GFDL Climate Variations and Predictability Group Research Summary

Seasonal Predictability of Extratropical Storm Tracks in GFDL's High-resolution Climate Prediction Model

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Extra-tropical storms can have substantial societal impacts, often bringing rapid and extreme changes in temperature, winds, rain and snow. Additionally, extra-tropical (ET) storms are a key element of the water and energy cycle in the planet. Therefore, building capability to predict the year-to-year variations in the statistics of ET storms and their impacts on extremes, is central to NOAA's mission and highly relevant to society.

In this study, we evaluate the predictability of regional variations in ET storm activity using a newly-developed high-resolution seasonal prediction system (GFDL-FLOR). The FLOR prediction system, which is an element of the North American Multi-Model Ensemble for seasonal prediction (NMME), demonstrates skill at predicting year-to-year variations of regional wintertime ET storm activity over North America many seasons in advance. We do so after demonstrating the model's ability to simulate regional ET activity.

The principal results of this study are that:

1. The leading predictable components of extratropical storm tracks are ENSO-related spatial pattern for both boreal winter and summer. These two predictable components for both seasons show significant correlation skill for all leads from 0 to 9 months, while the skill of predicting the boreal winter storm track is consistently higher than that of the austral winter.

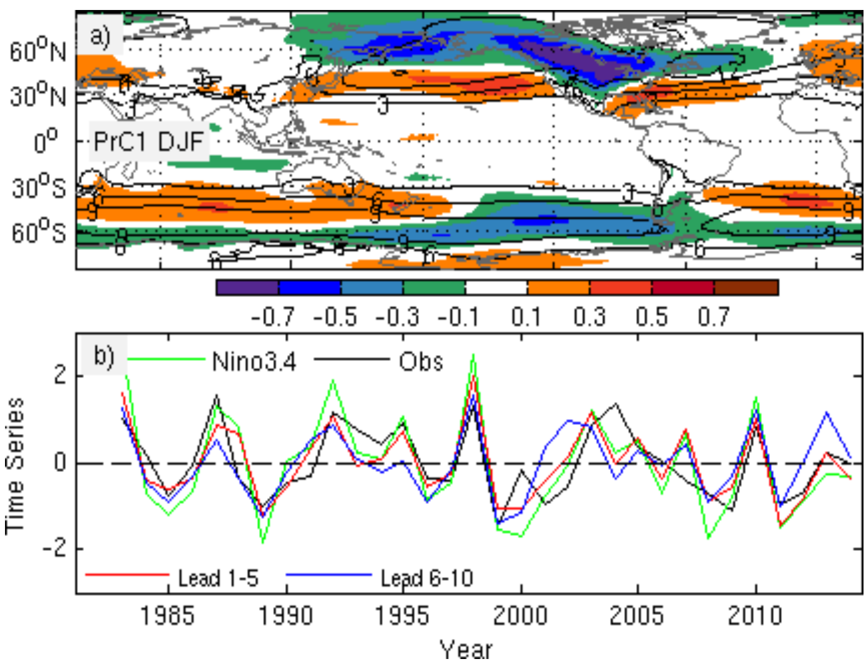

Figure 1. Map shows the most predictable pattern of year-to-year extratropical "storminess" variations. Over large areas of North America, this pattern explains over 35% of the year-to-year variations in seasonal storminess. Bottom panel shows the ability ability of the GFDL-FLOR prediction system to capture the observed year-to-year variations of this pattern (black line) from 1-5 months in advance (red line) and 6-10 months in advance (blue line), as well as the strong connection of this pattern to El Niño (green line).

2. The multidecadal oceanic variability and externally forced signal also contribute to seasonal predictions of mid-latitude storm tracks.
3. Over the region with strong storm track signals in North America, the model is able to predict the changes in statistics of extremes connected to storm track changes (e.g., extreme low and high sea level pressure and extreme 2m air temperature) in response to different ENSO phases.

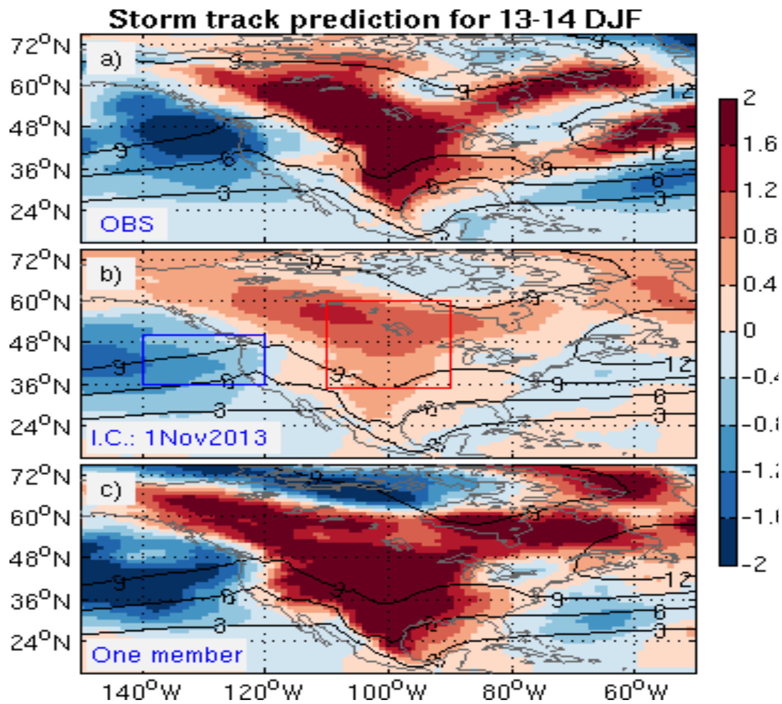

Figure 2. Upper panel shows the observed storm track anomalies (shading) for the 2013-2014 DJF season. Middle and bottom panels respectively show the ensemble mean and "best" member of the predicted storm track anomalies initialized on 1st November 2013. The black contour denotes the climatological storm tracks. Units are hPa.

We also found that the model successfully predicted the enhancive storm activity over North America for 2013-2014 DJF initialized on 1st November 2013. As it has been able to do in the tropics when focusing on tropical cyclones (Vecchi et al. 2014}, this high-resolution model is capable of providing regional information on the year-to-year variations in the statistics of extremes. 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 land surface temperature and precipitation (Jia et al. 2014), regional tropical cyclone activity (Vecchi et al. 2014), and Arctic sea-ice extent (Msadek 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 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:

Yang, X. and coauthors (2014): Seasonal predictability of extratropical storm tracks in GFDL's high-resolution climate prediction model. J. Climate (submitted).
http://www.gfdl.noaa.gov/cms-filesystem-action/user_files/gav/publications/stormtrack_v2.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

Msadek, R., G.A. Vecchi, M. Winton, R.G. Gudgel (2014): Importance of initial conditions in seasonal predictions of Arctic sea ice extent. *Geophys. Res. Lett.* doi:10.1002/2014GL060799

Vecchi, G.A., and coauthors (2014): On the Seasonal Forecasting to Regional Tropical Cyclone Activity. J. Climate in press doi:10.1175/JCLI-D-14-00158.1.
http://www.gfdl.noaa.gov/cms-filesystem-action/user_files/gav/publications/vetal_14_flor_tcs.pdf