NOAA Earth System Research Laboratory

Results from testing of EnKF and an EnKF-Var hybrid using the GFS during the 2010 hurricane season

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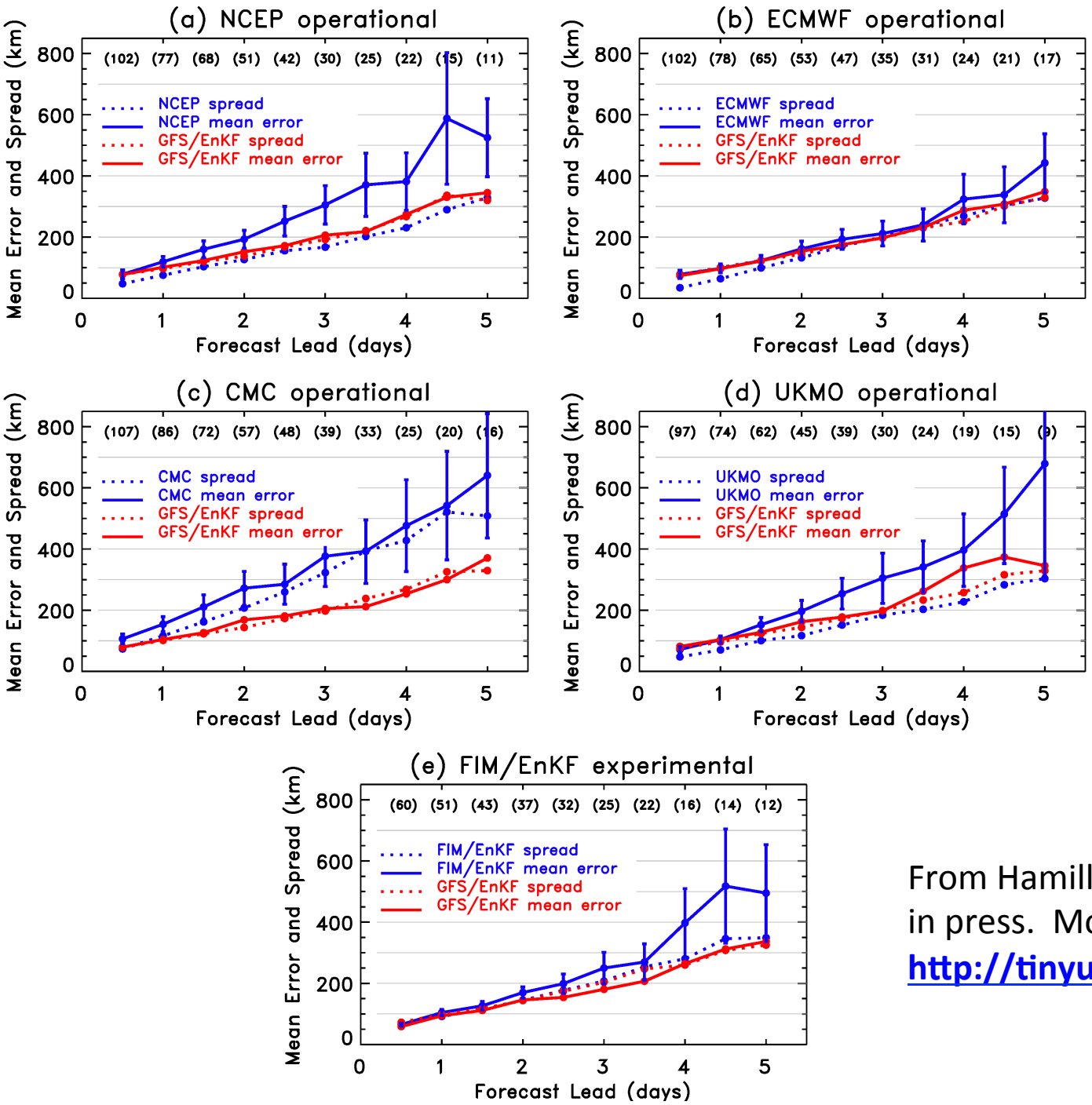


Review: EnKF tested in 2009 hurricane season with T382L64 GFS model, and performed well.

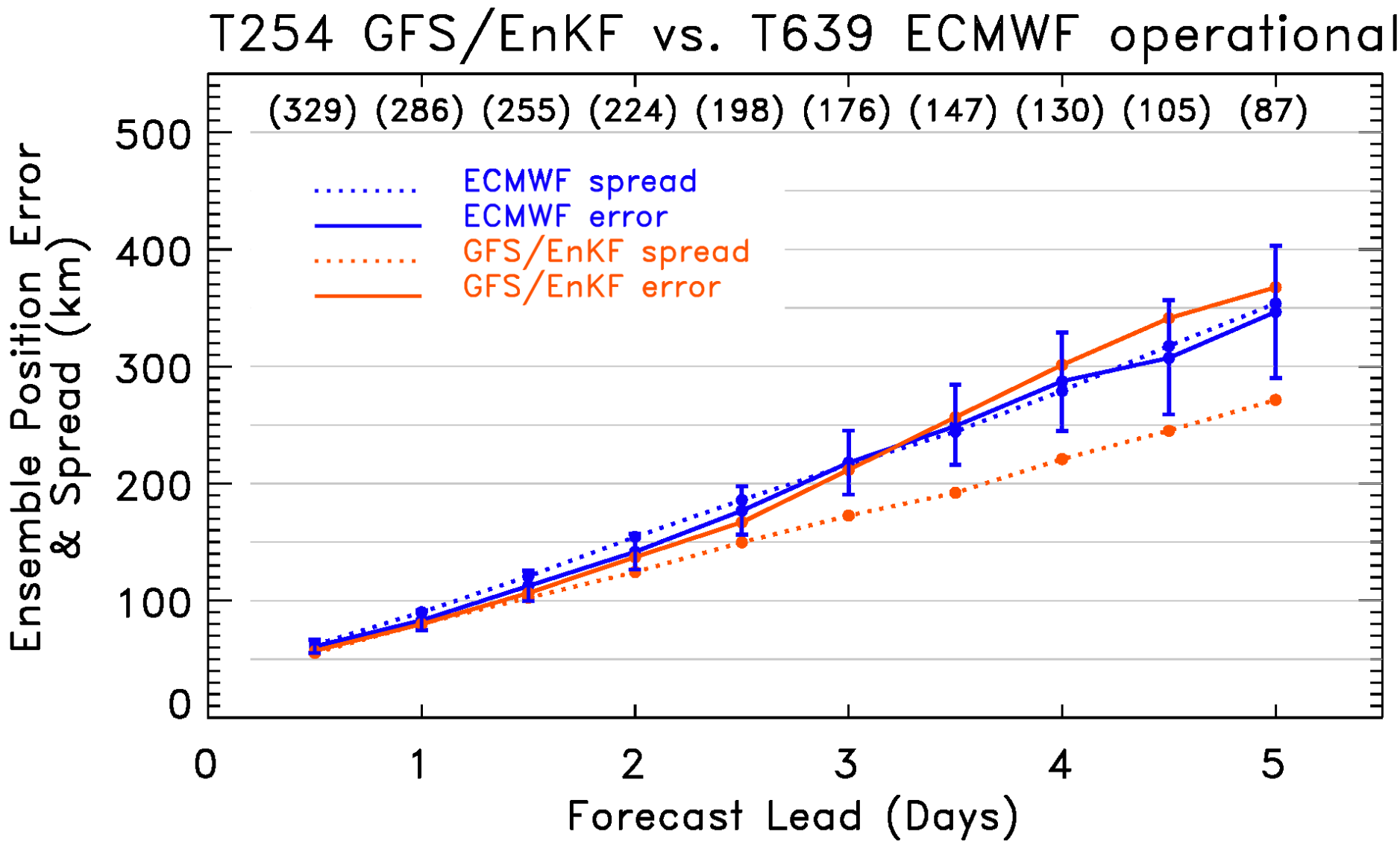
From Hamill et al., *MWR*, 2011, in press. More at **http://tinyurl.com/4c4x8aq**

Questions to address in 2010 season testing

- Can 2009's promising results be repeated, even if only a lower resolution version (T254L64) can be afforded this year?
- Can EnKF be further improved?
  - Separate assimilation of position / intensity?
  - Assimilation of CIRA wind retrievals?
  - Hybrid EnKF-Variational?
- Path to operations for this technology? Yes, via hybrid, hopefully ~ early 2012.
  - Hybrid ensemble-variational system development discussed more in talks J16.2-J16.5, Thursday, 11am.

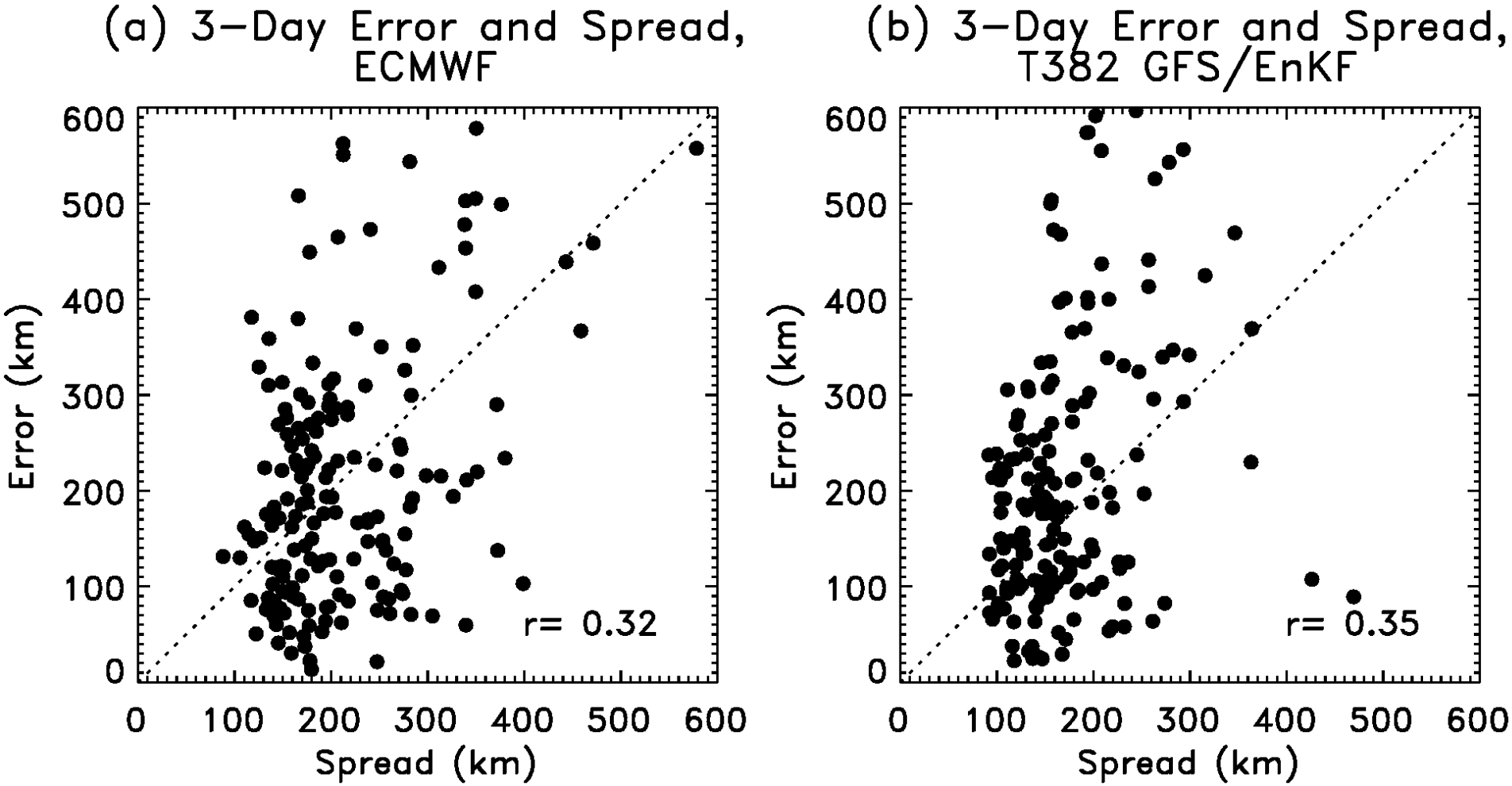
Configuration of 2010 GFS/EnKF

- Cycled from early June 2010 through end of October 2010
- T254L64 model (~70 km grid spacing at 25°N) this year, on ESRL tjet computer (vs. NSF computer last year).
- All observations assimilated by GSI, including radiances, assimilated by EnKF. Also: location and central pressure of TC from TCVitals.
- Verification against best track information.
- Comparisons against NCEP operational (T190, ETR perturbations); ECMWF; UKMO; CMC.
- Various additional experiments (EnKF control to initialize T574 GFS; assimilation of central pressure as separate position and intensity observations).



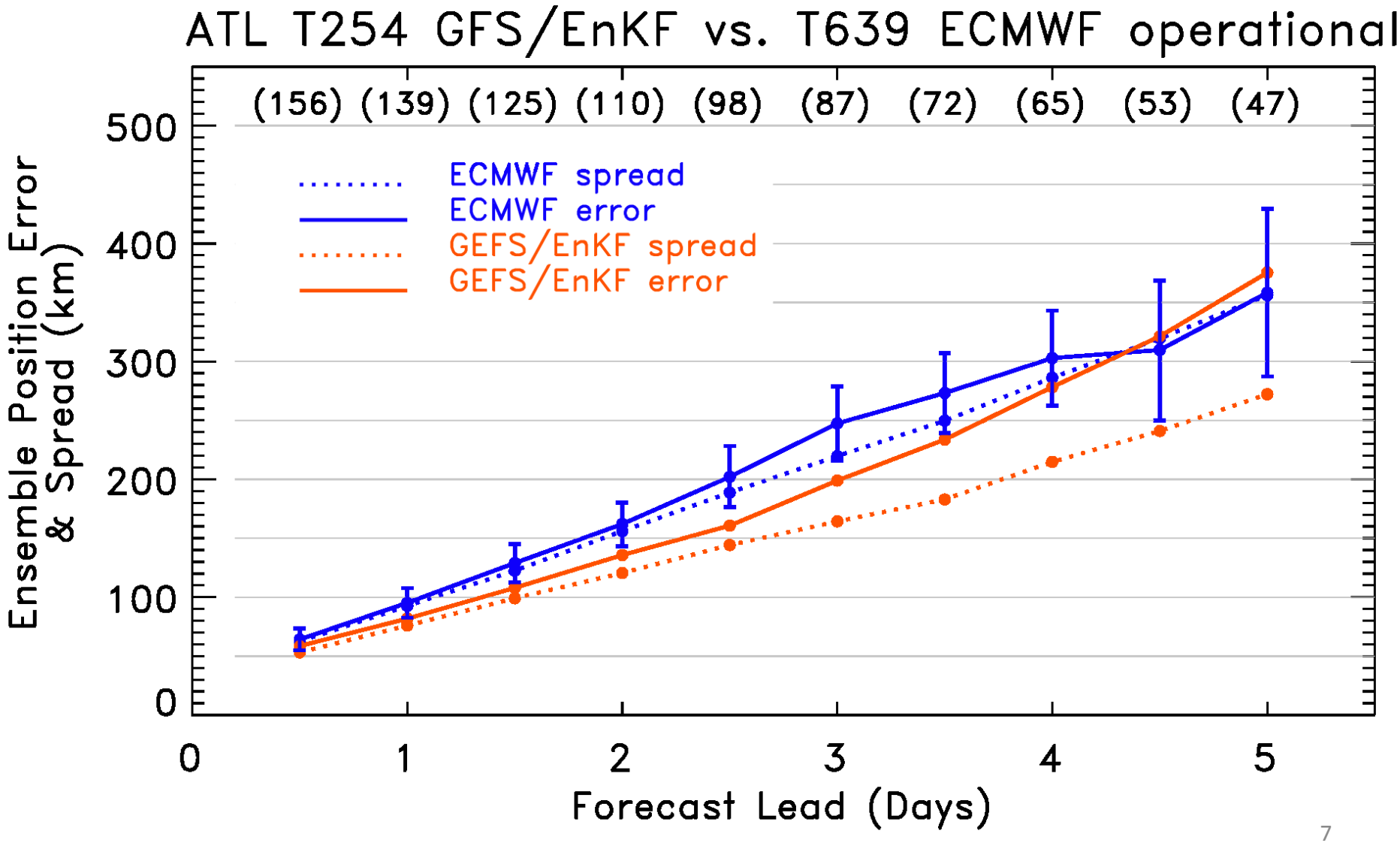
Not as competitive with ECMWF as last year, & GFS/EnKF spread inconsistency. Possible reasons: (1) lower resolution. (2) GFS change in vertical diffusion affects ensemble spread?

Spread vs. error, all basins, day 3

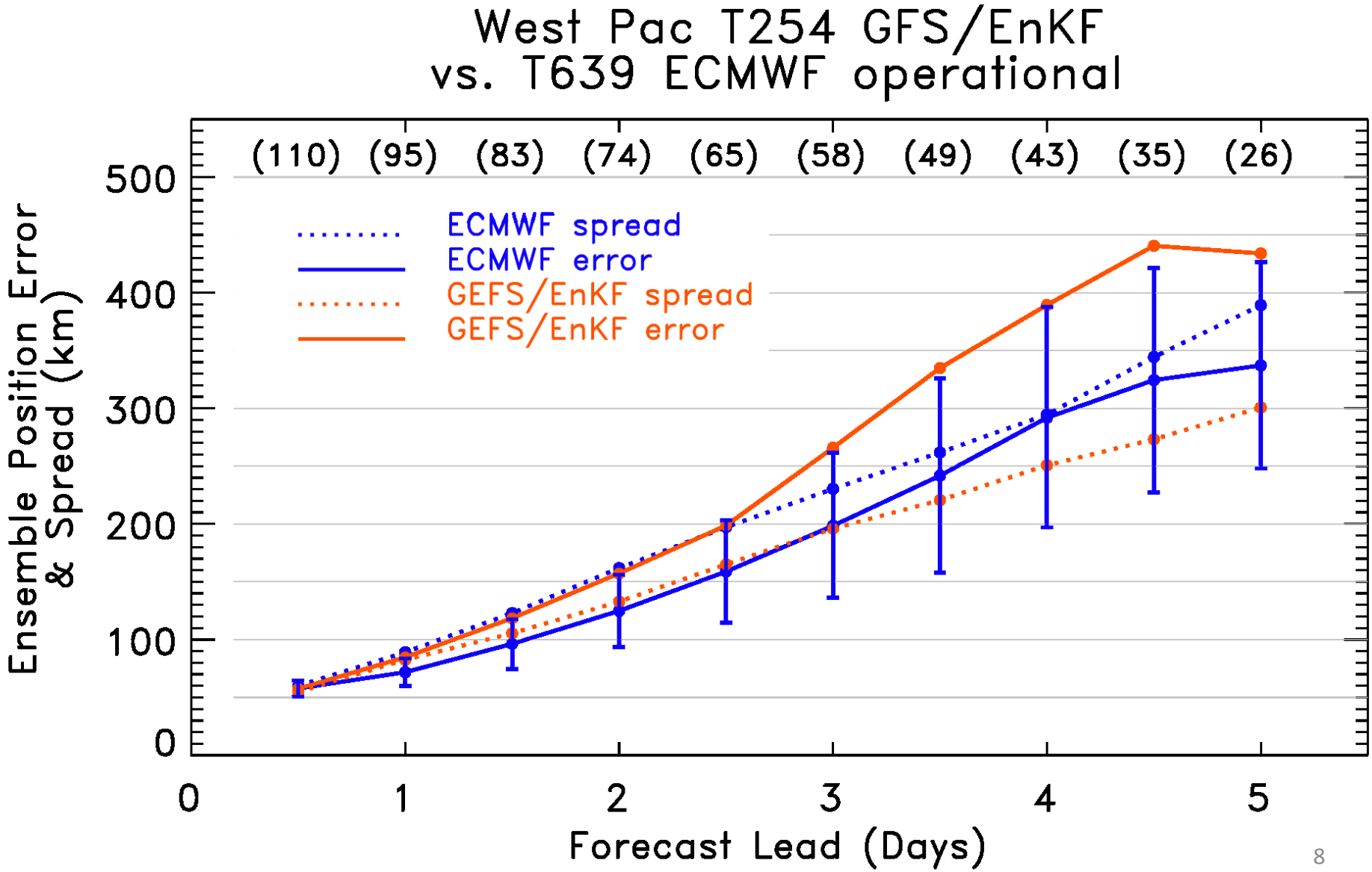


Underestimate of spread for GFS/EnKF primarily for storms with larger errors.

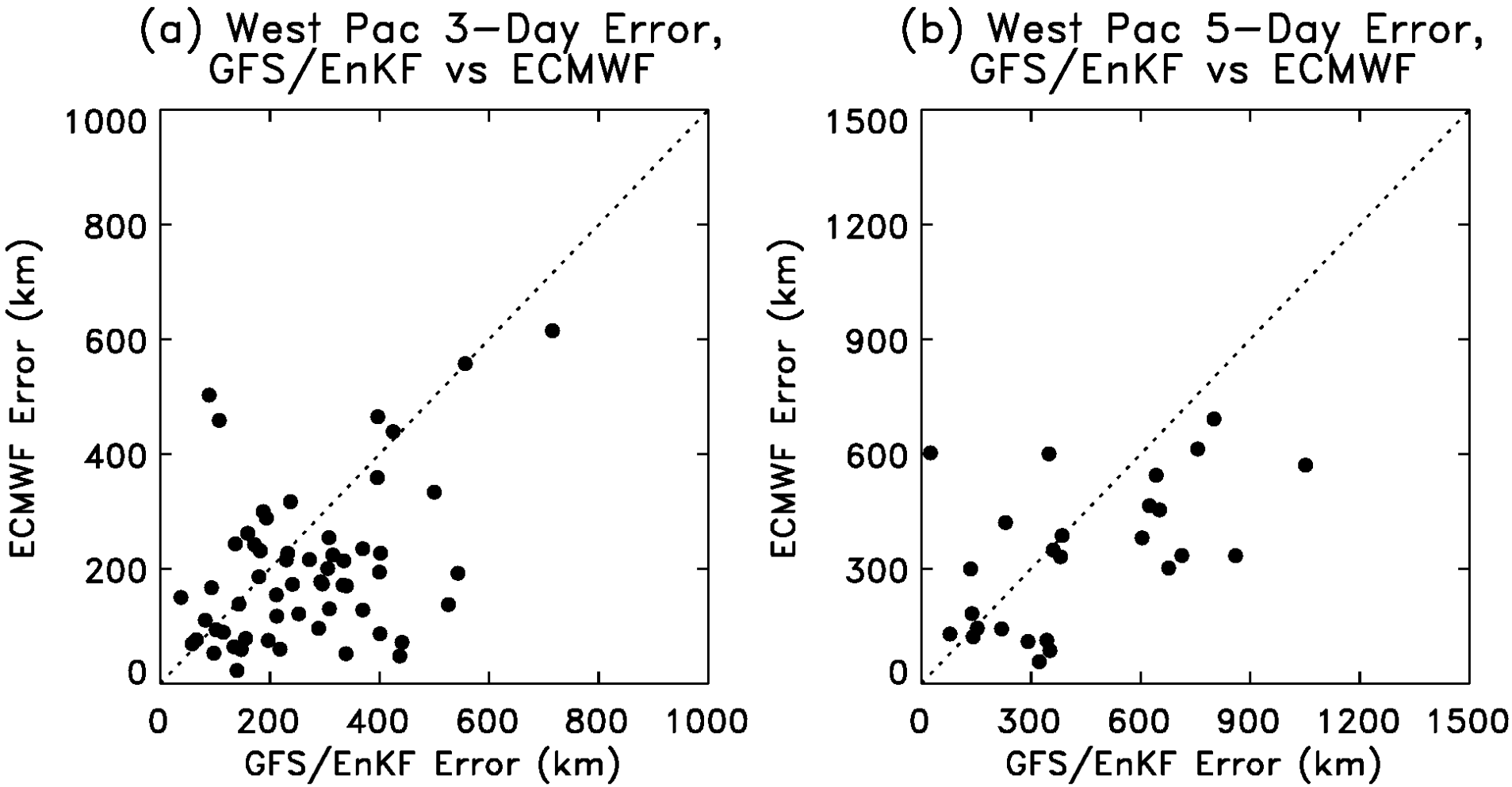
Track error, Atlantic basin only.



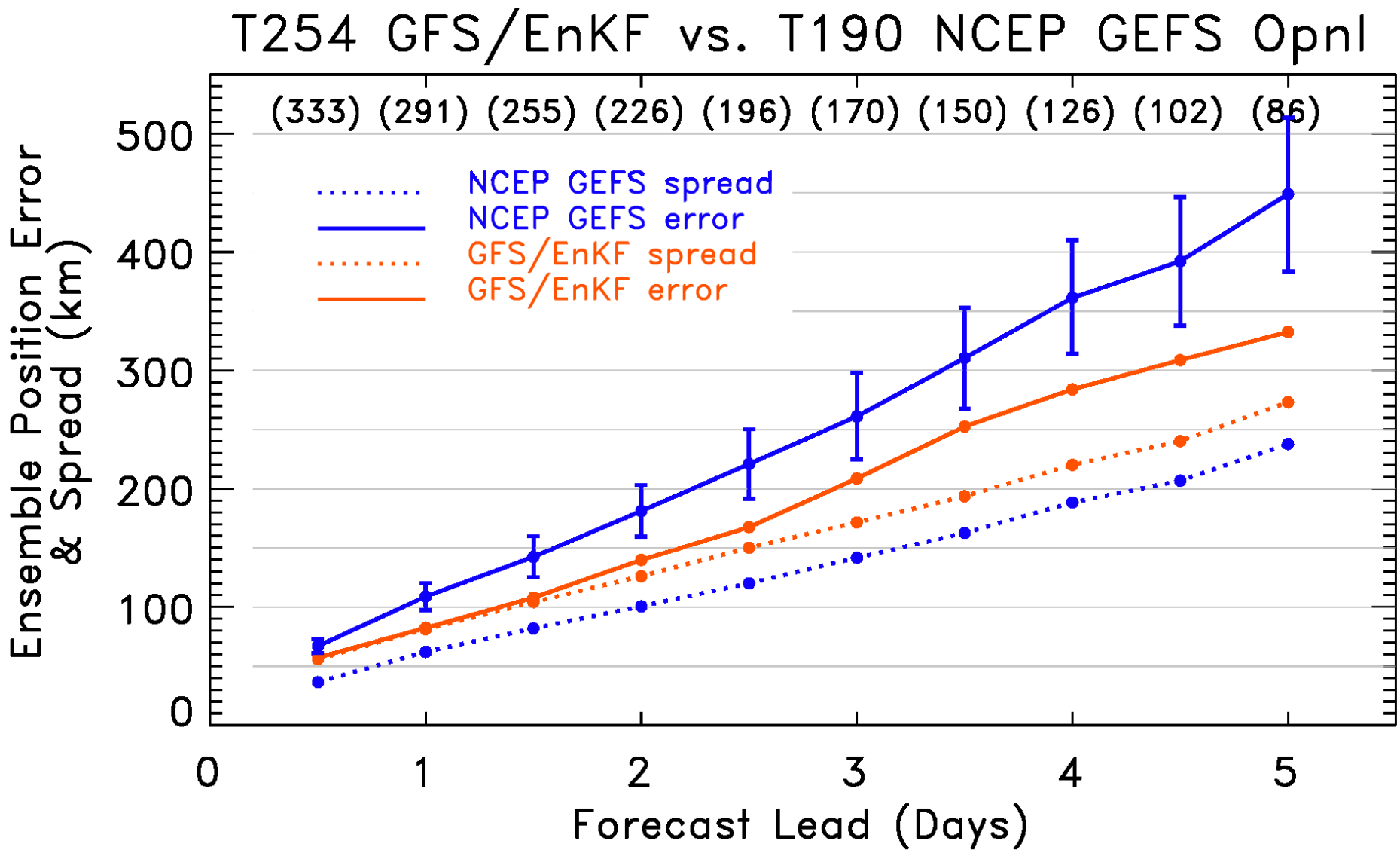
… Western Pacific only.



Scatterplot of West Pac errors, days 3 & 5

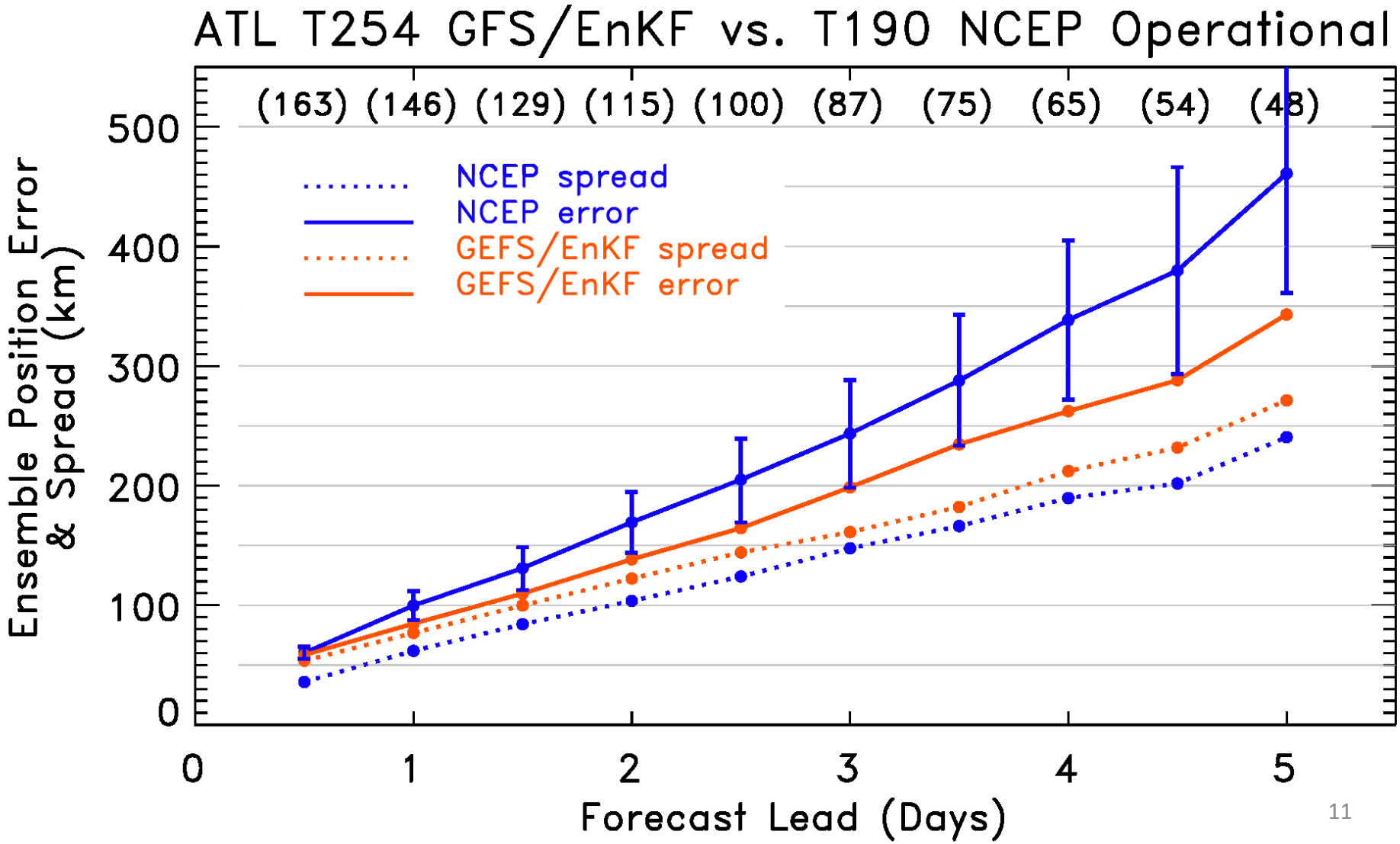


not a result of one or two outliers, ECMWF fairly consistently better.

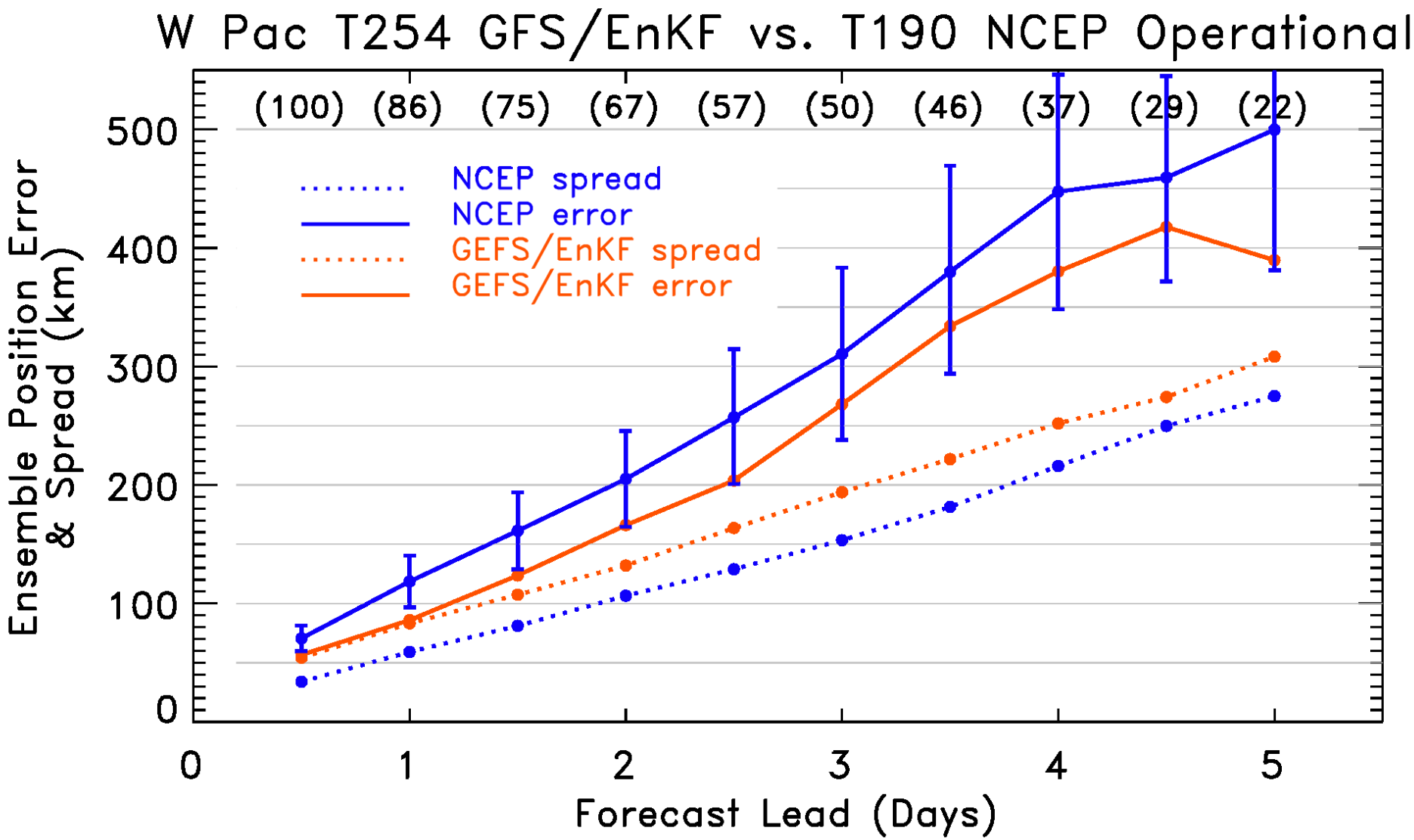


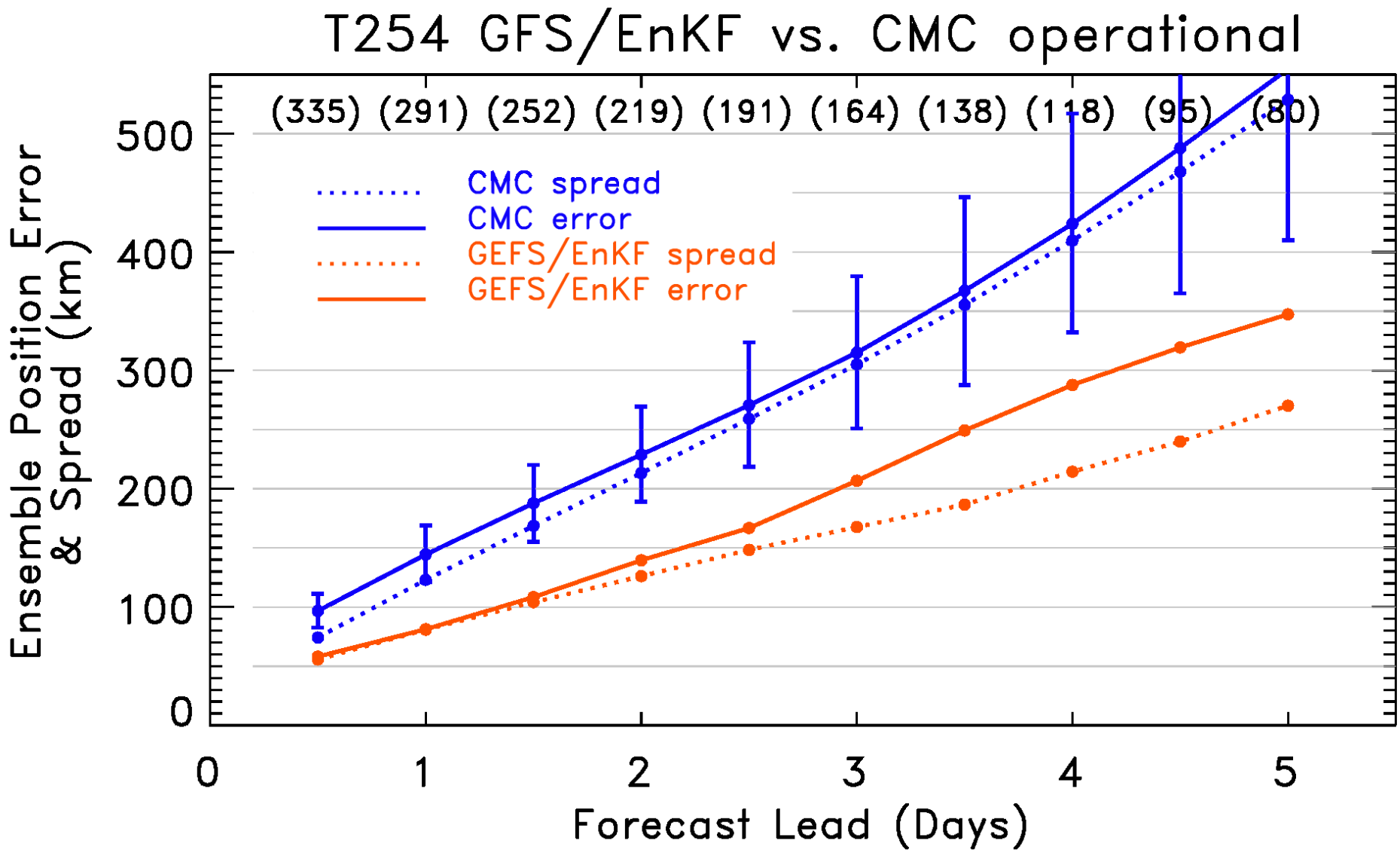
Out-performing NCEP operational, and differences are statistically significant.

… Atlantic only.

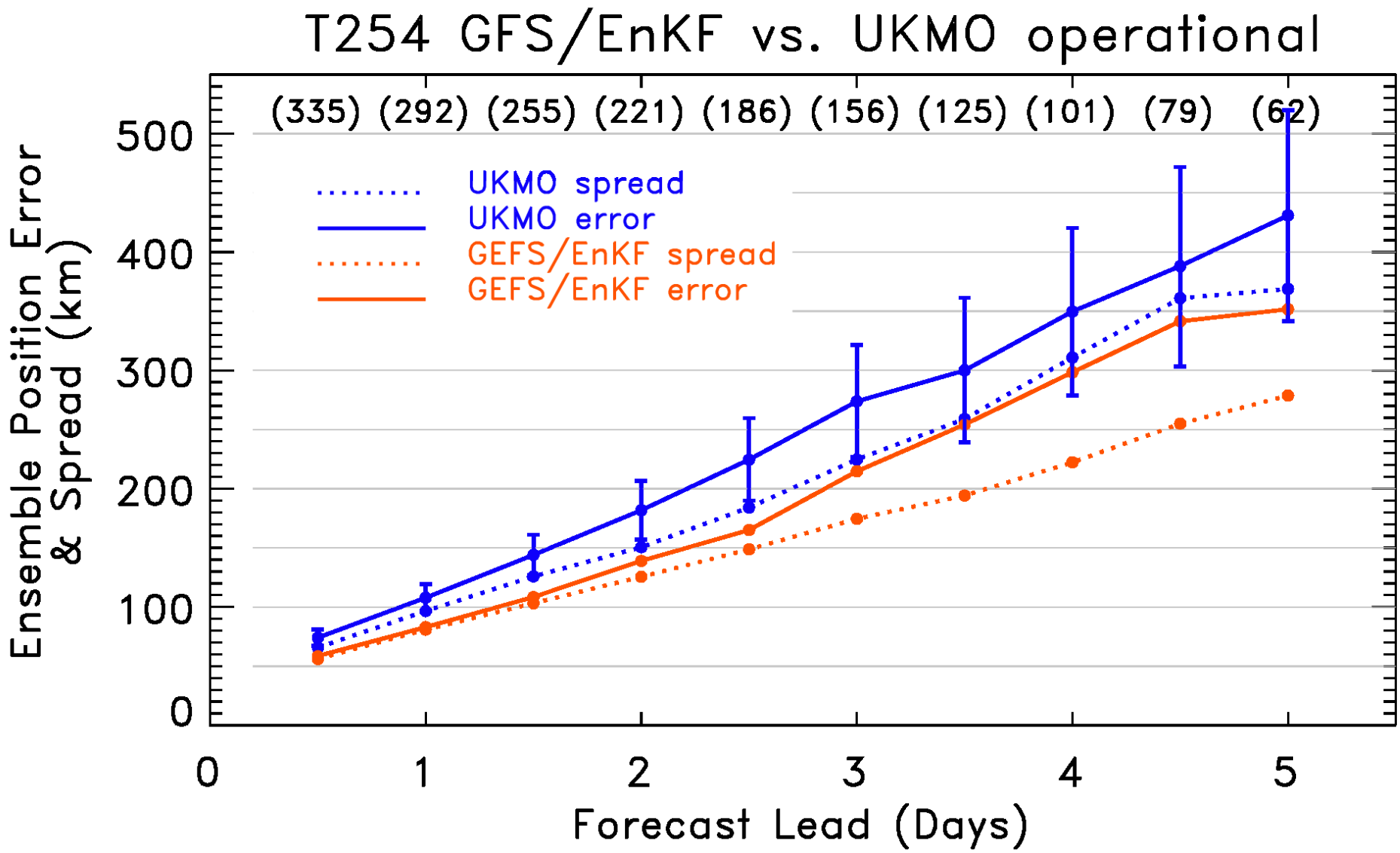


… Western Pacific only.

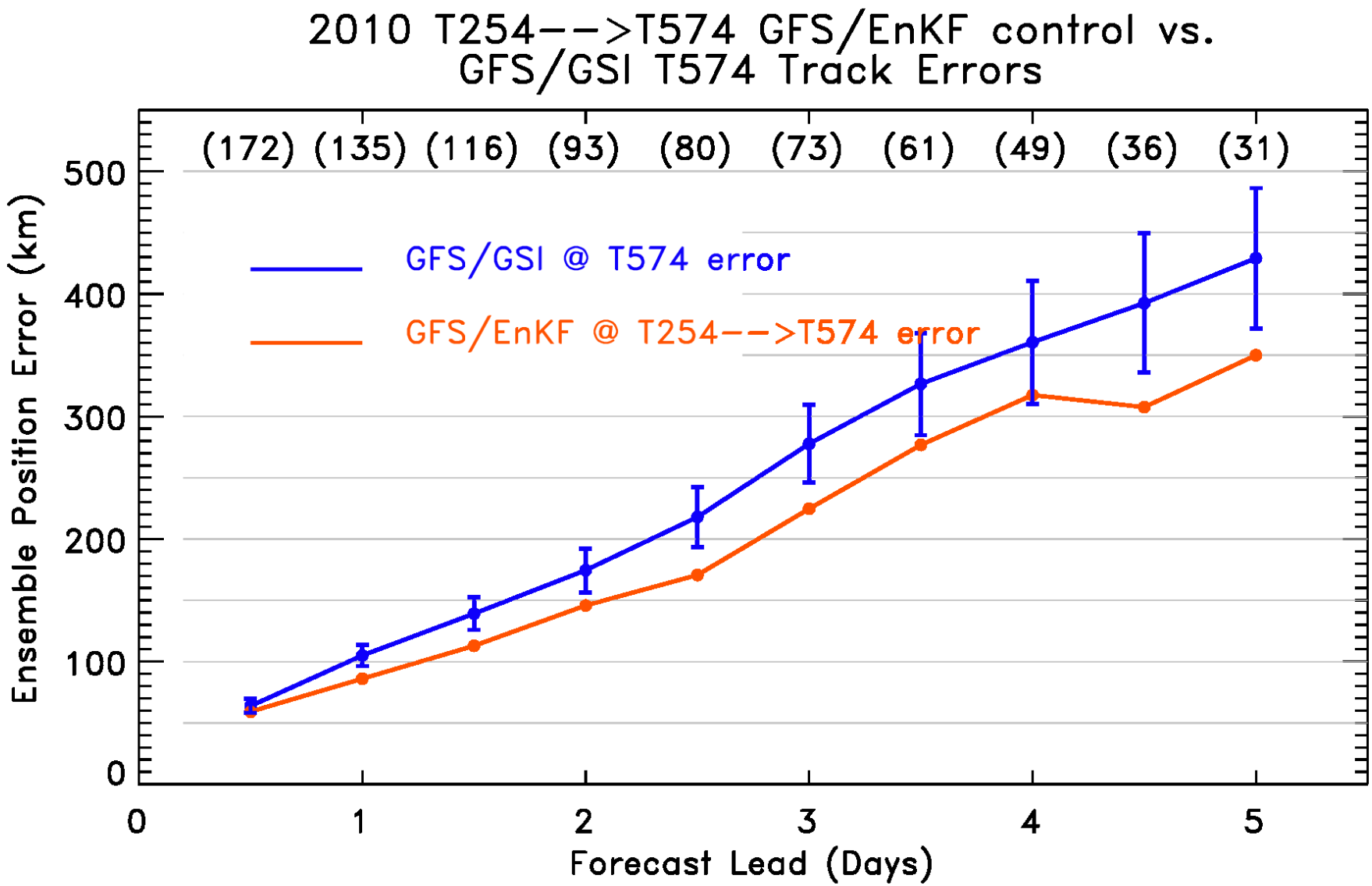




(Note vertical axis scaling changed, 550 to 850 km). CMC well calibrated but much higher in error.

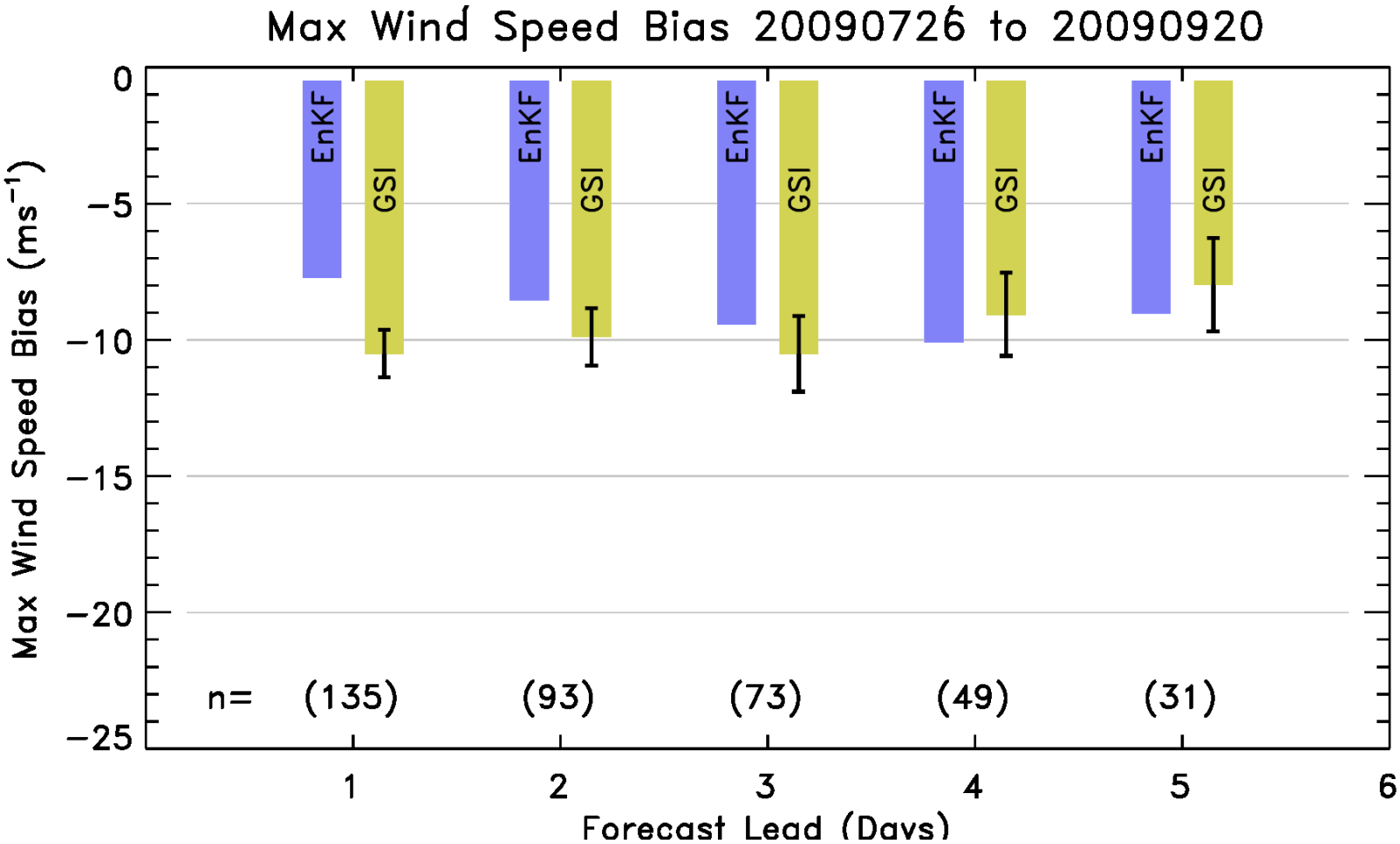


Somewhat better than UKMO, though differences not significant at longer leads.

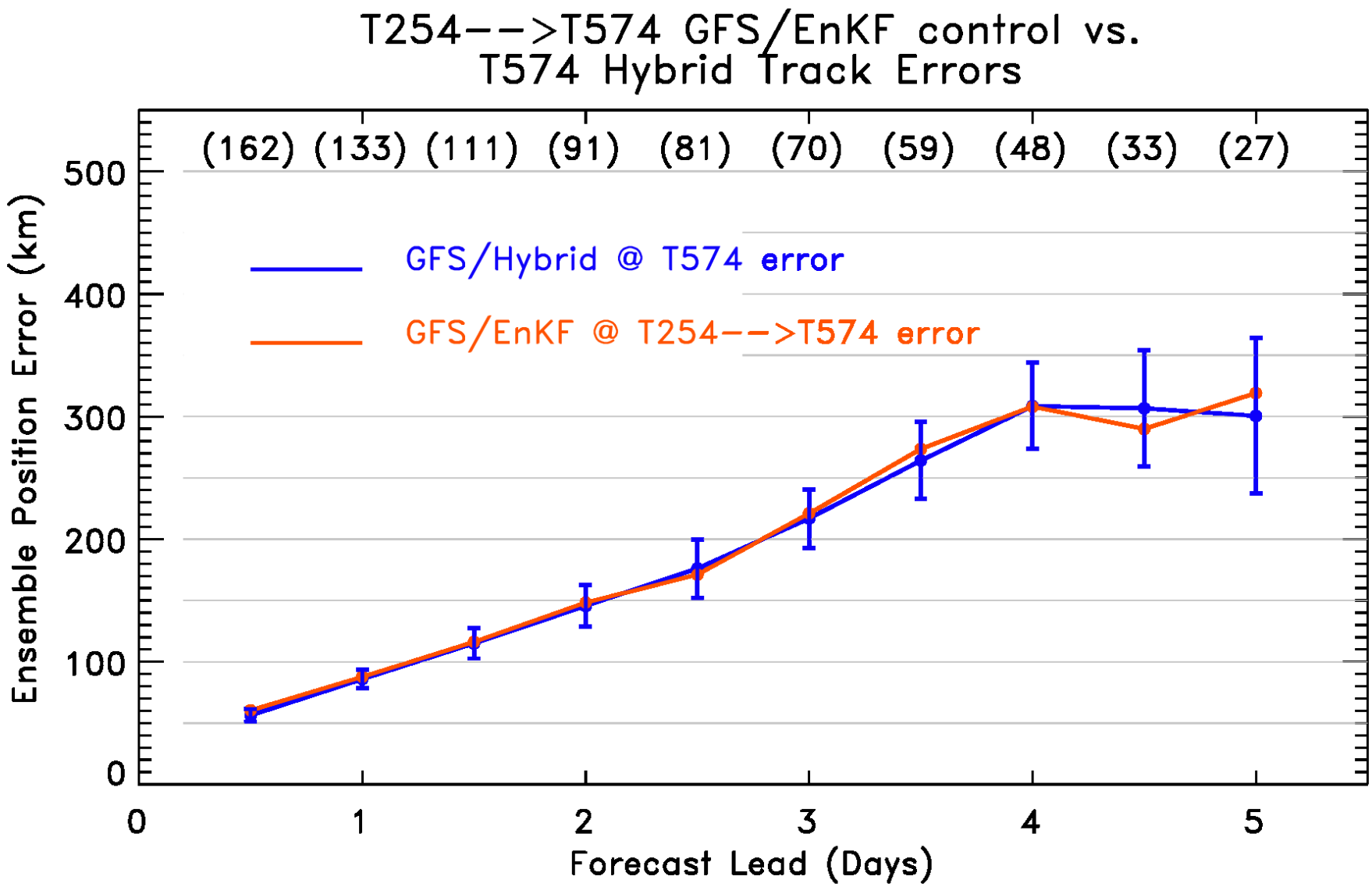


EnKF forecasts from T574 forecast model significantly lower in error than the operational control T574 forecast initialized by the GSI. Note data here only from July 26 to September 19.

EnKF vs. GSI, bias

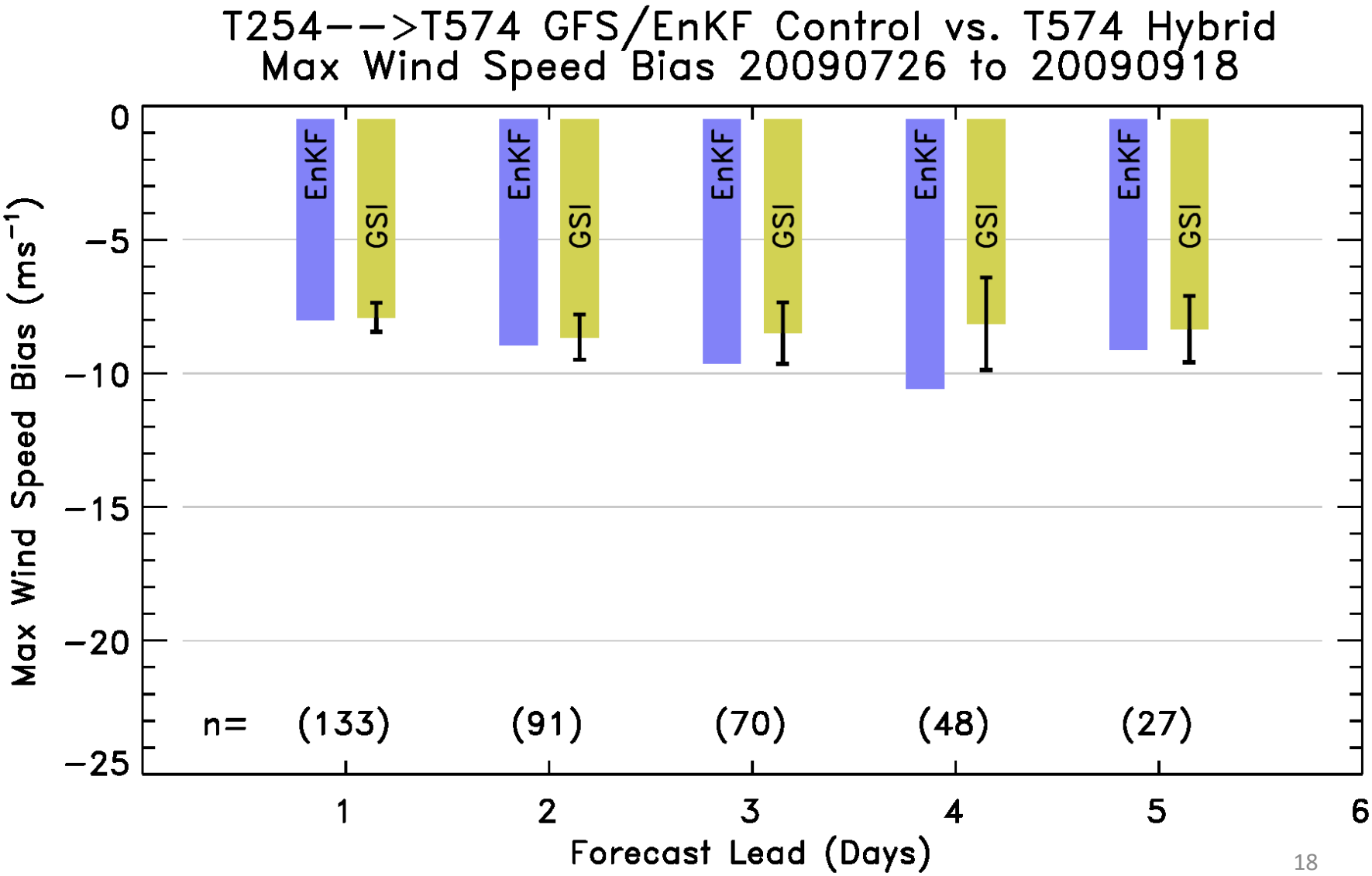


Reduced bias initially. Small sample size at longer leads, no statistical significance.



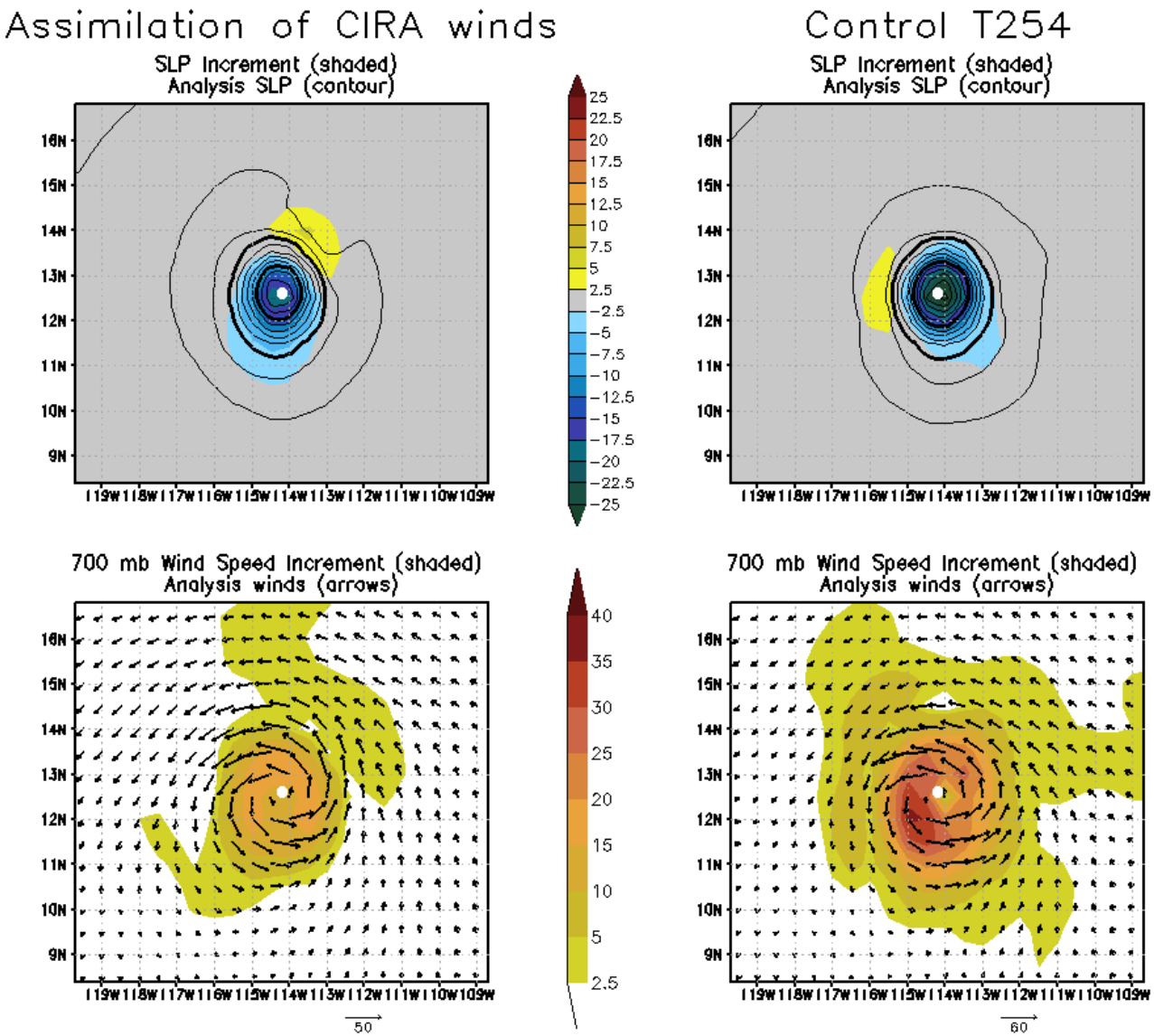
Hybrid and EnKF performance effectively indistinguishable in this metric.
Note data here only from July 26 to September 19.

EnKF vs. hybrid, bias



Impact of CIRA wind retrievals

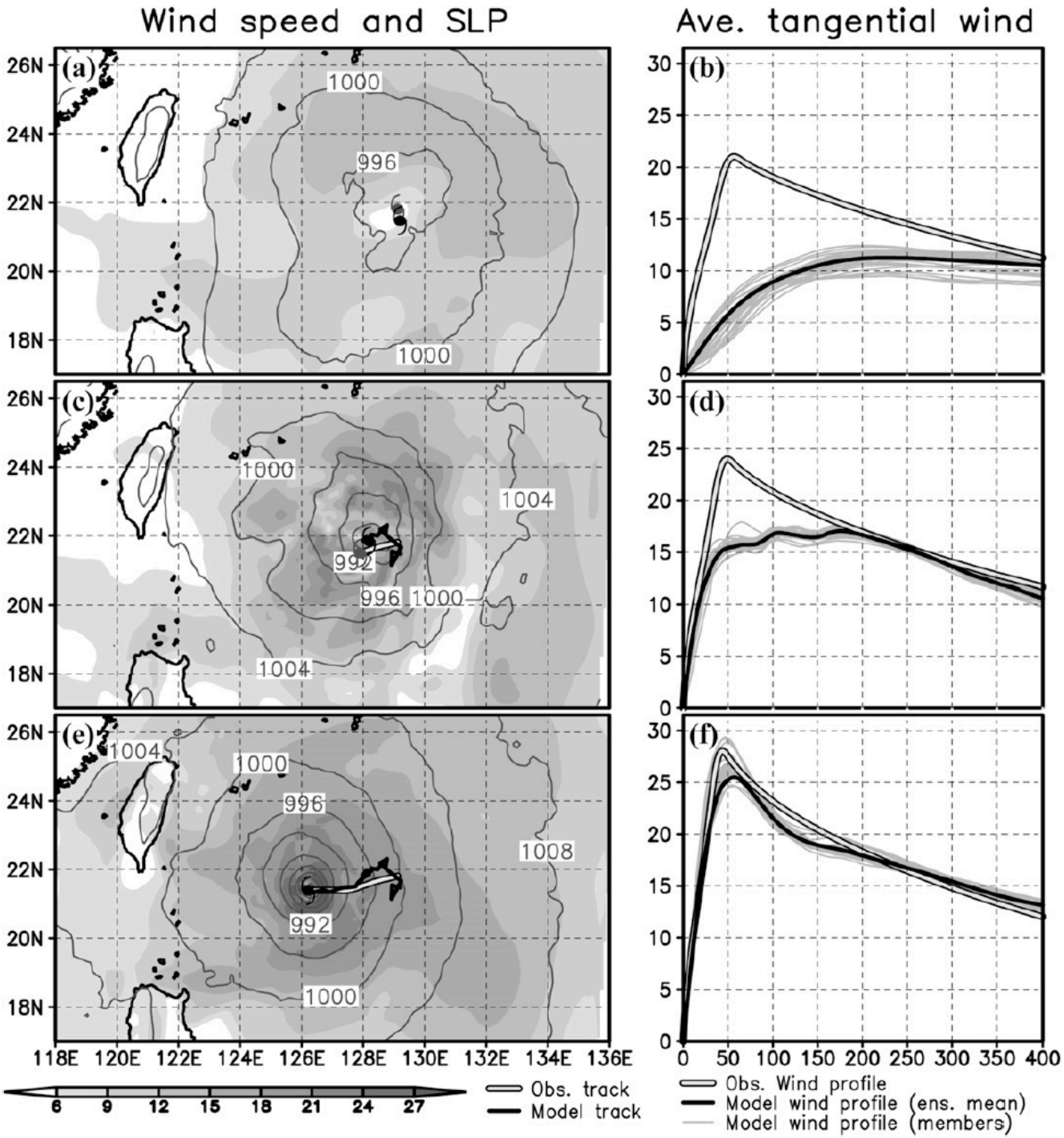
Celia: 12.6N −114.2W 0948mb 18Z24month2010



Generally smaller analysis increments when CIRA winds were retrieved, and slightly less intense analyzed vortices.

Subsequently, less filling of vortex in short-range forecast.

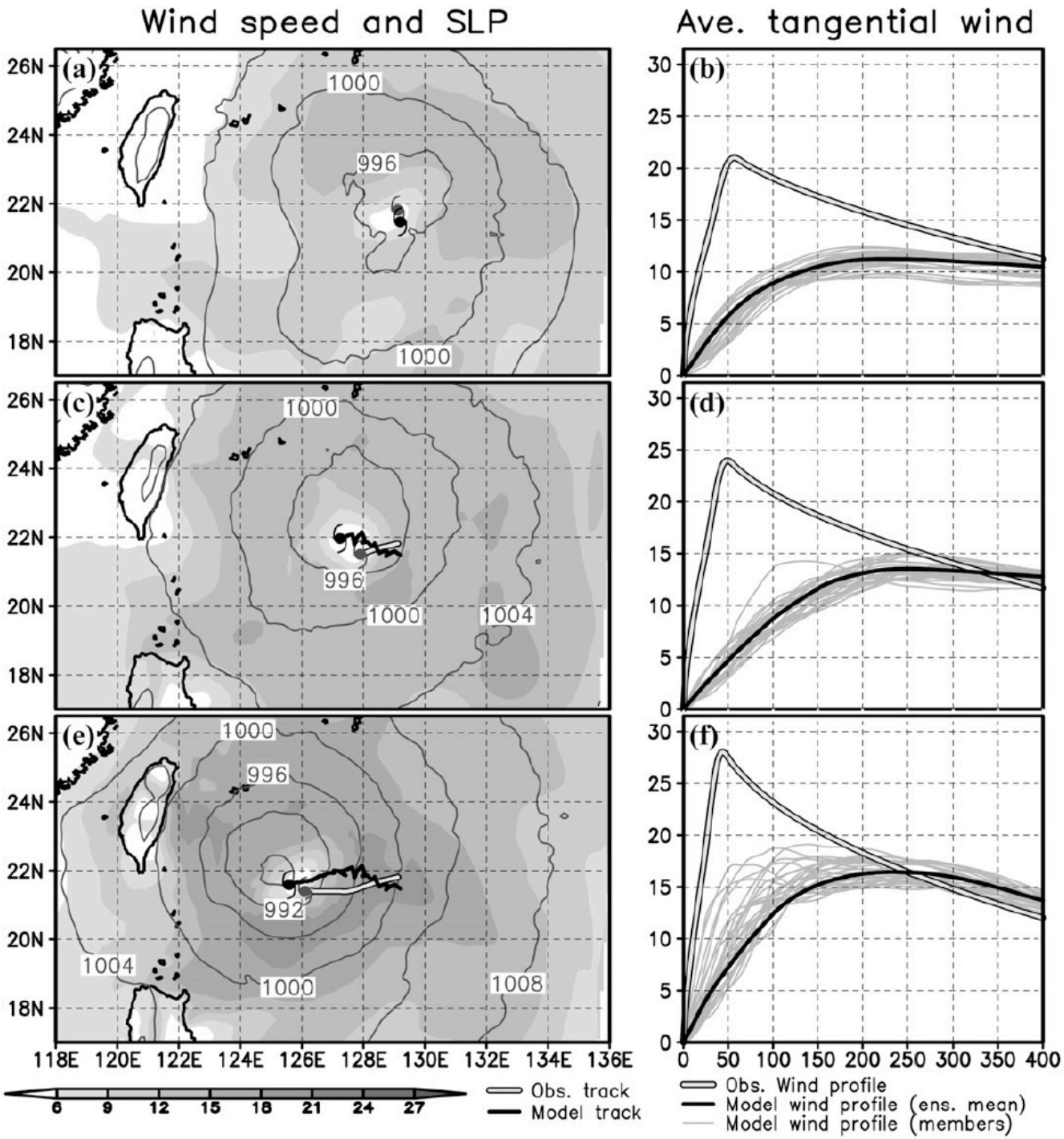
See also Slocum and Fiorino talk, Tuesday 1:45 PM in IOAS-AOLS



Following Chen and Snyder, MWR, 2007…

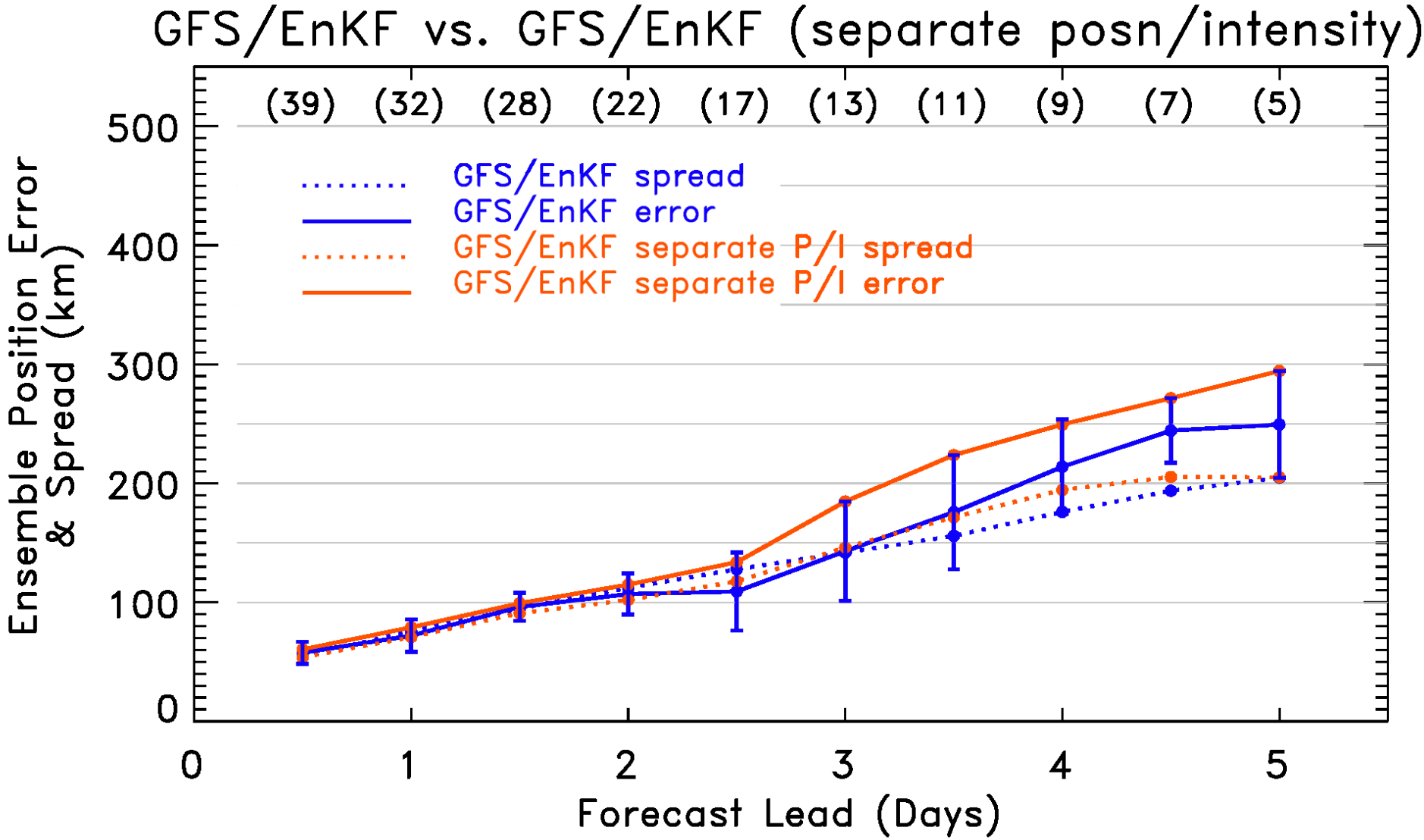
From Wu et al., JAS, Dec 2010:

Separate assimilation of the TC center position, the storm motion vector, and the axisymmetric surface wind structure, in this case from analyzed radii of the 34- and 50-kt winds from JTWC best-track database and the in-situ 10-m height surface wind from dropwindsonde data of the DOTSTAR mission.



Their reference is
with no data assimilation
performed…

Separate assimilation of position and intensity



Not the optimistic results suggested by recent articles, though small sample size.

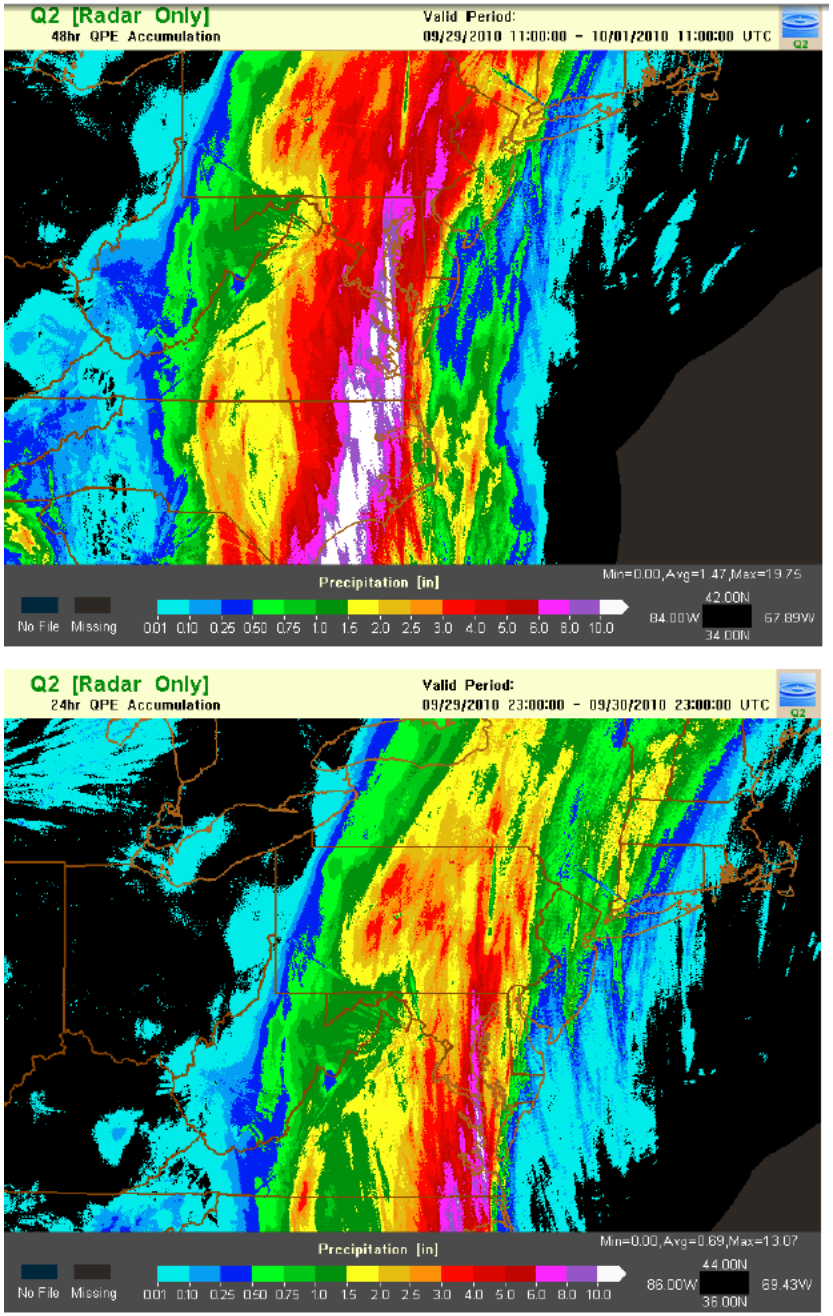


Figure 1. Q2 precipitation analysis over the Mid-Atlantic region. Upper panel is a 2-day total ending at 1100 UTC 1 October 2010 and the lower panels of the last 24 hours ending 2300 UTC 30 September 2010.

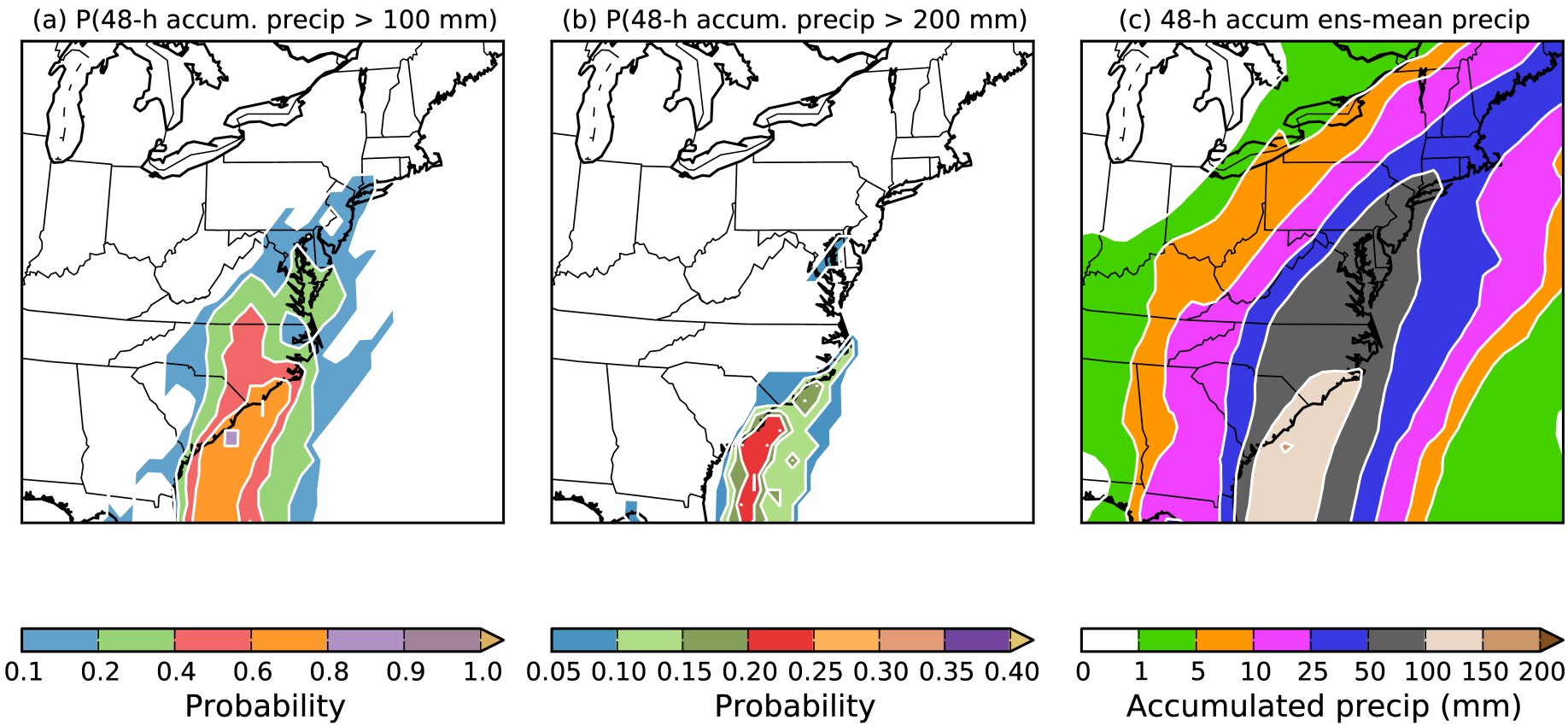
Case study: Extreme rainfall from remnants of Nicole, 29-30 September 2010

Massive and widespread East-coast rain event, linked in part to moisture advected ahead of remnants of tropical storm Nicole.

precipitation analysis, c/o Rich Grumm, NWS/WFO, State College PA

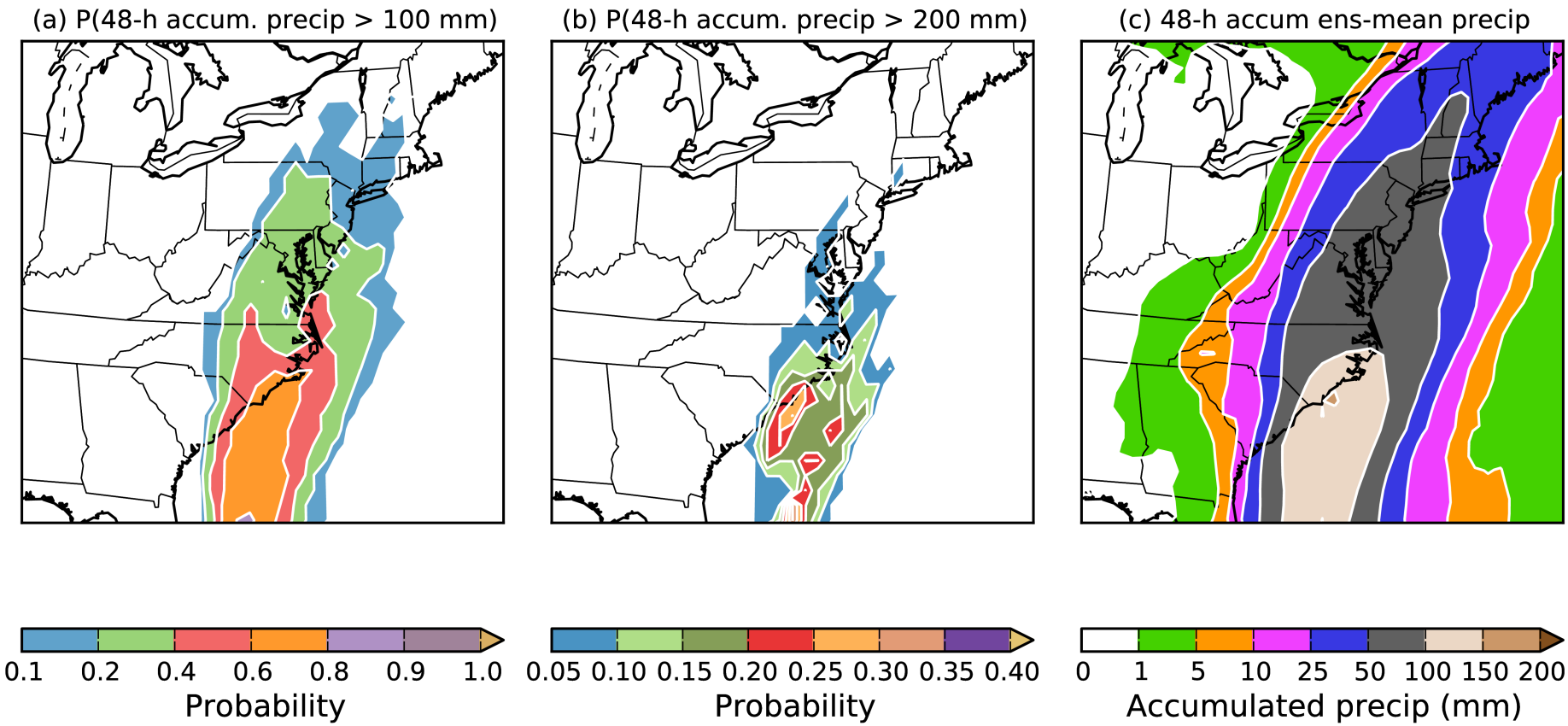
Probability and ensemble mean, GFS/EnKF

T254 GFS/EnKF 60-108 hour forecast from 2010092700



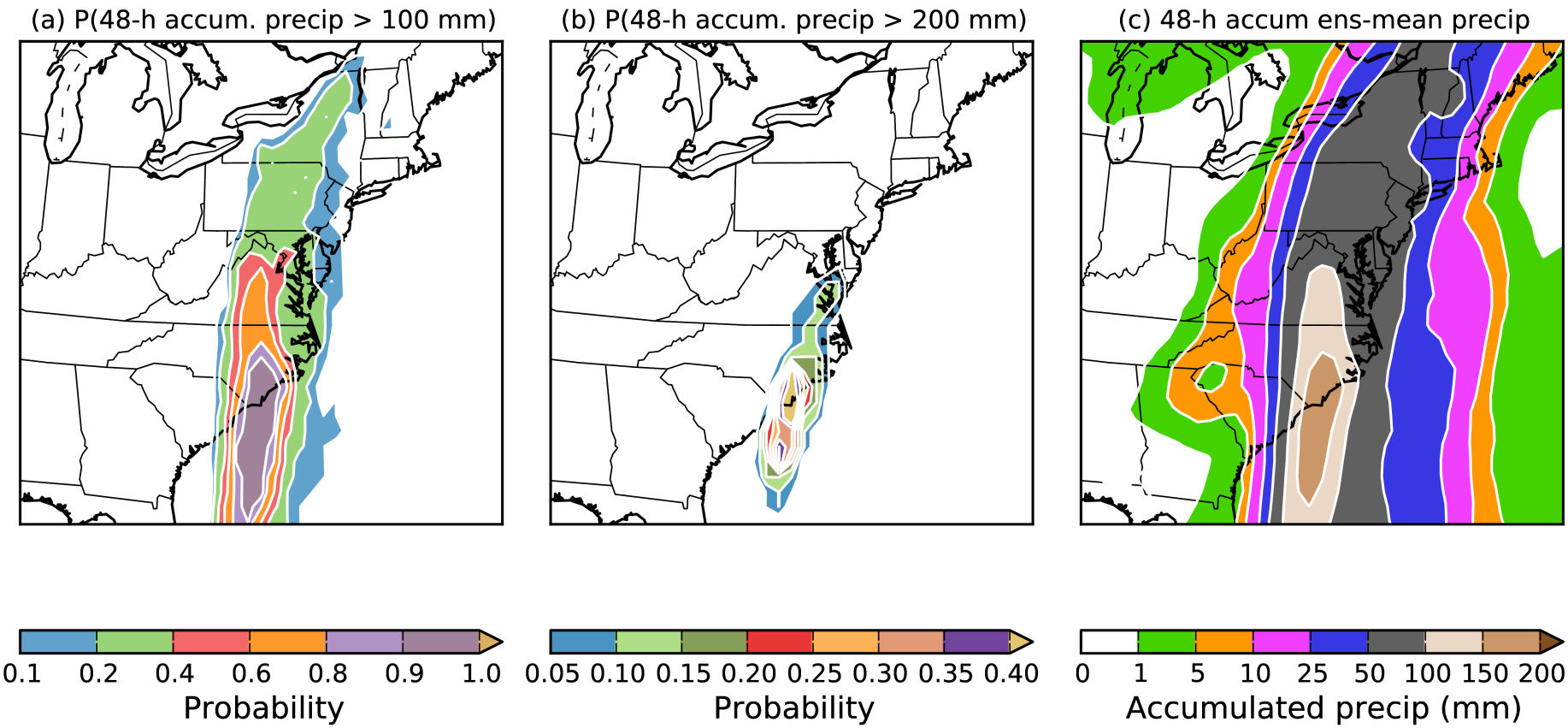
Probability and ensemble mean, GFS/EnKF

T254 GFS/EnKF 36-84 hour forecast from 2010092800



Probability and ensemble mean, GFS/EnKF

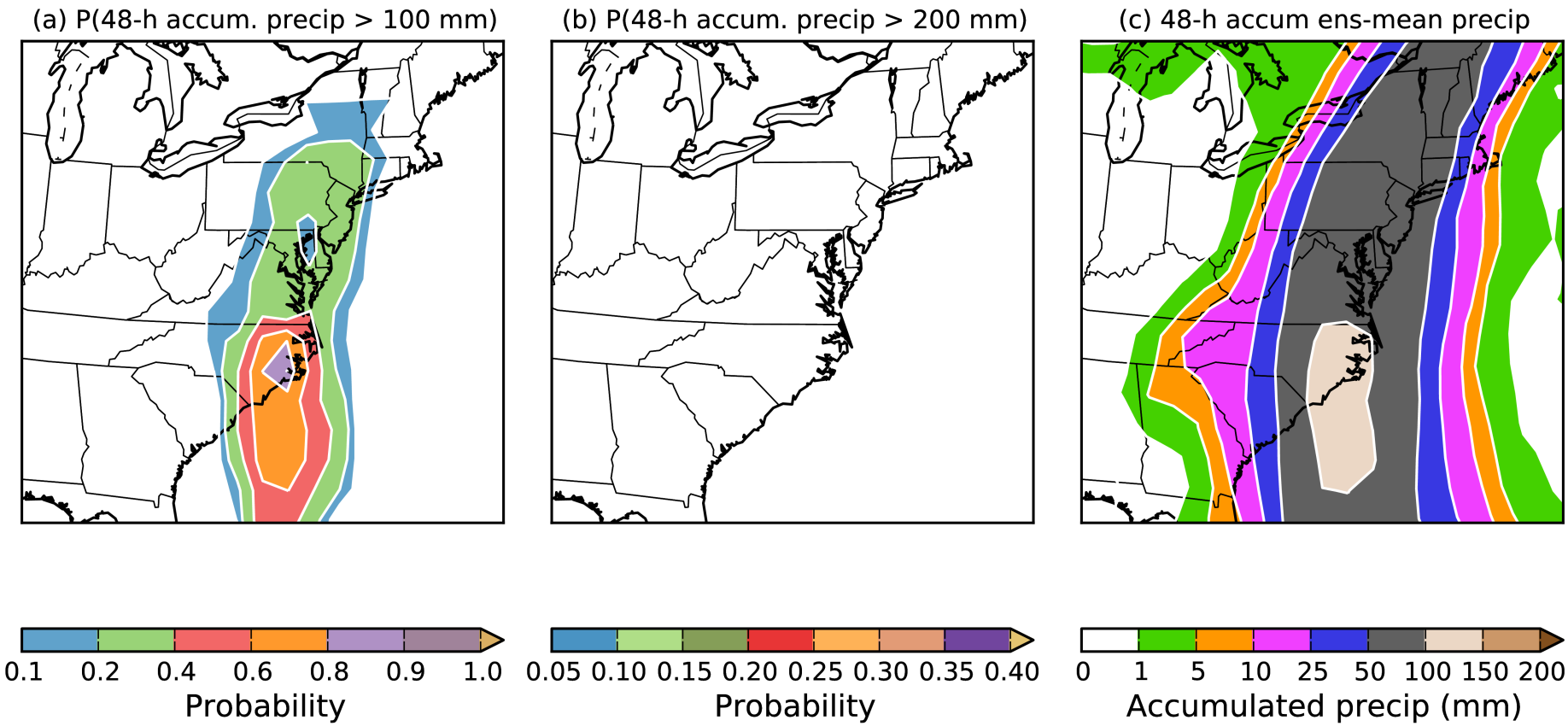
T254 GFS/EnKF 12-60 hour forecast from 2010092900



Axis of high probability for 100 mm too far west, but axis for 200 mm better. Ensemble-mean amounts in excess of 150 mm.

Probability and ensemble mean, NCEP opnl

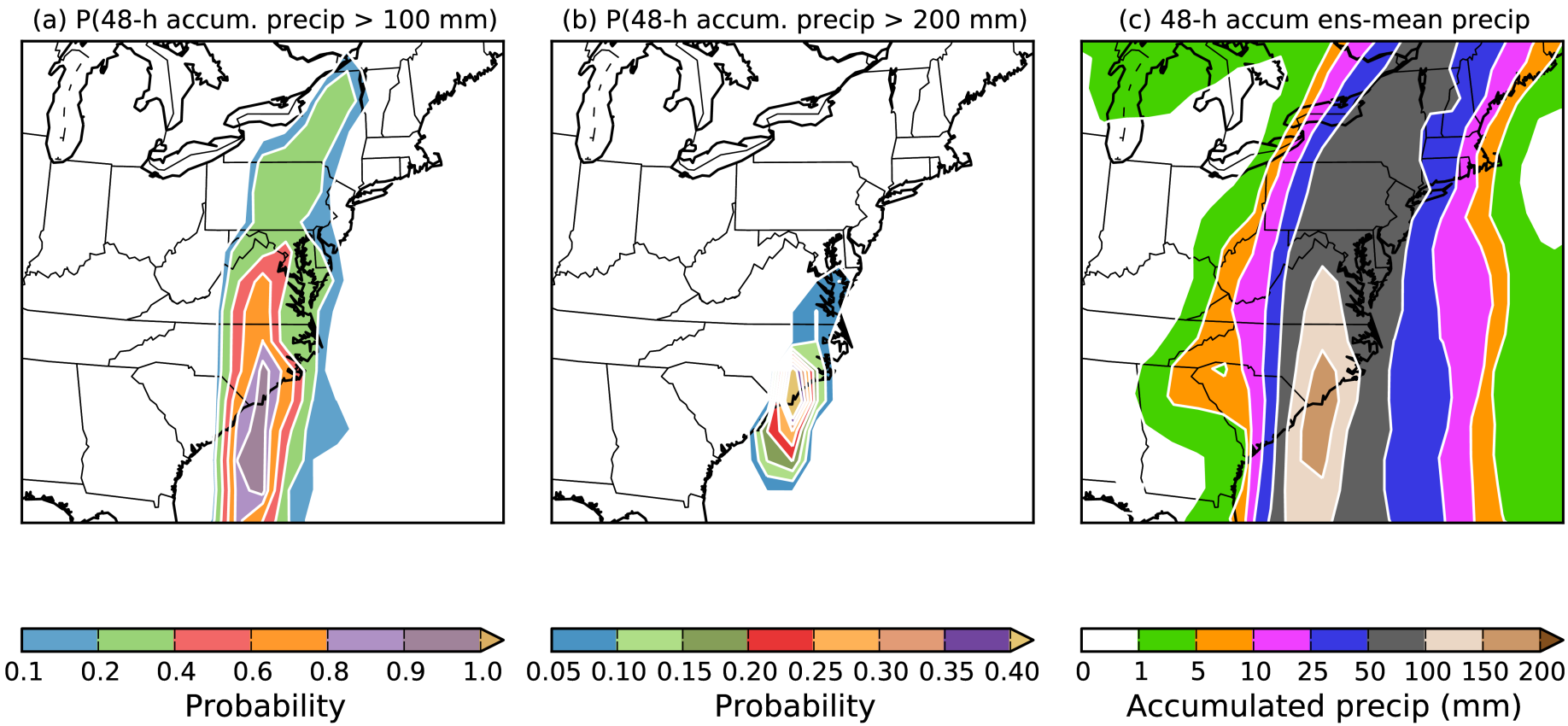
T190 Operational GFS, GSI-ETR 12-60 hour forecast from 2010092900



Better job with axis of high probability for 100 mm relative to GFS/EnKF on previous slide, but no probabilities in excess of 200 mm. Are the lesser amounts relative to GFS/EnKF a function of the coarser grid size (here, 1-degree grid vs. 0.5-degree for GFS-EnKF)?

Probability and ensemble mean, GFS/EnKF, degraded to 1-degree grid of operational

T254 GFS/EnKF 12-60 hour forecast from 2010092900



Axis of high probability for 100 mm too far west, but axis for 200 mm better. Ensemble-mean amounts in excess of 150 mm.

Conclusions

- T254 EnKF performance evaluated for NH summer 2010 season, and …
- ECMWF forecasts exhibit lower error, better spread-error relation at long leads.
  - ECMWF much better in W Pac, slightly worse in Atlantic
- Still, EnKF better than operational NCEP, CMC, UKMO forecasts.
- Performance of hybrid about the same as EnKF.
- Useful heavy precipitation forecasts before and with Nicole landfall.
- Close partnership with EMC, U. Oklahoma to operationally implement hybrid in ~2012.