The Bureau of Meteorology

BARPA-C: Kilometre-scale climate modelling development over Australia

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Funded by Australia Climate Service

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Convective scale climate projections over Australia

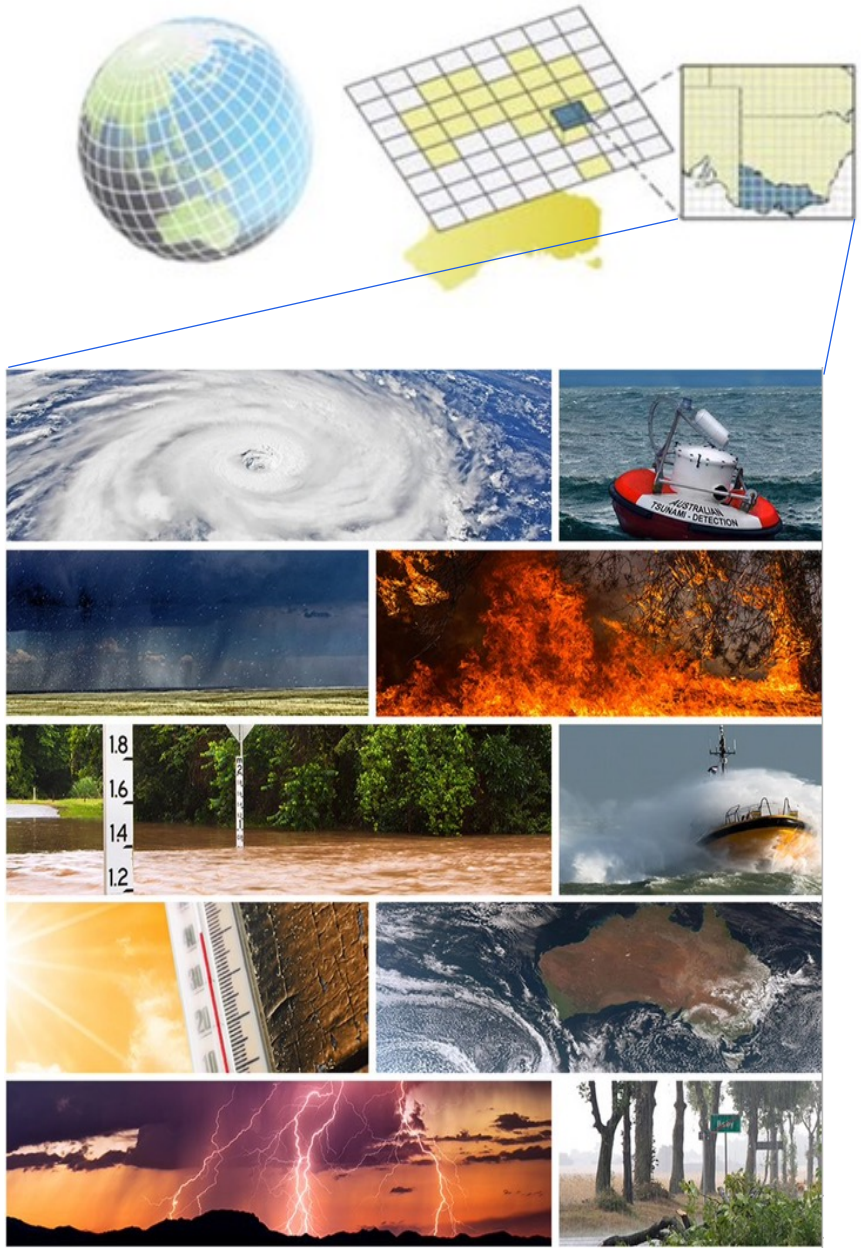
Motivation

- Australia's climate is highly variable with extreme weather events
- Many types of extreme events projected to become more extreme with climate change
- Increasing need for robust fine-scale present and future climate information

Agenda

- What is BARPA – BOM Atmospheric Regional Projections for Australia?
- Convective-scale experimental designs
- BARPA trial results

Also see Poster *Stassen et al., BARPA: Advancing the Australian regional climate information for decision making*



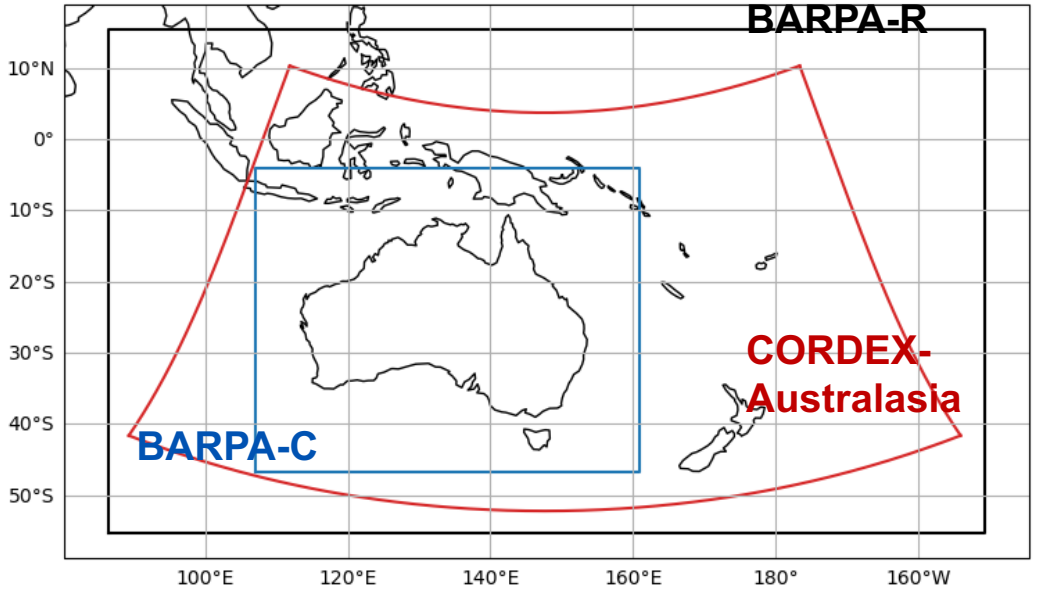
BARPA Model Specifications

BARPA-R: Regional-Scale Downscaling at 17 km

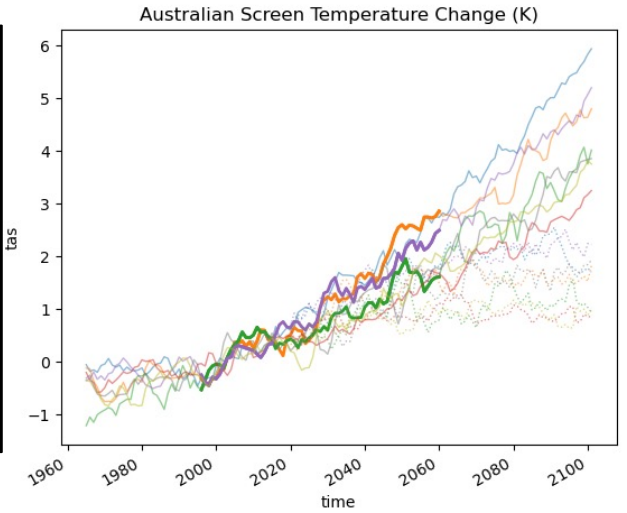
- 7 GCMs
- 4 experiments: evaluation, historical, ssp126 and ssp370.
- 1960 – 2100
- Atmosphere: UM vn11.9 GA7+fountain buster+GA8 convection
- Land: Jules vn6.0
- Postprocessing & QC workflows to CORDEX data standards

BARPA-C: Convective-permitting Scale Downscaling at 4.4 km

- 3 GCMs (tbc), nested in BARPA-R
- 3 experiments: 10-yr evaluation, historical, ssp370
- 1995 – 2060
- 1-year trial (2013)
- Postprocessing & QC workflows to CORDEX data standards
- Updated land-surface ancillaries
- Co-developed with ACCESS-A NWP model and BARRA-C2 reanalysis
- Intended to form an ensemble with CCAM-ACS, and to be complementary with NARCLIM and CORDEX-FPS.
- Atmosphere: UM vn13.0 RAL3.2
- Land: Jules vn7.0



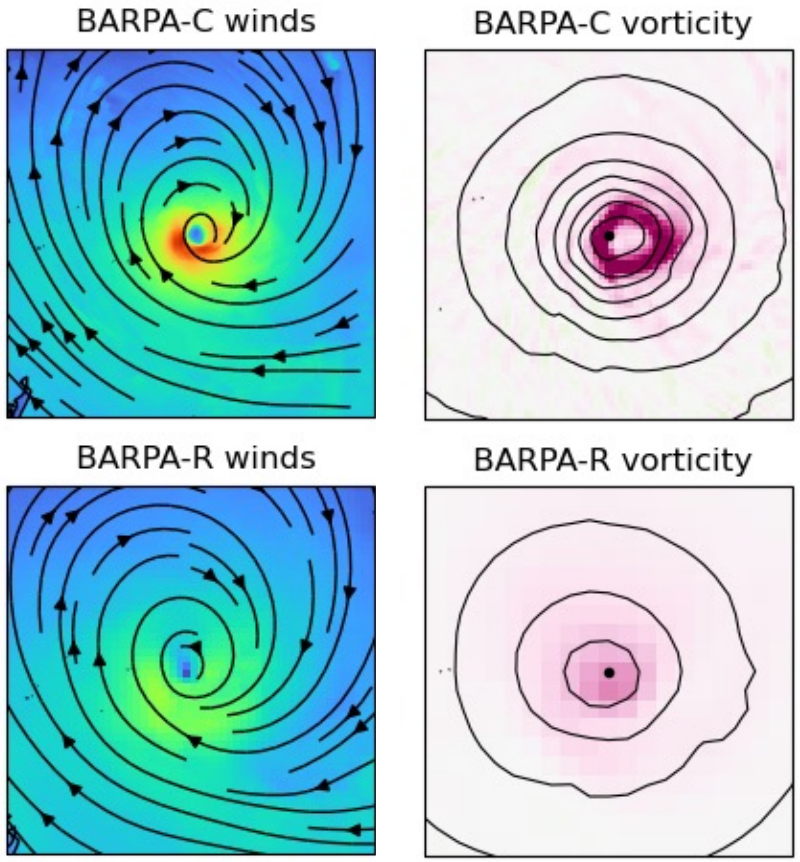
>> GCM projections downscaled with BARPA. Pale lines: BARPA-R, thick lines BARPA-C (tbc)



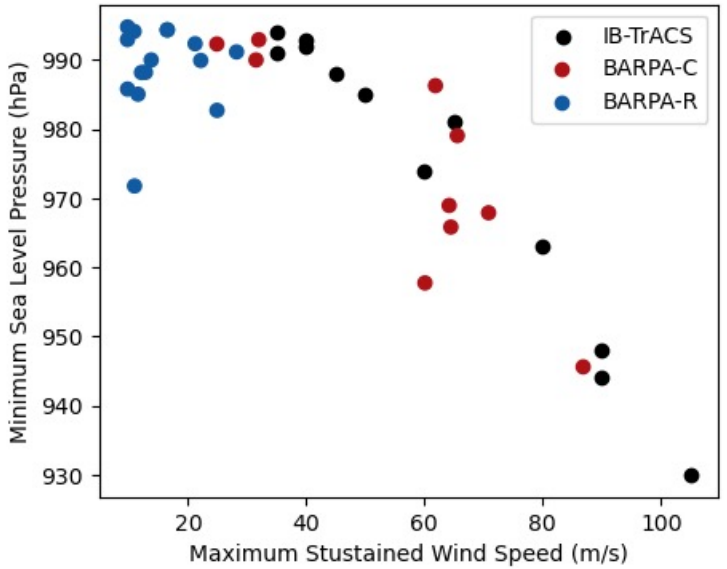
BARPA-C Hazard Processes: Tropical Cyclones

- BARPA-C cyclones show eyewall structures, vorticity rings, rapid intensification
- BARPA-C cyclones are getting to higher intensities and wind speeds than BARPA-R.
- Cyclone paths can differ substantially.
- Boundary interactions seem okay so far

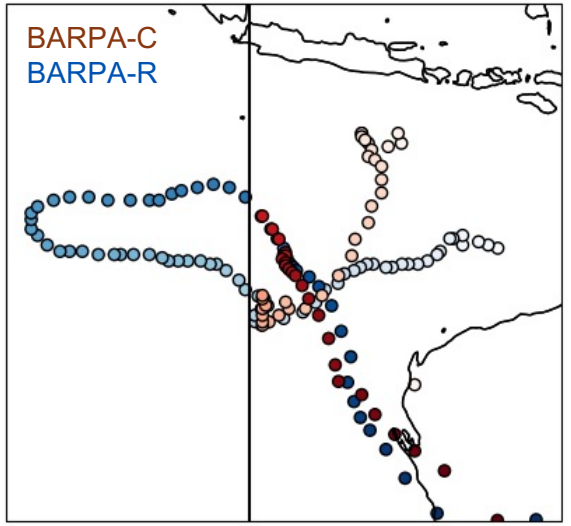
Snapshot of winds and vorticity



Pressure – Wind Speed Relationship



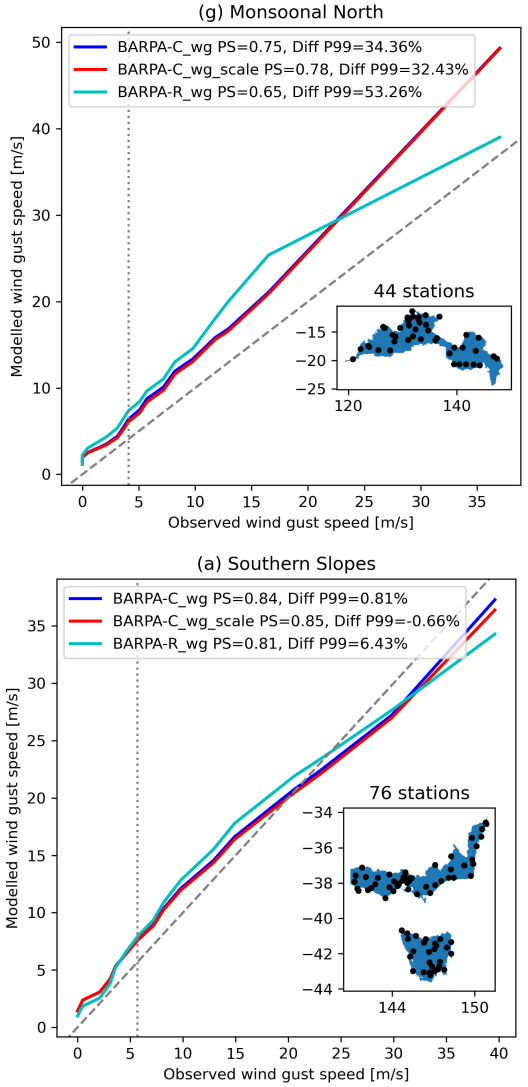
Example track path >

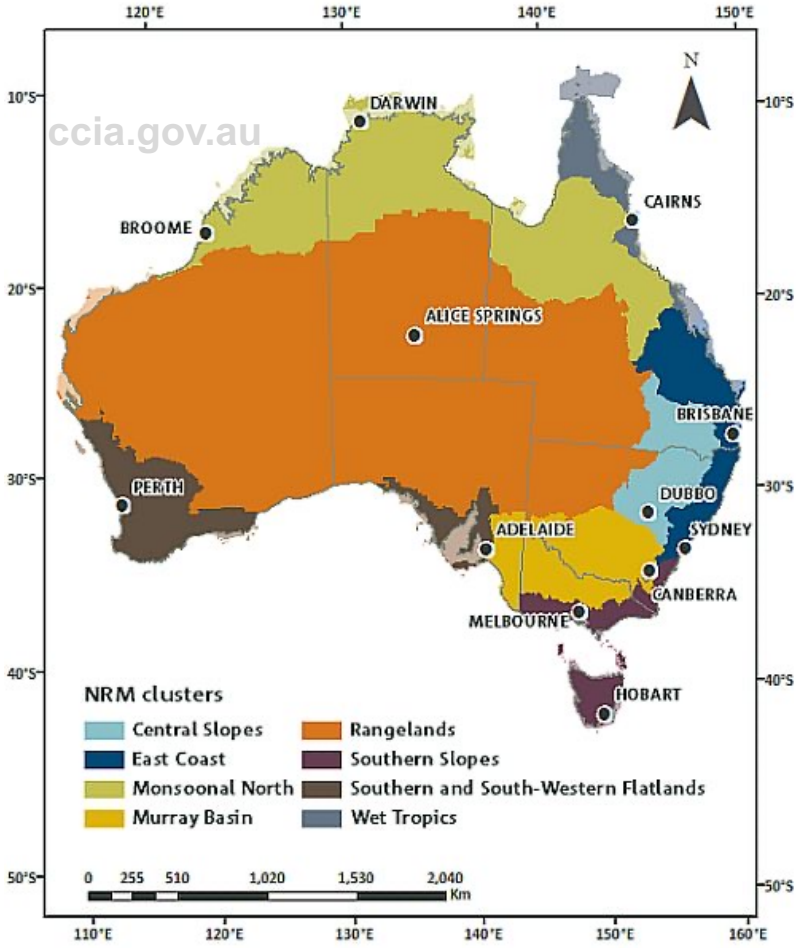


Wind Gusts compared to stations

Blue: BARPA-C wg
Red: BARPA-C wg_scale
Cyan: BARPA-R

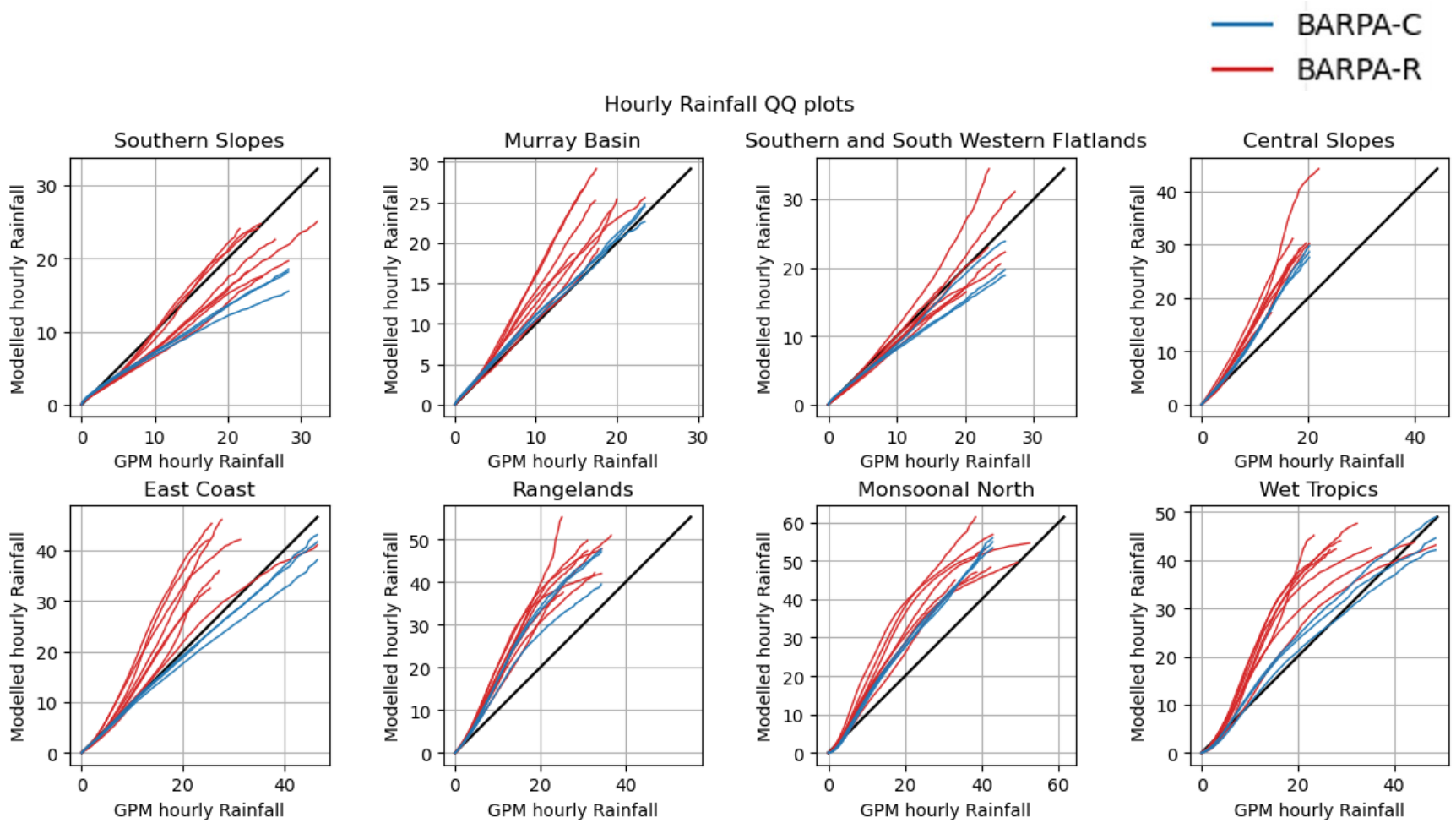
- We compared 2013 distributions of modelled to station-based hourly maximum wind gusts at station locations only.
- Stations have been QC-ed based on their gust factors
- In general, both BARPA-C variables are better than the BARPA-R one.
- Between the two BARPA-C wind gust variables, the scale-dependent variable is slightly better. We will use this going forward





Rainfall Distributions: Hourly QQ Plots

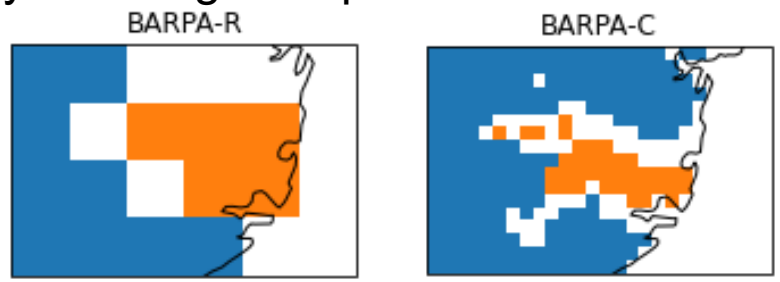
- We compared annual distributions of modelled to GPM hourly rainfall
- Distributions are compared across Australian regions on the coarsest grid (BARPA-R)
- Multiple years (BARPA-R) or trials (BARPA-C) are included to account for internal variability.
- BARPA-C shows improvement in all but one region.
- BARPA-R typically over-estimates extreme rainfall.
- Reference: GPM



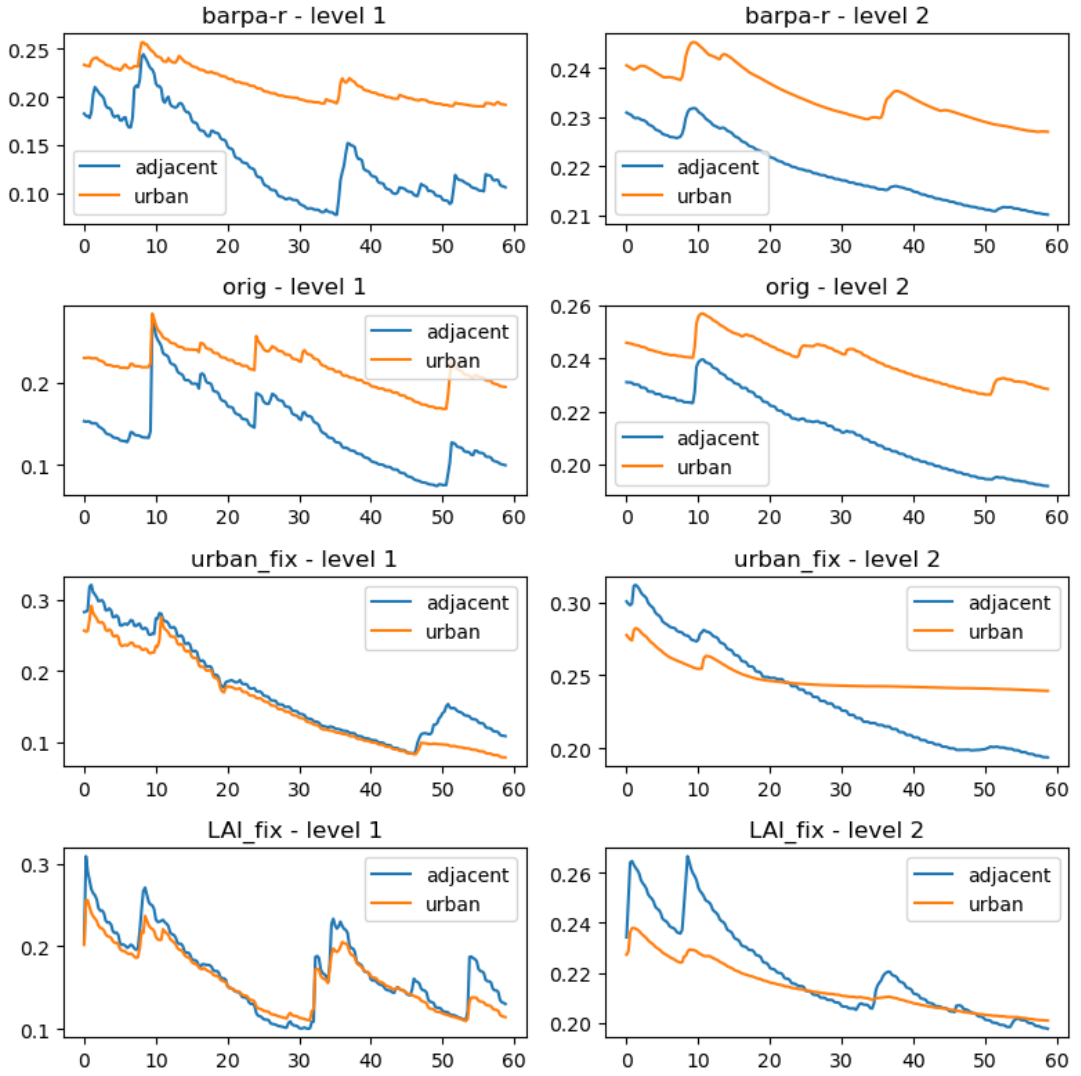
Urban Dry-down: Sydney

- Erroneously high soil moisture levels in urban areas due to issues with the soil physics
- Evident as slower dry-down in urban regions compared to adjacent non-urban grid-cells in Sydney.
- Fixed by
  1. Reducing urban fraction by using WorldCover dataset instead of ESA CCI default
  2. Patching Leaf Area Index, which is by default set to zero in urban areas by MODIS
- Fix (1) improved soil moisture in top soil level. Fix (2) improved soil moisture in the second soil level by enabling transpiration.

Masks used to generate time-series plots



Evolution of Soil Moisture (kg/m3) in and near Sydney



Collaboration with Mathew Lipson and Christoph Rudiger

Summary and future work

- CPM projections provides an important line of evidence to provide more reliable assessments of projected changes in the frequencies and intensities of hazardous weather systems across Australia

- The Bureau is developing convection permitting climate projections for the Australian Climate Service

- Early trials show promising results for hazard-relevant variables
  - wind gusts, tropical cyclones and extreme rainfall

- Next steps:
  - Run and evaluate 10-year ERA5 evaluation trial (2013-2022)
  - This time-period will enable use of additional high-resolution datasets for evaluation: radar data, Himawari satellite
  - Select GCM ensemble based on BARPA-R projections of extreme short duration rainfall trends.

The Bureau of Meteorology

Thank you

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