Bayesian methods for high resolution downscaling of regional climate model data

Maike Holthuijzen

University of Vermont

June 3, 2019

Outline

VERMONT EPSCoR

Introduction

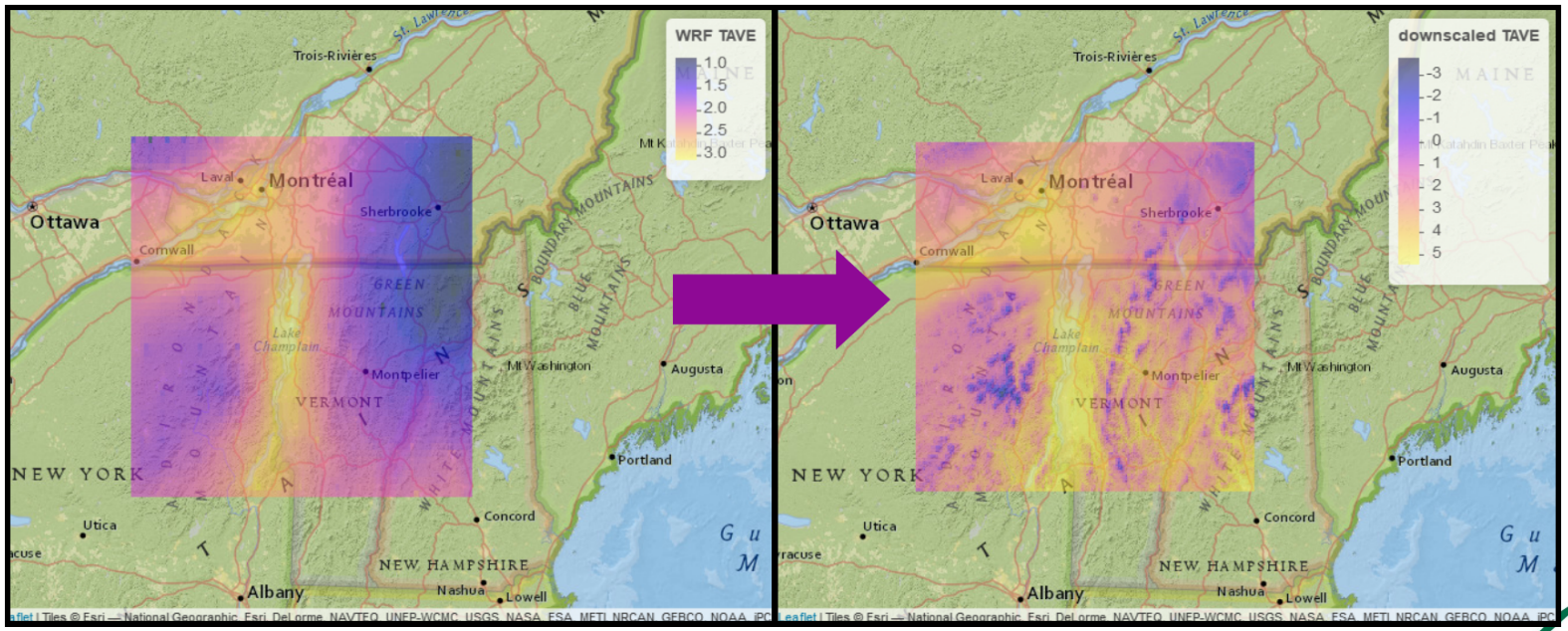
The need for high resolution, accurate climate products

- Resolution of global climate models (GCMs) and even regional climate models (RCMs) are far too coarse to model local climate
- Climate model projections are biased, which is especially problematic for predicting future extreme weather events [1], [2]
- **Fine scale, accurate climate projections are critical for local climate impact assessments**

VERMONT EPSCoR

Research contribution

1. High-resolution (1km) downscaling and bias correction of WRF daily average temperature (TAVE) and precipitation (PRECIP) output using Bayesian spatial hierarchical modeling
   - Bias correction based on historical, observed weather station data
2. Refining WRF output to better capture extreme climate events

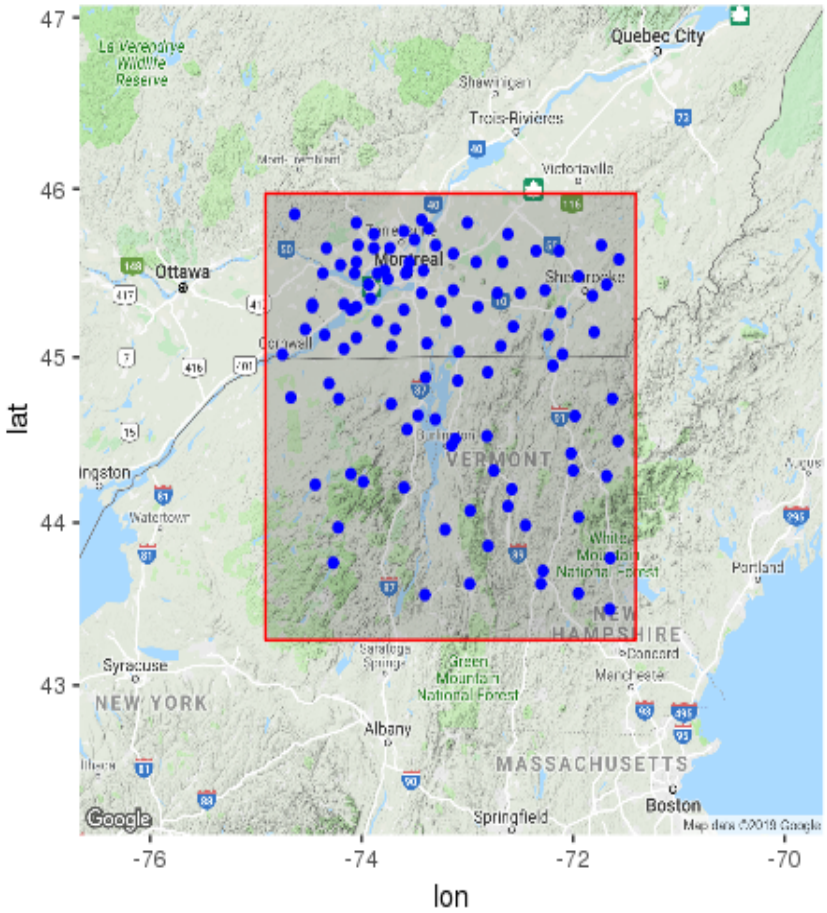


Downscaling adds value to climate model projections

VERMONT EPSCoR

Station Data

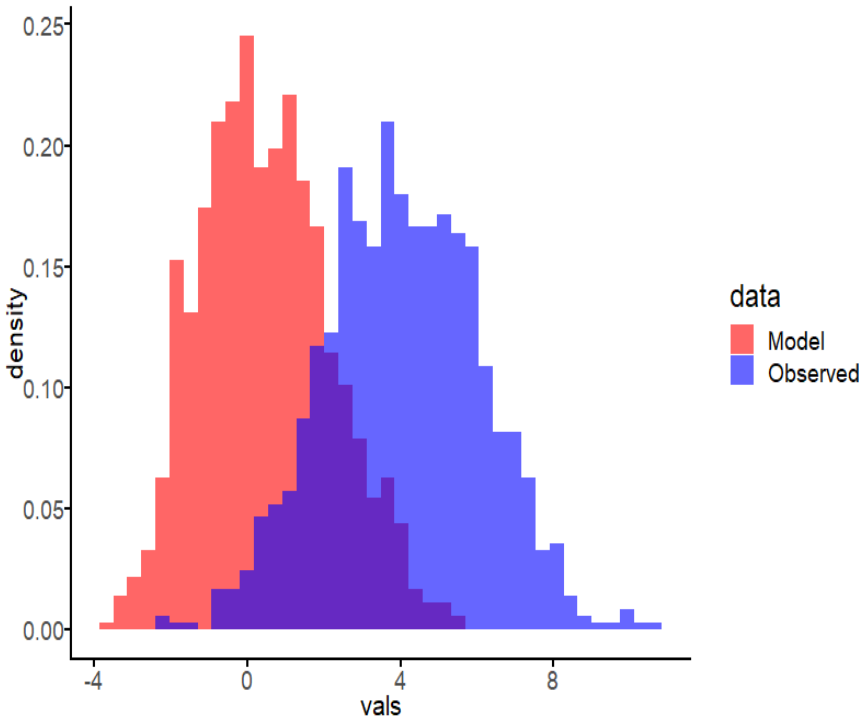
Source: Global Historical Climate network



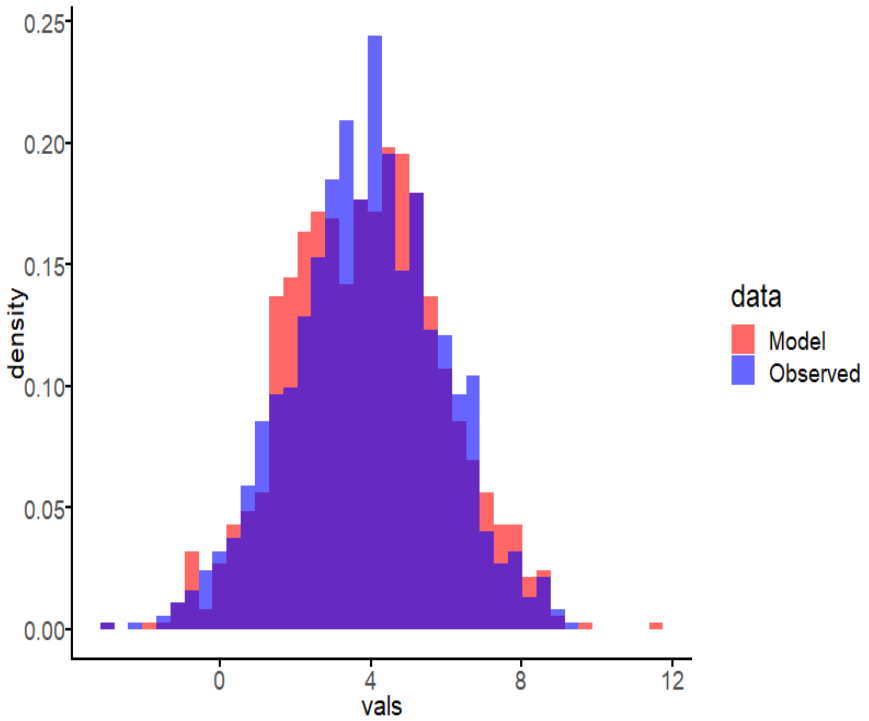
GHCN weather stations in the study domain

Bias correction

- Goal: Adjust model distribution to match that of historical data
- Quantify model and station distribution overlap with **Perkins skill score** [3]
- Method used for this study: quantile mapping

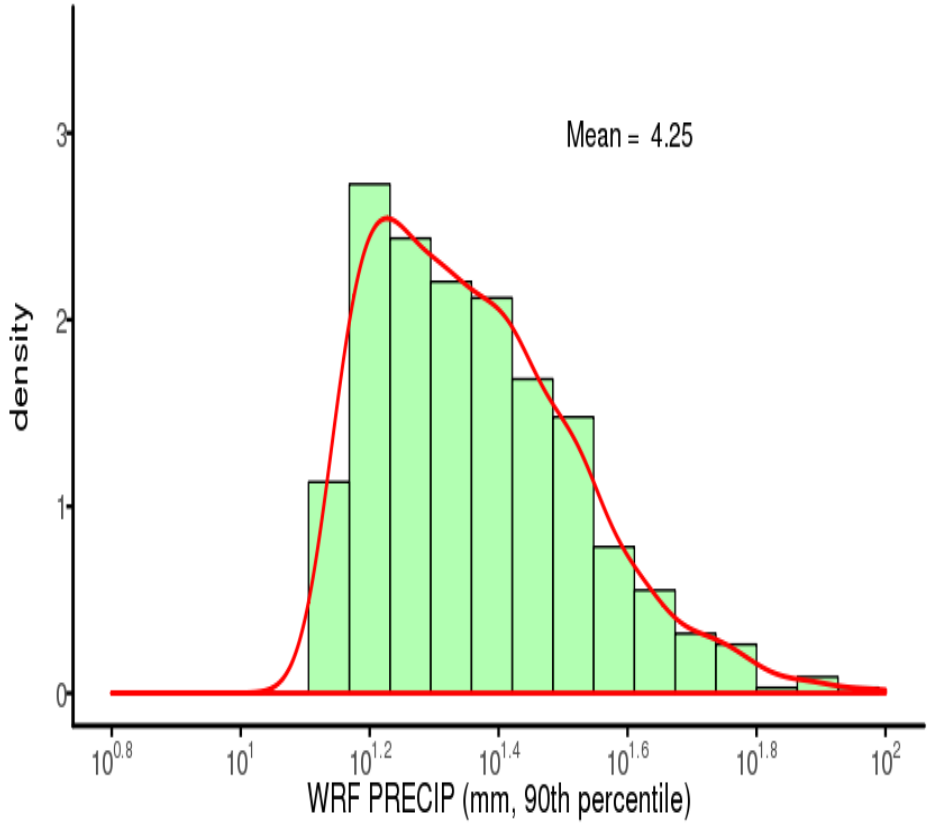


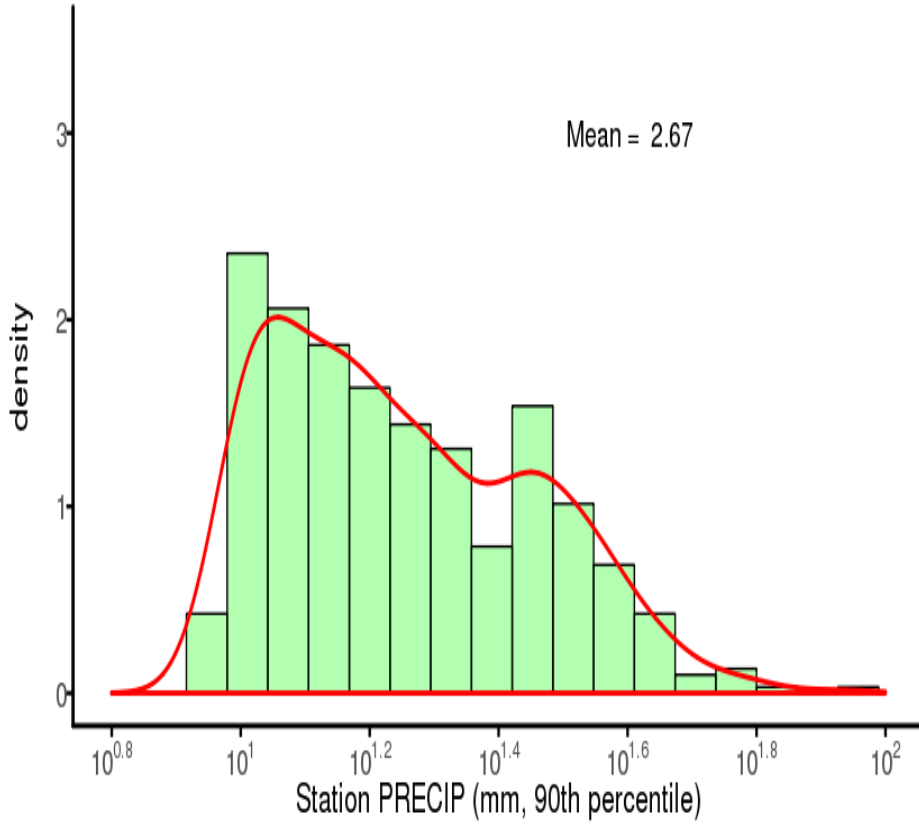
Before bias correction (skill score = 0.34)



After bias correction (skill score = 0.97)

WRF vs stations: extreme PRECIP





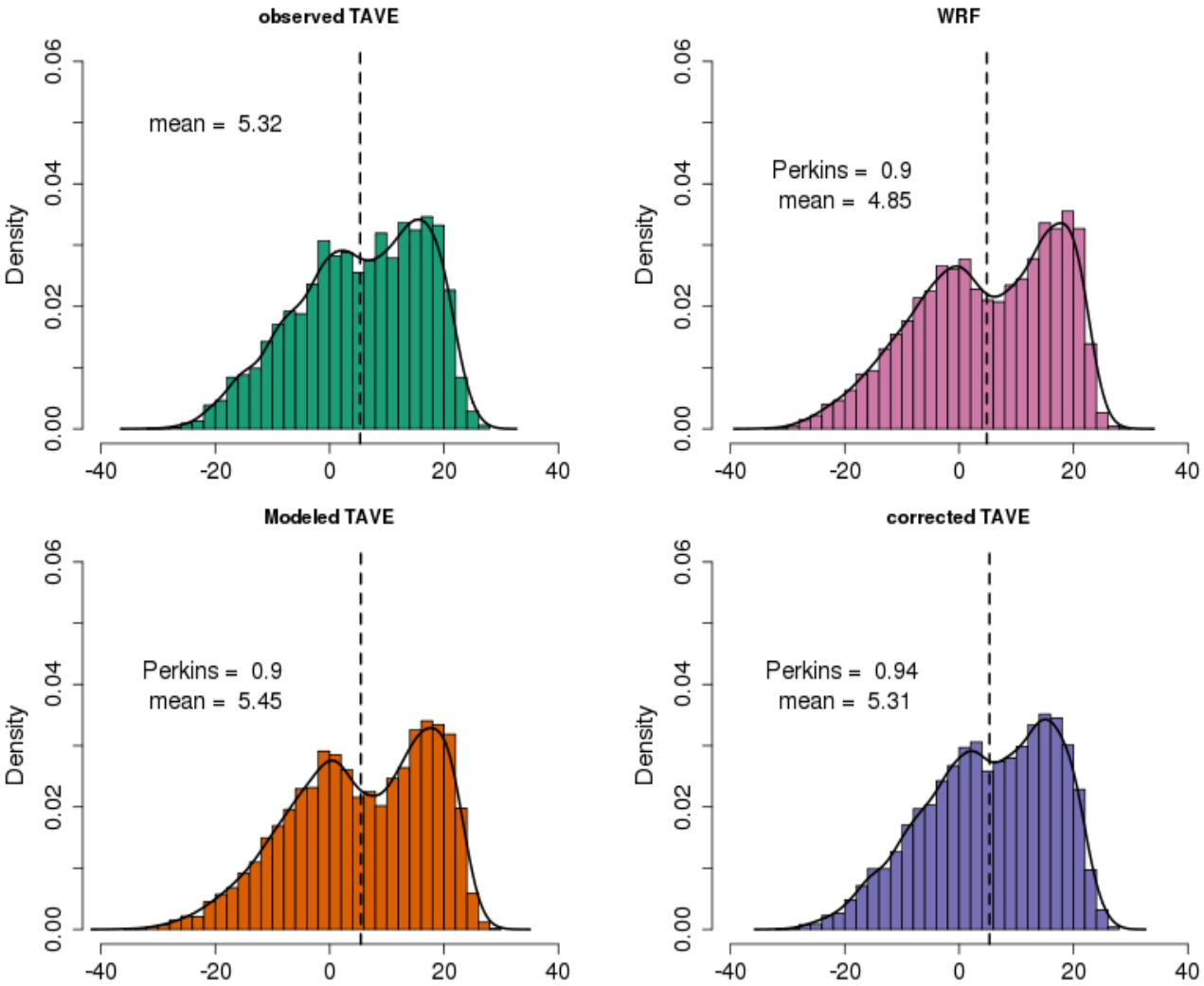
WRF PRECIP, 90th percentile, 1980-1994 (1 station)

Skill score = 0.56

Station PRECIP, 90th percentile, 1980-1994 (1 station)

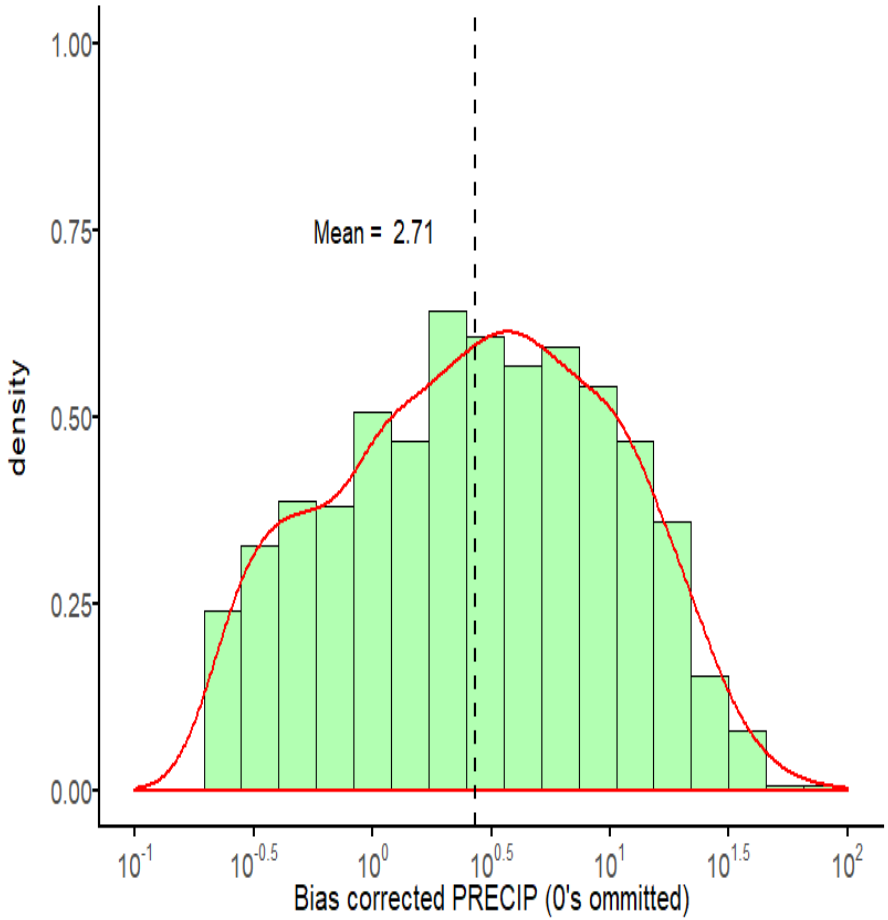
VERMONT EPSCoR

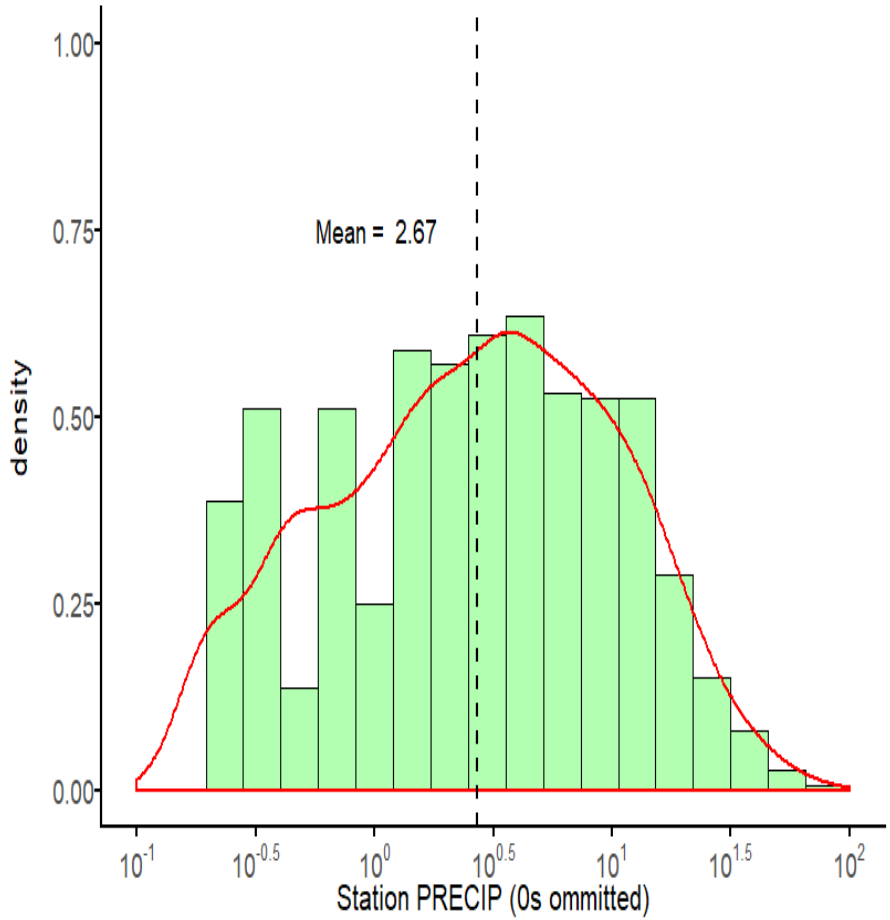
Preliminary results: TAVE



1980-1994 annual TAVE for 1 station: (turquoise), nearest WRF gridpoint (magenta), predictions from model (orange), bias-corrected predictions (purple)

Bias correcting WRF PRECIP



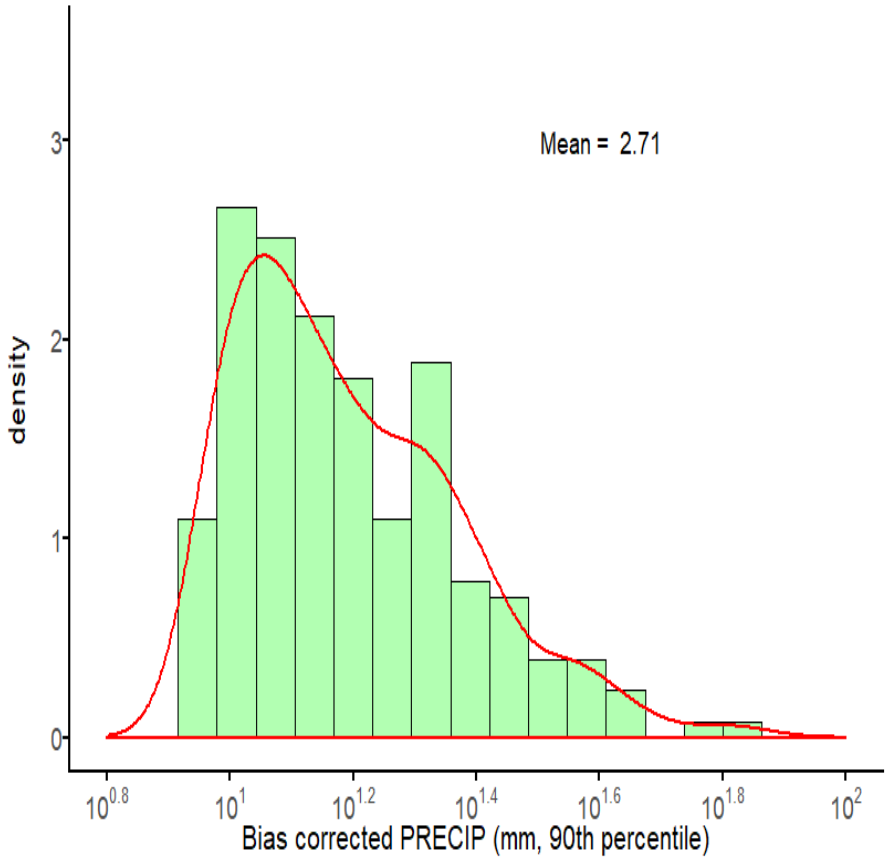


Bias corrected daily PRECIP, 1980-89 (log scale, zeros ommitted)

Skill score = 0.96

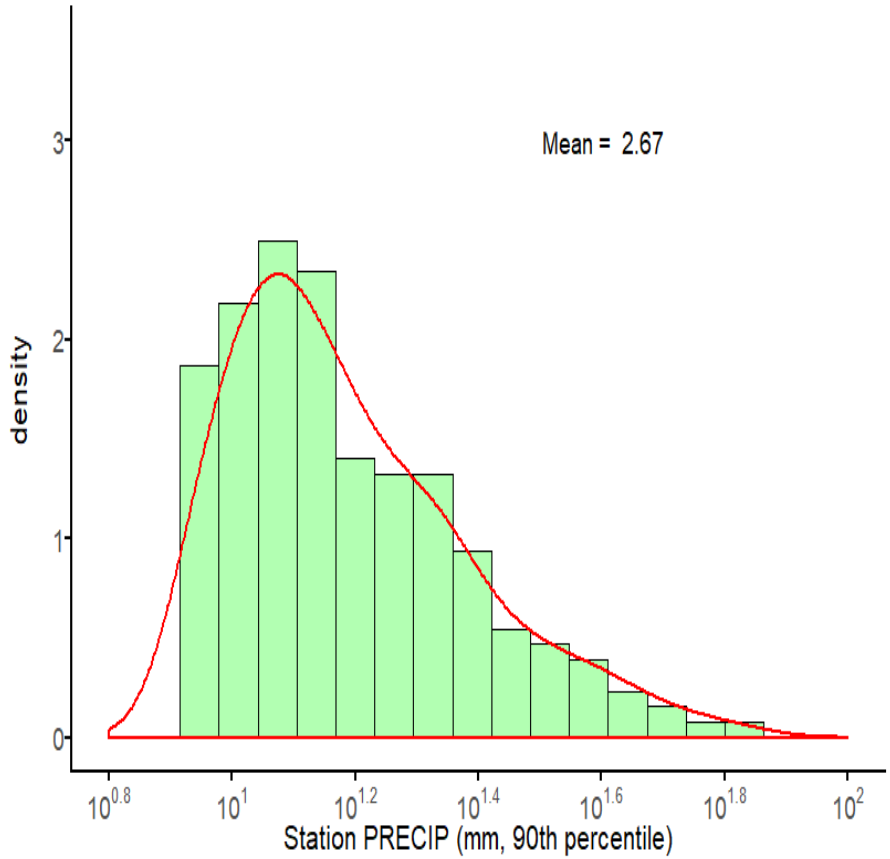
Station daily PRECIP, 1980-89 (log scale, zeros ommitted)

Bias correcting WRF extreme PRECIP



Bias corrected WRF PRECIP, 90th percentile, 1980-89 (log scale)

Skill score = 0.66



Station PRECIP, 90th percentile, 1980-89 (log scale)

VERMONT EPSCoR

Conclusion

Conclusion

- Raw WRF data exhibits some bias for both temperature and precipitation
- WRF performs better in capturing temperature than precipitation, especially extreme precipitation
- Bayesian model works adequately for temperature but may need some adjustment for modeling precipitation
- Quantile mapping for bias correction corrects mean and increases skill score

VERMONT EPSCoR

Future work

Future work

- Compare results among other methods of bias correction (e.g. distribution mapping)
- Adjust Bayesian spatial model to better capture precipitation
- Refine WRF output to better capture extreme events using extreme value theory

VERMONT EPSCoR

Thank you!

Cerulean warbler

VERMONT EPSCoR

References I

David R Easterling, Gerald A Meehl, Camille Parmesan, Stanley A Changnon, Thomas R Karl, and Linda O Mearns. Climate extremes: observations, modeling, and impacts. **science**, 289(5487):2068–2074, 2000.

CM Goodess, C Anagnostopoulou, A Bárdossy, C Frei, C Harpham, MR Haylock, Y Hundecha, P Maheras, J Ribalaygua, J Schmidli, et al. An intercomparison of statistical downscaling methods for europe and european regions–assessing their performance with respect to extreme temperature and precipitation events. **Climatic Change**, pages 1–68, 2007.

SE Perkins, AJ Pitman, NJ Holbrook, and J McAneney. Evaluation of the ar4 climate models' simulated daily maximum temperature, minimum temperature, and precipitation over australia using probability density functions. **Journal of climate**, 20(17):4356–4376, 2007.

VERMONT EPSCoR