The Parliament of the Commonwealth of Australia

Seasonal forecasting in Australia

House of Representatives
Standing Committee on Industry, Science and Innovation

November 2009
Canberra

ISBN 978-0-642-79260-0 (Printed version)

ISBN 978-0-642-79261-7 (HTML version)

Report cover images courtesy of Bureau of Meteorology (radar and sea surface temperature) and JupiterImages Unlimited (cloud, canola and dam).

Contents

Foreword

Many of Australia's economically important industries such as tourism and agriculture are crucially dependent on long-term meteorological forecasting, otherwise known as seasonal forecasting. This presents significant challenges as Australia is a vast continent with a diverse range of climatic conditions. The Committee's inquiry examined a number of these challenges and found that Australia needs to invest in resources and people to increase the reliability of seasonal forecasting for the benefit of individuals, businesses and emergency services.

Not only is seasonal forecasting essential for our agricultural industries, but for tourism and water management, the planning of large infrastructure projects and emergency services. In these industries, and others, information on long term weather forecasts influences a wide range of management decisions. For example, grain producers need to know about seasonal rainfall and the likelihood of frost. Less obvious examples include energy authorities needing to plan for extra energy loads during heat waves and the construction industry in North Queensland factoring in wet season down time. Emergency services rely on seasonal forecasting to plan for bushfires, floods and cyclones. Advanced warning of possible extreme events allows for strategic planning and preparation.

Australia once led the world in research and development in climate and weather forecasting but sadly has fallen behind in the last couple of decades. One of the major causes for the decline is the increasing reliance on supercomputing capability. Australia's supercomputing capacity has not kept up with comparable countries. New supercomputers that have just been provided to the Bureau of Meteorology and the Australian National University will not make up the shortfall. Limited computing capacity is hampering Australia's research efforts and our ability to attract top quality researchers.

Another concern is the reduction to the Bureau's staffing levels which is impeding its effectiveness and jeopardising long-term sustainability. Recruitment needs to be increased, employment conditions reviewed, career pathways encouraged and secure tenure provided to attract and retain more high-calibre personnel.

Another contributing factor to the falling standard of our weather forecasting is the quantity and quality of data coming from the network of weather stations across the country. Forecasting depends

on accurate, long term, observational data. The integrity of current data is being threatened by a number of factors: many existing weather stations are suffering the effects of age, resource cuts have lead to a decrease in qualified observational staff and there are significant gaps between weather stations across the continent. Additionally, there is concern that some weather stations could be better placed. More weather stations are required to improve the amount and integrity of the data being collected.

Challenges facing long-term seasonal forecasters include Australia's position in the Southern Hemisphere Indo-Pacific Region and the number of variables which need to be included in simulations. Much of the work done in the Northern Hemisphere is not useful to Australia's weather sensitive industries. Variables such as the El Niño effect and the Indian Ocean Dipole provide an abundance of data that must be incorporated into any reliable forecasting model. Other variables include particulates or aerosols like smoke from agriculture, deforestation, industry and volcanoes. Currently the effect of many of these variables on Australia's climate and weather patterns is not fully understood and more research on their impact is required.

Australia is a large land mass and long term forecasting needs to be tailored to regional needs to be useful and effective. Seasonal forecasts are only useful if the data is translated into meaningful information for end users. A number of State Governments are taking the lead in this regard, matching data to stakeholder requirements and producing a range of products that enable end users to gain maximum benefit from the Bureau's long-term weather forecasts.

Despite the difficulties identified by the inquiry, Australia is doing some impressive work in the research field, not only by the Bureau of Meteorology and CSIRO, but by State Government agencies and universities. However, the lack of a nationally coordinated research agenda and some reluctance to share information is hampering progress. The establishment of an institute of meteorological science to facilitate an ongoing partnership between the relevant research bodies will go someway to helping Australia make up lost ground and regain its place as a leader in long-term meteorological forecasting.

It is hoped the measures outlined in this report will boost Australia's capacity to provide suitable and meaningful seasonal forecasting products.

Maria Vamvakinou MP
Chair

Membership of the Committee

Chair	Ms Maria Vamvakinou MP	
Deputy Chair	Hon Fran Bailey MP	
Members	Mr James Bidgood MP (until 22/10/09)	Mr Michael Johnson MP
	Mr Nick Champion MP	Mr Rowan Ramsey MP
	Mr Darren Cheeseman MP	Ms Amanda Rishworth MP
	Dr Dennis Jensen MP	Mr Mike Symon MP

Committee Secretariat

Secretary	Mr Russell Chafer
Inquiry Secretary	Mr Anthony Overs
Research Officer	Dr Narelle McGlusky

Terms of reference

The inquiry will inquire into and report on long-term meteorological forecasting with particular reference to:

- The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems;
- Innovation in long-term meteorological forecasting methods and technology;
- The impact of accurate measurement of inter-seasonal climate variability on decision-making processes for agricultural production and other sectors such as tourism;
- Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail, and tsunami, in Australia and in neighbouring countries; and
- Strategies, systems and research overseas that could contribute to Australia's innovation in this area.

List of abbreviations and acronyms

4DVAR	Four-dimensional variational data assimilation
AAO	Antarctic Oscillation
AAS	Australian Academy of Science
ACCESS	Australian Community Climate and Earth System Simulator
ACRA	Atmospheric Circulation Reconstructions of the Earth
AMOS	Australian Meteorological and Oceanographic Society
APSFarm	Agricultural Production Systems Farm
APSIM	Agricultural Production Systems Simulator
APSRU	Agricultural Production Systems Research Unit
BoM or the Bureau	Bureau of Meteorology
CAWCR	Centre for Australian Weather and climate Research
CCS	Climate and Carbon Sciences Program
CCSM	Community Climate System Model
COAG	Council of Australian Governments
CPSU	Community and Public Sector Union
CRC	Cooperative Research Centre
CSIRO	Australian Commonwealth Scientific and Research Organisation

DAF	Western Australian Department of Agriculture and Food
DAFF	Department of Agriculture Fisheries and Forestry
DEC	Western Australian Department of Environment and Conservation
DERM	Queensland Department of Environment and Resource Management
ENSO	El Niño – Southern Oscillation
FESA	Fire and Emergency Services of Western Australia
IOCI	Indian Ocean Climate Initiative
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
LWA	Land and Water Australia
MJO	Madden Julian Oscillation
NCI	National Computer Infrastructure
PDO	Pacific Decadal Oscillation
POAMA	Predictive Ocean Atmosphere Model for Australia
PWS	Public Weather Service (UK)
QCCCE	Queensland Climate Change Centre of Excellence
R&D	Research and Development
SAFF	South Australian Farmers Federation
SAM	Southern Annular Mode
SILO	An internet website that provides a source of meteorological and agricultural data
SOI	Southern Oscillation Index

SPOTA-1	Seasonal Pacific Ocean Temperature Analysis
UK	United Kingdom
UKMO	United Kingdom Meteorological Office
WAFF	Western Australian Farmers Federation
WRF	Weather Research and Forecasting Model
WRMS	Weather Risk Management Services Pty Ltd

List of recommendations

3 Long-term forecasting models

Recommendation 1

The Committee recommends that CSIRO and the Bureau of Meteorology provide to the Australian Government a report with detailed explanatory information as to why a particular dynamic forecasting model or system was chosen for use in Australia. The report should be completed by the end of 2010.

Recommendation 2

The Committee recommends that weather and climate variables and influences, for example, particulates, be identified, thoroughly examined to assess their degree of impact on our weather and climate, and incorporated into forecasting models as necessary. Priority areas for incorporating these variables should be published.

Recommendation 3

The Committee recommends that the Australian Government increase funding for research into the effects of weather and climate variables such as El Nino and Indian Ocean Dipole that impact on Australia's forecasting abilities.

Recommendation 4

The Committee recommends that the Australian Government conduct a short review to determine what supercomputing facilities are required by CSIRO and the Bureau of Meteorology to conduct crucial forecasting operations and research. Any additional funding to increase supercomputing capacity should be made available as a priority so that all model research, development and application can be undertaken in Australia.

Recommendation 5

The Committee recommends that the Australian Government undertake an audit of weather stations that contribute data to forecasting models, to ensure that they comply with World Meteorological Organization guidelines. All necessary actions should be taken to ensure that all stations comply.

Recommendation 6

The Committee recommends that the Australian Government budgets for the purchase, installation and maintenance of additional weather stations in critical areas around the country. There should be broad consultation to consider the number of new stations needed and their placement.

4 Other issues

Recommendation 7

The Committee recommends that the Bureau of Meteorology employment conditions be reviewed and that a more secure tenure be provided to relevant staff, including increasing contracts from three years to five years.

Recommendation 8

The Committee recommends that the Australian Government establish an institute of meteorological science to develop an ongoing partnership between relevant research bodies and implement a coordinated research agenda.

1

Introduction

1.1 Weather and climate forecasting is vitally important to Australia's economic, environmental and social well-being and prosperity.

1.2 Weather and climate forecasting, at time scales from hours to days to seasons, influences many decisions made daily by all Australians.

1.3 Long-term or seasonal forecasts can influence major decisions in the agricultural sector, such as when or whether to plant particular crops. Planning for emergency management also relies on accurate seasonal forecasts.

1.4 A need has been identified for an increase in reliability of seasonal forecasts to better inform decisions made by landholders and other businesses and individuals across the country.

1.5 It is hoped the measures outlined in this report will boost Australia's capacity to provide suitable and meaningful seasonal forecasting products.

Background to the inquiry

1.6 The Committee agreed on 18 March 2009 to conduct an inquiry into long-term meteorological forecasting in Australia. The inquiry was referred to the Committee by Senator the Hon Kim Carr, the Australian Government Minister for Innovation, Industry, Science and Research.

1.7 The Terms of Reference called for the Committee to inquire into long-term meteorological forecasting in Australia with particular reference to:

- The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems;
- Innovation in long-term meteorological forecasting methods and technology;
- The impact of accurate measurement of inter-seasonal climate variability on decision-making processes for agricultural production and other sectors such as tourism;
- Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail, and tsunami, in Australia and in neighbouring countries; and
- Strategies, systems and research overseas that could contribute to Australia's innovation in this area.

1.8 The inquiry was advertised in the *Australian Financial Review* on 21 March 2009.

1.9 The Committee sought submissions from Australian Government Agencies, weather information providers, researchers and peak bodies representing various industry sectors.

1.10 The Committee received 34 submissions and four supplementary submissions. The submissions are listed at Appendix A.

1.11 The Committee received 11 exhibits to the inquiry, which were provided in addition to written submissions, received during public hearings or sent to the Committee by other parties. The exhibits are listed in Appendix B.

1.12 The Committee held nine public hearings across Australia, in Canberra, Melbourne, Sydney, Adelaide and Perth. The Committee called 41 witnesses. The witnesses are listed in Appendix C.

Structure of the report

1.13 Chapter Two examines the way long-term weather forecasting is currently undertaken in Australia, who is responsible and who uses the forecasts.

1.14 Chapter Three examines the types of models used in long-term forecasting in Australia, the variables being considered by the models, Australia's

supercomputing facilities, the use of automated weather stations, and model outputs and products for end users.

1.15 Chapter Four examines a number of other issues including emergency services, staffing and training, career pathways for Bureau of Meteorological staff, resourcing and the need for a coordinated research agenda.

2

Long-term meteorological forecasting in Australia

Definition of long-term meteorological forecasting

2.1 For the purposes of this inquiry, long-term meteorological forecasting is interpreted as the forecasting of weather and climate from one to several months in advance. The simpler term 'seasonal forecasting' is sometimes used. The inquiry did not focus on short-term weather forecasting (hours to several days) or on long-term climate-scale projections (years to centuries) other than as necessary to provide particular context to discussions on seasonal forecasting.

Forecasting in Australia

2.2 The Australian Government Bureau of Meteorology (BoM or the Bureau) stated that meteorological forecasting and climate modelling are important to Australia's economic, environmental and social well-being and prosperity.[1]

2.3 BoM added:

> Predictions of weather and climate at time scales from hours to days and across seasons can influence decisions that range from

1 BoM, *submission 4*, p. 3.

> emergency management procedures and systems through to when or whether to plant particular crops.[2]

2.4 BoM explained that Australia is also particularly vulnerable to:

> … the impacts of climate change which is projected to result in decreased rainfall and increased frequency of drier and warmer droughts for the southern part of the continent, with more intense and frequent extreme events such as heavy rainfall and tropical cyclones in the north.[3]

2.5 BoM added that Australia's location and size expose it to a range of weather extremes such as heatwaves, bushfires, cyclones, floods and storms.[4]

2.6 BoM explained that its current policy is to:

> … maintain a seasonal climate outlook service that draws on meteorological and related observations, a climate modelling capability, a suite of forecasting tools, and information available from similar services and research elsewhere.[5]

Australia's unique climate and weather

2.7 Several submissions reiterated the need for region-specific application of forecasting models. For example, the Australian Academy of Science (AAS) stated:

> Australia's position in the Southern Hemisphere Indo-Pacific Region demands specific national weather and climate research capability to ensure forecasting systems are tuned to provide maximum national benefit.[6]

2.8 The Department of Agriculture, Fisheries and Forestry (DAFF) added:

> The Southern Hemisphere is somewhat unique and a lot of efforts in the Northern Hemisphere are not going to address the sorts of

2 BoM, *submission 4*, p. 3.
3 BoM, *submission 4*, p. 3.
4 BoM, *submission 4*, p. 3.
5 BoM, *submission 4*, p. 3.
6 AAS, *submission 25*, p. 1.

> questions we want addressed and certainly not at the scale that farmers need this sort of very localised up-to-date information.[7]

2.9 CSIRO explained that Australia relies on international observation systems such as satellite data, and benefits considerably from weather and climate forecasting technology developments in other countries, adding that:

> National capacity to further develop forecasting technologies is essential, because of Australia's specific vulnerability to Southern Hemisphere phenomena that are not the focus of most developed nations' forecasting activities.[8]

2.10 A discussion of the unique weather and climate variables affecting Australia can be found in Chapter 3.

Who does our forecasting?

2.11 Under the *Meteorology Act 1955* the Bureau of Meteorology has responsibility for the collection of meteorological and related data and the forecasting of weather and the state of the atmosphere, including the issuing of warnings for severe events likely to endanger life and property. The Act also requires BoM to produce records of weather observations and maintain the national climate record.[9]

2.12 Seasonal forecasting for Australia is provided predominantly by BoM's Climate Services Program:

> The Bureau of Meteorology has interests in forecasting meteorological and related conditions on all timescales. The Bureau currently has a strong and reliable weather forecasting capability out to around seven days and some capability at seasonal timescales to produce outlooks for general rainfall and temperature conditions likely over a coming three-month period.[10]

7 DAFF, *transcript of evidence 3 June 2009*, p. 2.
8 CSIRO, *submission 16*, p. 15.
9 BoM, *submission 4*, p. 5.
10 BoM, *submission 4*, p. 3.

How seasonal forecasts are made

2.13 BoM stated that, for the past two decades, it has been issuing forecasts on expected anomalies in rainfall and temperature across Australia over the coming three months, i.e. seasonal forecasts.[11]

2.14 BoM and CSIRO discussed methods of forecasting:

> Most operational forecast products are based on statistical forecast methods that have been used for more than two decades. Some new, experimental dynamic forecasts are showing improved forecast skill and are expected to replace statistical forecasts in the future. They are currently used to provide additional guidance for the operational service.[12]

2.15 BoM's submission discussed at length the fundamentals of meteorological forecasting, including the difference between statistical and dynamic modelling:

> Meteorological forecasting in general involves gathering observations about past or present conditions that define and influence weather, and using those observations in some way to predict what the meteorological conditions will be at some future time. Forecasts can be based on statistics of the past ('statistical forecasts') but for weather are now almost exclusively based on complex models of the atmosphere, earth surface and ocean that take as input the observations of existing and past conditions.
>
> …
>
> A key assumption of statistical forecasting is that past weather and climate patterns are sound indicators of what can be expected in the future. Climate change challenges this assumption because it suggests that in the future the conditions that affect weather and climate increasingly will exceed the bounds of past experience. Consequently, a climatic state, i.e. the average conditions over a period such as a month or season, which is outside the bounds of the climatic record used to construct a statistically based forecast system, will likely be less well forecast than any climatic state that is within the bounds of that record.
>
> …

11 BoM, *submission 4*, p. 5.

12 BoM, *submission 4*, p. 3; CSIRO, *submission 16*, p. 4.

> Dynamic forecasting, however, is based on fundamental physical and dynamical relationships; relationships that are largely invariant to climate and climate change, and are conditioned by assimilating (dynamically) observations of the past and present state.[13]

2.16 BoM further explained that dynamic seasonal forecasting has distinct advantages over statistical forecasting in a changing climate regime:

> Dynamical forecasting models use extensive mathematical calculations based on the laws of physics, but do not start from perfect representations of the weather system (either in terms of equations or observations) and so do not produce exact forecasts of the future. Indeed, even the smallest of errors in an otherwise perfect model will grow over time, limiting predictability of weather to around 10-14 days. Hence, every forecast has a degree of uncertainty attached to it.[14]

2.17 BoM explained that the closeness of forecasts to actual events when reviewed with hindsight is referred to as 'forecast skill', and that this skill for a given time interval (e.g., daily forecasts) declines as predictions are made further into the future. BoM added:

> Hence, forecasts of tomorrow's weather are generally more skilful than forecasts of the weather five days from now … seasonal forecasts tend to involve statements about average conditions over future weeks to months rather than forecasts of specific conditions on particular days in a future season.[15]

2.18 BoM also explained levels of uncertainty and ensemble forecasting:

> Uncertainty, which grows with the length of a meteorological forecast, is being quantified by generating a series of forecasts under slightly different starting conditions in the model, which reflect the level of uncertainty in not being able to exactly prescribe the current state of weather everywhere, and then analysing the spread in the series of forecasts. This approach, termed ensemble forecasting, allows more appropriate probability statements, i.e. estimates of uncertainty, to be made about a forecast. Ensemble predictions generally provide more robust and reliable assessments of forecast conditions.[16]

13 BoM, *submission 4*, p. 6.
14 BoM, *submission 4*, p. 6.
15 BoM, *submission 4*, pp. 6-7.
16 BoM, *submission 4*, p. 7.

2.19 Professor Roger Stone, a climatology and water resources researcher, explained that outputs from climate forecasts (eg three or six month outlooks) are most appropriately described in probabilistic terms:

> … very much akin to the same way medical outlooks and 'odds' are described (eg – 'there is a 30% probability of survival after 5 years in a medical diagnosis' and 'there is a 30% chance of receiving the long-term median rainfall for this time of the year for your region over the next three months').[17]

How seasonal forecasts are used

2.20 BoM stated that reliable seasonal forecasting has considerable potential to deliver tangible benefits for forward planning and business operations in agriculture and other industry and government sectors.[18]

2.21 BoM further explained:

> Sound meteorological forecasts, including seasonal forecasts, are central to good risk management in agriculture and other weather sensitive industries as they enable informed planning and decision making well in advance of undertaking key activities. Skilful seasonal forecasts can be used to maximise benefit in good years as well as avoid losses in bad years. For example, 70-80% of profits are made in 30% of years in southern wheat growing regions. Improved information about which years are likely to be better (or poorer) has considerable potential benefit. A seasonal climate forecast can be used to determine the optimum time to sow, the area sown and the amount of fertilizer that might be required.[19]

2.22 BoM discussed the benefits of seasonal forecasts to some sectors:

- Seasonal forecasts can be used to obtain natural resource and risk management benefits in addition to economic benefits. Some work has focused on the use of seasonal forecasts to alter plant rotation strategies to reduce groundwater build-up and associated salinity increases …;
- … substantial increases in farm income can be achieved by adjusting stocking rates to match forecasts of plant growth and thus avoiding increases in natural resource degradation in

17 Prof Roger Stone, *submission 10*, p. 4.

18 BoM, *submission 4*, p. 7.

19 BoM, *submission 4*, pp. 9-10.

seasons expected to have lower plant growth. This is a clear benefit of seasonal forecasting but is difficult to quantify economically;

- There is considerable potential for whole-of-industry gains from climate forecasts. For example, sugar millers in Queensland use climate forecasts to plan mill maintenance and operating schedules. Transport and storage enterprises likewise could benefit from advance planning of capital expenditure, maintenance and operations based on robust seasonal forecasts;
- Reliable seasonal predictions of water availability are highly valuable for water resources management and irrigated agriculture, and could provide useful information on water allocation forecasts, water markets, and irrigation water availability;
- Long term air quality forecasting also depends on sound seasonal weather prediction. Early warning of likely air quality issues provides information for policy makers in formulating effective and targeted long term air pollution policies. Long-term air quality forecasting depends on accurate long-term meteorological forecasting because the meteorology affects air quality both directly and indirectly. Potential benefits from seasonal air quality forecasting include:
  - ⇒ more effective and better targeted air pollution control strategies;
  - ⇒ improved seasonal forecasts of hospital admissions because of air-quality-related patterns in asthma and other respiratory ailments; and
  - ⇒ quantifying the links between air quality and climate to ensure optimum mitigation and adaptation strategies.[20]

2.23 BoM stated that the key challenges to enhance the utility of seasonal forecasts for users include not only improving the skill, timeliness and delivery of the forecasts but also improving communication and understanding for users about the appropriate interpretation and use of the valuable but uncertain information contained in seasonal forecasts.[21]

2.24 The Weather Channel discussed the way in which seasonal forecasts are used, and the difficulties associated with media interpretation:

> At the Weather Channel we use a particular product, the Seasonal Outlook service, and we tend to avoid fifty-fifty-type situations because they are so difficult to explain, particularly in a 30-second grab. Also, they are particularly difficult to explain in newspapers.

20 BoM, *submission 4*, pp. 10-11.

21 BoM, *submission 4*, p. 11.

> I think the way the bureau explain them on their web site is the best way of doing it because they really go into all the nuances and the detail. It is a very difficult situation to explain.
>
> …
>
> What the bureau is trying to get across to the public is perfectly legitimate, in that if you use these forecasts, say, for a 10-year period, you are going to come out in front. If you are just going to use a forecast once then it is like backing a favourite at the racecourse; favourites do not always win. If you use these forecasts on a regular basis then you will come out in front and that is a difficult thing to get across, particularly in newspapers that are after a snappy headline. That can change the whole meaning of the product underlying it. It is a challenge … it is a difficult product to use and I think many farmers actually use it through agricultural consultants, and they talk about it in detail. It is a product that is very difficult to use for the mainstream media.[22]

2.25 Professor Roger Stone raised some of the challenges associated with any increase in the use of seasonal forecasts:

> Climate forecasting or 'long-range meteorological forecasting' … has been demonstrated to have considerable capabilities and modest but useful 'skill' for many regions of Australia. However, inter-agency jealousies, poorly trained (in climate systems) rural extension personnel, and poor representation in the media have all led to confusion and poor uptake in many sectors. It is believed a reason for this is that [seasonal forecasting] should more appropriately be represented as a 'risk management system' rather than a 'weather forecast' system.[23]

2.26 Professor Stone also explained that a considerable amount of work had been done in Queensland to integrate seasonal forecasts into management systems:

> Much advanced work in this field has been completed in Australia, especially in regards to agricultural applications at the APSRU group in Queensland (Agricultural Production Systems Research Unit – a joint CSIRO, Queensland Government, University of Queensland agency) to show the value of integrating *tested and scientifically published* climate forecast systems with

22 Weather Channel, *transcript of evidence 30 June 2009*, p. 12.

23 Prof Roger Stone, *submission 10*, p. 3.

> agricultural systems models. Work at APSRU has been world leading in that it was one of the first in the world to demonstrate the full value of climate forecasting through its potential to usefully change and help on-farm management decisions and also in being able to provide formulae for testing climate forecast skill associated with a given forecast system.[24]

2.27 BoM stated that the benefits of seasonal forecasting would be enhanced through clarification and education on the appropriate interpretation and application of forecasts and, accordingly, increased user-confidence about what season forecasts do (and don't) offer.[25]

2.28 BoM discussed the use of forecasts in decision making, and the need for interaction with forecast users:

> The limits to skill and the inherent uncertainty of seasonal forecasts are not yet well understood by end users, and user expectations of potential improvements in forecasts may be higher or lower than can be achieved. Seasonal forecasts will be most valuable and informative if their uncertainty is well-understood, well-communicated and well-used. Education of end-users in the best use of forecast probabilities is essential, and end-user participation in the development of the information products derived from the forecasting model, whether statistical or dynamical, provides considerable benefit.[26]

2.29 BoM added that seasonal forecasts should be one element in decision making processes:

> There are, of course, other considerations in determining the best management decisions; using seasonal forecasts is just one part of an overall forward planning and risk management strategy, which helps determine the way to lean, and not necessarily the way to jump. This distinction is important because of the uncertainty inherent in seasonal forecasts.[27]

2.30 The Queensland Department of Environment and Resource Management (DERM) discussed the need to easily incorporate forecasts into management systems:

---

24 Prof Roger Stone, *submission 10*, p. 4.

25 BoM, *submission 4*, p. 7.

26 BoM, *submission 4*, p. 10.

27 BoM, *submission 4*, p. 10.

> Seasonal climate forecasts need to be translated into terms that can be readily incorporated into management and decision making. The Queensland Government has learnt that a 'transparent' approach leads to a better understanding of the underlying processes, a better appreciation of the probabilistic nature of seasonal climate forecasts, and therefore encourages long-term adoption.[28]

2.31 DERM suggested that a lack of available specialist interpretation for some BoM products limits their effectiveness and uptake in some cases, and emphasised the importance of translating seasonal climate forecasts into more meaningful terms for decision-makers.[29]

2.32 DERM commented extensively on increasing the rate of adoption of seasonal forecasts by the community. The submission suggested that:

> Innovations with respect to increasing the rate of adoption by the community should concentrate on the need for continuous training of both advisory staff and the community. To assist better decision making, the contextual information that supports climate forecasting must be able to be understood by the business managers.[30]

2.33 DERM explained that it has provided "Managing for Climate Workshops" to help users better understand climate processes, the nature of seasonal climate forecasts and how to incorporate these into business and risk management frameworks, and that such workshops could be extended beyond the agricultural sector.[31]

2.34 DERM suggested that broader communication mechanisms should also be in place to:

> … disseminate targeted, useful, easy to understand, but risk cognisant climate forecasts that are applicable for a range of business purposes, through a range of mediums and communication processes (via the internet, message alert systems, workshops, preparation of case studies, extension programs).[32]

28 DERM, *submission 33*, p. 6.
29 DERM, *submission 33*, p. 6.
30 DERM, *submission 33*, p. 22.
31 DERM, *submission 33*, p. 22.
32 DERM, *submission 33*, p. 22.

2.35 DERM added:

> Such networks (including government departments, councils, community and catchment groups) provide the necessary link between climate forecasting and the development of policy responses, in order to support management systems and decision making. It also provides an essential feedback loop to ensure those on the ground responsible for implementing such solutions can influence their future development.[33]

2.36 DERM discussed the emerging need for the education of the next generation of research and advisory staff:

> In this respect, educational institutions have a role in incorporating climate information into practical courses, and in turn, current practitioners have a role in providing source of reference material and texts.[34]

2.37 DERM hopes that, given a more effective main-stream, broad-based promotion of seasonal climate forecasting, there will be less reliance in the future on high-profile 'gurus' and climate champions facilitating the adoption of seasonal climate forecast information by the community.[35]

2.38 DERM suggested the need for national agencies to further develop partnerships with state agencies, particularly as it may be difficult for national agencies to deal closely with a large Australia-wide user-base:

> These partnerships need to progress from a provider-user relationship to one which recognises the vital contribution that state agencies can play in both developing, value adding and extending climate information. Whilst each state may be at a different level in this regard, increased rates of adoption can only be expected by empowering state agencies … [36]

2.39 DERM believes there will be a continuing need and role for local interpretation of seasonal forecasts, both by the BoM regional office and the Queensland Government through the Queensland Climate Change Centre of Excellence (QCCCE):

---

33 DERM, *submission 33*, p. 22.
34 DERM, *submission 33*, p. 22.
35 DERM, *submission 33*, p. 22.
36 DERM, *submission 33*, pp. 22-23.

> As a practical measure to improve relevance of information to decision makers, the QCCCE recognises the importance of strengthening communication with the BoM regional office and collaboration with other state agencies. For example, through the exceptional drought periods in South-East Queensland this decade, the QCCCE has collaborated with water authorities, in particular SunWater, Department of Natural Resources and Water and the Water Commission to develop customised inflow and dam-level 'forecasts' bringing together the knowledge, data and skills of all agencies concerned.[37]

2.40 DERM added:

> With respect to rural industries, enhanced seasonal forecasting and decision support tools to assist producers in incorporating this information in their production decisions are an essential component in assisting producers become better prepared for drought.[38]

Improvements in forecasting

2.41 CSIRO stated that, as a direct result of the successful use of internationally available satellite data and contributions from Australian research and development, the predictive skill for southern hemisphere meteorology is now similar to that for the northern hemisphere.[39]

2.42 CSIRO explained that weather forecasts have improved significantly over the last few decades, as they have evolved from empirically based forecasts to today's forecasts which are based on computer models of the atmosphere.[40]

2.43 CSIRO further explained that, for the Southern Hemisphere, the forecast skill of the five day forecast today is as good as the three day forecast was in 1989.[41]

2.44 CSIRO added:

---

37 DERM, *submission 33*, p. 23.
38 DERM, *submission 33*, p. 23.
39 CSIRO, *submission 16*, p. 15.
40 CSIRO, *submission 16*, p. 10.
41 CSIRO, *submission 16*, p. 10.

> The improvements in forecast skill give scientists confidence that significant improvements in seasonal forecasts can also be achieved. Much of the improved skill … arises not only from better model representation of the atmosphere and oceans, but also the assimilation of increasing amounts of satellite data.[42]

2.45 CSIRO also stated that:

> Smarter systems and better use of existing and expected data streams, however, are needed to realise the full potential of weather forecasting systems and to provide forecasts at smaller spatial scales with reliability over longer lead times.[43]

2.46 BoM stated that existing seasonal forecasts for Australia appear to have reached their peak level of performance, and may even be declining in skill as the climate changes. BoM further explained that recent initiatives are focused on developing next-generation dynamic seasonal prediction models that can take changing climate conditions into account.[44]

Ways to improve Australian seasonal forecasting

2.47 Professor Neville Nicholls, a distinguished climate and weather researcher, stated that the limitations in the skill of seasonal forecasts need to be recognised, and that improvement of forecasts is feasible, however they will remain short of "perfect".[45]

2.48 Professor Nicholls reiterated that the statistical relationships between indices of the El Niño – Southern Oscillation and subsequent rainfall and temperature remain the core of the operational seasonal climate forecast system, despite any problems noted and the age of the statistical forecast system.[46]

2.49 Professor Nicholls noted that:

> Ultimately, the statistical forecast system will be replaced by improved coupled ocean-atmosphere models, capable of direct prediction of rainfall and temperature over Australia, so work is required to continue the development and improvement of these

42 CSIRO, *submission 16*, p. 10.
43 CSIRO, *submission 16*, p. 15.
44 BoM, *submission 4*, p. 3.
45 Prof Neville Nicholls, *submission 12*, p. 5.
46 Prof Neville Nicholls, *submission 12*, p. 5.

models, in parallel with the re-engineering of the statistical forecast system.[47]

2.50 Professor Nicholls made the following detailed suggestions and steps to be taken for the improvement of the seasonal forecast system:

- Re-engineer the operational forecast system run by the Bureau of Meteorology, to include new data that have become available since its initial introduction in the mid-1990s, and utilizing more modern statistical approaches.
- Re-engineer the system to include recent research on climate factors, other than the El Niño – Southern Oscillation and the Indian Ocean sea surface temperature patterns, affecting Australian rainfall.
- Develop a system that takes into account the long-term changes in Australian temperature and rainfall, and changes in the behaviour of the El Niño – Southern Oscillation, to avoid bias due to our changing climate.
- Develop a system that allows useful prediction across the "autumn predictability barrier". This will require more research on the causes of the barrier and methods to circumvent it.
- Provide sustained funding for the development of dynamical and empirical seasonal-to-interannual forecast systems, and their application.[48]

The next step

2.51 CSIRO discussed the role of the recently established Centre for Australian Weather and Climate Research (CAWCR):

> CAWCR comes under a joint research agreement between CSIRO and the Bureau of Meteorology. It is not a new institution. It is an unincorporated joint venture or partnership between CSIRO and the bureau. It is put together to essentially bring together research and development expertise from those organisations focussed on weather and climate research in the broadest of senses. It grew out of a recognition that Australia is a relatively small country which could not really afford to maintain separate R&D activities in different organisations, and it made sound sense for the bureau and CSIRO to get together and collaborate with the university sector to develop, in particular, Australia's future weather and climate forecasting capability. That is a key focus of the centre. The centre does not provide services directly to the community. Our

47 Prof Neville Nicholls, *submission 12*, p. 5.

48 Prof Neville Nicholls, *submission 12*, p. 5.

> research outputs are provided into the bureau for finessing into services as appropriate or as research outputs through CSIRO flagships and research themes. We do research across a very broad range of areas ranging from aviation, weather forecasting, research to support aviation forecasting, right through to climate and climate change simulation.[49]

2.52 BoM stated that, through its collaboration with CSIRO in the CAWCR, it now has world-class capability in the key area of climate and atmospheric research.[50]

2.53 CAWCR's activities are further discussed in Chapter 3.

Different forecasts and services

2.54 The Committee heard from a number of other forecasting agencies. Weather Risk Management Services Pty Ltd (WRMS), explained that they are able to value add to the basic information provided by the BoM and CSIRO:

> Weather Risk Management Services provides consulting services to weather and climate sensitive industries here in Australia and overseas as well. We generate the products that the Bureau of Meteorology and CSIRO are producing and far beyond. It is not just season outlooks but very detailed risk assessments. That is basically how we have built over the years our reputation here and abroad as well.[51]

2.55 WRMS told the Committee that this allows them to expand their services to weather sensitive industries beyond the usual users of long range weather information. The company:

> … specializes in tailored forecasting and weather and climate risk assessments for the Australian and overseas weather sensitive energy, soft commodities, construction and agricultural markets. Considerable expertise has been gained in R&D in numerical weather prediction modelling and climate modelling and directly applied in a commercially demanding environment to weather sensitive industries. WRMS has to prove every day, that weather

49 CSIRO, *transcript of evidence 18 May 2009*, pp. 31-32.

50 BoM, *submission 4*, p. 5.

51 WRMS, *transcript of evidence 30 June 2009*, p. 23.

> and climate forecasts can add value to weather sensitive industries.[52]

2.56 The Committee heard that WRMS could have provided useful information regarding the potential bushfire threat in Victoria in early 2009 but that they were constrained by both their business demands and legislative requirements regarding the dissemination of information:

> … Again, we already have these building blocks but we have to sit back and think: how do we actually do business in Australia? We have to do it in a smarter way. So how do we exchange this information? I do not receive any state or federal government funding. For example, I have customers who pay a fee to obtain certain information about heatwaves. Heatwaves in the southern states would indicate an increased airconditioning load coming up in the summer. This is basically what happened in the previous two summers. The interest was in that, and a by-product of it would obviously be bushfires. Bushfires also impact on the hydro catchments of AGL and Snowy Hydro. If you have a bushfire going through those catchments, it changes the catchment's characteristics and that can have an impact on the availability of electricity during critical periods.
>
> So, again, the building blocks are already there. The way that we exchange information has to change in this country, because it is basically one of the road blocks. I would be unfair to my customers, my clients, who are paying a lot [of] fees to obtain such sensitive information, if I exchanged it when we do not have any formalism to do so. It is not my bad intention to withhold information. It is basically a business case as such. So how do we do business in Australia? Are we actually allowed to exchange information? How do we cooperate with the Bureau of Meteorology, for example? The Bureau of Meteorology is allowed through various acts to issue the warnings, whereas we as a privately owned business and, as I understand it, other providers in Australia are not in a position legally to issue warnings. We may burn somebody. So there has to be a better formalism as to how we exchange this information.[53]

52 WRMS, *submission 21*, p. 1.

53 WRMS, *transcript of evidence 30 June 2009,* p. 27.

2.57 The Committee sought clarification of these claims from BoM. It considers that there is a need for private sector agencies who are able, to provide forecasts for targeted clients:

> In terms of the private sector, the bureau has a process whereby we put as much of the information we collect and produce through modelling and other capabilities out into the community and we provide a range of services in the public good for the Australian community. Because that information is out there, there is a private sector capability that builds up and it is not only on the seasonal forecasting it is on weather forecasting more targeted at specific users of the information. They are giving them more detailed services that we could not provide to specific groups, and they do it on a commercial basis. … We have a communication mechanism with them. We meet with them regularly and discuss where we are headed, what we are doing and what products we are actually bringing back into the public good side of things so that they are aware of what more information will be available and can look at their services and adjust to that accordingly. So it is very much a partnership from that point of view.[54]

2.58 However, BoM stated that warnings need to be tightly controlled to avoid misinformation:

> One area where we try to tow a fairly hard line is in the area of warnings. We believe, and it is fairly common practice around, that it is not good to have warnings coming from different sources giving conflicting information. That is one area where we expect the private sector not to encroach on, but that is not to say that there are not private individuals out there who do that as well.[55]

2.59 Concerning warnings regarding the potential high risk of bushfires in Victoria in 2009, BoM told the Committee that it had extensive consultations with fire agencies prior to the fire season:

> In terms of long lead forecasts, our standard forecast is a three-monthly forecast issued the month before, but there has been for some time now a collaboration between researchers and fire agencies. Workshops are held around September or October for the coming fire season. The one held in October last year provided an outlook for the coming fire season and so highlighted areas which had a higher risk of fire danger and so forth. In the outlook

54 BoM, *transcript of evidence 12 August 2009,* p. 11.

55 BoM, *transcript of evidence 12 August 2009,* p. 11.

> that was provided to fire agencies, southern Victoria was highlighted as an area of potential higher fire risk. It is not just public information that we make widely available on the website. We engage with agriculture and with fire agencies to provide more detailed forecasts, and that was done in the lead-up to the last fire season.[56]

2.60 The Community and Public Sector Union (CPSU) stated that its members were concerned about the potentially corrosive role of other organisations trying to compete with BoM's services, particularly in the long-term forecasting area:

> The Bureau is seen as the pre-eminent organisation for providing weather information in the short term, but NOT in the long term. We are being sidelined by inferior direct model output products from overseas organisations (often NOT a national Meteorological and Hydrological organisation), which provide misleading, contradictory and not well verified information.[57]

2.61 CPSU added that of particular concern is the:

> … "proliferation of private weather companies providing misleading material to the public". According to a Senior Meteorologist, the best specific day computer models have accuracy rates of only 60% or less when forecasting events such as rain seven days ahead. However "some companies" are exceeding what is possible with current computer modelling and "providing specific day forecasts for weeks even months ahead at specific locations … I believe many farmers are being misled by some of the long range products provided by the private sector".[58]

2.62 Another private forecasting agency whose work was brought to the attention of the Committee is Weather Action, a UK firm that uses solar activity to provide long term forecasts. The agency has recently extended its forecasts to Australia and appears to be having a fairly high success rate.[59]

56 BoM, *transcript of evidence 12 August 2009*, p. 12.

57 CPSU, *submission 3.1*, pp. 5-6.

58 CPSU, *submission 3.1*, p. 6.

59 John McLean, *supplementary submission 32.1*, pp. 4-5.

Using overseas forecasters

2.63 An article published in the *Weekly Times* on 17 June 2009 discussed the use by Victorian farmers of a Japanese forecast warning of unfavourable conditions for the winter growing season. The article states:

> Swan Hill grain grower Geoff Nalder said farmers would pay a lot of attention to Prof Yamagata's forecast.
>
> "He's been right on the money for the past three years," Mr Nalder said. "It's going to make us more cautious. We'll put our purchases on hold and trim back in other areas."[60]

2.64 When asked about the use of overseas forecasts, and why Australian farmers are relying on international forecasts instead of those projected by our own Bureau of Meteorology, Professor Neville Nicholls stated:

> I am not surprised and certainly not disappointed that Australian farmers are actually aware of that sort of information as well as the information that comes from the Bureau of Meteorology … it is not really an either/or situation at the moment; it is not just that our Japanese colleagues have worked all of this out and we haven't. It is a bit more interesting than that.[61]

2.65 Professor Nicholls explained further that differing forecasts arise due to disagreements over the degree of influence of climatic features:

> I am a close friend of Professor Yamagata. He knows my family well and visits us whenever he is in Melbourne. He and his colleagues have done interesting work following work that I did 20 years ago on the role of the Indian Ocean in governing Australian climate and rainfall variability. It has led to some really interesting scientific disputes. We have interesting and civilised disagreements over dinner. He would suggest that there is a stronger influence of the equatorial Indian Ocean on rainfall over southern Australia than I believe is appropriate. I think there is still a much stronger influence coming from the equatorial Pacific, but Toshio Yamagata thinks otherwise.[62]

2.66 Professor Nicholls explained the difficulties faced in developing useful seasonal forecasts:

---

60 www.weeklytimesnow.com.au/article/2009/06/17/87111_latest-news.html, accessed 4 November 2009.

61 Prof Neville Nicholls, *transcript of evidence 29 June 2009*, p. 15.

62 Prof Neville Nicholls, *transcript of evidence 29 June 2009*, p. 15.

> If we get back to the problem of how does a farmer make his mind up, this is again something that I try to address in my submission but this is a really challenging problem because the climate is changing and our old data do not include all the ramifications of that changing climate. It makes it really hard for the scientists and so devilishly difficult for a potential user to sort out these problems: which bits are climate change, which bits are the natural climate variability that we have been able to predict in the past and how do they interact? I admit I have no simple answer to this because I do not have a simple answer even to myself and it is something I have been thinking about for a long time.[63]

Value-adding forecasters

2.67 The Weather Channel explained its role in bringing forecast information to Australians:

> … we have an agreement with the Bureau of Meteorology under which they give us their products and their data free of charge in exchange for us distributing the information. In this information we cannot differ from the Bureau; our agreement specifies that our forecasts must be the same as the Bureau's, so we give the same information as the Bureau but we attempt to value add to the information. As an example, if the forecast is for a shower or two then we will say things like, 'mostly in the afternoon and we think we might get one to five millimetres'. We try to add a little more detail to the basic forecast.[64]

2.68 The Weather Channel explained that the additional forecast detail that it provides is derived from the vast amount of forecast and warning information from BoM, and that BoM often does not have the time or resources to provide that finer level of detail to the public.[65]

Committee comment

2.69 The Committee was astounded to learn that private enterprises are apparently able to forecast particular seasonal conditions and events, which may not necessarily have been forecast by our leading national agencies. The question that came to the mind of Committee members when this issue came to light was "how did you forecast these events and

63 Prof Neville Nicholls, *transcript of evidence 29 June 2009*, p. 15.

64 Weather Channel, *transcript of evidence 30 June 2009*, p. 9.

65 Weather Channel, *transcript of evidence 30 June 2009*, p. 11.

why didn't anyone else?" When considering the skills, knowledge and expertise in our national agencies, the question that came to mind was "what do they know that CSIRO and the Bureau don't?"

Impact of seasonal forecasts on agriculture and other industries

2.70 CSIRO and BoM explained that there is a wide range of industries that can and do benefit from seasonal forecasts, and a wide range of management decisions that can be altered in response to seasonal forecasts:

> Examples of potential or realized relevance of seasonal forecasts include:
>
> - dryland cropping, influencing sowing date, area, variety, fertilizer application, and mixed farming choices;
> - irrigated cropping, affecting use of irrigation water;
> - grazing, modifying stocking rates;
> - horticulture, influencing variety selection of annual crops, expected harvesting schedule and market supply;
> - viticulture, affecting planning for irrigation and harvests;
> - large infrastructure projects, allowing planning for rain delays;
> - emergency services, assisting planning and preparedness for likely extreme events;
> - water resources, influencing water rationing and irrigation allocations; and
> - tourism, through planning capacity and services for warmer/cooler seasons.[66]

2.71 The Western Australia Department of Agriculture and Food (DAF) discussed the key need for seasonal forecasting to better match the decision-making of agricultural enterprises:

> … there are critical times of the year for making major management decisions. Forecasts at these times of the year can have a major influence on the production, economic, environmental and social outcomes over much of WA. Primary interest is in prediction of the extremes of seasonal climate … Current seasonal forecasts are commonly expressed as probabilities of exceeding median rainfall (a two category outlook). This has little uptake unless the probability is either very

66 CSIRO, *submission 16*, p. 11; BoM, *submission 4*, p. 10.

> low or very high. Producers are seeking forecasts of the likelihood of seasonal climate (especially rainfall) extremes for specific times of the year, such as May to July, and August to September. After seasonal rainfall, grain producers also seek forecasts of the likelihood of frost events during August to September.[67]

2.72 DAF outlined the important periods in the calendar of operations and business decisions of cropping and animal enterprises in the agricultural area of WA:

- Summer/autumn for weed control and accumulation of stored soil moisture - if any;
- May to July for crop and pasture establishment. This is when the bulk of the variable costs are committed;
- August to October is when vegetative growth of crops and pastures, flowering of crops, grain fill and the beginning of harvest in the northern region occurs; and
- November to December for harvest.[68]

2.73 The Western Australia Farmers Federation (WAFF) discussed farmer confidence in seasonal forecasts:

> Because farmers are fairly conservative and because the way they operate their farms is reasonably conservative, until they convince themselves that what they are being told is true then they are not going to change. Even if there was a step change in the predictability there would still only be a very gradual change in farmer behaviour. What we are seeing now in farmer behaviour is that their confidence level in the prediction determines how far they go out. So you have some farmers that are quite confident and look at what is happening further out. The vast majority are back and are probably only using forecasts out to a month or six weeks.[69]

2.74 The South Australian Farmers Federation (SAFF) believes that adaptation to climate change is one of the biggest issues that will affect its membership, South Australia and Australian farming industries in the future:

> With climate change potentially causing an increase in the incidence of storms, flood, dust storms and heat waves, which may result in an increased risk of bushfires, it is vital that farmers

67 DAF, *submission 30*, pp. 4-5.

68 DAF, *submission 30*, p. 2.

69 WAFF, *transcript of evidence 13 July 2009*, p. 11.

> have access to the best weather forecasting data possible. Having access to accurate, reliable and regular weather information, farmers are able to plan their farming activities on a weekly, monthly, seasonal and yearly basis. With this information, they are able to adjust the types of crops that they sow or plant and when they harvest, and plan for the amount of water resources available to them if the drought is seen to continue.[70]

2.75 Seasonal forecasts have the potential to contribute significantly to other industries. Land and Water Australia (LWA) discussed two recent examples where accurate seasonal forecasts would have been beneficial to industry:

> Our experience suggests that many of the other sectors of the Australian economy are yet to appreciate the opportunities that forecasts with skill provide. Two examples:
>
> - Urban water authorities and energy authorities — all of our discussions with these sectors have shown that while there are opportunities for substantial savings [e.g. early implementation of demand management strategies; water supply from least cost sources like dams when the seasonal rainfall is expected to be substantial; base energy load manipulation in heat waves], their participation in R&D is minimal and their application of existing forecasts very limited.
> - Construction industry - this last wet season in North Queensland was predicted to be wet, yet was not factored into work schedules. An excellent example is the Port of Airlie marina development, where other than relocating equipment out of flood levels and pumping flood waters, no work was undertaken for the 4 months November 2008 to February 2009 inclusive. The result has been increased construction costs, delays and the expense of an idle workforce and equipment.[71]

2.76 DERM discussed the SILO system it has developed (based on observations provided to the Queensland Government courtesy of BoM), suggesting that the system has possibilities for the improvement of climate risk assessment.[72]

2.77 DERM explained further:

> In addition to agriculture, examples of other sectoral applications include:

---

70 SAFF, *transcript of evidence 14 July 2009*, p. 8.

71 LWA, *submission 7*, p. 12.

72 DERM, *submission 33*, p. 21.

- the tourism industry (e.g. peak holiday periods);
- mining (e.g. flooding of coal mines and coal stock piling);
- the electricity industry (e.g. assessment of anticipated peak load requirements);
- primary industries; (e.g. afforestation and reforestation activities);
- main roads (e.g. optimum construction periods and location);
- rail system (e.g. bridge construction and maintenance periods);
- pest management (e.g. agricultural chemical applications);
- human and animal health (e.g. heat day indices, mosquito breeding cycles and malaria outbreaks);
- building and construction (e.g. penalty contracts and number of wet days); and
- the meat industry (e.g. matching labour to continuity of animal supply).[73]

73 DERM, *submission 33*, p. 21.

3

Long-term forecasting models

Statistical and dynamic models

3.1 BoM and CSIRO stated that the direction being taken by most weather forecasting groups internationally, as in Australia, is to replace existing empirically based statistical schemes with systems based on dynamic models, when the dynamic systems have comparable or better skill than the existing statistical systems.[1]

3.2 DAF succinctly outlined the different model types:

> There are two main approaches to seasonal climate forecasting; statistical methods using statistical relationships between atmospheric or oceanic indicators and seasonal climate variables such as rainfall or temperature, and dynamical methods using global atmospheric and oceanic circulation models.
>
> Each approach has its own advantages and disadvantages. Statistical methods are computationally simpler, but forecasting skill has been weakened in recent decades by trends in both predictors and predicted climate elements … The dynamical approach is potentially the best tool for making seasonal predictions as they simulate the physical relationships that make each year's seasonal conditions unique. They also in principle have the ability to cope with changes in variables as climate change evolves. The major disadvantage is that they require complex

1 BoM, *submission 4*, p. 8; CSIRO, *submission 16*, p. 9.

> computational methods and resources, and remain sensitive to errors in the initial conditions for calculation.[2]

3.3 BoM explained the move from statistical to dynamic forecasting:

> The bureau has had this statistical model, and it has evolved over the last 20 years. One of the drivers towards dynamic forecasting is concern that those historical relationships, which are a foundation for the statistical models, between ocean temperatures and rainfall and temperatures may be changing as the climate is changing. So we are seeing some very strong trends in ocean temperatures and rainfall and temperature, and in some cases moving into new territory where those relationships have not been tested. So that is a further driver for bringing on these dynamic systems.[3]

3.4 BoM and CSIRO, have been developing successive versions of a dynamic coupled modelling system for seasonal forecasting, called POAMA (Predictive Ocean Atmosphere Model for Australia):

> The first version [of POAMA] was implemented in Bureau operations in 2002 and generated forecasts of El Niño sea surface temperature indices. Evaluations of El Nino forecast skill, using retrospective forecasts, showed that POAMA was useful out to at least 9 months into the future.[4]

3.5 The POAMA system was upgraded in 2007 to include forecasts of sea surface temperature in the equatorial Indian Ocean, which is also believed to be an important driver of weather and climate variability in Australia and the region.[5]

3.6 BoM and CSIRO discuss the skill of POAMA:

> Extensive analysis have been done of the capability of the POAMA system for regional forecasting of climate in the south east of Australia and in the subtropical Indian Ocean. These analyses have demonstrated that regional seasonal forecasts for Australia from POAMA have skill equivalent to, or better than, the current statistical approaches, though perhaps the uncertainty of the forecast is under-represented.[6]

---

2 DAF, *submission 30*, pp. 3-4.

3 BoM, *transcript of evidence 12 August 2009*, p. 25.

4 BoM, *submission 4*, p. 8; CSIRO, *submission 16*, p. 9.

5 BoM, *submission 4*, p. 8; CSIRO, *submission 16*, p. 9.

6 BoM, *submission 4*, p. 8; CSIRO, *submission 16*, p. 9.

3.7 CSIRO stated that, through the CAWCR partnership, POAMA continues to develop and improve, however:

> The newest version, POAMA-2, is significantly more demanding computationally than its predecessors … and so it will be used in real-time only on the Bureau's new supercomputer, which will be installed in late 2009. The new supercomputer will allow the skill for regional seasonal climate forecasts from POAMA-2 to be fully evaluated and delivered.[7]

3.8 CSIRO discussed the development of a new weather simulation system:

> Australia is building the next generation weather, climate and earth system simulation capability, called ACCESS (the Australian Community Climate and Earth System Simulator). ACCESS will deliver Australia's short-term weather forecasts, seasonal forecasts, and global and regional multi-decadal climate projections from local to global scales. ACCESS already is delivering short-term weather forecasts with greatly improved skill over the current system.[8]

3.9 CSIRO explained further:

> ACCESS will produce the nation's weather forecasts by late 2009 and by 2011 it will provide long-term global and regional climate projections and be a key platform for Australia's contributions to the IPCC [Intergovernmental Panel on Climate Change] Fifth Assessment.[9]

3.10 CSIRO discussed the integration of POAMA and ACCESS:

> The next phase of POAMA development (POAMA-3) will be to include the seasonal forecasting system within ACCESS, which is being developed to provide Australia's next generation weather prediction system and climate simulation system … ACCESS is already delivering much-improved short-term weather forecasts compared to the current operational system and is expected to deliver significant improvements in seasonal forecasts. Both the short-term weather forecasts and longer-term seasonal forecasts from ACCESS will be enhanced significantly by improved

7 BoM, *submission 4*, p. 8; CSIRO, *submission 16*, p. 9.

8 BoM, *submission 4*, p. 8; CSIRO, *submission 16*, p. 9.

9 BoM, *submission 4*, p. 8; CSIRO, *submission 16*, p. 17.

> assimilation of data from various land, ocean, automated and satellite sources of observations.[10]

3.11 AAS also discussed the development of ACCESS:

> … the national ACCESS initiative draws on recognised expertise across the Australian research sector, including from a small number of research intensive universities. The approach taken is intended to bring the best international and Australian modelling components together to build an Earth simulation system tailored to Australia's particular needs given its Southern Hemisphere situation.[11]

Requirements for model development

3.12 CSIRO stated that the main needs for more rapid development and deployment of ACCESS are:

> … significant enhancement of supercomputing infrastructure; increased staff capacity; and improved techniques for assimilating observations of the land, air and oceans, especially from satellites.[12]

3.13 CSIRO explained the need for enhanced computing resources:

> Delivering the full benefit of the ACCESS-based system through real-time operation of POAMA-3 will require a further step-change in supercomputing resources available to run the system in ensemble prediction mode at improved spatial and temporal resolution.[13]

3.14 CSIRO stated that the ACCESS project is developing a unified, national weather and climate modelling system, however, many more issues need to be addressed than available resources allow, making progress slow.[14]

3.15 CSIRO explained that some of the key areas of research and development most likely to improve seasonal forecasting skill in all model systems include:

- improving the simulation of El Niño and its different modes;
- improving the simulation of the Indian Ocean variability;

---

10 BoM, *submission 4*, p. 9; CSIRO, *submission 16*, p. 9.

11 AAS, *submission 25*, p. 6.

12 CSIRO, *submission 16*, p. 9.

13 CSIRO, *submission 16*, p. 9.

14 CSIRO, *submission 16*, pp. 9-10.

- improving the simulation of weather phenomena (e.g. cut off lows, blocking, tropical cyclones, tropical intra-seasonal waves, etc) and tropical processes that contribute to phenomena such as El Niño, which are all significant drivers of Australia's regional climate; and
- improving data assimilation techniques that incorporate in situ and satellite observations into the ACCESS model.[15]

The dynamic model

3.16 BoM and CSIRO have negotiated a Collaboration Agreement with the United Kingdom Meteorological Office's (UKMO) Hadley Centre to adopt the UKMO Unified Model, atmospheric chemistry module and data assimilation scheme as the core of ACCESS. CSIRO added:

> This heralds a significant strategic alliance between Australia and the UK to collaborate on the development and deployment of a consistent approach to climate and earth system modelling.[16]

3.17 The Unified Model is a 'high-powered computer-based climate and weather prediction program' considered the best in the world.[17] The Model is being adapted to Australian conditions and early tests have shown its use has provided a 'significant improvement on the Bureau's current operational numerical weather predication system'.[18] The Committee was told that the Unified Model supports four-dimensional variational data assimilation (4DVAR) allowing it to use more data more efficiently, exceeding the capabilities of POAMA.[19]

Criticism of model choice

3.18 The Committee heard evidence that the UK model has not had a high success rate with long term weather forecasts. John McLean, an information technology specialist who has applied his skills in analysis to various issues relating to climate change, provided written evidence of the

15 CSIRO, *submission 16*, p. 10.

16 CSIRO, *submission 16*, p. 17.

17 *Bureau of Meteorology Annual Report 2007-08*, www.bom.gov.au/inside/eiab/reports/ar07-08/, accessed 5 November 2009.

18 *Bureau of Meteorology Annual Report 2007-08*, www.bom.gov.au/inside/eiab/reports/ar07-08/, accessed 5 November 2009.

19 Dr J Larson, *submission 18*; WRMS, *submission 21,* p. 2.

lack of success of the model from 2007 until 2009.[20] He told the Committee:

> … in the UK the Met Office has been using modelling for seasonal forecasts over the last few years. 2007 was one of the wettest summers since, I think, 1913 and they had predicted a very hot summer. They tried again the next year and it was, again, a very wet summer. Last winter they predicted quite a mild and dry winter, and they had very heavy snow. They ran out of salt and grit for the roads.[21]

3.19 The Committee asked the CPSU if there were any particular risks with the ACCESS model that could be perceived as a weakness:

> The difficult is going to be getting enough resources to do all of the climate processes properly. I think the ACCESS model is already successfully doing single forecasts with data assimilation, which was really part of the main driver for the change—to get that capability into Australia for short-term forecasting. That has been delivered, and the short-term forecasts are improving and are really world competitive. That needed to happen, but that is only for short-term forecasting. To go on to the other processes, where you worry about climate and the longer term properties of the system, a lot more resources and manpower are needed to bring that model up to speed. I think that is what the researchers would say. So, having gone down this path and committed to having a model that does those sorts of forecasts—essentially having to build it and having to migrate it onto new computing platforms and arguing for enough resources to do all that—it is a fly by the seat of the pants affair at the moment. If you had unlimited resources you could try it on, but it could all just fail.[22]

Alternative models

3.20 Dr J. Walter Larson, a computational scientist with extensive climate modelling experience, described the open source models used in the US:

> The best example of combined software and performance engineering in the [climate/weather/oceans] arena is the US Weather Research and Forecasting Model (WRF)

20 John McLean, *supplementary submission 32.1.*

21 John McLean, *transcript of evidence 29 June 2009,* p. 42.

22 CPSU, *transcript of evidence 29 June 2009*, p. 62.

> The major academic-sector climate system model in the US is the Community Climate System Model (CCSM) … CCSM's governance structure engages the academic community as well as [Department of Energy] and [National Science Foundation] scientists, and is worth considering for future [climate/weather/oceans] systems development.[23]

3.21 Dr Larson explained that both WRF and CCSM are open source models:

> … both models are freely available for download at no cost. This means the models are widely used, and bugs are found and fixed. I believe the more "closed" approach in place here marginalises Australian researchers in the [climate/weather/oceans] field … [24]

3.22 Dr Larson discussed some of the benefits of an open source model:

> … open source is a good thing because you can engage more collaborators and you can get people using your code and potentially finding bugs. Again, I think if you are building software you need to change your mindset—finding bugs is a good thing. Your life is no better if that bug was undiscovered. It is just good to find them, fix them and move on.[25]

3.23 Dr Larson discussed the Hadley Centre's Unified Model:

> … something like the Hadley Centre Unified Model is not open source, for better or worse. I think they have found it is a valuable product and, for whatever reasons, they want to keep the source to themselves and control its release.[26]

3.24 Dr Larson explained that a closed source model may have disadvantages:

> … most of the modelling software is held quite tightly … I think I understand why it is held tightly like this. In my opinion, it is that the people who develop these things are strapped for cash, that they do not think of their code as being on par with the publication, that instead they view it as a less valuable thing that they spend evenings and weekends building and getting to work, and that they have only so much support, so it is a way of cost recovery or a source of funding. I would say that to some extent a lot of this closed source approach is something where science is viewed as a cost that must be recovered rather than, 'This is

23 Dr J Larson, *submission 18*, p. 3.
24 Dr J Larson, *submission 18*, p. 3.
25 Dr J Larson, *transcript of evidence 17 June 2009*, p. 6.
26 Dr J Larson, *transcript of evidence 17 June 2009*, p. 6.

> something that we fund,' and there are products that come out of it—software tools—that are meant to be used by the community at large.[27]

3.25 Dr Larson discussed at length the ability to integrate systems and models:

> … why don't we just cherry-pick things and be a really solid system integrator [?] … If we look at things from that perspective, I would say that there are some things about the UM that make it a little harder to couple to other systems …
>
> Most kinds of atmosphere ocean models do something that I would classify as explicit coupling … Because of the UM's numerics … it does what is called 'implicit coupling'. You have to do this kind of computed self-consistent solution between the ocean and the atmosphere for what is going on at the surface. That is a harder problem to solve. Most climate and atmosphere ocean models have gotten away with doing this as explicit coupling. It is a technical detail that makes coupling this to the rest of the system a little bit harder … That is one technical detail that I would say is making things a little bit harder than they need to be.
>
> … I would be perfectly happy with Australia cherry-picking stuff from other places, and then the idea would be to try and come up with better coupling mechanisms. But the coupler that has been imported for ACCESS is a bit of a finicky thing as well—again, this view is from what I have heard from the people working with it. Maybe we ought to concentrate some effort on trying to [develop] our own system for sticking everything together.[28]

3.26 DAF suggested that there is potential to develop advanced statistical methods of seasonal forecasting as an alternative to dynamical methods.

> Research conducted as part of the Indian Ocean Climate Initiative (IOCI, see www.ioci.org.au) demonstrated the potential for non-linear statistical methods in developing seasonal forecasts. These can cope with trends and jumps in data, and allow the strength of relationships between variables to be tested. They are also computationally simpler than global climate models.[29]

27 Dr J Larson, *transcript of evidence 17 June 2009*, p. 6.

28 Dr J Larson, *transcript of evidence 17 June 2009*, p. 9.

29 DAF, *submission 30*, p. 4.

Reliance on one model

3.27 CPSU stated that, with the development of dynamic models and the establishment of CAWCR, other research and modelling was essentially abandoned:

> … the decision was made to form CAWCR as a joint venture between the bureau and CSIRO, to consolidate effort. Part of that involved ditching the legacy models that were there—that is the strategy that was employed—and taking a new system on as a way of getting a step change in capability … I think simply the cost pressures meant that they tried to achieve an outcome within the budget parameters that they had. Essentially the way that was achieved was by cutting off legacy models scientists may have worked on for decades, where they knew how the system responded and they knew what they could get out of that in a scientifically meaningful way. They are now expected to deliver a new system which has a greater planned capacity, but from the working scientists' point of view it was not always a satisfactory way to achieve that expansion of capability.[30]

3.28 CPSU added:

> … from a lot of CSIRO scientists' point of view, [this] was a bit disappointing because there is no overlap there to do side-by-side comparisons to get a proper handover to a new technology.[31]

3.29 When asked if other forecasting models have been or are being considered, as opposed to utilising a single model, and possibly 'putting all our eggs in one basket', CAWCR explained:

> I think the answer there is: certainly no more so than in the past, and I would argue less so. There is certainly a strategy in place for us to move to the ACCESS modelling framework. That is a fairly well-considered strategy. We are putting a lot of effort into developing that framework. But I think the important thing to recognise is that that is not a single model—it is not a case of having one egg in one basket. So ACCESS is put together as a combination of an atmospheric model, an atmospheric chemistry model, an ocean model, a sea ice model and a land surface model. All of these things have to be put together into the framework. We at CSIRO and the Bureau of Meteorology have spent quite a bit of

30 CPSU, *transcript of evidence 29 June 2009*, pp. 58-59.

31 CPSU, *transcript of evidence 29 June 2009*, pp. 58-59.

> time looking at the best performers in each of those different areas around the world and we have, if you like, cherry picked from those available—from the top one, two or three ocean models or atmospheric models—to build the framework, a combination of all of those models, that we think will best serve Australia.[32]

3.30 CAWCR further explained the flexibility of its approach:

> In some respects that might be seen as saying, 'Well, you actually just picked one basket to put your eggs in in the ocean space,' but in fact what that allows us to do is to build flexibility into the framework. So the ultimate goal is to have a system which allows us, for example, if somebody comes up with a better ocean model to say, 'Let's have a look at that ocean model,' and to bring that into the framework. So we retain flexibility partly because we are working closely with the best people in all of the other research centres internationally. We use some of their models, we feed back to them the improvements we make and we benefit from then getting the upgrades that they have been making. So I think really far from putting all our eggs in one basket we are building an approach to climate, weather and long-term forecasting in Australia which is more flexible than it has been in the past. The step we have taken to go to the ACCESS system I think really does represent a significant quantum step forward that we would not have been able to make if we had just stuck to our own history, if you like.[33]

Testing and timeframes

3.31 DERM suggested that the skill of dynamical forecasts has rarely been assessed and compared with the skill of statistically based systems, thereby limiting the evaluation of dynamical forecasts.[34]

3.32 DERM stated:

> Dynamical forecasts are attractive, in that they may be able to better integrate the entire climate system (not just the ENSO component for instance). However, without an assessment of the individual track record of each model, the Queensland

32 CAWCR, *transcript of evidence 12 August 2009*, p. 25.

33 CAWCR, *transcript of evidence 12 August 2009*, p. 25.

34 DERM, *submission 33*, pp. 8-9.

> Government and general public will not be able to properly evaluate the efficacy of these systems.[35]

3.33 DERM explained further:

> There are now sufficient years where various statistical schemes and dynamical models have been operating in parallel, to begin to compare skill levels on an operational basis (i.e. 'as issued'). Notwithstanding the difficulties of evaluating statistical schemes over short time periods (around 10 years in this case), the Queensland Government recognises the importance of conducting such studies in order to benchmark alternative systems.[36]

3.34 BoM commented on the need for considerable testing when moving from one forecasting model to another:

> But just as when we shift from one statistical model to another, we need to go through all of the model validation and verification process, which takes time. Once we are satisfied that we have got a better model that is when the shift will be made. That work is being done now in terms of looking at the dynamic models and comparing them with statistical models.[37]

3.35 When asked about a transitional phase and a timeframe for adopting a new model, CAWCR explained:

> … at this point in time we already have some operational products from the dynamical models, which include El Nino forecasting, Indian Ocean dipole forecasting and Great Barrier Reef bleaching risk forecasting. Those are already produced by the Bureau as operational products from dynamical models. At this point in time, we have some trial regional rainfall and temperature products available, but they are still at the research level. There are still some issues with those. We are taking the approach that as we get to a level where we feel that dynamical products are superior than statistical products in every way then we transition those to an operational state.[38]

3.36 CAWCR explained further that dynamical models are the future, however there are currently some deficiencies that exist:

---

35 DERM, *submission 33*, p. 17.

36 DERM, *submission 33*, p. 17.

37 BoM, *transcript of evidence 12 August 2009*, p. 25.

38 BoM, *transcript of evidence 12 August 2009*, p. 24.

> We are trying to address those by maybe making some statistical corrections to the dynamical models. For things like regional rainfall there may be more of a hybrid approach initially—over the next two or three years. Some qualities of dynamical models tend to be not quite right. For example, they may have skill but they might be overconfident. Statistically correcting that overconfidence is something that we are looking at. So I suspect that there will be a gradual transition over the next few years. Dynamical models provide new products that do not presently exist with statistical models … When we feel that skill levels are demonstrated and published, we will be transitioning those to an operational level. It is a gradual transition. There will be many new products.[39]

Committee comment

3.37 The Committee recognises that it is not in a position to judge the merits of any particular models chosen for forecasting in Australia. However, the Committee is confident that our peak scientific and meteorological agencies are in the best position to be able to make informed and appropriate decisions regarding forecasting model choice based on Australia's needs.

3.38 The Committee would appreciate a transparent approach to decisions made by our peak scientific and meteorological agencies. The Committee recommends that CSIRO and the Bureau of Meteorology provide to the Australian Government detailed explanatory information as to why a particular dynamic forecasting model or system was chosen, and which other models were considered. The report should be completed by the end of 2010.

Recommendation 1

The Committee recommends that CSIRO and the Bureau of Meteorology provide to the Australian Government a report with detailed explanatory information as to why a particular dynamic forecasting model or system was chosen for use in Australia. The report should be completed by the end of 2010.

39 BoM, *transcript of evidence 12 August 2009*, pp. 24-25.

Model variables or inputs

3.39 This section of the chapter discusses some of the variables that are considered in the development of a forecasting model.

El Nino influences and autumn forecasts

3.40 Much of the variability in Australia's climate is connected with the atmospheric phenomenon called the Southern Oscillation, a major see-saw of air pressure and rainfall patterns between the Australian/Indonesian region and the eastern Pacific Ocean. The term El Niño refers to the situation when sea surface temperatures in the central to eastern Pacific Ocean are significantly warmer than normal. This recurs every three to eight years and is generally associated with a strong negative phase in the Southern Oscillation pendulum. El Niño events are associated with an increased risk of dry conditions across large areas of Australia. The period of strongest influence is the six months of winter/spring.[40]

3.41 Professor Neville Nichols suggested that the El Niño – Southern Oscillation (ENSO) allows for the production of skilful seasonal climate forecasts, because:

- El Niño events tend to cause dry conditions in eastern & northern Australia;
- El Niño events tend to last about 12 months; and
- El Niño events tend to start around March/April.[41]

3.42 Professor Nicholls added:

> This means that if in early winter we recognise that an El Niño event is underway, then we can forecast that below average rainfall is likely through late winter, spring and summer in eastern and northern Australia (as well as much of Indonesia and Papua New Guinea).[42]

3.43 Professor Nicholls explained further that there is a major limitation with forecasts based on the ENSO in that:

> … prediction across March/April (e.g. of early winter rainfall) is very difficult, because this is the time that El Niño events are starting to develop but may not yet be sufficiently strong to be

40 BoM, 'El Niño, La Niña and Australia's Climate', www.bom.gov.au/info/leaflets/nino-nina.pdf, accessed 4 November 2009.

41 Prof Neville Nicholls, *submission 12*, p. 3.

42 Prof Neville Nicholls, *submission 12*, p. 3.

> observed. This is known as the "autumn predictability barrier", and its causes are still not understood.[43]

3.44 CAWCR discussed the difficulties in providing a reliable autumn forecast, a seasonal forecast that is particularly important for the agricultural sector:

> We believe the reason for that is that the active period when ENSO [El Niño – Southern Oscillation] develops. That is when an El Niño typically develops, around that time of the year, and that is when models have more difficulty trying to get its triggering. We have made some progress in trying to do that with dynamical models by trying to incorporate subsurface ocean information that allows us to go back a bit further in time and use that information in the ocean subsurface to try to get through that barrier. But that is essentially just pushing the problem a little bit further back in time. It is a known problem of not just models, but also nature, and it is a reflection that that is the time of year when things happen. Once you have an El Niño developing, yes, you can probably predict what is going to happen subsequently, but its triggering is very difficult to predict. And that is probably our major limitation—not just in dynamical models, but in the statistical models as well. In fact, this problem is even worse in statistical models. Statistical models have a clear autumn predictability barrier. Essentially it is saying that is when changes happen.[44]

3.45 When asked what the key factors were in the development of a reliable autumn forecast CAWCR stated:

> I think it is a combination of lack of sophistication in our system and the specific network, but also it is a natural limitation. It is chaos, and it is when that chaos is most prevalent in the climate system because that is the time of the year when changes are happening and nature itself decides whether it is going this way or that way. That is a really difficult time to predict. Of course, when you get into May, June and July, nature has already started to take a path … and then it becomes more straightforward to predict what is going to happen in the future.[45]

43 Prof Neville Nicholls, *submission 12*, p. 3.

44 CAWCR, *transcript of evidence 12 August 2009*, p. 8.

45 CAWCR, *transcript of evidence 12 August 2009*, p. 8.

3.46 When asked what was needed to facilitate an increase in the reliability of autumn forecasts, CAWCR stated:

> There is not a simple answer to that. The primary phenomena, which are important, are El Niño and the Indian Ocean Dipole. There are various other secondary phenomena. It is fair to say at present that while we understand some aspects of El Niño there are a lot of aspects that we do not understand—and more so for the Indian Ocean Dipole. In summary, we need to invest in trying to understand El Niño and the Indian Ocean Dipole and trying to understand why our models do not simulate it so well. The two go hand in hand. What is holding us back is a combination of lack of sophistication in our modelling capabilities, supercomputing, but also a lack of many years of the observing network. It is quite a complex situation.[46]

3.47 CAWCR discussed the El Niño phenomenon at length:

> There have been several theories for the onset of El Niño. None of them fully explain what makes a particular year an El Niño or why you would expect one in a particular year. Some of those theories suggest that the stochastic part of the system, the random part, does play a role. Some theories relate to the slow movement of ocean currents over many years giving you a semi-regular cycle. I think each of those theories is partly right, but there is no unified theory that explains El Niño … What we are also realising is that El Niño comes in different flavours. Not every El Niño is the same
>
> …
>
> although models do simulate El Niño in a fashion there are significant differences between what the models will simulate and what can actually happen. The sea surface temperature anomalies might be too wide or too far east and so forth. Those particular aspects can be tightened up some what by a higher resolution model, we believe.
>
> …
>
> the oceans play a very important part, we believe, in the processes that generate ENSO activity. And it is only relatively recently that we have had the technology or the capability to be getting the richness of observations from the oceans that will allow us to test some of the physical theories about how the ocean works and how

46 CAWCR, *transcript of evidence 12 August 2009*, pp. 8-9.

> it interacts with the atmosphere. ENSO events have been going on for a long time … some people have a belief that the ENSO runs on a longer term cycle. We are really a bit behind the eight-ball in our observational richness regarding the ocean, because we do not have a long history of detailed observations of the ocean. We are only now just starting to get those … [47]

3.48 CAWCR added that the Argo program[48] has changed ocean observations dramatically:

> We have 3,000-odd floats scattered around the globe and if you look at a map of where they are you would infer there is a fairly rich cover. I think some oceanographers have said that we have got more information out of the Argo program in the last couple of years than we have out of the complete history of oceanography from ship-based observations.[49]

3.49 When asked if investing in more ocean observation technology was the way forward, CAWCR stated:

> The point there, I suppose, is that that richness of observation that we are now getting from the ocean is short-lived. We do not have a long history of it. Whether in the next 10, 20 or 50 years that would be where it would make most sense to put additional observational expenditure, is a question that would have to have a business case looked at around it. This is because it may in fact make more sense to build up our observational capabilities over the land or over the polar regions. I would not like to make a judgment call here on whether the oceans necessarily automatically are the places where we would put most of our future observational investment. But I think that is a case that would have to be evaluated in the context of the observations that come from all other sources.[50]

Indian Ocean influences

3.50 CSIRO discussed the importance of the Indian Ocean Dipole (IOD) on Australia's climate:

---

47 CAWCR, *transcript of evidence 12 August 2009*, pp. 17-19.

48 Argo is a global array of 3,000 free-drifting profiling floats that measures the temperature and salinity of the upper 2000 metres of the ocean.

49 CAWCR, *transcript of evidence 12 August 2009*, p. 19.

50 CAWCR, *transcript of evidence 12 August 2009*, pp. 19-20.

> We can go back to about 1900 and say that the Federation drought and the World War II drought and the current big dry all seem to be related to the fact that the negative phase of the Indian Ocean Dipole did not occur for a long period of time or occurred very infrequently. The ocean temperatures going back to the 1900s are not as certain as more recently … But nonetheless there is some information there, enough that we think we understand that the Indian Ocean Dipole is really quite important for us.[51]

3.51 CSIRO discussed the IOD further:

> … in the last 10 years, maybe, people have been beginning to understand that the Indian Ocean is important in its own right but it also acts together with the Pacific Ocean. When the two act together, you can get a very strong effect in Australia. When the two oppose each other, you can get parts of Australia wet and parts of Australia dry … Trying to understand where those two effects matter regionally in Australia is quite important. We do not understand the Indian Ocean as well yet. We do not understand some of the dynamical mechanisms of how the Indian Ocean affects us, but there is a lot of research happening right at the moment that is starting to unravel that.[52]

3.52 CAWCR also discussed the importance of the Indian Ocean in influencing Australia's weather and climate, and the need for further research on that influence:

> Probably the Indian Ocean—relative to some parts of the Pacific and certainly elsewhere, as in the Atlantic and so on—is a bit underdone, observationally and in research. So yes, that is an area where we would like to have more information. It is a difficult area to work in, in some ways, because some of the most interesting areas for Australia take a while for us to get to … In the Pacific Ocean we have a fairly extensive buoys network, as well as the Argo network … They give us a reasonably good sample of what is going on in the actual Pacific. We do not have that in the actual Indian Ocean; partly it is funding and partly it is because the Pacific has had the higher priority because that is where the engine room of El Niño is. With the recognition that [the Indian

51 CSIRO, *transcript of evidence 18 May 2009*, p. 18.

52 CSIRO, *transcript of evidence 18 May 2009,* p. 18.

> Ocean Dipole] is also important for Australian rainfall, that tends to emphasise the Indian Ocean more.[53]

3.53 Professor Roger Stone suggested that the effect of the Indian Ocean is a major gap in core science relating to climate forecast systems:

> … the relevance or otherwise of any independent contribution provided by the Indian Ocean through the Indian Ocean Dipole (IOD) or similar. Climate forecast systems that incorporate the IOD (in addition to ENSO), including that provided by the Bureau of Meteorology, have encountered some problems in operational skill, possibly due to rapid warming of sea-surface temperatures in the Indian Ocean. I understand BoM is working on correcting this problem although the results do not seem to have improved to any extent. This issue needs to be urgently resolved.[54]

3.54 CAWCR commented further on the IOD:

> We presently produce Indian Ocean forecasts in the same way that we produce El Niño forecasts, but the skill from the Indian Ocean is very limited compared to our ability to predict El Niño. It is true of every model internationally. We have identified that as one of our priority areas for research to try to understand why that is. It could be that there are not enough observations to initialise the models, it could be model deficiencies or it could be that that is the way that nature is, because the Indian Ocean Dipole is much more short-lived than El Niño. Our suspicion is that it is probably all three; we do not know to what extent it is one compared to the other. But it is an area that we have identified as a priority area for future research.[55]

3.55 DAF discussed Indian Ocean research:

> Research at the Bureau of Meteorology and more recently the University of New South Wales has shown that Indian Ocean sea surface temperatures can affect winter and spring rainfall over southern and south-eastern Australia. This influence is not explicitly captured by current operational seasonal climate forecasts.[56]

---

53 CAWCR, *transcript of evidence 12 August 2009*, p. 20.

54 Prof Roger Stone, *submission 10*, p. 5.

55 CAWCR, *transcript of evidence 12 August 2009*, p. 22.

56 DAF, *submission 30*, p. 4.

3.56 DAF recommended that:

> Seasonal forecast systems should include climate system influences from other ocean basins such as the Indian and Southern Oceans. These are especially relevant to Western Australia, South Australia and western Victoria.[57]

3.57 DAF added that:

> There is an ongoing need to maintain and enhance weather and climate observing capacity over WA and in the Indian and Southern oceans. This underpins not only dynamical climate methods, but also enables model verification and development of accurate statistics of climate variability and change.[58]

3.58 LWA discussed the performance of the POAMA model, and the need for incorporation of additional data concerning the Indian Ocean:

> … POAMA is exhibiting excellent skill based on 27 years of record to the level that substantial gains in profitability are likely. The story is far different in the northern sector of the wheatbelt where POAMA is exhibiting no skill. We explain this as the limited representation at this time of the Indian Ocean Dipole …[59]

Particulates

3.59 The Committee heard of the significant effect of particulates (or aerosols) in the atmosphere on climate and that Australia's geographic location make it susceptible to these effects:

> Particulates in the atmosphere (commonly smoke from agriculture, deforestation, industry and volcanoes) are now understood to have large effects on the global and regional climates. Australia is just to the south of Indonesia and Papua New Guinea, the most intense source of volcanic particulates in the world and also one of eight major sources of biomass burning and other anthropogenic particulates/smoke. It is now relatively easy to demonstrate a connection between the particulate plumes over this area and drought in south eastern Australia.[60]

57 DAF, *submission 30*, p. 3.
58 DAF, *submission 30*, p. 3.
59 LWA, *submission 7,* p. 7.
60 Keith Potts, *submission 17*.

3.60 Mr Keith Potts, a geophysicist, explained the dangers of not taking these particulates into consideration:

> Climate models do not currently represent accurately the combined effects of carbon dioxide and continental scale particulate/smoke plumes on the global and regional climates as the sensitivity of the models to changes in these agents varies significantly (CCS Program) and many models do not include all particulate/smoke species (IPCC fourth assessment report). Hence any forecast made using such models may be inaccurate even if they have reproduced the global temperature change during the twentieth century (CCS Program). Reliance on such forecasts is therefore at least questionable and at worst fatally flawed.[61]

3.61 The Committee asked why the influence of particulates is not being given more consideration in the current Australian models and Mr Potts suggested that:

> One of the issues has been that research in this region in this area—this industry if you like, which it now is—is basically done with computer models. The computer models do not have particulates or aerosols in them and therefore they cannot be researched because they cannot be modelled. It is as simple as that. There is no doubt that the models are getting better as computers get faster. Modelling particulates is much more difficult than modelling long-term greenhouse gases, which are well mixed across the whole atmosphere. As you can see in the papers that I gave you, the particulates are not, and they change constantly. Modelling them is much more difficult and therefore they have not been included. Where they are, their effects vary significantly between models.[62]

3.62 CAWCR explained that it is examining the particulates and aerosols issues and incorporating that variable in its models:

> … it is widely recognised that, certainly in the climate area, aerosols are an important part of the climate system and have a significant effect on radiation balances at the surface. We believe, as other people feel, that aerosols are an important part. We have developed aspects of aerosol treatment in our models and we will

61 Keith Potts, *submission 17.*

62 Keith Potts, *transcript of evidence 15 July 2009,* p. 23.

> continue to do so. We currently have a group of two scientists looking at the aerosol issue in the models … [63]

Lunar nodal cycle

3.63 Another possible influence on Australia's long term weather patterns was brought to the Committee's notice at its Melbourne hearing. Mr Charlie Nelson, a statistician, has been studying the statistical and historical effects of the lunar nodal cycle on rainfall patterns in Australia, with particular attention to Melbourne and the Murray Darling Basin. In his written submission Mr Nelson explained the lunar nodal cycle:

> The Sun's declination changes from +23.5˚ to -23.5˚ between the solstices due to the Earth's rotational axis being tilted at about 23.5˚ from the axis of orbital motion around the sun (the ecliptic). The Moon also changes in declination by the same average amount over a period of four weeks, the period of the Moon's orbit around the earth. But unlike the Sun, the maximum and minimum declination of the moon varies because the Moon's orbit around the Earth is inclined at 5˚ to the plane of the earth's orbit around the Sun. Thus, the maximum declination varies between 18.5˚ and 28.5˚.
>
> The two points at which the Moon's path crosses the ecliptic are known as the nodes. These nodes slowly move around the ecliptic, taking 18.6 years to complete one cycle.[64]

3.64 Mr Nelson told the Committee that during this cycle the pull of the moon on the Earth's oceans could affect weather and climate:

> The lunar node cycle means that the Moon, which on average, swings as far south as the tropic of Capricorn (just south of Exmouth on the Western Australian coast) has periods when it doesn't reach Port Hedland and others when it is overhead as far south as Geraldton. During the nine years before a major standstill, it is presumably dragging warm water further south and during the nine years before a minor standstill, it would be pulling cool water further north.[65]

63 CAWCR, *transcript of evidence 12 August 2009*, p. 10.

64 Foreseechange Pty Ltd, *submission 23*, pp. 3-4.

65 Foreseechange Pty Ltd, *submission 23*, p. 4.

Other variables

3.65 Land and Water Australia who are responsible for the *Managing Climate Variability Program* discussed a number of other climate drivers that will need to be incorporated into POAMA. These include:

- Southern Annular Mode (SAM);
- Madden Julian Oscillation (MJO); and
- Subtropical Ridge.[66]

3.66 The Southern Annular Mode (SAM), which is an atmospheric phenomena originating over the south pole, is known to affect Australia's rainfall patterns:

> The Southern Annular Mode, or SAM, also known as the Antarctic Oscillation (AAO), is a mode of variability which can affect rainfall in southern Australia. The SAM refers to the north/south movement of the strong westerly winds that dominate the middle to higher latitudes of the Southern Hemisphere. The belt of strong westerly winds in the Southern Hemisphere is also associated with the storm systems and cold fronts that move from west to east.
>
> During a "positive" SAM event, the belt of strong westerly winds contracts towards the south pole. This results in weaker than normal westerly winds and higher pressure over southern Australia. Conversely, a "negative" SAM event reflects an equatorward expansion of the belt of strong westerly winds. This shift in the westerly winds results in more storm systems and lower pressure over southern Australia.[67]

3.67 The Madden Julian Oscillation (MJO) is a phenomenon that enables intra-seasonal forecasts:

> The MJO is a belt of low pressure that propagates eastward across the equatorial Indian and Pacific Oceans usually taking between 30 to 60 days. Its passing can increase the likelihood of rain in northern Australia in particular. It is possible to forecast the likely timing of the MJO passage across the Australian region and, during this period, heightened prospects of rainfall.[68]

66 LWA, *submission 7*, p. 13.

67 BoM, 'Southern Annular Mode', www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.html?bookmark=sam, accessed 30 October 2009.

68 DERM, *submission 33,* p. 3.

3.68 The Subtropical Ridge is a belt of high pressure which affects Australia's seasonal weather patterns:

> The sub-tropical ridge runs across a belt of high pressure that encircles the globe in the middle latitudes. It is part of the global circulation of the atmosphere.
>
> The position of the sub-tropical ridge plays an important part in the way the weather in Australia varies from season to season.
>
> During the warmer half of the year in southern Australia (November to April), the sub-tropical ridge is generally located to the south of the continent. High pressure systems (also called anticyclones), which are associated with stable and dry conditions, generally move eastwards along the ridge.
>
> In autumn the sub-tropical ridge moves northward and remains over the Australian continent for most of the colder half of the year in southern Australia (May to October). Conditions along the ridge, under the influence of the high pressure systems dry and descending air, tend to be stable and drier.[69]

State, regional and local influences

3.69 The Committee took evidence from across Australia and was told that variables differ from region to region. These differences need to be taken into consideration when developing and applying forecasting models. For example, the Committee was advised by DERM that:

> … practical steps can be taken to improve statistically-based forecast schemes for Queensland: 1) remove indices of little relevance to Queensland (e.g. Indian Ocean sea-surface temperature in BoM's current sea surface temperature scheme); 2) replace these with indices of more relevance to Queensland e.g. an index which is sensitive to fluctuations in the PDO; 3) de-trend climate signals for observed climate change trends; and 4) customise systems to user-needs in terms of lead times and target periods.[70]

3.70 The Fire and Emergency Services of Western Australia (FESA) told the Committee that lack of attention to local influences hampered the usefulness of long term forecasts:

---

69 BoM, 'The Sub-tropical Ridge', www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.html?bookmark=stridge, accessed 30 October 2009.

70 DERM, *submission 33*, p. 7.

> Currently the long term meteorological forecasting and prediction information offered by Commonwealth agencies is limited. To meet the planning requirements in a State the size of Western Australia, data and information utilised needs to be State and region specific to address vulnerable, dispersed and isolated population groups.[71]

Other data issues

3.71 With regard to the efficacy of forecasting models, the Committee heard that consideration will need to be given to the 'appropriate benchmarks and documentation of historical track records' to ensure the consistency and reliability of data.[72] The Department of Environment and Resource Management provided the following example from Queensland rainfall data:

> There is a difference in the rainfall datasets held by the QCCCE [Queensland Climate Change Centre of Excellence] and those available through BoM. The QCCCE dataset commences in 1890, whilst the BoM dataset commences in 1900. The decade of the 1890s is extremely important in eastern Australia, in that it contains very wet years at the start of the 1890s and the Federation Drought, which commences at some locations in 1896 and lasts until 1902. These wet and dry periods are important in terms of ranking current conditions relative to the past (e.g. the drought in south-east Queensland in the early and mid-2000s). these periods also provide an important historical test for climate forecasting systems given the high variability that occurred in rainfall.[73]

3.72 DERM also cautioned that forecasting models need to be tested over time:

> Given that fluctuations in the strength of the relationship between ENSO and local climate has 'waxed and waned' over the years, an important question in evaluating the skill of forecasting systems is: how do such systems perform throughout the entire historical record, including periods such as 1920 to 1950 for example, during which the ENSO signal lacks persistence and there is low correlation between the ENSO indices and Queensland rainfall?[74]

71 FESA, *submission 29*, p 2.
72 DERM, *submission 33,* p. 17.
73 DERM, *submission 33*, p 17.
74 DERM, *submission 33*, p 6.

Committee comment

3.73 The Committee is concerned that CSIRO and the Bureau of Meteorology may have difficulty in considering and incorporating a substantial number of variables into their weather and climate models. Several submissions to the inquiry highlighted some key variables that may influence weather and climate. The Committee is keen to see those variables researched and assessed in detail.

3.74 The Committee recommends that variables and influences be thoroughly examined to assess their degree of impact on our weather and climate, and incorporate those variables into forecasting models as necessary.

Recommendation 2

The Committee recommends that weather and climate variables and influences, for example, particulates, be identified, thoroughly examined to assess their degree of impact on our weather and climate, and incorporated into forecasting models as necessary. Priority areas for incorporating these variables should be published.

3.75 CSIRO reiterated the need for improved techniques for assimilating observations of the land, air and oceans into forecasting models.

3.76 The Committee recognises that without accurate baseline information, our forecasting models will struggle to reach the required level of skill.

3.77 The Committee fully supports increasing funding for continuing and extended research into the effects of weather and climate variables such as El Nino and Indian Ocean Dipole.

3.78 The Committee recommends that the Australian Government increase funding for research into the effects of weather and climate variables such as El Nino and Indian Ocean Dipole that impact on Australia's forecasting abilities.

Recommendation 3

The Committee recommends that the Australian Government increase funding for research into the effects of weather and climate variables such as El Nino and Indian Ocean Dipole that impact on Australia's forecasting abilities.

Modelling limitations

Supercomputing

3.79 Many submissions to the inquiry raised the issue of having sufficient computing power to drive weather and climate models.

3.80 When asked how Australia compares with other countries or organisations, in terms of modelling computing power, LWA stated that Australia will get left behind quite quickly if funding is not increased in this area.[75]

3.81 Professor Christian Jakob, a researcher in the development of weather and climate prediction models, explained Australia's position, in terms of computational resources, in the international arena:

> … we have actually fallen behind the rest of the world significantly. I am co-chairing the World Meteorological Organisation's working group on numerical experimentation, and we review the computing at operational numerical weather prediction centres on a regular basis. I can tell you from the last meeting last year that Australia is at the bottom of the list now and will be at the bottom of the list with its plans for the foreseeable future … We are well behind countries like Brazil, Korea, Canada, India and China, so I am not even talking about big economies like the United States, the UK or Germany. We are well behind much smaller economies.[76]

3.82 The Australian Meteorological and Oceanographic Society (AMOS) also discussed the need for more computational resources:

75 LWA, *transcript of evidence 24 June 2009*, p. 6.

76 Prof Christian Jakob, *transcript of evidence 29 June 2009*, p. 3.

> … limited human and computational resources continue to hamper efforts in using the [ACCESS] system seamlessly and in particular in the long-range predictions that are the subject of this inquiry. A significant increase in resources, both human and computational, is required to stay abreast of the international community and to provide Australia with a prediction system that is state-of-the art, well supported and can meet society's demand for information on future weather and climate.[77]

3.83 AMOS explained the need for supercomputing and the restrictions placed on models due to a lack of computing resources:

> Meteorological computer models … all require very large investments in computing capabilities, and the availability of supercomputers. Access to supercomputing facilities by the Australian scientists developing and running these models is limited relative to those available to overseas scientists in America, Europe, and, increasingly through Asia (eg., China, India, Singapore and South Korea). The relative inferiority of supercomputer resources available to Australian scientists necessarily restricts the quality of the models run here and the quality of the forecasts available from these models.[78]

3.84 AMOS added:

> Although new supercomputers have just been provided to the Bureau of Meteorology and the Australian National University … these new computers will still leave Australia far behind the resources available in comparable countries.[79]

3.85 When asked if Australia is at a disadvantage in terms of super computing technology, compared with the rest of the world, CAWCR stated:

> Certainly the supercomputing developments internationally are roaring ahead of Australia's developments. Largely that is underpinned by greater capacity and interest in Europe, where several countries contribute to the cost of those … we are going through a supercomputer upgrade specifically to bring us up to speed on where we are able to function at the moment—and that is a very welcome advance. The $50 million allocated to supercomputing in the recent Super Science Initiative will help with that. How that money will be spent and where it will leave us

77 AMOS, *submission 11*, p. 4.

78 AMOS, *submission 11*, p. 5.

79 AMOS, *submission 11*, pp. 5-6.

> in the supercomputing ranks is being worked through at the moment.[80]

3.86 CAWCR further explained:

> So this is one of those things where we would always like to have a bigger and better supercomputer, but investment in that sort of infrastructure is a policy matter and we have just had a fairly significant upgrade on where we were formerly. We are working through where that will place us in terms of forecasting capacity, climate simulation and so on.[81]

3.87 Professor Jakob also discussed failing to attract quality researchers due to the poor state of resources available:

> To attract the best scientists you need to give them the equipment that they need to do the best science. Once you have fallen behind in that it becomes harder to attract the scientists over here. They would rather go to a centre where there is the fastest supercomputer in the world and do their work there. So we really have to work on that.[82]

3.88 Professor Jakob explained the need for vastly improved computing facilities:

> It is important to note and it is often forgotten that the computer required needs to be many times bigger than what you need to make the actual forecasts so that the research to improve those forecasts can be carried out in parallel. Often we buy computers that are just about right to make the predictions operationally so that we have forecasts but there is no space to run experiments to improve them, and that is a very big problem in many, many countries. Here, for instance, I have heard recently that the Bureau and CSIRO have sufficient computing resources for weather and climate but it is a struggle to actually do the very large set of experiments that is required to improve the seasonal prediction system, because that is a very, very big computational task.[83]

3.89 CAWCR explained having to sacrifice some aspects of its work due to the limited computing capacity available, and what could be achieved with more resources:

---

80 CAWCR, *transcript of evidence 12 August 2009*, pp. 1-2.

81 CAWCR, *transcript of evidence 12 August 2009*, pp. 1-2.

82 Prof Christian Jakob, *transcript of evidence 29 June 2009*, p. 6.

83 Prof Christian Jakob, *transcript of evidence 29 June 2009*, p. 3.

> … we have to do a big trade-off … with the supercomputing we have. Because we have limited supercomputing, we need models that run faster, which means they are much lower resolution than we would like. Important things like El Nino and the Indian Ocean Dipole are very important for model resolution. So we have to sacrifice some amount of simulation of those particular features in order to gain experience in ensemble forecasting. Therefore, a more powerful supercomputer would allow us to be able to do both the ensemble forecasting and have the high resolution models that we are looking for.[84]

3.90 Dr Larson stated that the lack of computational resources in Australia is a problem, explaining that Australia has only one machine in the top 500 listing of the world's fastest supercomputers (New Zealand, by comparison has three machines in the Top 500). Dr Larson added that the one machine is owned by a computer animation company, not a government research body.[85]

3.91 Dr Larson suggested that a significant problem exists in the lack of support for the emerging field of computational science, an interdisciplinary area that combines computer science, high performance computing, software engineering, and numerical analysis:

> Computational scientists seek to solve algorithmic problems relevant to computer modelling in many fields of science and engineering … We are not training future generations of people who have the necessary skills to develop superior, performance-portable algorithms in support of the types of short-to-medium range weather forecasting, seasonal-to-interannual prediction, climate, and other environmental modelling the Australian taxpayer expects from our [climate/weather/oceans] forecasting and research bodies … we are diminishing our future national competitiveness in this field.[86]

Committee comment

3.92 The Committee acknowledges and welcomes the Australian Government's recent additional provision of funds for supercomputing facilities. However, the Committee recognises that, in terms of

84 CAWCR, *transcript of evidence 12 August 2009*, p. 4.

85 Dr J Larson, *submission 18*, p. 2.

86 Dr J Larson, *submission 18*, p. 2.

supercomputing resources for weather forecasting, Australia is significantly behind many other countries.

3.93 The Committee also recognises the need for independence and development of systems here in Australia that address our unique weather and climate forecasting needs.

3.94 The Committee agrees that the supercomputing issue needs to be fully investigated.

3.95 The Committee recommends that the Australian Government conduct a short review to determine what supercomputing facilities are required by CSIRO and the Bureau of Meteorology to conduct crucial forecasting operations and research. Any additional funding to increase supercomputing capacity should be made available as a priority so that all model research, development and application can be undertaken in Australia.

Recommendation 4

The Committee recommends that the Australian Government conduct a short review to determine what supercomputing facilities are required by CSIRO and the Bureau of Meteorology to conduct crucial forecasting operations and research. Any additional funding to increase supercomputing capacity should be made available as a priority so that all model research, development and application can be undertaken in Australia.

Weather stations

3.96 A possible limitation on forecast models is the quantity and quality of data coming from the network of weather stations in Australia.

Network and coverage of weather stations

3.97 When asked about the need for more weather stations in particular areas across the country, SAFF stated:

> The Bureau of Meteorology are well aware of that, because that is something that farming organisations across Australia have been calling for over a number of years. Other organisations—like, for instance, our natural resource management boards in South

> Australia—have also been calling for more weather-recording stations, to better provide information to farmers and to community people in rural and regional areas across South Australia. The difficulty for the Bureau of Meteorology, as I understand it, is around resourcing. I do understand that, but that does not stop us from highlighting the need that is out there.[87]

3.98 SAFF suggested that an appropriate number of weather stations would have the potential to take greater account of geographic differences in some areas:

> At the moment the models that they use when they model where rainfall patterns have occurred do not necessarily take into account things like rain shadows—I guess those topographical differences and differences across a regional area. It is just a blanket line that cuts across without taking into consideration where some of those differences could actually be.[88]

3.99 SAFF explained further:

> … it would really take some knowledge and skills within the Bureau of Meteorology to understand where the gaps in information are at the moment and where we actually need additional information … that would help focus attention on where we might need additional data points and even potentially asking organisations like the Farmers Federation, natural resource management boards and some of those other regional based groups that may be able to identify where some of the gaps currently are.[89]

3.100 When asked if any particular regions or areas, such as high-value agricultural production areas, required more weather stations than others, SAFF suggested:

> … we actually do need better information in some of our more marginal areas of the State to better understand what is actually happening there for farmers to be making some really good decisions in those areas so that they are not going to go broke or out of business. We do need them to be there.[90]

---

87 SAFF, *transcript of evidence 14 July 2009*, p. 15.
88 SAFF, *transcript of evidence 14 July 2009*, p. 17.
89 SAFF, *transcript of evidence 14 July 2009*, p. 18.
90 SAFF, *transcript of evidence 14 July 2009*, p. 18.

3.101 The Western Australian Department of Environment and Conservation (DEC) suggested that there may be particular regional data deficiencies:

> … there are few high-quality daily rainfall datasets for the north-western half of WA. The enhancement and development of these datasets is a major logistical and scientific undertaking … Improving both the spatial coverage of datasets and removing errors in those datasets will allow a more reliable assessment of climate variability, particularly in data-sparse regions, such as the north-west.[91]

3.102 FESA identified the need for a broader range of data collection across the State to support long range forecasting and prediction capability, in particular, by introducing a greater coverage and reporting without the reliance on human presence.[92]

3.103 DAF also commented on weather station coverage:

> Australia has good climate records by global standards, and this has underpinned the availability of information via the Bureau of Meteorology's web site and through computer packages such as Australian RAINMAN. Major degrading issues at present are the poor coverage over much of inland Australia, and the decline in the number of quality observing sites generally. Many computer tools or systems developed to assist with agricultural decision making rely on accurate historical climate data, and so the provision of accurate climate records is vital.[93]

3.104 FESA explained that the weather stations in the northern part of Western Australia are essentially stand alone stations, their coverage does not overlap, and there are significant gaps between one station and the next:

> The northern portion of the state certainly has a deficiency of [weather stations]. To use the Kimberley as an example, there is one in Broome, one in Wyndham, one in Fitzroy Crossing—and just between Fitzroy Crossing and Broome, I think, there is about 400 kilometres. There is one in Halls Creek, which I think is 297 kilometres away from Fitzroy Crossing … [94]

91 DEC, *submission 31*, p. 4.

92 FESA, *submission 29*, p. 9.

93 DAF, *submission 30*, pp. 6-7.

94 FESA, *transcript of evidence 13 July 2009*, p. 18.

3.105 FESA also added that there are similar weather station coverage gaps in the south of the state, however the gaps are not as large as those in the north.[95]

3.106 FESA explained the need for an increased observational network for remote parts of Western Australia:

> As I understand it, about a third of the Kimberley is burnt on an annual basis with unplanned fires. It produces about 48 per cent of the greenhouse gas emissions from the agricultural sector in Western Australia. We spend a lot of time and effort trying to reduce the impact of fires in the Kimberley. Having better forecasting tools and weather stations would improve our fire management in those areas.[96]

3.107 When asked about the gap in the number of weather stations in regional areas, BoM explained:

> … it comes down to how you would balance your composite data collection network. We operate a range of automatic weather stations and we have people who collect weather information and provide it to the bureau using electronic field books; there are all sorts of methods we use to collect our data and information. You then build that up into a full satellite based data collection. So it is a composite observing system that uses all of those components to add up. For having automatic weather stations in remote areas there is a burden in terms of the additional cost of maintaining them. We therefore tend to look very closely at how many we need versus the capabilities in terms of remote sensing information … [97]

Purchasing an automated weather station

3.108 The suggestion that community groups or peak bodies purchase their own weather stations arose during the inquiry.

3.109 BoM discussed the purchase of an automatic weather station:

> The standard [automatic weather station] that we operate on average would cost $100,000 to install and purchase. That does the standard set of parameters. If you want to do fewer sets of parameters at lower accuracy then you can purchase lower quality instruments and that would cost less. If you want to get higher

95 FESA, *transcript of evidence 13 July 2009*, p. 18.

96 FESA, *transcript of evidence 13 July 2009*, p. 18.

97 BoM, *transcript of evidence 12 August 2009*, p. 16.

> quality ones, such as those we need for aviation, then they cost about $250,000 … So it does vary but that is the sort of order we are talking about. The average life is about 10 years.[98]

3.110 BoM also discussed maintenance of automatic weather stations:

> [maintenance cost] varies, depending on whether they are in remote localities … It costs in the order of $10,000 or $20,000 per year to maintain.[99]

3.111 When asked about the possibility of having a community purchase their own automatic weather station, BoM explained some of the issues:

> It has happened in some places. There are issues with that sort of thing. A lot of the issues come down to the investment they want to put into it. Again, it is a fit-for-purpose thing for the data. If you are talking about long-term climate information, then you need really good quality stability—consistency across the country in those sorts of things. We talked before about siting. You need to look at the standard of the equipment, the information flow, how that gets into the Bureau, who would handle the communications, costs and things like that. We would need to look at it from that point of view. There is also the issue of replacement. My understanding is that we cannot just take something like that and put it into our capital program, and then the government has to fund it. It is really up to the group to recognise that, if you are going to purchase one, there will be a long-term commitment to its operation. We have had situations where we take data from other groups. We just need to go through the hoops and jumps to make sure of the quality and that sort of thing before we bring it into our systems.[100]

Inaccuracies

3.112 Mr McLean, bluntly explained his concerns regarding data accuracy:

> Before worrying about the accuracy of the CSIRO's climate models perhaps we need to be more concerned about the accuracy of the temperature data being fed into them.[101]

3.113 Mr McLean added that CSIRO's climate models are:

98 BoM, *transcript of evidence 12 August 2009,* p. 26.
99 BoM, *transcript of evidence 12 August 2009*, p. 26.
100 BoM, *transcript of evidence 12 August 2009*, p. 26.
101 John McLean, *submission 32.1*, p. 17.

> … manually "tuned" to match historic temperature patterns as closely as possible but if that temperature data is wrong then the whole exercise is rather pointless … [102]

3.114 CPSU also discussed data inaccuracies and their impact on modelling and model verification:

> A model is fantastic and we certainly need research into improving what our models can do, but unless we have observations to input into those models then it is a case of rubbish in, rubbish out. If you do not have good observations to know exactly what is happening now, you cannot expect to have a good understanding of what is going to happen into the future. We also need those observations to be able to, after the fact, ground-truth the models. If the modelling is saying that it is going to be wetter in the next three months then we need to have the observations to be able to say, 'Was it wetter or was it drier?' It is used for verifying the models, as well as initialising the models before they go on.[103]

3.115 BoM discussed its data collection processes, explaining that it has established a good climate record:

> We have many, many stations, as the Bureau has been going for 100 years or so. We have relied on a broad range of different types of stations to collect our data. We have our own stations—about 35 major stations around the country. Clearly that is not enough to get a good characterisation of the climate across the country, but they provide a very strong benchmark for our data. In the past we have relied on cooperative observers—postmasters, police stations, teachers or farmers—to collect the data for us. Some of those records stop and start as we go backward and forward through time. Nevertheless, we have probably trawled through 10,000 or 11,000 different rainfall stations, and we have now come up with a set of rainfall statistics. We have been very carefully looking at them, looking at the history of the site, whether it has shifted and whether or not it has been contaminated by, as you said, a car park, a building or a tree; even a growing tree can contaminate a climatic record. We have been very carefully through a subset of our records to develop a set of, I believe, about 100 of what we would call major climatic stations which we

102 John McLean, *submission 32.1*, p. 17.

103 CPSU, *transcript of evidence 29 June 2009*, p. 55.

> believe fairly represent the broad-scale climate. They do not represent the building of cities, changing farming practices or what we would call non-climatic effects; they truly represent the climate. So we are now quite confident that the stations that we have to document what we call the climate record of Australia are well established, and of course we do everything in our power to maintain that climate record. We believe that is the *sine qua non* of any meteorological service. If you do not have a sound climatic record then it compromises a lot of what you do.[104]

3.116 BoM also explained that it collects data from standard automatic weather stations:

> At the moment the automatic weather station has pretty much a standard set of equipment. We are currently looking at the next generation of that, in terms of what will come along and replace it. We are primarily looking at it from the point of view of greater levels of quality control at the site itself to make sure that the instrumentation is working well … The basic [automatic weather stations] across the Bureau at the moment are fairly standard.[105]

Poor placement of stations

3.117 Mr McLean discussed changes that may occur at weather stations that have the potential to impact on accurate recordings:

> The recorded data is a verbatim record of observations but notes are supposed to be made about changes to the local environment that might influence temperature and researchers are advised to draw their own conclusions. I know of three worrying situations in Victoria - Nhill where about 20 years ago the instruments were moved from an old airfield (a training base in World War II) to a site on the edge of town, Cape Nelson, where coastal scrub is now higher than the instrument and shelters it from wind, and Laverton, a former military airfield that was in open country until about 15 years ago and is now being progressively surrounded by housing. I wonder how many Australian observation stations have seen their local environments undergo change, not just in the 3 members of the reference network that I mention here but right across Australia.[106]

104 BoM, *transcript of evidence 18 May 2009*, p. 8.

105 BoM, *transcript of evidence 12 August 2009*, p. 7.

106 John McLean, *submission 32*, p. 13.

3.118 When asked if there had been particular spikes or changes in the data from those stations, Mr McLean stated:

> In the two instances that I listed, I do not think so. Cape Nelson, down at Portland, would be very difficult, because you would have a slow change over time as the vegetation grew.[107]

3.119 Mr McLean added that some examples might show significant changes in data:

> I have seen examples out of the US where there have been quite sudden jumps, and they can attribute it to some change in the local environment. But a slow change over time is much more difficult to spot.[108]

3.120 In discussing the example of Laverton raised in his submission, Mr McLean stated:

> [Laverton] is becoming a part of the metropolitan area, yes, at a slow change. That one is interesting because it is blocking the south and south-westerly winds, or interfering with those, and they are our core winds here in Melbourne … The Bureau of Met is supposed to log these changes … [109]

3.121 Mr McLean suggested that the BoM reference network of high-quality stations with quite long data was supposed to be monitored carefully, and stated that a log was to be kept of what had changed in the local area that could conceivably have impacted temperatures.[110]

3.122 Mr McLean also suggested that in the USA:

> … something like over 80 per cent of stations are not [sited] in accordance with the defined standards. They have been put in parking lots or near air-conditioning ducts, barbecues and things like this. It has been an absolute shocker. I think they expected maybe 20 per cent, but there would be lucky to be 20 per cent that actually comply with their requirements.[111]

3.123 When asked about weather station placement, BoM explained:

> We have got guidelines for the sighting and placement of our observing networks, depending on the specific type of

107 John McLean, *transcript of evidence 29 June 2009*, p. 46.
108 John McLean, *transcript of evidence 29 June 2009*, pp. 46-47.
109 John McLean, *transcript of evidence 29 June 2009*, p. 47.
110 John McLean, *transcript of evidence 29 June 2009*, p. 47.
111 John McLean, *transcript of evidence 29 June 2009*, p. 48.

> instrumentation. Those are developed on the basis of guidelines from the World Meteorological Organisation. When you are looking at the accuracy of information you need to look at the quality of the instrumentation that has been put in place: what are the specifications associated with it, what is the sighting and you also look at the fitness for purpose—and that is a very good point that you are making. It may be that groups put stations in certain places because they need to know information for a particular purpose for that place and it is therefore put in at that particular site. But in terms of the stations we use for long term climate monitoring, there is a very detailed set of standards that are required to be met, including visitation for recalibration of the sites and those sorts of things.[112]

3.124 When questioned further about data integrity in the US example, BoM stated:

> I would be surprised if in the IPCC analyses within the US they have allowed data that could be in question being included in the analysis. I would think that the data sets used within the IPCC process are ones where the sites have been checked for all of the standards.[113]

Resources and staffing

3.125 CPSU discussed the potential long-term impact of under-funding on BoM's services and the potential impact on Australia's economic performance:

> "A degraded observation network (which is what will happen if the Bureau continues to be under funded) will result in inaccurate measurement of inter-seasonal climate variability, and will have negative feed-on effects to all sectors of the community".[114]

3.126 CPSU commented on the downgrading of data collection as a result of funding constraints:

> One member noted that: "Our observations base has been seriously eroded and that affects the climate record and the amount of data available for weather and climate models to

112 BoM, *transcript of evidence 12 August 2009*, pp. 15-16.

113 BoM, *transcript of evidence 12 August 2009*, p. 16.

114 CPSU, *submission 3.1*, p. 4.

> diagnose weather … Other nations have much denser networks for surface based, upper air and climate data collection".[115]

3.127 CPSU explained that, of Australia's 17 global upper-air network stations:

> … five of them actually face a reduction in the number of qualified bureau staff who are going to be working there under a current observations reconfiguration plan, and that observations reconfiguration plan has been brought about because of staffing pressures.[116]

3.128 CPSU commented further on the need for adequate staffing:

> … the number of observers that we have is just getting lower and lower, so people have to be spread around this network in a more efficient way. If we had more money to support these then, in an ideal world, certainly at these particular stations we would have the highest staffing level required to do the duties to the proper level that we need.[117]

3.129 CPSU further discussed observation station staffing issues at length:

> According to the information I have about the observer reconfiguration, 160 of those technical staff work across the 50 stations that are staffed. About 140 are permanently located at one station or another, and the rest are relief staff. They move around quite a lot, as you can imagine, because people need to take leave and they get sick. Last October, which is when these figures are from—and I think the situation remains the same—most of those stations had between two and five employees. A proposal of the Bureau is that 23 stations each be staffed by a single trained observer. That obviously goes to the points that have been made about the staffing needed to cover those areas, even with our improved equipment.[118]

3.130 CPSU added that its members have particular industrial concerns including redeployment of staff across the country and health and safety issues.[119]

3.131 CPSU also explained that staff have very strong concerns about the integrity of data collection:

---

115 CPSU, *submission 3.1*, p. 5.
116 CPSU, *transcript of evidence 29 June 2009*, p. 55.
117 CPSU, *transcript of evidence 29 June 2009*, p. 55.
118 CPSU, *transcript of evidence 29 June 2009*, p. 60.
119 CPSU, *transcript of evidence 29 June 2009*, p. 60.

> It really concerns them that some of the changes being made in this area are going to mean that data is not as good as it could be … that has impacts when you are trying to do your long-term science and check your previous hypotheses … This is a clear example of where those funding pressures are biting.[120]

3.132 BoM discussed the move away from the human observer and towards the automatic weather station:

> In other words, all we need now is a place to put the instrumentation. It is telemetered automatically into the Bureau. We are then able, of course, to get measurements not every three hours but measurements as frequently as we like. We can even go down to one minute; we can be recording the wind, the temperature and the pressure every minute or every six minutes or whatever period we want. The move towards automation is really the way to go. We get much better, consistent and reliable data.[121]

3.133 CPSU also raised the issue of transferring maintenance responsibility to observers.

> … they are attempting a program of multi-skilling the observers so that they can do some of the routine maintenance on the equipment. I have seen that sort of thinking in the CSIRO in the maintenance of high-end scientific equipment where they have tried to cut corners. It can be a false economy. The real value of some of the highly trained people looking at equipment and servicing it regularly is in spotting problems when they are minor. It takes a lot of expertise to do that. They might not have to make serious interventions on a day-to-day basis but if they spend years looking at equipment they have enough skill and understanding to detect problems before they become catastrophes, and that is a great efficiency in the system which is hard to capture … [122]

3.134 A CPSU representative explained further:

> Expensive equipment requires dedicated people with a lot of knowledge to maintain it, keep it running and keep the integrity at the plant level. You cannot find that as an efficiency, particularly if you try to cut corners by saying, 'We'll buy better equipment. It should require less maintenance. We can train our operator to just

120 CPSU, *transcript of evidence 29 June 2009*, p. 60.

121 BoM, *transcript of evidence 18 May 2009*, pp. 9-10.

122 CPSU, *transcript of evidence 29 June 2009*, p. 59.

> change the oil or whatever, and she'll be sweet.' Sad to say, that thinking does operate in organisations. But I have to caution against that and make sure that I put in a word to support technical people on the ground, who probably are not recognised enough in organisations and can sometimes bear the brunt of the costs and have workloads shifted onto them, which ultimately causes a lot of problems for the organisation.[123]

Committee comment

3.135 The Committee notes the importance of data integrity and understands that data integrity is threatened, not only by the loss of weather stations, but by a range of factors affecting the stations, including age and changing conditions.

3.136 The Committee is concerned at the loss of qualified observational staff from the BoM and the effect this is having on manning weather stations. The Committee is also concerned with the move to multi-skilling staff and expecting observational staff to perform maintenance and repairs on sensitive, scientific equipment.

3.137 The Committee notes the importance of weather station placement and understands that stations have not always been optimally placed.

3.138 The Committee recommends that the Australian Government undertake an audit of weather stations that contribute data to forecasting models, to ensure that they comply with World Meteorological Organization guidelines. All necessary actions should be taken to ensure that all stations comply.

Recommendation 5

The Committee recommends that the Australian Government undertake an audit of weather stations that contribute data to forecasting models, to ensure that they comply with World Meteorological Organization guidelines. All necessary actions should be taken to ensure that all stations comply.

123 CPSU, *transcript of evidence 29 June 2009*, pp. 59-60.

3.139 The Committee understands that more weather stations are required to increase accuracy and coverage to support seasonal forecasting and prediction capability. There is a need to identify critical areas where there are data deficiencies and look to add additional stations to address those areas.

3.140 The Committee recommends that the Australian Government budgets for the purchase, installation and maintenance of additional weather stations in critical areas around the country. There should be broad consultation to consider the number of new stations needed and their placement.

Recommendation 6

The Committee recommends that the Australian Government budgets for the purchase, installation and maintenance of additional weather stations in critical areas around the country. There should be broad consultation to consider the number of new stations needed and their placement.

Model outputs and products

3.141 An issue raised by many witnesses to the inquiry was how to transform the data generated by long-term weather forecasting into useful, accessible information for stakeholders. AMOS explained the challenge:

> … how do you get the information that we have across to, on the one hand, the general public, the media and people who have broad interest in whether there is going to be a drought next season or not, and to an individual user who is worried about the farm gate, his or her particular farm and what decisions he or she might be making now. We have really struggled with this. It is a really complex problem and it is easy to get confused. Because of the chaotic nature of the atmosphere … these forecasts are all probabilistic.[124]

3.142 AMOS told the Committee that there is always a danger that consumers will be overwhelmed by the amount of information available and will not be able to use it for important decision-making. One solution is tailoring forecasts for individual needs but this too presents problems:

124 AMOS, *transcript of evidence 29 June 2009,* p. 10.

> This is feasible but it is very person intensive. ... It is very demanding to have people sit down with farmers or groups of farmers and say: 'You're really interested in this decision. This is the sort of information that the science can provide that will be useful,' but we aren't going to put that on a website or publish it in the Australian or a weekly rural magazine because it is too much information for most people and we find that most people overreact to it or underreact to it.[125]

3.143 AMOS added that, rather than improving decision-making, supplying more information via the BoM web site had the potential to lead to rash or unwise decisions.

> The Bureau can quite easily provide more information about those details than you see on their website, but we do not think it is useful in a broad sense. What we would like people to do is not make decisions based on a one-inch headline on the front of the Herald Sun.
>
> We think it is really important to get that message across. For instance, we are concerned at the moment we are slipping into a new El Nino which may increase the chances of drier than normal conditions over much of eastern Australia over the next few months. … It is great to have a one-inch headline in the Herald Sun, but we do not want farmers to go out and sell the whole kit and caboodle and bet their last shirt that there is going to be a drought. It just depends on what sorts of decisions you are making, how much you should value that forecast.[126]

3.144 In their submission to the inquiry, DERM also identified lack of understanding, rather than lack of access or information as a root problem:

> Rather than lack of access to seasonal climate forecasting information, a major limitation to adoption is likely to be the confusion resulting from the range of the number of available forecasts/climate risk assessment systems. A lack of understanding of the underlying science, and the lack of a transparent track record will also limit the adoption of some systems, even if these systems result in improvement to skill and lead-time (e.g. global climate models, QCCCE's SPOTA-1 system).[127]

---

125 AMOS, *transcript of evidence 29 June 2009*, p. 10.

126 AMOS, *transcript of evidence 29 June 2009*, pp. 10-11.

127 DERM, *submission 33*, p. 18.

3.145 To combat this problem, AMOS suggested that help be provided to ensure optimal use is made of the complex information being generated by current forecast systems, not just by the agricultural sector but all stakeholders:

> We would like the situation where they can come to an adviser, who understands the science, understands the farmers' decision-making processes and what they have to do, and match the needs of farmers with the abilities of the science much better than we can just by broadcasting a very broad forecast.[128]
>
> …
>
> But the point is, we have talked about the agricultural sector but there are other sectors that do not make optimal use of existing forecast information on all timescales—on seasonal timescales and also on weather timescales. There is a lot that could be done, working with the users to make them use the products in an optimal way. There is no perfect way. It is difficult because of the chaotic nature of the problem, the probabilistic nature of the forecasts. It is much harder to deal with.[129]
>
> …
>
> That is why every user has a different need and so the agricultural sector will not have the same need as someone else. That is why it is such a labour-intensive, human resource intensive problem, because you need to work with all these sectors and it is all very complicated and different. So it is a big problem.[130]

3.146 The Committee heard that the Queensland Government is a world leader in delivering information to end users and matching their requirements.[131] In their submission to the inquiry DERM detailed some of the programs they have developed to assist stakeholders to gain the maximum benefit from long-term weather forecasts:

> Despite several years of drought, Queensland has been able to largely maintain agricultural production which can, in part, be attributable to the application of tools by primary producers to better manage climate risk. Queensland has developed a range of tools such as RAINMAN, WhopperCropper, APSIM, APSFarm,

128 AMOS, *transcript of evidence 29 June 2009,* p. 11.
129 AMOS, *transcript of evidence 29 June 2009*, p. 12.
130 AMOS, *transcript of evidence 29 June 2009*, p. 12.
131 AMOS, *transcript of evidence 29 June 2009,* p. 11.

> Irrigation Optimiser, Nitrogen Calculator, and DROUGHTPLAN that can use the Southern Oscillation Index (SOI) phase system to make forecasts. Other states and territories have similar programs.[132]

3.147 DERM also provided examples of how they have tailored forecasts to meet the needs of stakeholders:

> Seasonal climate risk forecasts in Australia are generally issued on a rolling basis for the next three months (e.g. the SOI Phase system, BoM's sea-surface temperature scheme). This rolling three-month forecast at zero lead-time makes it difficult for agricultural managers, particularly pastoralists in Australia managing large properties, to implement key decisions based on the forecast, when the lag between the predictor and predictand is zero. Several surveys of pastoralists in northern Australia indicated that longer lead-times would be useful. These surveys showed that forecasts for the northern Australian wet season (November-March), issued firstly in June using the April/May SOI phase and reissued each month for the same forecast period counting down from five- to zero-month lead-time, would be most useful for application in management in these regions.[133]

3.148 DERM explained that this process must go beyond simply tailoring forecasts and translate the data into relevant information:

> Not only is there a need to tailor or customise forecasts to meet the needs of decision makers and other stakeholders (e.g. a forecast targeting a particular season at a certain lead-time) it is also important to translate seasonal forecast information into terms that can readily be incorporated into management and decision-making. This may involve systems analysis and the use of models to translate climate information into more relevant information for decision makers (e.g. pasture or crop production rather than rainfall).[134]

3.149 However, even with this type of assistance, witnesses stressed that end users require more education and training to make the best use of outputs and products from long-term weather forecasts. AMOS spoke of an 'education program for users'[135] and DERM told the Committee that the

---

132 DERM, *submission 33*, p. 18.

133 DERM, *submission 33,* pp. 17-18.

134 DERM, *submission 33,* p. 18.

135 AMOS, *transcript of evidence 29 June 2009,* p. 12.

uptake and availability of their programs 'could potentially be improved by providing training to growers and consultants'.[136]

Committee comment

3.150 The Committee noted the difficulties inherent in translating meteorological forecasting data into useful end user products.

3.151 The Committee was impressed by the model outputs and products developed by DERM. The Committee would welcome greater coordination and dissemination of these products. The Committee would encourage a future institute of meteorology, as proposed in Recommendation 10 of this report, to take a leading role in this process.

3.152 The Committee noted the need for the media to be better educated and informed regarding the interpretation and translation of forecasting data and information and urges restraint regarding sensationalist headlines.

136 DERM, *submission 33,* p. 18.

4

Other issues

4.1 This chapter looks at a number of other issues which were drawn to the attention of the Committee during the course of the inquiry. These include:

- the use of long-term weather forecasting by the emergency services;
- staffing and training issues;
- the lack of stable career paths in the industry;
- the lack of adequate resourcing for the Bureau of Meteorology; and
- the need for a coordinated research agenda between government, universities and the private sector.

Emergency services

4.2 BoM explained the role that long term forecasting plays in combating natural disasters:

> Emergency response management by definition involves reacting to extreme events. Seasonal forecasting cannot provide prescriptive forecasts of specific events but can improve significantly our knowledge of the likely occurrence during coming seasons of meteorological conditions conducive to extreme events such as fire or flood. Such forecasts facilitate strategic planning and response logistics and provide advanced warning for emergency agencies, industry, and the community.[1]

---

1 BoM, *submission 4*, p. 4.

4.3 BoM further explained:

> The main benefit of long-term meteorological forecasting to emergency management and disaster mitigation lies in the ability to predict what types of events are more likely to occur in the medium to long term. Knowledge of the likelihood of various types of extreme events and their impact on the environment (e.g. fuel state for bushfires) in the coming season allows disaster mitigation preparation to better focus on the more likely threats. This approach assists emergency services organisations through targeted logistics planning and pre-season public education towards the most likely hazards expected in the coming season.
>
> The Bureau of Meteorology has close relationships with the emergency management and emergency services sectors across all jurisdictional levels and provides support to emergency management planning processes and emergency services responses.
>
> Improved seasonal forecasting assists the Bureau in the provision of early warnings of severe events conducive to severe conditions, including fire, heatwaves, tropical cyclones, severe storms and floods.
>
> Better forecasts of conditions favourable for example to droughts, prolonged heavy rain, the occurrence of tropical cyclones, bushfire risk, a few weeks to months in advance would provide considerable socio-economic benefit for Australia (and for most Pacific Islands and Territories as well as Asian countries to the north of Australia) in planning to mitigate potential natural disasters. [2]

4.4 FESA told the Committee that it uses meteorological information for both strategic and operational planning:

> Meteorological forecasts and outlooks are used for:
>
> - long term planning – 2 years and beyond for strategic planning of service delivery, inter-government and national coordination, resourcing and others such as land use planning;
> - developing prevention and preparation (mitigation and adaptation) strategies for the medium term – 12 month to 2 year outlooks;
> - short term preparation based on 7 to 14 day forecasts; and

2 BoM, *submission 4*, p. 12.

- response to immediate and day-to-day emergency events with real time data and information for event management including community and industry safety.[3]

4.5 In their submission to the inquiry the DERM confirmed the importance of forecasting to their emergency services:

- Emergency services in Queensland use weather forecasts for a number of purposes including operational response, pre-positioning capability, risk management, planning, community information, reports and profiling expected natural hazard behaviour (e.g. bushfires).
- Providing timely meteorological forecast data allows response strategies to be put in place and allows emergency services to be adequately prepared in terms of staff levels, transportation, pre-positioning of emergency supplies and preparation of evacuation centres.[4]

4.6 FESA identified a number of problems with the current system, including under resourcing of BoM. FESA strongly supports the BoM but told the Committee:

> … we perceive that the staffing levels are at the bare minimum and there is limited opportunity for new or extended projects to be initiated. WA is a very large state and we would like to see an increase in the number of automatic weather stations, other tools and the capability of BOM to meet the needs of WA, including needs not yet identified. We are seeking enhanced climate-modelling techniques applicable to Western Australia and enhanced long-term meteorological prediction systems. We are of the opinion that BOM should be funded to a level that ensures that it is at the cutting edge of research and has the capacity to provide forecast services that ensure that the community receives optimum protection, particularly in regard to the provision of information to fire and emergency services in Western Australia.[5]

4.7 DEC reiterated these concerns:

> In WA, BoM currently has limited capacity to provide for and deliver fire weather training programs to emergency services groups. It is also understood that there may be insufficient internal training capacity for BoM forecasters.
>
> …

3 FESA, *submission 29,* p. 2.

4 DERM, *submission 33*, p. 12.

5 FESA, *transcript of evidence 13 July 2009,* p. 16.

> BoM must be adequately resourced and supported with trained staff to undertake this work. The current observation network is fundamentally inadequate for existing requirements and leaves a number of communities and large areas of remote Western Australia with no detailed forecasting capacity.[6]

4.8 DEC further discussed the resourcing it believes that BoM needs in Western Australia:

> There is no shared lightning detection network in Western Australia. DEC believes that BoM should be resourced to provide a lightning detection network and capacity to provide a public map of the data for use by emergency services and land managers.
>
> DEC also requests that BoM be funded and resourced to provide more frequent radiosonde balloon flights to improve the frequency of sampling the low level winds and air moisture for bushfire weather forecasting in the more densely populated areas of the south-west.
>
> BoM radar coverage in WA needs to be increased and improved to include Doppler capacity that can monitor wind changes and boundaries. Large sections of the State are not covered at this stage.
>
> DEC would also support an increase in the number of weather datum buoys to assist in the provision of forecasts for its marine park and other marine operations.[7]

4.9 DERM also faced difficulties because of the under resourcing of BoM:

> Detailed analysis of local storm, flood and cyclone events is currently provided by BoM to assist emergency management agencies, especially the State Emergency Service and Emergency management Queensland. However, the Queensland Government has found that the level of expertise required to interpret BoM data and models is not always available, limiting the effective use of BoM data. Furthermore, limited resources and an operational focus of key government service agencies often impacts on the level of expertise required to interpret national meteorological data (e.g. BoM data) and models.[8]

---

6 DEC, *submission 31,* p. 3.

7 DEC, *submission 31*, p. 4.

8 DERM, *submission 33*, p. 14.

Staffing and training issues

4.10 A number of witnesses expressed concern over the level of staffing at the BoM and the flow on effect on the quality of long-term meteorological forecasting. The CPSU outlined the current situation:

> Around 50 per cent of the bureau's overall budget is spent on salaries for staff. So in a shrinking budget situation either we pay people less or we have fewer people to do the same amount of work. That is the reality. In 2007-08 it was a particularly bad year and there was so much pressure on funding that we did not have any new observers or meteorologists recruited. I work in the training centre and we run training courses for new recruits, but in that year we did not run them because there was simply no money to pay those people, because they get paid when they do their training as well.[9]

4.11 CPSU provided examples from several States of recent staff cutting:

> In the Northern Territory, for example, staffing pressures reduced a 13-person roster down to an 11-person roster during 2008, but that workload remained the same. Because of the staffing pressures, particularly in the Northern Territory, they have completed a workload assessment to see how much time is actually needed to complete everything required on this shift. They found that forecasters need 14 to 18 hours to do their work properly but they have to shove this into a 12-hour shift. So these pressures jeopardise the quality of the service that is being output by those forecasters.
>
> In Western Australia, as well, the roster has been reduced from 13 to 11 people. One person—previously there were two people—is responsible for all the aviation-type forecasting for about a third of the country, with Western Australia being one of the largest areas we have. In South Australia, again, a roster which previously had 10 people on it has now been reduced to about eight people. There has been further pressure to reduce that to seven, although the forecasters have fought this strongly. They believe eight is the minimum number needed to complete the jobs.
>
> In Tasmania there have been two contractors used to fill gaps in the roster over the past few years. Sometimes this was for periods of about a fortnight and sometimes it was for several months.

9 CPSU, *transcript of evidence 29 June 2009,* p. 53.

> Contractors have also been required to fill gaps in the South Australian Severe Weather Section. Severe weather watch, such as for bushfires and severe thunderstorms, is one of the most high-impact things we deal with. We are relying on contract staff to come in and fill these gaps. Here in Victoria we lost one full-time severe weather position as well. This required some US forecasters to come in and fill those gaps over the past summer. So, in one of the worst fire seasons we have had, we had one less full-time position and backfilling from overseas staff.[10]

4.12 Additionally, the CPSU told the Committee that observational staff have been reduced across the country:

> The number of technical officers—both observers and engineering staff—has been continually reducing since 2003. In 2003 we had 560 technical officer staff, whereas now we are down to 476 technical officer staff as at 30 June 2008. So that is decreasing. We have taken some new technologies on board to help fill some of these gaps, but technology needs to be serviced—we need to have engineers who are able to go out—and it is a very broadly-spread network. If we do not have these people who can maintain these instruments then the quality of that information could be impacted upon as well.[11]

Careers

4.13 CPSU discussed the need for suitable funding to enable retention of qualified staff:

> One manager observed that: "We have some talented research scientists here in Australia who are capable of providing great innovation to help improve long-term forecasting methods and technology. They can only do this if they are given a stable job and sufficient resources to do the work". Australia will not be a world leader and may lose the current level of international respect it has achieved if sufficient resources are not available to attract, retain and train properly qualified staff, along with the funds to invest in research and innovation.[12]

10 CPSU, *transcript of evidence 29 June 2009,* p. 54.

11 CPSU, *transcript of evidence 29 June 2009*, p. 54.

12 CPSU, *submission 3.1*, p. 2.

4.14 The Committee asked the BoM about their recruiting process and what training programs they had in place:

> We run a meteorology course within the Bureau each year. Students range in age from 14 to about 20 years old. The majority would come along from a Bureau of Meteorology perspective, but we do provide training to other, external groups as well. We have maintained that program fairly regularly over years, so that keeps the numbers coming in, if you like.[13]

4.15 The Committee further asked whether or not the BoM was having difficulty filling its recruitment requirements:

> Probably the thing that has changed a little bit is that when we advertised the courses five, six years ago we would get 200 or 300 applicants for these 20 positions, but in more recent times it has got down to around 100. Now, that is still a good field from which to pick up 20 people, but that is a trend we have noticed—the declining numbers that are applying for the positions—and we assume that that is related, potentially, to the declining number of science graduates coming through. But we certainly have not had any trouble filling the positions.[14]

4.16 The Committee also expressed concern regarding the extensive use of short-term contracts for staff. The CPSU confirmed this was an issue:

> That will always be an aspect of working in this sector. From our point of view, it is an industrial concern for people as most people want to have security at their work, to know where they are going in the longer term and to have that option. It is also a concern in terms of the quality of the work that the organisation is able to produce if both individuals and the organisation do not have that longer-term capacity to plan what they are doing. I think it does create difficulties.[15]

4.17 The CPSU suggested that the prevalence of short-term contracts is part of the managerial culture which has emerged due to fear of overloading an organisation with 'dead wood', permanent employees who do not perform. The CPSU advised that this could be avoided by implementing a strict regime of performance assessment and management. CSIRO have implemented such a scheme:

---

13 BoM, *transcript of evidence 12 August 2009*, p. 5.

14 BoM, *transcript of evidence 12 August 2009*, p. 6.

15 CPSU, *transcript of evidence 29 June 2009,* p. 64.

> A slight innovation in our last enterprise agreement, which goes back to the point again, is that we now have five-year reviews of staff at a lower level in the organisation—five-year reviews have been operating at a higher level—and that does not win us any friends of our members when we implement those sorts of changes. But, on the whole, the science community recognises that performance has to be a key part of the whole deal, and I would still argue that it is a more efficient way of dealing with people. If you are managing people properly and reviewing performance and setting directions, people who know they are not performing are likely to move on anyway. But, if you have a hard contract, I have seen it turn out to be just so inefficient so many times. People use the last year of the contract, even if it is the fourth or fifth year of a five-year contract. It is still a huge inefficiency in the system compared to proper review and workforce planning and minimising the use of contracts. We have a lot of support for that basic position from the membership and even among managers, I suppose, in the organisation; they can see benefits in that. But it is a never-ending battle to maintain that position in the fight because of the culture of using short-term contracts, which I find particularly galling in a long-term science organisation.[16]

4.18 Another solution put forward by the CPSU is to improve the conditions of contract workers and to extend the term of contracts from three years to five or six years:

> I will get back to the point that we fought for a long while in our organisation to get more equity for term people, so we got severance payments for them and other conditions. In effect, they became the equivalent of full-time employees if you wanted to get rid of anyone at any particular time. So if a person was on a three-year contract and that came to an end they were entitled to a severance payment so they may as well have been ongoing.[17]

16 CPSU, *transcript of evidence 29 June 2009*, p. 64.

17 CPSU, *transcript of evidence 29 June 2009,* p. 63.

Adequate resourcing

4.19 CPSU stated that this inquiry should address the need for BoM to be funded to maintain staffing levels that preserve efficient, effective and high standard long-term forecasting.[18]

4.20 Further, CPSU suggested that particular budgetary measures, such as accrual accounting and the two per cent efficiency dividend, moves towards shorter term project funding rather than ongoing funding.[19]

4.21 CPSU added that its members are:

> … particularly concerned that, while the range and quality of services provided by BoM has increased dramatically in recent years, due to funding constraints no commensurate increase in staffing has occurred. Our members are committed to delivering efficient and effective public services, and firmly believe these can only be achieved through adequate public funding.[20]

4.22 CPSU believes that current funding pressures damage BoM's capacity for innovation:

> With reduced staffing levels BoM will have fewer motivated, skilled and experienced employees. This will compromise the integrity of the Bureau's observational data, and reduce its capacity to extract value from the high standard climate change monitoring tools it has developed. Innovation opportunities and essential services will be severely curtailed under such circumstances.[21]

4.23 CPSU discussed the value of all forecasting services, quoting the UK example:

> … in monetary terms [forecasting] benefits the nation far more than it costs. The 2007 study specifically examined the Met Office's Public Weather Service (PWS) which is responsible for weather forecasting and climate prediction. The total PWS budget of £UK83.2 million was contrasted to the 'public value' of £UK353.2 million which the service generates. The PWS saves lives and

18 CPSU, *submission 3*, p. 1.
19 CPSU, *submission 3*, p. 1.
20 CPSU, *submission 3*, pp. 1-2.
21 CPSU, *submission 3*, p. 2.

> delivers financial benefits while serving ten different government departments, over 600 different agencies, and the UK public.[22]

4.24 CPSU stated that its members have supported the UK approach to valuing the service provided by their government forecaster:

> In the words of a CPSU member who is also a climatologist: "To some degree, dynamical climate forecasting in the Bureau exists on a shoestring. Achieving a critical mass of people and expertise in this area, even if it only improves outlooks marginally, will return such investment many times over …"[23]

4.25 CPSU stated that BoM must be fully funded for the services it provides:

> … feedback from our members, and the information and recommendations contained in other submissions to the inquiry, suggest that the demands on BoM's long-term meteorological forecasting capacity will continue to increase. This will require an ongoing commitment to fully fund, and adequately staff, the Bureau for its services.[24]

4.26 CPSU provided several examples of services or data quality diminishing due to limited funding. One particular example was that of staffing levels in observation stations:

> Human Observers are particularly important to provide data for climate models. One CPSU member pointed out that: "The models used to produce long-term forecasts rely on good observations as a starting point for their computations and for verification of the model, after the season has [passed]. Despite this important role, the number of human observers in the Bureau is decreasing and there were no new observers at all coming into the Bureau in 2007/08 (there was no observer training course in 2008).[25]

4.27 CPSU pointed out that BoM itself drew attention to the problems arising from the Commonwealth government's public sector funding models in its 2008 submission to the Senate Inquiry on Climate Change and the Australian Agricultural Sector:

> "Despite the best efforts of the Bureau to rationalise its basic monitoring networks and to continue to improve efficiency

22 CPSU, *submission 3.1*, p. 2; Met Office, 'How valuable is the Met Office?', www.metoffice.gov.uk/corporate/verification/valuable.html, accessed 25 October 2009.

23 CPSU, *submission 3.1*, p. 3.

24 CPSU, *submission 3.1*, p. 2.

25 CPSU, *submission 3.1*, p. 7.

> 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.[26]

Committee comment

4.28 The Committee agrees that the Bureau of Meteorology provides a crucial national service, relied upon by government, business and the public.

4.29 The Committee recognises that the services provided by the Bureau of Meteorology are of far greater value than the relatively modest investment by government, and that the Bureau should be fully funded and adequately staffed to meet the nation's needs.

4.30 The Committee is concerned by the erosion of qualified staff from the Bureau of Meteorology and recommends that steps be taken to ensure adequate staffing levels for the Bureau.

4.31 To this end, the Committee recommends that employment conditions be reviewed and that a more secure tenure be provided to relevant staff, including increasing contracts from three years to five years.

Recommendation 7

The Committee recommends that the Bureau of Meteorology employment conditions be reviewed and that a more secure tenure be provided to relevant staff, including increasing contracts from three years to five years.

26 CPSU, *submission 3.1*, p. 7.

Coordination of research between government, universities and the private sector

4.32 The Committee heard of the extensive research being conducted, not only by the BoM and CSIRO but by State Government agencies and universities. However, the Committee was told that there is no coordinated research agenda.

4.33 Professor Nicholls discussed the current fragmented approach to forecasting research:

> Australia's operational climate forecasting systems are based on the work, a couple of decades ago, of a few scientists in the Bureau of Meteorology and Queensland Department of Primary Industries who had the security and resources to pursue innovative research on this challenging topic. More recently, the development of improved forecast systems has relied on short-term research contracts from a variety of agencies. These funding agencies have little interest in the development of an improved national forecast system, because of their very specific geographical and sector foci.[27]

4.34 Professor Nicholls stated that the recognition that reliance on such a fragmented approach would lead to little improvement in forecast systems led to proposals to establish a national centre, institute or funding mechanism dedicated to the development and application of improved seasonal to inter-annual climate forecasts. However, despite several such proposals, such an enterprise has not been established.[28]

4.35 Professor Nicholls recommended the establishment of a dedicated research facility for weather and climate research:

> The simplest strategy to ensure that Australia develops innovative and improved approaches to increase our ability to forecast seasonal-to-interannual climate fluctuations such as droughts, and to use such forecasts effectively, is to establish a centre of excellence or a CRC with long-term (more than seven years) funding and dedicated staff and resources. Such a centre would combine the expertise of climate researchers in universities, the

27 Prof Neville Nicholls, *submission 12*, p. 5.

28 Prof Neville Nicholls, *submission 12*, p. 5.

> CSIRO, the Bureau of Meteorology, and various State Government bodies in a collaborative approach to this challenging problem.[29]

4.36 Professor Nicholls emphasised that:

> The alternative, current approach, of competitive bidding by individual researchers for small, short-term research grants militates against collaboration between agencies and universities, and is ineffective in the development of the complex systems needed for operational climate prediction.[30]

4.37 Professor Nicholls added that:

> Continued reliance on a fragmented approach to funding Australian research on seasonal-to-interannual climate prediction will ensure that Australia's performance in this field continues to slip relative to other countries, where climate prediction research is more effectively resourced. Eventually, this fragmented approach will ensure that Australia becomes reliant on other countries to provide the systems and models for prediction, and probably even the forecasts themselves.[31]

4.38 The Australian Academy of Science discussed the problems of integrating weather and climate research in Australia:

> An on-going problem, however, relates to integration of research from various groups into a national common agenda. The creation of the CAWCR and the ACCESS initiative has begun to address this problem but the formal links between CAWCR and the research intensive Universities remain formative.[32]

4.39 The Committee asked CSIRO whether the organisation had formal links with the universities to facilitate a cross-institutional research agenda particularly with regard to access to the CSIRO computing facilities. CSIRO told the Committee:

> Yes, across both the Bureau and CSIRO in research and development. We have strong links with folk in the university sector across a number of universities who are working on climate and meteorological science, basic physics and oceanography, so we do have very strong collaborative links with the university sector. In terms of the model development, … of building the

29 Prof Neville Nicholls, *submission 12*, p. 6.
30 Prof Neville Nicholls, *submission 12*, p. 6.
31 Prof Neville Nicholls, *submission 12*, p. 6.
32 AAS, *submission 25*, p. 6.

> access modelling framework, we have formal structures to engage with the university sector. We have an access coordination committee which meets frequently for the university, the bureau folk and CSIRO researchers to discuss how that collaboration should work. Just this year the National Computational Infrastructure facility dedicated two full-time positions to support that research collaboration on the development and application of access …
>
> In terms of access to supercomputers … the academic community does have access to the National Computational Infrastructure facility here in Canberra at the Australian National University.[33]

4.40 The Committee queried why some academics may be missing out on access to supercomputing facilities. CSIRO told the Committee that the research field is very competitive:

> It may be that their research priorities do not float to the top in the competitive processes of academia. The use of the National Computational Infrastructure supercomputer does have a large component of merit based allocations of time on it, so it may be that some academics are not competitive and others are.
>
> I am on the merit allocation committee for the NCI machine. Each year we review the proposals from the researchers and the stronger ones will get a share of time on that machine. Some will have quite a large share of time on that machine, those that could easily facilitate working with us directly with our modelling systems that we already have on that machine.[34]

4.41 The Committee was also impressed by the amount of research work being undertaken by state agencies. The Queensland Government has taken a whole-of-government approach to weather and climate and established the Queensland Climate Change Centre of Excellence (QCCCE). The Centre's work includes:

> … climate system modelling using global and regional climate models; developing, promoting and interpreting seasonal climate forecasts; providing tools to assist industry better manage climate variability and to assess and adapt to climate change risks; and collaborating with national and international climate institutions.[35]

---

33 CSIRO, *transcript of evidence 12 August 2009*, p. 6.

34 CSIRO, *transcript of evidence 12 August 2009*, p. 7.

35 DERM, *submission 33,* p. 4.

4.42 The QCCCE is contributing to the international research agenda through collaboration with a number of international centres including:

> … the UK Met Office Hadley Centre, The Walker Institute, in the USA institutions such as the IRI, University of Colorado and National Oceanic Atmospheric Administration, and in China the Chinese Academy of Sciences, to promote research of particular relevance to Queensland, in particular improving understanding and modelling of phenomena such as ENSO, the Pacific Decadal Oscillation and to improve historical climate data sets by contributing to the international ACRA (Atmospheric Circulation Reconstructions of the Earth) project.[36]

4.43 DEC told the Committee of the collaborative research program being undertaken by the Western Australian Government, the BoM and CSIRO through the Indian Ocean Climate Initiative (IOCI). The IOCI focuses on the detection and attribution of climate change and providing climate change projections for Western Australia.[37]

4.44 To coordinate and extend these various collaborative efforts the Australian Academy of Science suggested that the draft proposals put forward by the Australian Climate Change Science Program developed by the Department of Climate Change are implemented to overcome the structural limitations in the current system.[38] The Australian Climate Change Science National Framework calls for a National Climate Change Science strategy which includes:

- A high level coordination group comprising major funding bodies, key research organisations and senior scientists and chaired by the Chief Scientist. The coordination group will develop and oversee execution of an implementation plan for this Framework;
- The implementation plan will draw on the resources of all relevant organisations. Where necessary, the high level coordination group will facilitate formation of cross-institutional teams to advance key elements of climate change science;
- The Chief Scientist will report annually to the Minister for Climate Change and Water and the Minister for Innovation Industry Science and Research on progress in implementing this Framework;

36 DERM, *submission 33*, p. 29.

37 DEC, *transcript of evidence 13 July 2009*, p. 27.

38 AAS, *submission 25*, p. 6.

- The Department of Climate Change will establish a mechanism to liaise with States and Territories and other stakeholders on climate change science, with a particular emphasis on ensuring the national program delivers useful information about likely future climate change.[39]

4.45 The CSIRO Staff Association suggested that Australia needed broad participation from all sectors of the economy and society to improve meteorological prediction and forecasting. In their submission to the inquiry they detailed the steps that need to be taken to encourage coordination, cooperation and innovation across relevant sectors:

- Universities should increasingly be involved in national efforts for meteorological prediction and forecasting, but some coordination is required (say a "hubs-and-spokes" model often invoked in the Higher Education debate at present);
- State and Federal governments should act jointly, say through COAG (Council of Australian Governments), to promote meteorological prediction and forecasting in emergency response, planning and development and aspects of regulation (chemical hazards, building codes);
- Support for open access to meteorological and forecasting prediction and observational data to facilitate whole-of-government decision making and whole-of-research sector participation;
- Enhanced information technology platforms and infrastructure to facilitate and enable coordination and communication aiming at the broadest participation of all levels of society;
- Enhancing process studies as coordinated priorities (radiative, subgrid scale and boundary-layer parameterisations, cloud and convective models, terrestrial parameterisation, social and economic models), particularly for Australian conditions;
- Clearly, some diversity in systems and approaches at least at the R&D level should be encouraged, with a balance between focus and diversity, to address the wide scope of meteorological prediction and forecasting; and
- Developmental innovation should be shared both domestically and internationally with coordination and enhancement of collaborations, with an outcome of expansion of overall services.[40]

39 Australian Climate Change Science: A National Framework, imos.org.au/fileadmin/user_upload/shared/IMOS%20General/documents/external_reports/cc-science-framework.pdf, accessed 4 November 2009.

40 CSIRO Staff Association, *submission 9.*

Committee comment

4.46 The Committee was impressed by the extent of the research being carried out in Australia by, not only the Bureau of Meteorology and CSIRO, but State Government agencies and universities.

4.47 However, the Committee was concerned to hear that there appears to be a lack of national coordination to the research agenda and that information is not being shared effectively.

4.48 The Committee noted that Australia was once in the forefront of meteorological research but has now fallen behind and that the lack of coordination between government, universities and the private sector may be a contributing factor to this lapse.

4.49 The Committee understands that Australia faces substantial challenges due to the range and diversity of its weather regions. Many of Australia's economically important industries, including agriculture and tourism, are extremely weather sensitive and require reliable forecasting information to ensure future viability. The continuous development of innovative end products to enhance management and decision-making is essential for Australia's future economic well-being. Australia also faces the challenge of extreme weather conditions and inherent natural disasters. A coordinated research effort is required to improve the capability and capacity of emergency services to combat and respond to disastrous events.

4.50 The Committee recommends the establishment of an institute of meteorological science to develop an ongoing partnership between the relevant research bodies and implement a coordinated research agenda.

Recommendation 8

The Committee recommends that the Australian Government establish an institute of meteorological science to develop an ongoing partnership between relevant research bodies and implement a coordinated research agenda.

Maria Vamvakinou MP

Committee Chair

November 2009

A

Appendix A – List of Submissions

1	Mr Tom Quirk
2	Mr Des Moore
3	Community and Public Sector Union
3-1	Community and Public Sector Union SUPPLEMENTARY (to Submission No. 3)
4	Bureau of Meteorology
5	The Weather Channel
6	South Australian Water Corporation
7	Land and Water Australia
8	South Australian Farmers Federation
9	CSIRO Staff Association
10	Professor Roger Stone
11	Australian Meteorological and Oceanographic Society
12	Prof Neville Nicholls
13	Ms Mary Voice
14	Qantas Airways Ltd
15	Department of Primary Industries and Resources (South Australia)
16	CSIRO
17	Mr Keith Potts

17-1	Mr Keith Potts SUPPLEMENTARY (to Submission No. 17)
18	Dr J. Walter Larson
19	Firewatch Australia Pty Ltd
20	Department of Environment and Heritage (South Australia)
21	Weather Risk Management Services Pty Ltd
22	Prof Christian Jakob
23	Foreseechange Pty Ltd
23-1	Foreseechange Pty Ltd SUPPLEMENTARY (to Submission No. 23)
24	Australian Nuclear Science and Technology Organisation
25	Australian Academy of Science
26	The Western Australian Farmers Federation (Inc)
27	Department of Agriculture, Fisheries and Forestry
28	Mr Geoffrey Carpenter
29	Fire and Emergency Services Authority (Western Australia)
30	Department of Agriculture and Food (Western Australia)
31	Department of Environment and Conservation (Western Australia)
32	Mr John McLean
32-1	Mr John McLean SUPPLEMENTARY (to Submission No. 32)
33	Department of Environment and Resource Management (Queensland)
34	Department of Environment, Water, Heritage and the Arts

B

Appendix B – List of Exhibits

1 Mr Tom Quirk

Bush Fire Prevention: Space-age Technology to Protect the Community

(Related to Submission No. 19)

2 Firewatch

Use of Firewatch in the State of Brandenburg

(Related to Submission No. 19)

3 Firewatch

Early Detection of Forest Fires (Firewatch)

(Related to Submission No. 19)

4 Firewatch

Forest fire detector

(Related to Submission No. 19)

5 Firewatch

Experimentation Report: CEREN (Firewatch)

(Related to Submission No. 19)

6 Land and Water Australia

Managing Climate Variability Research and Development Strategy, 2008-2014

(Related to Submission No. 7)

7 Land and Water Australia

CliMag (Edition 16, January 2009)

(Related to Submission No. 7)

8 Land and Water Australia

Climate Kelpie - Sample pages

(Related to Submission No. 7)

9 Land and Water Australia

Farm-level adaptation options: south-eastern South Australia

(Related to Submission No. 7)

10 Land and Water Australia

Farm-level adaptation options: Wimmera-Mallee

(Related to Submission No. 7)

11 Land and Water Australia

Farm-level adaptation options: North East Agricultural Region, Western Australia

(Related to Submission No. 7)

12 Land and Water Australia

Improved Climate Forecasting for Australia's Climate Regions Important to Agriculture: by Alves and Hendon

(Related to Submission No. 7)

13 Professor Roger Stone

A comparison of two seasonal rainfall forecasting systems for Australia: by RJB Fawcett and RC Stone

(Related to Submission No. 10)

14 Mr Keith Potts

Aerosol Regional Dimming, Droughts, El Nino and Climate Change by Keith A Potts

(Related to Submission No. 17)

15 Firewatch Australia Pty Ltd

System description: Automated early warning system for forest fires

(Related to Submission No. 19)

16 Mr John McLean

(Related to Submission No. 32)

17 Bureau of Meteorology

Seasonal Outlook Briefing (BoM) May 2009

(Related to Submission No. 4)

18 Department of Environment and Resource Management (Queensland)

Detailed Inventory of QCCCE Seasonal Climate Risk Products and Services - 22 April 2009

(Related to Submission No. 33)

19 Firewatch Australia Pty Ltd

Examples of views - Neptune-Oberems firewatch monitoring system

(Related to Submission No. 19)

20 Mr Keith Potts

Particulates

(Related to Submission No. 17)

21 Mr Geoffrey Carpenter

Weather Maps - Bureau of Meteorology

(Related to Submission No. 28)

22 Land and Water Australia

Managing Climate Variability

(Related to Submission No. 7)

C

Appendix C – List of Public Hearings

Monday, 18 May 2009 - Melbourne

Bureau of Meteorology

Dr David Jones, Supervisor Climate Analysis, National Climate Centre

Dr David Walland, A/g Superintendent, National Climate Centre

CSIRO

Dr Oscar Alves, Leader - Seasonal Prediction and Climate Variability Group, Centre for Australian Weather and Climate Research

Dr Helen Cleugh, Theme Leader, Climate and Atmosphere

Dr Mark Howden, Theme Leader, Adaptive Primary Industries and Enterprises

Dr Tom Keenan, Deputy Director, Centre for Australian Weather and Climate Research

Dr Bruce Mapstone, Director, Centre for Australian Weather and Climate Research

Dr Peter McIntosh, Principal Research Scientist

Dr Penny Whetton, Leader, Climate Change Research Group

Wednesday, 3 June 2009 - Canberra

Bureau of Rural Sciences

Dr James Findlay, General Manager, Climate Change and Water Science Branch

Wednesday, 17 June 2009 - Canberra

Individuals

Dr J. Walter Larson

Wednesday, 24 June 2009 - Canberra

Grains Research and Development Corporation

Dr Martin Blumenthal, Manager, Agronomy, Soil and Environment

Land and Water Australia

Mr Colin Creighton, Coordinator, Managing Climate Variability

Dr Michael Robinson, Executive Director

Monday, 29 June 2009 - Melbourne

Individuals

Prof Christian Jakob

Mr John McLean

Prof Neville Nicholls

Mr Tom Quirk

Community and Public Sector Union

Ms Monica Long, Section Secretary

Ms Louise Persse, National President

CSIRO Staff Association

Dr Michael Borgas, President

Foreseechange Pty Ltd

Mr Charlie Nelson

Institute for Private Enterprises

Mr Des Moore, Director

Tuesday, 30 June 2009 - Sydney

Firewatch Australia Pty Ltd

Mr David Goodrich, Executive Director

Qantas Airways Ltd

Mr Graham Rennie, Manager, Flight Dispatch, Operational Policy and Industrial Affairs

The Weather Channel

Mr Richard Whitaker, Senior Meteorologist

Weather Risk Management Services Pty Ltd

Dr Christian Werner, Managing Director

Monday, 13 July 2009 - Perth

Department of Environment and Conservation (Western Australia)

Ms I-Lyn Loo, Technical Specialist, Office of Climate Change

Mr Richard Sneeuwjagt, State Manager, Fire Management Services

Fire and Emergency Services Authority (Western Australia)

Mr Malcolm Cronstedt, Acting Assistant Chief Operations Officer (Country)

Mr Ralph Smith, Manager, Bushfire and Environmental Protection Branch

Western Australian Farmers Federation

Mr Alan Hill, Director of Policy

Mr Dale Park, General Executive, Land Management and Climate Change Portfolio Holder

Tuesday, 14 July 2009 - Adelaide

Individuals

Mr Geoffrey Carpenter

Mr Keith Potts

South Australian Farmers Federation

Ms Sharon Starick, Chair, Natural Resources Committee

South Australian Water Corporation

Mr James Gifford, State Engineering Coordinator

Mr Tony McLoughlin, Principal Project Manager

Wednesday, 12 August 2009 - Canberra

Bureau of Meteorology

Mr Neil Plummer, Acting Assistant Director, Climate and Oceans Branch, Water Division

Mr Bruce Stewart, Acting Deputy Director, Water, National Climate Centre

CSIRO

Dr Oscar Alves, Leader - Seasonal Prediction and Climate Variability Group, Centre for Australian Weather and Climate Research

Dr Tony Hirst, Research Team Leader

Dr Mark Howden, Theme Leader, Adaptive Primary Industries and Enterprises

Dr Bruce Mapstone, Director, Centre for Australian Weather and Climate Research