Australian Government
Bureau of Meteorology

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In reply please quote
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Ms Jeanette Radcliffe
Secretary
Senate Standing Committee on
Rural and Regional Affairs and Transport
PO Box 6100
Parliament House
CANBERRA ACT 2600

Dear Ms Radcliffe

Climate Change and the Australian Agricultural Sector

Thank you for the invitation to comment on the issues outlined in your letter of 10 October 2007. The Director of Meteorology, Dr Geoff Love, has asked me to respond on his behalf.

As the national agency for the collection of weather, water and climate data, the Bureau of Meteorology makes the attached submission to the Senate Standing Committee.

Yours sincerely

G Foley
Deputy Director (Services)

1 February 2008

Submission by the Australian Bureau of Meteorology
to the Senate Inquiry on
Climate Change and the Australian Agricultural Sector

The Bureau of Meteorology (Bureau) offers the following submission on the matter referred by the Senate on 19 September 2007 to the Standing Committee on Rural and Regional Affairs and Transport regarding:

i. the scientific evidence available on the likely future climate of Australia's key agricultural production zones, and its implications for current farm enterprises and possible future industries;
ii. the need for a national strategy to assist Australian agricultural industries to adapt to climate change; and
iii. the adequacy of existing drought assistance and exceptional circumstances programs to cope with long-term climatic changes.

Key Points

The scientific evidence available on the likely future climate of Australia's key agricultural production zones, and its implications for current farm enterprises and possible future industries

- While uncertainties remain about the details of climate change much is known with sufficient confidence to aid decision-making;
- Some recent trends in Australian climate are almost certainly a consequence of an enhanced greenhouse effect (e.g. general warming over the continent) while other trends are either a likely consequence (e.g. decreasing rainfall over southwest Western Australia) or require further evidence to draw conclusions (e.g. drying over southeast Australia);

The Bureau of Meteorology is the national agency for the collection of weather, water and climate data, and carries out an extensive program of analysis and monitoring of climate variability and change, the results of which are made freely available at its website.

The need for a national strategy to assist Australian agricultural industries to adapt to climate change

- There are both risks and opportunities for Australian primary industries from climate change but current climate projections suggest that, under a 'business as usual' scenario, for the agriculture sector, the balance would be towards negative impacts overall;
- Consequently, responding to climate change will require actions to mitigate/reduce greenhouse gas emissions together with actions to adapt to climate change that is already projected to occur regardless of the actions that might be taken globally to curb emissions;
- The large spatial coherence of projected changes in temperature, rainfall and other variables lends itself to both national and regional adaptation strategies.

The Bureau of Meteorology is collaborating with CSIRO and a number of other Commonwealth and State agencies in the development of comprehensive data sets aimed at understanding the likely impacts of climate change and variability on Australia's rural industries and pointing the way forward for the most effective ways of adapting on a range of time scales..

The adequacy of existing drought assistance and exceptional circumstances programs to cope with long-term climatic changes.

- Effectively communicating and integrating weather and climate information into agricultural planning including both natural variability and long-term changes is essential for improving decision-making within Australia's agricultural industry and throughout all of the nation's rural communities;
- Better understanding of climate variability, with particularly emphasis on improving predictions of the onset and course of major droughts and large-scale floods, will be critical to interpreting and applying climate change projections of Australian climate.

The Bureau and CSIRO are jointly developing world class climate models and related technologies through the recently established Centre for Australian Weather and Climate Research. This work must continue to be supported through the Department of Climate Change (formerly Australian Greenhouse Office) administered Australian Climate Change Science Program and the National Climate Change Adaptation Framework as well as sector-based industries and organisations.

Continued maintenance of the climate record in perpetuity, which involves the routine sampling of meteorological and related hydrological and oceanographic data across the nation and surrounding oceans, remains a cornerstone to understanding and adapting to climate change and variability. The Bureau's observational networks for establishing the climate record, the foundations of which were laid down 100 years ago, have served Australia well and must be secured for future generations, yet they are gradually being eroded. The Bureau would particularly like to draw the attention of the Committee to the need to maintain and indeed expand this critical component of national infrastructure.

The Bureau of Meteorology looks forward to the outcomes of the Committee's deliberations and expresses it willingness to contribute should any actions and recommendations pertinent to its national mandate and competence be included in the final report.

Response to the Terms of Reference

i) The scientific evidence available on the likely future climate of Australia's key agricultural production zones, and its implications for current farm enterprises and possible future industries

The fourth Intergovernmental Panel on Climate Change report (IPCC 2007) presents a comprehensive summary of the current scientific understanding of climate change. It is clear that Australia and the globe are currently experiencing rapid climate change. This change is observed in atmospheric and oceanic temperatures, weather circulation patterns, sea level rise, and changes to snow and ice. It is very likely that most of the warming observed since the mid-20th century is due to the accumulation of greenhouse gases in the atmosphere. CO_2 concentrations have increased from around 311 parts per million volume (ppmv) in 1950 (from ice core data) to in excess of 380ppm in 2007 (as recorded at Australia's Cape Grim baseline station); an increase of over 20% in 50 years. According to ice cores, this is the highest concentration in the earth's atmosphere for at least 700,000 years. Most of this increase can be attributed to human activities.

The IPCC (2007) report noted that for the sub-tropical regions of the globe, including large areas within Australia, Africa, Central America and the Mediterranean Basin, declines in water availability are projected to affect areas that are currently suitable for rain-fed crops. Increased climate extremes might also promote plant disease and pest outbreaks.

Most importantly, the report notes that for low latitude regions, which for Australia would include all areas north of a line from approximately Rockhampton in the east to Carnarvon in the west, even moderate temperature increases (1-2°C) are likely to have a negative yield impact on crops and pastures.

For much of sub-tropical Australia, projections using a mid-range CO_2 emissions scenario[1] suggest a rainfall decline of around 5% in winter and spring by 2030 (CSIRO and Bureau of Meteorology 2007), with reductions of 10% in the south west. By 2050, median decreases of 5-10% are likely in the south, with reductions of up to 20% in the south west. By 2070, reductions of around 10% cover much of the continent, with large areas likely to experience reductions of up to 20%.

As a result, the corresponding decrease in annual mean runoff by 2100 is also projected to be within the range 10-20%, with subsequent reductions in water availability for agriculture.

It is worth noting that for 2030, projections using B1, A1B, A1FI SRES emissions scenarios (which are "low", "medium" and "high" in the context of the scenarios considered in the CSIRO-Bureau (2007) report) show only small difference in the magnitude and distribution of winter and spring rainfall changes, whereas at 2050 and 2070, there is spread in the scenario outcomes. At 2070, the high emissions scenarios show significant areas with rainfall reductions of up to 40%, particularly in the spring, with at least 10% of scenarios showing reductions of greater than 40% for both winter and spring.

[1] As it is unclear which future paths anthropogenic emissions of carbon dioxide, as well as methane, nitrous oxide and sulfur dioxide, will take, the IPCC developed a set of four "storylines" for the future world: A1, which involves rapid economic growth, new technologies, and population peaking mid century; A2, which involves slower economic growth and continuously increasing population; B1, which involves the same population change as A1 and fast economic growth, but with an introduction of clean and resource efficient technologies, and B2, which involves continuous population growth but local solutions to economic, social and environmental sustainability. From these storyline, a total of 40 emissions scenarios were developed by six modelling teams. All were considered equally valid. The final six scenarios chosen included one from each of A2, B1 and B2, and three from the A1 storyline; A1F1 (fossil fuel intensive), A1B (balanced) and A1T (predominantly non-fossil fuel). A1F1 is effectively the highest emissions scenario; A1B is considered mid-range; while B1 is the lowest. The IPCC no longer considers any of the scenarios to be "business as usual".

Warming beyond 3°C is projected to have negative impacts for crops and pastures in all regions. At 2030, virtually all scenarios suggest a median warming of between 0.6 and 1.5°C. At 2050 the mid-level emissions scenarios suggest median increases of between 1.5 and 2°C for the agricultural areas, whilst mid-range projections for 2070 suggest increases of up to 3°C for agricultural areas. If “high” emissions are considered for 2070, large areas may warm by around 4°C, with the continent-wide best estimate of 3.4°C.

The CSIRO and Bureau of Meteorology (2007) report notes that, due to the statistics used to combine models, these temperature projections are conservative, and that “*There is a significant possibility that warming may occur in excess of these values, particularly later in the century, although the likelihood of this occurrence is impossible to estimate at this stage.*”

The impacts of climate change on agriculture will (at least initially) be largely felt through the interaction of climate variability with the longer term trends, leading in particular to more frequent extreme events with, for example, heatwaves and droughts tending to be more frequent and intense. Such outcomes might be characterised by events such as the recent droughts, which have seen record high temperatures compounding the rainfall deficiencies.

This interaction means that climate change is likely to occur as a series of shocks during which systems experience new combinations of stressors. Without careful management such shocks have the potential to generate abrupt adaptive responses. A key requirement for managing these shocks will be suitable early warning and monitoring systems, and generally enhanced resilience.

Consequently, climate change scenarios that include increased frequency of heat stress, droughts and flooding events inevitably point to reductions in crop yields and livestock productivity beyond impacts that would follow from changes in the mean state alone. For instance, the intensity of rainfall (i.e., rain per rainday), particularly in the tropics and the southeast, is forecast to increase in all scenarios, suggesting increased rates of erosion and flood frequency. Correspondingly, the number of dry days is also projected to increase, especially in the central and western regions, suggesting that periods between rain events will become longer. The risk of hail is also projected to increase along Australia’s east coast, including large parts of the eastern Murray Darling Basin.

The recent warming experienced over Australia means that Australia is now routinely experiencing monthly and annually averaged temperatures that lie well outside historical experience. This pattern will likely to accelerate during this century. Beyond a mid-range warming (~3C) the climate of Australia would be unlike anything in the observational record with the potential for new extremes of heat, drought, and rainfall. Warmings of greater than 5C are likely for example under an A1F1 emission scenario, though the timing of such magnitude warming is dependent on the rate of emissions growth and the behaviour of the natural carbon cycle. Paleoclimatic evidence shows that such warmings would likely lead to persistent, extremely high summer temperatures across much of inland Australia; potentially well in excess of 50C, which would be very disruptive to both plant and animal life.

ii) The need for a national strategy to assist Australian agricultural industries to adapt to climate change

All of Australia has undergone, and/or will undergo, some impact from climate change, be it changes to temperature, rainfall, humidity, wind, hail, bushfire, thunderstorms, or even sea level rise. Correspondingly, it is inevitable that agriculture will experience both risks and opportunities right across the continent. Current climate projections suggest that in general, impacts to Australia's agriculture will be negative. Hence it is clear that any action, just as occurs with these meteorological variables, will need to cross all boundaries.

While it is clear that responding to climate change will require local, regional and global actions to reduce greenhouse gas emissions, adaptation to change that is already locked in to the climate system will be required regardless of the actions that might be taken globally to curb emissions. Even if emissions were curbed immediately, warming will continue to occur for some considerable time due to inertia in the climate system (IPCC 2007).

To best adapt to climate change both long and short term planning is required.

Long term plans require long term projections for the Australian climate, and hence continued research and improvements of climate models and in methods used to produce projections are essential. In late 2006 senior researchers from the Bureau of Meteorology and CSIRO defined Australia's climate change knowledge gaps and research priorities (Holper and Power 2007). Of particular note was the need to improve the simulations of the earth's climate system by advancing to new generation climate models, which not only contain the physics of the atmosphere, oceans and cryosphere (as done in earlier generation models), but also the physics and/or chemistry of interrelated aspects such as the biosphere and radiatively active gases. Such improvements would also include a full carbon cycle, covering the terrestrial (including full vegetation model), ocean and atmosphere systems.

This project (The Australian Community Climate and Earth Systems Simulator, or ACCESS[2]) is viewed as central to providing improved accuracy of regional climate projections, as well as the improved ability to feed into projections of direct relevance to agriculture, water management, and natural resource management, amongst others, which would be of direct concern to Australia's primary industries.

ACCESS will also provide the vehicle for the next generation of seasonal and longer range forecasts. To do this, and to provide the high level projections described above, continued support is vital through the Department of Climate Change administered Australian Climate Change Science Program and the National Climate Change Adaptation Framework as well as sector-based industries and organisations.

Other priority areas identified in the Bureau/CSIRO report include the need to support development of model downscaling (i.e., using statistics to relate broadscale model results to fine, local, scales of relevance to primary industries), including: the digitisation

[2] http://www.accessimulator.org.au/

and homogenisation of additional data suitable for downscaling; improvements in our understanding of the processes causing changes in climate that directly affect primary industries, and improving the ability to provide continuous information on climate over the coming decades, not just for 2030, 2050, 2070 and 2100.

It is hoped that the projections for Australia from the ACCESS model will also be included in a proposed Climate Projections Online database (please see a more detailed description in section (**iii**)). Such a database would have the ability to provide a wealth of information from several models, enabling better estimations of risk than by using one model alone, and hence improve risk management. Such a future climate database is a key to planning adaptation in the longer term for all primary industry and natural resource managers. Such a detailed database has already been developed for the United States.

For shorter time frames, the Bureau has been active in providing information that can inform users about current and short-term future conditions. The Bureau's seasonal outlook service for rainfall and temperature[3] currently uses statistical relationships between the Indian and Pacific oceans and Australian rainfall and temperature to make outlooks for the season ahead. Through continued research and development, the ACCESS model will be able to provide further advances in the seasonal outlook skill, and thus better inform users as to the seasonal conditions they will face.

Furthermore, for several years the Bureau has offered a regular commentary on the state of the El Niño –Southern Oscillation (ENSO) via its ENSO Wrap Up service[4]. This service provides the public with a briefing on the current thinking of Bureau climatologists with respect to the drivers of Australia's climate variability, and hence can assist the user manage climate-related risk in the short to medium term.

On even shorter time frames the Bureau not only delivers all its standard weather forecasting products for use by primary industries, but has also established the Water and the Land (WATL) website[5], with the objective to provide meteorological information specifically tailored for primary industry and natural resource management. In particular, its most popular product provides 8-day graphical outlooks of rainfall. This is, to some degree, a sense of the future direction of weather forecasts, with graphical information as well as site based forecasts, meaning all Australians will have access to a "local" forecast of short term events.

The Bureau is also heavily involved in the Australian Water Availability Project (AWAP); a partnership between the Bureau of Rural Sciences, the CSIRO, the Bureau of Meteorology, and the Centre for Resource and Environmental Studies at the Australian National University (ANU). This project aims to develop an operational system for monitoring and predicting soil moisture and other components of the water balance for all of Australia at spatial scales down to 1km, and for time scales ranging from weekly to several decades.

It is clear that climate change will have an Australia-wide impact, and hence this requires both national and regional strategies for long and short term adaptation. Such strategies

[3] http://www.bom.gov.au/climate/ahead/
[4] http://www.bom.gov.au/climate/enso/
[5] http://www.bom.gov.au/watl

must prioritise the basic underlying data, information and associated tools, which can most efficiently be developed and/or maintained at a national level but may also be applied on a national or regional basis. The Bureau of Meteorology strives for national consistency with regional detail.

iii) The adequacy of existing drought assistance and exceptional circumstances programs to cope with long-term climatic changes

Data from the Bureau's monitoring network – both real-time and historical – and its associated management (e.g., quality control, archival and analysis) is a cornerstone to the both drought assistance and exceptional circumstances programs.

Without knowledge of the areal extent of regions experiencing drought, the timescale of the drought being experienced, the amount of rain needed to alleviate drought, and the placing of a drought in a historical context, it would be impossible to form an objective assessment of a current drought event.

Data on all time and space scales down to local level is, therefore, vital to the assessment of individual farmers, communities and rural industries that are genuinely in need. It is for this reason that the integrity of the Bureau's climate monitoring system, which has served the public for 100 years, be sustained.

It is also vital that information from this monitoring system is fed into a carefully managed database that is made available to all users, and in particular to applicants and assessors of drought assistance and exceptional circumstances. The Bureau currently offers a suite of information on historical data through its online climate change tracker website[6], and its maps of historical analyses of rainfall, temperature, circulation patterns and drought areas[7]. For examining local (station) information the Bureau has instigated public access to the national database via the Climate Data Information Online project[8]. Although this project is significantly under-resourced to deliver on its full potential, it is intended that it be expanded over time as resources permit to allow greater access to the national climate data record.

Information is supplied to the National Agricultural Monitoring System (NAMS)[9], a multi-organisation project managed by the Bureau of Rural Sciences which is directly related to providing local climate and production information for dryland/broadacre and irrigated industries, for over 600 regions throughout Australia. Such information will soon become even more accurate and detailed. Drawing on earlier research and development at the Australian National University and the Bureau's research division, the Bureau's National Climate Centre, in its contribution towards the goals of AWAP (see section **ii**), now generates state of the art, very high resolution (0.05º×0.05º) climate analyses for daily maximum temperature, daily minimum temperature, rainfall and vapour pressure. The new analyses represent a substantial improvement over existing analyses with significantly lower errors and substantially improved representation of local detail and topographical effects.

6 http://www.bom.gov.au/climate/change/
7 http://www.bom.gov.au/climate/
8 http://www.bom.gov.au/climate/averages/
9 http://www.nams.gov.au/

It is important to note that none of the developments above would be possible without the Bureau's climate monitoring network and database. It is vital to the drought assistance and exceptional circumstance programs that both the monitoring networks and historical database are funded appropriately and in perpetuity. Despite the best efforts of the Bureau to rationalise its basic monitoring networks and to continue to improve efficiency through the introduction of the latest technology, the relentless pressure of "productivity dividends" will inevitably place the integrity and future continuity of Australia's climate record in jeopardy.

Drought assistance and exceptional circumstance programs will also be one of the key users of modelled information about Australia's future climate. For instance, as drought assessment often relies upon return periods of low rainfall (e.g., if a region has experienced, say, a one-in-twenty year dry event) then it is of great importance to determine if any changes to these return periods may occur. If, for instance, historical one-in-twenty year dry events may soon become one-in-fifteen year events, this potential change in risk is of central importance to formulating future drought and drought relief policy.

To enable such assessments, further research is needed. Central to the Bureau's modelling of the future climate in collaboration with CSIRO, and to provide stakeholders with data that can feed into their own agriculture, water management, and natural resource management models, is the ongoing support of the ACCESS program (see section **ii**).

A database of future climate projections will be needed to enable programs such as exceptional circumstances and drought assistance to make objective plans for a changing climate. The proposed Climate Projections Online database, managed by the Bureau of Meteorology and the CSIRO, is under consideration in response to a request from the Department of Climate Change to tackle actions identified by the National Climate Change Adaptation Framework, and recommendations by the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) Independent Working Group report *Climate change in Australia: Regional impacts and adaptation*.

Much like the Bureau's historical database, a climate projections database would contain detailed information from a number of global climate models for periods up to, and possibly beyond, 2100. The data base will need to be revised and updated in an ongoing manner as climate models and projections improve over coming years.

Such a wealth of future climate information available in the one location and delivered in relatively simple formats and via easy to use tools could easily be mined by researchers both internal and external to the Bureau to best inform processes such as the exceptional circumstances and drought assistance programs.

Likewise, Australia's climate monitoring network and priceless database of historical observations, and the associated Bureau programs to ensure the data's archival, quality control, analysis and dissemination, cannot be understated in their importance to Australia's understanding and, ultimately, response, to climate change. As such, it is imperative that they receive the strongest ongoing support possible.

References

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