Late Quaternary Southern Hemisphere extratropical cyclone characteristics

Richard Wardle and Ian Simmonds

School of Earth Sciences
The University of Melbourne
Victoria, Australia, 3010
Email: rwardle@unimelb.edu.au

In our work we apply a modelling approach to understanding global climate and regional changes for the Australian continent that have occurred during the Last Glacial Cycle. Many previous modelling studies of palaeoenvironments have focused on the changes to the mean fields. However a more complete understanding of climate variability can be attained by an appreciation of the characteristics of that variability. Here we focus on the extratropical cyclones that are associated with weather systems over the globe. This is particularly true in the Southern Hemisphere, and especially for Australia.

The global numerical simulations are performed with an atmospheric GCM (MUGCM, see Wardle and Simmonds 2003) which successfully replicates the present day (PD) mean climatology and its variability. To elucidate the development and intensification of extratropical cyclones during a particular epoch, we apply a state-of-the-art vortex tracking scheme (Simmonds *et al.* 1999). We present here, results for the mid-Holocene (MH), some 6000 years before present. This is an epoch for which relatively large amounts of palaeo data exist (e.g., Kershaw *et al.* 2000) and for which there is a clear understanding of the climate forcings. Model boundary conditions are the same as for the PD except for the orbital forcings and the atmospheric CO_2 concentrations which are set appropriately.

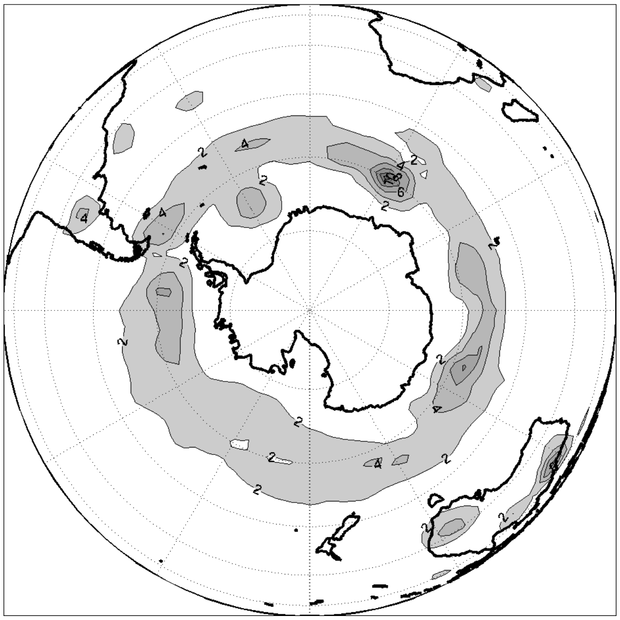
The modelled density of cyclonic systems [the mean number per analysis found in 10^3 (deg lat)^2 area] during DJF and JJA are presented in Fig. 1a-b. The seasonal anomalies in system density from those of the present day (PD) are shown in Fig. 1c-d. During DJF the differing baroclinicity of the palaeo climate yields in general more systems near 60^{o}S except in the Pacific where the maxima lies somewhat further equatorward. For Australia there is a reduction in the number of systems over the continent consistent with the weakening of the Australian heat low during the southern summer (Wardle and Simmonds 2002). During JJA, the statistically significant changes in the number of systems are for the most part increases, particularly around 50^{o}S, south of Australia and in the eastern Atlantic Ocean.

Kershaw A.P., P.G. Quilty, B. David, S. Van Huet, and A McMinn, 2000: Palaeobiogeography of the Quaternary of Australia. *Memoir of the Association of Australian Palaeontologists,* **23**, 471-516.

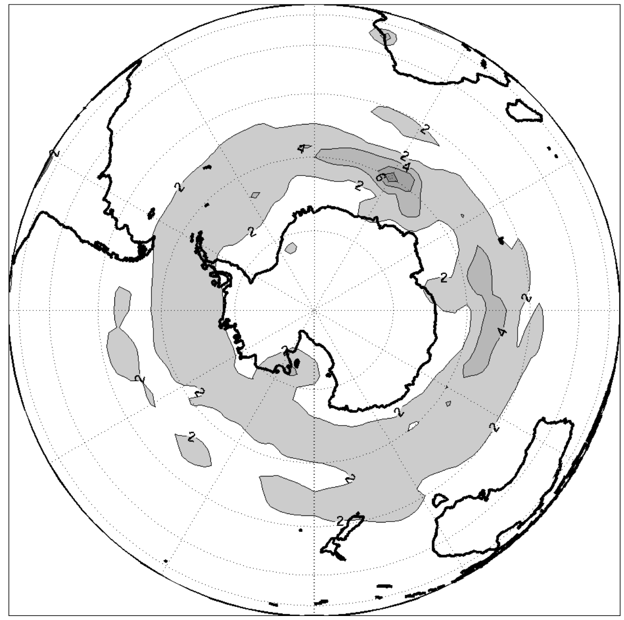
Simmonds, I., R.J., Murray, and R.M. Leighton, 1999: A refinement of cyclone tracking methods with data from FROST. *Aust. Meteor. Mag.*, Special Issue, 35-49.

Wardle, R., and I. Simmonds, 2002: Reconstructing Australian environments of the last glacial cycle through quantitative modelling. *WGNE Report No. 32. WMO/TD-No. 1105.*

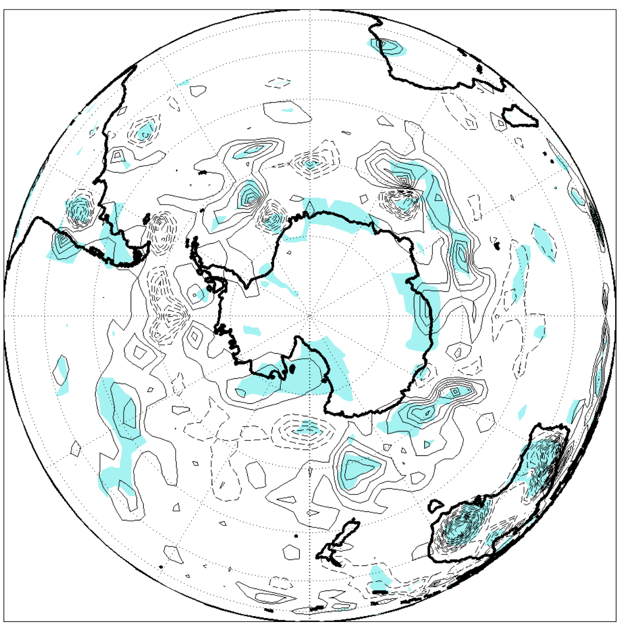
Wardle, R., and I. Simmonds, 2003: The climatology of the Melbourne University General Circulation Model version R21L9. *The University of Melbourne, School of Earth Sciences Report Number 03-01.*



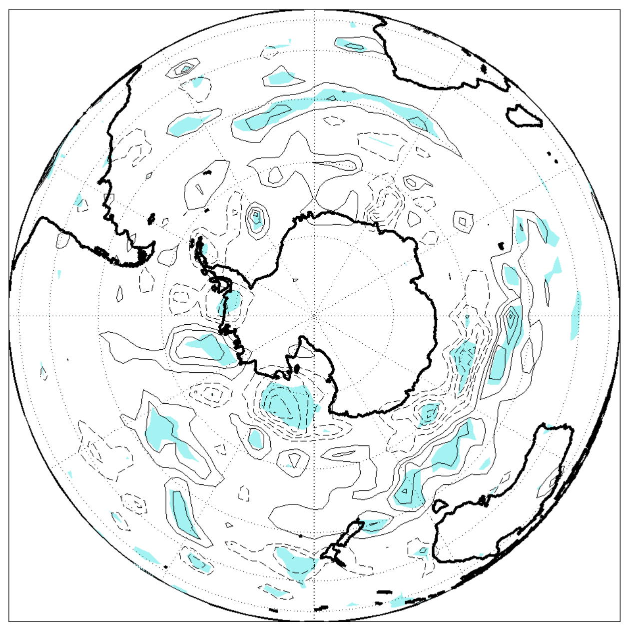
(a) MH DJF system density



(b) MH JJA system density



(c) DJF system density anomaly (PD-MH)



(d) JJA system density anomaly (PD-MH)

Figure 1: The modelled mid-Holocene (MH) cyclonic system density during (a) DJF and (b) JJA. The anomalies from present day (PD) are presented in (c) and (d) for DJF and JJA respectively. In (c) and (d), negative (positive) anomalies are dashed (solid) and anomalies significant at the 95% level are shaded. The contour intervals are (a)-(b) 2×10^{-3} (deg lat)$^{-2}$ and (c)-(d) 0.2×10^{-3} (deg lat)$^{-2}$.