BARPA: Advancing the Australian regional climate information for decision making

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1. Introduction

- The **Australian Climate Service (ACS)** aims to provide improved data, intelligence and expert advice on climate risks of natural hazards and climate extremes to support and inform decision-making in Australia.
- A key tool of the ACS is regional climate modelling to downscale global climate model (GCM) simulations to **regional and convection-permitting resolutions**.
- Guided by **National Partnership for Climate Projections (NPCP)** for delivery of nationally aligned, sustainable, and integrated approach for Australian projections between state and territory governments, CSIRO, Bureau of Meteorology and universities (Figure 1). We also follow **CORDEX-CMIP6** international standards.

2. Modelling framework and model setup

- CMIP6 models are selected under a 'sparse matrix' approach based on their performance for the Indo-Pacific and Australia, representation of the full CMIP6 ensemble, data availability and model independence (*Grose et al. doi:10.1016/j.cliser.2023.100368*).
- ACS and NPCP support **a diversity of models to form a national ensemble of projections**. This includes the Bureau's Atmospheric Regional Projections for Australia (BARPA) that uses Bureau's atmosphere/land models for reanalysis, NWP and seasonal forecasting.

BARPA-R Regional Scale Projections for CORDEX-CMIP6

- UKMO Unified Model for atmosphere & JULES for land surface: 0.154° horizontal grid, L63 with 40 km lid, CORDEX-Australasia domain, HadREM3-GA7-05 science configuration (*Su et al., Bureau Research Report 069*)
- Boundary conditions (6-hourly LBC and SST) from GCMs and upper tropospheric nudging (11km above surface) of potential temperature and horizontal winds. Easy Aerosol scheme for radiative forcing.
- Experiments include, Evaluation run ERA5 (1979 – 2022) & 7xCMIP6 historical, SSP1-2.6 & SSP3-7.0 (1960 – 2100). CMIP6 models are ACCESS-CM2, ACCESS-ESM1-5, EC-Earth3, CMCC-ESM2, NortESM2-MM, CESM2, MPI-ESM1-2-HR

BARPA-C Convective Scale Projection over Australia

- UKMO UM & JULES: 0.04° horizontal grid, L70 with 40 km lid, RAL3.2 configuration, nested in BARPA-R, with hourly LBC.
- Evaluation run ERA5 (2012 – 2022) & 3xCMIP6 historical & SSP3-7.0 (targeting 1995-2060 with possible extension to 2080).

3. Evaluation

BARPA-R – production near completed (*Howard et al., paper in review*)

- BARPA-R generally performs on par with ERA5.
- Overall biases: underestimation of winter diurnal temperature range, wet rainfall bias in summer
- BARPA-R captures stronger wind conditions than ERA5, in better agreement with observed statistics.
- Long-term trends and modes of variability (ENSO, SAM, IOD) well captured in rainfall and near surface temperature.

BARPA-C – Evaluation run in progress

- Trials shows promising results for extreme events

4. Future Work

- Focus on convection permitting projections with BARPA-C
- Run and evaluate 10-year ERA5 evaluation trial
- Select GCM ensemble to downscale with BARPA-C

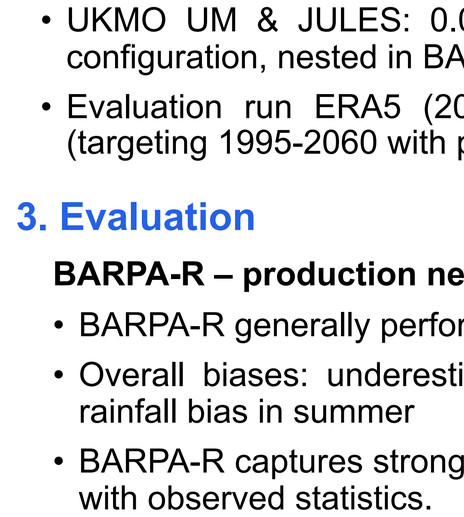

Fig 7: Eyewall and vorticity rings in BARPA-C (top) and BARPA-R (bottom).

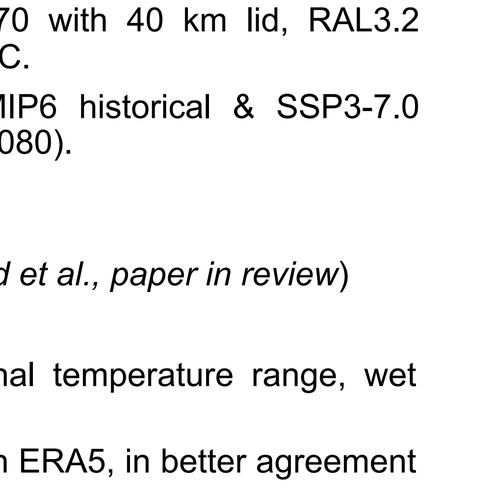

Fig 8: BARPA-R and BARPA-C wind gusts compared to observations.

BARPA-C shows more realistic tropical cyclone structures, and improves on overestimation of wind gust in BARPA-R.

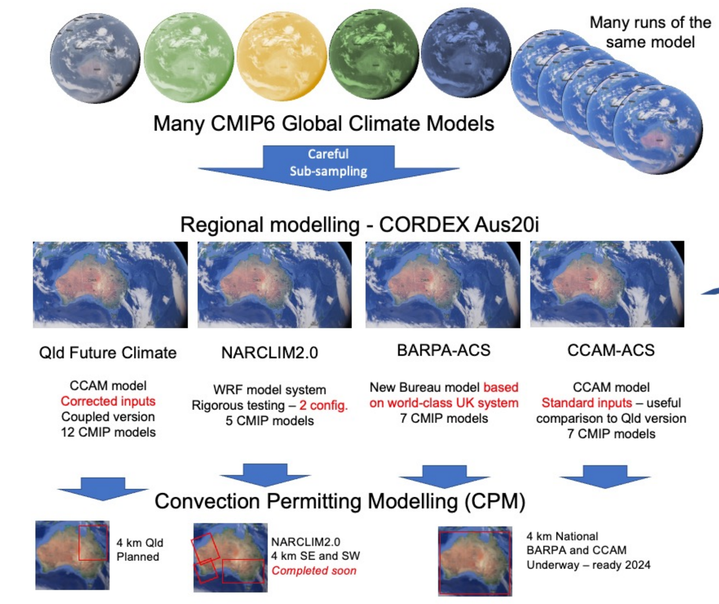

Figure 1: BARPA modelling contributes to National Partnership for Climate Projections (NPCP), to deliver Climate Projections Roadmap for Australia (www.dcceew.gov.au).

Sampling of CMIP and CORDEX dimensions in a 'sparse matrix'

	Qld	NarCLIM2.0	BARPA-ACS	CCAM-ACS
GCM 1	X	X		X
GCM 2	X			
GCM 3		X		
GCM 4			X	
GCM 5	X	X		X
…		X		

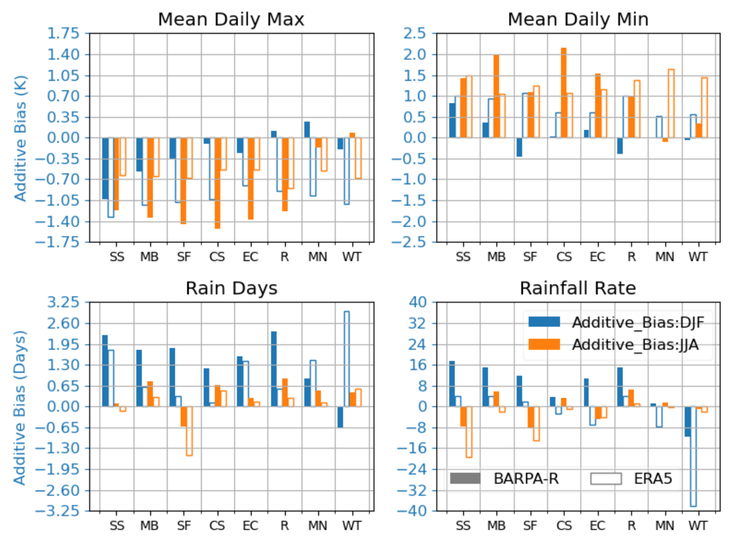

Figure 2: Temperature and rainfall biases against observations for different NRM clusters. BARPA-R: filled bars, ERA5: unfilled bars.

Biases in BARPA-R are generally comparable to those of ERA5. Reduced diurnal temperature range in winter.

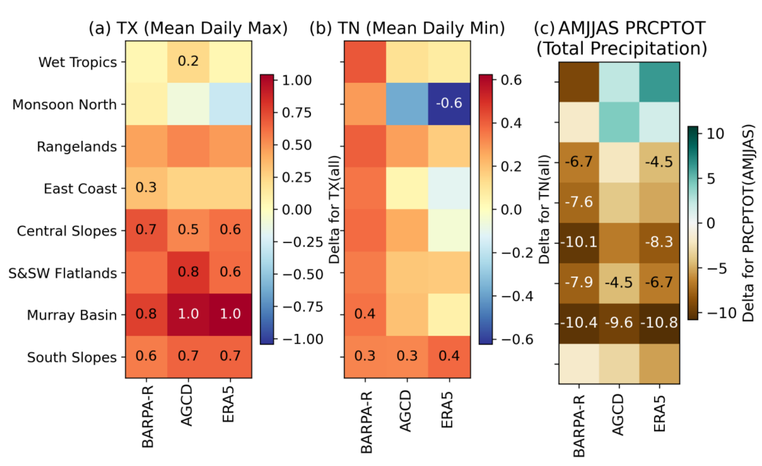

Figure 3: Decadal trends in BARPA-R for mean daily maximum (a), minimum (b) and total precipitation.

Annual Tmax warming and winter precip drying trends in BARPA-R are comparable to observed. Tmin trend is stronger than obs but not significant.

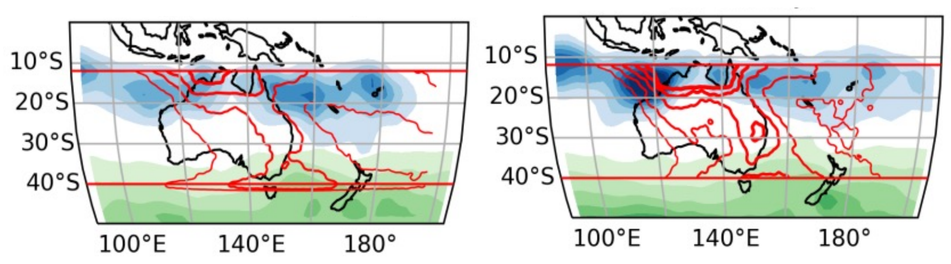

Figure 4: Tropical Cyclone, extra-tropical cyclone and NW Cloud Band distributions for (left) BARPA-R and (right) observations.
BARPA-R shows generally good performance, albeit too few cloud bands.

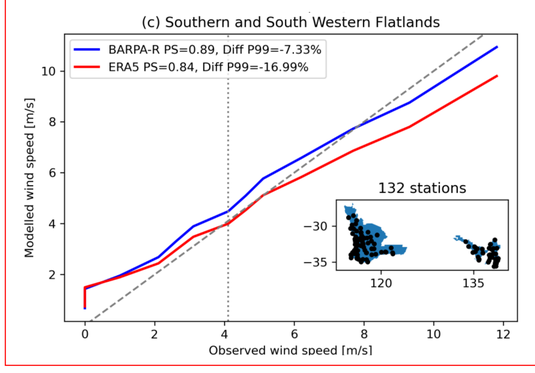

Figure 5: Wind speed QQ plot comparing wind speeds to station observations in southern and southwestern flatlands.

BARPA-R captures stronger wind statistics, see in observations, than simulated in ERA5.

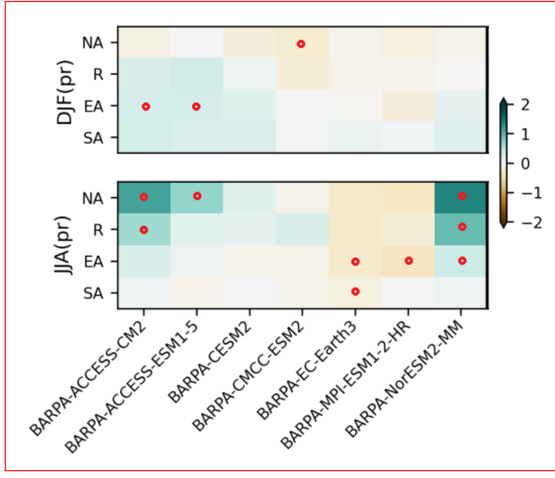

Figure 6: Benchmark assessment of fractional precipitation bias across the BARPA-R ensemble by super-NRM clusters (N/E/S Australia and Rangelands). The benchmark is set as the ensemble mean of CMIP6 models downscaled by CORDEX-Australasia.

BARPA-R shows particularly good performance in DJF compared to CMIP6. We are experimenting with defining objective benchmarks to evaluate our models.

Data to be available via National Computational Infrastructure (NCI) Data Collection nci.org.au. This work is funded by the Australian Climate Service.