Australian climate in coupled and uncoupled climate model simulations

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Objectives

We propose an investigation of a range of aspects of Australian climate, as simulated by the CMIP2 models. The primary aspect of the project will compare the annual and monthly climate of a suite of models participating in both the AMIP2 and CMIP simulations with those of observations and reanalyses. Initial emphasis will be the seasonal (monthly) variation across Australia of temperature, precipitation and surface pressure, to determine how well the observed climatologies, as well as their seasonal variations are captured by the models. By contrasting model AMIP2 and CMIP control simulations, it will allow us to assess the influence of SST deficiencies in coupled models in simulating Australian climate. It also enables us to assess the role of air-sea interactions in affecting the Australian climate variability. Depending upon results from individual models, a much more detailed analysis of variability (using CMIP2+ data as available) may then be undertaken. This will depend upon the performance of models at the monthly timescale, and will consider more detailed aspects of seasonal variation. A further component of the study will address the impact of climate change on temperature and precipitation as modeled by the CMIP2 and CMIP2+ models. Other variables (e.g. cloud cover, soil moisture, winds) will be assessed, as available, in both current climate and under climate change.

Background

The Australian continent extends from the tropics to mid latitudes, and poses a particular challenge for climate models. The Australian tropics are strongly influenced by the surrounding oceans, and are subject to a strongly varying seasonal cycle of precipitation and surface pressure, dominated by the Australian component of the Asian-Australian monsoon (e.g. McBride, 1998). Total precipitation in northern Australia is strongly influenced by ENSO, showing marked interannual variability. Winter conditions in tropical Australia, on the other hand are subject to mild, and relatively dry, southeast trades.

Southern Australian regions are subject to eastward moving mid latitudes cyclones. The mean location of the cyclone belt varies seasonally from south of the continent in summer, to the southern portion of the continent in winter, with consequent seasonality of temperature and precipitation. Central parts of the continent are predominantly dry, with occasional precipitation episodes penetrating from the north and south. Other distinctive features contribute to mid continental precipitation, such as north-west cloud bands. Topography across the continent is generally low, although the eastern ranges have a significant impact on regional temperatures and precipitation.

These patterns of precipitation: monsoonal in the north, Mediterranean in the southwest, 'mid lattitude' in the southeast, and dry in the centre are important features to capture in climate models. As part of the AMIP2 subproject 12, Zhang et al., (2002) have reported a preliminary analysis of sixteen AMIP2 models in their simulations of key surface climate and surface fluxes in the Australian region. Significant model deficiencies in their simulations of rainfall and surface temperature climatologies were identified. Similarly Harvey and McAvaney (2002) intercompared a large number of AMIP2 models in their simulations of the double-jet structure in the Southern Hemisphere. Using observed SST conditions in AMIP2 model integrations, such results may represent an upper limit of current GCMs in simulating Australian current climate. One of the key foci of this project being proposed is, therefore, to evaluate how well the Australian climate is simulated in the fully coupled experiments. This is a necessary component in the ongoing efforts of projecting future climate changes in Australia using coupled climate models.

CMIP2 offers a unique opportunity to examine how a broad range of coupled models represent features of pressure temperature and precipitation in the current Australian region climate, including their seasonal and geographical variations. It also provides an opportunity to consider how these important features change under idealised climate warming by many models. The IPCC assessment of vulnerability report (Watson et al., 1998) noted particular concern for Australia for changes to the timing, intensity and location of tropical monsoon systems, and location and intensities of mid lattitude weather systems and the subtropical anti cyclone belt. Soil moisture changes are also important, and can be expected to follow from rainfall changes, and changes in evaporation. Such issues will be pursued in the course of this diagnostic project, subject to data availibility.

Methodology

The first stage of the study will involve a comparison of annual and monthly CMIP2 control simulations with ‘observed’ values. ‘Observational’ data sets here include the Australian Bureau of Meteorology rainfall and temperature data sets, as well as ERA-40 and NCEP reanalyses. Comparisons will be of mean fields, as well as geographical patterns and seasonal changes of surface temperature, precipitation and MSLP. Results will then be compared to the analysis of the AMIP2 experiments. Monthly mean CMIP fields will be used for this comparison.

Interannual variability will also be considered. In addition to the calculation of standard deviation from multi-year model integrations in measuring the interannual climate variations simulated by the models, Linear Error in Probability Score (LEPS) (Potts et al., 1996), which has been used in Zhang et al. (2002) and in seasonal forecasting verifications, will be calculated in estimating the model skills in their AMIP2 simulations of interannual climate variations in the period of 1979 to 1997. To further understand the role of ENSO in affecting Australian climate interannual variations, some simple statistics, such as the correlations of surface climate variables with Nino3.4 index, will be calculated in CMIP experiments. Results will then be compared with an analysis of AMIP2 models to explore the role of air-sea interactions in modulating the ENSO impacts on Australian climate variations.

Finally, changes in transient model results will be compared with corresponding control climates. This will consist of comparisons of the last 20 years of the control versus the transient experiments, as well as comparisons of the full experiment time series.

References

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