ARW/EnKF performance for the 2009 Hurricane Season

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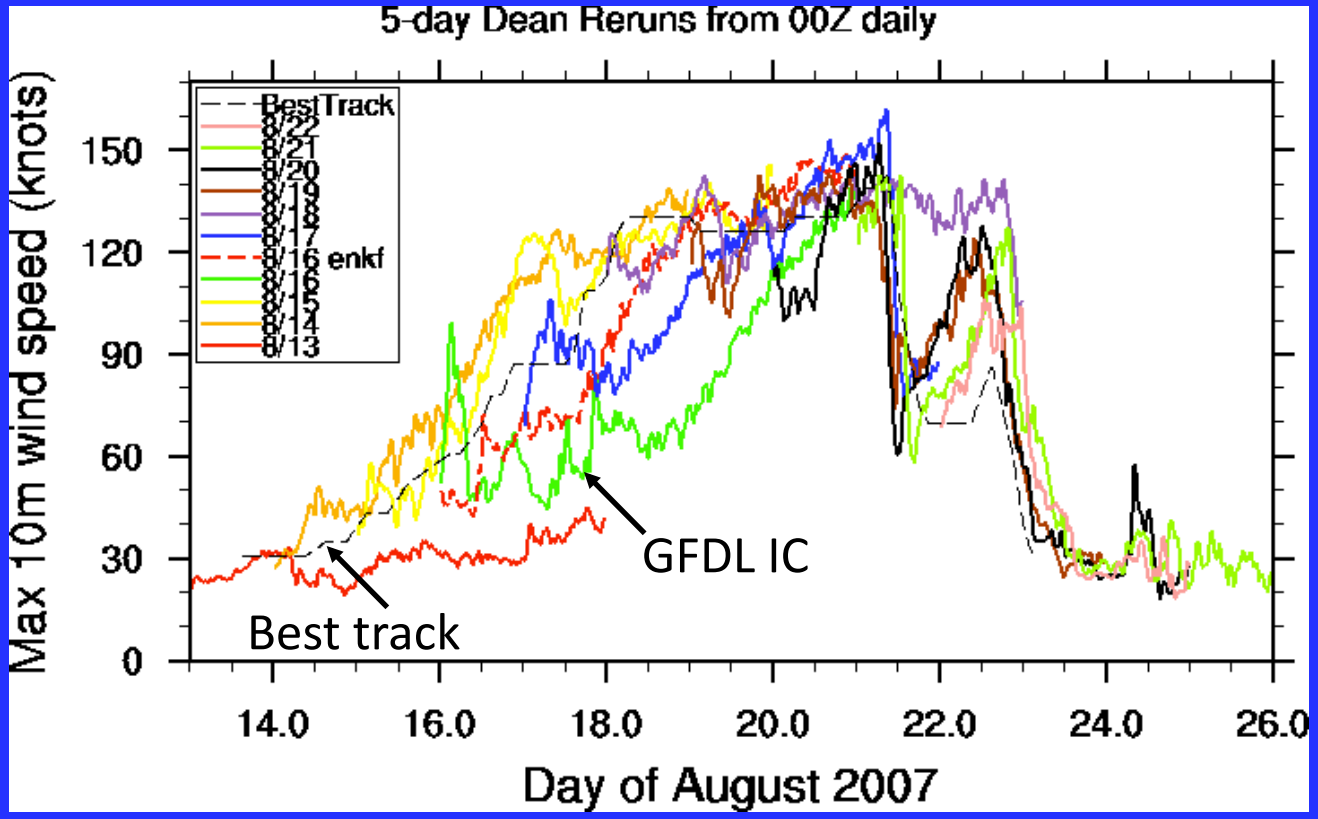
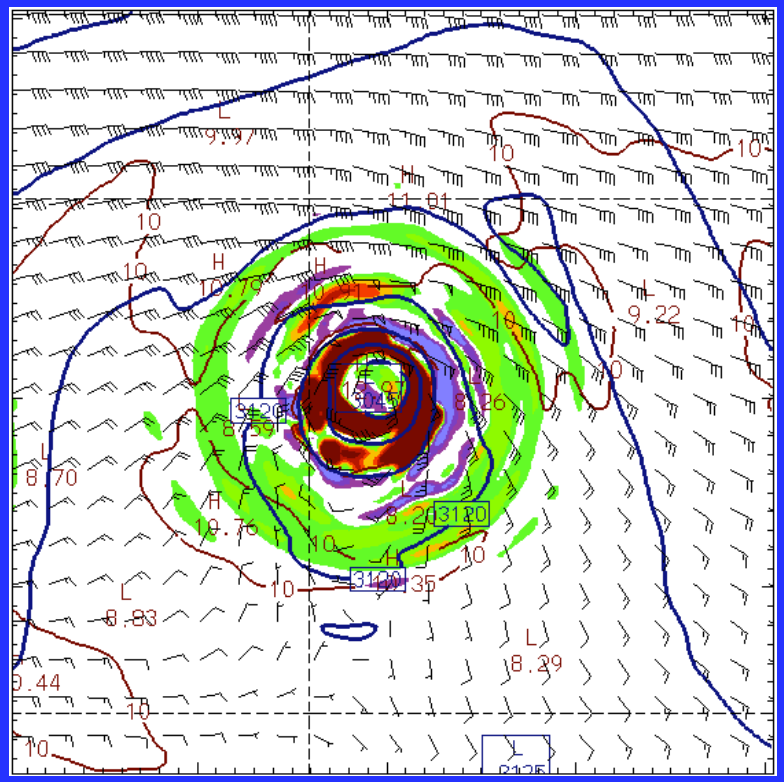
Background

- Models need high spatial resolution to resolve important features within TC such as eyewall, rainbands, etc.
- Initializing from bogus vortex can be problematic:

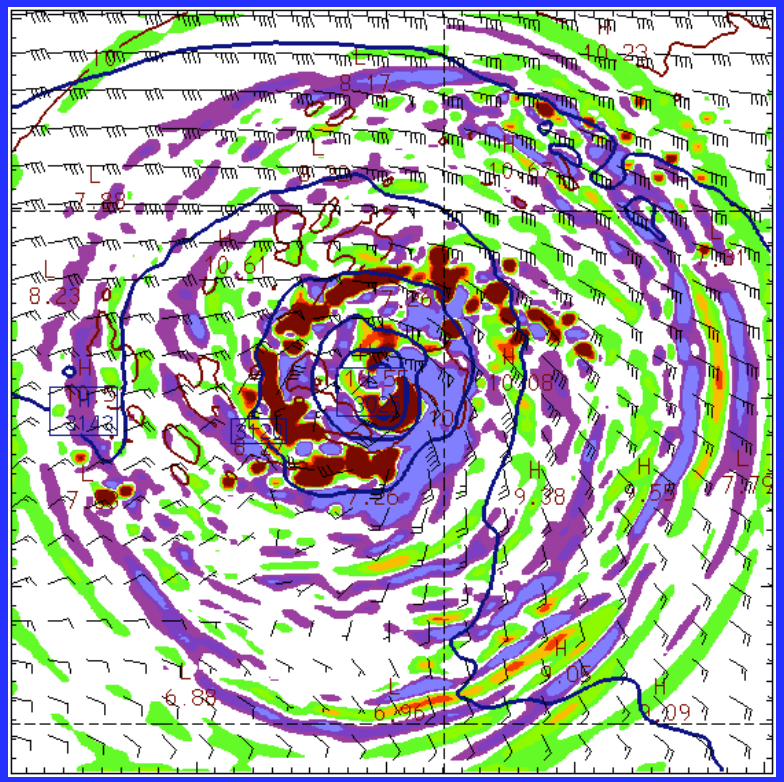


Vertical Motion Distribution

Time + 1 hour

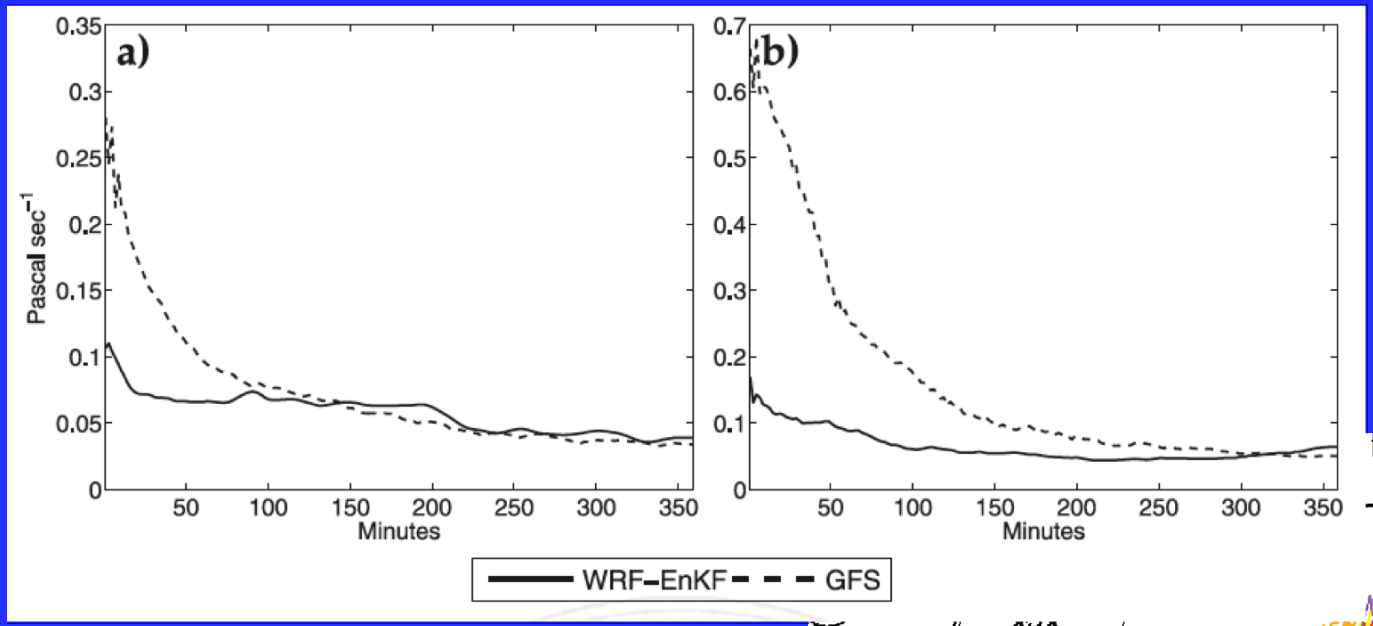


Time + 5 hour

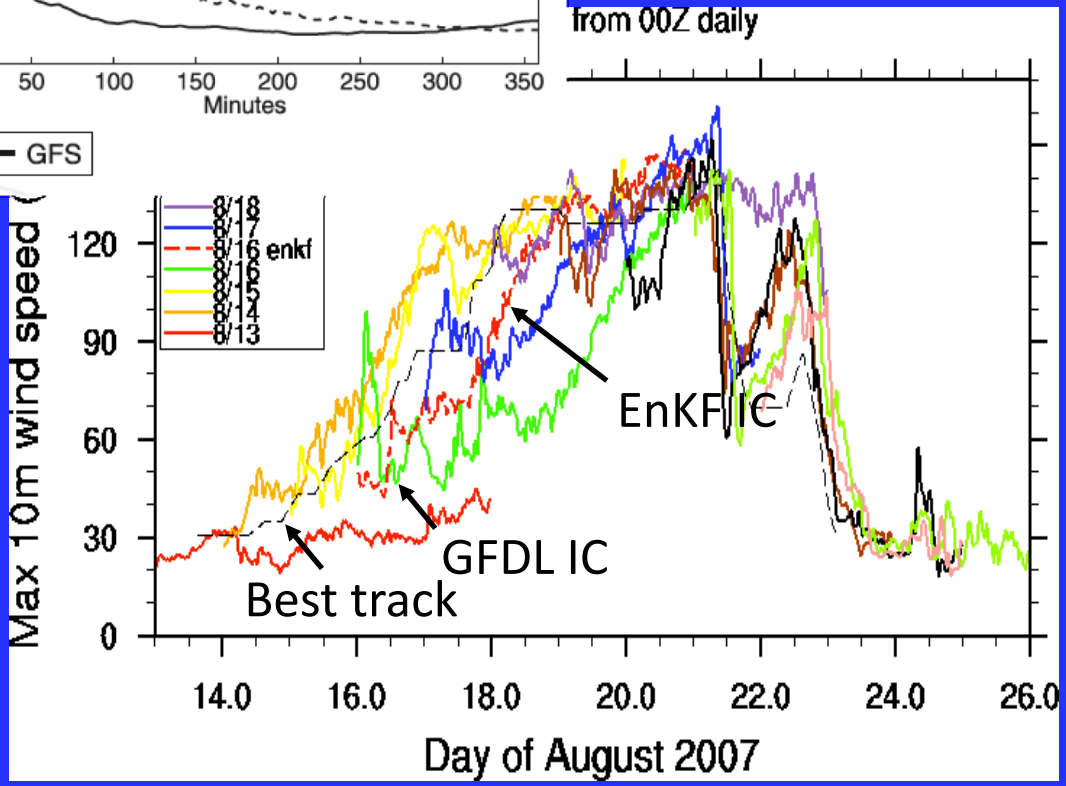


"Even with the finer-resolution GFDL initial condition, significant adjustment of the vortex occurred within the first 12 h. This shortcoming strongly supports the need for a data assimilation and initialization procedure that is specific to the AHW." - Davis et al. 2008 (WAF)

Background



Torn and Hakim (2009) MWR

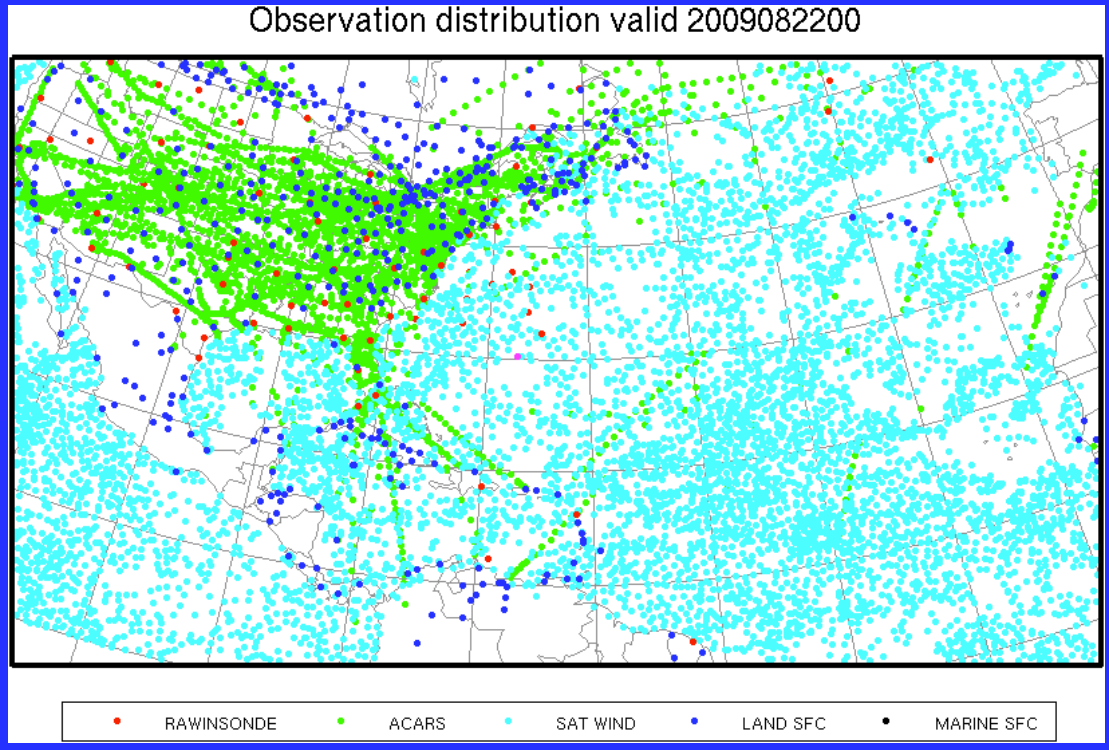


Overview

- NCAR was asked to participate in NOAA Hurricane Forecast Improvement Project (HFIP) multi-model ensemble. Required running real-time forecasts during 2009 Atlantic season
- Wanted initial conditions that:
  - Have a good estimate of environment
  - Have a “decent” estimate of TC structure
  - Does not lead to initialization problem
- Provides a good opportunity to evaluate ensemble data assimilation systems over variety of storms

Assimilation System

- WRF ARW (v3.1), 36 km horizontal resolution, 96 ensemble members, DART assimilation system.
- Observations assimilated each six hours from surface and marine stations (P_{sfc}), rawinsondes, synoptic dropsondes, ACARS, sat. winds, TC advisory position and minimum SLP
- Initialized system at 0000 UTC 10 August. System cycled continuously beyond that point (through 10 November)

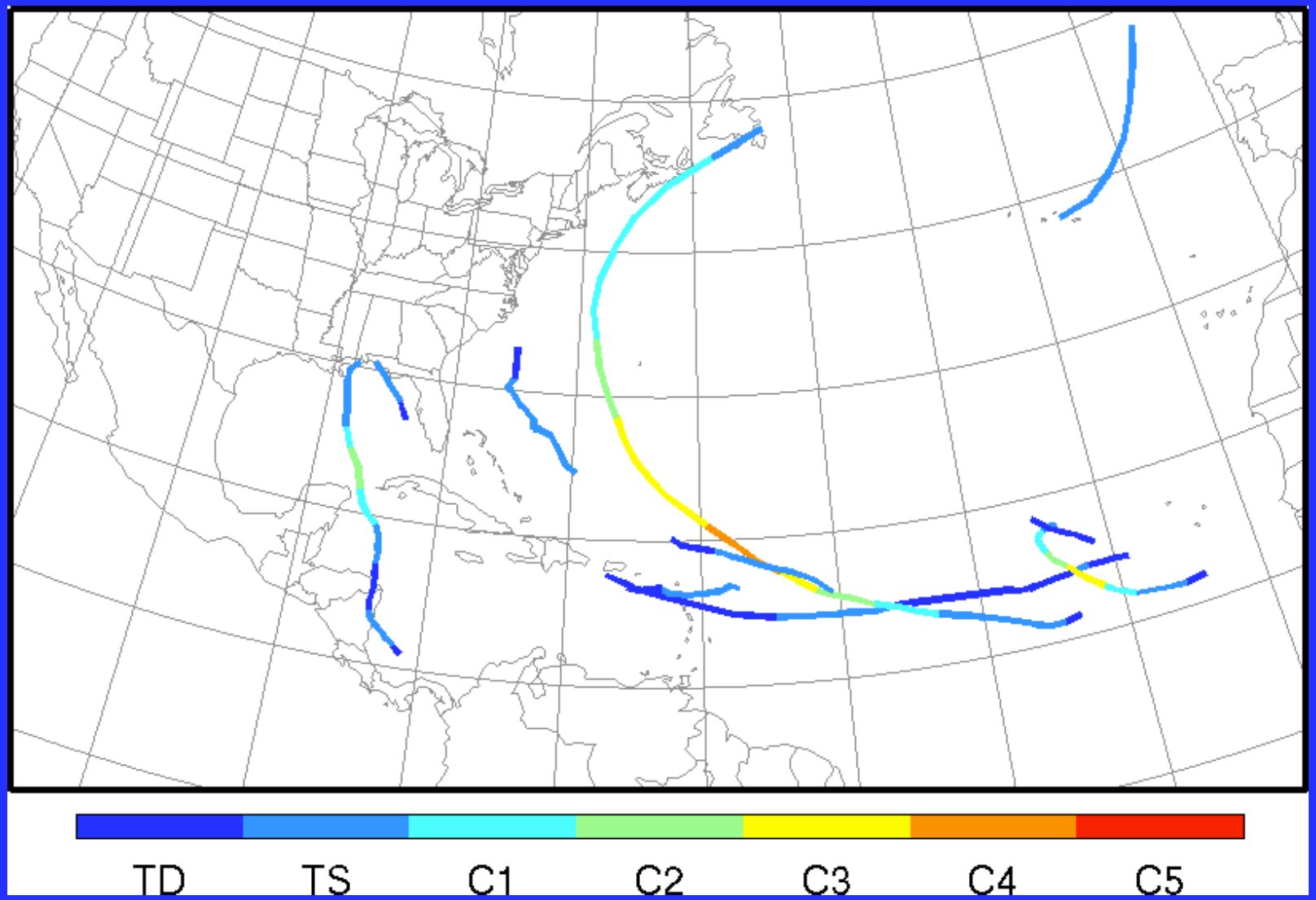


Assimilation System Cont.

- Anderson adaptive inflation (inflation computed from innovation statistics and correlations)
- Adaptive localization, where radius is reduced from 2000 km when number of observations greater than 1600 within 2000 km of observation location
- Fixed Covariance boundary perturbations
- Initial condition for high-resolution forecast chosen by minimizing:

$$\sum_{j=1}^{N_{storms}} \left(\left(\frac{Lat_{i,j} - \overline{Lat_j}}{\sigma_{Lat}} \right)^2 + \left(\frac{Lon_{i,j} - \overline{Lon_j}}{\sigma_{Lon}} \right)^2 + 2 \left(\frac{MSLP_{i,j} - \overline{Adv\_MSLP_j}}{\sigma_{MSLP}} \right)^2 \right)$$

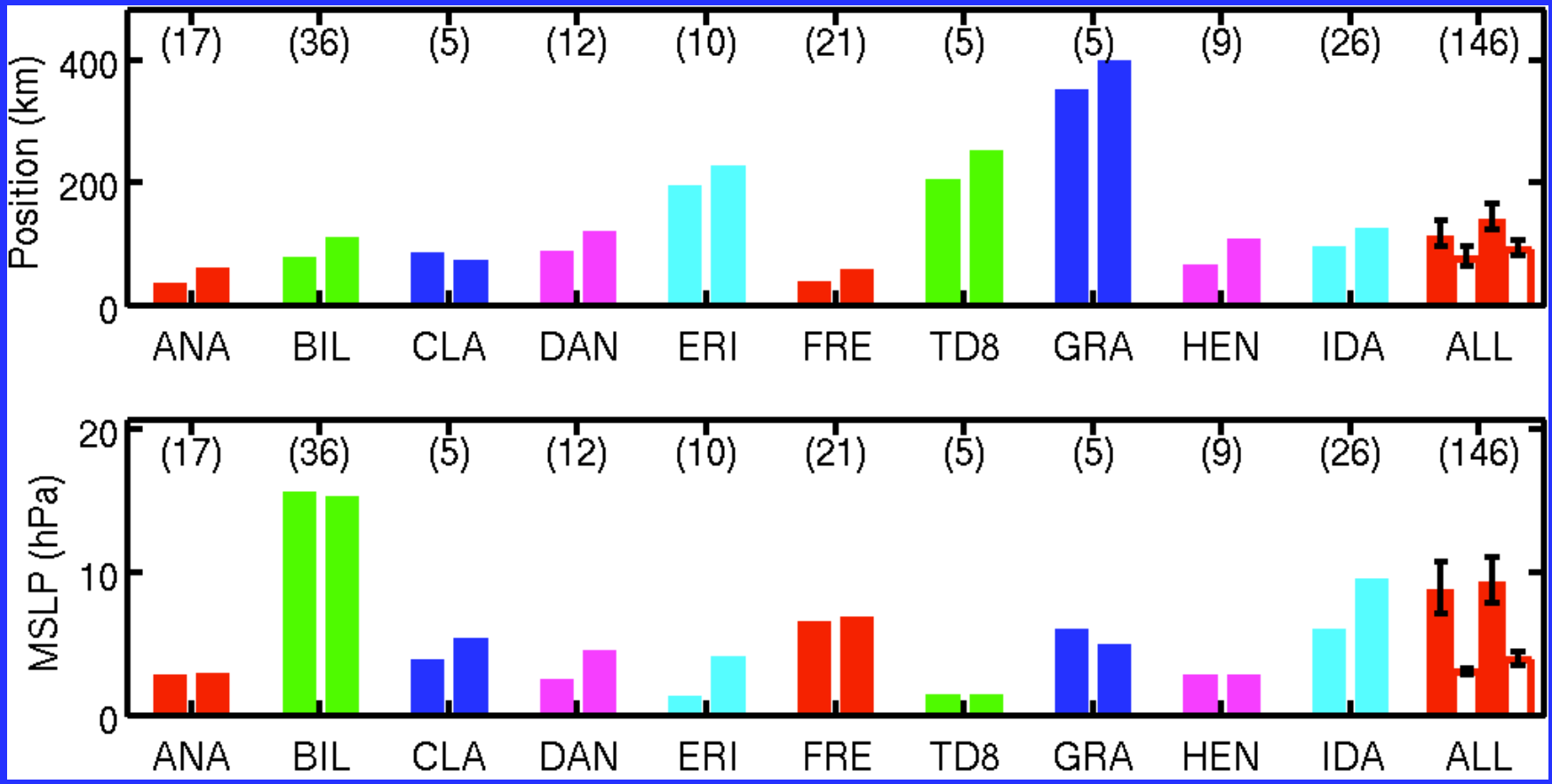
2009 Storms



Verification

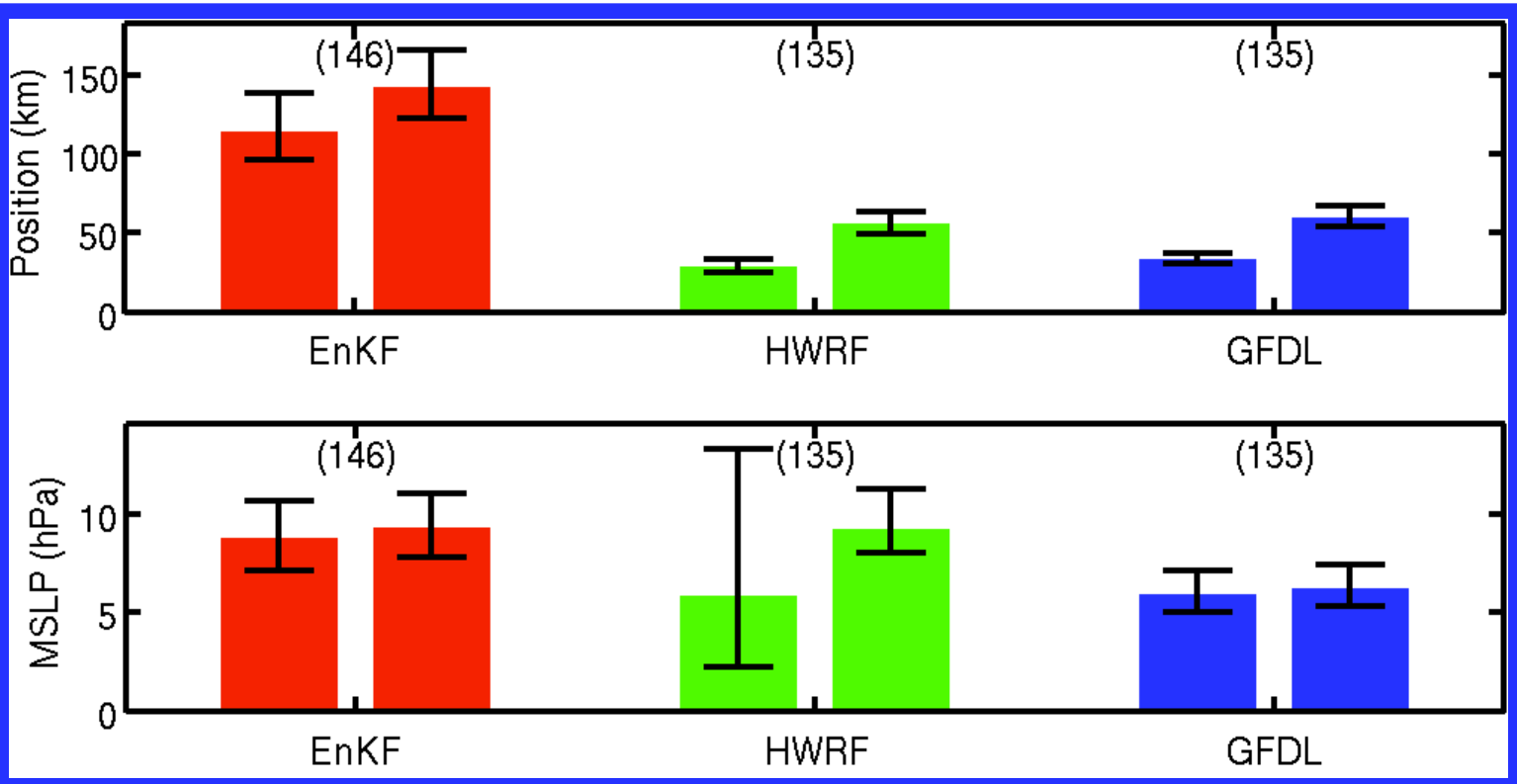
- Verify analysis and 6 hour forecasts against best track TC position and intensity
- Not the same as assimilated TC position and intensity
- Relationship between best track and advisory akin to analysis and background forecast

Cycling Errors

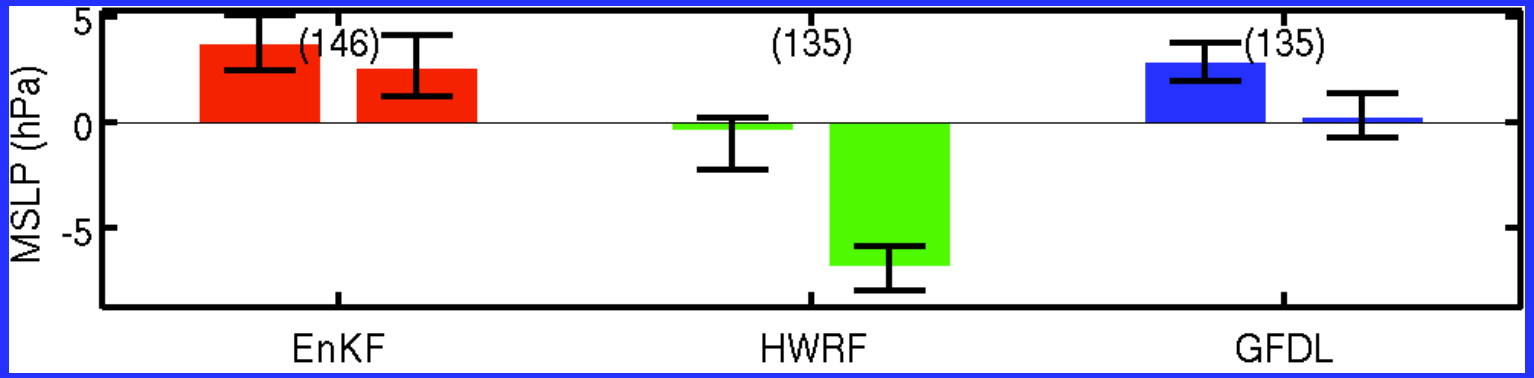


Cycling Error

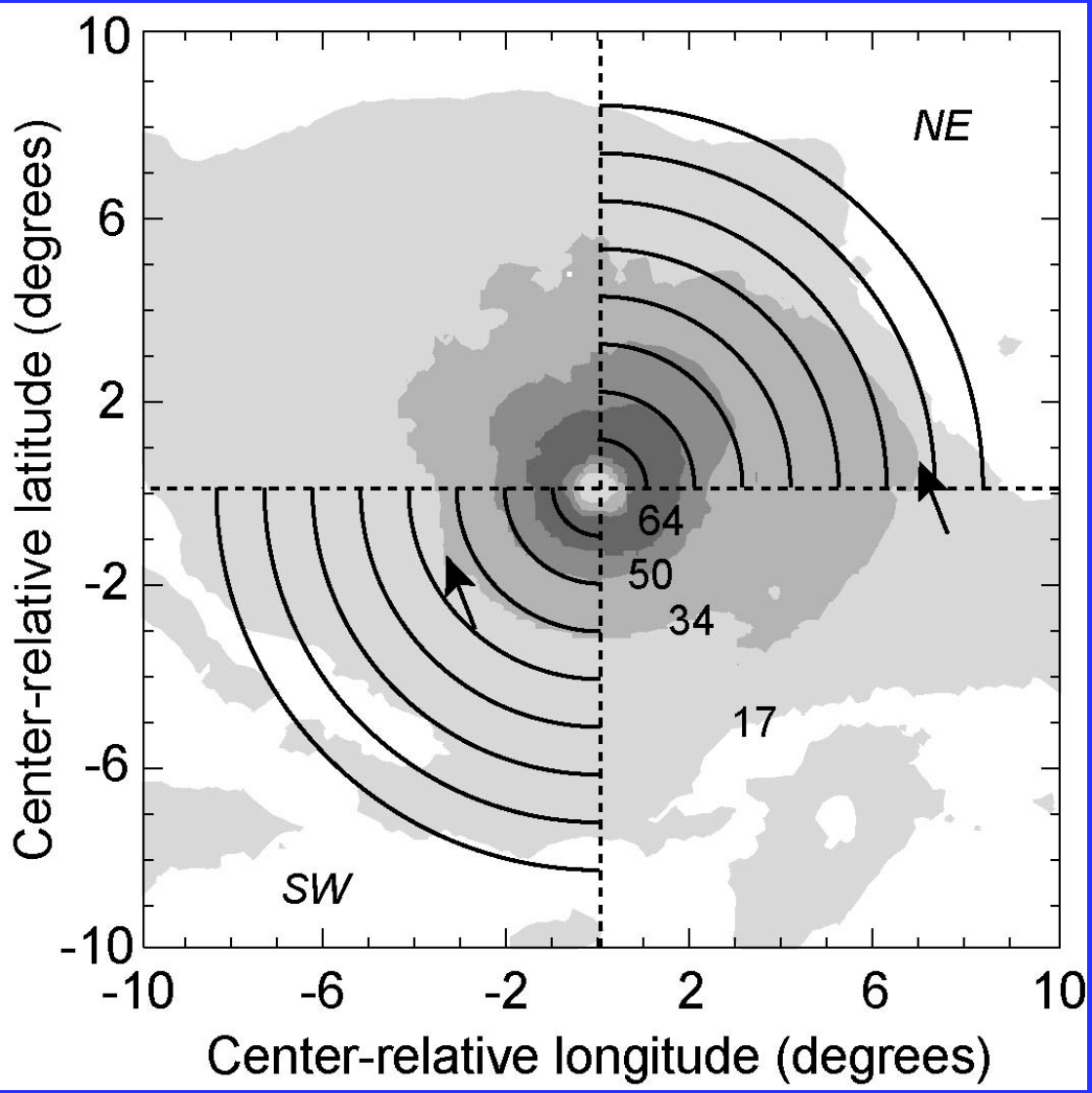
RMS Error



Bias



Wind Radii



Wind Radii not often discussed, but very important aspect of TC

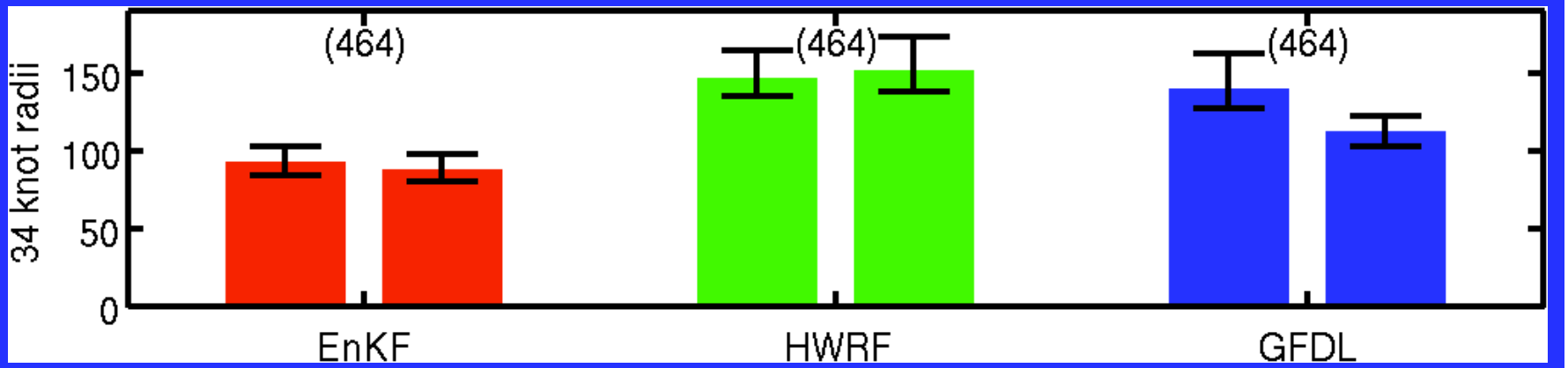
These distances determine:

- region of wind damage
- area over which fluxes occur
- wind driven stresses for storm surge models

Davis et al. 2010

34 Knot Wind Radii

RMS Error



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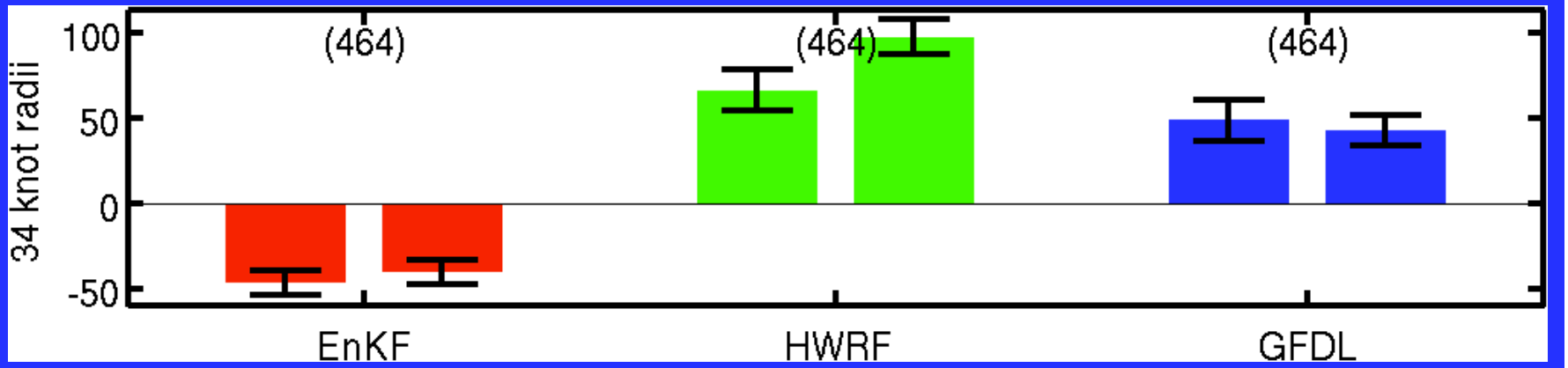
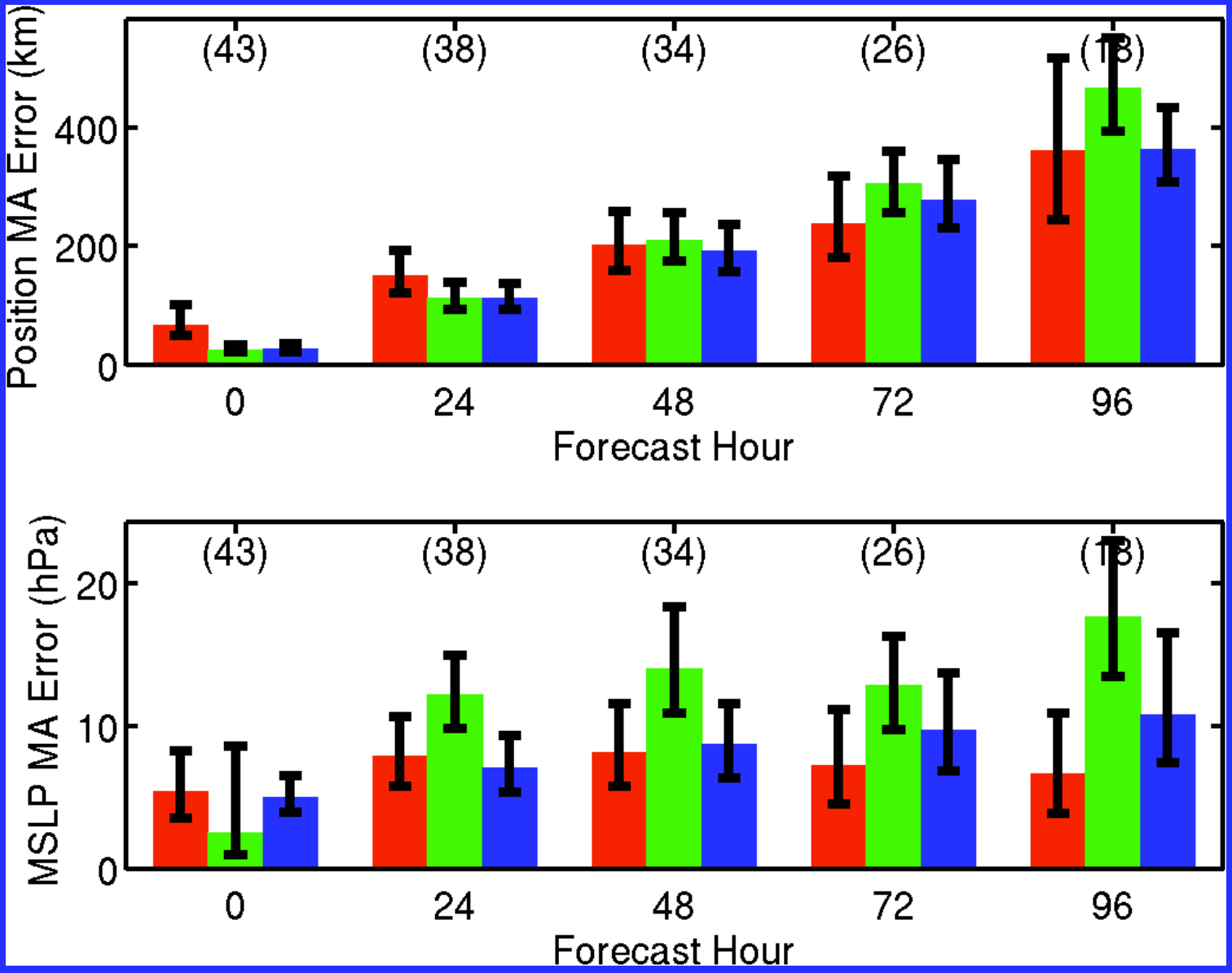
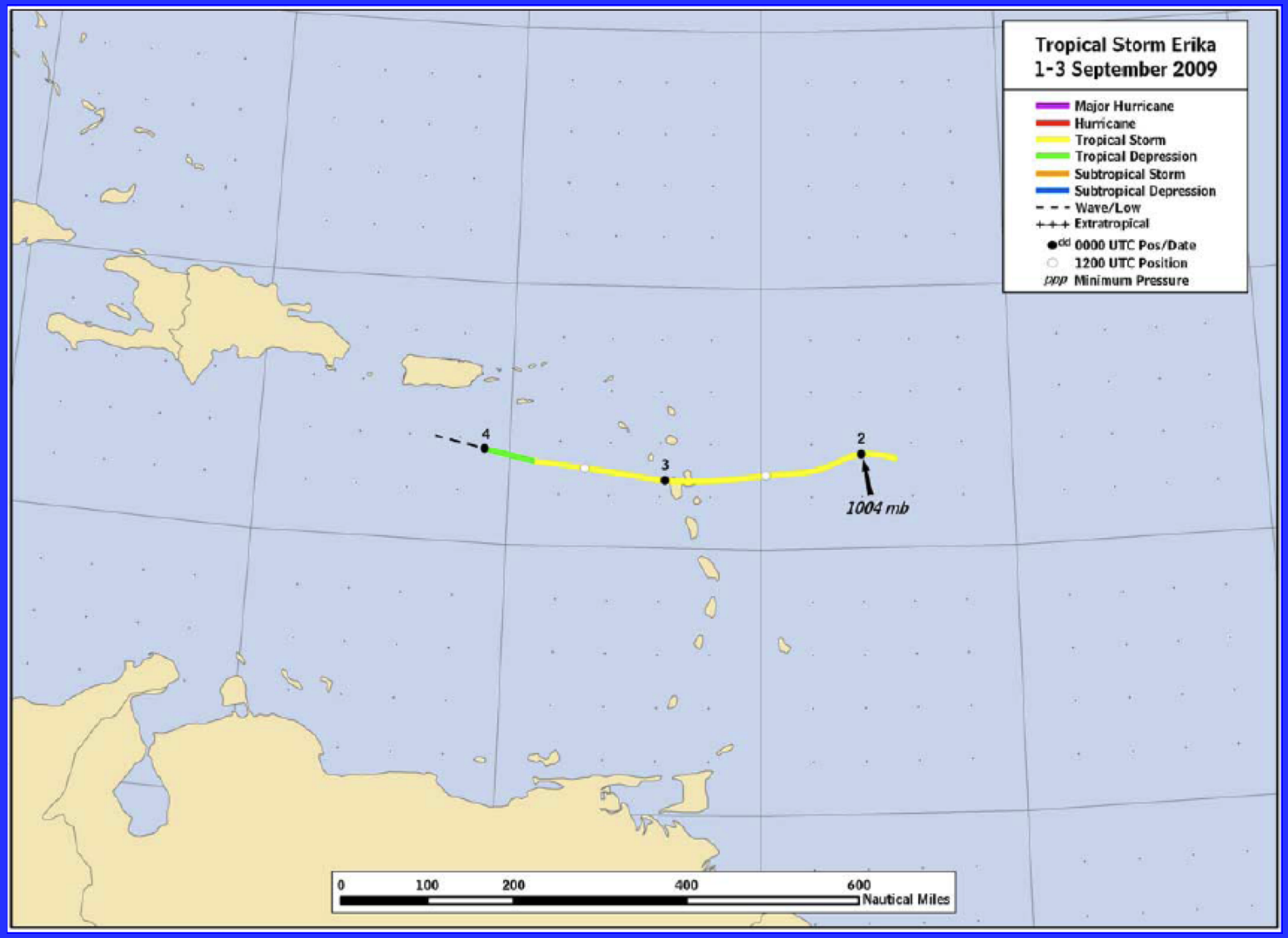


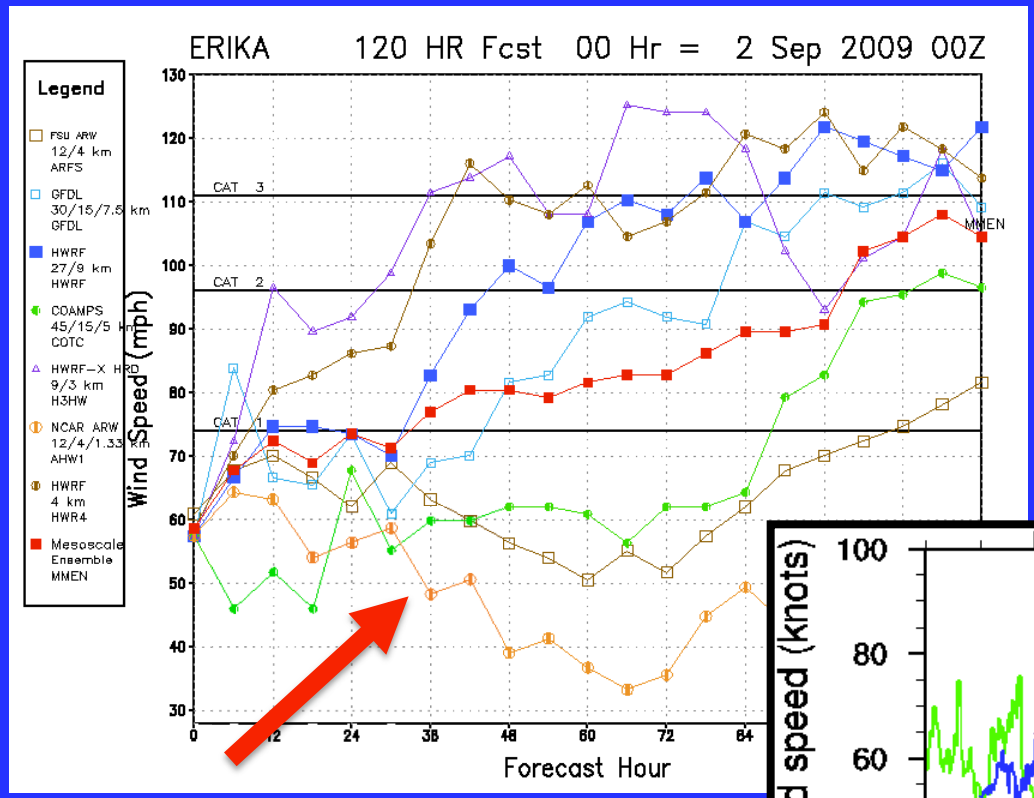
High-Resolution Forecast

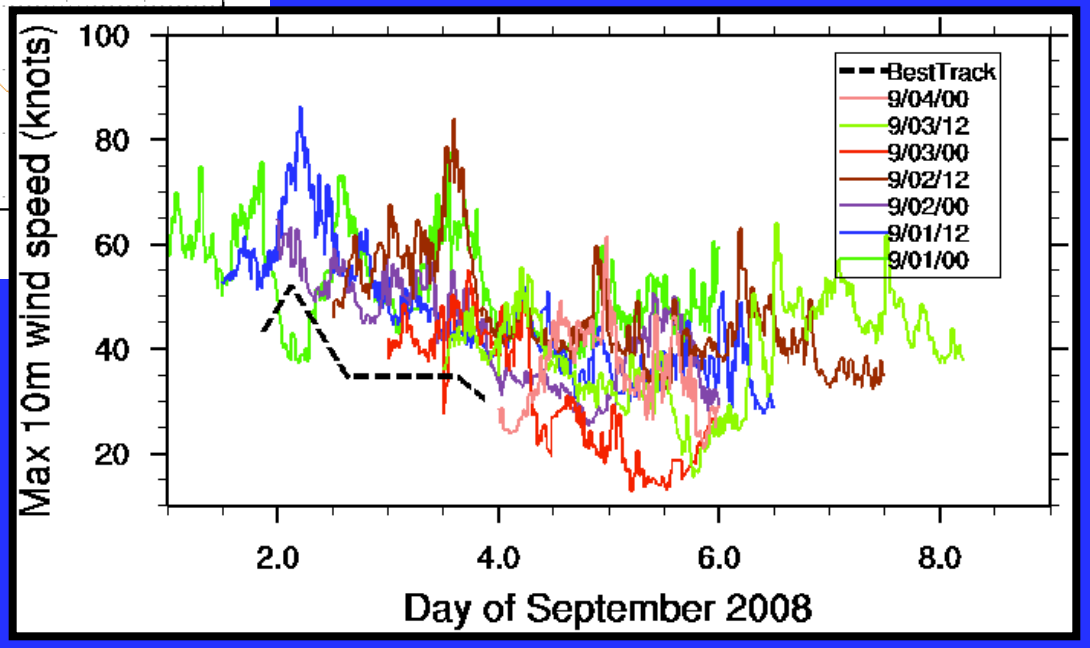


Tropical Storm Erika

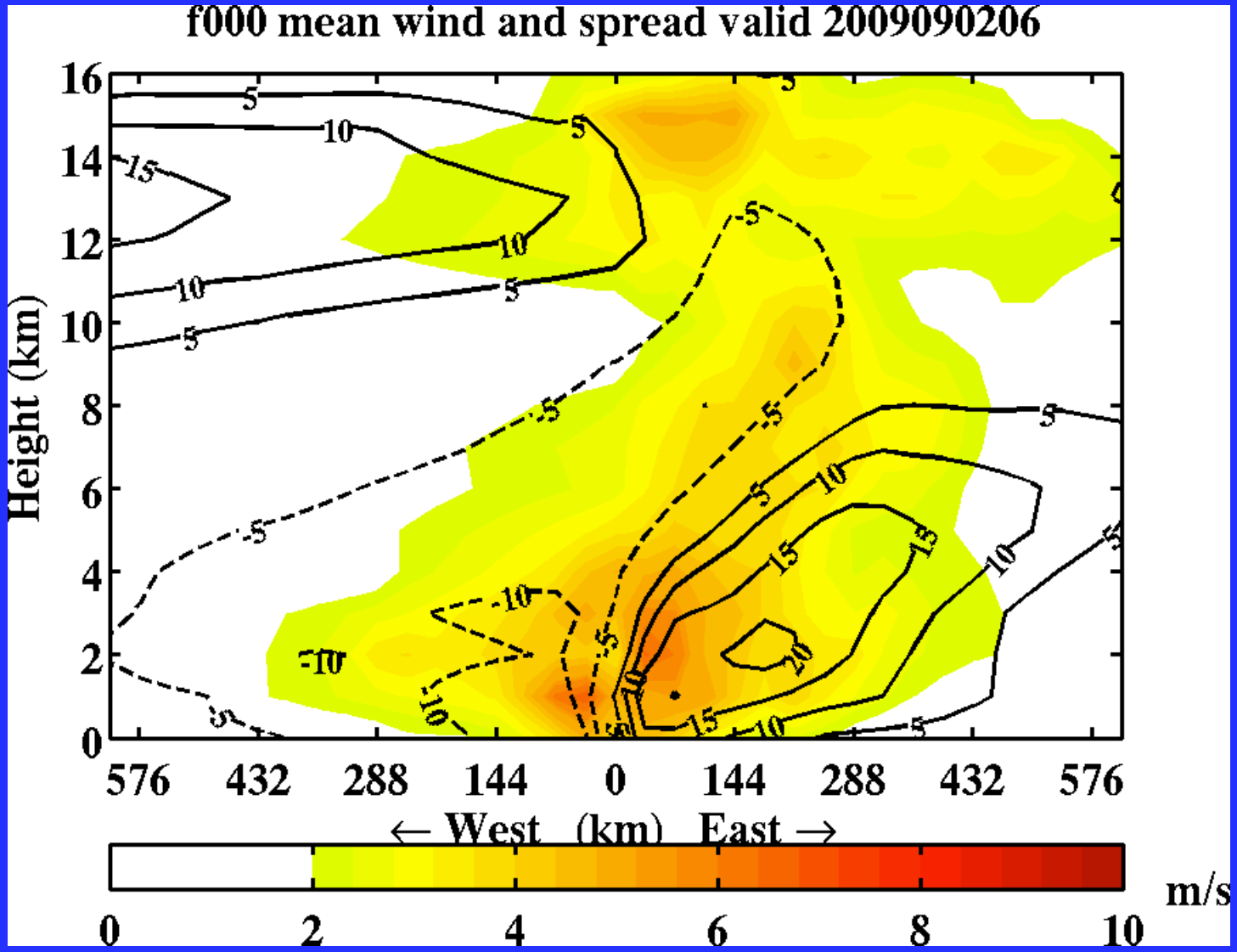


Erika Forecast





Wind Cross Section



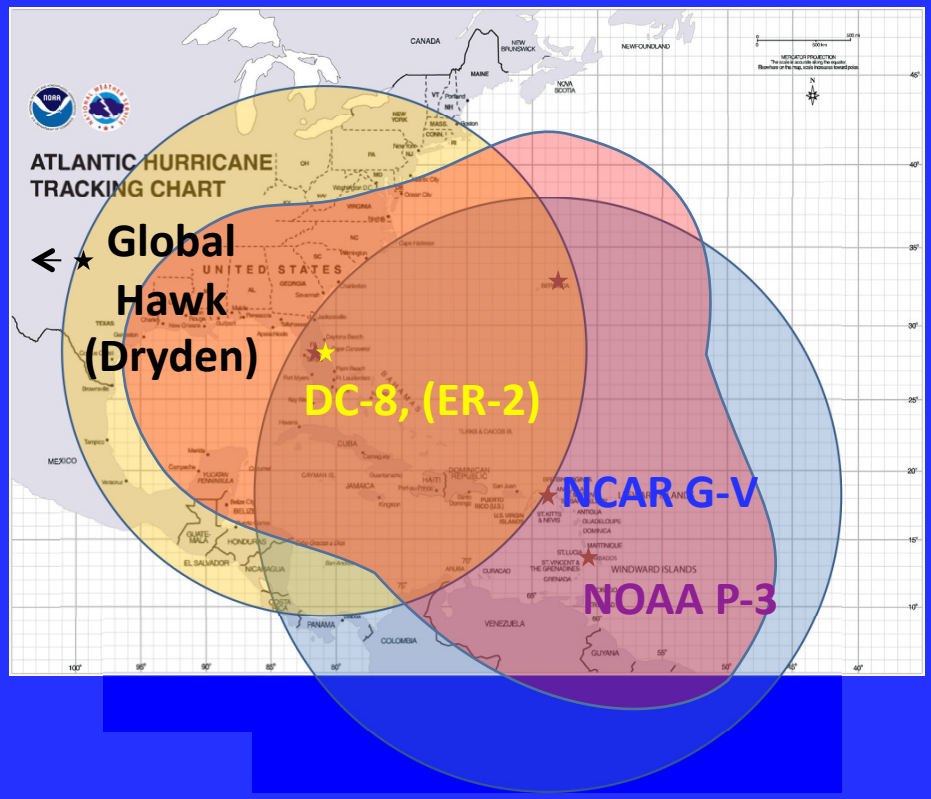
Summary & Conclusions

- Initial conditions from an EnKF system lead to reduced “spin-up” problems compared to bogus schemes
- Used this approach to generate coarse ICs for high-resolution forecasts during 2009 season
- Analysis has larger position errors, similar intensity errors and lower TC size errors compared to operational TC models.
- High-resolution forecasts benefit from EnKF ICs during highly-sheared storms, stems from having tilted initial vortex and explicit convection
- Several planned improvements for upcoming season including higher resolution and treatment for pre-genesis systems

PREDICT

PREDICT: PRE-Depression Investigation of Cloud-systems in the Tropics

- 15 August – 30 Sept. 2010
- Base: St. Croix Virgin Islands
- NCAR G-V: 200 research hours
- 10+ disturbances sampled, 25 flights
- 550 dropsondes
- Microwave Temperature Profiler
- Differential GPS (geopotential height on p-sfc)
- Small Ice Detector
- Cloud Particle Imager
- CVI
- Cloud radar



Courtesy: Chris Davis, NCAR