# *PRELIMINARY:* Diagnosing climate change impacts on Hurricane Florence experimental forecasts

Alyssa M. Stansfield, Stony Brook University
Kevin A. Reed, Stony Brook University
Michael F. Wehner, Lawrence Berkeley National Lab
Colin M. Zarzycki, National Center for Atmospheric Research

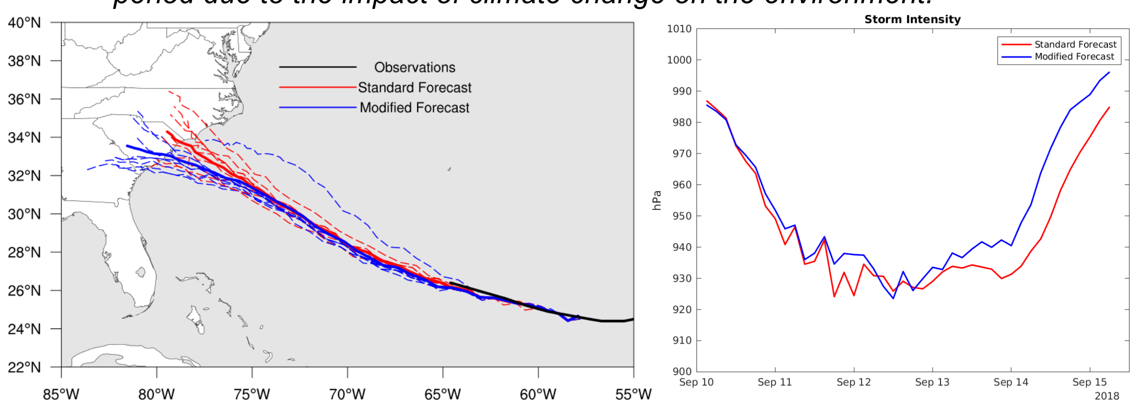
Near real-time ensemble forecasts of Hurricane Florence are performed using the Community Atmosphere Model (CAM) version 5. Two sets of ensembles forecasts are completed (***Initialized Sept 10, 2018 at 00Z***):

**Standard Forecast:** With observed initial atmospheric conditions and sea surface temperatures (SSTs) adapted from NOAA's operational Global Forecast System model.

**Modified Forecast:** With observed initial conditions modified to remove the CAM5-simulated climate change signal from the temperature, moisture, and SST fields to represent a world without climate change.

Through comparison of the standard and modified ensemble forecasts for Hurricane Florence, the impact of climate change on the storm's size, rainfall, and intensity can be quantified.

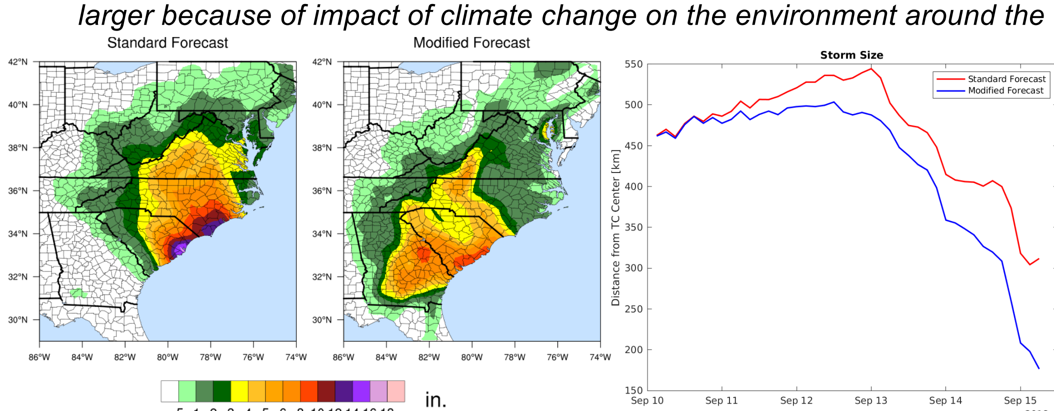
**Intensity:** *The preliminary results suggest that the forecasted minimum surface pressure of Hurricane Florence is slightly lower (i.e., more intense) for much of the forecast period due to the impact of climate change on the environment.*




***Left:*** Individual ensemble forecasts (dashed) and ensemble mean (solid) of Hurricane Florence.
***Right:*** Time evolution of the ensemble average minimum surface pressure.

**Rainfall:** *The preliminary results suggest that the forecasted Hurricane Florence rainfall amounts over North and South Carolina are increased due to climate change, likely linked to warmer sea surface temperatures and available moisture in the atmosphere.*

**Storm Size:** *The preliminary results suggest that the forecasted size of Hurricane Florence is larger because of impact of climate change on the environment around the storm.*




***Left:*** Ensemble average accumulated rainfall Hurricane Florence forecasts.
***Right:*** Time evolution of the ensemble average outer storm size (radius of approximately 18 mph).

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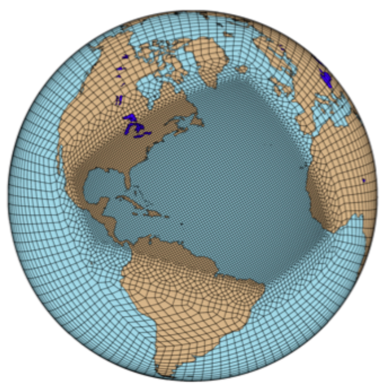
**Methodology.** CAM5 is set up in a variable-resolution configuration with a base grid spacing of ~100 km, similar to conventional atmospheric general circulation models, and a refined region over the North Atlantic basin with a grid spacing of ~28 km. CAM-VR is initialized with atmospheric analyses from NOAA's Global Forecast System (GFS) following the technique outlined in Zarzycki and Jablonowski (2015) and run for 7 days. For Hurricane Florence, the model is initialized on 9/10 at 00z. To account for model uncertainty in storm characteristics, a 10-member ensemble is created by randomly varying three parameters (c0_ocn, tau, and dmpdz) in the deep convective parameterization (Zhang and McFarlane 1995). TC tracks from the forecast runs are generated using the TempestExtremes algorithm (Ullrich and Zarzycki 2017). For modified forecasts with the climate change signal removed, the methodology follows the the framework of Wehner et al. (2018). In particular, the air temperature, specific humidity, and sea surface temperature from the observed initial conditions are modified to remove climate change effect. CAM5 climate simulations from the C20C Detection and Attribution project are used to calculate the difference between 2006-2016 climatological conditions for September and those of a simulation using pre-industrial 1850 conditions to approximate the change in the environment attributed to climate change. Additionally, the greenhouse gas concentrations, solar radiation conditions, ozone concentration, and atmospheric aerosol concentrations are all set to their pre-industrial levels for the modified forecasts.



Depiction of the CAM5 variable-resolution computational grid.

**References.**

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