BIAS CORRECTED CLIMATE FORCING DATASETS FOR LAND SURFACE MODELLING OVER NORTH AMERICA

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STORY

- Assess Impacts of Climate and Land Use/Cover Change on the Hydrology of MRB & SRB & Uncertainty to Forcing Data … CCRN objectives
- MESH was selected to do the hydrological modelling … MESH requires 7 met variables at sub-daily time steps
- MRB is affected by permafrost → requires continuous simulations, early start, a lot of spinning to properly initialize a deep soil profile
- Looked around for available datasets, pros/cons, hydrological performance, etc.
- Decided to calibrate using GEM-CaPA
- … Bias Correction …

DATASETS

- What Datasets are available with all 7 variables:
  - Princeton 1901-2012 – 3hrourly – 0.5° – Global
  - WFD 1901-2001 – 3hourly – 0.5° – Global
  - WFDEI 1979-2016 - 3hourly – 0.5° – Global
  - GEM-CaPA 2002-Now – hourly (6hourly) – 10-15km – NA
  - CanRCM4 1951-2100 – hourly – 0.5° – NA (an Ensemble of 15 members: RCP8.5 CanESM2)
  - WRF 2000-2015 – hourly – 4km (CTL + PGW corresponding to 2080s) – Western Canada
  - NARCAPP – daily
  - CORDEX-NA – daily
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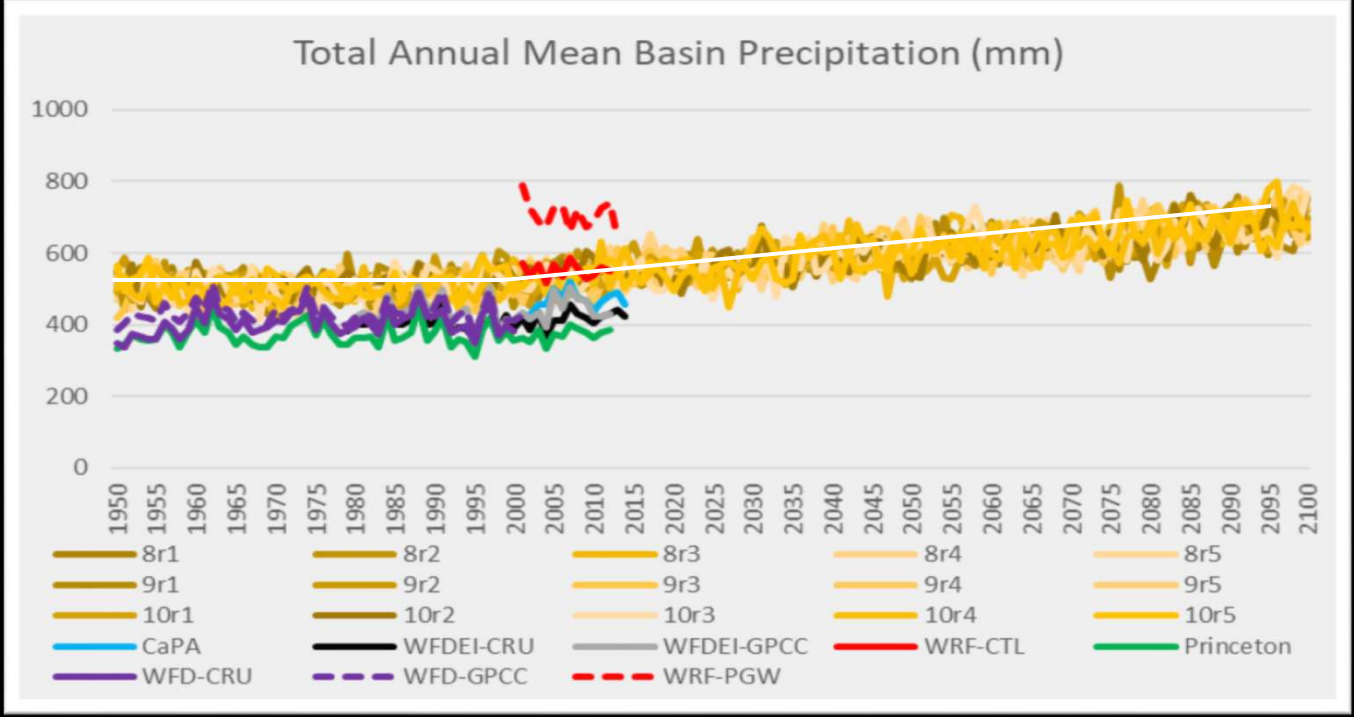
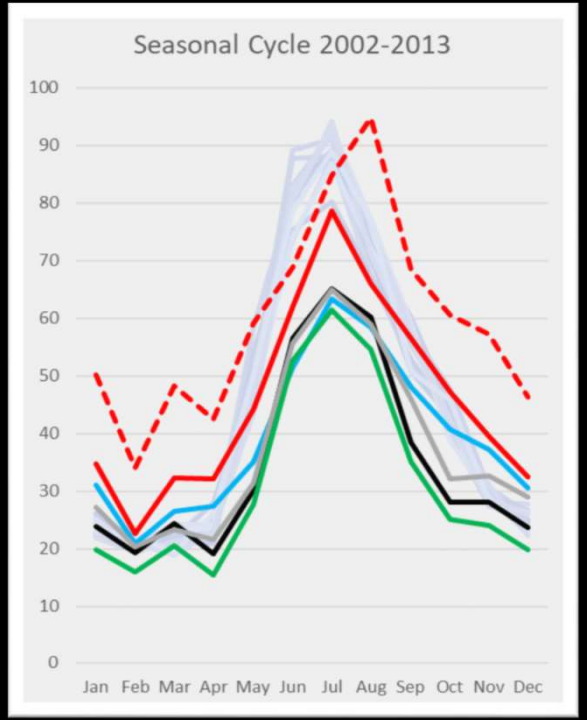
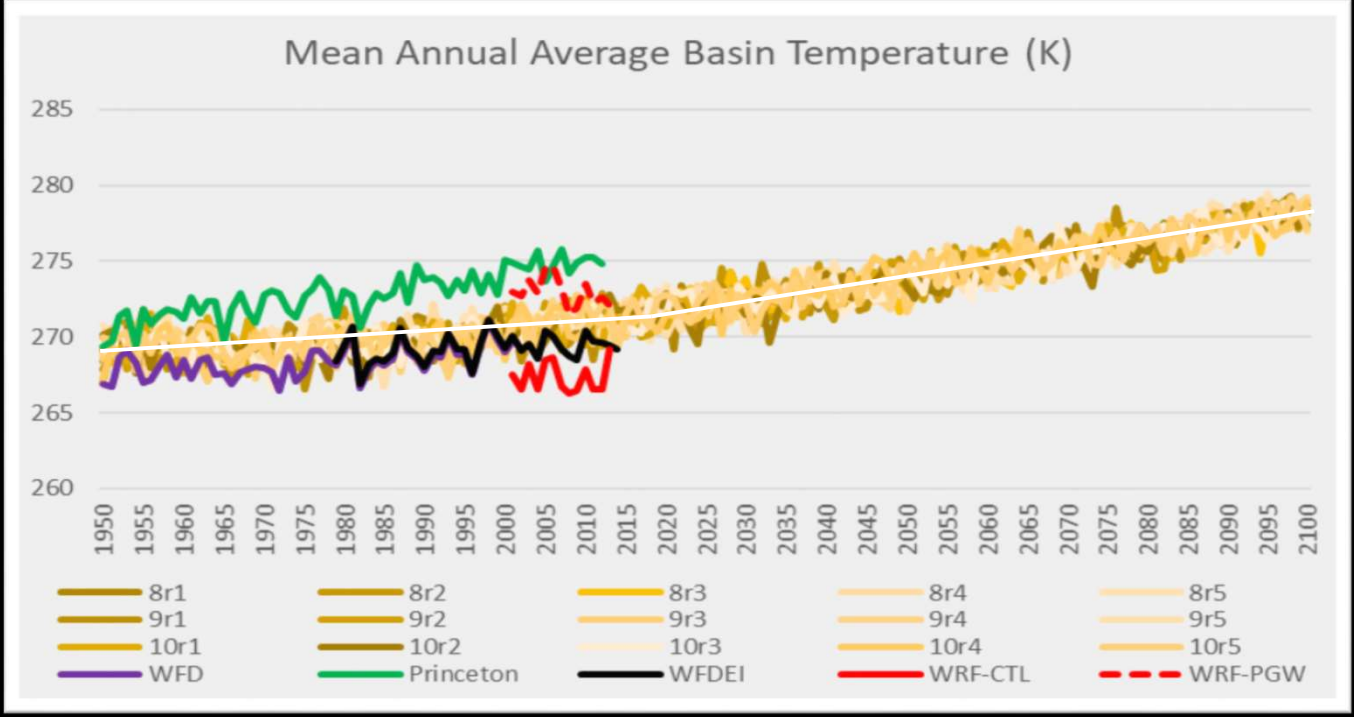
COMPARISON OF DATASETS - PR

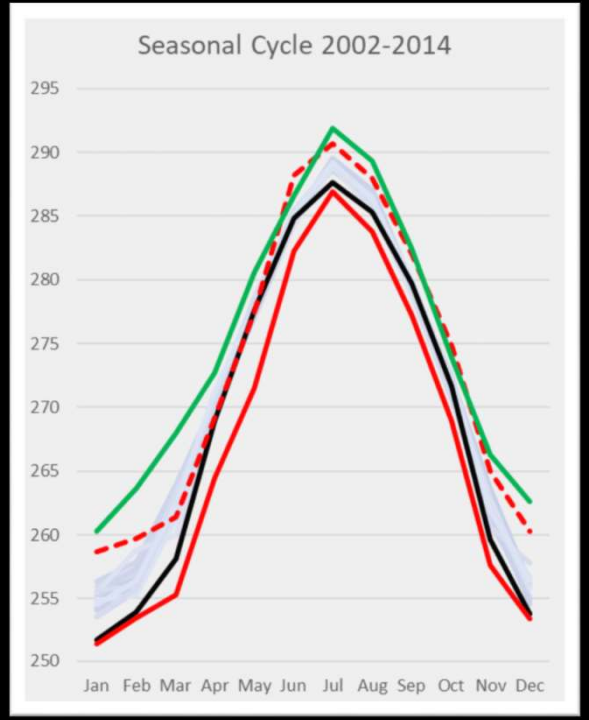




15 Ensemble Members – MRB Average
Increasing Precipitation Trend starting 2010

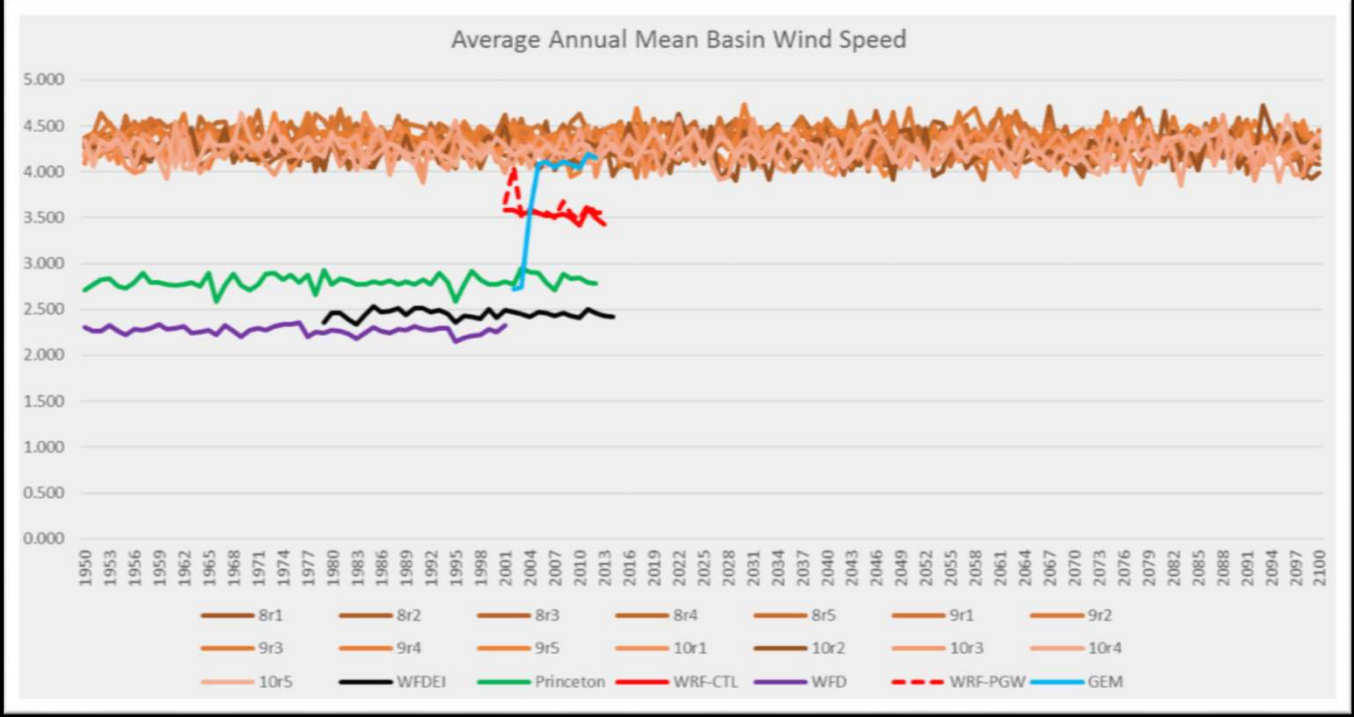
COMPARISON OF DATASETS - TA

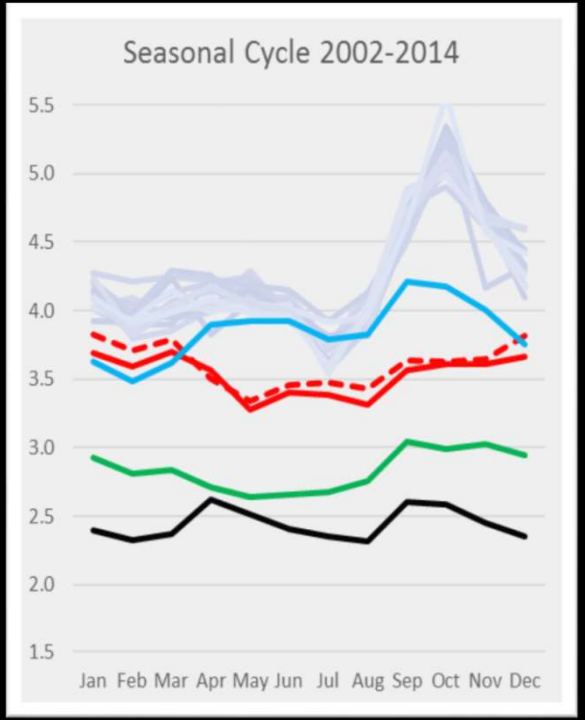




15 Ensemble Members – MRB Average
Increasing Temperature Trend accelerating starting 2000

COMPARISON OF DATASETS - WIND



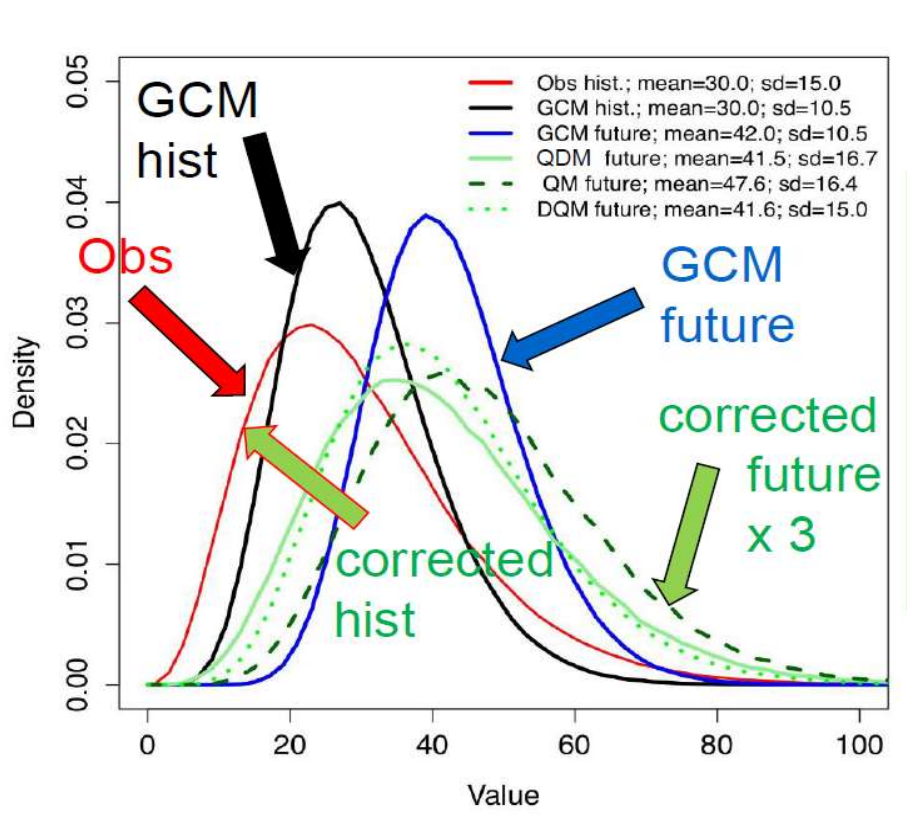


BIAS CORRECTION

- Adjusting model-simulated quantities to remove systematic errors relative to reference data
- Often criticized to destroy physical relations, underestimates variability, etc.
- To overcome this, to some extent, we used Alex Cannon Multi-variate quantile mapping – to preserve some physical realism. Fitting is done separately for each month

- Objective: Bias correct CanRCM4 & WRF: what is the **reference dataset?**
  - GEM-CaPA – too short for CanRCM4 but worked for WRF
  - WFDEI – biased vs GEM-CaPA, especially Windspeed
  - Princeton – more biased: hotter and drier in general
  - 2 stages: correct WFDEI vs GEM-CaPA: the result is long enough, similar to GEM-CaPA
  - Then used WFDEI-GEM-CaPA to correct CanRCM4 ensemble
  - We had ~~**CanRCM4-GEM-CaPA**~~ and ~~**CanRCM4-WFDEI**~~

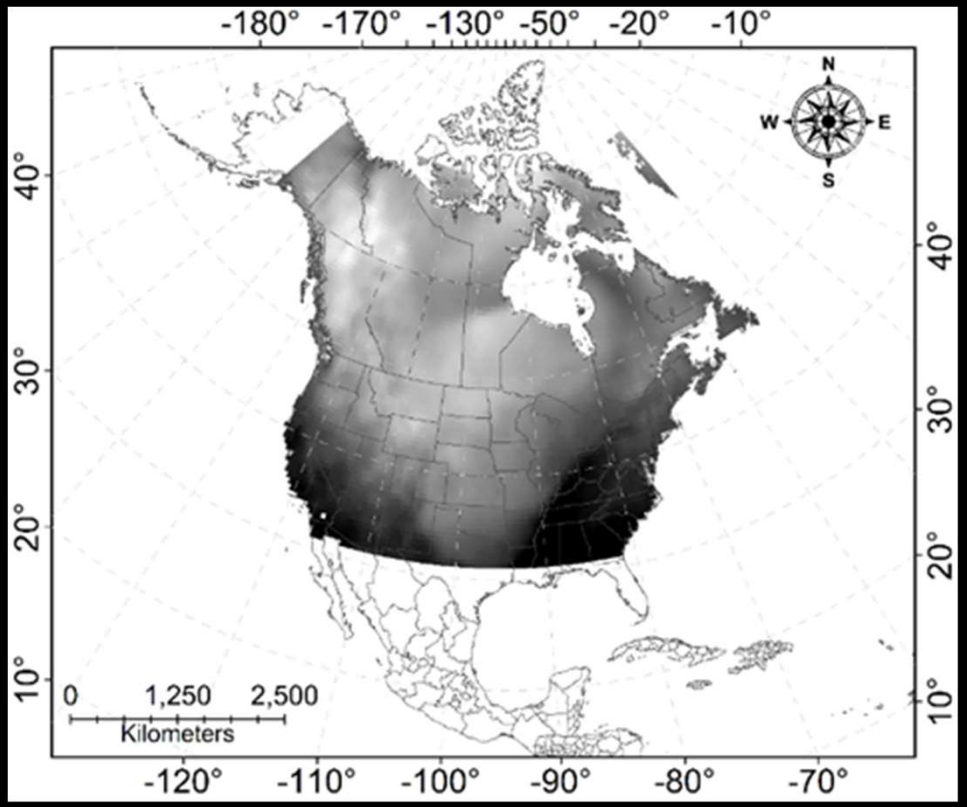
QUANTILE MAPPING

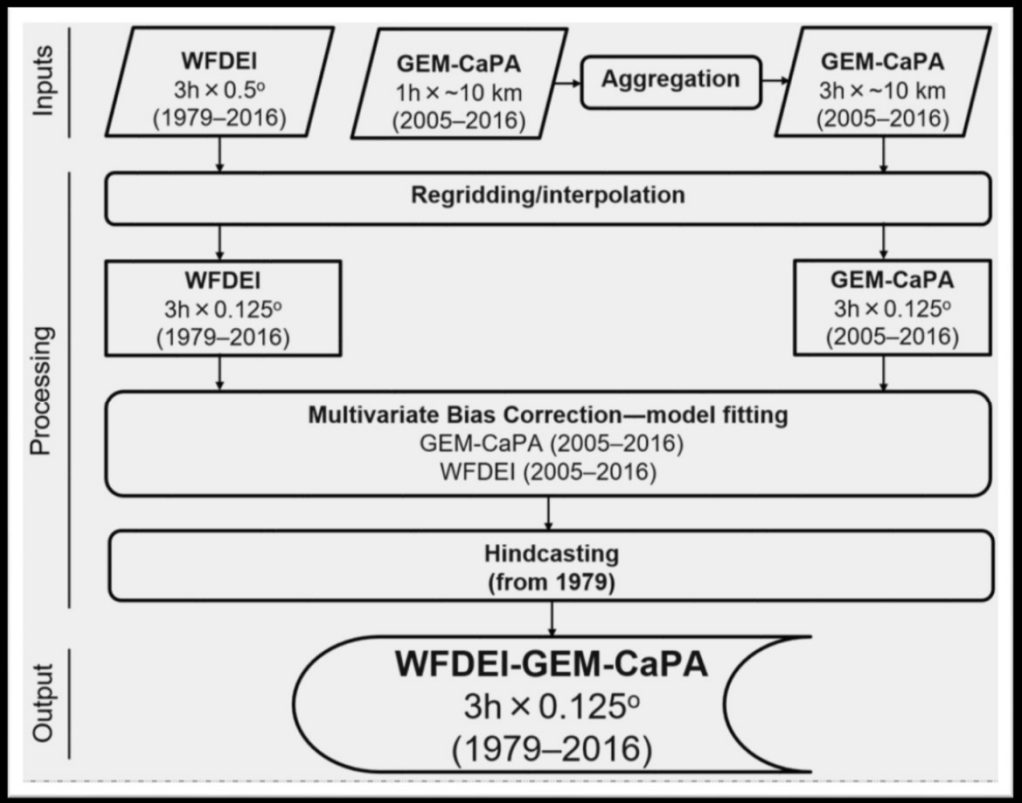


Cannon et al. (2015)

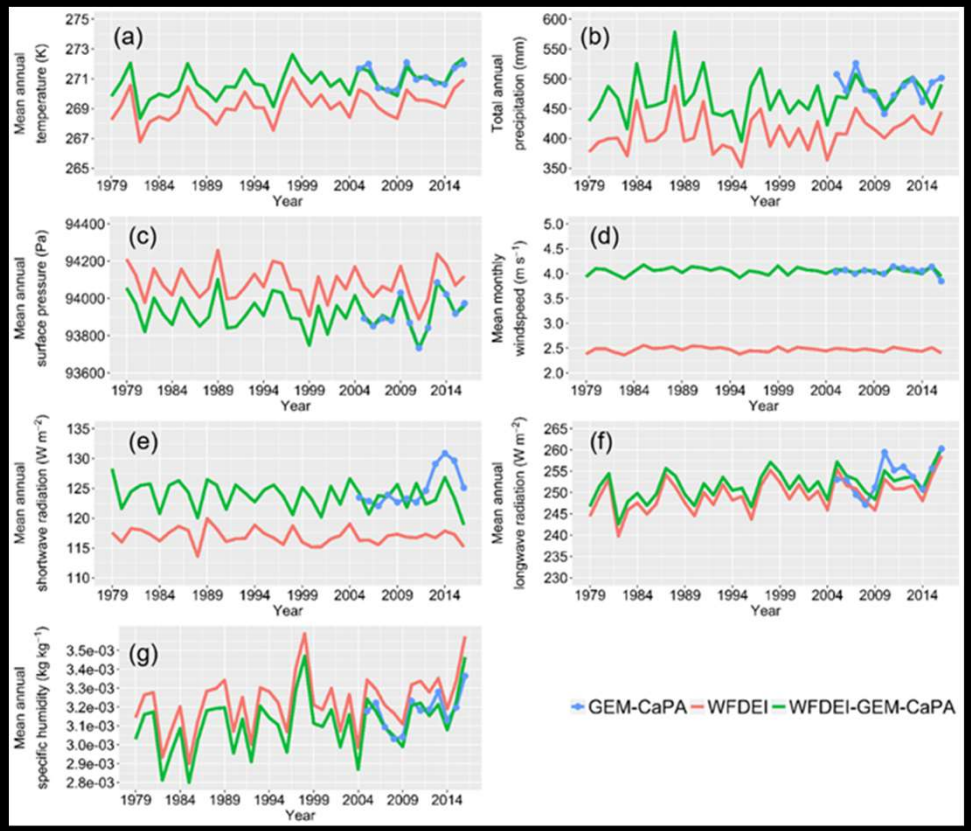
- The simplest bias correction would correct the mean of the two distributions to be equal (equivalent to Delta Change Factor methods)
- Quantile mapping divides the distribution into bins to correct the higher moments as well as the mean
- Assumes stationarity → biases remain similar in the future

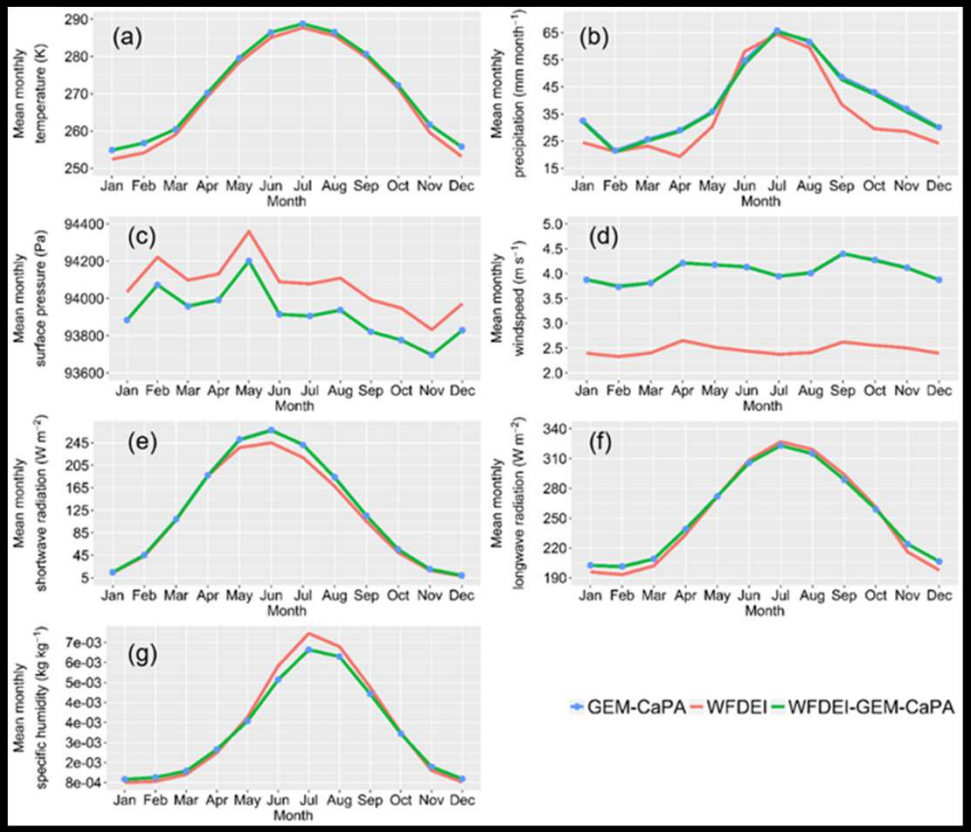
WFDEI-GEM-CAPA





WFDEI-GEM-CAPA: BIAS CORRECTION PERFORMANCE





OBTAINING **WFDEI-GEM-CAPA**

- Dataset has been already published at:
  Federated Research Data Repository (http://dx.doi.org/10.20383/101.0111)

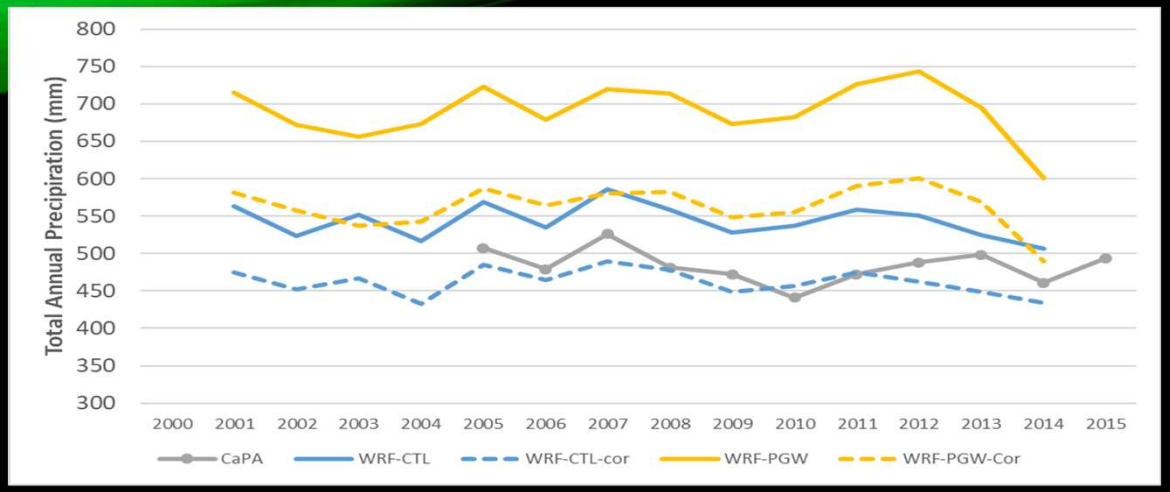
- Paper about the dataset was submitted to ESSD and is available online at:
  https://www.earth-syst-sci-data-discuss.net/essd-2018-128/

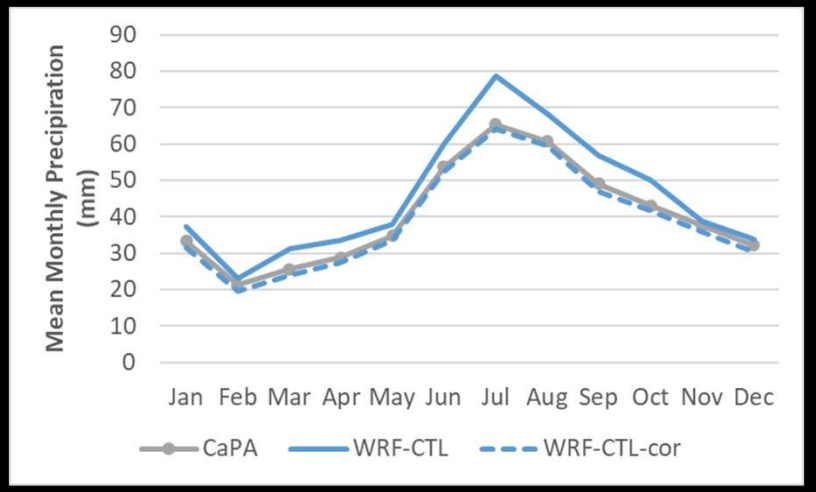
- The dataset is being used to bias correct CanRCM4 ensemble – correction is done, currently in evaluation phase – a similar publication will be prepared: **CanRCM4-WFDEI-GEM-CaPA**

WRF-GEM-CAPA

- Same procedure applied (multi-variate quantile mapping) to correct WRF_CTL and WRF_PGW over the Western Canada Domain
- Main Biases with WRF: cold in spring, more precipitation especially summer
- Main disadvantage: WRF 4km had to be aggregated to 10km (0.125°)
- Not yet published but can be made available – it is on Graham as well as the uncorrected one (which was partly made available on CaSPAr

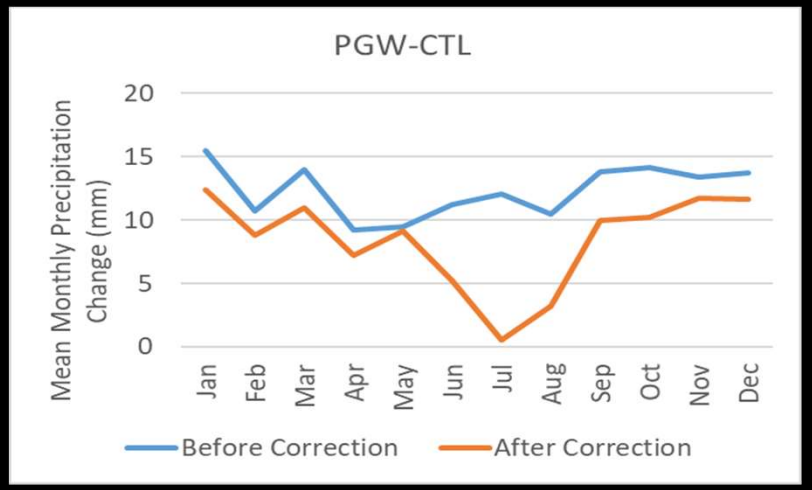
WRF-GEM-CAPA – PR



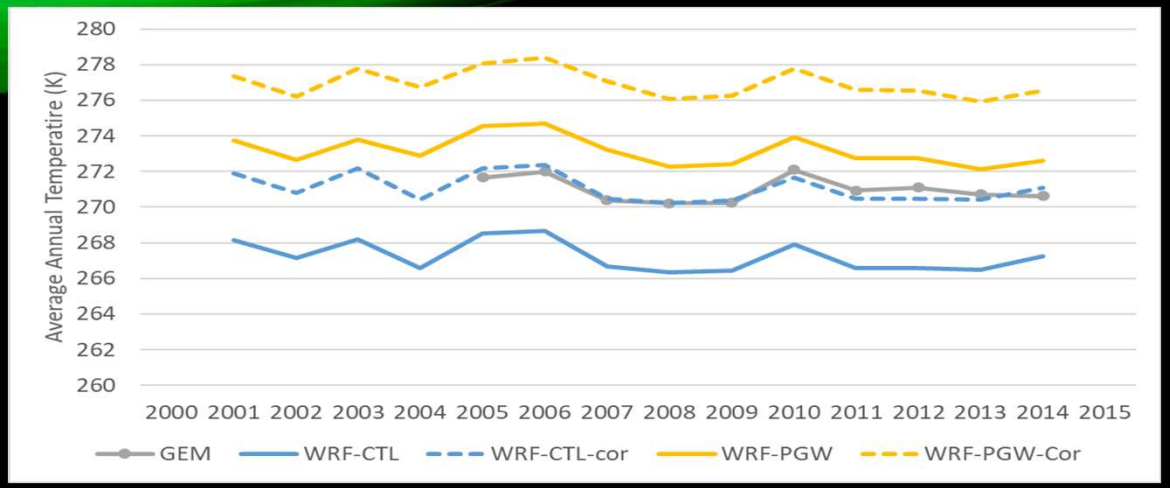


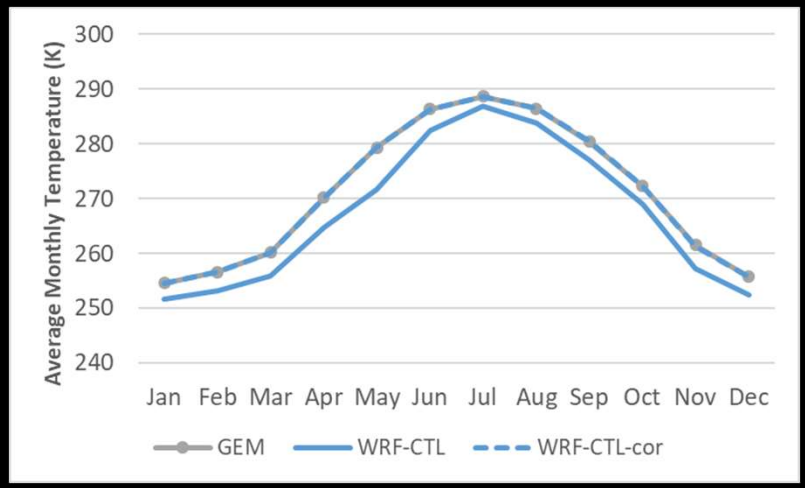
- The annual series show that the bias is corrected (WRF-CTL-Cor matches CaPA) and inter-annual variability is preserved for WRF-CTL and WRF-PGW
- Average Annual Oct 2004 - Sep 2015
  - CaPA: 486 mm
  - WRF-CTL (Before, After Correction): 550, 467 mm
  - WRF-PGW (Before, After Correction: 702, 571 mm

- The climate change signal is not preserved (PGW – CTL) after correction but better than the SV case except for summer months … may be patterns are shifting in space

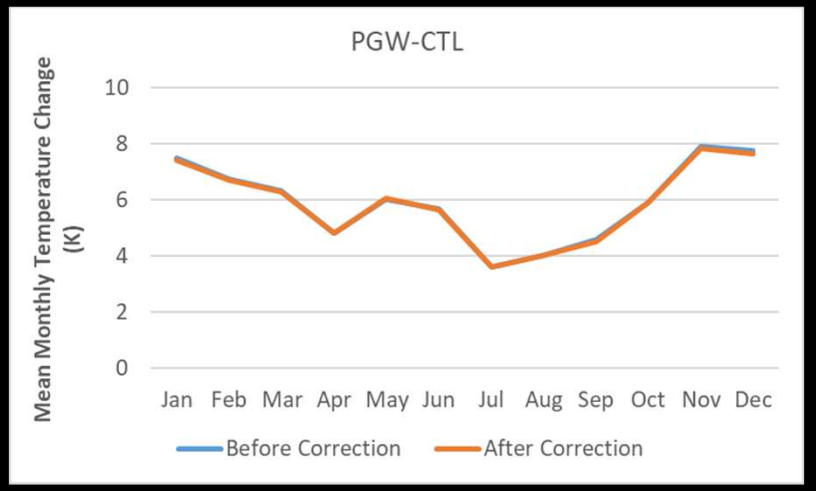


WRF-GEM-CAPA – TA





- Average Annual Oct 2004 - Sep 2015
  - GEM: 271.02 K
  - WRF-CTL (Before, After Correction): 267.17, 271.00 K
  - WRF-PGW (Before, After Correction: 273.18, 276.97 K
- The monthly distributions show that bias was corrected giving identical seasonal distribution to GEM over the correction period
- The climate change signal is preserved (PGW – CTL) after correction



SOME NOTES

- LEAP YEARS
  - CanRCM4 uses 365-day Calendar
  - We removed Feb 29 from WFDEI and GEM-CaPA prior to Bias Correction
  - WFEDEI-GEM-CaPA has 365-day Calendar
  - Quick Fix: repeat Feb 28 data for Feb 29 on Leap years
  - Suggestions?

  - WRF-GEM-CaPA has Leap years

- Observation Height
  - MESH requires height for humidity& temperature and windspeed
  - GEM-CaPA is at 40m
  - WFDEI is surface (2 and 10m)
  - WFDEI-GEM-CaPA is at 40m
  - CanRCM4 is available at Surface and LML (about 38m but varies)
  - CanRCM4-WFDEI-GEM-CaPA is at 40m
  - WRF is surface
  - WRF-GEM-CaPA is at 40m

SUMMARY

- New composite datasets have been created:
  - WFDEI-GEM-CaPA (1979-2016) 3h 0.125 NA
  - WRF-GEM-CaPA (2000-2015) 1h 0.125 WC
  - CanRCM4-WFDEI-GEM-CaPA 3h 0.125 NA
- Original ones remain for comparison
- Hydrological modelling is used for further evaluation
- Is GEM-CaPA good enough to base all the correction on?