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A New Dataset to Analyze Extreme Events in New England

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1. Introduction

In recent years, New England has been experiencing changes in regional climatology such as more frequent land falling tropical cyclones, Nor’easters and heat waves. Cost of the damages caused by these changes has been alarming for the regional economy and stakeholders. To prepare for these impacts in city and state levels, it is essential to be able to simulate future changes in regional climatology and extreme events. Global model projections have been too coarse to assess changes in regional scales and the impacts assessment models such as economic tools and hydrological, forest and ecosystem models require much higher resolution data that is capable of simulating, in detail, changes in extreme events. Hence, downscaling methodologies have been proposed to produce the high-resolution climate variables needed to assess climate change impacts at regional scales. Statistical downscaling, where historical statistical relations are obtained between observed and modeled variables, is commonly used due to its smaller computational cost. However, the downside of the method is that it assumes statistical relations between variables remain the same in to the future. Dynamical downscaling, on the other hand, uses regional climate models to downscale global model projections meaning that variables are calculated based on physically based parameterizations produced from theory, observations and retrievals through years of research.

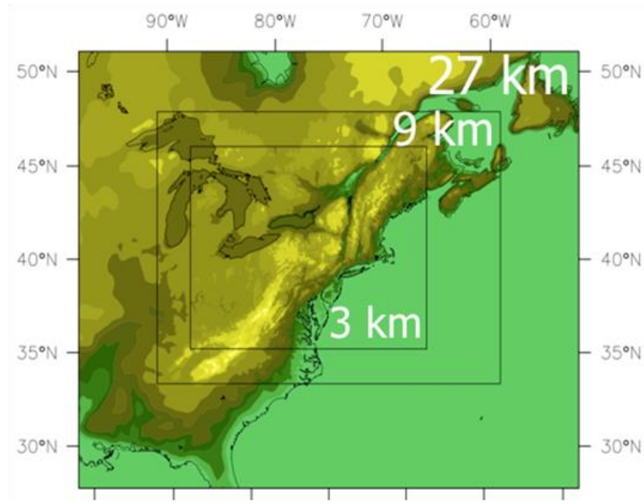

Fig. 1 Simulation domain used in our WRF simulations.

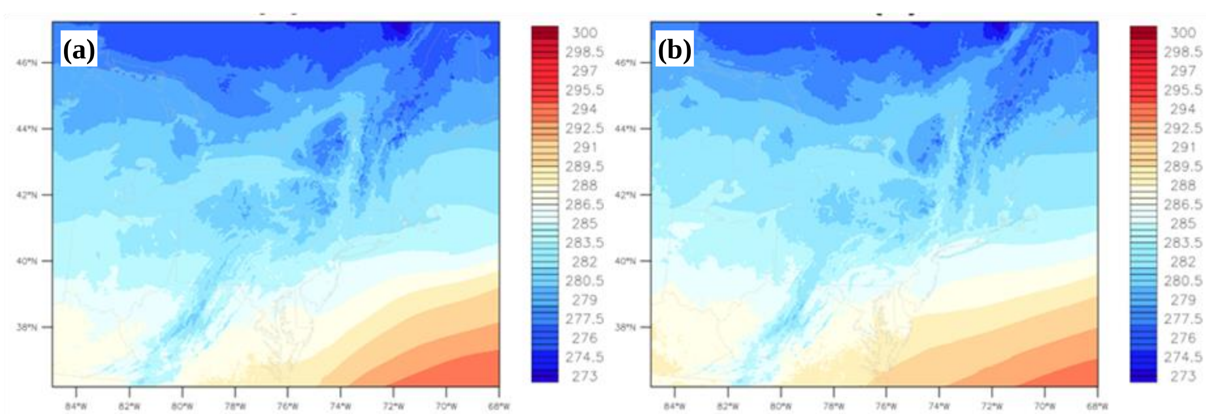

Fig. 2 Annual mean 2m air temperature (K) for **(a)** ERA-Interim driven WRF simulations **(b)** CESM driven WRF simulations for 2006-2015.

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Our study is part of the efforts through a National Science Foundation Experimental Program to Stimulate Competitive Research (NSF EPSCoR) funded inter-disciplinary project (New Hampshire EPSCoR Ecosystems and Society) aiming to assess climate change impacts on regional hydrology, ecosystems and economy in New Hampshire in order to support sustainable management of natural resources and regional economy. Because these changes are highly sensitive to changes in extremes, we choose to use dynamical downscaling.

2. Methodology

We dynamically downscale bias corrected CESM projections (Bruyere *et al.*, 2014 and 2015) under a high impacts emissions scenario (representative concentration pathway (RCP) 8.5) using the Weather Research and Forecasting (WRF) model (Skamarock *et al.*, 2008) version 3.6.1 for three time slices representative of Present Day (PD) (2006-2020), Mid Future (MF) (2041-2060) and Far Future (FF) (2081-2100) time periods. In our WRF simulations, we use three nested domains with 27, 9 and 3 km horizontal resolutions (Figure 1) and two-way nesting. We use ~ 45-day simulations to simulate each month (15+30; 15+31; 15+28) within the time slices omitting first 15-days for initialization. In all our CESM driven WRF simulations, greenhouse gas concentrations for RCP 8.5 are implemented to interact with the WRF radiation scheme (RRTMG). Convection is resolved in the innermost domain. To evaluate our model performance, we also perform reanalysis driven (ERA-Interim) historical simulations (2006-2015) using the same model setup.

3. Data availability

The aim of this NSF funded study is to produce this high-resolution future climate dataset to be used in further impacts assessment models and to enable further downscaling studies. For this reason, all input, boundary, restart and output files are available for public use. Eventually the data will be available through the Data Distribution Center at University of New Hampshire. Until then, we ask that interested parties contact the authors of this report directly to obtain the subset of their interest. Please note that there is a usage policy in effect. To obtain a full list of all available output variables and for all other questions regarding the details of the simulations, please contact the first author (muge@mit.edu).

4. Analysis & discussion

For this short report, we will focus on temperatures and temperature extremes. In Figure 2, we present historical (2006-2015) annual mean 2 m air temperature for domain 3 (the innermost domain with 3 km horizontal resolution) from (a) ERA-Interim driven and (b) CESM driven WRF simulations. Our WRF model setup is capable of producing both the magnitude and structure of mean state temperature at 2 meters exceptionally well (Figure 2).

We provide a preview of extreme temperatures simulated into the future with comparison to PD time periods using percentile exceedances at 95 % (Figure 3).

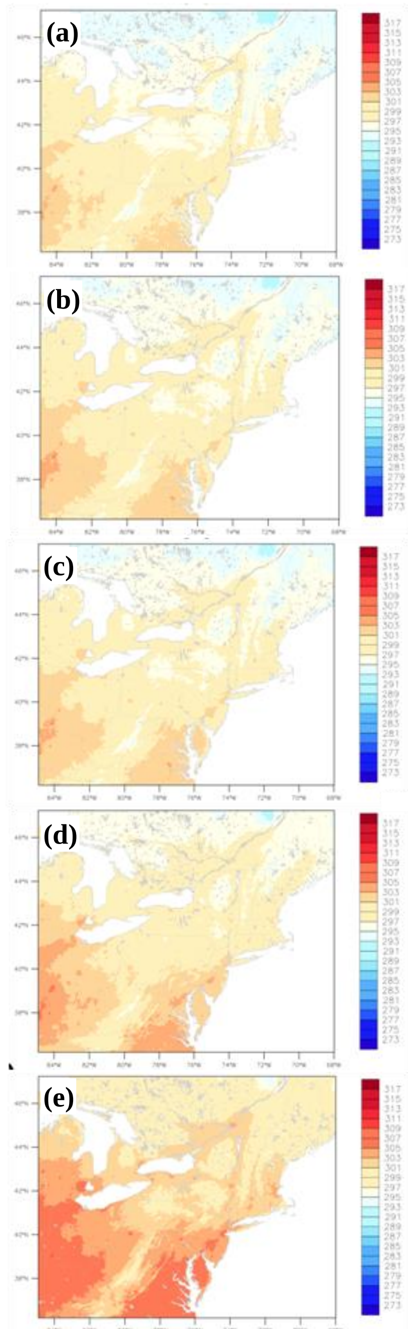

Fig. 3 95th percentiles of 2m air temperature for **(a)** ERA-Interim driven WRF simulations (2006-2015), **(b)** CESM driven WRF historical simulations (2006-2015), **(c)** CESM driven WRF present day simulations (2006-2020), **(d)** CESM driven WRF mid future simulations (2041-2060), **(e)** CESM driven WRF far future simulations (2081-2100).

While mean characteristics are well represented in Historical CESM driven WRF simulations compared to ERA-Interim driven WRF simulations, the former has overall slightly higher temperatures in extreme (Figure 3). As seen in Figure 3, extreme temperature events become more severe into the future. The average number of days per year where 2m air temperatures exceed 303K averaged over domain 3 is 1.6 days for PD and 12.4 days for FF time periods.

Several journal articles detailing our simulations and analyzing our output are currently in preparation.

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