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Analysis and Provision of NA-CORDEX Regional Climate Projections

NA-CORDEX

The NA-CORDEX Archive

Regional climate change scenario data and guidance for North America, for use in impacts, decision-making, and climate science for DoD facilities and managed impacts areas.

The NA-CORDEX data archive contains output from regional climate models (RCMs) run over a domain covering most of North America using boundary conditions from global climate model (GCM) simulations in the CMIP5 archive. These simulations run from 1950-2100 with a spatial resolution of 0.22°/25km or 0.44°/50km. Data is available for impacts-relevant variables at daily and longer frequencies in CF-compliant NetCDF format.

https://na-cordex.org/

Why analyze bias correction?

Climate projections have systematic bias. It is common practice to apply a bias correction to climate model outputs for use in impacts. There are many bias correction methods that will adjust model outputs to match the statistics of observations, but the results don't always make sense. These analyses help us understand where the bias-corrected results are meaningful.

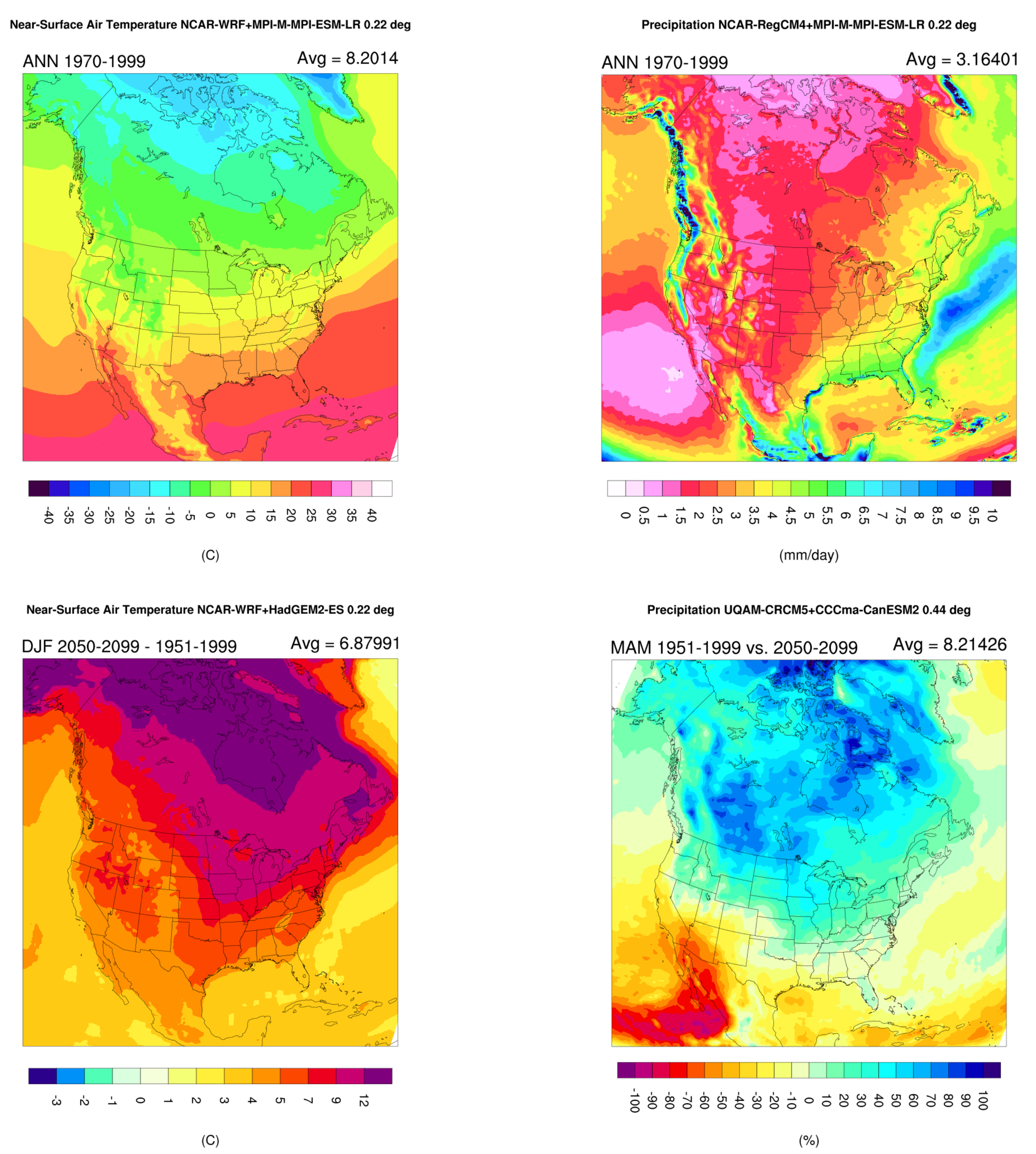
New Data and Data Products

Seth McGinnis, Daniel Korytina, & Tristan Rendfrey, NCAR

More Variables: We have added more impacts-relevant variables. The archive now includes (all daily):
precipitation • minimum, maximum, and average temperature • surface humidity
incoming solar radiation • surface winds • surface pressure

Bias Correction: We have performed a univariate bias correction using the KDDM (Kernel Density Distribution Mapping) method on the GCM-driven outputs for the 7 variables in the METDATA observed dataset (tmin, tmax, precip, humidity, solar radiation, and surface winds). We have also developed the computational framework for a multivariate bias correction and used it to perform a preliminary test correction.

Visualizations: We have produced more than 2000 figures and made them available through the project website for use in selecting simulation results. These figures show maps of the climatology and change signals for seasonal and annual average temperature and precipitation for different 30-year and 50-year periods for different GCM-driven simulations in the archive. These figures are distributed via Google Drive, which provides robust and reliable service, high-quality UI, and powerful search capabilities.

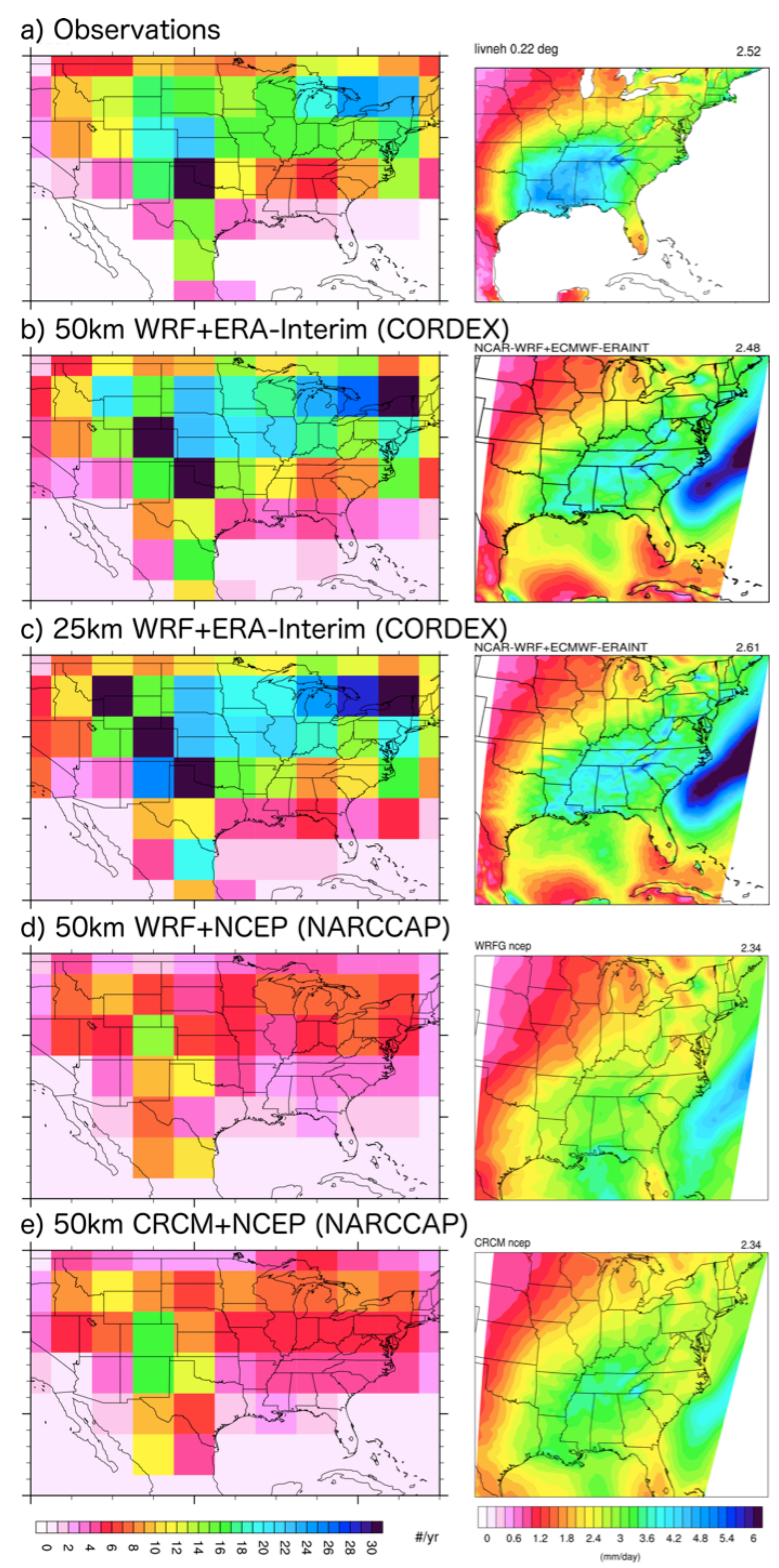


Extratropical Cyclone (ETC) Tracking

Melissa Bukovsky & Rachel McCrary, NCAR

We have built an extratropical cyclone (ETC) tracking system and applied it to various observation-based datasets and the NARCCAP and CORDEX regional climate models (RCMs). Work is ongoing to examine the role of ETCs in historical simulation precipitation bias as well as in forcing future changes in precipitation.

This analysis below focuses on cool-season (Nov-Mar) precipitation in the Deep South. Plots are for 1980-2004. Left column: the average number of ETCs per season to pass through a given 5x5 degree box. Right column: precipitation.



The 25km WRF+ERA-Interim simulation has more intense precipitation and a slightly increased number of ETCs. We will investigate how much of the increase is due to the ETCs versus other factors. The NARCCAP simulations shown here have less rain and significantly fewer ETCs than the CORDEX simulations. Much of the NARCCP ETC bias is likely coming from the NCEP reanalysis driving the simulations, as it is a pervasive problem across all the NCEP-driven simulations (not all shown here). However, the WRF+NCEP simulation has less ETC activity than the CRCM from the continental divide to the east coast, likely contributing to its stronger dry bias.

Perfect Model Evaluation

Joe Barsugli, Candida Dewes, & Imtiaz Rangwala, NOAA-PSD

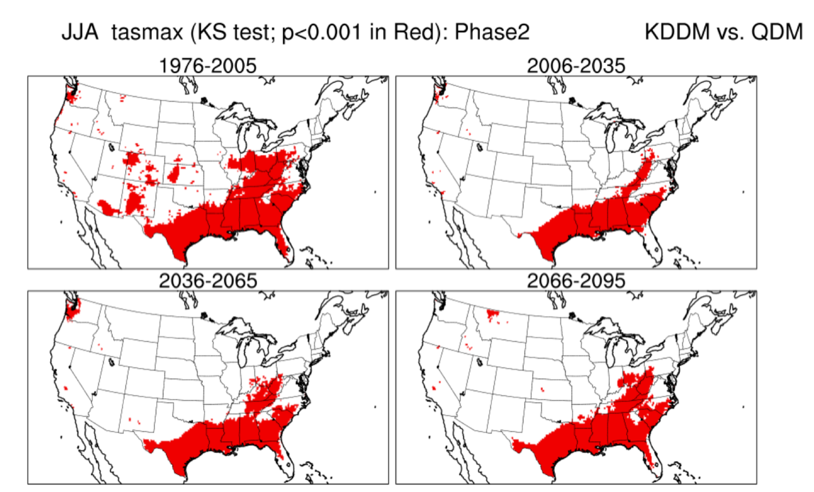
The Perfect Model framework for evaluation of statistical downscaling and bias correction methods uses high-resolution regional climate model simulations as a proxy for future observations.

Phase 1: RCM outputs are coarsened, then statistically downscaled back to the original resolution. Differences between the original data and the downscaled data show where the statistical downscaling method has difficulty capturing fine-scale details. Phase 1 analysis featured in the NA-CORDEX poster for the 2017 Symposium.

Phase 2: Uses two different regional models (RCMs) driven with the same global model. Bias correction is applied to adjust the output from the first RCM to match the output from the second RCM for the historical period (1950-2005). The same adjustment is then applied to the future period (2006-2100.) Differences between bias-corrected RCM1 and RCM2 for the future period show where the bias correction method has difficulty compensating for differences in the models. The differences between two models are analogous to the differences between one model and reality.

Comparison of two bias-correction methods

KDDM and QDM bias-corrected daily data are very similar for most of CONUS except for the southeastern US. Areas in red indicate regions where the distributions of the two datasets are significantly different.

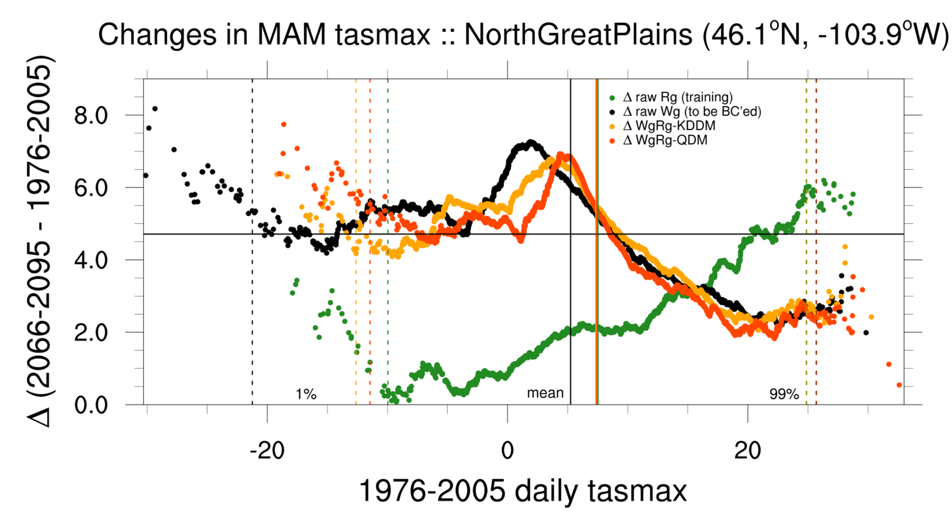


Localized analysis

We have developed a quantile change diagram expressed in terms of absolute temperature coordinates (not anomaly temperatures) that reveals the behavior of these methods at critical temperatures such as the freezing point of water for Phase 2 experiments.

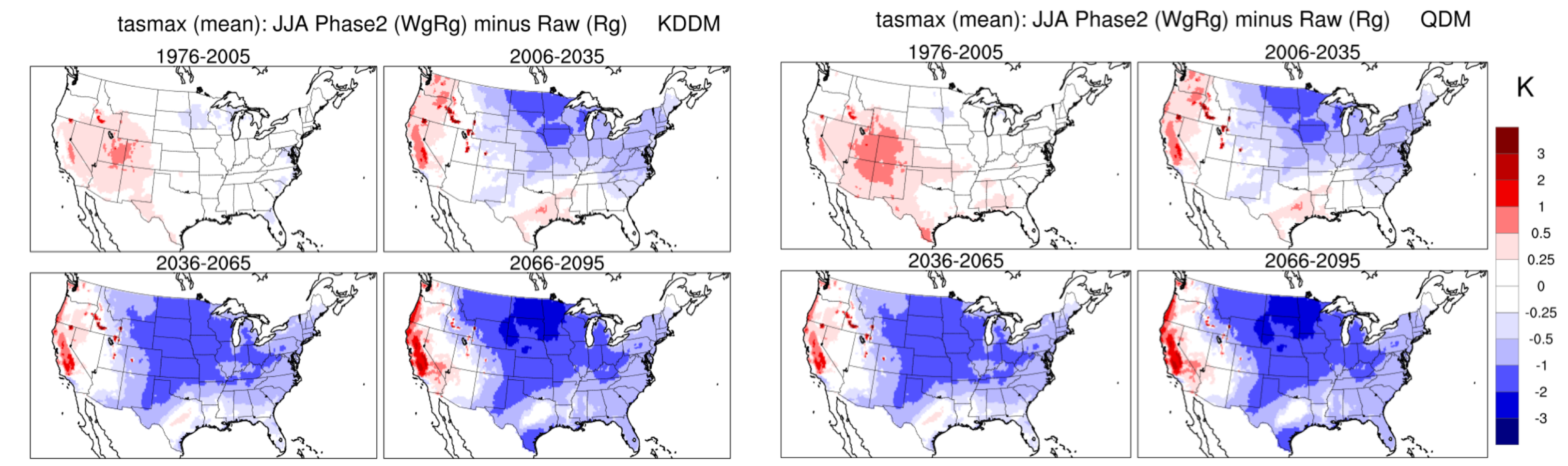
This figure shows a quantile change diagram for the daily maximum temperature for a location in the Northern Great Plains for Spring (March-May). The change (°C) from historic to future periods is plotted against the temperature (°C) in the historic period.

The raw WRF model (black) shows larger increase in the vicinity of 0°C, a possible influence of the snow-albedo feedbacks; whereas the raw RegCM4 model (green), the "truth" in this perfect model configuration, has larger changes at temperatures higher than 0°C, suggesting that snow-albedo feedback is not dominant. When the WRF is bias-corrected using either QDM (orange) or KDDM (yellow) it mostly retains the signature of this feedback, but the "peak" near zero degrees Celsius is shifted to warmer temperatures, as a result of applying the bias correction on temperature anomalies.



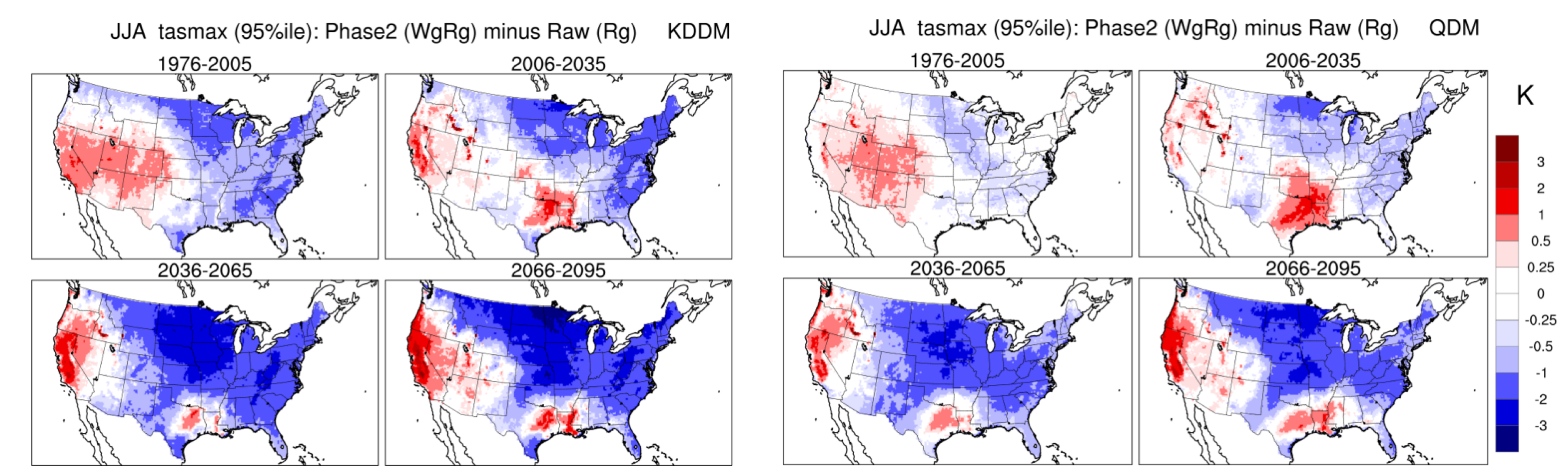
Phase 2 Analysis

This analysis compares two bias correction methods: Kernel Density Distribution Mapping (KDDM) and Quantile Delta Mapping (QDM). These methods are both forms of quantile mapping, the primary difference being that QDM aims to preserve trends in each quantile while KDDM does not. These figures show the WgRg experiment, where outputs from WRF driven by GFDL (Wg) are bias-corrected to match RegCM4 driven by GFDL (Rg). All bias corrections are applied at the daily timescale. "Error" here means the difference between the bias-corrected Wg and the raw RG that it is supposed to match.



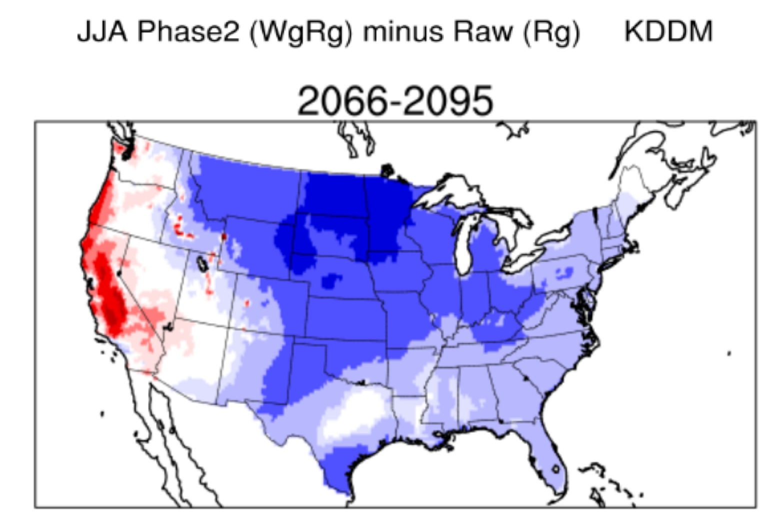
JJA mean

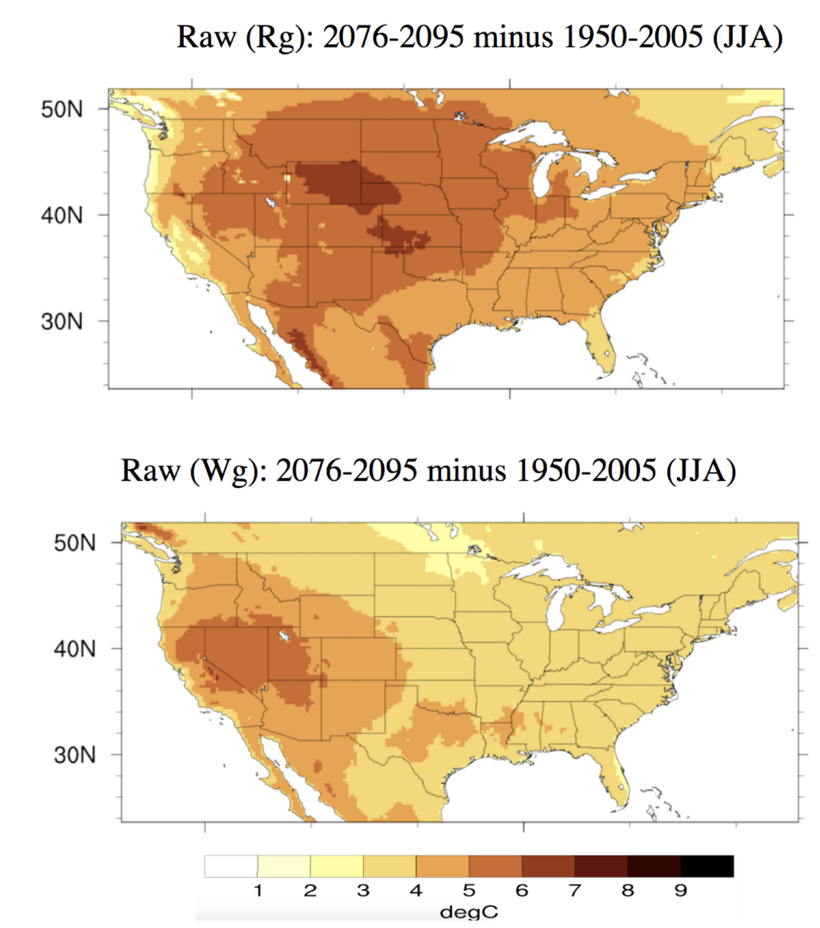
Errors in seasonal means are nearly identical between KDDM and QDM



JJA 95th percentile

Large errors (as much as 2-3 °C or greater) can be seen at several locations. These errors increase as 21st century progresses The spatial pattern of the errors is very similar for both bias correction methods, although QDM has a somewhat smaller error magnitude.





Different Climate Change Signals

Large errors in Phase 2 experiments are found to be associated with the mismatch in the climate change signal between the two RCMs. Part of this mismatch arises from the different RCM climate sensitivities and climatological biases (hot vs. cold and/or wet vs. dry).