The pursuit of fine-resolution climate projections to simulate physically plausible impacts on water resources

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The main objective of the Victorian Climate Initiative (VicCI) is to provide an improved understanding of the risks that climate change poses to water supplies and enrich the information that underpins current water resource planning decisions. Fine scale resolution dynamical downscaling has the capability to enhance such understandings, but what resolution is fine enough?

Context

To test the importance of spatial resolution in downscaling data for runoff projections, the Weather and Research Forecasting (WRF)[1] community model (version 3.6.1) is set up to conduct a series of experiments for selected case studies. The scales of interest are 3 and 10 km. These resolutions relate to the spatial scales where WRF is able to resolve convective motions in the atmosphere (<3km) and the finest resolution whereby it is advisable to use parameterised convection in WRF (>10km). ***WRF is set up to use three nested spatial domains, with a resolution of 50 km (D01), 10km (D02) and 2km (D03) respectively (Figure 1a)***. Ten configurations of WRF is considered, testing the more complex microphysics (mp) options (see Table 1 and Box 1). However, simulations using the mp-scheme Morrison (N4 and N9) and NSSL (N5 and N10) did not complete, leaving 6 configurations to be assessed for each case study.

This poster shows results for the 2 week period (8th to 21st of August 2010) within the south-east Australian cold season (April to October). During this period, rainfall is triggered by an upper level trough and low level cold front associated with a low pressure system developing on the 10th of August over Victoria; moving westward over the next few days. Further passages of cold fronts occur during the period 15-17th of August (Figure 1b), and again on the 19th-20th of August.

For all case studies, ensemble members are assessed against daily gridded (5 by 5 km) observed rainfall from the Australian Water Availability Project (AWAP)[2]. To enable comparison, ***WRF output for D02 and D03 are re-gridded to the AWAP resolution for the spatial extent of D03.***

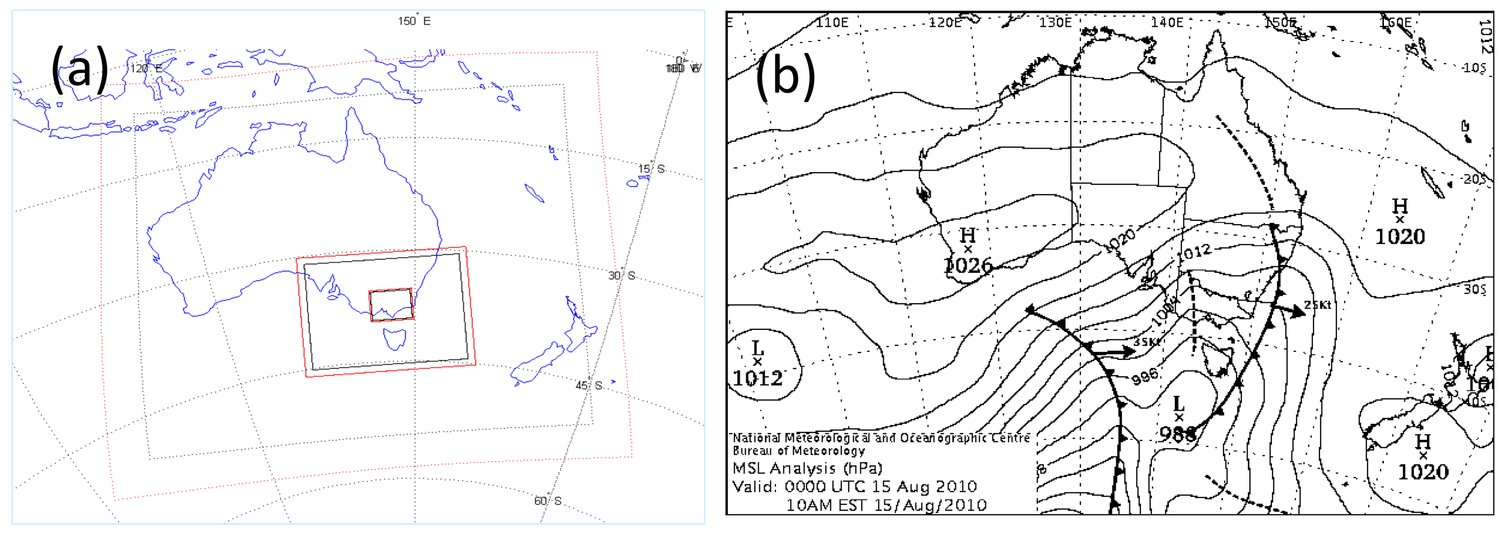

Figure 1: a) Spatial extent of the three model domains D01, D02 and D03 (in decreasing size). The red lines denote the outer boundary and the black lines the model domains (excluding the relaxation zone where information from bordering nests are blended). (b) Mean sea level pressure analysis (00UTC) from the 15th of August 2010. Source for b): The Australian Bureau of Meteorology online analysis chart archive.

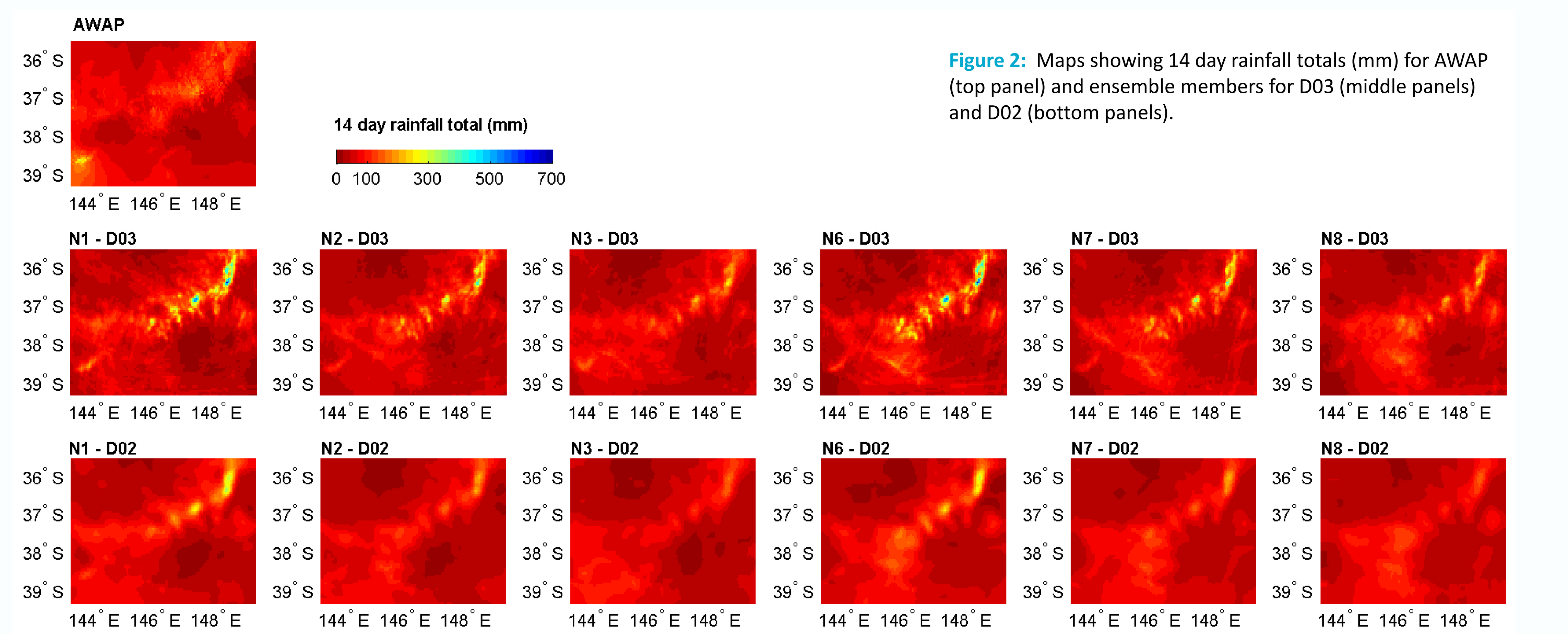

Figure 2: Maps showing 14 day rainfall totals (mm) for AWAP (top panel) and ensemble members for D03 (middle panels) and D02 (bottom panels).

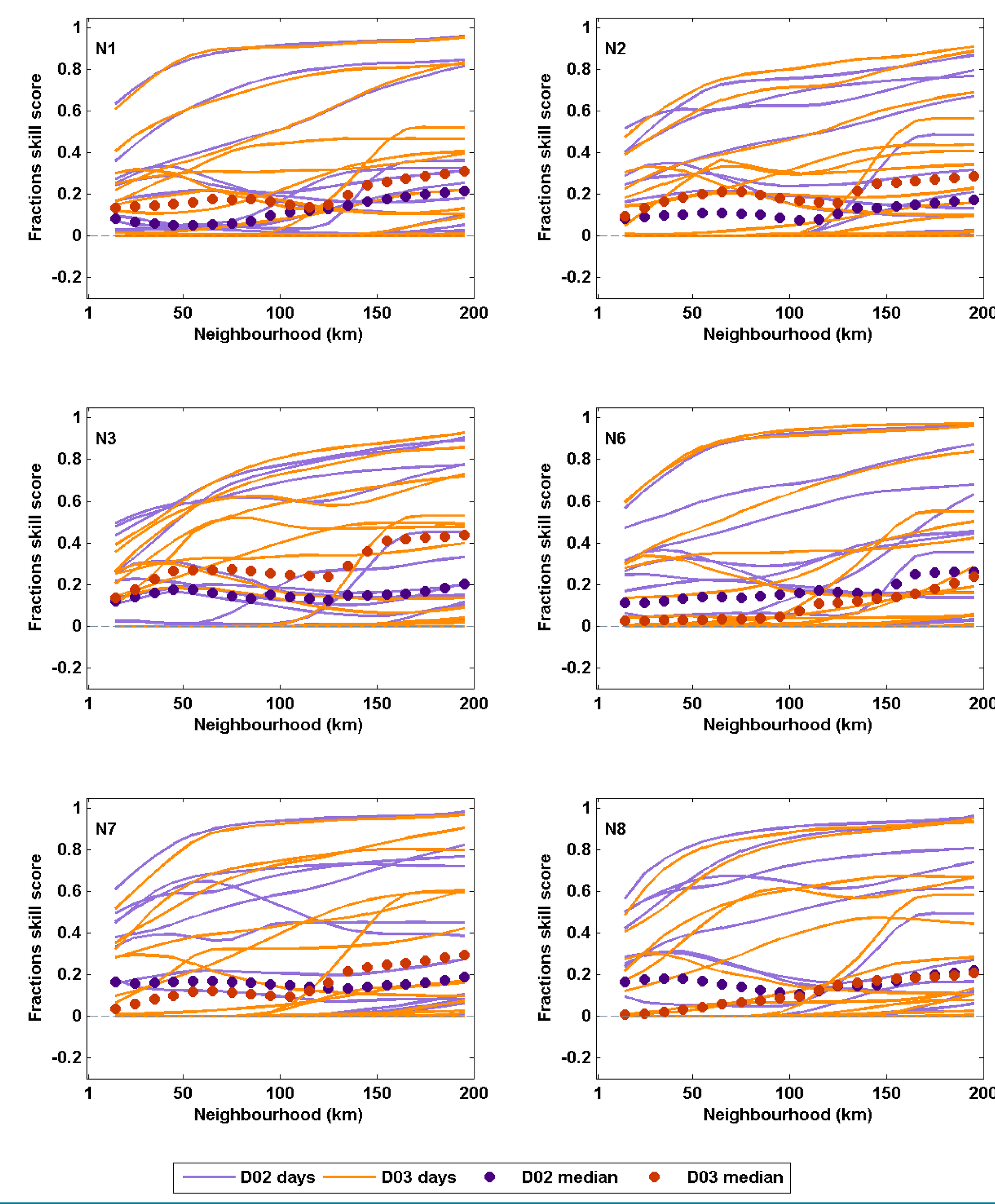

Figure 4: FSS calculated for daily rainfall maps for D02 (blue) and D03 (orange); one line per day. The median FSS per domain and day is marked with a dot (blue for D02 and orange for D03). FSS range from 0 to 1, where 1 is a perfect overlap of rainfall patterns.

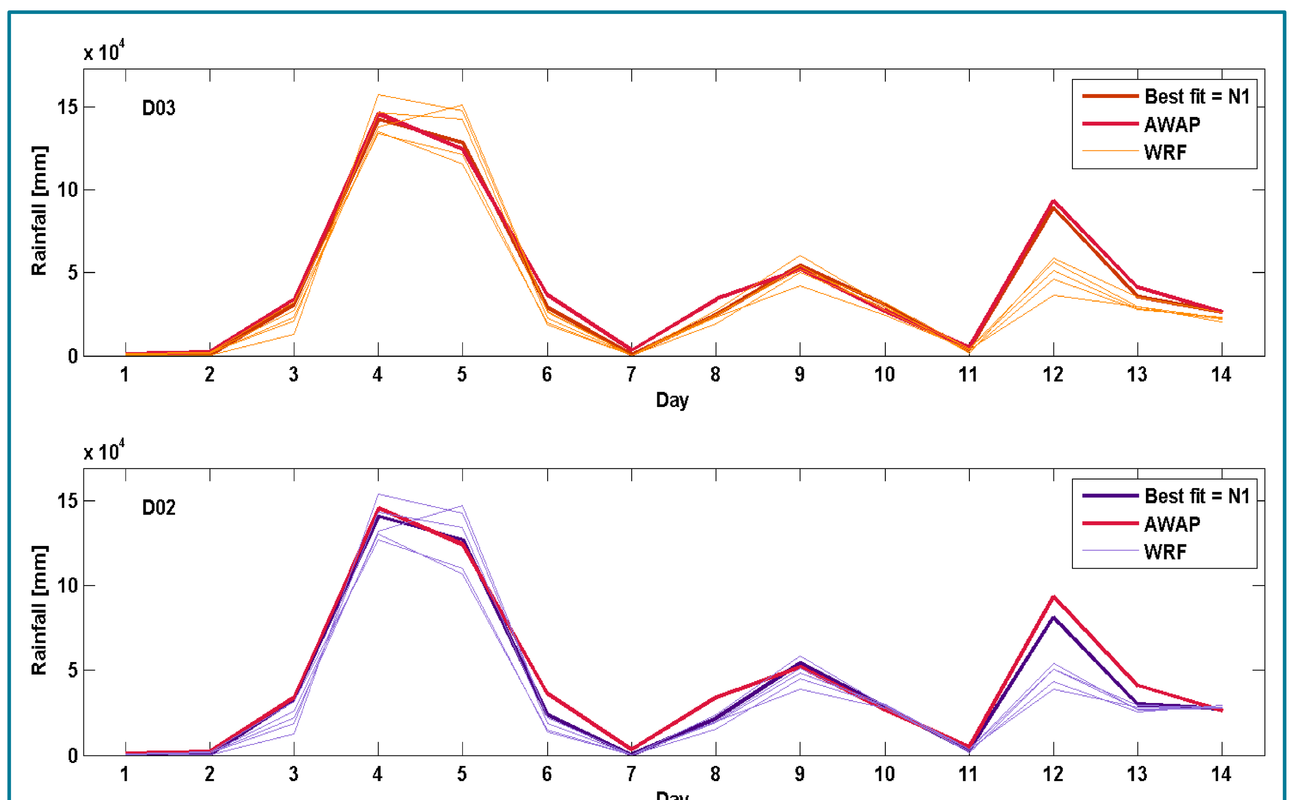

Figure 3: Temporal evolution of daily domain total rainfall (mm) in D03 (top) and D02 (bottom). Pale blue and orange lines indicate WRF simulations (dark blue and orange lines indicates best fit), red line is observed (AWAP).

What does results show?

For this region and time period, ensemble members gave a good representation of the timing of events and overall rainfall totals falling within the model domain (Fig. 2 and 3). In both domains, ensemble member N1 (mp scheme WDM6 in combination with pbl scheme MYNN) showed the closest resemblance to the observed totals (Fig.3).

Model skill in simulating daily rainfall was assessed using the Fractions Skill Score (FSS)[3]. The FSS metric computes skill on fraction of rainfall occurring within a neighbourhood area. Skill vary greatly, but generally increases for neighbourhoods over 100-150 km (Fig. 4). Somewhat larger median values for daily FSS is shown for N3 in D03. Quantile-quantile plots of daily grid-cell rainfall show that D02 simulations tend to have lower high rainfall values compared to AWAP (Fig. 5). This is not seen in D03 values, though WRF configurations using mp-physics WDM6 give higher high rainfall values than AWAP. The D03 simulations provide greater detail, but necessarily greater skill (with the exception of improved simulation of high rainfall values). Further analysis is required to form conclusions on the relative merits of very high resolution downscaling for the purpose of adaptation planning for water resources.

Table 1: List of micro physics and planetary boundary layer (PBL) options for ensemble members N1-N10. Acronyms are spelled out in Box 1.

ID	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10
Micro-physics	WDM6	Thompson	Milbrandt	Morrison	NSSL	WDM6	Thompson	Milbrandt	Morrison	NSSL
PBL	MYNN	MYNN	MYNN	MYNN	MYNN	YSU	YSU	YSU	YSU	YSU

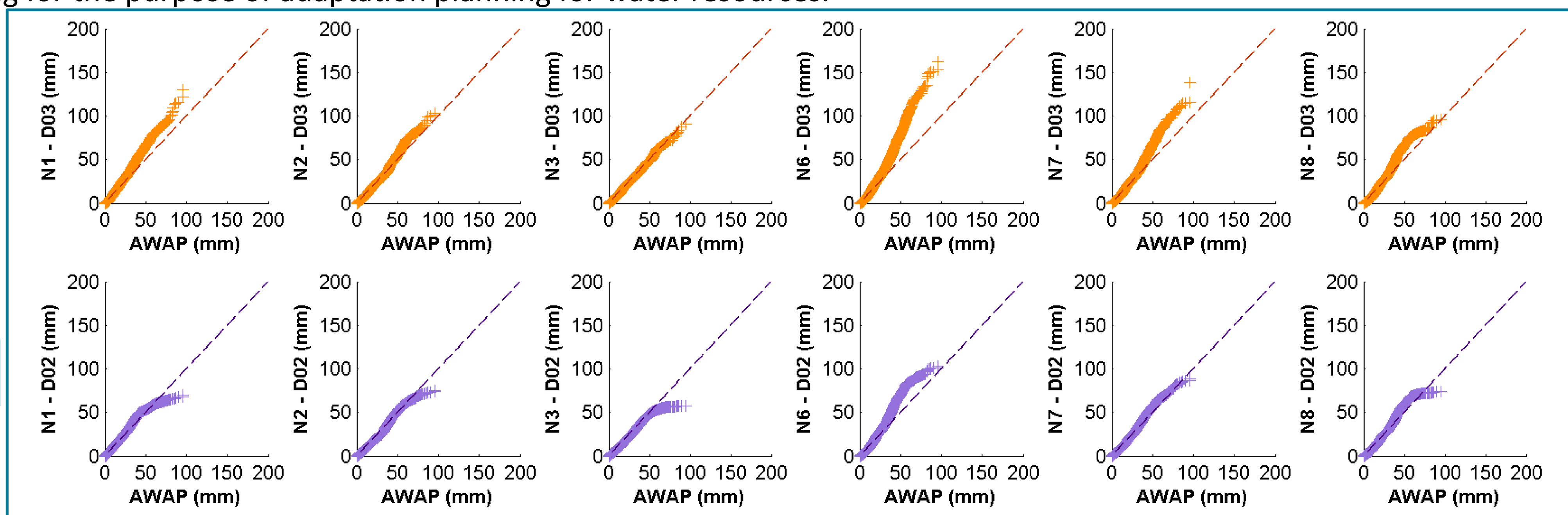

Figure 5: Quantile-quantile plots of daily grid-cell AWAP rainfall (x-axis) versus daily grid-cell WRF output (y-axis) for ensemble members for D03 (top panels) and D02 (bottom panels). Values are in mm.

Box 1: Physics ensemble details

Selecting physics schemes for WRF was made with the requirements for the fine-resolution innermost domain at focus. Guidance was sought from WRF support material and peer-review literature relevant for the VicCI case study in terms of it s geographical location and application[4]. The following schemes are common to all ensemble members: ***short and long wave radiation schemes***: the rapid radiative transfer model for GCMs for long and short wave radiation (RRTMG); ***land surface model scheme***: Noah Land surface model; ***cumulus scheme*** (d01 and d02): Betts-Miller-Janjic (BMJ); ***surface physics scheme***: fifth generation Penn State/NCAR Mesoscale Model (MM5); ***microphysics scheme*** (allowing 5 hydrometeors, some estimated using double moment schemes): the WRF double moment 6-class (WDM6) scheme, the Thompson scheme, the Milbrandt scheme, the Morrison scheme and the National Oceanic and Atmospheric Administration (NOAA) National Severe Storms Laboratory (NSSL) scheme; ***planetary boundary layer (PBL) scheme***: local closure scheme Mellor-Yamada Nakanishi and Niino Level 2.5 scheme (MYNN) and the non-local closure scheme Yonsei University scheme (YSU). References for each parameter scheme are given at: http://www2.mmm.ucar.edu/wrf/users/wrfv3.5/phys_references.html

FOR FURTHER INFORMATION
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