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CMIP6 climate projections for the Australasia CORDEX domain using dynamical downscaling

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Introduction and Methodology

Variable resolution global CCAM model was used to dynamically downscaled 15 CMIP6 GCMs to a 10 km resolution over Australia for SSPs 126, 245 and 370 - Table 1). The ensemble includes 5 simulations with coupled atmosphere-ocean CCAM for each of SSP scenarios. Simulations were completed for 1960-2100 period and data is extracted at 20 km CORDEX Australasian domain for core, tier 1 and selected tier 2 variables which are being published at NCI ESGF CORDEX archive. CCAM model performance was assessed using grided Australian AGCD historical data and model skill for historical period was compared with host CMIP6 global models (Chapman et al., Earth's Future) using KGE and Perkins skill scores.

CMIP6 Model	Model full namewe dynamically downscaled 15 CMIP6 GCMs to a 10 km resolution over Australia using variable resolution global CCAM (Conformal Cubic Atmospheric model) for each SSP 126, 245 and 370. This ensemble includes 5 simulations with coupled atmosphere-ocean CCAM for each of SSP scenario.	Ensemble member	Resolution
ACCESS-ESM1-5	Australian Community Climate and Earth System Simulator, version 1.5, CCAM atmospheric model version	r6i1p1f1	1.875 x 1.25°
ACCESS-ESM1-5_oc	Australian Community Climate and Earth System Simulator, version 1.5, CCAM coupled ocean model version	r20i1p1f1 r40i1p1f1	1.875 x 1.25°
ACCESS_CM2_oc	Australian Community Climate and Earth System Simulator, version 2, CCAM coupled ocean version	r2i1p1f1	1.875 x 1.25°
CMCC-ESM2	Centro Euro-Mediterraneo sui Cambiamenti Climatici	r1i1p1f1	0.9 x 1.25°
CNRM-CM6-1-HR	Centre National de Recherches Météorologiques Coupled Global Climate Model, version 6.1, high-resolution	r1i1p1f2	0.5 x 0.5°
CNRM-CM6-1-HR_oc	Centre National de Recherches Météorologiques Coupled Global Climate Model, version 6.1, high-resolution, CCAM coupled ocean version	r1i1p1f2	0.5 x 0.5°
EC-Earth3	European Community Earth-System Model, version 3	r1i1p1f1	0.8 x 0.8°
FGOALS-g3	Flexible Global Ocean-Atmosphere-Land System Model, grid point version 3	r5i1p1f1	2.5 x 2.5
GFDL-ESM4	Geophysical Fluid Dynamics Laboratory Earth System Model, version 4	r1i1p1f1	1 x 1°
GISS-E2-2-G	Goddard Institute for Space Studies Model E2.2G	r2i1p1f2	2. x 2.5°
MPI-ESM1-2-LR	Max Planck Institute Earth System Model, version 1.2, low resolution	r9i1p1f1	1.9 x 1.9
MRI-ESM2-0	Meteorological Research Institute Earth System Model, version 2.0	r1i1p1f1	1.125 x 1.125°
NorESM2-MM	Norwegian Earth System Model, version 2, 1 degree resolution	r1i1p1f1	1 x 1°
NorESM2-MM_oc	Norwegian Earth System Model, version 2, 1 degree resolution, CCAM coupled ocean version	r1i1p1f1	1 x 1°

Results - model evaluation and projected changes

CCAM simulations show reduced RMSE and higher correlation compared to CMIP6 host models. Downscaled simulations have narrower spread for correlation and RMSE compared to CMIP6 models. In general, downscaled simulations have better skill especially for upper tails of distribution

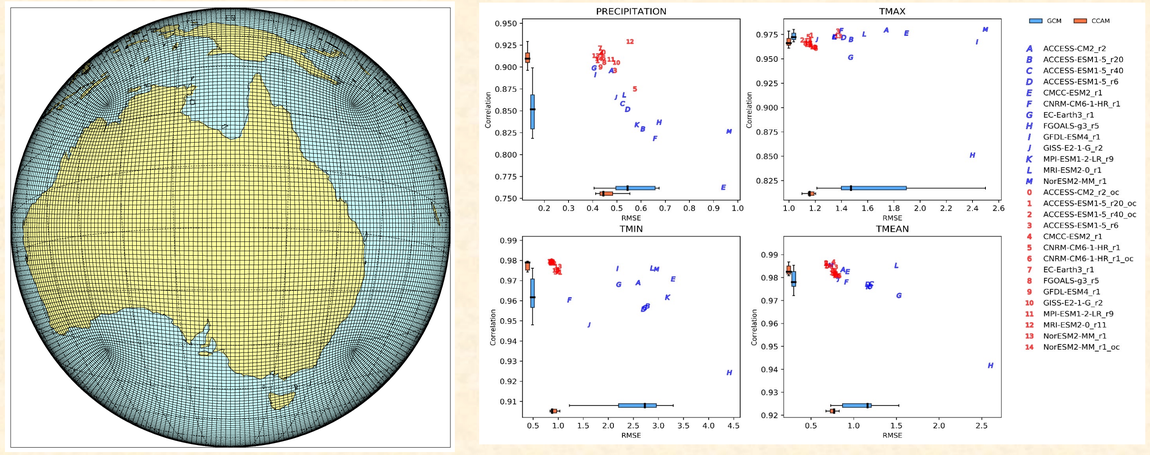

Figure 1. a) CCAM C288 stretched grid used for downscaling. b) Scatter plot of spatial RMSE and correlation for precipitation, temperatures (Tmax, Tmin & Tmean) for Australia from individual CMIP6 host models and CCAM downscaled models.

Projected temperature change by end of 21st century are comparable in magnitude and patterns of change for ensemble average for CMIP6 and CCAM downscaled simulations (Fig 2). Temperature is projected to increase by 1.2°C for SSP126, 2.3°C for SSP245 and 3.5°C SSP370 for Australia.

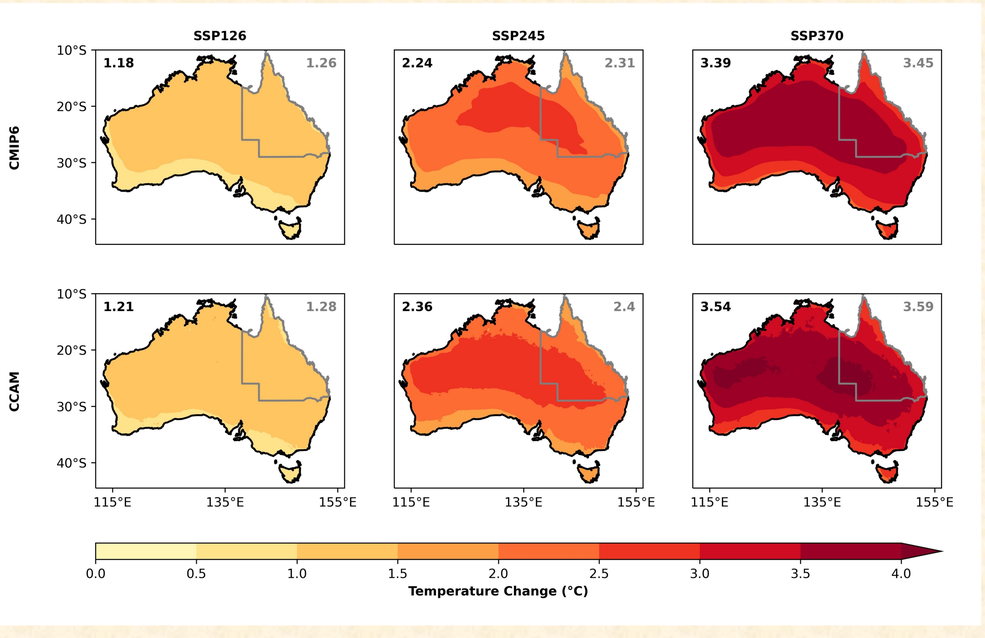

Figure 2. Projected ensemble average mean annual temperature change for SSPs 126, 245 and 370 for Australia by 2090 (2080-2099 – 1995-2014) from CMIP6 models (top panel) and CCAM (bottom panel). Numbers in top left and right corners are area average for Australia and Queensland.

Projected precipitation change by 2050 are comparable in magnitude and patterns of change for ensemble average from CMIP6 and CCAM downscaled simulations (Fig 3). In general, downscaled precipitation change show less drying compared to CMIP6 models, especially for SSP245 and 370 where large parts of Australia from NW to SE show rainfall increase.

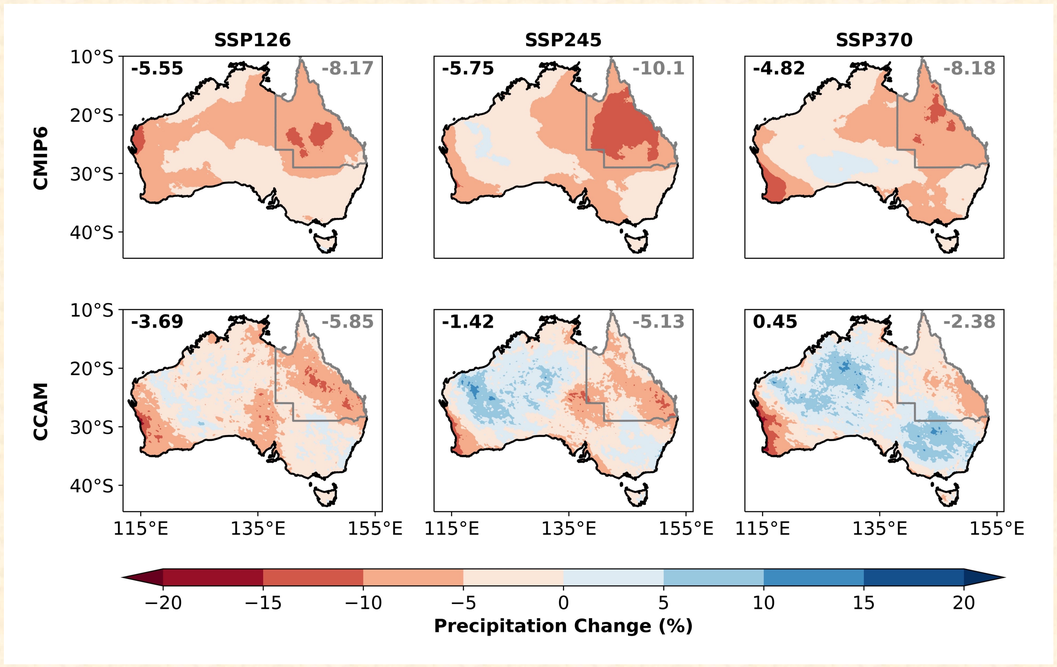

Fig 3. Projected ensemble average mean annual precipitation change (%) for SSPs 126, 245 and 370 for Australia by 2050 (2040-2059 – 1995-2014) from CMIP6 models (top panel) and CCAM (bottom panel). Numbers in top left and right corners are area average for Australia and Queensland.

For SSP370 by 2090 the CCAM downscaled projections show larger temperature increase and reduced spread compared to CMIP6 models. Precipitation projection show smaller range and less precipitation decrease compared to CMIP6 models. CCAM simulations tend to reduce outliers for temperature and especially for rainfall. Pair of simulations with interactive ocean and atmosphere only CCAM show that precipitation change for coupled model are towards an increase compared to atmospheric only CCAM (Fig 4).

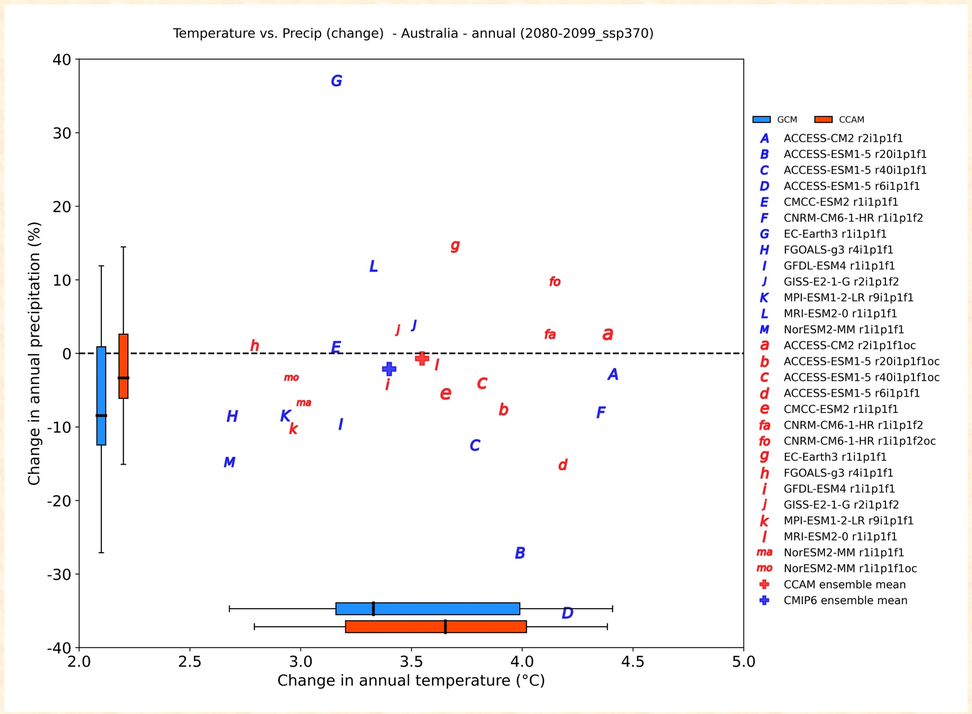

Figure 4. Plot of projected annual temperature and precipitation change for SSP370 by 2090 for Australia. Individual CMIP6 and downscaled models are shown including ensemble average change. Whisker plots show median and spread of projections.

Conclusion

- An ensemble of 15 downscaled CCAM simulations from CMIP6 ensemble for each of SSPs (126, 245 & 370) were completed at 10 km spatial resolution over Australia. This downscaled dataset is the largest and at highest spatial resolution so far for Australia and is being used for Queensland Future Climate (https://www.longpaddock.qld.gov.au/qld-future-climate/dashboard/) Program.
- Historical simulations were evaluated using observed AGCD grided data and compared to CMIP6 host models. CCAM downscaled simulations show better skill for seasonal, annual cycle and daily rainfall, maximum, minimum and mean temperatures using KGE and Perkins skill score.
- Projected temperature and precipitation changes are consistent between CMIP6 and downscaled models. In general, CCAM simulations have larger temperature increase and less rainfall reduction compared to CMIP6 models.
- Model output has been processed following the CORDEX Data Reference Syntax (DRS) and is being published on NCI Earth System Grid Federation Node.

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