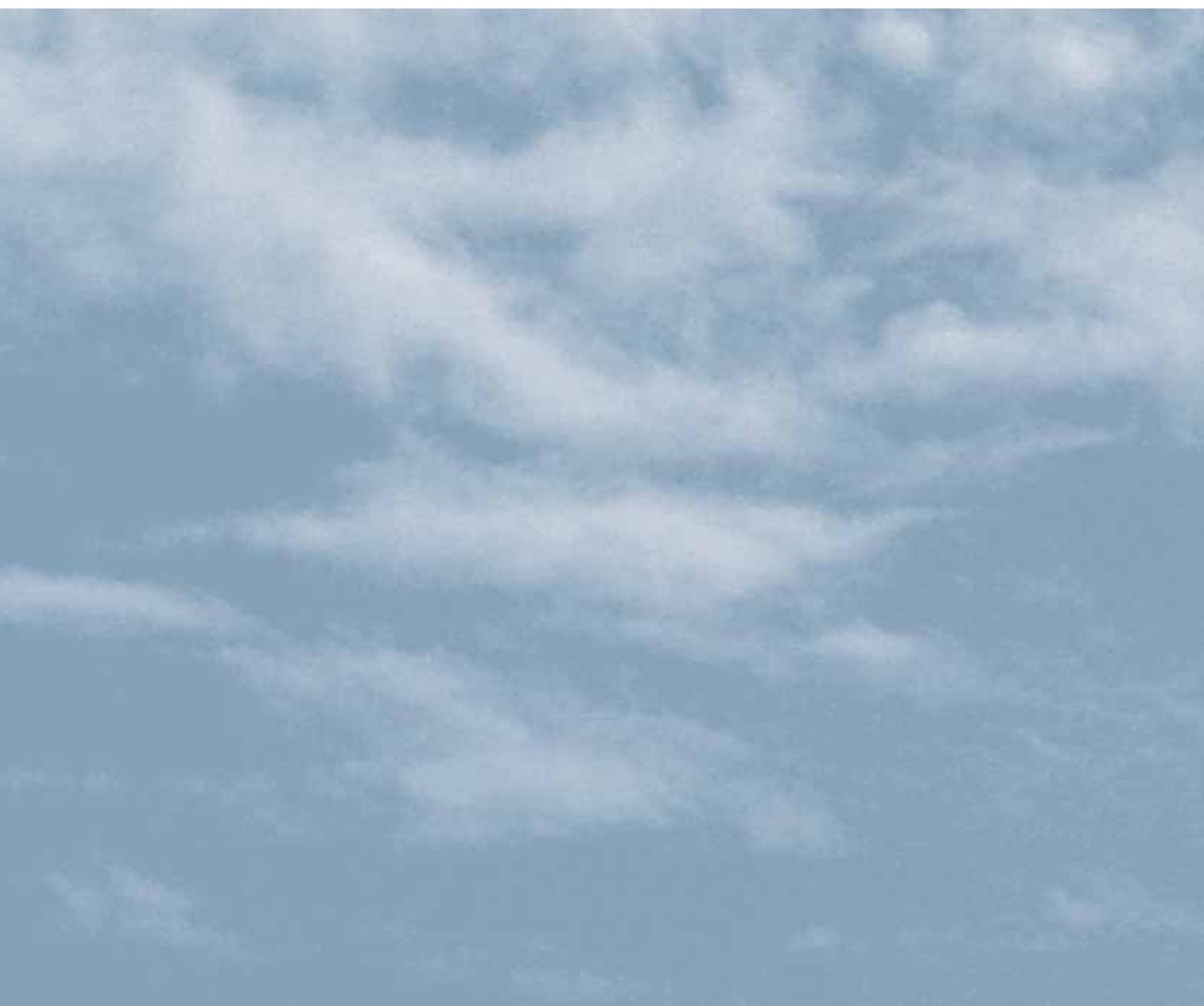




Australian Government
Bureau of Meteorology

ACORN-SAT in an organisational, data and network context

Report 2 for the Independent Peer Review of the ACORN-SAT data-set



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1. Purpose

This report will provide context for the Australian Climate Observations Reference Network Surface Air Temperature (ACORN-SAT) for the Independent Peer Review (IPR) and specifically on how ACORN-SAT sits within the context of:

- the operations of the Australian Bureau of Meteorology (Bureau); and
- other data-sets and climate observation networks within Australia and internationally.

2. ACORN-SAT: an organisational context

2.1 Mission of the Bureau of Meteorology

The Bureau's official climate record extends back into the mid-nineteenth century and the observation recording, collection, management and provision are fundamental and critical functions of a national meteorological service - the 'lifeblood' of the organisation.

The Bureau's Strategic plan (Bureau of Meteorology 2010) gives emphasis to these functions at several places. Within this plan, the Bureau's mission is to:

"Provide Australians with the information they need to manage and live within their natural environment, encompassing the atmosphere, oceans, water and land. To achieve this, the Bureau of Meteorology:

- monitors and reports on current environmental conditions
- analyses and explains trends in environmental data
- provides forecasts, warnings and long-term outlooks on environmental phenomena that affect the safety, prosperity and resilience of Australians, and
- fosters greater public understanding and use of environmental intelligence."

The Strategic plan also emphasises the Bureau's commitment to reducing the uncertainty in long-range climate change monitoring and projections. With regard to our international responsibilities the plan states:

"Australia's weather and climate are part of a global system. Our geographic position provides us with an important role in monitoring and researching the atmosphere and oceans for our own needs as much as the world's. International cooperation plays a vital part in the Bureau's operation, enabling it to draw on, and benefit from, scientific, technological and operational developments and expertise in other countries. In return, we make a major contribution to the effectiveness of the total international effort from which all countries benefit."

International data exchange is essential for the compilation and analysis of global climate data-sets for climate variability and climate change monitoring and research. Consequently, the Bureau's involvement in international climate observation, services and research programs is an important part of its business. With regard to ACORN-SAT, the policy and plans of both the Global Climate Observing System (e.g. GCOS 2010) and the World Meteorological Organization's (WMO) Commission for Climatology (see http://www.wmo.int/pages/prog/wcp/ccl/index_en.html) are particularly relevant.

2.2 Organisational design

The Bureau's Program and Functional Structure for 2010-11 is provided in the Appendices. With regard to the maintenance of the ACORN-SAT network and the development and analysis of its data-set, the following areas of the Bureau are of particular importance:

- The Observations and Engineering Support Program: this Program, including its supporting regional observations sections, have responsibilities for the recording and collection of observations, including surface air temperature. The ACORN-SAT is considered a priority observation network within this program.
- The Information Communications and Technologies Support Program: this program has responsibility for data communications and server infrastructure for the collection of observations and hosting of the Bureau's many databases, including the Bureau's ADAM (Australian Data Archive for Meteorology) climate database.
- The National Meteorological and Oceanographic Centre: this centre is aligned with the Warnings and Weather Forecasts Program. Its responsibilities include the management of the Bureau's 'real-time' database where the vast majority of surface observations are ingested and temporarily reside, including the observations that are ingested into the ADAM climate database.

- The Climate Information Program: manages the ADAM climate database and provides a range of climate products and services, including through its Regional Climate Services Centres, from this national asset.

The Climate Information Program focuses on the management of the nation's climate and related data and provides a range of value-added climate products and services for Australia. More specifically, the Program provides high quality climate and related data and information, monitors climate variability and change, and provides climate prediction services and climate advisory services for Governments and other key stakeholders. The Climate Information Program also participates in collaborative projects that support the delivery of climatological services internationally, especially for national meteorological and hydrological services in the south-west Pacific. The primary benefits of the Program's information, products and services are risk reduction and better decision making in relation to recent and future climate conditions.



Figure 1. The Bureau of Meteorology's Quality Monitoring System.

To expand on the role of the Climate Information Program within the context of ACORN-SAT, the Bureau has:

- A climate data management section that manages the ADAM climate database, including performing quality assurance and control, station monitoring and records management. A sophisticated Quality Monitoring System (see Figure 1) has been developed to improve both data quality and operational efficiencies within the Program.
- A climate data services section that ensures that stakeholders, including in government agencies, industry, research institutions and the wider community, have ready access to climate data. This section has recently developed a Climate Data Online tool to improve data access and enhance operational efficiencies.
- A climate monitoring unit that is responsible for the development of reference data-sets, i.e. where sophisticated data analysis techniques have been developed and implemented to provide data-sets such as that for ACORN-SAT to be used for climate change monitoring. Key products developed by this unit are the Australian and regional Annual Climate Statements (e.g. http://www.bom.gov.au/announcements/media_releases/climate/data/) and the 'Climate Change Tracker' online system (Figure 2). The former are end of the year releases and generate much public and media interest as summaries on the Australian climate. The latter make a range of spatial and time series related data and products accessible online and have a high interest and uptake amongst Bureau stakeholders.

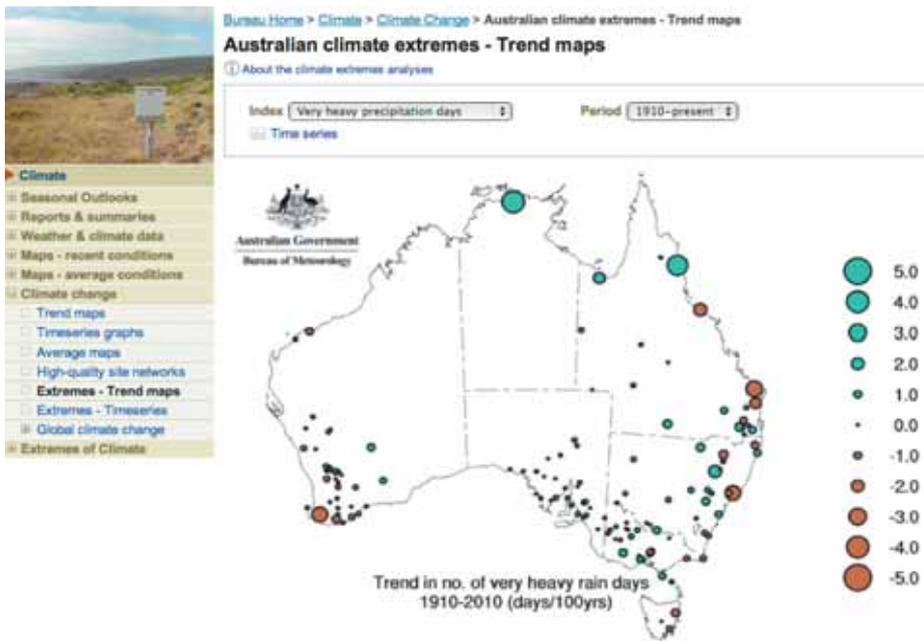


Figure 2. The Bureau of Meteorology's Climate Change Tracker.

2.3 A short history of reference climate data-set development

Increasing interest in climate change from the late-1980s generated a demand for national and global climate data-sets with surface air temperature leading the way due to its direct relevance to the global warming signal. In terms of the recent history behind the ACORN-SAT data-set, the following points are of note:

- Early-to-mid 1990s: Reference data-set (or 'high quality' data-set as this was termed at the time) development progressed within the Bureau and through research in collaboration between the Bureau of Meteorology Research Centre and the University of Melbourne (e.g. Torok & Nicholls 1996). Surface air temperature and rainfall were the priorities and a Reference Climate Station (RCS) network and 'high quality' rainfall network were defined by the Bureau.
- Mid-1990s: A review of the operation of the Bureau documented concerns over the quality and reliability of core Bureau functions, including observations (Slatyer 1996).
- Mid-to-late 1990s: enhancement of climate monitoring capabilities through:
 - establishing automatic weather stations (AWSs) at several RCS locations where continuing manual observations were proving difficult
 - improving inspections and maintenance at RCS locations
 - converting old technology AWSs to more modern technologies
 - ensuring parallel observation programs at many locations subject to site change, e.g. manual observations switching to AWS
 - prioritising inspection and maintenance at RCS sites
 - developing and building an improved location metadata database (SitesDb).
- Late 1990s to early 2000s: development of a daily temperature reference data-set (Trewin 2001) and increasing the volume of historical computerised climate records through the CLIMARC project.
- Mid-to-late 2000s: implementation of the Bureau's Quality Monitoring System (QMS) and 'Climate Change Tracker' for monitoring long-term climate variability and change.
- Late 2000s: assisting Pacific Island National Meteorological Services develop improved reference data-sets through the Pacific Climate Change Science Program (funded by AusAID and the Department of Climate Change and Energy Efficiency).

3. ACORN-SAT: an Australian and international context

ACORN-SAT is a priority climate network for the Bureau and Australia and also contributes to international networks. This section will describe these linkages and will also describe the ACORN-SAT in the context of national and international networks and data-sets.

3.1 ACORN-SAT in the context of other climate networks

It has become common practice over the last 25 years for a subset of meteorological observing networks to be designated as being especially suitable for climate trend analyses. These special networks are based on criteria which vary depending on the context but are normally related to the length and completeness of available data, the standard of observations, and the quality and long-term consistency of the observation site.

Such networks have been defined both on an 'official' basis under the auspices of the WMO or the Global Climate Observing System (GCOS), and on a less formal basis by agencies or researchers defining data-sets for analysis.

3.2 'Official' climate networks

WMO identifies three levels of surface network for climatological purposes, each of which is also recognised by the Bureau of Meteorology:

- RCS
- Regional Basic Climatological Network (RBCN)
- GCOS Surface Network (GSN).

The standards expected of a station are comparable across these three networks. Conceptually, the RCS network is defined nationally, the RBCN is defined by WMO's Regional Associations¹ and the GSN is defined globally, with RCS networks having the highest station density and GSN the lowest. This distinction is less important in Australia, with its large land area and relatively sparse station network, than in many other countries; indeed the Australian component of the RBCN is slightly larger than the Australian RCS network. There are currently 94 Australian² RCS stations, 103 RBCN stations and 59 GSN stations, out of a total of 774 currently operating Australian stations.

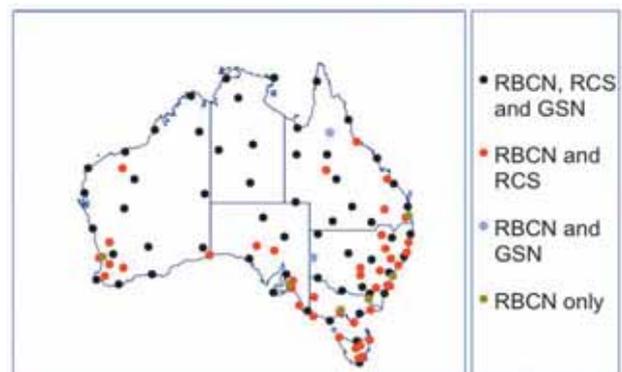


Figure 3. The GCOS Surface Network (GSN), Regional Basic Climatological Network (RBCN) and Reference Climate Station (RCS) networks within Australia.

¹ There are six Regional Associations, corresponding broadly with the non-Antarctic continents. Regional Association V, of which Australia is a member, covers the south-west Pacific, north and west as far as Indonesia, Malaysia and the Philippines.

² Not including stations in Antarctica or on remote offshore islands.

3.3 Networks defined for the purpose of data-sets

A number of networks have been defined, both nationally and internationally, for the purpose of developing climate change data-sets. The best-known such network internationally is the Global Historical Climatology Network (GHCN; Peterson & Vose 1997), defined by the U.S. National Climatic Data Center (NCDC). This network, which supports the global surface temperature analyses of both NCDC and NASA-GIS, is defined on the basis of data availability, without significant consideration of data homogeneity or quality in initial station selection (although these factors become relevant in downstream analyses). Another significant international network is that underlying the European Climate Assessment and Dataset (ECA&D; Klok & Klein Tank 2009).

In Australia, the two reference surface air temperature data-sets, which were in existence prior to the development of ACORN-SAT, have been the high-quality annual (Torok & Nicholls 1996; Della-Marta et al. 2004) and high-quality daily (Trewin 2001) temperature data-sets. These data-sets, which are described in more detail in another report in this series, are both subsets of the full Australian observation network. They were selected on the basis of data availability³ and station homogeneity and quality. The networks supporting these data-sets currently contain 134 (annual) and 103 (daily) stations respectively.

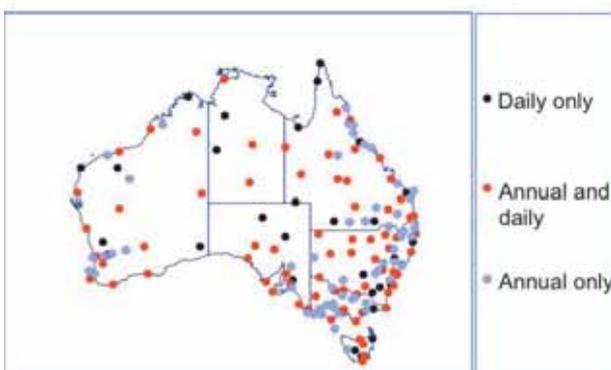


Figure 4. Existing Australian high-quality data-set station networks showing those which have had adjustments applied at the daily and/or annual level.

³ Data availability is greater at annual resolution than at daily resolution due to limited digitisation of daily data as discussed in another report in this series.

3.4 ACORN-SAT in the context of national and international data-sets

The network underlying the ACORN-SAT data-set contains 112 stations. It is based on the existing high-quality daily network of 103 stations. A further ten stations have been added, and one deleted.

There is a strong representation of ACORN-SAT stations in the various major national and international networks of which Australia is a part. Of the 59 Australian GSN stations, 51 are also ACORN-SAT stations. Of the 94 Australian RCS stations, 78 are also ACORN-SAT stations. Of the 103 Australian RBCN stations, 82 are also ACORN-SAT stations. As it contains the stations which report internationally on a monthly basis, the RBCN also forms the major underlying set for ongoing updates of the GHCN.

Of those GSN/RCS/RBCN stations that are not included in the ACORN-SAT network, most have been excluded because of a limited period of record or a limited amount of digitised data at the daily timescale. Some sites in the former category will become valuable data-sets over time; sites in the latter category may be included in future versions of ACORN-SAT as and when their historical data are fully digitised. There are also a few cases where ACORN-SAT uses a nearby site with a longer period of record (e.g. Hobart instead of Hobart Airport), and a few sites which have been excluded from ACORN-SAT because of poor site quality at some point in their history. The ACORN-SAT network also includes a number of stations that are not in any of the GSN/RCS/RBCN classifications, reflecting a higher station density in some regions.

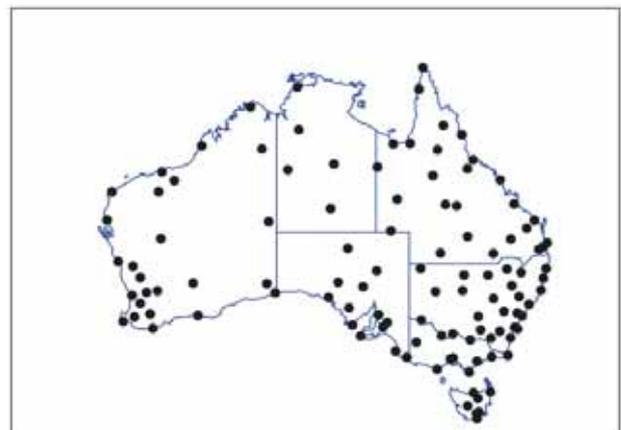


Figure 5. The ACORN-SAT network.

4. Summary

The Bureau's update of its Australian Climate Observations Reference Network surface air temperature (ACORN-SAT) data-set is consistent with its continuous improvement approach to science and services.

The product is an output from the Bureau's Climate Information Program and is heavily dependent on other areas of the organisation – especially its Observations, IT, Research and International functions. The ACORN-SAT network is a subset of the wider Bureau observations network and other networks and data-sets used for special climate purposes, both within Australia and internationally.

The Bureau plans to publicly release the ACORN-SAT data-set, the series of reports (including this one) and the Independent Peer Review (IPR) findings. These releases are expected to follow the completion of the IPR and after the Bureau reviews and responds to the IPR findings. In addition, the Bureau's work will also be reviewed internally and externally through seeking publication of its works in the scientific literature.

5. References

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6. Appendices

Bureau Program and Functional Structure 2010-11

Outcome: informed safety, security and economic decisions by Governments, industry, and the community through the provision of information, forecasts, services and research relating to weather, climate and water.

Government Program	Component	Primary Function	Responsible Manager
1.1 Bureau of Meteorology	1.1 Observations Op Ex \$44M Cap Ex \$3M	1.1.1 Taking and recording of meteorological observations to meet agreed needs and priorities	ADO
		1.1.2 Taking and recording of ocean and sea-level observations to meet agreed needs and priorities	ADO
		1.1.3 Taking and recording of space weather observations to meet agreed needs and priorities	ADR
		1.1.4 Taking and recording of hydrological observations to meet agreed needs and priorities	ADP
	1.2 Warnings & Weather Forecasts Op Ex \$57M Cap Ex \$3M	1.2.1 Forecasting weather, and warning of weather conditions likely to endanger life or property	ADS
		1.2.2 Tsunami warnings	ADS
		1.2.3 Space weather warnings and advice	ADS
		1.2.4 Promotion and advancement of meteorological science by means of research	CBR
		1.2.5 Promoting the understanding and use of meteorological information	ADS
		1.2.6 Providing forecasts and related products to the aviation sector	ADS
		1.2.7 Providing forecasts and briefings to the ADF including support for exercise and operations	ADS
		1.2.8 Providing forecasts and information on the state of the oceans	ADS
	1.3 Climate Information Op Ex \$13M Cap Ex \$2M	1.3.1 Maintaining and publishing the climate record	ADC
		1.3.2 Monitoring of climate variability and change	ADC
		1.3.3 Seasonal climate prediction	ADC
		1.3.4 Ocean climate	ADC
		1.3.5 Climate research (uptake, implementation)	ADRD
		1.3.6 Furnishing advice on climate matters	ADC
		1.3.7 Climate Information System	ADC

Government Program	Component	Primary Function	Responsible Manager
1.1 Bureau of Meteorology <i>cont.</i>	1.4 Environmental Information Op Ex \$1M	1.4.1 Issuing national environmental information standards	ADEI
		1.4.2 Development of environmental information systems	ADEI
		1.4.3 Collecting and publishing environmental information	ADEI
	1.5 Water Information Op Ex \$29M Cap Ex \$8M	1.5.1 Issuing national water information standards	ADD
		1.5.2 Collecting and publishing water information	ADD
		1.5.3 Conducting regular national water assessments	ADW
		1.5.4 Publishing an annual National Water Account	ADW
		1.5.5 Providing a national flood warning and forecasting service	ADP
		1.5.6 Providing water availability forecasts	ADP
		1.5.7 Development of Water Information Systems	ADIP
		1.5.8 Water information research	DDW
	1.6 Observations & Engineering Op Ex \$8M Cap Ex \$30M	1.6.1 Delivering observations data and metadata to meet the needs of warnings, weather forecasts and climate information	ADO
		1.6.2 Maintenance of robust and sustainable national observations infrastructure	ADO
	1.7 Research Op Ex \$15M Cap Ex \$3M	1.7.1 Atmosphere-Land observation and assessment	ADRD
		1.7.2 Ocean observation, assessment and prediction	ADRD
1.7.3 Coupled earth systems modelling		ADRD	
1.7.4 Weather and environmental prediction		ADRD	
1.7.5 Seasonal prediction, climate variability and climate change		ADRD	

Government Program	Component	Primary Function	Responsible Manager		
1.1 Bureau of Meteorology <i>cont.</i>	1.8	Information Communication & Technologies Op Ex \$23M Cap Ex \$16M	1.8.1	Operate data centres and provide computing services to support Bureau programs and research	ADI
			1.8.2	Provide the Bureau's telecommunications and telephony needs to underpin operations and the dissemination of product	ADI
	1.9	Corporate Op Ex \$59M Cap Ex \$14M	1.9.1	Provide financial and budgeting services, including reporting, asset management and governance arrangements	ADF
			1.9.2	Provide business systems and services including contracting functions and costing and pricing	ADF
			1.9.3	Government liaison, corporate coordination, international cooperation and the executive	ADE
			1.9.4	Providing legal, property and office services	ADM
			1.9.5	Workforce management and scientific, technical and general training support	ADM
			1.9.6	Communication and public education (community understanding of weather, climate, water and the Bureau's services)	ADE
			1.9.7	Planning and strategic advice	DDC
2.1	2.1	Modernisation & Extension of Hydrologic Monitoring Systems Op Ex \$20M	2.1	Modernisation and Extension of Hydrologic Monitoring Systems	ADD

Acronyms Key

ADC	Assistant Director (Climate Information Services)
ADD	Assistant Director (Water Data)
ADE	Assistant Director (Executive and International Affairs)
ADEI	Assistant Director (Environmental Information)
ADF	Assistant Director (Finance and Budgets)
ADI	Assistant Director (Information Technology)
ADIP	Assistant Director (IT Planning and Development)
ADM	Assistant Director (Management)
ADO	Assistant Director (Observations and Engineering)
ADP	Assistant Director (Water Forecasting Services)
ADR	Assistant Director (Ionospheric Prediction Service)
ARDR	Deputy Director Centre for Australian Weather and Climate Research
ADS	Assistant Director (Services)
ADW	Assistant Director (Water Analysis and Reporting)
DDC	Deputy Director (Corporate Services)
DDW	Deputy Director (Water and Climate)



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