The national requirement for high quality and timely climate data, information, analyses and prediction, has increased substantially over recent years as users have become more aware of the benefit that such information can bring to both public and private sector decision making. Wide interest in the climate change issue has focussed particular attention on the need for long term, high quality, systematic climate monitoring systems, that will contribute both to an improved understanding of the complexities of the naturally varying climate system and the detection of trends over time due to either natural influences or human activities.

Climate Services encompass the provision of climatic data, information and advice to the general public and a wide range of specialist users. Long-term climatic data, obtained from both basic and special observation networks and stored in the National Climatological Data Bank, are published in the form of climate summaries and atlases, and made available in both hard copy and computer-compatible form for use in research, design and other applications. Climate Services also include the month-to-month and year-to-year monitoring of major climatic fluctuations such as drought and flood rains and, to the extent possible, the prediction of climatic anomalies and trends likely to affect agriculture and other weather and climate sensitive sectors of the economy.

The Bureau of Meteorology’s Climate Services are coordinated by the National Climate Centre (NCC), located in the Bureau’s Head Office, and are provided through the NCC, Regional Offices and Field Meteorological Offices around Australia.

The past year saw increased benefits to the community through a range of enhanced climate services, from the National Climate Centre and the Climate and Consultative Services Sections of the Bureau’s seven Regional Offices.
Highlights

Major achievements in 2001-02 included:
- completion of the Climate Archives (CLIMARC) project, which resulted in the conversion and electronic storage of pre-1957 daily and hourly records from 51 locations around Australia;
- online availability of nearly 300,000 climate related monitoring products;
- launch of the El Niño Wrap-up service, which includes the provision of climate prediction information in support of agricultural related organisations and rural and regional Australia.

Resource Use

The resources committed to Climate Services during 2001-02 are summarised in Table 3 and given in more detail in Table 10.

Performance

Performance during 2001-02 was assessed at two levels in terms of the:
- quality, quantity and price of the outputs directed to the achievement of the planned outcome relative to the agreed target levels; and the
- 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 2001-02 for the Environment and Heritage Portfolio (Budget Related Paper No. 1.7). The performance for 2001-02 against each of the performance measures and targets for quality, quantity and price of outputs is summarised in Appendix 11.

The contribution to achievement of the planned outcome during 2001-02, assessed in terms of the indicators listed in Appendix 12, is reviewed below for each of the individual outputs (Archived Data, Climate Data Service and Climate Monitoring Service), drawing on the performance information summarised in Appendix 11.

Archived Data

Australian meteorological and related data are collected, monitored, quality controlled and stored in an appropriate and secure form, to meet the essential present and future national and international needs for climate data. The national climate archive is of central importance to the operations of the Bureau and provides the foundation for many of its research and service functions. Responsibility for the management of the national climate archive lies with the NCC, which provides the essential meteorological and technical expertise. Data management strategies were more closely integrated within the Bureau in 2001-02 through the establishment of an Ad Hoc Data Management Committee, which brought together data experts from the Bureau’s Observations and Engineering Branch and its regional Climate and Consultative Services Sections.

National and international obligations for systematic observations under the UN Framework Convention on Climate Change served as a key driver in maintaining up-to-date and effective climate data management practices.

Continued service improvement is underpinned by a sound mix of meteorological and IT expertise. To this end, staff training in 2001-02, focused on databases, records management and desk-based ergonomics. The use of external contract staff in areas such as records management, database management, systems development and data entry, continued during the year.
Table 10. Climate Services expenses and revenue (’000) and staff level for 2001-02 compared with the actuals for 2000-01 and with the 2001-02 Budget and Budget plus Additional Estimates appropriations.

<table>
<thead>
<tr>
<th></th>
<th>ACTUAL 2000-01 ($’000)</th>
<th>BUDGET 2001-02 ($’000)</th>
<th>BUDGET &amp; ADD. EST. 2001-02 ($’000)</th>
<th>ACTUAL 2001-02 ($’000)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FINANCIAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EXPENSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee Expenses (Appropriation)</td>
<td>7,493</td>
<td>7,350</td>
<td>7,350</td>
<td>8,186</td>
</tr>
<tr>
<td>Employee Expenses (Section 31)</td>
<td>128</td>
<td>156</td>
<td>156</td>
<td>112</td>
</tr>
<tr>
<td>Supply of Goods and Services (Appropriation)</td>
<td>1,435</td>
<td>678</td>
<td>678</td>
<td>1,318</td>
</tr>
<tr>
<td>Supply of Goods and Services (Section 31)</td>
<td>445</td>
<td>505</td>
<td>505</td>
<td>338</td>
</tr>
<tr>
<td>Operating Lease Rentals</td>
<td>1,202</td>
<td>1,317</td>
<td>1,317</td>
<td>1,152</td>
</tr>
<tr>
<td>Depreciation</td>
<td>543</td>
<td>519</td>
<td>519</td>
<td>222</td>
</tr>
<tr>
<td>Other Goods and Services Expenses (WMO Contribution)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL EXPENSE</strong></td>
<td>11,246</td>
<td>10,525</td>
<td>10,525</td>
<td>11,328</td>
</tr>
<tr>
<td><strong>REVENUE</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Appropriations</td>
<td>9,875</td>
<td>9,667</td>
<td>9,659</td>
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<tr>
<td>Sale of Goods and Services</td>
<td>869</td>
<td>657</td>
<td>981</td>
<td>981</td>
</tr>
<tr>
<td>Miscellaneous - other</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
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<tr>
<td><strong>TOTAL REVENUE</strong></td>
<td>10,747</td>
<td>10,324</td>
<td>10,640</td>
<td>10,943</td>
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<tr>
<td><strong>STAFFING</strong></td>
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<td></td>
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<tr>
<td>Staff Years (actual)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Funded from Employee Expenses (Appropriation)</td>
<td>117.4</td>
<td>118.5</td>
<td>118.5</td>
<td>105.7</td>
</tr>
<tr>
<td>- Funded from Supplier Expenses (Appropriation)</td>
<td>4.7</td>
<td>5.1</td>
<td>5.1</td>
<td>8.9</td>
</tr>
<tr>
<td>- Funded from Section 31 Receipts</td>
<td>1.8</td>
<td>4.6</td>
<td>4.6</td>
<td>2.1</td>
</tr>
<tr>
<td>- Funded from Capitalised Salaries (Asset Replacement)</td>
<td>0.9</td>
<td>0.7</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>124.8</td>
<td>128.9</td>
<td>128.9</td>
<td>117.2</td>
</tr>
</tbody>
</table>

*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.
Data collection and archival efficiency were improved through the increased use of automated observing and reporting systems. Improvements were also made to the data archive infrastructure. Commissioning of a new database computer significantly enhanced access to the climate database. Database backup processes were reduced by more than half and the time for which the database was offline was significantly reduced.

Efficiencies with respect to both archival and subsequent access were also gained through the electronic storage of manuscript data. Systems were developed to enable digitisation of pluviograph (rainfall intensity) and monthly rainfall return charts from scanned images.

All targets were met for the archival of quality controlled data to the national climate database, both in terms of the percentage of the data that was subject to full quality control procedures (Figure 39) and in terms of the overall volume of data archived (Figure 40).

**Enhancing the climate record**

The climate database was enhanced to better meet community needs through the continued development of systems to manage a greater range of data types. During 2001-02, half-hourly aviation reports, one and ten minute data from automatic weather stations and solar radiation data from in-situ and satellite sources were added to the database.

A significant achievement in 2001-02 was the completion of the CLIMARC project. The project involved the data entry and quality control of more than 40,000 monthly climate records going back to 1858. Strict quality control procedures were maintained throughout the project, and investigations have already shown that CLIMARC data significantly reduce analysis errors associated with pre-1957 temperatures. CLIMARC was jointly funded by the Bureau, various state government agencies, Agriculture, Fisheries and Forestry – Australia and Australia’s rural R&D (Research and Development) Corporations under the Climate Variability in Agriculture R&D Program (CVAP).

**Improving data quality**

With increased and more diversified usage of climate data, demands for improved quality management continued to grow. These demands were addressed through
quality monitoring activities in several areas of the Bureau. Most operational data quality control was performed within the NCC, but related activities were undertaken within the Observations and Engineering Branch and the National Meteorological and Oceanographic Operations Centre (NMOC). Liaison between the relevant areas, and also with the Regional Offices, continued to be a high priority.

During 2001-02, the Bureau improved data quality through:

• continued development of a Quality Monitoring System with a focus on real-time quality monitoring;
• implementation of new quality control systems for data from automatic weather stations and electronic field books, in line with the systems developed for the CLIMARC project;
• improved quality control systems for daily rainfall data; and
• progressive implementation of specific data quality strategies recommended through the first Data Quality Workshop that was held in March 2001.

Improving metadata

Metadata (information about data and how they are collected) are very important in the study of long-term climate, as they enable users to determine the extent to which the observations have been made on a consistent basis through the period of record. The demand for metadata from the national and international scientific community, and from the Bureau’s broader user community, continued to increase.

Improvements were made to the organisation and accessibility of the Bureau’s metadata, many of which exist only in manuscript form, through:

• implementation of a technologically robust structure for the collection and electronic storage of historical station-related metadata;
• progressive electronic imaging of historical observer instruction manuals; and
• completion of a pilot project to image documents in station history files, subsequently extended to cover all similar files.

Preserving original records

The review and consolidation of Bureau scientific and other records held at National Archives Australia (NAA) continued in response to NAA pressures for a reduction in the Bureau’s holdings, with the overall Bureau objective being to ensure that Australia’s climate record is made permanently more secure and accessible. The material deposited by the Bureau includes original observation records, station history files, synoptic analyses and administrative files, much of which it is essential to retain.

Bureau holdings in all NAA facilities were reduced by about 30 per cent in 2001-02. The process of ensuring that only duplicate or non-essential records are disposed of is highly resource intensive and the NAA’s progressive withdrawal from its historical responsibility for providing permanent archival of all the Bureau’s climatic records has placed heavy demands on the Bureau. Preparation of paper-based records was completed in the Queensland Regional Office, which holds the largest volume (some 1.5 km of material) of all the Bureau’s Regional Offices, and scanning of the documents commenced. The examination and preparation of records commenced in the Western Australian Regional Office, while the records in Sydney were reviewed.

The review of records held by the NAA revealed some valuable historical documents. The original Swan River records (Western Australia) from 1830 were inspected, as were the first weather maps from the 1880s drawn under Clement Wragge in Brisbane. In Sydney, meteorological folios from the exploration expedition by Major Mitchell were inspected, as
were notes on the 1830s Australian sighting of Halley’s Comet. Also held in Sydney were old photographs and glass slides, some of which could be valuable for improving our knowledge of the early observation network, including identification of old instruments.

The final outcome of this work will be the preservation of vital scientific records held on documents, charts and other material currently held by the NAA. The records have only been available in manuscript form, and conversion to electronic format will allow the information to be more readily available to the community.

**International activities**

During 2001-02, the Bureau continued to contribute to efforts to improve the management of global climate data, both in fulfilment of its responsibilities to the WMO and in recognition of the importance of good quality global data to the effective monitoring and prediction of Australian climate. Achievements included:

- participation in the WMO Climate Database Management System (CDMS) project, which was aimed at the identification of candidate database systems to meet the broad needs of WMO Members;
- the completion of a four-week consultancy with Technology Park Malaysia, resulting in the development of the Malaysian climate database;
- presentation of a paper on ‘Changing Technologies for Data Management’ at the WMO Technical Conference on Climate Services for the Twenty-first Century; and
- participation in a WMO sponsored climate database evaluation exercise for the identification of the next generation CDMS.

Photograph recovered through the Bureau’s review of material held by the National Archives Australia showing a flood at Maitland, May 1889.

Photograph of an old Dines anemograph - recovered from archived Bureau records.
Climate Data Service

The Climate Data Service involves the supply of climate data and information to meet a wide range of individual and community needs. In addition to preparation of standard summaries and analyses of climate data and extracts from the computer archive, advice is provided to assist users in their data selection, inter alia, on observing standards, the instrumentation used and the completeness of the data record.

Operational services and products

As confirmed by user feedback, Regional Offices in each State and some Field Meteorological Offices continued to meet most of the routine or locally focussed requests for climate data, their task made more efficient through direct access to the national climate archive (ADAM). This arrangement delivered a national approach to serving climate data requirements and, together with access to a Regional Library in each Regional Office, ensured that comprehensive local expertise was available to the data users. Within the NCC in Melbourne, national standard products were developed using CD-ROM technology, expertise was supplied for large and complex data requests and for technical matters relating to the extraction of data from the archive. Load-sharing and backup arrangements between the NCC and the Climate and Consultative Services (CCS) Sections in the Regional Offices were implemented as needed, helping to ensure more efficient service delivery and fewer delays in busy periods.

During 2001-02, there was a strong emphasis on improving user access to climate data which resulted in an increase in the number and range of ‘packaged products’. Consolidation of standard climate data sets on CD-ROM, standard map analyses, the automation of routine data extractions and the continued development of software tools have made climate data more readily accessible and their delivery more efficient.

The use and utility of email, for requests and subsequent supply of data, continued to grow and resulted in the more timely provision of data and information to clients. Figure 41 shows the email requests received through the web feedback pages (which does not include requests sent directly to staff). About 5000 requests were handled effectively in 2001-02.

The Bureau’s website continued to be a vital avenue for access to climate information for the Australian community. Figure 42 shows that there were about 1.5 million visits per month to the climate web pages, about a quarter of these from outside Australia (Figure 43).

![Figure 41. The monthly numbers of request emails from the climate website feedback facility.](image-url)
Improvements to the accessibility and timely provision of climate data were made through the ongoing development of software tools. The development of a new version of ‘EVE’, a menu-driven software application for data retrieval, provided fast and ready access to the Bureau’s climate database.

New products were made available through the development of The Climate Zone application on the Bureau’s internal website. A variety of monthly and seasonal statistics were integrated into The Climate Zone, and a new multi-day product enabled the extraction of climate data for a range of elements on a weekly or multi-day basis.

Basic climate data were supplied for about 170 sites around Australia in support of a pilot project aimed at improving international access to meteorological information through the WMO website for climate and forecast information.

The NCC continued to collaborate with other areas of the Bureau on the development of a new Services Information Management System (SIMS), which will become a focus for client management information. When completed, SIMS will serve the needs of all services managers across the Bureau and will support provision of improved performance information on all aspects of Bureau services. This will ensure better reporting and increased ability to plan for future service developments to meet emerging client requirements.

The Climate Monitoring Service provides a range of timely climate monitoring and prediction information and products in a variety of formats. Routine publications include the Monthly Rainfall Review, Monthly Drought Review, the Seasonal Climate Outlook, Annual Climate Summary and the Climate Monitoring Bulletin (CMB).
All production deadlines were met during the year. In accordance with an agreement with the National Climatic Data Center (NCDC) in North Carolina USA, those sections of the CMB relating to Australian conditions (summary, rainfall and rainfall deficiency) were routinely sent to NCDC for inclusion in its monthly global climate summaries.

Other routine monitoring products included seasonal summaries (summer, autumn, winter, spring), focusing on the Australasian region, for publication in the Australian Meteorological Magazine. Climate and Consultative Services Sections in each State capital city and Darwin continued the regular production of their Monthly Weather Reviews and the Darwin office maintained the production of the Tropical Diagnostic Statement and Weekly Tropical Climate Note. The Darwin office also supplied biannual Tropical Circulation Summaries to the Australian Meteorological Magazine. To ensure timely and efficient service delivery, most products were made available immediately on the Bureau’s website.

A new milestone was set in 2001-02, with almost 300,000 distinct climate related monitoring products available to the community through the Bureau’s website. This enormous growth in the accuracy, sophistication, and diversity of the climate monitor-
ing undertaken by the Bureau, was achieved through the adoption of new science and technology.

A significant addition to the monitoring service was the weekly El Niño summary page, called the ‘El Niño Wrap-up’. This product, which generated considerable media and user interest, provided a valuable medium for the timely relay of information on the state of the El Niño and Southern Oscillation phenomena. The value of this new service was particularly apparent during autumn 2002, when the Pacific basin experienced rapid changes on sub-monthly time scales, forewarning of the possible development of El Niño conditions later in the year (Figure 44). The use of this service and its information content was widespread, and agencies such as the Bureau of Rural Sciences, the Australian Bureau of Agricultural and Resource Economics, and state based agricultural agencies benefited from the information.

In fulfilment of government environmental reporting requirements, the NCC also provided significant information for the Atmosphere chapter of the National State of the Environment Report, which was launched by the Minister for the Environment and Heritage, the Hon Dr David Kemp, in March. The streamlined systems for the production of atmospheric indicators as developed for the report, will also support the ongoing real-time monitoring of related environmental, social and economic influences in the future.

Climate prediction

The climate prediction service, especially the rainfall outlook component, continued to be widely used by both the public and business sectors, especially primary industry users, for planning and risk manage-

Figure 44. The Southern Oscillation Index (SOI), 1996-2002, indicating the negative SOI values associated with the 1997-98 El Niño and the positive values associated with the extended La Niña which ended in early 2001.
ment. In late summer 2002, the Bureau warned of an approximate doubling in the risk of the development of an El Niño. The need for users to plan for the development of possible El Niño conditions was reinforced by the serious long-term rainfall deficiencies that existed in many parts of Australia. Media interest was at a high level, and regular interviews were conducted with radio, newspapers (particularly rural and regional) and television stations. General enquiries significantly increased, and were well serviced, in autumn and early winter (2002) in response to the development of drought conditions over large parts of eastern Australia (Figure 45) and indications of a developing El Niño.

A major initiative by the Bureau in 2001-02 resulted in the extension of climate outlook services for more effective resource management. The development of a number of experimental outlooks for water resource managers in Victoria was broadened later in 2001-02, with the preparation of project outlines for incorporating climate prediction activities into the proposed Cooperative Research Centre for Bushfire Research.

A new web-based application designed to add value to the Bureau's climate prediction services was launched in 2001-02. The system allows users to investigate the accuracy of rainfall and temperature climate outlooks from the Bureau's climate outlook model, together with outlooks from a number of research systems (Figure 46). This system represents the culmination of a joint two-year project by the Bureau, Agriculture, Fisheries and Forestry – Australia and Australia's rural R&D Corporations under the CVAP.

Figure 45. Australian rainfall, Autumn 2002. A dry period over much of Australia as the signs of a developing El Niño increased.
Climate variability

The Reference Climate Station (RCS) network is Australia’s premier observation network and provides high quality data for monitoring climate variability and detecting long-term climate trends. Resources were directed during 2001-02 to help maintain these stations to the high standards required. The continued installation of automatic weather stations and electronic field books throughout the network helped secure the future of these valuable climate records and provided access to more timely and frequent data.

The RCS network continued to play a key role in meeting Australia’s commitments to international global climate monitoring. Many RCS sites have been included in the Global Climate Observing System (GCOS) Surface Network (GSN) (Figure 47), which was designed to identify the global patterns of climate change.

Data monitoring tools, which provide for more effective management of the RCS network, were developed as part of the
ongoing effort to improve data quality. These tools enable the assessment of impacts of network-wide changes, such as the introduction of an automated retrieval system for missing observations.

A project aimed at improving Australia’s high-quality temperature and rainfall datasets commenced in 2001-02. These homogeneous datasets provided the basis for calculation of several of the indicators used in the 2001 National State of the Environment Report. The project will also include an assessment of the homogeneity of the data prior to the application of site matching and data correction techniques.

**Mapping and surveys**

The NCC continued to address community demand for the generation of new reference climate maps and other climate-related maps, and for improved access to climatological information, through:

- provision of climatological maps of evapotranspiration and monthly and annual maps of relative humidity and sunshine hours (Figure 48) through the Bureau’s website;
- development of an interactive CD-ROM-based application for the interrogation and retrieval of annual and monthly values of the various evapotranspiration variables and gridded evapotranspiration data for modeling and research purposes. The data delivery system underlying this interactive CD-ROM will be a model for future climate map delivery in the NCC; and
- continued development of new maps, including average monthly and annual

![Number of Reports from GSN Stations During Aug 2001-Jan 2002](image)

**Figure 47.** Reporting statistics from the Global Climate Observing System (GCOS) Surface Network (GSN). This is one of several tools developed to monitor the performance of GCOS networks.
rainday frequency and annual average number of days over 40°C.

As follow up to the publication of the *Rainfall Atlas of Australia* in 2000-01, a poster of Australian rainfall over the 20th Century was published and a version included in the *Year Book 2001 Australia* (Centenary of Federation edition).

The demand for specialised climate mapping products, on a user-pays basis, continued throughout the year. Basic and quality-enhanced maps and gridded data were provided, in both electronic and printed formats, to a wide range of users, including students, researchers, agribusiness and consultant companies and all levels of government.

## Communicating climate information

Enhancement of climate service delivery to the agricultural sector, through the Bureau’s SILO website, continued in 2001-02 and benefited from further funding by the Climate Variability in Agriculture Research and Development Program (CVAP). The success of the service was reflected by a fifty per cent increase in the number of subscribers to the website. Development of the new version of SILO focussed on better integrating weather and climate information.

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**Figure 48.** Sample sunshine hour map - these maps are freely available to the community through the Bureau’s website.
Bureau attendance and displays at major agricultural shows in all States and Territories, and at National Science Week was useful in promoting climate services and strengthening user liaison. Queensland Regional Office staff, in conjunction with the Queensland Centre for Climate Applications (QCCA), presented information sessions at provincial centres across Queensland aimed at helping farmers and graziers cope effectively with, and manage for, climate variability.

Public education and liaison objectives were met through presentations to conferences, schools and target user groups, contributions to specialist (e.g. Beef Improvement News) and scientific publications and follow up to web site feedback and interaction through the media. Visits to the NCC and Regional Offices, particularly by intensive users of climate data, such as state agriculture departments, provided useful opportunities to share expertise and experiences.

Work continued on two publications aimed at enhancing the community’s understanding of weather and climate in Australia. The first is a summary of 50 major climate and weather events during the 20th Century, while the second describes Australia’s basic climate, its variability, the development of knowledge about climate science and the applications of climate information. Both are scheduled for publication in 2002-03.

International climate information exchange

The Bureau continued to support National Meteorological and Hydrological Services (NMHS)s in the South Pacific through the continued production of the South Pacific Seasonal Outlook Reference Material. This monthly bulletin provides detailed information on the current state of the climate system, as well as longer-range forecasts of El Niño and Southern Oscillation conditions, with an emphasis on possible impacts upon the South Pacific region. This work was complemented by the participation of NCC staff in a monthly teleconference of South Pacific nations, organised by the New Zealand National Institute of Water and Atmospheric Research. The forum produces the Island Climate Update - a publicly available summary of the current climate and longer range outlooks - for the South Pacific.

During 2001-02, the NCC was involved in a range of capacity building activities, which included:

- participation in a workshop, hosted by the Asia-Pacific Network in Auckland, aimed at improving the effectiveness of climate analysis by South Pacific nations;
- involvement in the WMO-sponsored Regional Association V (RA V) Working Group on Climate Matters, which focused on improving the capabilities of NMHSs to deliver climate services in their countries;
- participation in international activities aimed at developing a Pacific Island GCOS action plan to address priority climate observing system needs in the region; and
- collaboration with AusAID (Australian Agency for International Development), and as part of the United States - Australia Climate Action Partnership, in the development of a project action plan for the capacity building of South Pacific NMHSs in the area of climate prediction and observations.