



Statistical post-processing of GCM forecasts

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Introduction

Aims of post-processing

- Match forecasts to application scale
- Generate accurate and reliable forecasts
 - Remove bias
 - Quantify uncertainty
- Extract as much skill from the model as possible
- Shield users from poor forecasts

Many post-processing methods exist

- Additive / multiplicative bias correction [Crochemore et al. \(2017\)](#); [Ines and Hansen \(2006\)](#)
- Quantile mapping [Crochemore et al. \(2017\)](#); [Ines and Hansen \(2017\)](#)
- Conditional resampling of historical rainfall [Beckers et al. \(2016\)](#); [Wang et al. \(2011\)](#)
- Analogue downscaling [Shao and Li \(2013\)](#); [Charles et al. \(2013\)](#)
- Non-homogenous hidden Markov model [Pineda and Willems \(2016\)](#)
- Disaggregation through weather generation [Hansen and Ines. \(2015\)](#)
- Dynamical downscaling (RCMs) [Xue et al. \(2014\)](#)

BJP post-processing

- Multivariate joint probability model with parameter uncertainty
- Ens-mean predictors, model generated uncertainty
- Models forecast/obs correlation
- Plus methods for:
 - Data transformation (non-normal variables)
 - Zero-value handling (e.g. rainfall)
 - Imposing spatial / temporal correlation structures (Schaake Shuffle)
 - Daily, monthly, seasonal

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A new method for post-processing daily sub-seasonal to seasonal rainfall forecasts from GCMs and evaluation for 12 Australian catchments

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Abstract. Rainfall forecasts are an integral part of hydrological forecasting systems of sub-daily to seasonal time scales. In seasonal forecasting, global climate models (GCMs) are the go-to source for rainfall forecasts. However, for hydrological applications, GCM forecasts are often biased and unreliable in accuracy, spread, and metric calibration is required before use. There are sophisticated statistical techniques for calibrating monthly and seasonal aggregations of the forecasts. However, calibration of seasonal forecasts at the daily time step typically uses very simple statistical methods or climate analogue methods. These methods generally lack the exploitation of sub-daily rainfall, or daily and coherent forecasts of daily amounts, and seasonal accumulated totals. In this study, we propose and evaluate a Rainfall Post-Processing method for Seasonal forecasts (RPPS) based on the Bayesian joint probability approach for calibrating daily forecasts and the Schaake Shuffle approach for correcting the daily ensemble members of different lead times. We apply the method to post-process ACCIS30-3 forecasts for 12 seasonal and sub-seasonal catchments across Australia and for 12 installation sites. RPPS significantly reduces bias in raw forecasts and improves both skill and reliability. RPPS forecasts are more skillful and reliable than forecasts

4554 MONTHLY WEATHER RE

Toward Accurate and Reliable Forecasts of A

by Calibrating and Merging Multiple

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ABSTRACT

The majority of operational climate models produce near perfect seasonal rainfall forecasts from coupled general circulation models (CGCMs). Seasonal rainfall forecasting is highly challenging, and GCM rainfall forecasts are still poor for many regions and seasons. Additionally, seasonal forecasts are not well understood because the forecast probabilities are statistically unstable. A common strategy employed to improve the overall accuracy and reliability of GCM forecasts is to merge forecasts from multiple models into a multimodel ensemble (MME). The most widely used technique is to simply pool all of the forecast ensemble members from multiple GCMs, even when it is known as a nonoptimal choice. In this paper, seasonal rainfall forecasts are produced using the Predictive Ocean-Atmosphere Model for Australia (POAMA). In this paper, the authors demonstrate that an ensemble approach based on merging forecasts from POAMA with those from three operational models in the ENSEMBLE-4 dataset markedly improves forecast accuracy. The authors propose and evaluate a merging procedure for producing MMEs. This procedure is implemented in the individual MMs, called here by being Bayesian joint probability forecasts, and the overall parameter uncertainty. The calibration task is statistically more complex, specifically, the individual calibration of the GCMs is required to improve forecast accuracy. The authors demonstrate that the use of GCMs results in better forecast accuracy, while maintaining reliability, than using POAMA only. Compared with using equal-weight merging, MME weighting produces higher skill and reliability.

Ensemble by post-processing coupled general circulation model output

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ARTICLE DISCUSSION
Monthly atmospheric forecasts with long lead times are being sought by water managers in Australia to help plan for the future. For many seasons, the most accurate forecasts are produced by coupled general circulation models (CGCMs) or producer monthly rainfall forecasts for the period of November and December. Using GCM rainfall forecasts and one CGCM for surface temperature forecasts, the Schaake Shuffle is used to produce ensemble members of individual models to form monthly rainfall forecasts. The authors demonstrate that the use of GCMs results in better forecast accuracy, while maintaining reliability, than using POAMA only. Compared with using equal-weight merging, MME weighting produces higher skill and reliability.

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Journal of Geophysics Research
RESEARCH ARTICLE
HYDROLOGICAL CYCLES
precipitation over China

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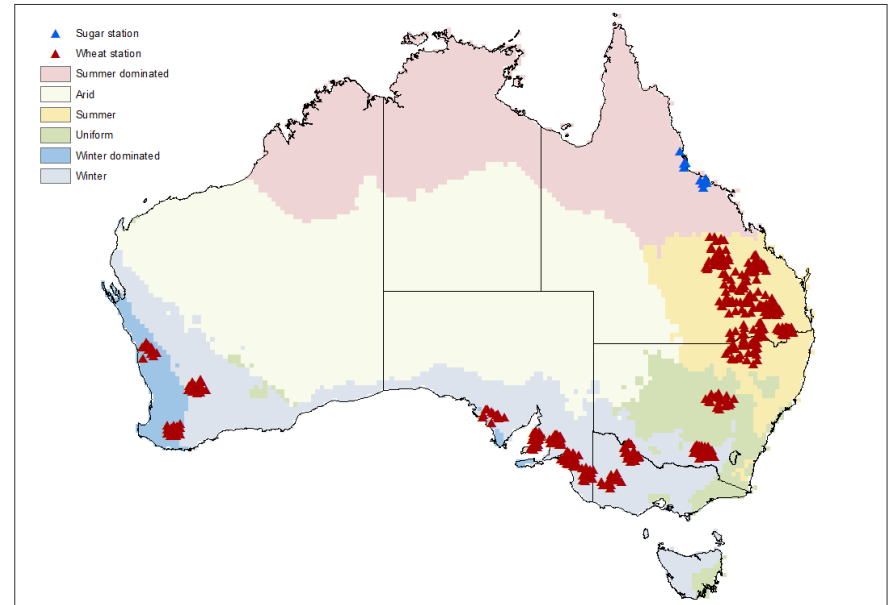
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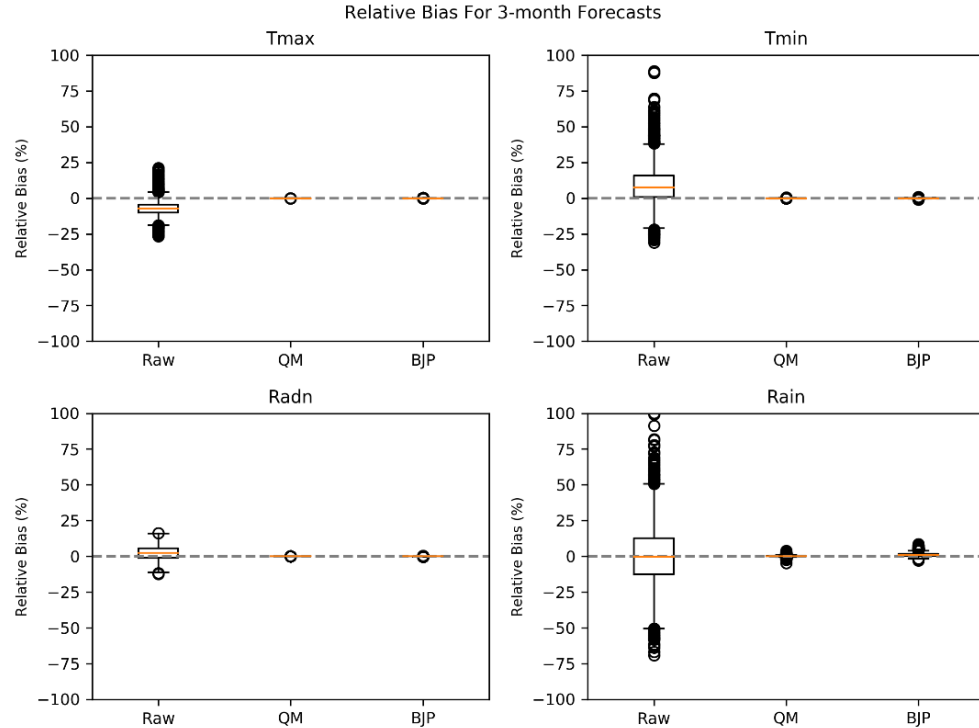
Examples and applications

Post-processing seasonal forecasts

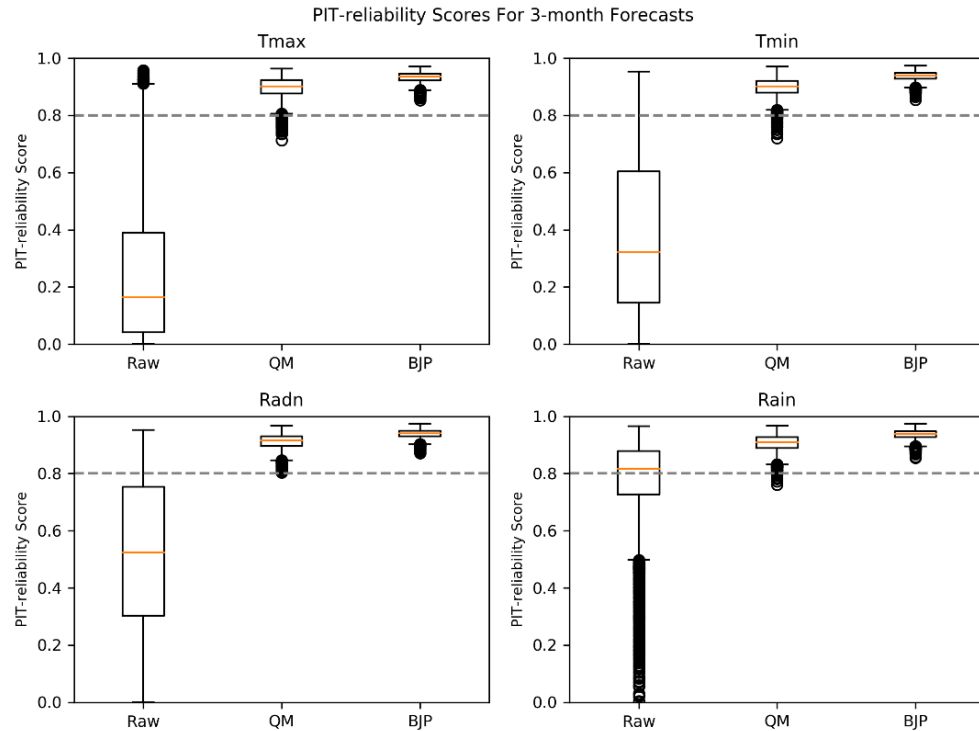
- ECMWF Sys4
- Tmin, Tmax, Rain, Radn
- 3-month forecasts
- 1981-2016
- Compare BJP with raw & QM



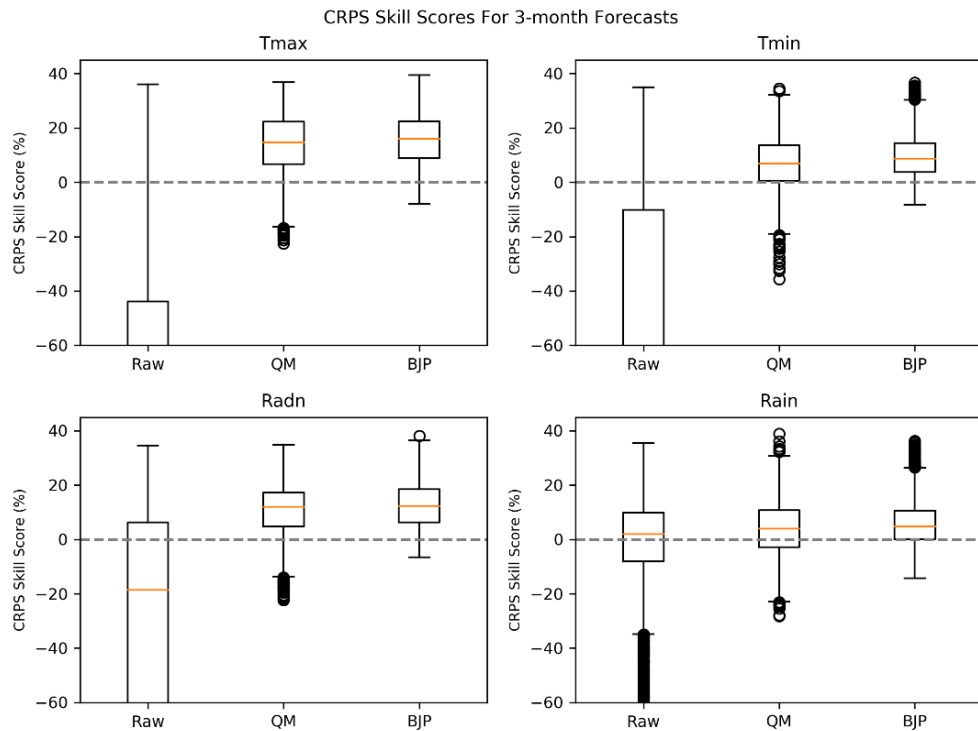
Post-processing removes bias



Post-processing improves reliability

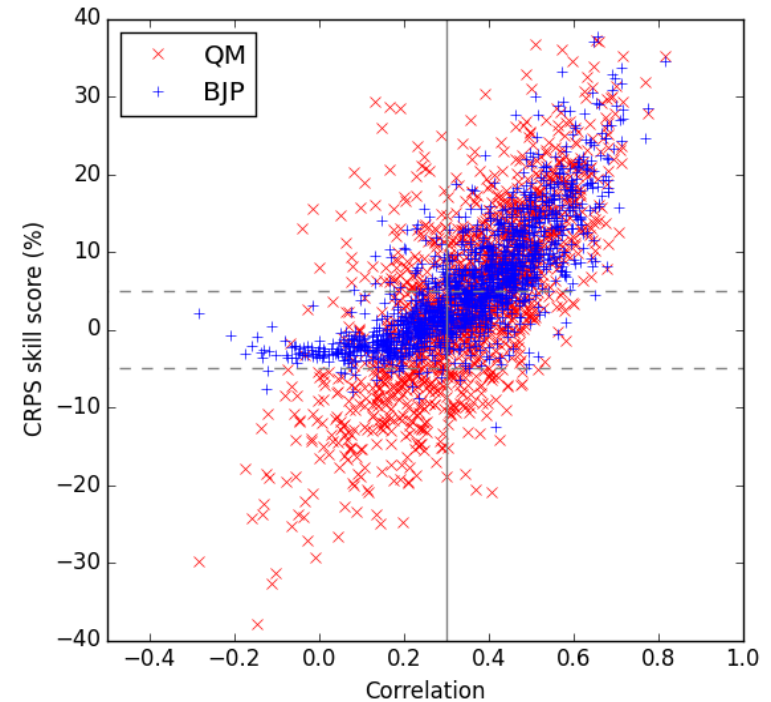


Post-processing improves skill



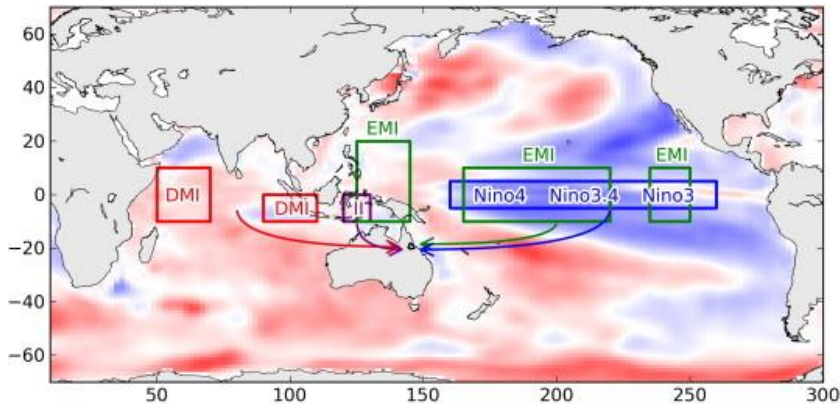
BJP provides better overall calibration than QM

- BJP returns forecasts to climatology when there is little skill

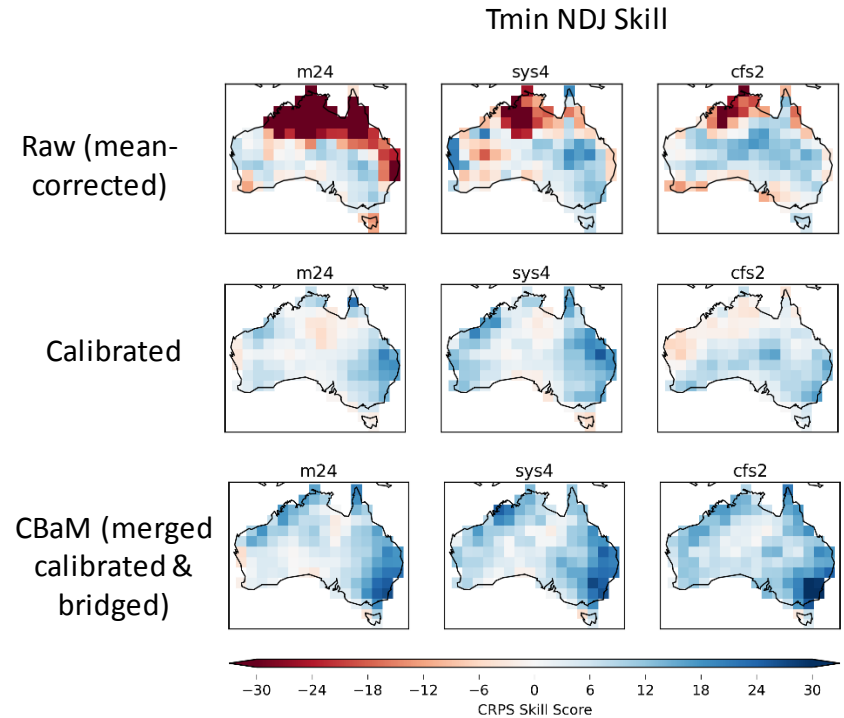


Zhao, T., J.C. Bennett, Q.J. Wang, A. Schepen, A.W. Wood, D.E. Robertson, and M. Ramos (2017)
How Suitable is Quantile Mapping For Postprocessing GCM Precipitation Forecasts?
J. Climate, 30, 3185–3196, <https://doi.org/10.1175/JCLI-D-16-0652.1>

BJP permits alternative or multiple predictors

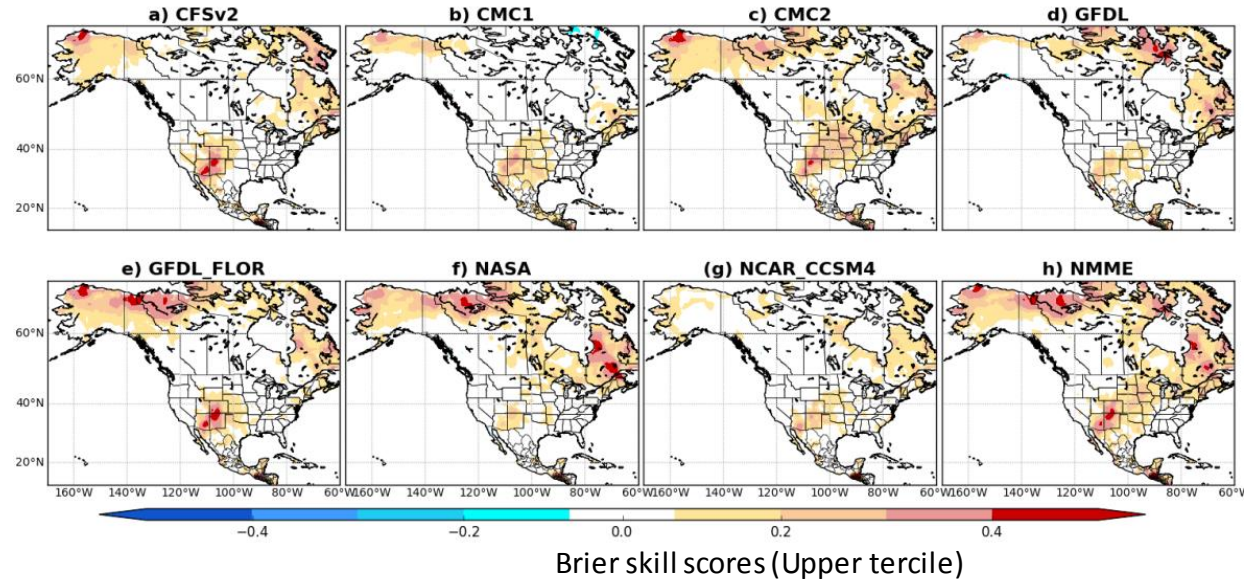


CBaM: Calibration, Bridging and Merging
BJP + BMA



CBaM can combine multiple GCM forecasts

- NMME
- 3-month temperature outlook

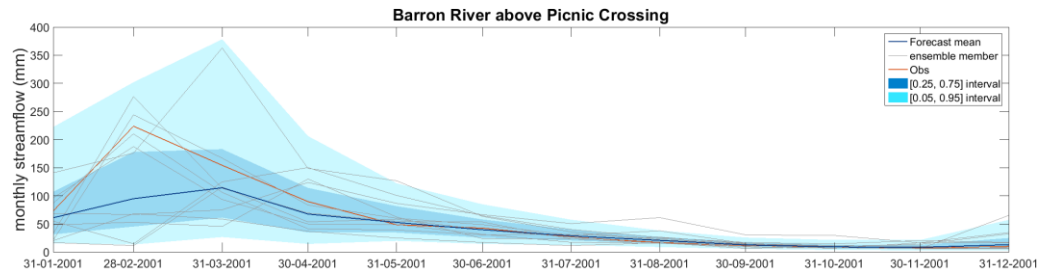
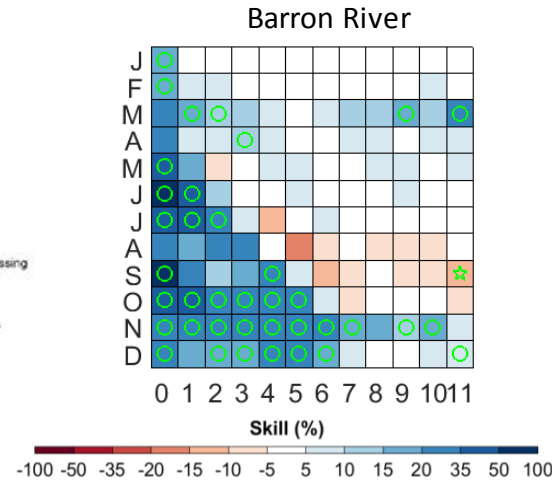
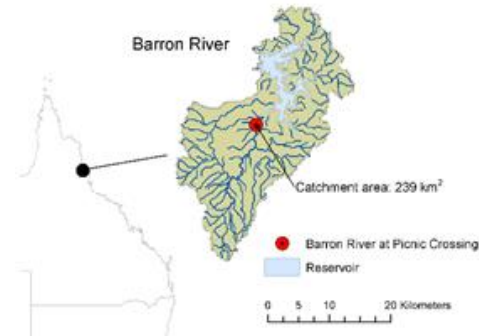
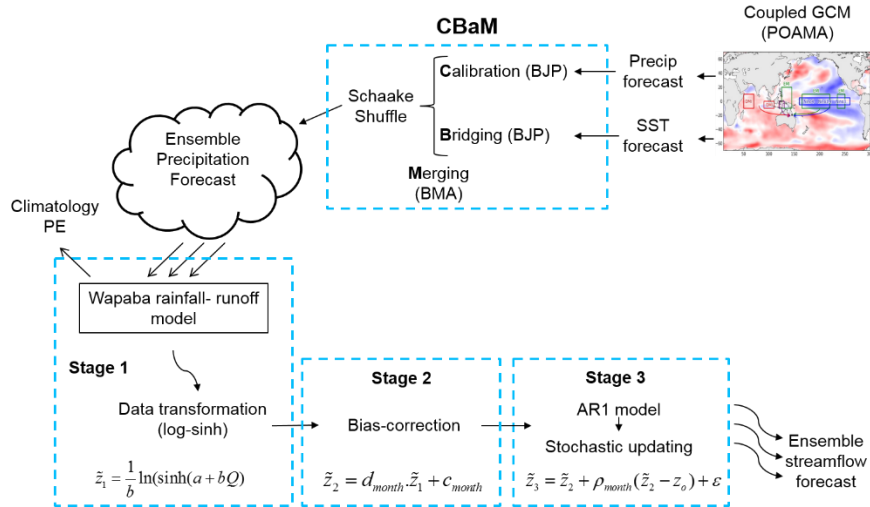


S Strazzo, DC Collins, A Schepen, QJ Wang, E Becker, L Jia (2018)

Application of a hybrid statistical-dynamical prediction system to seasonal forecasts of North American temperature and precipitation

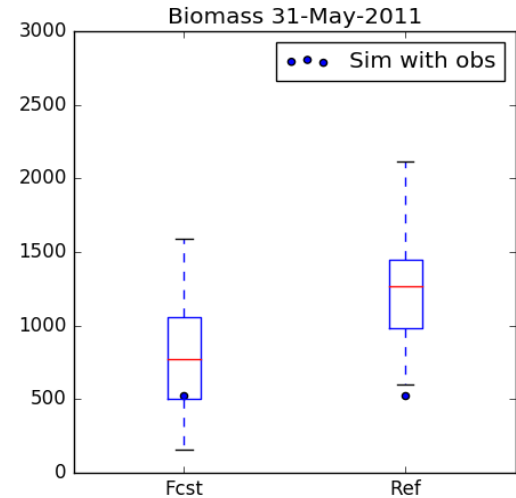
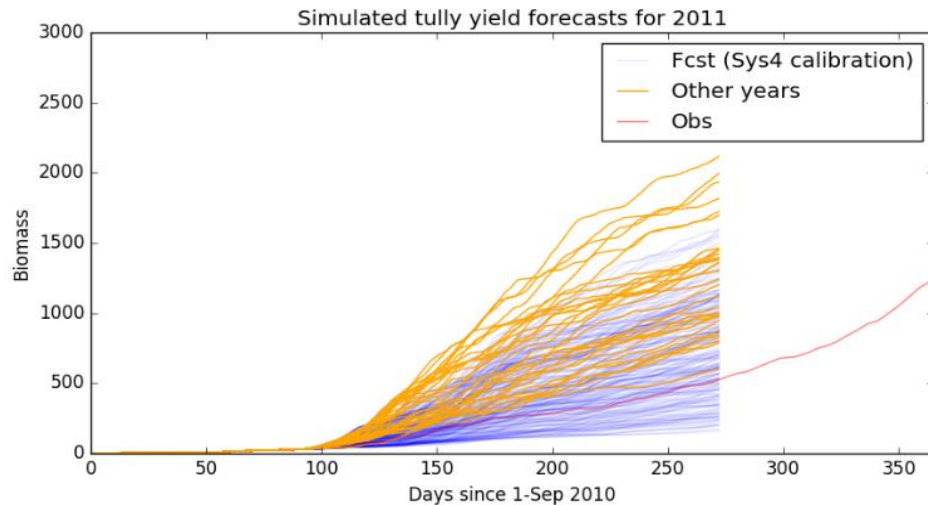
Monthly Weather Review (In Review)

Example application 1: monthly streamflow forecasting



Example application 2: daily crop yield forecasts

Sys4 (rain,tmin,tmax,radn) → BJP-daily → Schaake Shuffle → APSIM (sugar) → Biomass



Future work and summary

New challenges

- Using all ensemble members in the calibration
- Embedding calibration in CAFE forecast-analysis system (ensemble rich, hindcast poor)
- Multi-time-scale post-processing (days, months, seasons, years)
- Post-processing spatial fields

Summary

- Improving the usefulness of GCM forecasts at grid and application scales using BJP and other methods
- Capturing skill where it is available and capitalising on the strengths of multiple models through forecast combination
- Generating ensemble streamflow / crop outlooks consistent with climate forecasts
- Developing new methods to work with ensemble systems and across multiple time horizons

Thank you

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