Evaluating mid-Holocene precipitation over Australasia and the Maritime Continent in climate models

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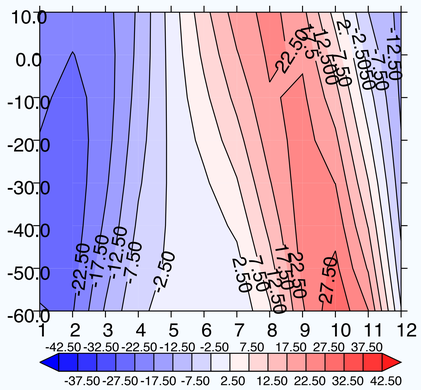

Figure 1: The zonal mean change in monthly mean insolation between the 6 ka and 0 ka simulations from PMIP (Wm^{-2}).

1: Introduction

- The Australasian INTIMATE project was undertaken to develop a consistent chronological assessment of the climate of the past 30000 years over Australia, New Zealand and the Maritime Continent.
- Little use of this comprehensive resource for evaluating the available climate model data so far.
- Poster presents the initial assessment of model simulations of the mid-Holocene over the Australasian and Maritime Continents (from the Paleoclimate Modelling Intercomparison Project, PMIP2 and 3).
- Focus on Southern Hemisphere (SH) warm season (Oct.-Mar.).
- Two modeling studies[1,2] suggest the Australian monsoon was weaker at 6 ka but only accounted for Dec.-Feb. rainfall[1] or included PMIP1 (prescribed sea surface temperatures) simulations in the ensemble mean[2], which bias results.
- This poster takes account of the whole monsoon period (Oct.-Mar.) and only simulations with dynamical oceans (PMIP2 and 3).
- Re-evaluate the changes in precipitation, given that SH insolation was higher in the early monsoon period (Sep.-Nov.) and lower later (Jan.-Mar.)–Fig 1.

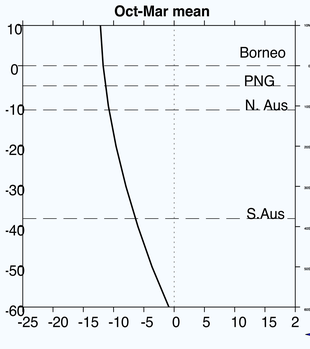

Figure 2: The difference in zonal mean insolation (Wm^{-2}) for the 6 ka simulations relative to the 0 ka simulations from PMIP.

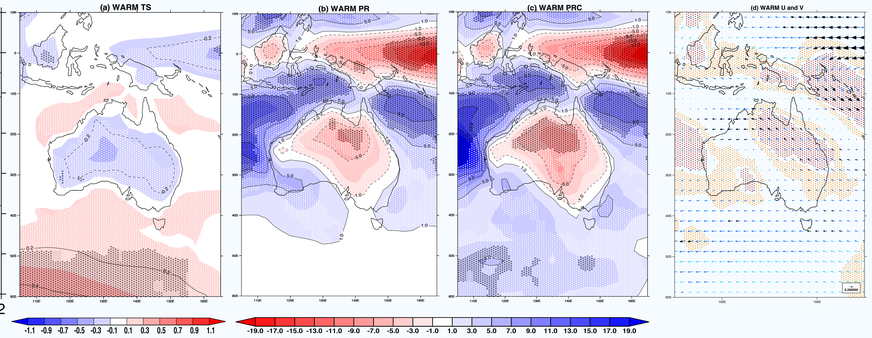

Figure 3: The ensemble mean change in (a) TS – surface temperature (K), (b) PR – precipitation (%), (c) PRC – convective precipitation (%) and (d) the combined zonal (U) and meridional (V) wind field (ms^{-1}). In (a)–(c) white stippling implies >67% of the models agree on the sign of the change and black stippling >80% agreement. In (d) blue (black) arrows imply >67% (>80%) of models agree on the sign of the change in the zonal wind field and orange (red) stipples show where >67% (>80%) of the models agree on the sign of the change in the meridional wind field.

2: October to March

- Reduction in insolation by 5-10 Wm^{-2} over Australia and >10 Wm^{-2} over Borneo and Papua New Guinea (PNG) (Fig 2).
- Weak cooling (0.0-0.3 K) over each land mass with <80% model agreement (Fig 3a, white stippling).
- Weak drying over land masses (1-3% reduction in precipitation) and weak model agreement. (Fig 3b, c).
- Some evidence of more southeasterly flow over Australia, consistent with drying (Fig 3d).
- Reduced precipitation (total and convective) over Borneo and PNG where insolation is reduced (Figs 2 and 3b,c).
- Overall, weak change in precipitation implies the full monsoon season (i.e. Oct.-Mar.) similar in strength to present over northern Australia.
- Changes not as strong as those of an earlier study[1], which only focused on Dec.-Feb.
- Also evidence of weaker westerlies in the mid-latitudes to the south of Australia (Fig 3d).

3: OND

- 0-10 Wm^{-2} higher insolation over Australia (Fig 4).
- Hotter land surface (Fig 5a).
- More precipitation (Fig 5b), particularly convective (Fig 5c).
- Stronger onshore flow (Fig 5d), higher moisture transport.
- Strong agreement in TS, PR and PRC (>80% models).

4: JFM

- Insolation reduced by ~20 Wm^{-2} (Fig 6).
- Colder surface temperatures (Fig 7a).
- Reduced total and convective precipitation (Fig 7b,c).
- Anomalous anticyclone (divergence) over Aus. (Fig 7d).
- Strong model agreement for all fields (>80% models).

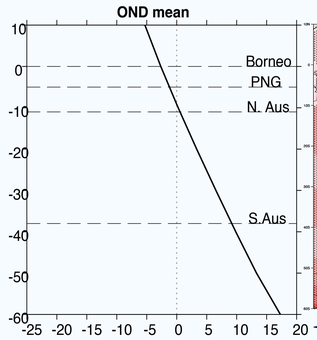

Figure 4: Same as Fig 2 except for OND mean (Wm^{-2}).

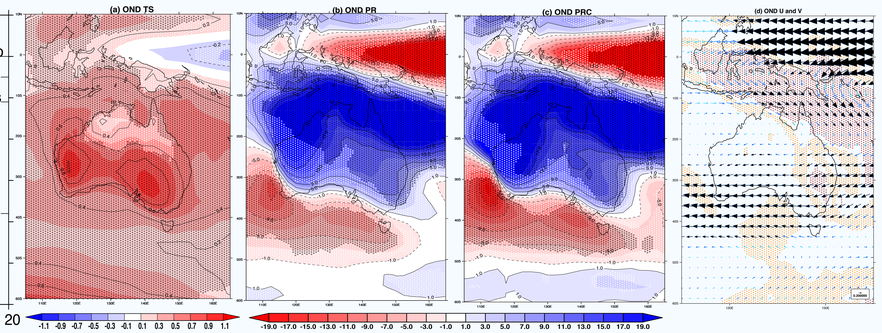

Figure 5: Same as Fig 3 (6k – 0ka variables) except for OND – (a) TS (K), (b) PR (%), (c) PRC (%), (d) wind field (vectors, ms^{-1}).

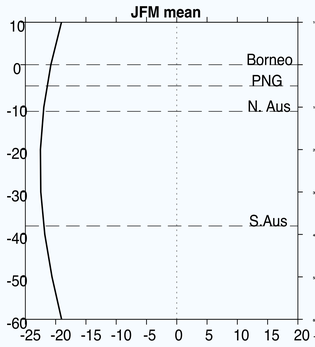

Figure 6: Same as Fig 2 except for JFM mean (Wm^{-2}).

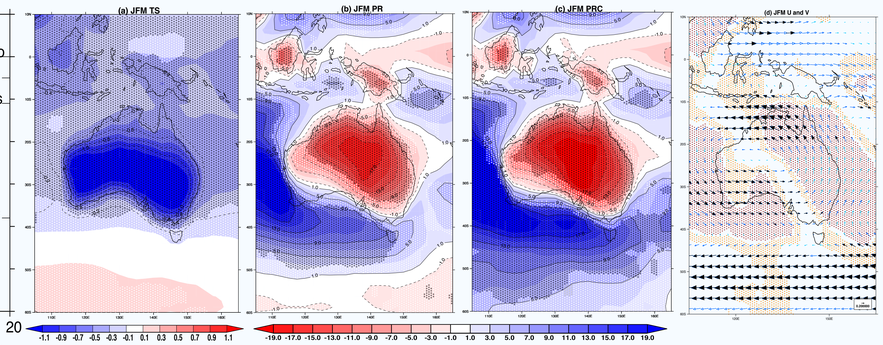

Figure 7: Same as Fig 3 (6k – 0ka variables) except for JFM – (a) TS (K), (b) PR (%), (c) PRC (%), (d) wind field (vectors, ms^{-1}).

5: AUS-INTIMATE assessment

- Evidence of increased coastal dune activity in northern Australia around 6 ka suggests slightly drier conditions but may be due to a sea-level maximum at this time[2,3].
- Weaker mid-latitude westerlies implied from drier conditions over Western Tasmania and SW Victoria[4,5].
- Speleothem records indicate reduced precipitation in the Kimberley and Borneo, although wetter in Flores[6,7,8].
- Thermal maximum of Indo-Pacific Warm Pool and offshore southern Australia[9,10,11].
- Peak in east coast and Lake Eyre Basin fluvial discharge and stabilisation of interior dunes[12,13].
- Increase in biomass burning in the N temperate zone, but decreased burning in S Australia (including Tas.)[14].

6: Conclusions

- Models suggest that monsoon rainfall was higher in OND and lower in JFM at 6 ka relative to 0 ka.
- Overall Australian monsoon precipitation (Oct.-Mar.) only slightly lower than at present in the 6 ka simulations.
- Response of simulated convection to insolation driven TS changes over land (Australia, Borneo, PNG) suggests strong direct thermal response of the land.
- Model convection too sensitive to TS? **Possibly.**
- Results show the importance of considering the whole monsoon season (Oct.-Mar.) and not just DJF[1].
- Model results generally supported by the proxy records; however, resolving differences in timing of peak strength of the monsoon is currently beyond the proxy capabilities.

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