Quantifying relationships between rainfall and synoptic activity in the Australian region

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Differences in past climate regimes have primarily been associated with changes to the pole-to-equator temperature gradient (Budyko and Izrael, 1991). Changing the pole-to-equator temperature gradient could significantly alter the eddy fluxes, such as heat and moisture fluxes, that are associated with mid-latitude synoptic activity in the atmosphere (Lindzen, 1994).

Here we investigate the extent to which interannual variations in synoptic activity in the southeast of Australia are related to the interannual variations in rainfall. The climate of Australia is characterized by low annual mean rainfall and high rainfall variability making it sensitive to small changes in rainfall. Cyclone statistics for the southern hemisphere are generated by the Melbourne University vortex tracking scheme (Simmonds *et al.*, 1999) from the NCEP-NCAR Reanalysis dataset (Kalnay *et al.*, 1996). Four properties of the cyclones are presented here, namely the mean system density, the mean radius of systems and two measures of the 'strength' of the cyclones; the 'intensity' (Laplacian of the pressure at the center of the system) and the mean 'depth', which is proportional to the intensity times the radius squared (the area). Annual mean southeast Australian rainfall is computed from the Jones and Weymouth (1997) Australian precipitation dataset.

In Figure 1, we plot the correlation of the first differences of the time series of annual southeast Australian rainfall with the first differences of the four cyclone characteristics, for the period 1958-1997. All correlations are performed with the first differences of the time series to remove the effect of any trends. Shading in Figure 1 indicates regions where the correlation differs significantly from zero at the 95% confidence level. In Figure 1a, there is little significant correlation between the rainfall and the number of systems. In Figure 1b, the rainfall is positively correlated with the Laplacian of pressure in the vicinity of the southeastern region. The distribution of correlations with radius suggest a positive correlation over much of southern Australia and the Southern Ocean north of about 45^{o}S, with significant negative correlations to the south of this latitude (Figure 1c). This pattern is also pronounced in the correlations with the depth (Figure 1d). The distributions shown in Figure 1 suggest that the high rainfall is associated with systems with larger radii displaced to the north.

It is clear from Figure 1 that all aspects of cyclonic systems must be considered to build a more complete picture of the climate state. The net effect of the cyclones cannot simply be thought of in terms of their frequency, their size and intensity are also very important. Moreover, any future changes to the pole-to-equator temperature gradient and hence, the characterisitcs of synoptic systems (such as the radii), could profoundly impact other climate parameters, such as rainfall, in southeastern Australia, where the synoptic systems play an important climatic role.

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Jones, D. and G. Weymouth, 1997: An Australian monthly rainfall dataset. Technical Report No. 70, Bureau of Meteorology, 19pp.

Kalnay, E., and Co-authors, 1996: The NCEP-NCAR Reanalysis Project. *Bull. Amer. Meteorol. Soc.*, 77, 437-471.

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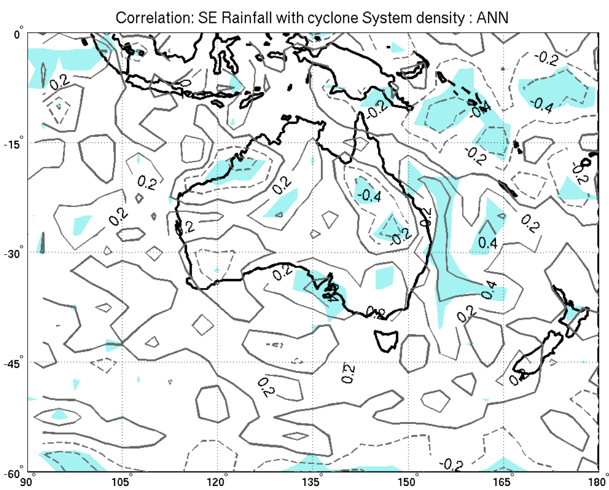
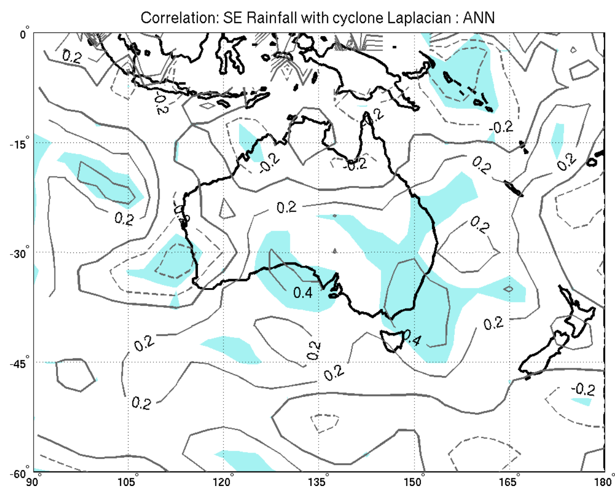
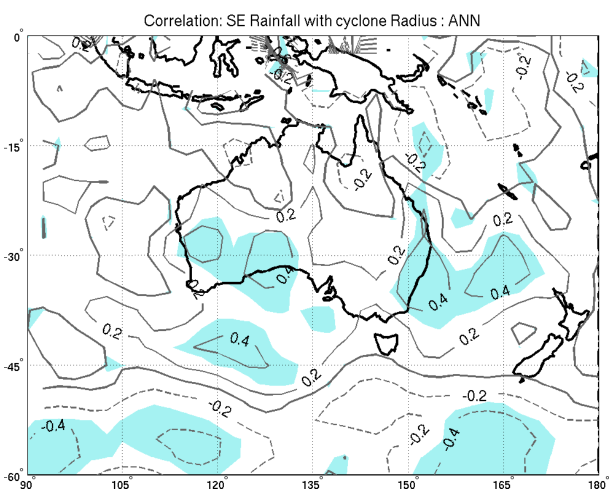


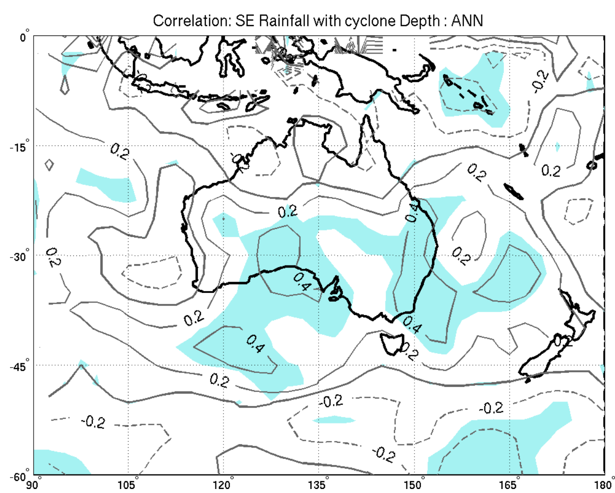
(a) Mean system density



(b) Mean Laplacian of pressure



(c) Mean system radius



(d) Mean system depth

Figure 1: Correlation of the first differences of the annual time series of southeast Australian rainfall and the first differences of annual mean (a) system density, (b) Laplacian of pressure, (c) system radius and (d) system depth. The contour interval is 0.2. Statistical significance at the 95% confidence level is shaded.