Simulation and Prediction of Category 4 and 5 Hurricanes in the High-Resolution GFDL HiFLOR Coupled Climate Model

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Submitted to the *Journal of Climate*

Extremely intense tropical cyclones (TCs), such as categories 4 and 5 hurricanes, have marked socio-economic impacts. Therefore, developing a global dynamical model that has skill in predicting/simulating intense TCs is central to NOAA's mission and highly relevant to society.

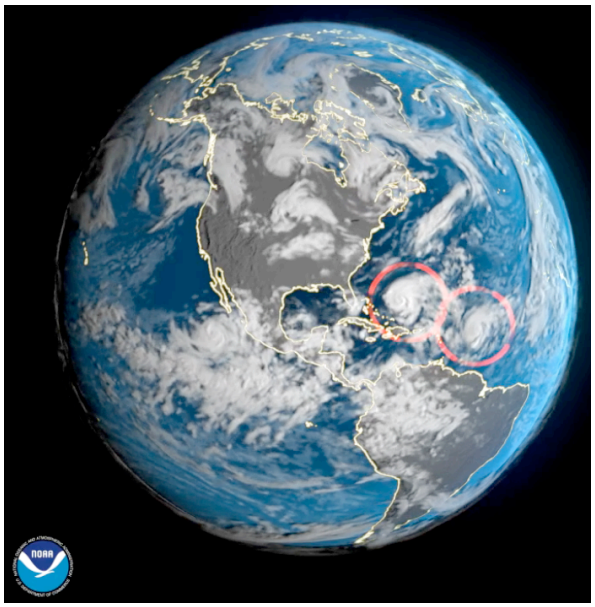
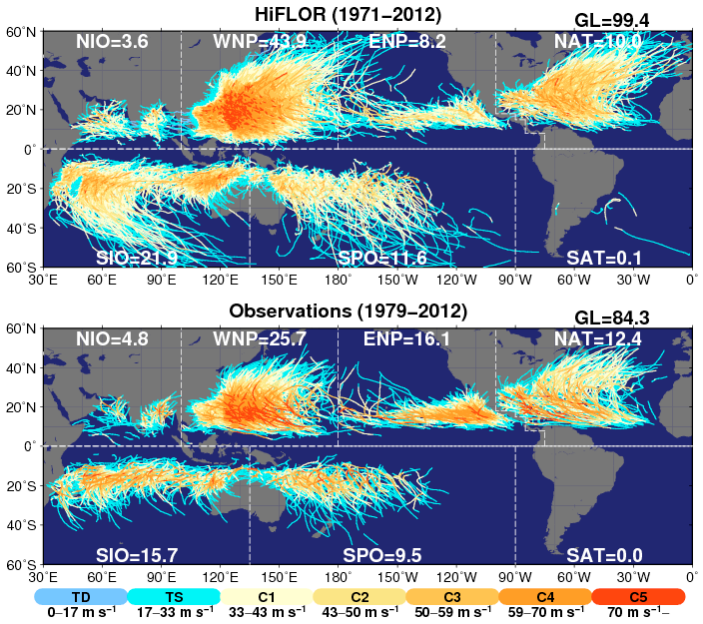


Fig. 1: Clouds from a HiFLOR simulation, showing two hurricanes in the Atlantic. (Figure Remik Ziemlinski)

In order to tackle the problem of understanding and predicting the variations and changes in regional hydrometeorological conditions and extreme events (particularly Category 4 & 5 hurricanes) on timescales of weeks to centuries, scientists at GFDL have developed a new high-resolution 25-km mesh coupled model (HiFLOR). HiFLOR was developed from FLOR (Vecchi et al. 2014) by quadrupling the number of horizontal grid cells of the atmosphere and land components (from a 50-km to 25-km mesh). HiFLOR leads to substantial improvements in the simulation and prediction of TCs, relative to FLOR, a model which is currently used for real-time seasonal predictions through the NMME.

1. HiFLOR reproduces the climatological spatial distribution of the global TCs more realistically than FLOR does, and is able to simulate extremely intense TCs (Categories 4 and 5) reasonably well compared to observations (Fig. 2).
2. HiFLOR exhibited high correlation coefficients with the observed interannual variations of hurricanes (r=0.77) and categories 4 and 5 hurricanes (r=0.63) in the North Atlantic (Fig.3).
3. Both FLOR and HiFLOR exhibit a strong 30–80-day Madden-Julian Oscillation, whose active phase enhances TC genesis as observed, indicating potential skill in predicting TC genesis events at intraseasonal time scales.
4. Retrospective seasonal forecasts for 1997/1998 TC seasons reveal that HiFLOR has substantial skill in predicting the observed contrasts between 1997 and 1998 in terms of frequency of hurricanes and category 4 and 5 hurricanes, and their spatial distributions across the Northern Hemisphere months in advance.



This is the first time that a global general circulation model has successfully reproduced the observed year-by-year variations in category 4 and 5 hurricanes. These results highlight potential skill of HiFLOR for the subseasonal and seasonal prediction of intense TCs.

Fig. 2 HiFLOR simulates the geographic and intensity distribution of tropical cyclones. *Tropical cyclone tracks from an SST-restored ensemble in HiFLOR (top) and observations (bottom); colors denote different TC intensities by Saffir-Simpson scale. Adapted from Murakami et al. (2015).*

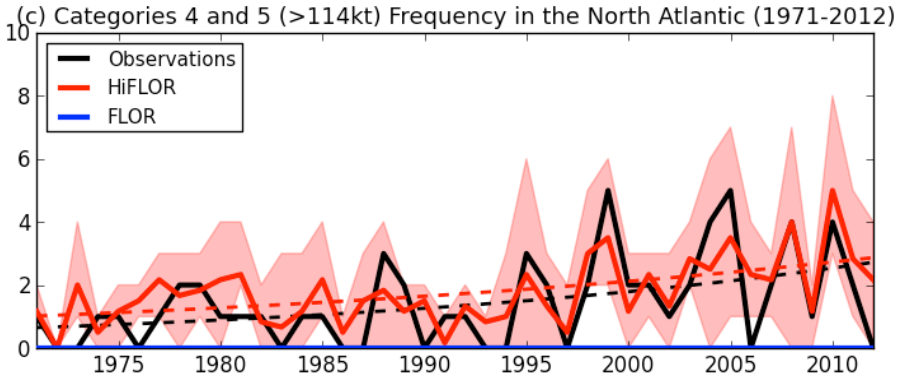


Fig. 3 HiFLOR captures observed variation and change in North Atlantic Cat.4-5 hurricane frequency. *Black shows observations and red the results of an ensemble SST-restored experiments with HiFLOR. Adapted from Murakami* et al. *(2015).*

The development of HiFLOR was enabled by years of earth systems research and model development at GFDL – including the breakthrough high-resolution modeling efforts of Delworth et al. (2012), Chen and Lin (2013), and Vecchi et al. (2014), and the seasonal to decadal prediction efforts (*e.g.,* Yang et al. 2013; Jia et al. 2015). Enhancements to NOAA's research supercomputing capability including access to Gaea and access to the Department of Energy Titan computer at the Oakridge National Laboratory made this work possible.

Manuscript:

Murakami, M., and coauthors, 2015: Simulation and prediction of Category 4 and 5 hurricanes in the high-resolution GFDL HiFLOR coupled climate model. *J. Climate* (*submitted*).
http://www.gfdl.noaa.gov/cms-filesystem-action/user_files/gav/publications/draft_v20150319.pdf

Related Reference:

Vecchi, G. A., and co-authors, 2014: On the seasonal forecasting of regional tropical cyclone activity. *J. Climate*, http://www.gfdl.noaa.gov/cms-filesystem-action/user_files/gav/web_files/tc_prediction_research_summary_cvp_gfdl.pdf