyle, Alex Reinicke, NRL

COAMPS Observation Impact

Adjoint Based Diagnostics for Hurricane Earl

Impact of Hurricane Hunter Flight Level Winds (Per Forecast in J/kg)

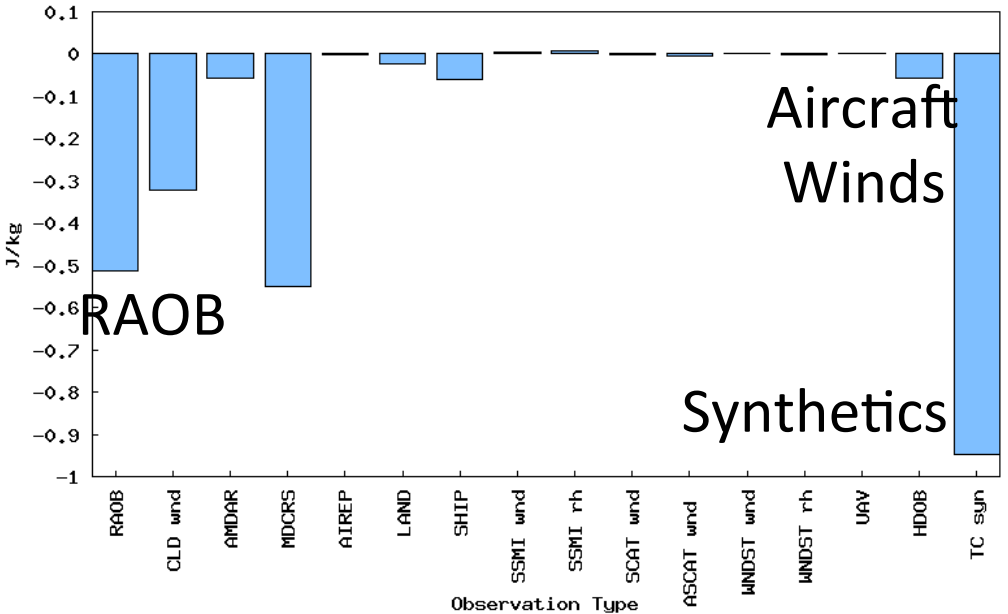
Without Synthetics



Adjoints for COAMPS-TC and NAVDAS (3DVar) have been Developed and Used to Compute the Observation Impact on Forecast Error

Negative Values Indicate Forecast Improvement

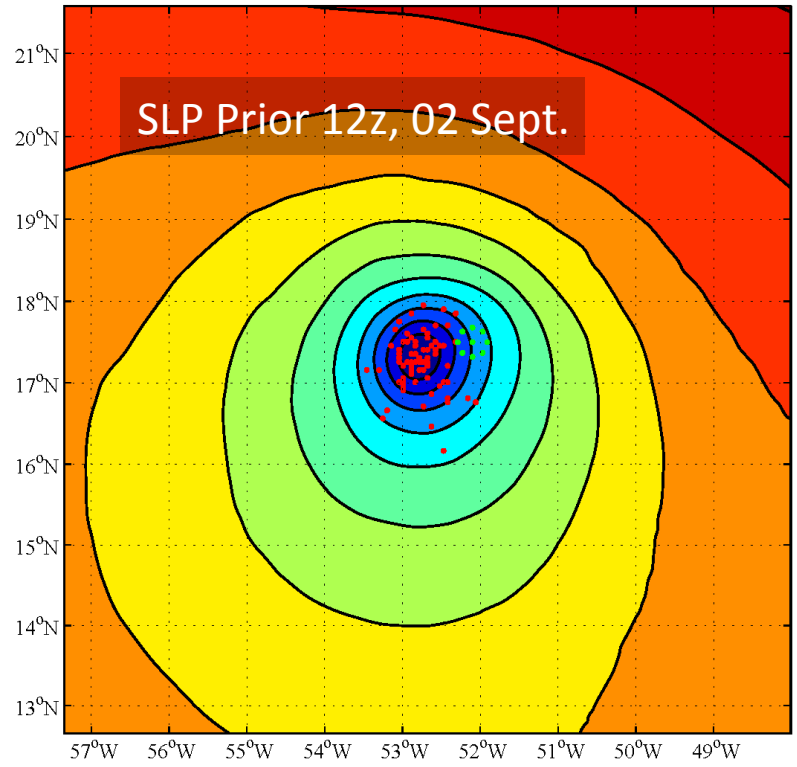
With Synthetics

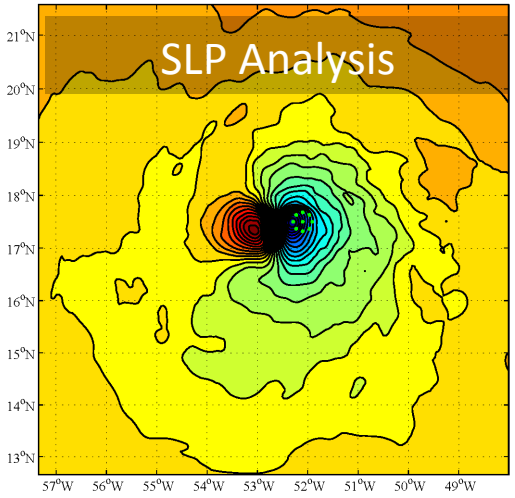


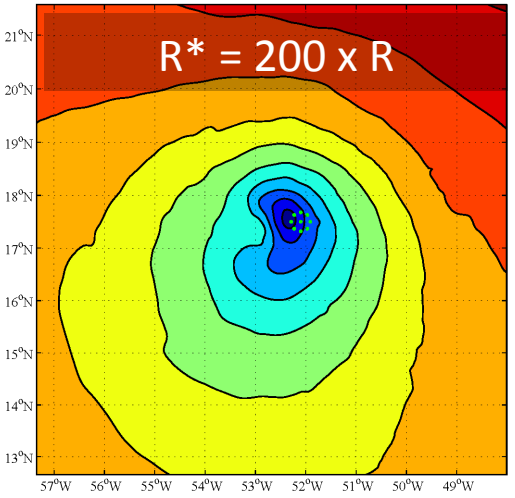
C. Amerault, P. Pauley, J. Doyle

08/28-09/04 2010

Storm Scale Assimilation (COAMPS-TC)





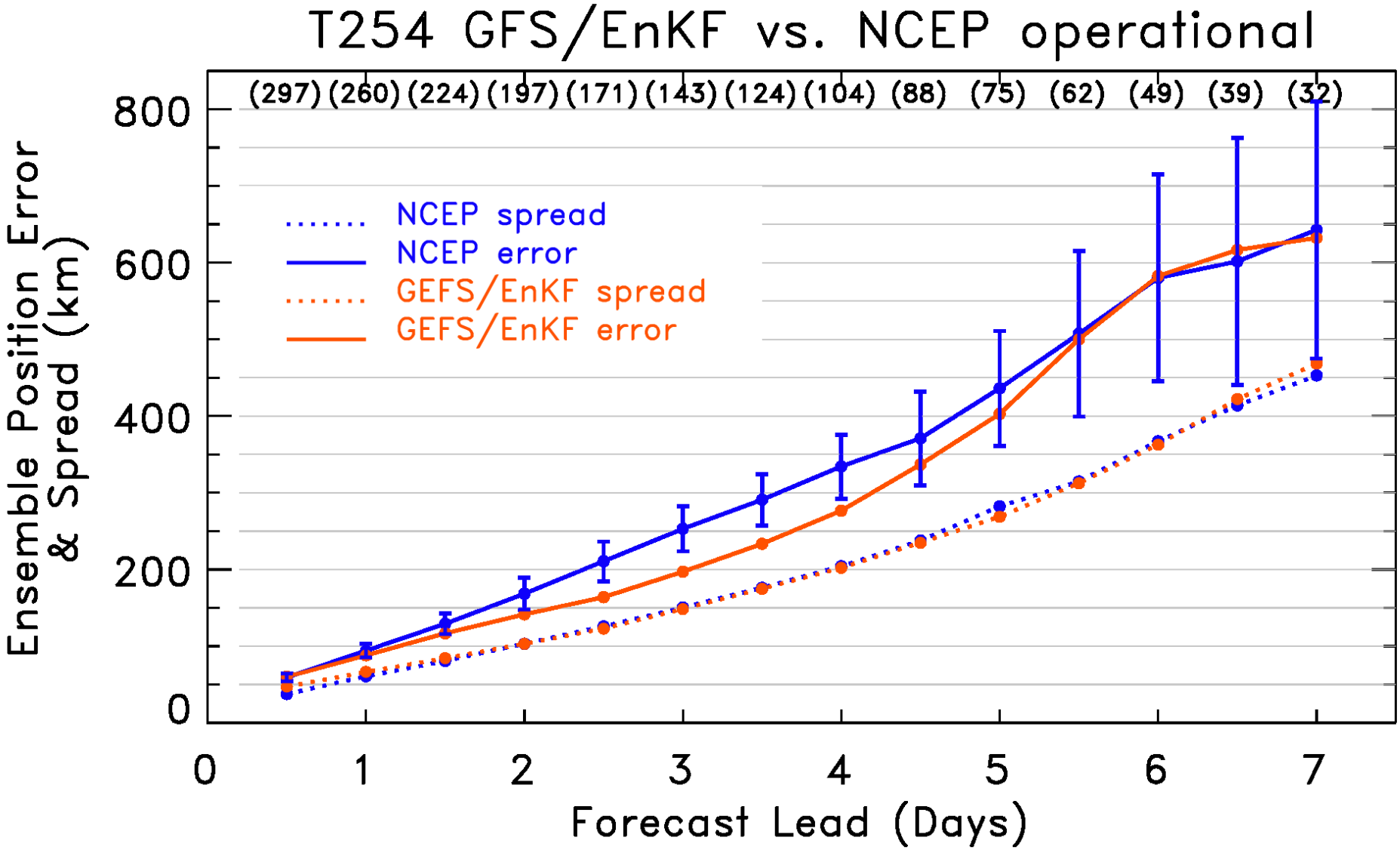


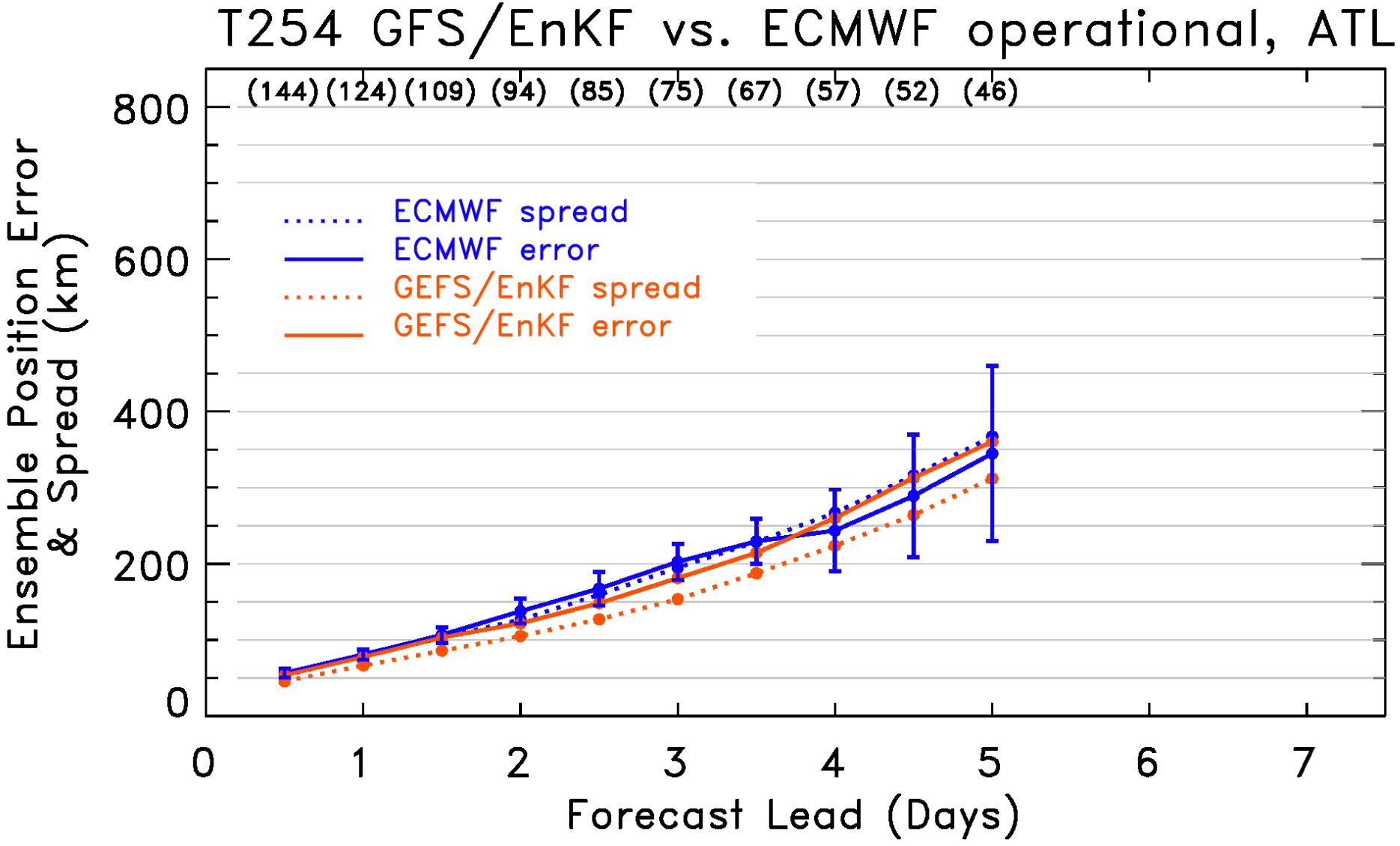
Large ensemble spread, observation outside of envelope of model storms leads to unphysical increments. Can be partially remedied by reduction in ob error. Need for field alignment/ relocation?

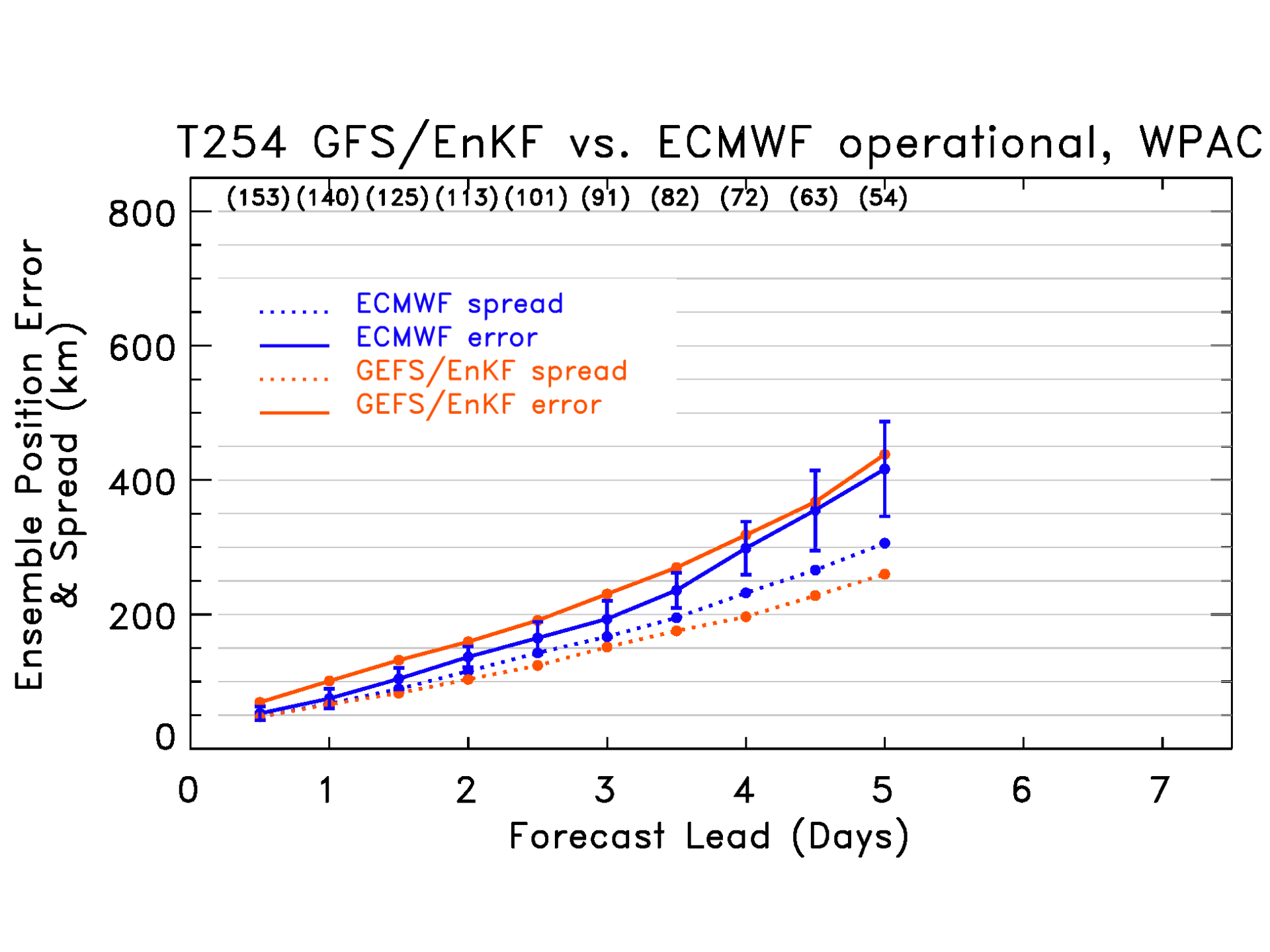
GFS/EnKF Realtime Demo 2011

- 80 member EnKF, T574L64.
- 20 member T254L64 forecasts to 168-h
- 10 member FIM 60-km forecasts to 240-h.
- BCs and ICs for regional EnKF systems (NCAR/ U. of Albany, AOML, NRL).

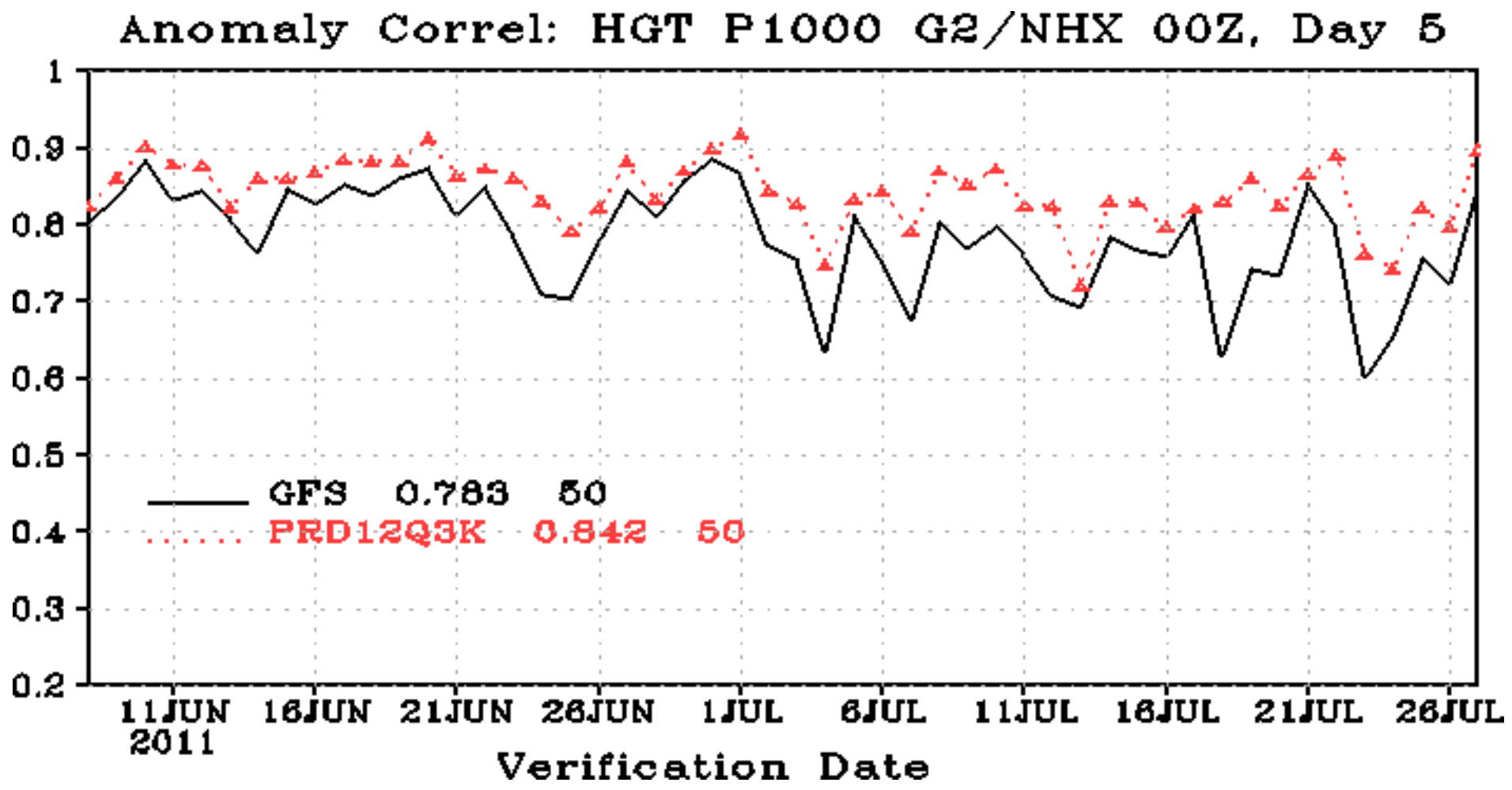
Jeff Whitaker, Tom Hamill, Phil Pegion, Henry Winterbottom ESRL


T254 GFS/EnKF vs. NCEP operational
(297) (260) (224) (197) (171) (143) (124) (104) (88) (75) (62) (49) (39) (32)
NCEP spread
NCEP error
GEFS/EnKF spread
GEFS/EnKF error
Ensemble Position Error & Spread (km)
0
200
400
600
800
0
1
2
3
4
5
6
7
Forecast Lead (Days)

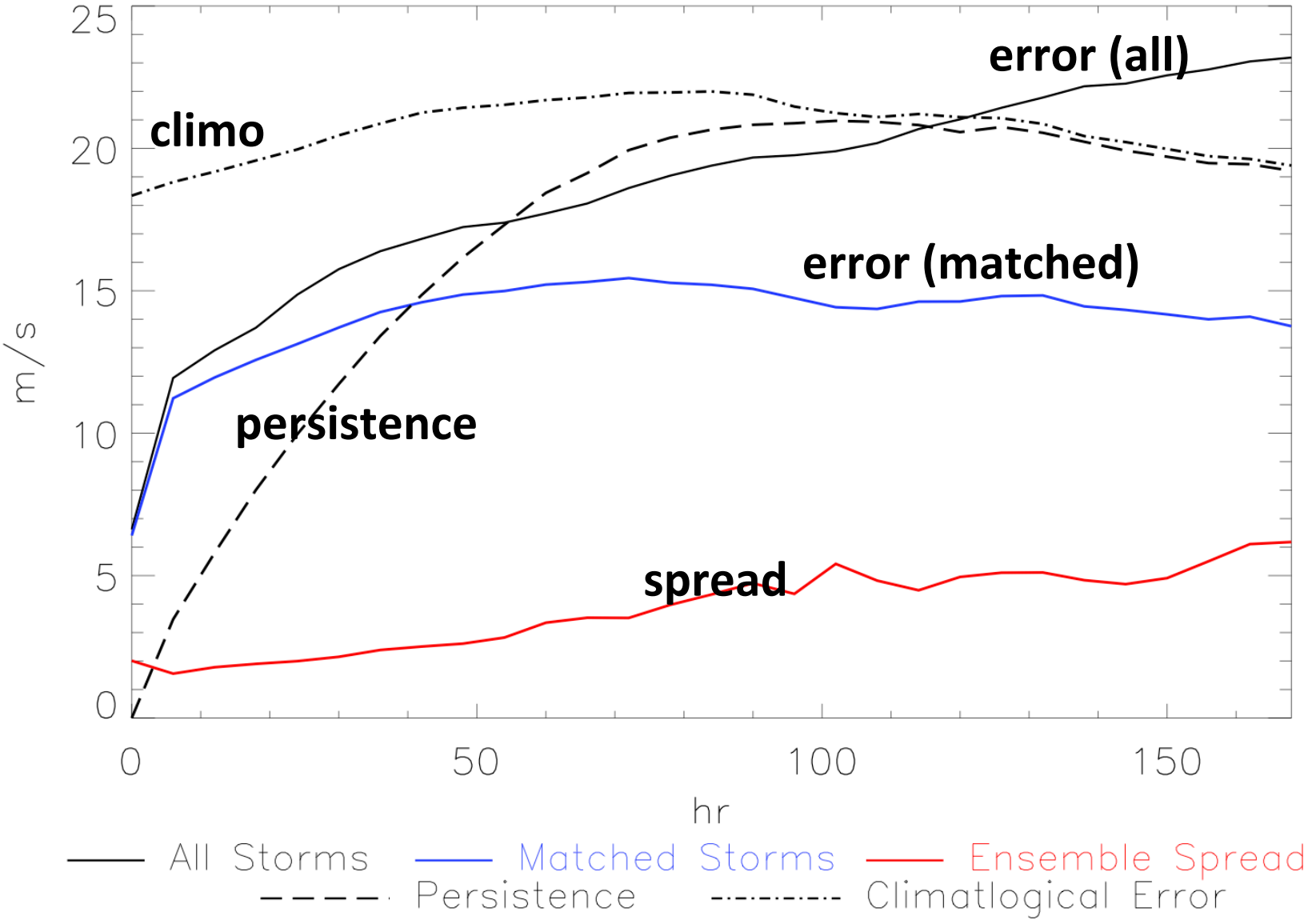

T254 GFS/EnKF vs. ECMWF operational, ATL
(144) (124) (109) (94) (85) (75) (67) (57) (52) (46)
ECMWF spread
ECMWF error
GEFS/EnKF spread
GEFS/EnKF error
Ensemble Position Error & Spread (km)
800
600
400
200
0
0
1
2
3
4
5
6
7
Forecast Lead (Days)


T254 GFS/EnKF vs. ECMWF operational, WPAC
(153) (140) (125) (113) (101) (91) (82) (72) (63) (54)
ECMWF spread
ECMWF error
GEFS/EnKF spread
GEFS/EnKF error
Ensemble Position Error & Spread (km)
800
600
400
200
0
0
1
2
3
4
5
6
7
Forecast Lead (Days)

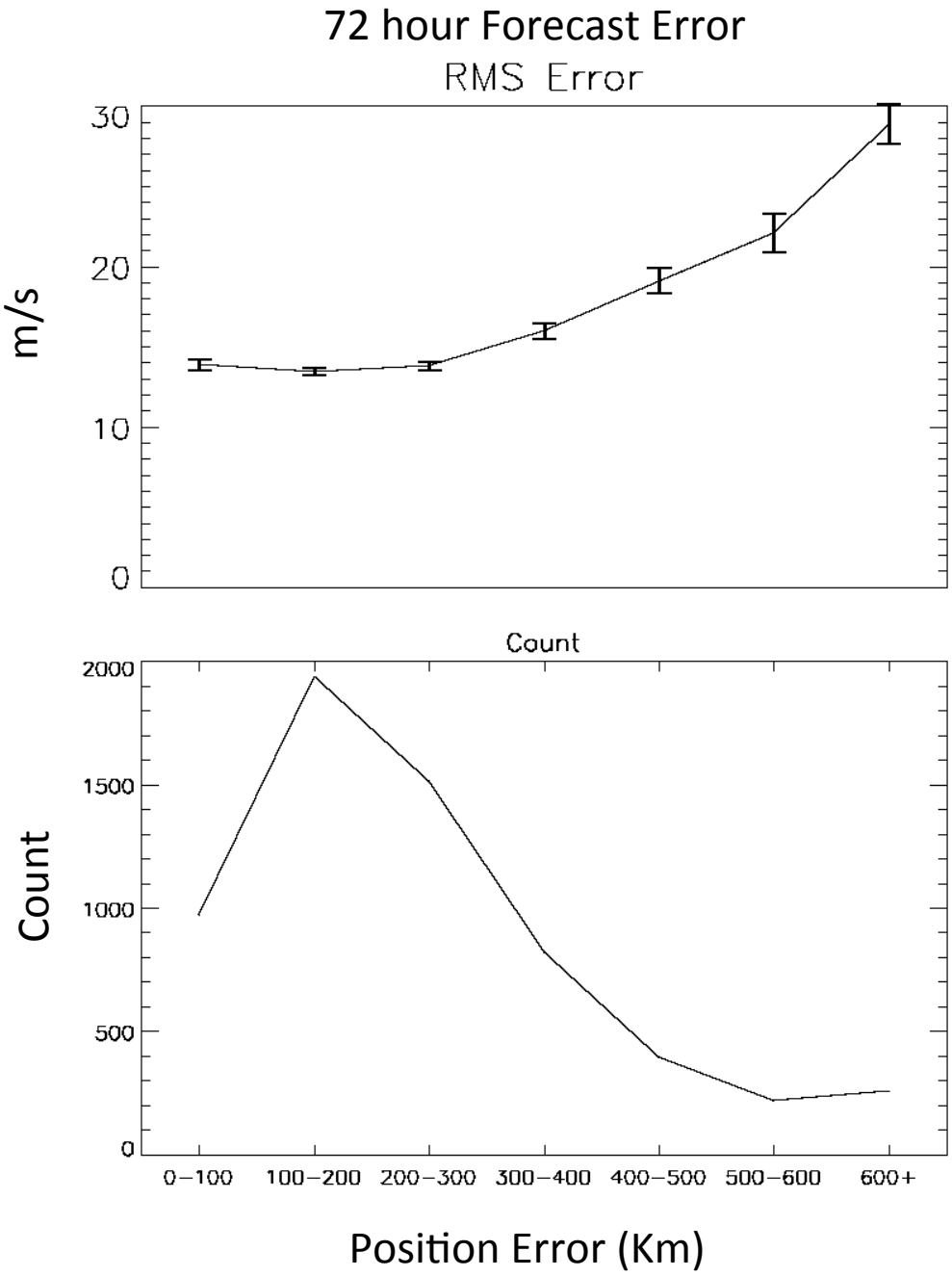
Global GSI/EnKF into NCEP operations



Verification of intensity forecasts



Relationship between Track and Intensity Error



Issues

- Need to include the effects of model error! (spread way too small, esp for intensity).
- How important is it to analyze initial asymmetries/PBL structure?
- Track errors in regional models are large (limit usefulness of intensity forecasts).
- Intensity verification issues.
- Need to address spin-down problems.
- GFS biases in Pacific.
- How to move toward more integrated DA/model development process?