Australian Academy of Science

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Committee Secretary
Standing Committee on Industry, Science and Innovation
PO Box 6021
House of Representatives
Parliament House
CANBERRA ACT 2600

Dear Committee Secretary

The Australian Academy of Science welcomes the opportunity to provide a submission to the House of Representatives Standing Committee on Industry, Science and Innovation's *Inquiry into long term meteorological forecasting in Australia.*

Australia's size, location and climate make many activities especially vulnerable to seasonal weather conditions. Accurate measurement of actual seasonal weather is an important aid to reliable forecasts of future conditions. Improved long-term forecasts of seasonal climate will significantly benefit planning and management of a diverse range of industries (agriculture, power, health, transport, infrastructure and water services) and enhance emergency responses to natural disasters.

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. However, Australia derives great benefit from international collaboration in observation systems and weather and climate research modelling, and significant future improvements may be derived from adapting international best-practice models to Australian conditions. Continued access to international developments and observation networks, including satellites, depends on continued contributions from Australia to international research and development.

Long-term forecasting in Australia is provided mainly by the Bureau of Meteorology. Climate modelling is provided by a suite of researchers, mainly located in the Centre for Australian Weather and Climate Research and five Universities. The integration of these efforts is developing but is hampered by resourcing.

Continued support for Australian climate and weather research and development of Australia's climate modelling capability will be necessary to maximise national benefit and advantage from international innovation. This will require on-going investment in national supercomputing, observation and higher education infrastructure.

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The Academy would be pleased to respond to any issues which the committee would like to explore further.

Yours sincerely

Kurt Lambeck

Australian Academy of Science

A submission to the House of Representatives Standing Committee on Industry, Science and Innovation
Inquiry into long term meteorological forecasting in Australia

29 April 2009

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Summary

Capsule summaries of the points presented in this submission against each of the Terms of References are provided below. More detail is provided in the following pages.

ToR 1: The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems

Long-term forecasting in Australia is provided mainly by the Bureau of Meteorology. Forecast skill has improved substantially due to the implementation of new dynamic modelling systems. Future improvements will be expected from adapting international best-practice models to Australian conditions, providing integrated data observing systems are maintained and expanded. Delivery of national benefit will require ongoing support for Australian climate and weather research and continued development of Australia's climate modelling capability. Climate modelling is provided by a suite of research providers, mainly located in CAWCR and five Universities. The integration of these efforts is developing but is hampered by resourcing, supercomputing resources, IT support and infrastructure.

ToR 2: Innovation in long-term meteorological forecasting methods and technology

The Australian Community Climate and Earth System Simulator (ACCESS) will be the next generation weather, climate and earth system simulation system for Australia. The goal with ACCESS is to provide seamless integration of short-term weather forecasts, long-term forecasts, and global and regional climate projections across all spatial scales. This capability will underpin much of Australia's future weather and climate research. Continuing investment in national supercomputing infrastructure and integrated observation systems will be central to further advances in all facets of national weather forecasting and weather and climate research.

ToR 3: The impact of accurate measurement of inter-seasonal climate variability on decision-making processes for agricultural production and other sectors such as tourism

Australia's size, location and climate make many activities especially vulnerable to seasonal weather conditions. Activities in many sectors are planned seasons in advance and depend on formal or informal expectation of future conditions. Accurate measurement of actual seasonal weather is an important aid to reliable forecasts of future conditions. Improved long-term forecasts of seasonal climate will benefit significantly planning and management of agricultural, power, health, transport, infrastructure and water industries and services across much of Australia.

ToR 4: Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail, and tsunami, in Australia and in neighbouring countries

Emergency services are geared to respond quickly to unpredictable events. Long-term forecasting will not provide specific information about when or where particular events will occur but will provide advance warning of the sorts of events that are most likely in future seasons. Such early warning of future conditions will enable strategic planning to underpin appropriate and targeted emergency response when specific events occur.

ToR 5: Strategies, systems and research overseas that could contribute to Australia's innovation in this area

Australia derives great benefit from international collaboration in observation systems and weather and climate research and modelling. Continued benefit from international developments and observation networks, including satellites, depends on continued contributions from Australia to international research and development. Australia's position in the Southern Hemisphere Indo-Pacific Region, however, demands specific national weather and climate research capability to ensure forecasting systems are tuned to provide maximum national benefit. Delivering maximum advantage from international and national innovation will require on-going investment in national supercomputing, observation and higher education infrastructure.

Introduction

Long-term meteorological forecasting (being forecasting from weeks to several months into the future) is an important aid to many sectors of the Australian community, including industry and all levels of government. Weather forecasting by definition is uncertain because it involves making prediction about future events within a chaotic system. The accuracy of forecasts is improved by on-going research into ways of modelling weather and climate and development of efficient and informative tools for delivering forecast information to the public. This submission is concerned primarily with the research underpinnings of long-term forecasting and areas in which further research is likely to improve forecasting accuracy and reliability for Australia.

We address all five Terms of Reference.

Response to the Terms of Reference

1. The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems

> Long-term forecasting in Australia is provided mainly by the Bureau of Meteorology. Forecast skill has improved substantially due to the implementation of new dynamic modelling systems. Future improvements will be expected from adapting international best-practice models to Australian conditions, providing integrated data observing systems are maintained and expanded. Delivery of national benefit will require ongoing support for Australian climate and weather research and continued development of Australia's climate modelling capability. Climate modelling is provided by a suite of research providers, mainly located in CAWCR and five universities. The integration of these efforts is developing but is hampered by resourcing, supercomputing resources, IT support and infrastructure.

Long-term forecasting increasingly is being seen as part of a continuum of weather and climate prediction that extends from the immediate or very short-term prediction of today's weather out to projections of potential climate change over decades or centuries. The longer term forecasts and climate predictions generally are done at coarse regional or global scales, whilst short term forecasts apply more locally. In general, short term weather forecasts, long-term weather forecasts and climate projections have been delivered historically from different modelling or statistical prediction systems.

Long-term forecasts in Australia are delivered mainly by the Bureau of Meteorology. Forecast accuracy and reliability generally have been relatively poor historically but there has been some improvement in skill in recent years. The introduction of improved dynamic modelling of weather and climate for Australia (see Term of Reference 2) promises significant improvements over previous systems. For example, experimental outputs from the POAMA dynamic modelling system have shown forecasting skill equal to or better than the existing operational statistical methods. The new systems, however, are likely to require significant investment in additional supercomputing infrastructure and data acquisition and assimilation systems, especially from satellite and other automated observing systems for the land, atmosphere and oceans.

Australia's climate modelling capability generally has ranked well compared to international efforts. The CSIRO Mk 3, Mk3.5 and Mk3.6 Global Climate Models have been the mainstays of Australian climate projections whilst atmospheric and ocean models developed by the Bureau of Meteorology have provided the main weather forecasting services. Each of these systems is now being superseded with more advanced model systems built from internationally leading components for application to Australia. Ongoing investment in weather and climate research and modelling will be essential to deliver the benefits of these new systems to Australia.

2. Innovation in long-term meteorological forecasting methods and technology

> The Australian Community Climate and Earth System Simulator (ACCESS) will be the next generation weather, climate and earth system simulation system for Australia. The goal with ACCESS is to provide seamless integration of short-term weather forecasts, long-term forecasts, and global and regional climate projections across all spatial scales. This capability will underpin much of Australia's future weather and climate research. Continuing investment in national supercomputing infrastructure and integrated observation systems will be central to further advances in all facets of national weather forecasting and weather and climate research.

Recent trends in research and development of forecasting systems have favoured delivering all weather and climate forecasts from a single modelling framework that captures the dynamics and interaction of the major components of the Earth system – land surface, atmosphere, oceans and cryosphere. Australia has embarked on development of a state of the art earth system modelling capability – the Australian Community Climate and Earth System Simulator (ACCESS) to deliver international best practice weather and climate research, development and forecasting. Led by the Centre for Australian Weather and Climate Research (CAWCR), a partnership between the CSIRO and the Bureau of Meteorology, 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. 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. The draft proposals highlighted in the Australian Climate Change Science Program developed by the Department of Climate Change are designed to address these structural limitations and are very welcome.

The ACCESS system will provide improved short-term weather forecasting, the next generation of Australia's long-term weather forecasting system (POAMA-3), and an internationally competitive coupled Earth system climate modelling environment. The goal in developing ACCESS, therefore, is to realize the seamless integration of weather and climate prediction across all feasible scales of time and space. ACCESS also will provide a significant advance in climate and weather research capability for the Australian research community, including universities, CSIRO, the Bureau of Meteorology and state centres.

Realisation of the full capacity of ACCESS to improve long-term forecasting and related weather and climate research will require significant ongoing investment in (a) national supercomputing capacity (b) national and international observing systems and (c) human resources. This includes resourcing of undergraduate and postgraduate training, addressing weaknesses in collaborative structures via innovative information technological developments, provison of data services and removal of impediments that prevent effective collaboration between Universities and CAWCR. These steps should include reducing fundamental impediments to cross-institutional and cross-disciplinary collaboration within the Australian Research Council funding mechanisms. In addition, weather forecasting relies heavily on assimilation of observations of the land, atmosphere and ocean and long-term weather forecasting in particular requires long-term observations of the ocean. A nationally integrated observing system would enhance significantly the observational base from which long-term forecasting could be improved.

3. The impact of accurate measurement of inter-seasonal climate variability on decision-making processes for agricultural production and other sectors such as tourism

> Australia's size, location and climate make many activities especially vulnerable to seasonal weather conditions. Activities in many sectors are planned seasons in advance and depend on formal or informal expectation of future conditions. Accurate measurement of actual seasonal weather is an important aid to reliable forecasts of future conditions. Improved long-term forecasts of seasonal climate will benefit significantly planning and management of agricultural, power, health, transport, infrastructure and water industries and services across much of Australia.

Australia's size and latitudinal extent, from the tropics to cold temperate regions, make it vulnerable to diverse seasonal weather variations that profoundly influence many aspects of life. Water supply, or shortage of it, is of particular importance over much of Australia and extremes of temperature, especially heat waves, are important in many population centres. 'Accurate measurement' of seasonal conditions that have already occurred may be seen as of less importance than 'accurate forecasts' of what should be expected in coming seasons, though the former clearly improves capacity to predict the latter. A particularly important component of long-term forecasting and the likelihood of seasonal predisposition to certain extremes is robust observations of the ocean. As an island continent, Australia's climate is affected strongly by the conditions of the oceans around it. Observations of ocean conditions provide good indicators of likely climate conditions that flow over the continent many months into the future. Assimilation of these ocean observations into good climate models is a key aspect of long-term forecasting. Observations of the land surface and atmosphere indicate how major climatic systems will develop at shorter time scales. Hence, improving long-term seasonal forecasting will require both ongoing and enhanced observation networks to record actual weather events over all seasons, continued research into key drivers of Australian climate, and development of Australia's forecasting capacity.

Long-term forecasts of the prospect of rain, drought, heat waves or, in some areas, snowfall provide important information for planning business activities in many sectors. Key decisions often are taken seasons in advance and depend on formal or informal expectation of future conditions. Agricultural industries, especially those growing annual crops, would be obvious beneficiaries of improved long-term forecasts but other sectors also could benefit from advance knowledge of likely climatic conditions in future seasons. Transport, storage, wholesale and retail industries associated with agricultural production could benefit from forward planning based on expected production conditions. Power companies will be able to better manage peak supply during periods of very hot or cold weather if they had reliable forecasts of likely future conditions. Infrastructure planning and management would benefit from advance warning of wet or very hot conditions that delay building activities or disrupt services, such as occurred during very hot weather in Melbourne in February 2009. Severe weather also effects population health and so has ramifications for health services and school management. These services might benefit from advance warning of adverse seasonal conditions.

Water management will be a major beneficiary of improved long-term forecasting, especially of precipitation and temperature. Water shortage is now chronic in many population centres, irrigation schemes and natural flows across Australia. Management of water allocation and use is a major challenge in most jurisdictions, especially in the southern half of the continent. Allocations of water use need to be made in advance for many users so that decisions can be made in the context of certainty about what water will be available in coming seasons. Maintaining and improving the skill of long-term forecasts, therefore, will be an important aid to water management from the perspectives of policy makers, regulators and water users.

4. Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail, and tsunami, in Australia and in neighbouring countries

> Emergency services are geared to respond quickly to unpredictable events. Long-term forecasting will not provide specific information about when or where particular events will occur but will provide advance warning of the sorts of events that are most likely in future seasons. Such early warning of future conditions will enable strategic planning to underpin appropriate and targeted emergency response when specific events occur.

Emergency response management is a particular case of the many sectors that would benefit from improved long-term forecasting. Long-term forecasting cannot predict with certainty when or where specific extreme events or natural disasters will occur, but forecasts of the seasonal conditions that are likely to favour different types of events is particularly important. For example, having early and reliable warning that a season is likely to be one of high or extreme fire risk or, alternatively, flood prone allows for targeted advanced planning of emergency responses should either fire or flood occur.

Many of Australia’s neighbours also are subject to the effects of extreme weather events, especially those in the tropical Pacific that experience tropical cyclones. Meteorological services in many Pacific Island countries are supported through Australian agencies, including the Bureau of Meteorology, and stand to benefit directly or indirectly from improved long-term forecasting services developed for Australia. Australia, as a leading developed nation in the region and one of the world’s leading weather and climate modelling nations, has potential to deliver great benefit to other nations in the region. Long-term forecasts generally require modelling the Earth system at regional or greater scales as part of delivering local forecasts, so delivering forecasting benefits to regional neighbours should not entail great extra cost for Australia. But at the same time it also enhances the quality of Australian forecasts. Some additional data storage and supercomputing capacity may be required.

Development of robust dynamic climate modelling approaches to long-term forecasting is likely to improve forecast skill significantly but is also particularly important in the context of climate change. Various extremes of weather, including storms, heavy rain, extreme heat waves, and high winds, are expected to change in frequency and distribution because of climate change. Consequential risks from these extremes of weather, such as fire, flood and drought risk, also are likely to change as a general climate changes. Dynamic climate model based forecasting, such as being developed with ACCESS, is the only method of quantitatively projecting what these changes in seasonal extremes are likely to be. Anticipation of such change will be essential for adapting to climate change through, for example, modifying building codes to ensure buildings withstand expected changes in extreme events. Improving the accuracy and reliability of long-term forecasting in the context of climate change will require continued research into climate change and further development of robust systems for measuring and modelling the Earth system.

5. Strategies, systems and research overseas that could contribute to Australia's innovation in this area

> Australia derives great benefit from international collaboration in observation systems and weather and climate research and modelling. Continued benefit from international developments and observation networks, including satellites, depends on continued contributions from Australia to international research and development. Australia's position in the Southern Hemisphere Indo-Pacific Region, however, demands specific national weather and climate research capability to ensure forecasting systems are organised to provide maximum national benefit. Delivering maximum advantage from international and national innovation will require on-going investment in national supercomputing, observation and higher education infrastructure.

Australia benefits a great deal from international collaboration in research and various international organisations related to research. Weather forecasting and climate prediction are areas where Australia derives essential benefits from international research and development and operational activities. All forecasting systems rely in some way on observations of the land surface, atmosphere and ocean conditions, either from the past or in near-real-time. Modern forecasting depends on high levels of data assimilation from many sources, especially automatic recording systems on satellites, in the ocean and at remote weather stations. Australia has extremely limited capacity to acquire many of these essential observations and relies almost totally on facilities (e.g., satellites) that are made available because of our international collaborations. Supporting ongoing international collaboration will be key to sustaining these benefits whilst also ensuring that Australian innovation is returned to the global research and development pool. Maintaining support for Australian participation in international coordination of scientific research in the areas of the enquiry, such as through groups like the World Meteorology Organisation (WMO), World Climate Research Program (WCRP), the Climate Variability and Predictability program (CLIVAR), Global Energy and Water cycle Experiment (GEWEX), International Geosphere-Biosphere Programme and others, is an important part of retaining Australian access and contribution to global technology advances.

Weather and climate research that underpins improvements in, among other things, long-term forecasting is now almost completely an international endeavour. Many of the most significant advances in forecasting technology and Earth system modelling are shared among national research and services agencies. Australia is benefiting from this behaviour in the development of ACCESS, which is based on atmospheric physics and chemistry models from the United Kingdom, ocean and sea ice models from the United States of America, and land surface and carbon cycle models from Australia. The combination of these 'world-best' components into the ACCESS system will provide Australia with state of the art weather, climate and Earth system modelling capability.

It is important to note, however, that ACCESS needs to be adjusted to service Australia's needs because of our position in the Southern Hemisphere Indo-Pacific region where most developed countries have relatively little specific interest. This includes Antarctica. Further, investment in ACCESS development is currently very low compared to international efforts, with the ACCESS development team approximately only about 60% of what was estimated to be necessary for timely progress. Maintaining forecasting capability specific to Australian needs requires support for Australian research, development and operation of weather and climate forecasting systems, including support for supercomputing, observation and higher education infrastructure.

Conclusion

Long-term forecasting is an essential component of providing the Australian community with the information necessary to respond to the weather and climate challenges that affect the continent. Unlike short-term forecasting, however, long-term forecasting has only recently begun to benefit from improvements in dynamic weather, climate and Earth system modelling. Australia stands to gain significant national benefit across industry, community and government sectors with improvement in long-term forecasting. Such improvement, however, will require ongoing investment in relevant research and development infrastructure, including supercomputing facilities, automated observation technologies and the effective integration of university research and training into the development of the next generation of models.