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Hydrology and Earth System Sciences Discussions

Interactive comment on "Changes in Köppen-Geiger climate types under a future climate for Australia: hydrological implications" *by* R. S. Crosbie et al.

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We would like to thank Anonymous Referee #2 for their helpful comments through undertaking their review of our manuscript. Our responses to their comments are below.

Reviewer #2: My main concern with this paper is the lack of detail in the methods section about how information from the IPCC AR4 GCM runs is used to calculate the Köppen climate maps. Considering these maps are the main contribution of the paper, more detail about their construction is required than is given. A reference to two works (one of which is under review) is inadequate. In particular a detailed explanation of

how the monthly precipitation and temperature scaling factors per degree of global warming are derived is required. A discussion is also required about why scaling factors are used instead of directly calculating Köppen climate maps from GCM output. The revised paper needs to be clear about why scaling factors are being used and how the scaling factors are derived. In the papers current form it is not possible to assess the appropriateness of the methods adopted.

Response: The reference to the two works (one of which is under review) was for the degree of global warming for the 2030 and 2050 climates not the downscaling. These two papers (the second of which has now been accepted for publication) were referenced here as they have previously used these levels of global warming for 2030 (Post et al., 2012) and 2050 (Crosbie et al., 2012). These papers were cited in preference to the many technical reports (Barron et al., 2010; Barron et al., 2011; Crosbie et al., 2011; CSIRO, 2008; CSIRO, 2009a; CSIRO, 2009b; CSIRO, 2009c) as journal papers are perceived to be of a higher quality and therefore have greater legitimacy.

The downscaling of GCM data to a local scale using methods adopting a scaling factor approach has been accepted by the hydrological community as fit-for-purpose (although not necessarily the best method available). All of the above cited technical reports have used a variant of the scaling factor approach used here, but with an added step modifying daily rainfall intensities (Chiew et al., 2009). The monthly approach used here was referenced back to three papers on Page 7419 Lines 15-16 (Mitchell, 2003; Mpelasoka and Chiew, 2009; Suppiah et al., 2007), only a brief summary of the method used was presented as the details have been previously published (with a combined 207 citations for the 3 papers above).

Downscaling is necessary when using GCM data for hydrological applications as the magnitude of the rainfall data is often quite different to the observed. For the AR4 models for the historical period, Lim and Roderick (2008) showed that the average annual rainfall across Australia varies from $\sim$100 mm/yr to $\sim$1000 mm/yr, it should be $\sim$450 mm/yr. A sentence will be added to the next version of the manuscript to explain why downscaling is necessary.

Reviewer #2: One consequence of applying a scaling factor to the observed precipitation and temperature is that the future projections of Köppen climate type are presented in the spatial resolution of the observed data and not the resolution of the projection generating GCMs (which are much coarser). The authors need to acknowledge that information from coarse scale GCM projections has been downscaled to produce the high spatial resolution future Köppen maps.

Response: A sentence will be added to the next version of the manuscript to say why the GCM data was downscaled. New sentence: For the future climate scenarios the outputs of the GCMs had to be downscaled from the coarse grid of the GCMs (>1°) to the fine grid of the historical climate data (0.05°), downscaling is also necessary to remove the bias from the GCM data (Fowler et al., 2007).

Minor comments/corrections: Reviewer #2: Page 7418 Lines 17-19: The second level of the Köppen system is not always determined by temperature as stated (see tropical and arid climates) and the third level is not always determined by precipitation as stated (see arid climates). This sentence needs to be revised accordingly.

Response: Reviewer is correct; the sentence will be changed in the next version of manuscript. Revised sentence: Within these five top level climate types there are a number of further classes with a second level and third level delineated by metrics derived from monthly rainfall and temperature. For a full description of the classification criteria the reader is referred to Peel et al. (2007).

Reviewer #2: Page 7418 Line 25: Are the anomalies from the year 1990 or the period 1961-1990?

Response: This sentence was poorly worded and will be revised. The anomalies are calculated from a 30 year period – 1971-2000. The year 1990 was only used as an example to demonstrate that there is a lot of data behind these climate surfaces. Revised

sentence: These are created by interpolation of rainfall and temperature anomalies from observation data relative to the period 1971-2000, for the year 1990 this included over 6000 rainfall stations and 600 temperature stations (Jones et al., 2009).

Reviewer #2: Page 7419 Line 18: The reader is expecting six global warming scenarios (3 for 2030 and 3 for 2050) not five. Add a comment earlier that the +1.0oC scenario that occurs in both periods is not repeated and thus there are five global warming scenarios.

Response: The scenarios are already listed on Page 7419 Lines 4-5. A note will be added to the text at Line 18 to say that the +1.0°C is used in both the 2030 and 2050 global warming scenarios.

Reviewer #2: Page 7420 Line 19: Replace ‘The most variability is seen’ with ‘The most variability between GCMs is seen’.

Response: Change will be made in the next version of the manuscript.

Reviewer #2: Page 7423 Line 25: Do you mean ‘water limited’ or ‘energy limited’ here? I suspect you mean energy limited.

Response: Reviewer is correct; change will be made in the next version of the manuscript.

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