GFDL Climate Variations and Predictability Group Research Summary

On the Seasonal Forecasting of Regional Tropical Cyclone Activity

by G.A. Vecchi, T. Delworth, R. Gudgel, S. Kapnick, A. Rosati, A.T. Wittenberg, F. Zeng, W. Anderson, V. Balaji, K. Dixon, L. Jia, H.-S. Kim, L. Krishnamurthy, R. Msadek, W.F. Stern, S.D. Underwood, G. Villarini, X. Yang, S. Zhang

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Tropical cyclones (TCs, which include hurricanes and typhoons) are a major climate hazard across the Northern Hemisphere, and have exhibited variability and change on year-to-year timescales. Therefore, understanding and predicting future year-to-year TC activity is central to NOAA's mission and highly relevant to society. Of particular relevance for decision support is predicting seasonal activity on regional spatial scales (scales smaller than the entire basin) – a goal that has remained elusive.

We use a new high-resolution coupled climate model developed at NOAA-GFDL (GFDL-FLOR) to assess predictions of regional seasonal TC activity produced up to three seasons in advance. These predictions are for activity on spatial scales much smaller than, for example, the entire Atlantic basin. We do so after demonstrating the model's ability to simulate regional TC activity, as well as the more tradition prediction of basin-wide hurricane frequency in the Atlantic. We also assess the impact of systematic errors in the climate model (model "biases") on TC simulation and prediction.

The principal results of this study are that:

1) The new high-resolutions climate model, GFDL-FLOR, exhibits substantial skill at recovering the key features of regional TC activity – with the skill improving after systematic model errors are corrected.

2) Long-lead (multi-month lead) forecasts of seasonal hurricane frequency in the Atlantic with the new system outperform other published methods:

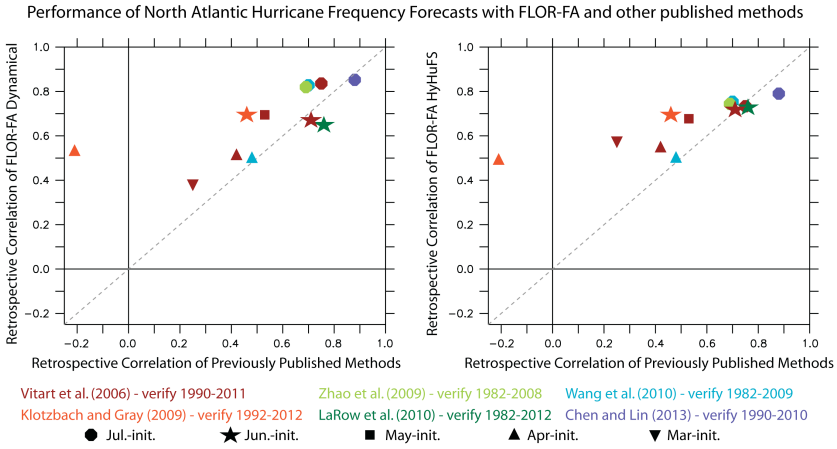

Figure 1: Skill at predictions of North Atlantic seasonal hurricane frequency with FLOR (vertical axis) compared to other methods in the literature (horizontal axis). When a symbol is above the diagonal, FLOR outperforms the other methods. (Adapted from Vecchi et al. 2014)

3) FLOR exhibits substantial skill at predicting regional-scale year-to-year variations in TC activity over the period 1982-2011 (seasonal predictions of regional TC activity):

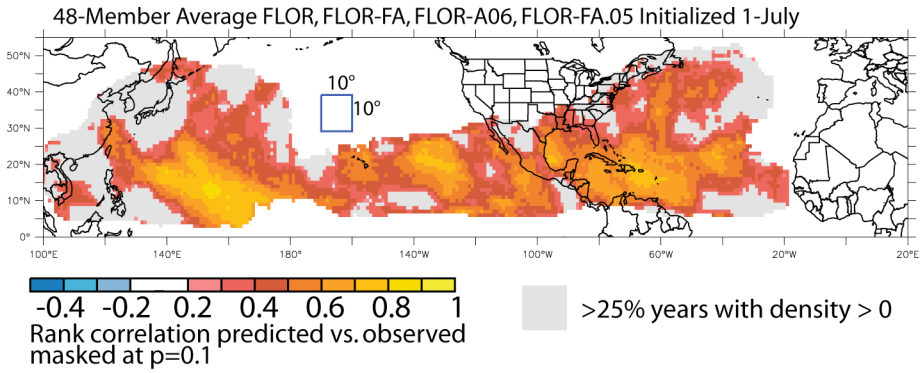

Figure 2: Map showing in colored shading areas where FLOR has documented skill at prediction regional tropical cyclone activity over the season. (Adapted from Vecchi et al. 2014)

4) Correcting systematic model errors in simulation of surface ocean temperatures leads to: a) improved prediction skill for North Atlantic hurricane frequency, and b) substantial improvements in skill of seasonal prediction of regional TC activity – adding over three months to the prediction horizon.

These results suggest that high-resolution coupled climate models enable the seasonal prediction of regional TC activity many months in advance– and point towards avenues to improve these exciting and encouraging results. Output from predictions with GFDL-FLOR is being made available to the NWS (and world) through the North American Multi-Model Ensemble for Seasonal Prediction (NMME).

The development of GFDL-FLOR, which has also resulted in enhancements in the ability to predict seasonal precipitation and temperature over land (Jia *et al.* 2014), was enabled by years of climate research and model development at GFDL – including the breakthrough high-resolution modeling efforts of Delworth et al. (2012), Zhao et al. (2009) and Chen and Lin (2013), and the GFDL seasonal to decadal prediction efforts (*e.g.,* Zhang and Rosati 2010; Yang *et al.* 2013). Enhancements to NOAA's research supercomputing capability including access to Gaea at the Oakridge National Laboratory made this work possible.

Manuscripts available:

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http://www.gfdl.noaa.gov/cms-filesystem-action/user_files/gav/publications/vetal_14_flor_tcs.pdf

Jia, L. and coauthors (2014): Improved Seasonal Prediction Skill of Land Temperature and Precipitation in a GFDL High-Resolution Climate Model, *J. Climate (submitted).*
http://www.gfdl.noaa.gov/cms-filesystem-action/user_files/gav/publications/jetal_14_flor_tsandpr.pdf