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)

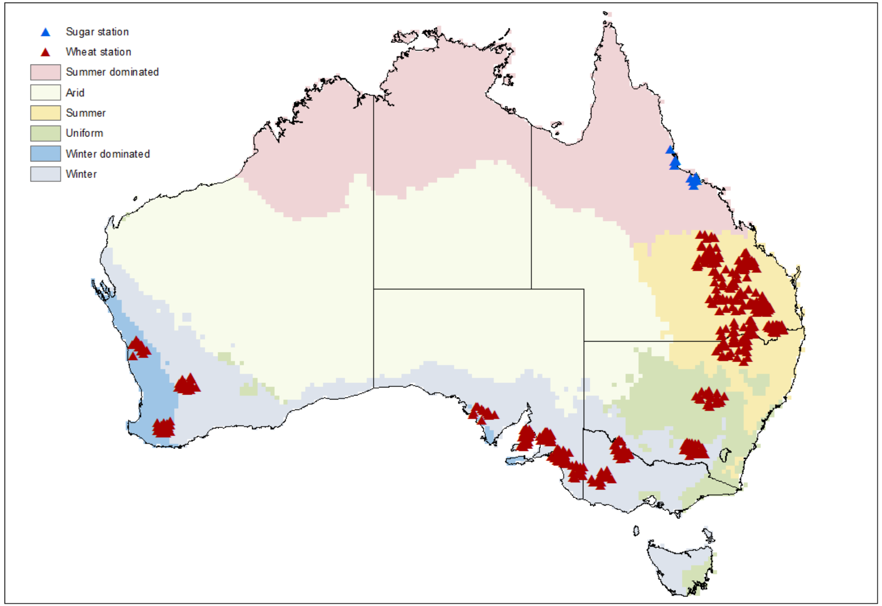
BJP post-processing

- 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

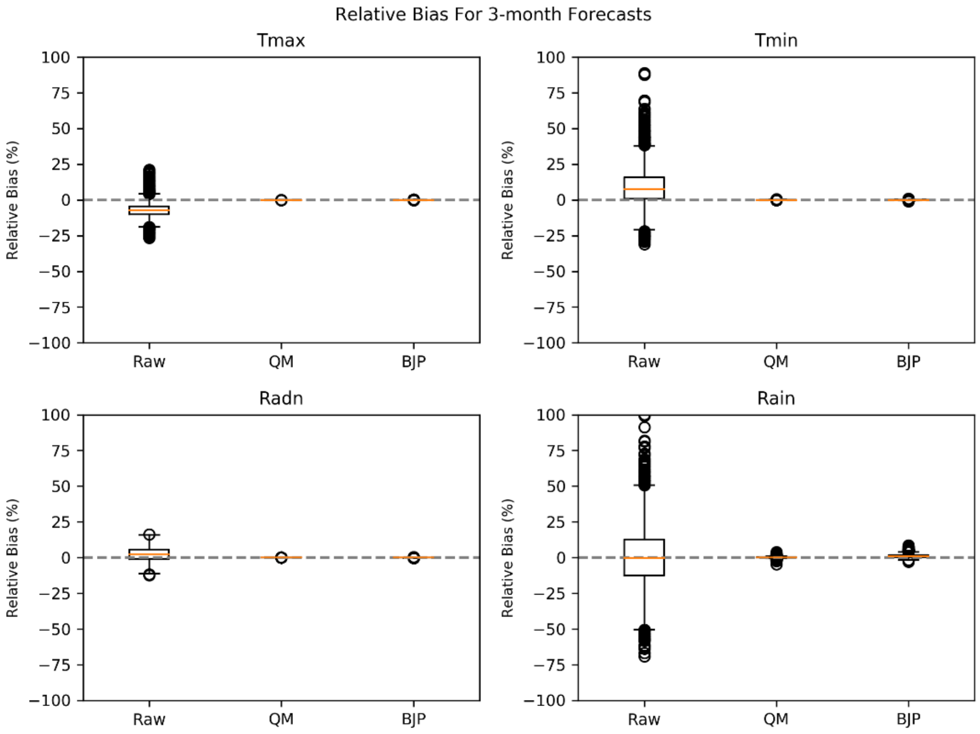
Examples and applications

Post-processing seasonal forecasts

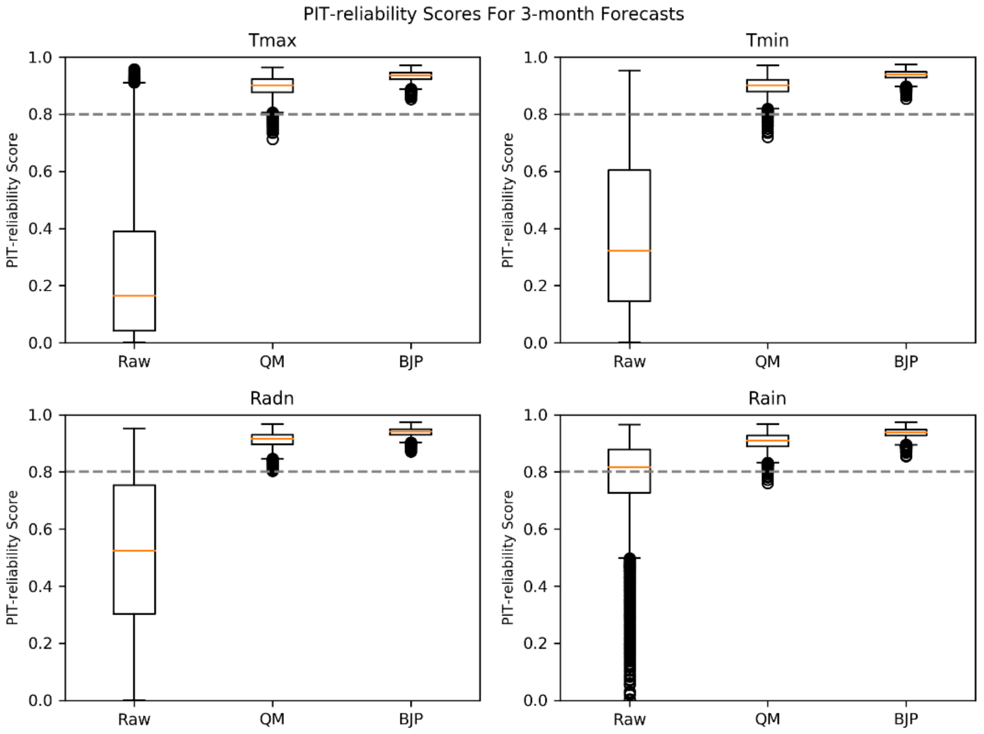
- ECMWF Sys4
- Tmin, Tmax, Rain, Radn
- 3-month forecasts
- 1981-2016
- Compare BJP with raw & QM



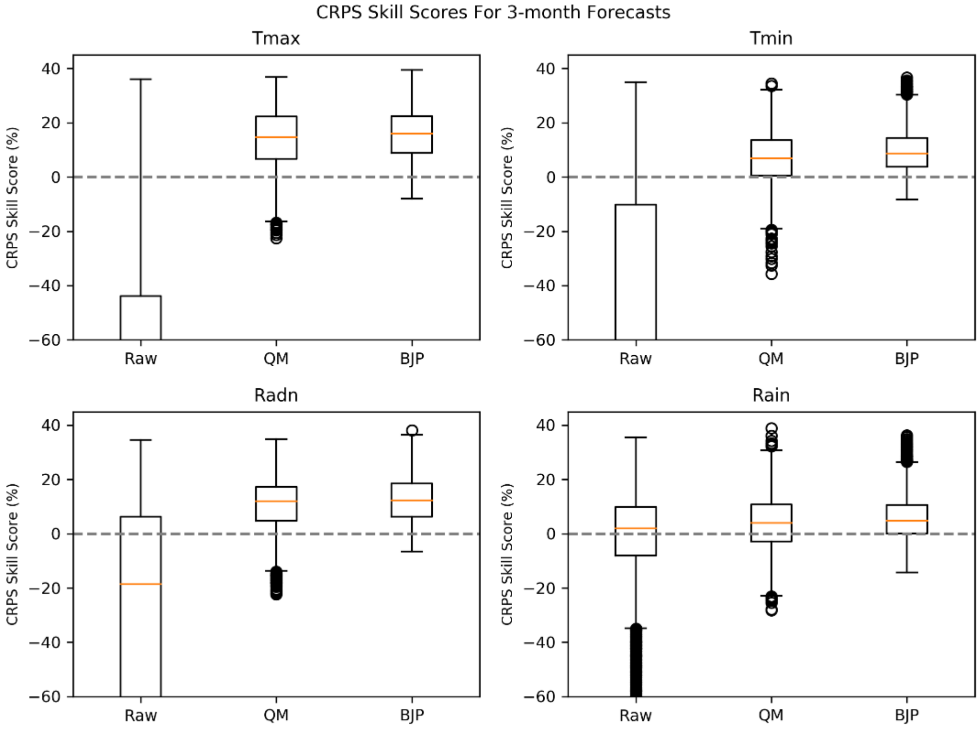
Post-processing removes bias



Post-processing improves reliability

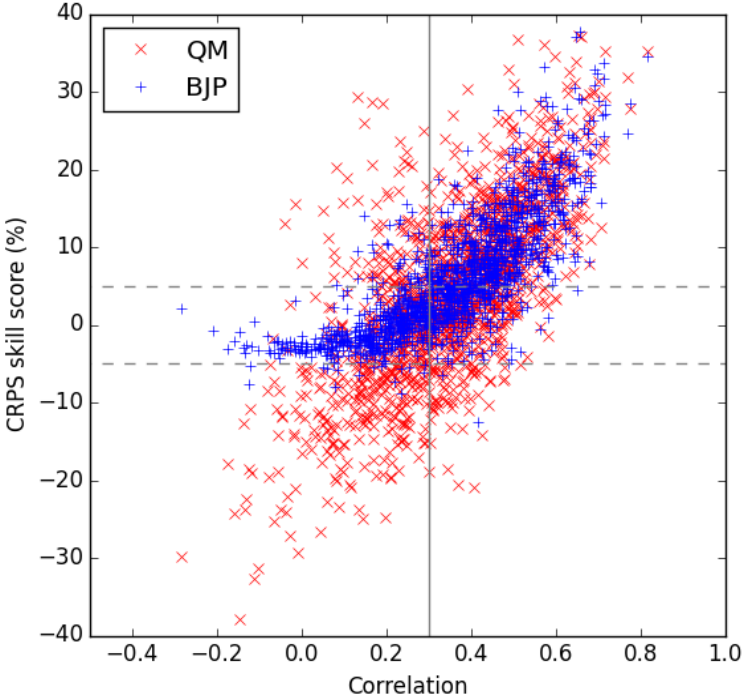


Post-processing improves skill



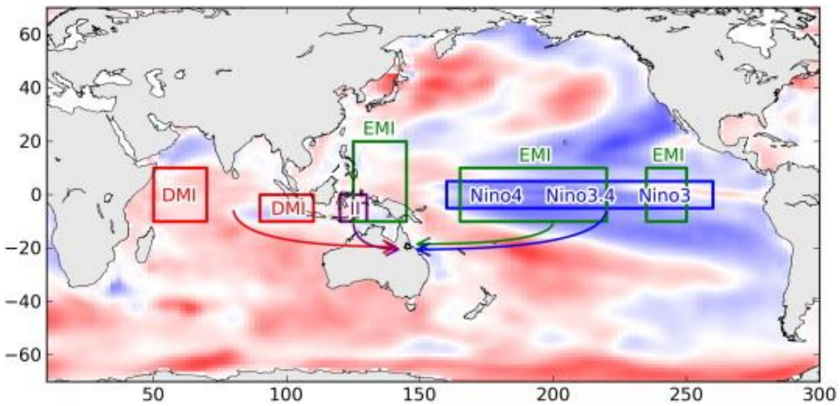
BJP provides better overall calibration than QM

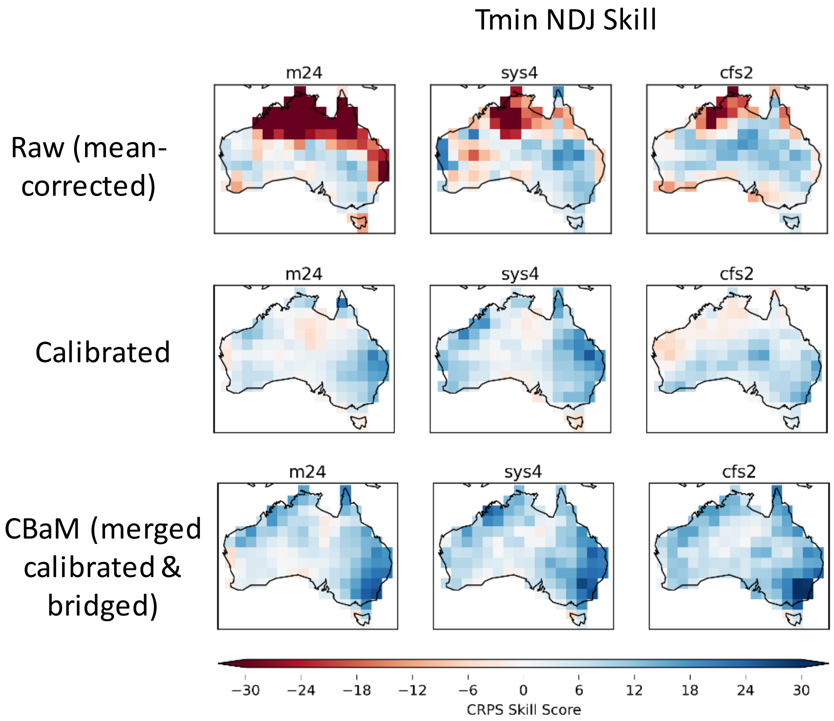
- BJP returns forecasts to climatology when there is little skill



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



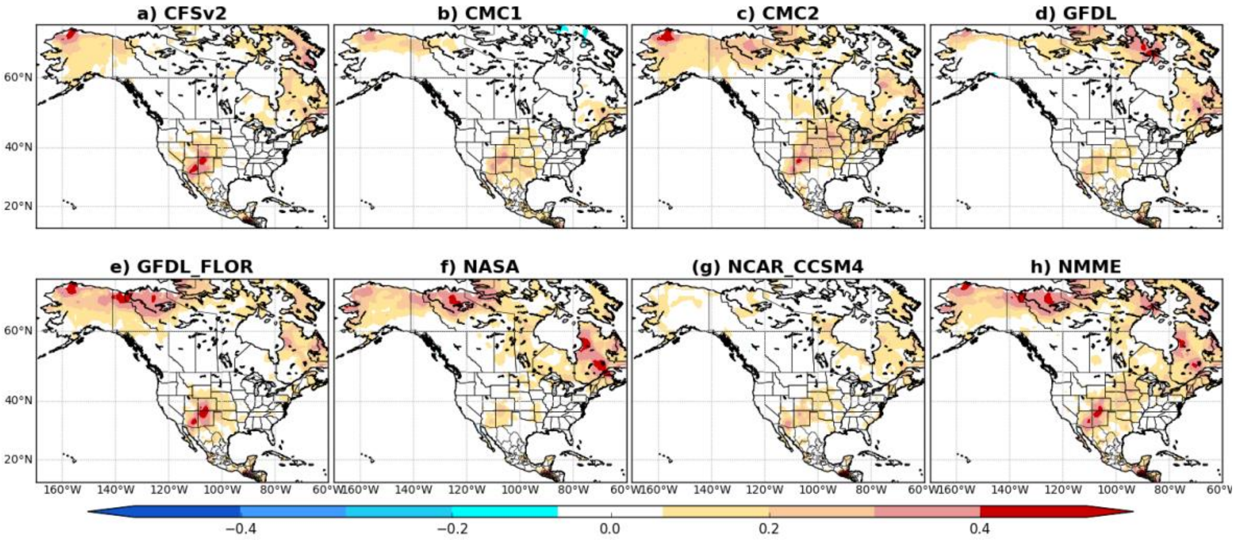


CBaM: Calibration, Bridging and Merging

BJP + BMA

CBaM can combine multiple GCM forecasts

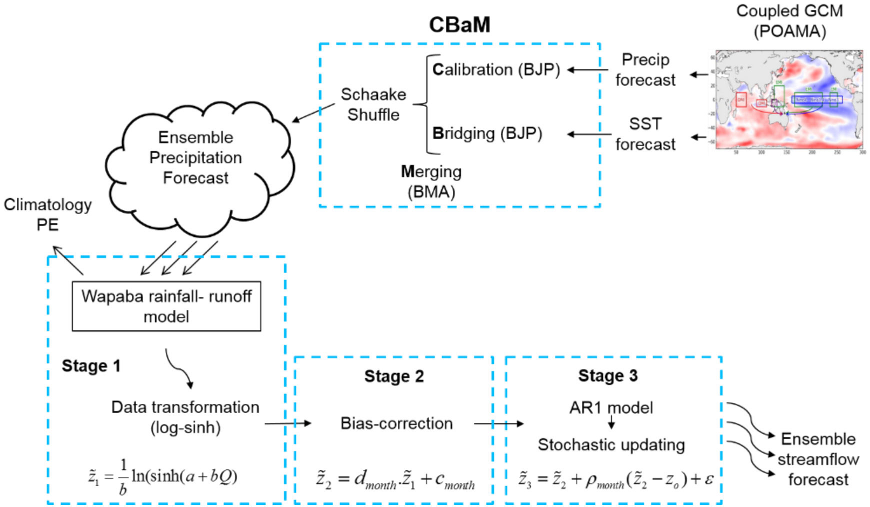
- NMME
- 3-month temperature outlook

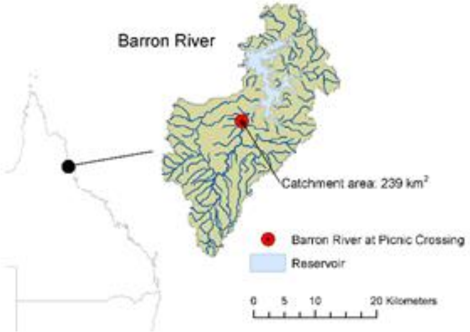


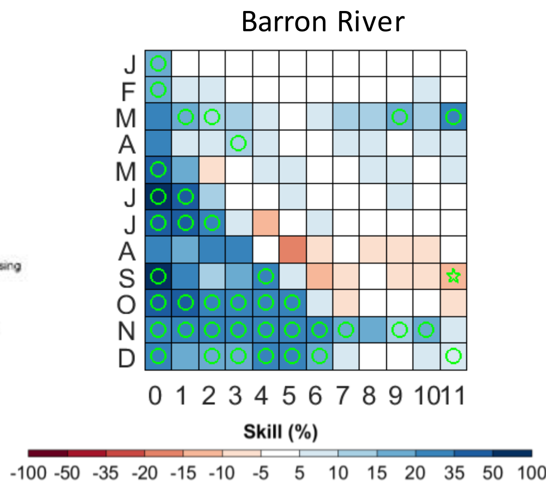
Brier skill scores (Upper tercile)

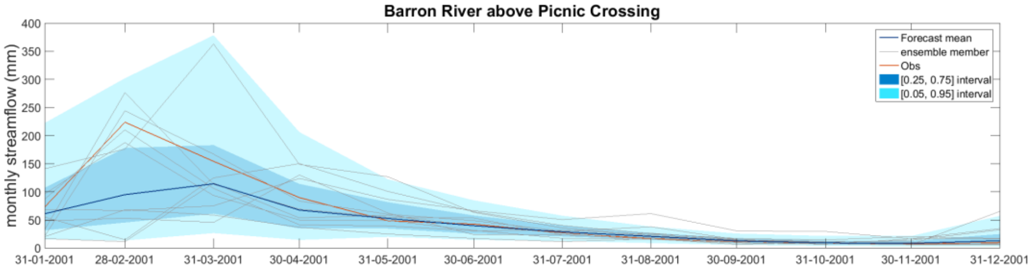
S Strazzo, DC Collins, A Schepen, QJ Wang, E Becker, L Jia (2018)
Application of a hybrid statistical-dynamical prediction system to seasonal forecasts of North American temperature and precipitation
Monthly Weather Review (In Review)

Example application 1: monthly streamflow forecasting



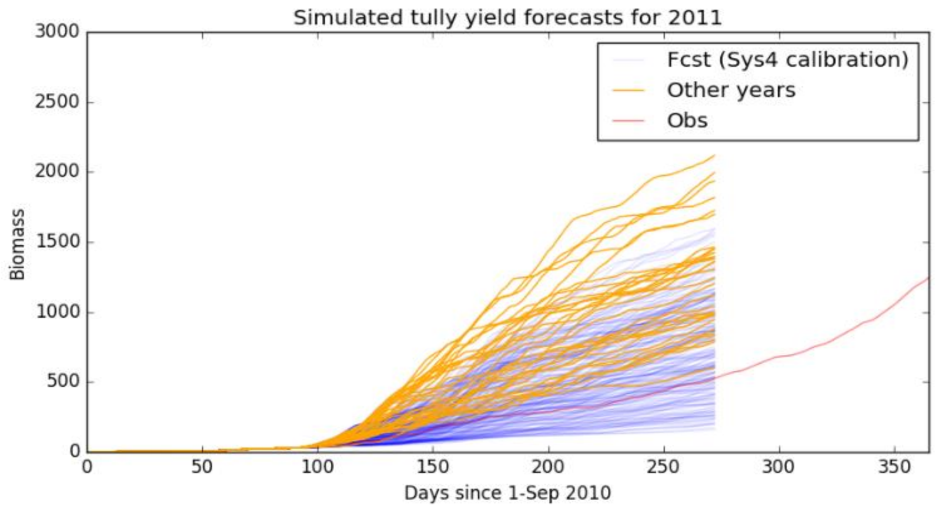


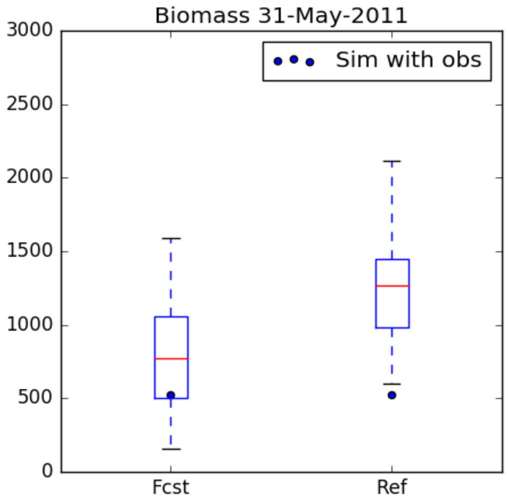




Example application 2: daily crop yield forecasts

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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