A CRITICAL REVIEW OF SOME RECENT AUSTRALIAN REGIONAL CLIMATE REPORTS

by

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A CRITICAL REVIEW OF SOME RECENT AUSTRALIAN REGIONAL CLIMATE REPORTS

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ABSTRACT

Regional Climate Reports prepared by the CSIRO for five states and the Northern Territory of Australia have been accepted by governments for planning and policy purposes without critical analysis. This review examines the credibility of those reports, in particular the historical trends they describe and the accuracy of the numerical models that are used for both hindcasting and forecasting climate to 2100. The reports are found to be lacking in four crucial areas; by the inclusion of misleading trends, omission of relevant influences, use of poorly performing models and, critically, unjustified claims of accuracy for their output projections. As planning tools the CSIRO model-derived forecasts are of doubtful if any value. Caveat Emptor.

1. INTRODUCTION

Over the last eight years, Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) has prepared climate reports for various authorities in all Australian states. These reports contain an analysis of climate trends since 1950 followed by projections of climate change to either 2070 or 2100, presumably with the intention of providing accurate guidance regarding future climatic conditions.

Customers for these reports have included various government departments, "greenhouse" organisations, water management authorities and planning authorities. The reports have been used to determine government policies, to encourage the public to save water and to cast doubt upon the future viability of ski resorts in south eastern Australia.

The reports' customers dismiss criticisms of their climate predictions by expressing confidence in the CSIRO and asserting that they are the premier provider of this type of report (personal experience), but this does not address the substance of scientific criticism and is anyway no great accolade when the CSIRO is essentially the *only* such provider.

The widespread use of such reports and the sums of public money being spent on them are good reasons for undertaking a review of their credibility, reliability and applicability.

Because some co-authors of one report may also be co-authors of others, the reports are referenced herein by the Australian states to which they apply, with full citations provided at the end of the paper.

2. THE ANALYSIS OF CLIMATE TRENDS

Despite the persuasiveness of information based on trends, the chaotic nature of meteorological data usually makes fitting trend-lines from a specific start date rather meaningless. The starting date chosen arbitrarily or wittingly for these climate reports exerts a strong control on both the slope and sign of the trend line that results.

All of the reports use trendlines fitted from 1950, a year which lies close to the start of a period of warming after at least 40 previous years in which the 11-year running averages of temperature varied only slightly (Fig 1). Australia's mean temperature increased at a rate of 1.57C/century between 1950 and 2003 but by only 0.87C/century from 1910 to 2003.Year 1950 was also the beginning of a brief period of greater rainfall in several states, an increase that returned during the 1970s; inevitably, then, when rainfall in the 1990s reverted towards the levels of 1910–1949 it produced a declining trend. (Fig 1).

The New South Wales (NSW) climate report provides a good illustration of the misleading nature of the trends for temperature and rainfall (Fig. 2).

The rainfall trend from 1950 to 2003 is a decline of 14.3mm/decade however rainfall in 1950 was the highest ever recorded (930mm) and more than 60% greater than the 1950–2003 average of 565mm. Removing that maximum year by moving forward to 1951 and adjusting also for the record minimum rainfall of 2002 (by averaging the rainfall for 2001 and 2003) produces a trend for 1951–2003 of a decline of 3.8mm/decade, a very mild decline that is almost one-quarter of the original figure.

The NSW report emphasised the recent decline in rainfall, but failed to mention at the same time that the 521mm/year average for the decade 1994–2003 was greater than the 490mm/year average in the 5 decades from 1900 to 1949. Readers were given no opportunity to reflect upon the important question as to whether rainfall in the earlier period might be more typical and the period since 1950 abnormally wet.

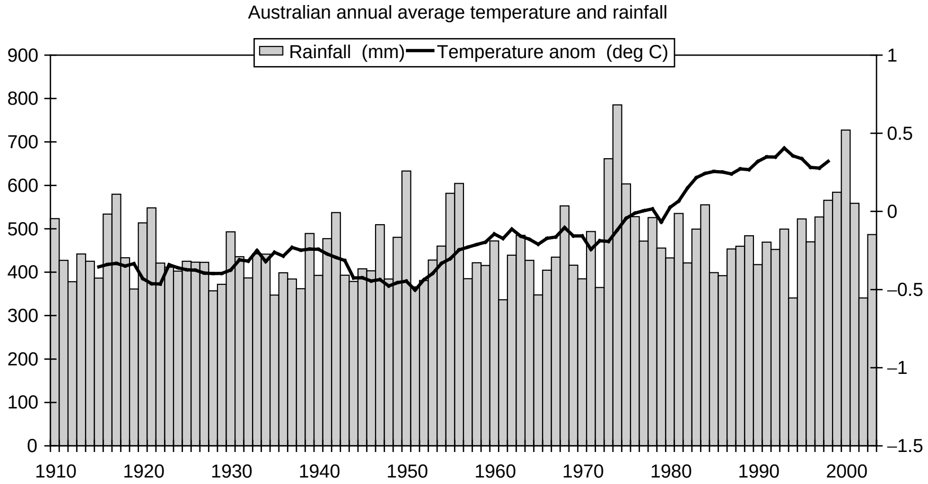

Figure 1: Australia's annual average rainfall (left scale) and temperature (11-year running average, right scale). The average temperature increases from about 1950.

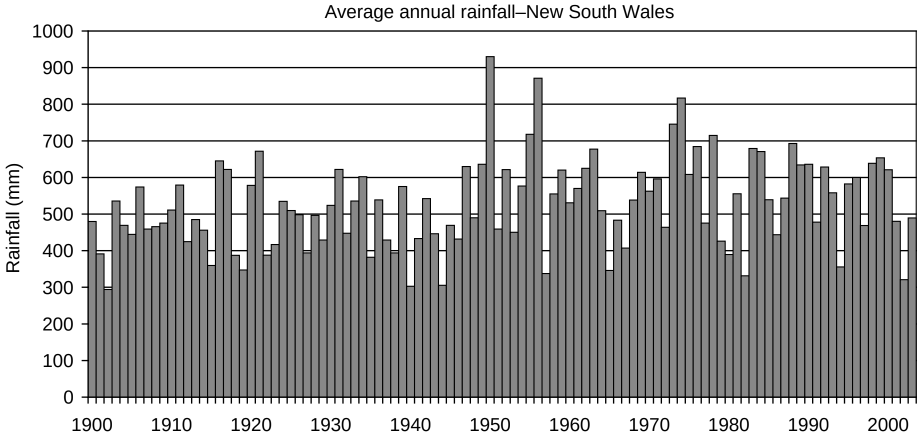

Figure 2: Average annual rainfall in New South Wales (in mm). The maximum recorded is in 1950, the start of the period analysed in the CSIRO report.

Temperature trends are distorted in similar fashion, this time by the presence of an abnormally low value of –1.3°C in 1956. Synthesising a new mean temperature for 1956 (lowest in the period) and 1976 (2nd lowest) by averaging those of the previous and following years reduces the trend from an increase of 0.17°C/decade to 0.15°C/decade. But even this lower figure is about 70% greater than the trend of 0.09°C/decade calculated for the 94 years from 1910 to 2003, a more benign trend that has so far lasted for almost a century. Again, we are handicapped because we have little idea of annual average temperatures in New South Wales for any more than the last 100 years and therefore have no clear notion of whether the recent period of warming departs significantly from normal historical climate variation. Such critically important issues cannot be resolved using meteorological data and predictive computer modelling alone, but require the use of geological data for their elucidation. That this issue is left unaddressed in all of the CSIRO climate reports constitutes a collective and fatal weakness.

3. DEALING WITH EL NIÑO AND LA NINA CONDITIONS

The CSIRO climate reports acknowledge that El Niño conditions are a significant influence on Australia's climate, especially in the eastern states, but they fail to allow for the implications of such an influence.

We are told "The El Niño-Southern Oscillation (ENSO) is one of the most important contributions to year-to-year climate variability over Australia. " (Victorian report, p. 17) and that "year-to-year observed variations in rainfall over Queensland are substantially related to variations in ENSO (variations in Pacific Ocean temperatures account for between 20 and 45% of Queensland's rainfall)." (Queensland final report, p.42)

The New South Wales report says "Robust relationships exist between Australian temperatures and rainfall, and the Southern Oscillation Index (SOI) – a measure of the strength of the El Niño-Southern Oscillation (ENSO).... Correlations between seasonal SOI and NSW maximum temperatures are mostly negative, meaning that when the SOI is high (typically wet), maximum temperatures tend to be low." (NSW report, p. 17). In plainer terms, El Niño conditions are usually associated with less rainfall and higher maximum temperatures.

In its discussion of possible changes in sea level the Northern Territory report states that the less-than-average rise at Darwin "... is a result of more frequent, persistent and intense El Niño events in the last two decades." (NT report, p. 44).

We also told that "the causes of ENSO are complicated and not fully understood, which makes ENSO difficult to represent in climate models, the main tool used to make predictions about the effects of climate change on rainfall." (Qld report, p. 1).

Taken together these points raise two important issues.

(a) The CSIRO climate reports show rainfall and temperature trends for a time period that includes both El Niño and La Nina conditions. We are told that "many El Niño years (such as 1965, 1982, 1994 and 2002) were associated with very low rainfall." (NSW report, p. 5) but no attempt is made to filter these effects when calculating trends and we cannot determine how much warming is in fact to El Niño conditions.

(b) Without a thorough understanding of the influence of ENSO activity it is impossible to determine the degree to which ENSO contributes to Australian climate conditions or properly include such conditions in predictive computer models. Further, if this lack of understanding leads to an overestimation of the influence of other climate factors, then better knowledge of ENSO conditions could easily refute model predictions which are based on such assumptions.

Australia's Bureau of Meteorology (BOM) uses the Troup Southern Oscillation Index (SOI) that is the standardised anomaly of the Mean Sea Level Pressure difference between Tahiti and Darwin. The pressure anomaly is multiplied by 10 to compute the SOI, with negative values indicating El Niño and positive values La Nina conditions,

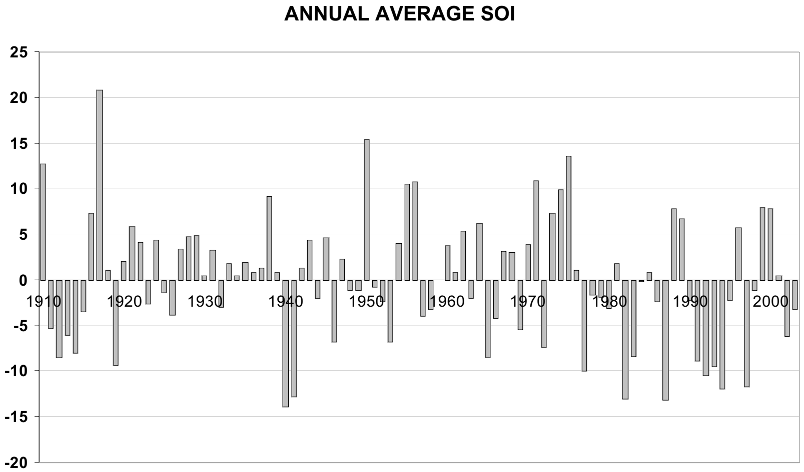

Figure 3: Annual average Southern Oscillation Index (SOI) with negative values indicating El Nino conditions and positive values La Nina conditions.

in a range where the absolute value rarely exceeds 30 on a monthly basis and 10 as an annual average (cf. Fig. 3).

A first order calculation of the influence of El Niño and La Nina conditions can be made by calculating the temperature and rainfall trends after omitting the data for years in which the annual average SOI was greater than +10 (i.e. significant La Nina) or less than –10 (i.e. significant El Niño). This results in the omission of data for La Nina years 1950, 1955, 1956, 1971 and 1975 and El Niño years 1982, 1987, 1992, 1994 and 1997. The change in trends is shown in Fig. 4.

The omission of this data produces a clear decrease in the trend for annual average maximum temperature anomalies and a slight increase in the trend for minimum temperatures. El Niño conditions occurred in 5 years of the 1990s, although only 3 were greater than the threshold of –10, and this could well account for a significant part of the recent warming trend.

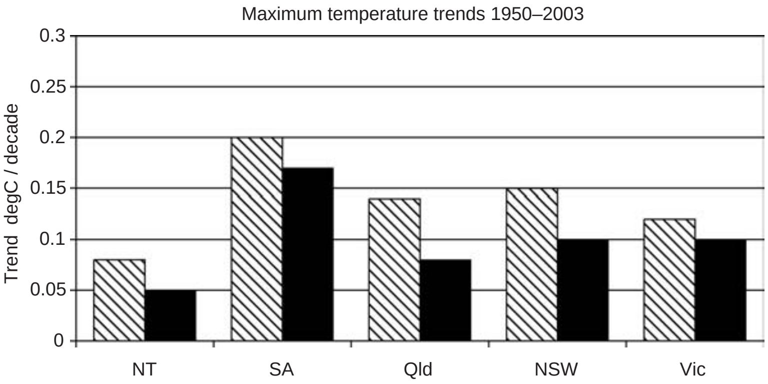

Figure 4(a): Trends in each state for maximum temperature for all years (light) and excluding years where the absolute value of the SOI exceeded 10 (dark).

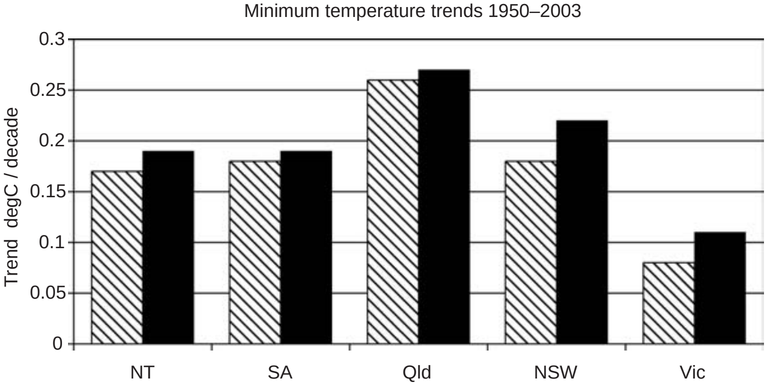

Figure 4(b): Ditto for minimum temperature.

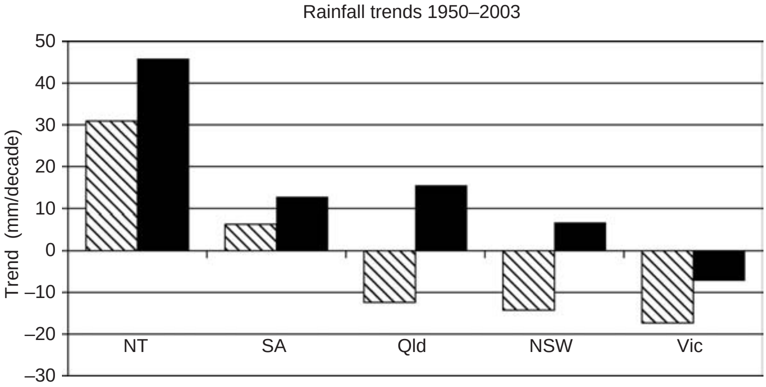

Figure 4(c): Ditto for rainfall.

The exclusion of the data for years of severe SOI conditions has a severe impact also on the trend of increased rainfall compared to the trend when all years are included. In particular, the trends of decreasing rainfall noted in the Queensland and New South Wales reports become increases when the years of strong SOI conditions are omitted. These results may stem from the short dataset, 54 years in total and 44 after omissions, or they may indicate that the decline in rainfall reported by CSIRO is very largely a result of recent El Niño conditions.

This analysis of SOI conditions, though simple, is adequate to cast significant doubt upon the assertions in the CSIRO reports that recent temperature increase and rainfall decline are due to anthropogenic climate change. It should also serve as a strong reminder that any differences between the output of mathematical models and meteorological observations cannot be attributed to anthropogenic warming without first taking all natural climate factors into account.

4. THE ACCURACY OF MODEL “HINDCASTS”

The selection of climate models for forecasting is based upon an assessment of the accuracy of models when they are used to hindcast the period from 1950 to 2003. This assessment is made by comparing the model results with observed climate factors, using a combination of pattern correlation coefficients and root mean square (RMS) error.

The application of correlation analysis produces a dimensionless number between 1 and –1, where 1 indicates perfect positive correlation, 0 random (i.e. non-existent) correlation and –1 perfect negative correlation. Correlation analysis can also be viewed as a measure of the temporal sequence of rises and falls in time series data. The RMS error provides an indication of the magnitude of the discrepancy between observed and calculated values across the two datasets values.

Pattern Correlation Coefficients

The scientific community generally regards a correlation of greater than 0.8 as “strong” and less than 0.5 as “weak” however these conventional limits are not always used by CSIRO when their model projections are matched with known observational data.

For example, the Queensland report (p. 52) states that a correlation coefficient of "greater than 0.6 for Jan–June and down to about 0.45 for Jul–Dec" for sea-surface temperature (SST) is "good agreement", and later states "In climatological analysis, a correlation with a magnitude of 0.5 or more (either positive or negative) often represents a strong relationship". The Victorian report (p. 11) claims that a correlation coefficient of less than 0.6 is "relatively weak" and greater than 0.8 is "strong" but argues later (p. 20) for the use of a lower limit of just 0.4 when complex rainfall and circulation patters are being modelled. Finally, in the South Australian report, a correlation coefficient of less than 0.6 is taken to indicate poor spatial patterns for minimum temperatures but despite this, when discussing the performance of models for rainfall prediction in each season, the report states (p. 20) that "considering the complexity of the correlations being compared, a correlation of at least 0.5 indicates reasonable model performance".

It appears that the subjective designation of the value of the correlation coefficient as "strong", "good" or "reasonable" is made to justify the selection of the relatively better performing models, irrespective of actual correlation values. Clearly, such casual use of conventional statistics provides no meaningful measure of model accuracy.

In the Victorian study (p. 21), despite the use of the low figure of 0.4 as the lower bound of acceptable correlation, only 4 of 12 models met the selection criterion for autumn rainfall, 9 for winter rainfall, 1 for spring rainfall and 1 for summer rainfall. Should the lower bound be raised to 0.6, which the same report earlier indicates to be "relatively weak", then probably none of these model runs would have performed acceptably. Similarly, the South Australian study (p. 20) adopts a minimum correlation coefficient of 0.5 for the composite modelling of South Australian rainfall and regional sea-level pressure. This produces 10 acceptable models for rainfall and pressure in summer, 1 for autumn, 3 for winter and 8 for spring. If the minimum acceptable correlation coefficient were to be raised to 0.6 (as used in the other reports), then these numbers would fall to 7, 0, 2 and 4, respectively, with no single model performing acceptably in more than two seasons. Even as presented in the South Australian report, the results of 6 of the 12 models show negative correlation for winter rainfall as low as –0.82 which represents a strong inverse correlation.

Error Magnitude

When comparing model predictions with actual meteorological measurements, the RMS error indicates the magnitude of a discrepancy between values which have been respectively calculated and observed. The RMS error is an absolute value which can be misleading because an RMS error of 10 would be acceptable if the original base value was in the order of 1000 but unacceptable if the base value was 2.

The CSIRO reports are biased towards generating low values for RMS errors because they deal with temperature departures from a mean value rather than an absolute value. Rainfall calculations are based on millimetres per day which means that values will rarely exceed 2.0 and for which an RMS error value of 2.0 will indicate a discrepancy of 50%.

For the New South Wales, Northern Territory and South Australian reports a "demerit" system was used to determine which models simulated 1961–90 conditions better than others. For all three instances the acceptable RMS error for temperature and for rainfall was 2.0 except for Northern Territory rainfall where a cut-off 3.0 was applied. The average annual rainfall for the 3 states was 1.55, 1.51 and 0.64 mm/day, respectively, indicating that the "acceptable" values showed as much as a 300% error (i.e. 3 x 0.64 is less than 2.0). Of course, the lower limit for rainfall is 0 and that figure falls within acceptable limits in all cases..

Regarding the Northern Territory report specifically, averaged seasonal temoeratures during 1950-2003 showed less than a 0.08°C difference from the 1961–90 averages. Standard deviations of the seasonal mean temperatures in each year were less than 0.83, but very few of the climate models used produced results close to that figure (see Table 1). Most models were unable to produce results with an RMS error of less than 1.5°C (Northern Territory report, p. 28) and their credibility should be doubted.

Table 1: Few of the 12 models produced results close to Northern Territory temperatures

	Summer (DJF)	Autumn (MAM)	Winter (JJA)	Spring (SON)
Standard deviation of temperature anomaly	0.729	0.829	0.814	0.750
No. models with RMSE < standard deviation	1	0	0	0
No. models with RMSE < 1°C	3	1	0	1
No. models with RMSE <1.5°C	5	2	0	5

The RMS errors when hindcasting rainfall are no better (see table 2), because despite the minimum calculated value being limited to 0. RMS errors were typically between 50% and 100% of the observed seasonal total, and even higher in the low rainfall months of winter and spring.

South Australia is the driest state in Australia so the RMS errors for rainfall there are particularly interesting. Summer rainfall across 1961–90 averaged 0.69mm/day, yet 7 models had RMS errors of at least 100% of this value, one with an error of approximately 400%. Autumn rainfall averaged 0.68mm/day but RMS errors on most models exceeded 50%. Similar situations were found for winter and spring, with averages of 0.64mm/day and 0.58mm/day respectively. The annual average rainfall in the period was 236mm, whereas most of the climate models predicted rainfall of at least 360mm, more than 50% greater.

Table 2: RMS errors of climate model rainfall calculation compared to observed rainfall

	Summer (DJF)	Autumn (MAM)	Winter (JJA)	Spring (SON)
Observed rainfall (mm/day)	3.54	1.56	0.21	0.74
No. models with RMSE >50% of observedl	7	12	11	12
No. models with RMSE >100% of observed	1	1	9	7

Other Dubious Claims of Accuracy in Hindcasting

Many of the graphs of calculated and observed climate factors in the printed CSIRO reports are reproduced too small. Their size and scale makes it difficult for readers to accurately perceive the detail, whereas digital enlargement and enhancement of the electronic versions of the reports reveals important discrepancies between observed and modelled time series.

For example, Fig. 5 shows enhanced graphs of projected and observed minimum and maximum temperatures for parts of Queensland. The original graphs in the report have been cropped and enlarged with grid lines added and a common vertical scale.

It is clear from these two re-presented figures that the model projections are a poor match for the observations both temporally and in their magnitude, which is different to the impression created by the original graphs in the report. Similar comments can be made about when they have also been replaced, for the other graphs of minimum and maximum temperature reproduced in the CSIRO Queensland report (pp. 23–4).

Despite the obvious discrepancies in these and the other four accompanying graphs the Queensland report states (p. 22) “when averaged over the three regions, there is

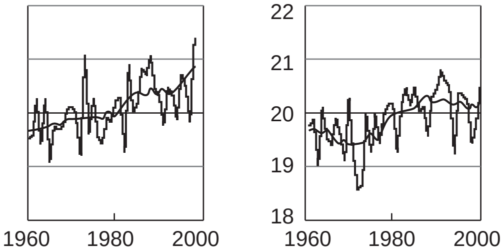

Figure 5(a): Observed (left) and calculated (right) average minimum temperature for North Queensland to the same scale.

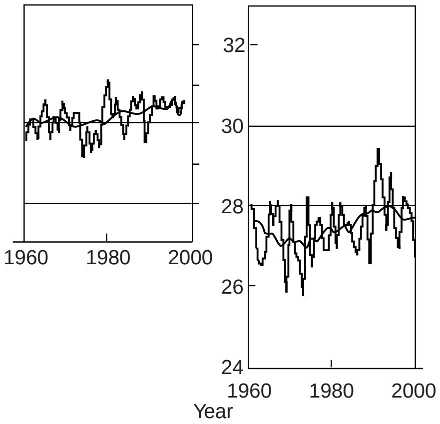

Figure 5(b): Observed and calculated average maximum temperatures for central Queensland to the same scale.

very good agreement between the observed and simulated records”. [my emphasis] This is a strange statement to make when the climate report is discussing three separate regions of the state as distinct entities and not as a composite. Later, on p. 22, the report says that “in summary, there is good agreement between observations and DARLAM-60 simulations of maximum and minimum temperatures”. Such a conclusion is not supported by the graphs.

Again, despite the obvious discrepancies, the Queensland report (p. 29) claims that “in summary, rainfall is well simulated by DARLAM-60 in summer and winter. Simulated autumn rainfall is generally less than observed, and simulated spring rainfall is too great.”. No evidence is presented to support such a claim because the graphs refer only to the periods April-September and November-March, for both of which periods the rainfall is over-estimated by a substantial amount.

The April-September rainfall projected for North Queensland is approximately 100% greater than the observed levels, for central Queensland about 50% greater, and for the south-east of the state reasonably similar in terms of running averages, but showing far less variation in annual levels (ibid, p. 31–32). For the other half of the year the projected levels range from about 30% to 50% above the observed levels.

Similar unsupported claims of accuracy also occur in the Victorian report, which states (p. 21) that “... the observed regional warming up to 2000 is broadly consistent with the climate model simulations”. Using digital enhancement of the relevant graphs and adding the 11-year running averages of the annual observed mean temperature prior to 1950 casts doubt on this statement (see Fig. 6). It is clear that although the “Mark 2” model produced similar output to the measured temperature from 1955 to 1975, outside this period there are wide discrepancies. The DARLAM60 model is even worse, with very obvious mismatches in timing and magnitude from 1960 to 2000 (Fig. 6).

5. CLIMATE PROJECTION METHODOLOGY

Assumptions about carbon dioxide or poor models

A variety of greenhouse gas emission scenarios are applied to the different climate models in each CSIRO state study although commonly only one or two scenarios are applied to any one model.

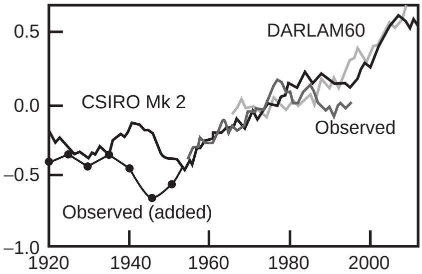

Figure 5: Poor correlation of 11-year running averages of predicted temperatures and observed temperature in Victoria extended back to 1920. Predictions from CSIRO Mk2 model in black, DARLAM60 prediction in light grey and observed temperature (with data from 1920 to 1955 added) in medium grey.

Table 3: Summary of the greenhouse gas emission scenarios used in the CSIRO reports

Scenario	Comments	Carbon Dioxide at year 2100
SRES A1FI	Fossil-fuel intensive, constant CO_2 emissions from 2080	950 ppm
SRES A1T	Decreasing CO_2 emissions from 2030	575 ppm
SRES A1B	Decreasing CO_2 emissions from 2050	705 ppm
SRES A2	Increase in emissions almost linear to 2100	850 ppm
SRES B1	Emissions rise gradually then decrease from 2040	550 ppm
SRES B2	Linear increase in emissions to 2100	610 ppm
IS92a	Total greenhouse emissions equivalenced to CO_2 emissions, almost linear to 2100	705 ppm (?)
1% increase	1% increase in CO_2 per annum	1004 ppm
Observed	Based on Mauna Loa (included here for comparison)	535 ppm

Typically, scenarios A1, A2, B1 and B2 from the Intergovernmental Panel on Climate Change (IPCC) are applied, but a “1% increase in CO_2 p.a.” and a scenario designated “IS92a” (e.g. NSW report, p. 26) are also used. The IPCC scenarios are defined in the reports, and are included in graphs along with IS92a. The “1% increase in CO_2 p.a.” scenario is not described but presumably defines a compounding increase in gas levels rather than a flat increase equivalent to 1% of the level in a specified year. In 2003, the annual average CO_2 level at Mauna Loa, Hawaii was 375ppm, from which it can be calculated that the “1% increase” scenario adopts a questionable level of 1004ppm after 100 years. (See Table 3)

Scenario IS92a uses a concept of “equivalent” CO_2 level, which incorporates all sulphate aerosol and greenhouse gas (excluding the dominant gas, water vapour!) forcings into one figure. The New South Wales climate report claims an equivalent level of about 705ppm by the year 2100 but the Canadian Centre for Climate Modelling and Analysis (CCCma) determines the level to be 1422ppm. The IPCC (2000) warned against the use of this scenario by saying that it was neither more likely than any other scenario nor “central with respect to the published literature, particularly in some of its regional input assumptions”.

The average increase in atmospheric carbon dioxide per year from 1960 to 2001 as measured at Mauna Loa has been just 0.36%, and that time period includes several drought years and at least one year of exceptionally high rainfall, all of which saw annual increases greater than normal. If this rate of increase is sustained, the level by the year 2100 will be 535ppm, an increase of less than 50% on today’s levels and well below all the values used in the models in the CSIRO climate reports.

The New South Wales study used 14 models, some of which applied just one of the various emissions scenarios, several used two and one used four. The report says (p. 34) that the results of two pairs of models were averaged because “the individual patterns were similar”. In both instances of averaging, a model using a IS92a scenario was averaged with a model using SRES A2 and B2 scenarios. All three scenarios show almost constant increase in carbon dioxide to year 2100, the IS92a scenario to 705 ppm (20 Gigatonnes carbon), the SRES A2 scenario to 850ppm (29 Gt carbon) and the SRES B2 scenario to 610ppm (610ppm (13.5 Gt carbon). Scenario SRESA shows an increase of 145ppm greater than IS92a and SRES B2 95ppm less than ISA92a, both of which are greater than or equal to the increase in atmospheric CO_2, levels from pre-industrial times to the present day and which is claimed to be responsible for recent global warming. The reported similarity of output from models that use such widely different CO_2 inputs indicates either that carbon dioxide has very little effect on temperature, or that the models are inadequate, or both.

Lack of disclosure of methods, algorithms and parameterisation

The CSIRO reports provide little information about the algorithms and assumptions that were used within the climate models that they applied. Given this lack of information, it is impossible for interested third parties to attempt to replicate the work, and as climate science advances over time it will not be possible to confirm or refute the credibility of the CSIRO projections. For example, if the models proved to be inaccurate when dealing with humid conditions, and yet predicted that humid conditions would arise, then these predictions would clearly become unreliable.

The disclaimer to several of the CSIRO climate reports states "...models involve simplifications of the real physical processes that are not fully understood...", which is in agreement with the IPCC 2001 report which said that 8 of 11 listed climate factors were poorly understood. One example of these uncertainties is changes in cloud cover, the effects of which continues to be debated. Some authorities argue that an increase in (low) cloud causes an increase in albedo and thus has a negative effect on temperature, whereas others believe that a greater positive effect stems from the reduction in emissions of longwave radiation that is engendered by clouds.

Climate models use "parameterisation" for climate factors such as these that are not well understood. It is common practice to modify these parameters until the model produces results that approximate to historical patterns. The CSIRO climate reports provide no information about the parameterisation which has been adopted, but a recent study of climate models (Lee, 1997) found "significant differences in the magnitudes and even the signs of cloud radiation feedbacks, depending on [a modeller's] choice of parameterization schemes". Ringer *et al* (2004) confirmed this by showing that the poor cloud parameterization in climate models can lead to errors and Graham *et al* showed that cloud cover influences the uptake of CO_2, the greenhouse gas the CSIRO regards as the most significant for modelling purposes.

Programming errors

Various studies within the IT industry indicate that in late testing – that is, testing a software package after separately testing and correcting its individual modules – the number of coding lines containing an error ranges from 0.1% to 1%, with complex code tending to the higher end of the range (Putnam & Myers, 1992). Assuming that a climate model contains 500,000 lines of source code the number of error lines in the complete package can therefore be estimated to range between 500 and 5000. Some, perhaps many, of these errors may have no significant effect on the model output, whereas others will materially affect it. However, it only requires one software error with high impact to render the results of a model run valueless. To my knowledge, this issue has not been confronted by the CSIRO modellers, nor by their international colleagues who provide future climate scenarios to the IPCC. How, then, can we trust the accuracy of climate predictions made using these models?

6. RANGE OF OUTPUTS FROM CLIMATE MODELS

A disturbing factor in all of these reports is the range of the projections that are produced by different models that aim to forecast any particular climate factor. Models that are individually claimed to be at least reasonably accurate (although are demonstrably otherwise) produce results that vary widely.

For example, under the SRES emission scenarios, temperatures in the coastal and southern areas of New South Wales are predicted to increase by between 0.7 and 4.8°C by 2070, by between 0.3 and 5.6°C in the central west, and by between 0.9 and 6.4°C in the north. These values represent a huge variation from levels which have been experienced in the last 50 years however, such discrepancies are entirely to be expected amongst models whose RMS errors are as substantial as those used by CSIRO.

In the same report, the summer rainfall predictions for a large part of the west and south of NSW range from a decrease in rainfall of 40% to an increase of 40%. The report implies (p. 36) that consensus among models for annual rainfall should be accepted as credible despite any lack or shortfall in model validation. Regarding the RMS errors of rainfall predictions, the report makes the comment (p. 32) that most models achieved RMS errors less than 2mm per day but this compares unfavourably to the daily average of 1.55 mm of rain over the 1950–2003 period.

The Northern Territory rainfall predictions for 2070 range from a wet season increase of 20% to decrease of 40%, and a dry season increase of 20% to decrease of 60%. This is an extraordinary range of up to 80% however, as we saw earlier, the RMS error for almost all models is usually in excess of 50%. In the same report, the increase in the number of days over 35°C is predicted to range between 13 and 300 days in coastal areas, 16 and 104 days in the south, 30 and 200 days in the north and 26 and 130 days in the centre. Whereas a range of ± 20% might generally be perceived to be a crude estimation, these numbers can be expressed as 156.5 days ± 92%, 60 days ± 73%, 115 days ± 74% and 78 days ± 67% respectively. It is difficult to take such inadequate estimates seriously and that they appear to have been accepted without comment is a gross indictment of the adequacy of scientific audit advice available to state and territory governments in Australia.

7. OTHER ISSUES

Information is not presented clearly

The presentation of the CSIRO state climate reports often makes it difficult for a reader to verify the claims based on historical data, or to easily understand the meaning of figures, tables and textual information.

Graphs are often reproduced too small, vary in scale, lack grid lines or are in colours which impede understanding. Few large graphs of historical temperature and rainfall are provided and so the user has no real appreciation of the context. Graphs of rainfall data are sometimes shown as seasonal averages, sometimes as other groupings of three months, and sometimes as daily averages. The rainfall graphs in the Northern Territory report (p. 24) show “wet season” (Nov–Apr) and “dry season” (May–Oct) average total rainfall on one graph, but then later (p. 28) RMS errors are discussed in terms of daily averages for each of four seasons.

Though annual data is generally presented per calendar year, sometimes it is represented as March to February. Because seasons begin on the first of the month, it is unclear whether the label “summer” includes the December preceding the January of the year in question, or is the December of the same year.

Some reports include colour-coded maps of Australia that are too small to show detail, or have colour legends that are impossible to read but no accompanying text explanation (e.g. NSW report, pp. 17–18).

Given that the aim of the CSIRO reports was to provide clear guidance to policy makers about future climate, it is surprising to find that comparative graphs of observed and predicted conditions are too small to be clearly understood and often are shown as two separate graphs with only a small overlapping period by which to verify the modelling. One is forced to suspect that enlargement of these graphs was eschewed because it would clearly show the discrepancies present and have readers questioning the many statements that are made about good accuracy.

Failure to take other climate factors into account

Two serious omissions from the CSIRO scenario reports are (i) any real discussion of climate factors other than temperature and rainfall, and (ii) the absence altogether of any consideration of long-term, geological cycles and trends. Some reports make brief mention of cyclones, and perhaps a cursory discussion of El Niño. But, as I have shown above, though the influence of El Niño is regarded as strong, it has nonetheless not been taken into account in the modelling.

Australia’s climate is influenced by onshore winds, warm in the north and cool in the south. It is not uncommon in summer for strong northerly winds to bring hot air to southern Australia and cause temperatures to exceed 40°C for several days, nor for cold southerly winds in winter to similarly hold temperatures below 10°C. Neither the South Australian report nor the Victorian report contained any mention of these winds, despite their relative absence or presence exerting a substantial influence on temperature, and therefore being an important factor to be considered when determining climate trends and validating climate models.

Clouds are also a significant climate factor, especially in southern Australia during the winter. Cloudy winter nights reduce heat loss through long-wave radiation, and reduced cloud during winter days causes higher maximum temperatures, and even more so when little surface or near-surface water is available for evaporation. Veizer (2005) comments “In the general climate models (GCM), the bulk of the calculated temperature increase is attributed to “positive water vapour feedback”. In the sundriven alternative, ... [c]louds then cool, act as a mirror and reflect the solar energy back into space.”

The Bureau of Meteorology also highlighted the influence of clouds in the warm year of 2002 saying “The dry conditions were accompanied by much warmer than normal daytime temperatures ... But despite the high daytime temperatures, reduced cloudiness resulted in overnight temperatures being closer to average with the Australian mean minimum temperature being only 0.01°C below normal.” (BoM, 2002). Yet beyond unexplained and doubtless generic parameterization, no account is taken of changing local cloud conditions in the CSIRO models.

8. CONCLUSION

The CSIRO predictive reports discussed in this paper contain misleading climate trends and suppositions, based on inaccurate models and other dubious methodologies.

Although temperature and rainfall trends that CSIRO presents may be correct across a specific historic period, they may also be very atypical of the more general, longer-term climate picture. By judicious selection of the start and end of the period to be analysed, favourable circumstances can be created for the anthropogenic warming hypothesis. In particular, the CSIRO’s choice of 1950 as the start year for their analyses has resulted in very misleading temperature and rainfall trends for some states.

The discussion of historical climate that CSIRO presents makes no attempt to isolate and filter the effects of important controlling factors such as El Niño/La Nina conditions. Geological evidence for long-term climate trends is also completely ignored. As a result, the specific climate predictions made in the CSIRO reports have little if any validity. Inevitably, too, the predictions give an inaccurate picture of the causes of climate variation, and the distortion of the base against which the CSIRO models are validated leads to false conclusions about a human influence on climate.

The climate models used in the preparation of the CSIRO reports are far less accurate than claimed. Pattern correlations are often below acceptable standard, and RMS errors are often equivalent to more than twice the observed values for rainfall and temperature anomaly. In addition, data presentation in the reports is inconsistent, poor and often misleading, especially when the output from models is compared to observations. Too often, the casual reader is left with an impression that is very different to that which is gained by careful, detailed analysis.

Ultimately one might pose the question “why was it necessary to try to predict climate to 2100 or 2070 using mathematical models that are still in their infancy, and have inaccuracies that are so abundant and obvious?”. Surely a better initial step would have been to try to develop more accurate predictions of climate over shorter periods of a few years to a decade or so in the hope that such research will in due course lead to the development of more useful long-range models.

REFERENCES

(a) Climate Reports

New South Wales report: K. Hennessy, C. Page, K. McInnes, R. Jones, J. Bathols, D. Collins and D. Jones – “*Climate Change in New South Wales: Part 1: Past climate variability and projected changes in average climate*”, CSIRO 2004, online at http://www.cmar.csiro.au/ar/publications/hennessy_2004b.pdf (accessed Nov 2005).

Northern Territory report: K. Hennessy, C. Page, K. McInnes, K. Walsh, B. Pittock, J. Bathols and R. Suppiah – “*Climate Change in the Northern Territory*”, CSIRO 2004 online at http://www.nreta.nt.gov.au/whatwedo/greenhouse/documents/pdf/ntclimatechange.pdf (accessed Nov 2005).

Queensland 3rd annual report: Kevin Walsh, Kevin Hennessy, Roger Jones, Kathy McInnes, Cher Page, Barrie Pittock, Ramasamy Suppiah and Peter Whetton – "*Climate Change in Queensland under Enhanced Greenhouse Conditions: Third Annual Report, 1999–2000*" online at http://www.cmar.csiro.au/ar/publications/walsh_2001a.pdf (accessed Nov 2005).

Queensland final report: Kevin Walsh, Wenju Cai, Kevin Hennessy, Roger Jones, Kathy McInnes, Kim Nguyen, Cher Page and Peter Whetton – "*Climate Change in Queensland under Enhanced Greenhouse Conditions: Final Report 2002*" online at http://www.cmar.csiro.au/ar/publications/walsh_2004a.pdf (accessed Nov 2005).

South Australian report: K. L. McInnes, R. Suppiah, P. H.Whetton, K. J. Hennessy and R. N. Jones – "*Climate change in South Australia – Report on: Assessment of climate change, impacts and possible adaptation strategies relevant to South Australia*" online at http://www.environment.sa.gov.au/sustainability/pdfs/csiro_report.pdf (accessed Nov 2005).

Victorian report: R. Suppiah, P. H. Whetton and I. G. Watterson – "*Climate Change in Victoria – Assessment of climate change for Victoria: 2001–2002*" online at http://www.dar.csiro.au/publications/suppiah_2004a.pdf (accessed Nov 2005).

Victorian high resolution report: P.H.Whetton, R. Suppiah, K. L. McInnes, K. J. Hennessy, and R. N. Jones – "*Climate change in Victoria – High resolution regional assessment of climate change impacts*", The State of Victoria, Department of Natural Resources and Environment, 2002 online at http://www.greenhouse.vic.gov.au/climatechange.pdf (accessed Nov 2005).

(b) Other References

Bureau of Meteorology – "*S.O.I. Archives – 1876 to present*" online at http://www.bom.gov.au/climate/current/soihtm1.shtml (accessed Dec 2005).

Bureau of Meteorology – "*Annual Australian Climate Summary 2002*" online at http://www. bom.gov.au/announcements/media_releases/climate/change/20030106.shtml (accessed Dec 2005).

CCCma (Canadian Centre for Climate Modelling and Analysis) – "*CGCM RUNS FORCING: Equivalent CO_2 concentrations used in CCCma coupled global climate model simulations*", online at http://www.cccma.bc.ec.gr.ca/data/cgcm/cgcm_forcing.shtml.

Eric A. Graham, Stephen S. Mulkey, Kaoru Kitajima, Nathan G. Phillips, and S. Joseph Wright – Cloud cover limits net CO_2 uptake and growth of a rainforest tree during tropical rainy seasons, *PNAS* 100: 572–576; published online before print as 10.1073/pnas.0133045100.

Intergovernmental Panel on Climate Change (IPCC) – "*IPCC Special Report Emissions Scenarios*", 2000, section 1.4.

Lee, W.-H., *et al.*, 1997, "Cloud radiation forcings and feedbacks: General circulation model tests and observational validation", *Journal of Climate*, 10, 24792496.

Putnam, L. H. & Myers, W, 1992, *Measures for Excellence: Reliable Software on Time,* on *Budget*, Yourdon, Englewood Cliffs, NJ.

Ringer, Mark A. & Allan, Richard P. (2004) – Evaluating climate model simulations of tropical cloud. *Tellus A* 56 (4), 308–327. doi: 10.1111/ j.1600–0870.2004.00061.x.

Veizer, Ján – Celestial Climate Driver: A Perspective from Four Billion Years of the Carbon Cycle, *Geoscience Canada*, 32 (1), 13–28.