Regional Hydrological Response from Statistically Downscaled Future Climate Projections in 21st Century

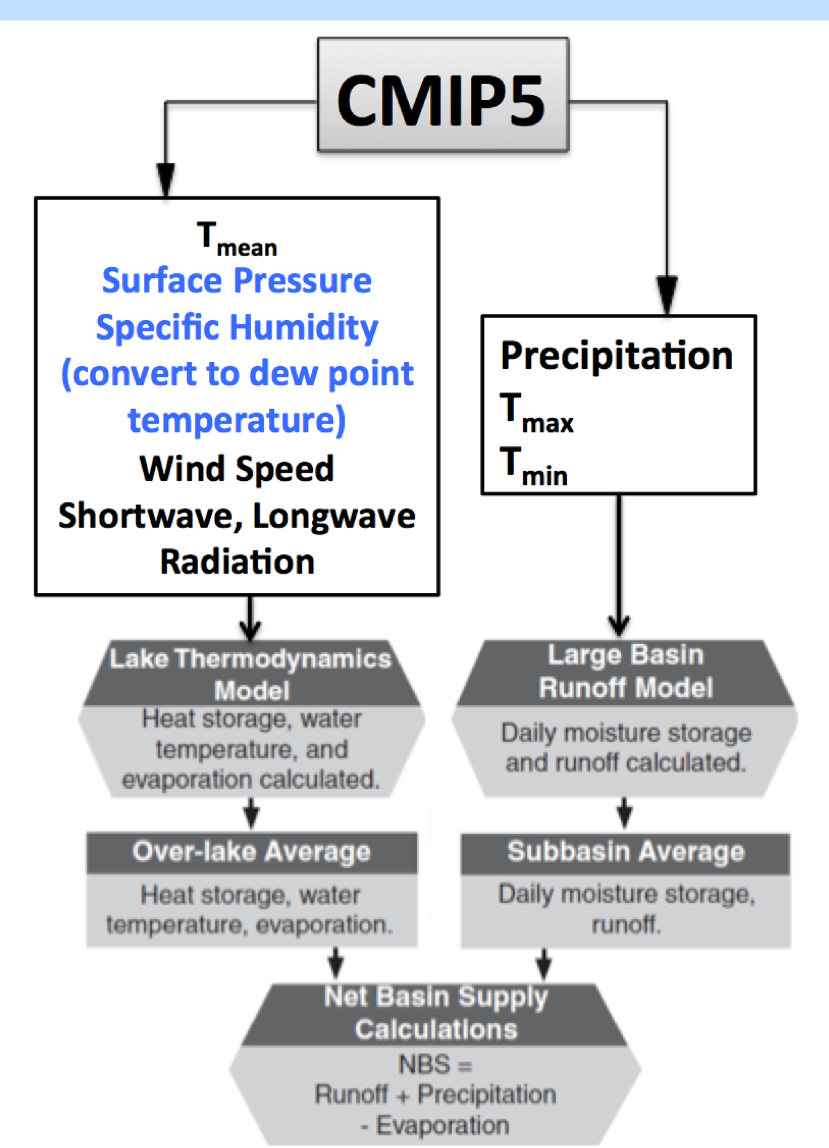
Lisi Pei[1,2], Andrew Gronewold[2], Tim Hunter[2], Rebecca Bolinger[3]
[1]University Corporation for Atmospheric Research, [2]NOAA Great Lakes Environmental Research Laboratory, [3]Colorado State University

462

Introduction

Understanding how future climate change signals propagate into hydrological response is critical for water supply forecasting and water resources management. To demonstrate how this understanding can be improved at regional scales, we studied the hydrological response of the Laurentian Great Lakes under future climate change scenarios in the 21st century using a conventional regional hydrological modeling system (the Great Lakes Advanced Hydrologic Prediction System, or GL-AHPS) forced by statistically downscaled CMIP5 (Coupled Model Intercomparison Project Phase 5, Taylor et al. 2012) future projections. The Great Lakes serve as a unique case study because they constitute the largest bodies of fresh surface water on Earth, and because their basin is bisected by the international border between the United States and Canada, a feature that complicates water level and runoff modeling and forecasting. The GL-AHPS framework is specifically designed to address these unique challenges. Existing model validation results indicate that the GL-AHPS model framework provides reasonable simulation of historical seasonal water supplies, but has significant deficiencies on longer time scales. A major component of this study, therefore, includes reformulating key algorithms within the GL-AHPS system (including those governing evapotranspiration), and assessing the benefits of those improvements.

Modeling Framework



19 CMIP5 Model Ensemble

- bcc-csm1-1
- CCSM4
- CSIRO-Mk3-6-0
- GFDL-ESM2G
- GISS-E2-R
- HadGEM2-ES
- IPSL-CM5A-LR
- MIROC5
- MPI-ESM-MR
- MRI-CGCM3
- NorESM1-M
- CanESM2
- CNRM-CM5
- GFDL-CM3
- GFDL-ESM2M
- HadGEM2-CC
- inmcm4
- IPSL-CM5A-MR
- MIROC-ESM

Figure 1. GL-AHPS Modeling framework (Gronewold et al. 2011)

Acknowledgements & References

This work is supported by the UCAR Cooperative Programs for the Advancement of Earth System Science (CPAESS), NOAA Great Lakes Environmental Research Laboratory, New York Power Authority, and Ontario Power Generation.

Cannon, A. J., S. R. Sobie, and T. Q. Murdock, 2015: Bias correction of GCM precipitation by quantile mapping: how well do methods preserve changes in quantiles and extremes? Journal of Climate, 28 (17), 6938–6959.

Cosgrove, B. A., and Coauthors, 2003: Real-time and retrospective forcing in the North American land data assimilation system (NLDAS) project. Journal of Geophysical Research: Atmospheres, 108 (D22).

Gronewold, A. D., A. H. Clites, T. S. Hunter, and C. A. Stow, 2011: An appraisal of the Great Lakes advanced hydrologic prediction system. Journal of Great Lakes Research, 37 (3), 577–583.

Taylor, K. E., R. J. Stouffer, and G. A. Meehl, 2012: An overview of cmip5 and the experiment design. Bulletin of the American Meteorological Society, 93 (4), 485.

Statistical Downscaling

The Quantile-Delta-Mapping (QDM, Cannon et al. 2015) method is applied to bias-correct the 19 CMIP5 model ensemble's monthly meteorological outputs in 2006-2095 (precipitation, 2-m air temperature, radiation, wind, humidity, surface pressure). This method helps preserve the climate change signals in the projected future climatology, along with correcting the biases in each quantile of the distribution according to the model's historical performances. The forcing field (file A) for the NLDAS2 (North American Land Data Assimilation System Phase 2, Cosgrove et al. 2003) from 1979-2005 is used as the proxy for observation, while CaPA (Canadian Precipitation Analysis) precipitation field during 2002-2015 is jointly applied over the Midwest. The validation is conducted in 2006-2015 for the bias-corrected fields, comparing to the NLDAS2 and CaPA datasets.

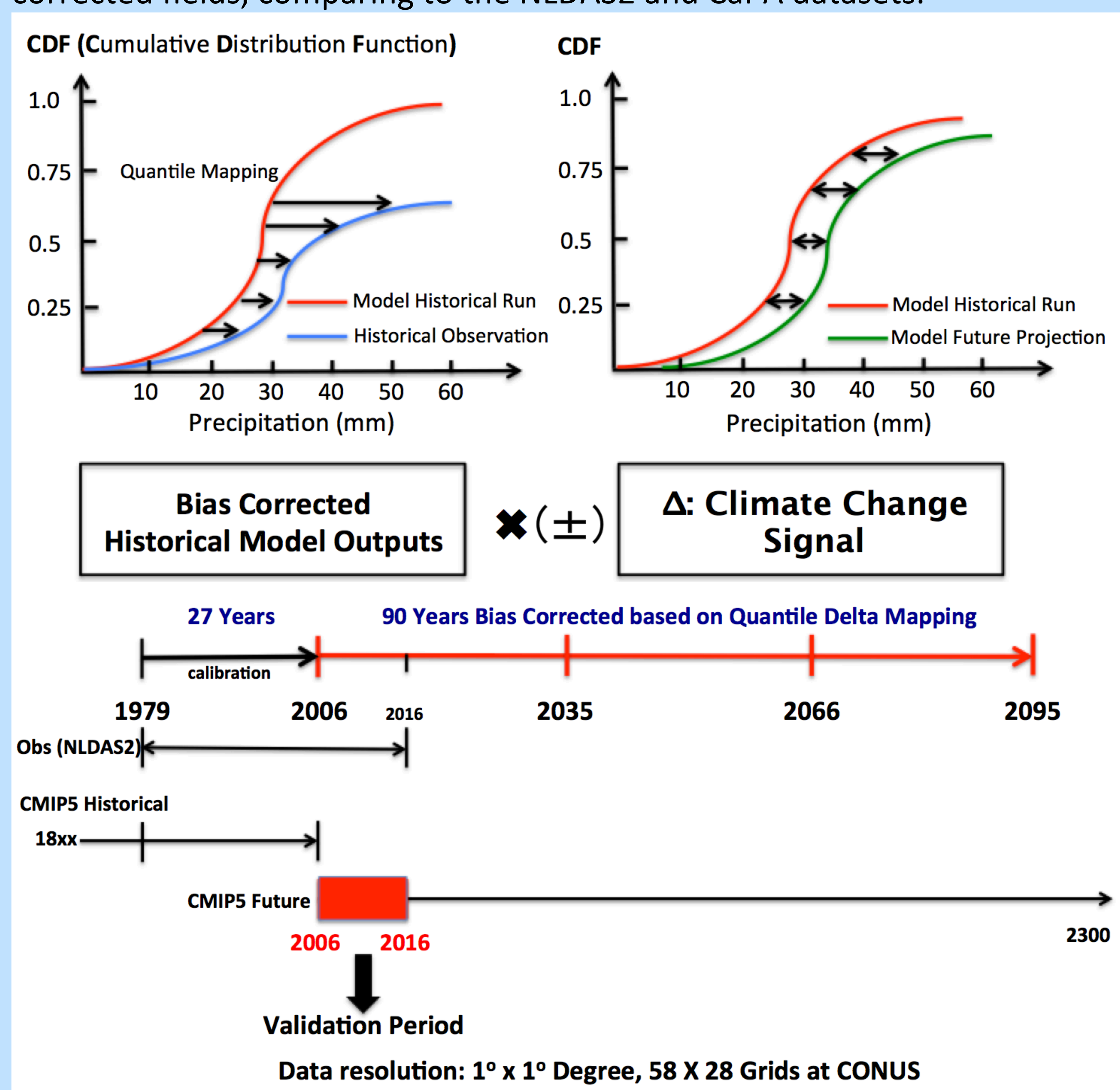
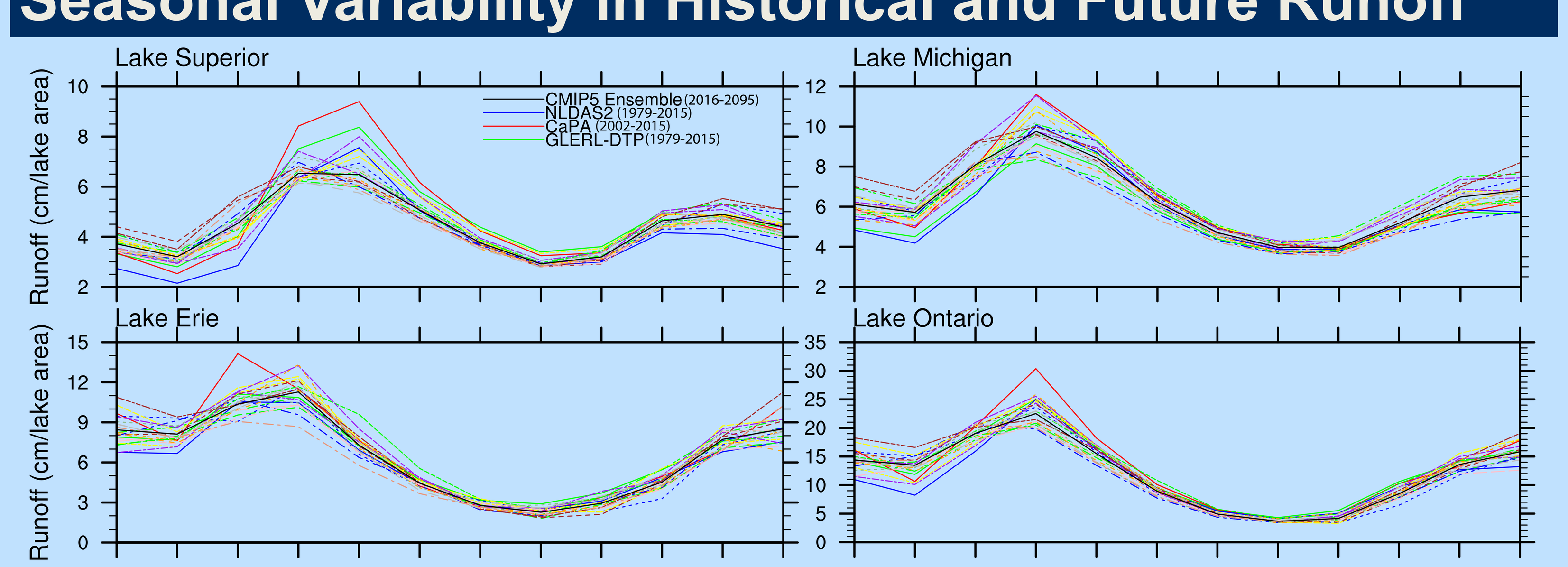
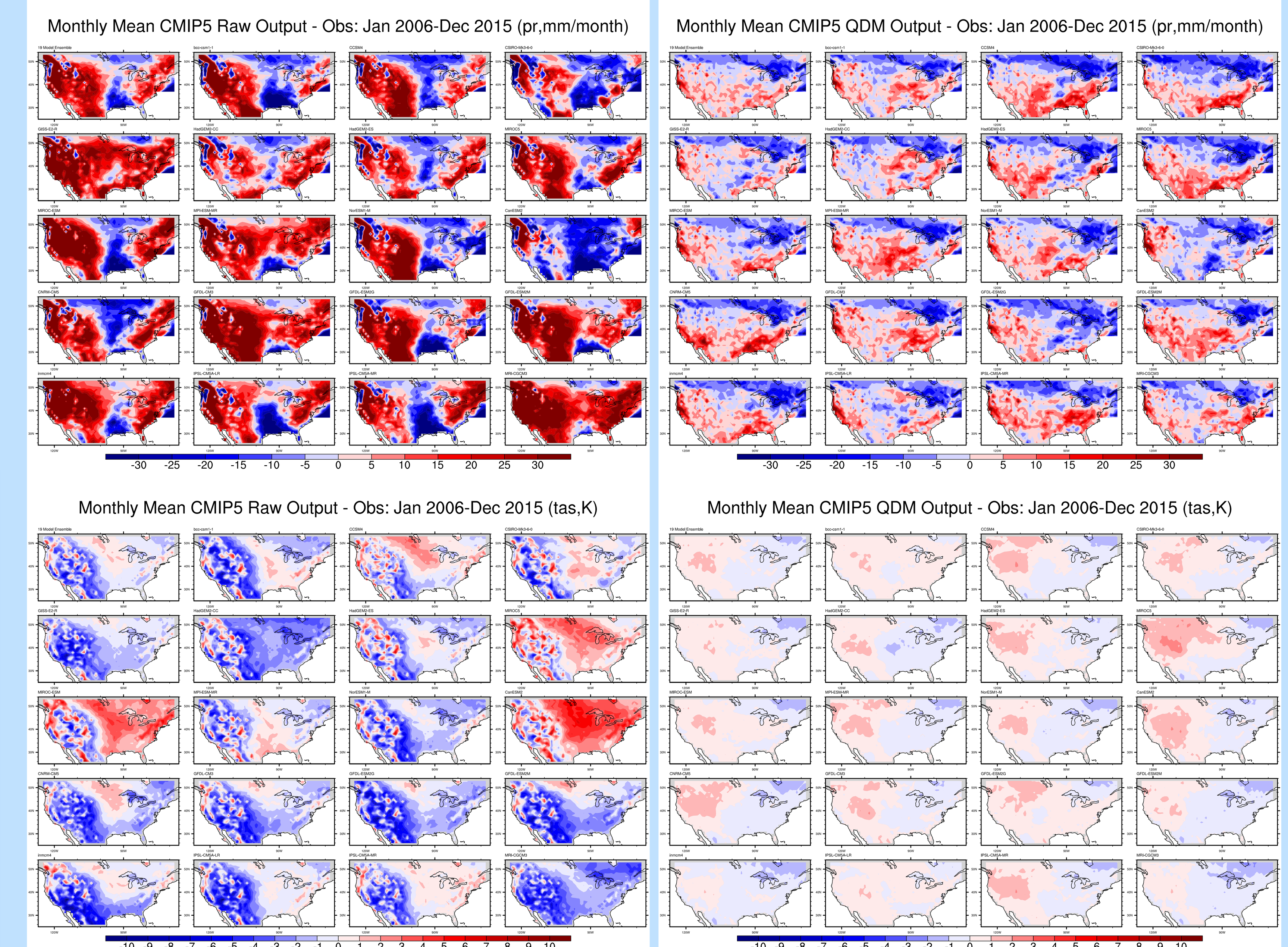


Figure 2. Illustration of Quantile-Delta-Mapping method and logistics of Bias-correction and validation

Seasonal Variability in Historical and Future Runoff



Validation of Bias-Corrected Precipitation and T2



Hydrological Response by GL-AHPS over Great Lakes