

METEOROLOGICAL AND RELATED RESEARCH

OBJECTIVE

To advance the science of meteorology, develop an integrated, comprehensive description and scientific understanding of Australia's weather and climate, develop the application of meteorology in the national interest and improve the operations and services of the Bureau.

OUTPUT

Original publications on Australian and global meteorology, hydrology and oceanography in the peer-reviewed scientific literature along with reviews, project reports, conference presentations, and the general build-up of scientific expertise, reputation and influence in the international scientific community; together with published and unpublished contributions to the development and implementation of new and improved applications of meteorology and new operational meteorological and related systems and techniques; and effective Australian participation in international research programmes directed towards improved understanding of southern hemisphere and Australian meteorology and oceanography

OUTCOME

Advancement of meteorological science and understanding of the mechanisms of Australian weather and climate.

Meteorological and Related Research includes both research undertaken in fulfillment of the Bureau's responsibilities as a national research agency to contribute to the advancement of meteorological science in Australia and research aimed at developing the application of meteorology to the needs of the Australian community. The Bureau of Meteorology Research Centre (BMRC), in collaboration with the operational areas of the Bureau, carries out the main research activities reported in this chapter. This is complemented by a program of supporting research and development undertaken in the Bureau's Regional

Offices, Head Office Branches and the BMRC, including an annually reviewed program of high priority techniques development projects. Supporting research and development activities are reported as part of the chapter on Cross-cutting and Corporate Activities.

Meteorological research in Australia is carried out by the Bureau, the CSIRO, a number of university groups and, to a lesser extent, by other government departments and agencies and the private sector. In recent years, the Bureau and CSIRO, as the two major agencies engaged in atmospheric research, have worked closely to

ensure that Bureau/CSIRO plans for atmospheric and related research are coordinated effectively and to identify joint research activities and areas of collaboration at the project level, particularly between the BMRC, CSIRO Atmospheric Research (CAR) and CSIRO Marine Research (CMR).

To improve further the coordination of meteorological and related research in Australia and to provide support for the strengthening of programs in meteorology at Australian universities, the Bureau actively participated in the development of multi-agency agreements to establish new research centres in meteorology and related disciplines under the Government's Cooperative Research Centre (CRC) program. During 2002-03, the Bureau participated in:

- the CRC for the Antarctic and Southern Ocean Environment at the University of Tasmania with CSIRO Marine Research, the Australian Antarctic Division, Geoscience Australia and the University of Tasmania;
- the CRC for Antarctic Climate and Ecosystems which replaces the CRC for the Antarctic and Southern Ocean Environment;
- the CRC for Catchment Hydrology at Monash University with CSIRO Land and Water, the Department of Sustainability and Environment (Victoria), Melbourne Water, Monash University, the Murray-Darling Basin Commission, Goulburn Murray Water (Victoria) and The University of Melbourne; and
- the development of a new CRC for Bushfire Research to commence in July 2003.

Bureau staff participated actively in the research and research training programs of a number of Australian universities. The Director of Meteorology continued to serve as a Professorial Fellow in the School of Earth Sciences of The University of Melbourne and chaired the University's Community and Industry Advisory Board

(CIAB) for Environmental Programs. The Bureau also provided partial funding for the Chair in Meteorology at Monash University.

The scientific development activities of the BMRC include pure research, strategic research and applied research. Together, they fulfill the Bureau's statutory responsibility for the advancement of meteorological science and the development of the useful application of meteorology to community needs. They also provide the foundation for the research and development that supports the Bureau's operations and services through the development of advanced systems and techniques.

Research in the BMRC is based around six thematic groups, as summarised in Table 6. The nature of research is such that each of the groups, and most of the projects undertaken within each, include a combination of strategic and applied research. A small component of the activity is aimed at pure research.

Highlights

Major achievements in 2002-03 included:

- commencement of a major collaboration with the Royal Australian Navy (RAN) and CSIRO for the development of a new ocean analysis, assimilation and prediction system;
- implementation of significant systems changes, which contributed to improvements in operational systems including the UV and ozone analysis and forecast system, the Environmental Emergency Response system and numerical models for weather and climate prediction;
- improvements in the assimilation of meteorological observations, particularly from satellites, into numerical weather prediction models; and
- participation in the development of a successful bid for a new CRC for Bushfire Research.

Table 6. The six BMRC research groups.

Research Group	Objective
Model Development	To conduct research on atmospheric modelling to support weather and climate research and operations
Data Assimilation	To conduct research on advanced data assimilation systems for use in numerical models
Climate Dynamics	To use climate models to improve understanding of climate predictability, variability and change, and to improve the performance of climate models through evaluation and diagnostic studies
Weather Forecasting	To improve understanding of mesoscale processes, and to develop systems to enhance weather forecasting services
Climate Forecasting	To improve understanding of Australian climate, including the effects of climate change, and to develop systems to predict climate on scales beyond the medium range
Ocean & Marine Forecasting	To improve understanding of the variability of the oceans and marine environment of the Australian region, and to develop systems for monitoring and predicting ocean variability

Resource Use

The resources committed to Meteorological and Related Research are summarized in Table 3 and shown in more detail in Table 7.

Performance

Performance during 2002-03 was assessed at two levels in terms of the:

- quality, quantity and price of the out-

puts directed to the achievement of the planned outcome relative to agreed target levels; and

- contribution of the outputs to the achievement of the planned outcome.

The measures used as a basis for performance assessment were as published in the Portfolio Budget Statements 2002-03 for the Environment and Heritage Portfolio (Budget Related Paper No. 1.7). The performance for 2002-03 against each of the performance measures and targets for quality, quantity and price of outputs is summarised in Appendix 12.

The contribution to achievement of the

Table 7. Meteorological and Related Research expenses and revenue (\$'000) and staff level for 2002-03 compared with the actuals for 2001-02 and with the 2002-03 Budget and Budget plus Additional Estimates appropriations.

	ACTUAL	BUDGET	BUDGET & ADD. EST.	ACTUAL
	2001-02	2002-03	2002-03	2002-03
	(\$'000)	(\$'000)	(\$'000)	(\$'000)
<i>FINANCIAL</i>				
EXPENSES				
Employee Expenses (Appropriation)	6,424	5957	5971	6,625
Employee Expenses (Section 31)	533	721	720	800
Supply of Goods and Services (Appropriation)	1,104	789	795	1,034
Supply of Goods and Services (Section 31)	485	1,938	1,897	528
Operating Lease Rentals	650	790	791	555
Depreciation	157	527	530	1787
Other Goods and Services Expenses (WMO Contribution)	0	0	0	0
TOTAL EXPENSE*	9,353	10,722	10,704	9,720
REVENUE				
Appropriations	7,626	7,858	7,900	7,558
Sale of Goods and Services	3,237	2,659	2,617	1,598
Miscellaneous - other	2	0	0	4
TOTAL REVENUE*	10,865	10,517	10,517	9,160
<i>STAFFING</i>				
Staff Years (actual)				
- Funded from Employee Expenses (Appropriation)	73.9	63.0	63.2	69.3
- Funded from Supplier Expenses (Appropriation)	2.4	2.0	2.0	0.6
- Funded from Section 31 Receipts	9.9	9.9	9.9	11.7
- Funded from Capitalised Salaries (Asset Replacement)	1.9	1.9	1.9	1.7
TOTAL STAFFING	88.1	76.8	77.0	83.3

*The operating result (Total Revenue less Total Expense) provides funds required to pay the Capital Use Charge as a dividend from Equity on the Balance Sheet. The Bureau's dividend is some \$20m per annum.

planned outcome during 2002-03, assessed in terms of the indicators listed in Appendix 13, is reviewed below for each of the individual outputs (Pure Research, Strategic Research and Applied Research), drawing on the performance information summarised in Appendix 12.

Pure Research

A small but essential component of BMRC activity is directed to pure research, which has intrinsic scientific value and is aimed at advancing the science of meteorology. This research lays the foundation for all other research in the BMRC by ensuring that the work is well connected with current international advances in the science. Examples of this research undertaken in 2002-03 include studies of the structure and behaviour of tropical cyclones and investigation of the potential predictability of climate.

Tropical cyclones are a major weather hazard for northern Australia and many other regions around the world. Research into the structure of tropical cyclones has continued through an extensive comparison of observations with predictions from analytical and numerical models. The results were in good agreement and have additionally demonstrated the possible role of asymmetric friction near landfall as a major modifier of the near-surface winds and convective structure in tropical cyclones. Modelling experiments have confirmed the importance of this process and observations of anomalous damage patterns also lend support to the model results.

Theoretical work on the predictability of climate at seasonal and longer time scales with scientists from New Zealand's National Institute of Water and Atmospheric Research (NIWA) has led to the development of a new method for studying variability at these scales. The method, which utilises monthly means of climate data to study climate variations resulting from intraseasonal variability, is

far more efficient than present methods which use daily means. Application of the method to a study of the Southern Hemisphere winter circulation showed that results using the two methods produced similar results.

Strategic Research

Much of the strategic research in the BMRC involves the development of the scientific infrastructure to manipulate and analyse meteorological and related data. Significant components of this infrastructure are the numerical models that use the joint Bureau-CSIRO supercomputer to simulate and predict the state of the atmosphere and ocean. Associated with these models are software systems used to assimilate atmospheric and oceanic observations into the numerical models, to ensure dynamically consistent analyses of the state of the atmosphere and ocean. These analyses in turn provide accurate and consistent estimates of the initial conditions needed by the models to predict the future state of the atmosphere and ocean. Numerical data and assimilation and prediction systems are fundamental elements of modern meteorology and oceanography.

The process of model development includes refining the numerical techniques and representations of the physical world in models in order to improve the accuracy of forecasts - an ongoing process which develops together with the increasing capabilities of modern supercomputers and observing systems. Recent model developments include improvements to the BMRC Atmospheric Model (BAM) which is designed to allow the Bureau's operational local area (LAPS) and global (GASP) systems to use the same underlying physical representations of the atmosphere for weather and climate applications. BAM is also now used as the atmospheric component of an operational coupled (atmosphere/ocean) model for seasonal forecasting.

The quest for improved accuracy in precipitation forecasting for the Australian region has led to the inclusion of a Bulk Explicit Microphysics (BEM) scheme in LAPS. The scheme includes representation of the actual microphysical processes involved in the generation of clouds, rain and electrical activity rather than using a single parameterisation which models the average behaviour of a series of processes. Test runs have demonstrated a positive impact of the system on precipitation forecasts. (Figure 25).

The forecasting of tropical cyclones remains a high priority for BMRC research and the tropical cyclone version of LAPS (TCLAPS) has been upgraded to include a significantly higher resolution in the vertical dimension and is under test prior to operational implementation.

Assessment of the effectiveness of models in simulating the real world has been improved with the development of various systems, such as the Model and Climatological data Comparison System (MACCS) and a system for producing synthetic satellite images from model output (Figure 26), which measure the performance of models.

Ensemble prediction systems (EPS) maximise the usefulness of numerical model output by producing forecasts based on a number (ensemble) of different model runs (of one model or different models) based on slightly different initial conditions. The resulting forecasts are particularly useful for forecasters because the spread of forecasts produced indicates the inherent reliability of the predictions. Ensemble prediction systems have been developed for both the GASP and LAPS models (Figure 27), with the LAPS version incorporating ensemble prediction of tropical cyclone tracks.

With the ever-increasing amount of data available, particularly from meteorological satellites and oceanographic platforms, it is important that the various models are able to handle large volumes of information in a

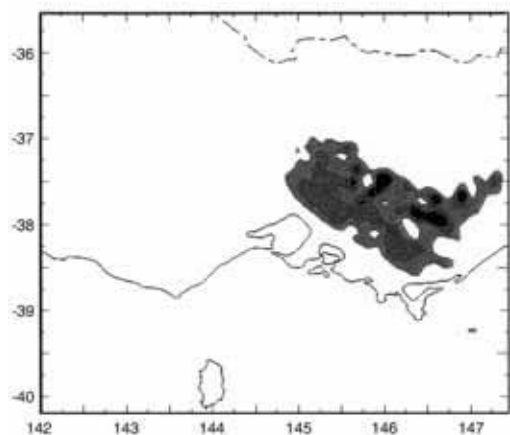


Figure 25. A microphysics scheme such as BEM (Bulk Explicit Microphysics) improves the realism of the representation of moisture in atmospheric models by modelling details of the distribution of cloud, rain water, ice crystals, snow and graupel. In this example, an area of lightning activity forecast by the LAPS model incorporating the BEM scheme (upper panel) corresponds well with radar observations of the position of an area of convective rainfall (lower panel).

timely and accurate manner. To this end, the BMRC has made a significant effort to