Improving the accuracy of regional climate models using Bayesian modeling and bias correction

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Summer 2018
University of Vermont

June 11, 2018

Improving the Weather Research and Forecasting model (WRF) through bias correction

- Bias: the correspondence or lack thereof between a mean forecast and mean observation averaged over a certain domain and time. (World Meteorological Association, 2009)
- Errors from *global* climate models can be compounded in the dynamical downscaling process, potentially *biasing* predictions produced by WRF
- Correcting bias adds value when we downscale WRF from 4km to 1km resolution

Bias correction with quantile mapping

Quantile mapping: bias correction method that can correct discrepancies between modeled and observed distributions for climate variables

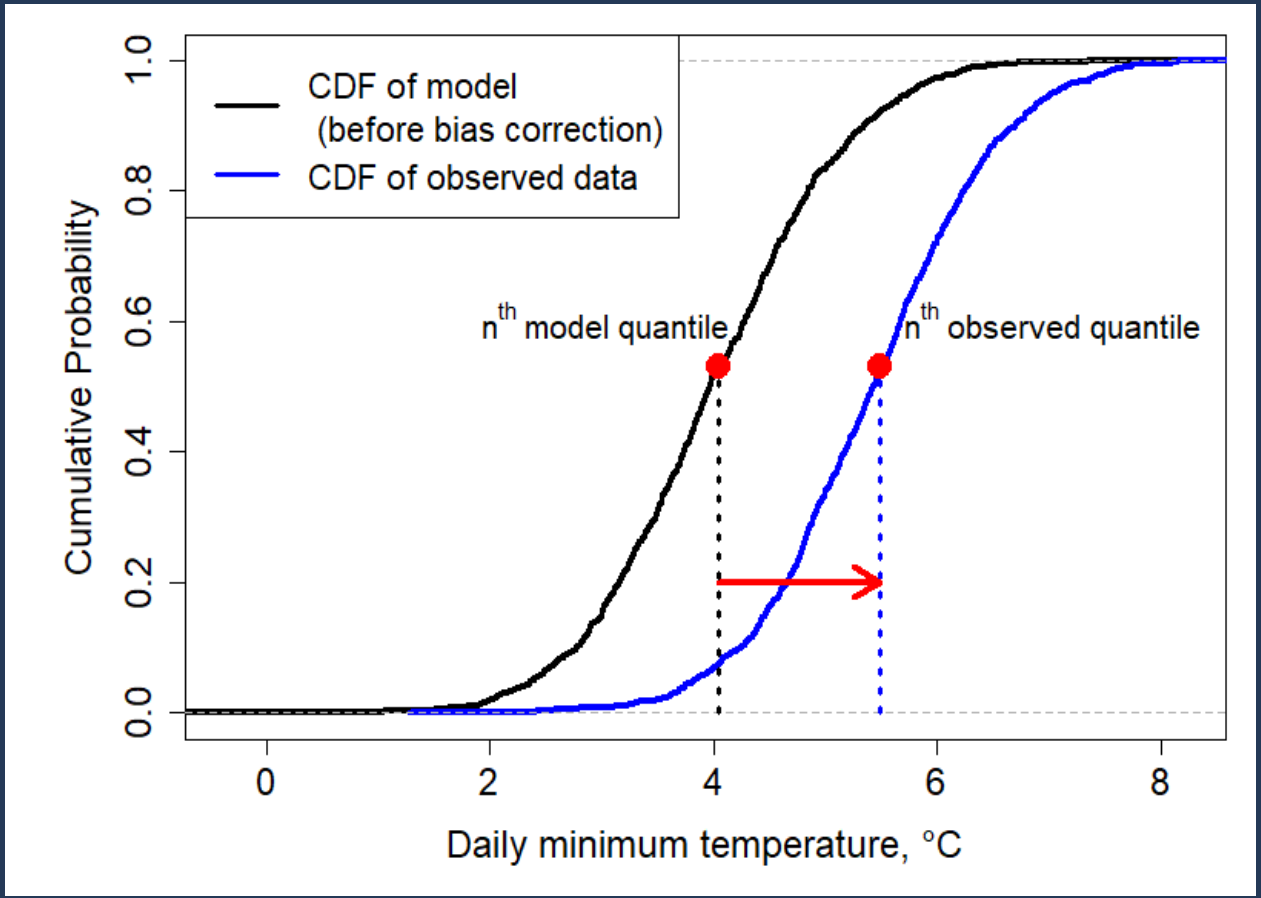

Figure 1: Schematic showing model and observed quantile before bias correction

Bias correction with quantile mapping

$$y_{corrected} = F^{-1}_{observed}(F_{model}(x))$$

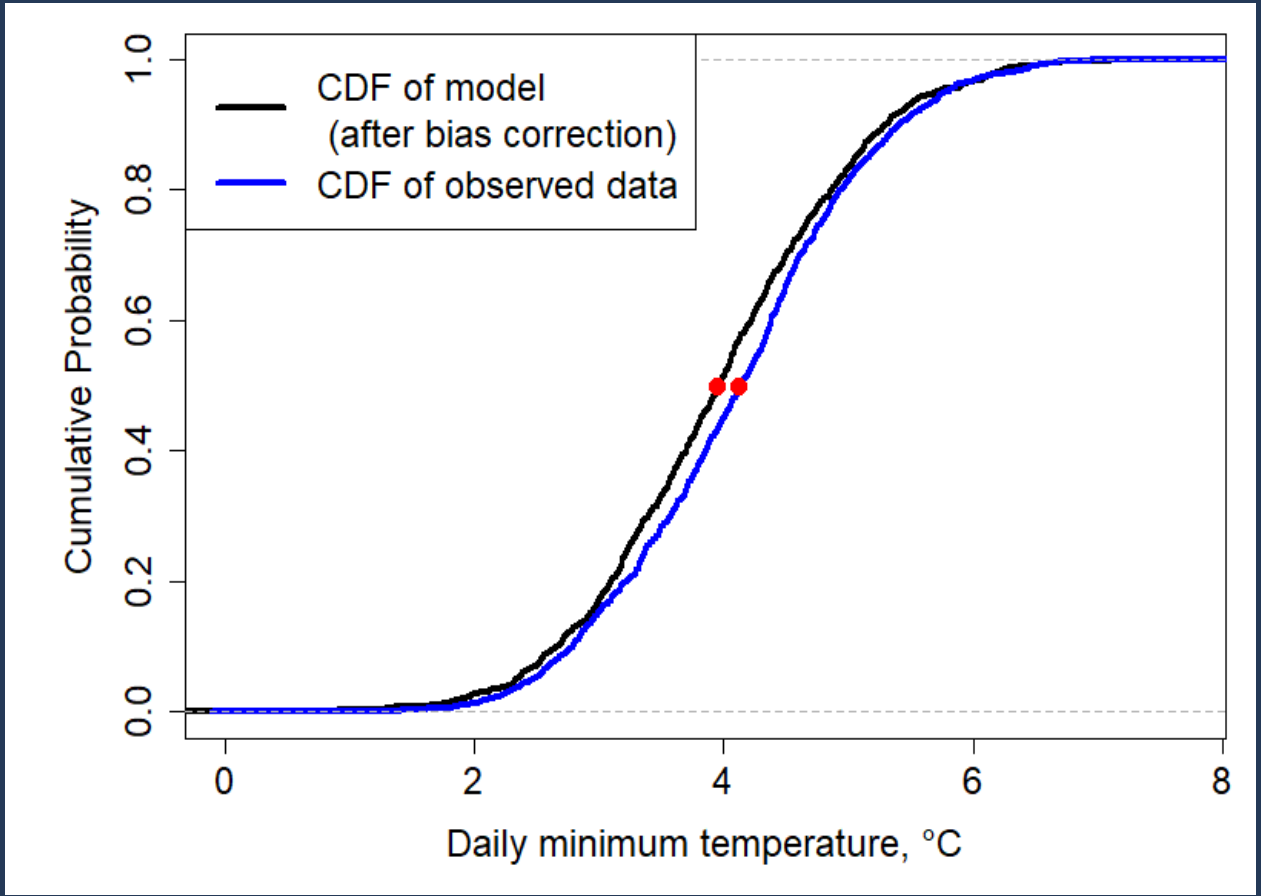

Figure 2: Schematic showing model and observed quantile after bias correction

Overall goal: improve accuracy of WRF climate simulations

Specific objectives

1. Fit Bayesian spatial model to gridded WRF projections
2. Use Bayesian model to reproject to weather station locations
3. Downscale WRF projections with elevational lapse rates to ~ 1km resolution
4. Compare predictions to observed station data
5. Conduct bias-correction via quantile mapping or other method

Methods: Bayesian modeling

Bayesian hierarchical spatial model

Basic spatial model form: $Y(s) = \mu(s) + w(s) + \epsilon(s)$

$$\mu_s = x^T(s)\beta,$$

where residuals are partitioned into spatial, $w(s)$, and nonspatial, $\epsilon(s)$, components.

Components of model development

1. Evaluate Bayesian model performance by fitting to daily station data
2. Validate model using simulated station data
3. Fit Bayesian model to WRF gridded data and reproject to station locations

Historical Climate Network Weather Stations

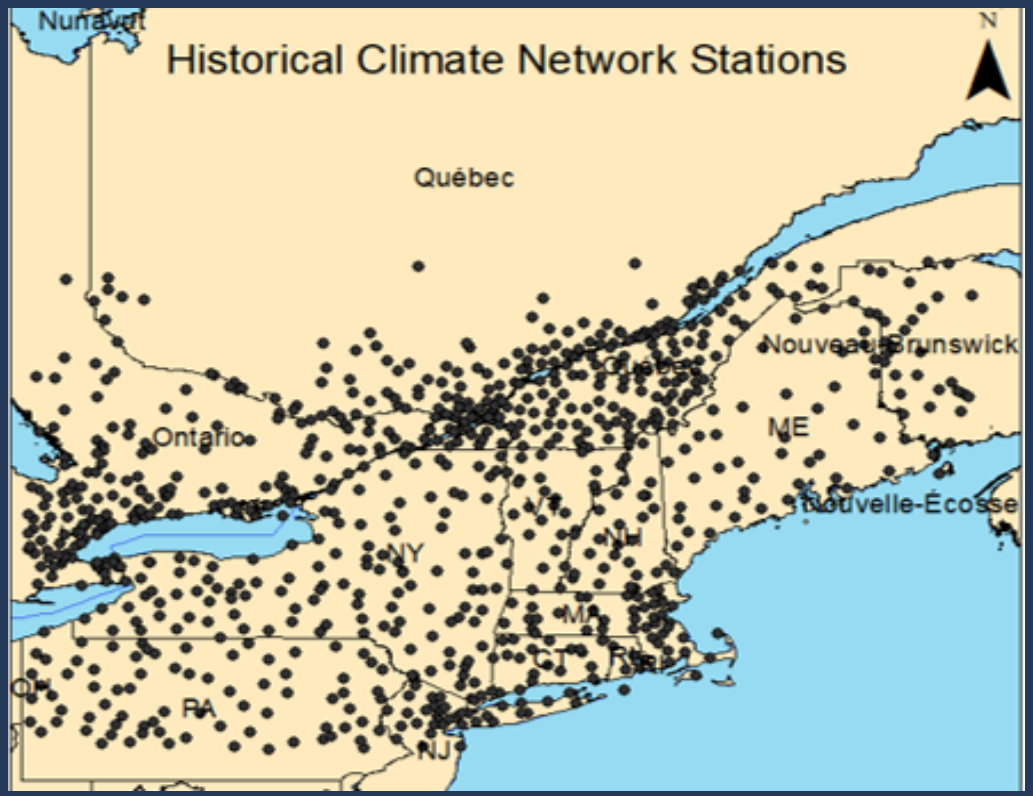

Figure 3: HCN station data over middle domain of study area

Preliminary results from spatial modeling

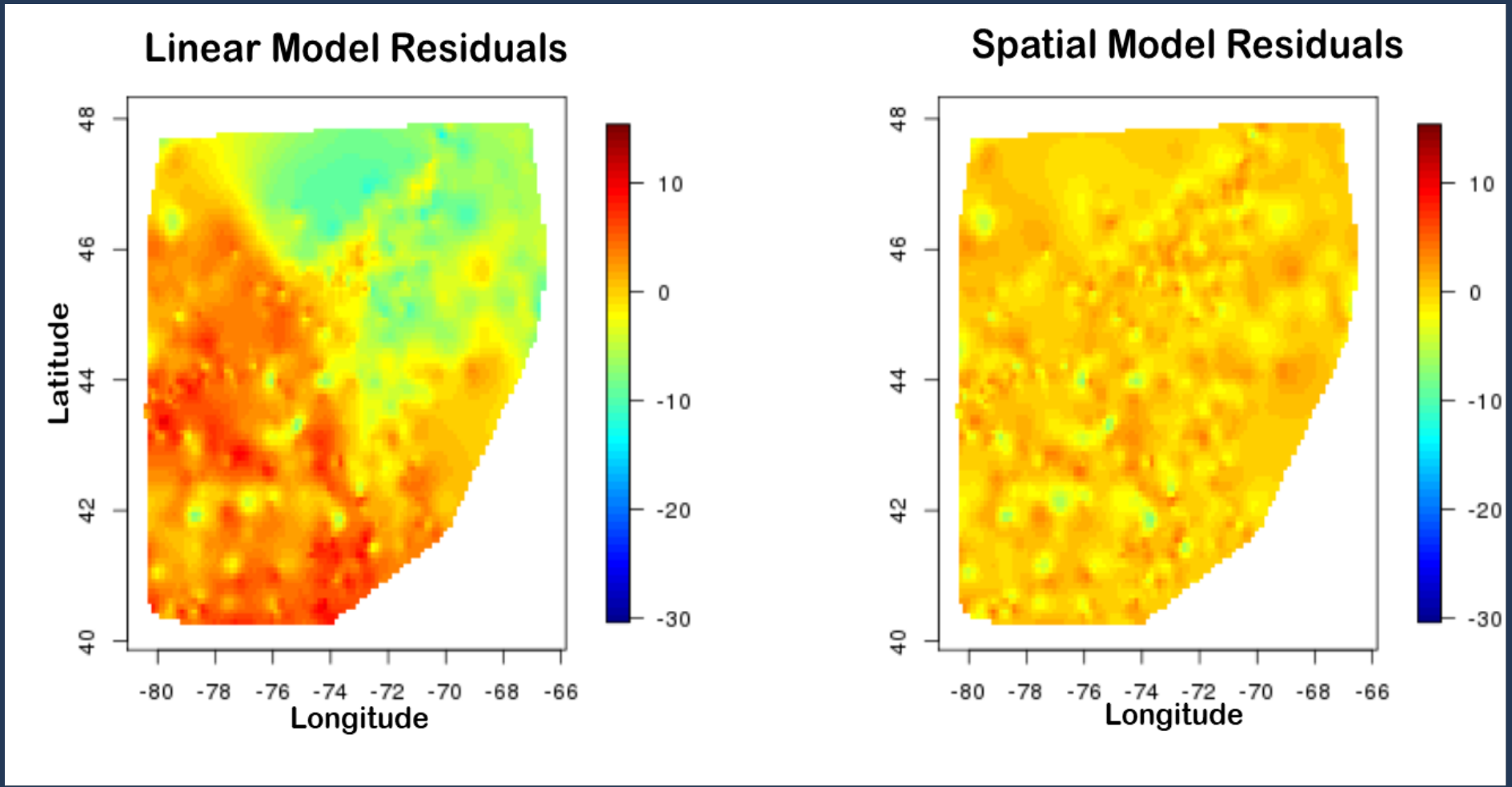

Figure 4: Plots of residuals from a linear model (right) and Bayesian spatial model (right). *Note decrease in residual variability in the right plot.*

Future work

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1. Evaluate stationarity of lapse rates for station data
2. Proceed with downscaling and bias correction
3. Assess ability of processed WRF predictions to capture extreme events