GOVERNMENT OF WESTERN AUSTRALIA

Western Australian Satellite Technology and Applications Consortium

Annual Report 1997

WASTAC Members

Bureau of Meteorology
GPO Box 1289K
Melbourne VIC 3001

Curtin University of Technology
Kent Street
Bentley WA 6012

CSIRO
Office of Space Science and Applications
GPO Box 3023
Canberra ACT 2601

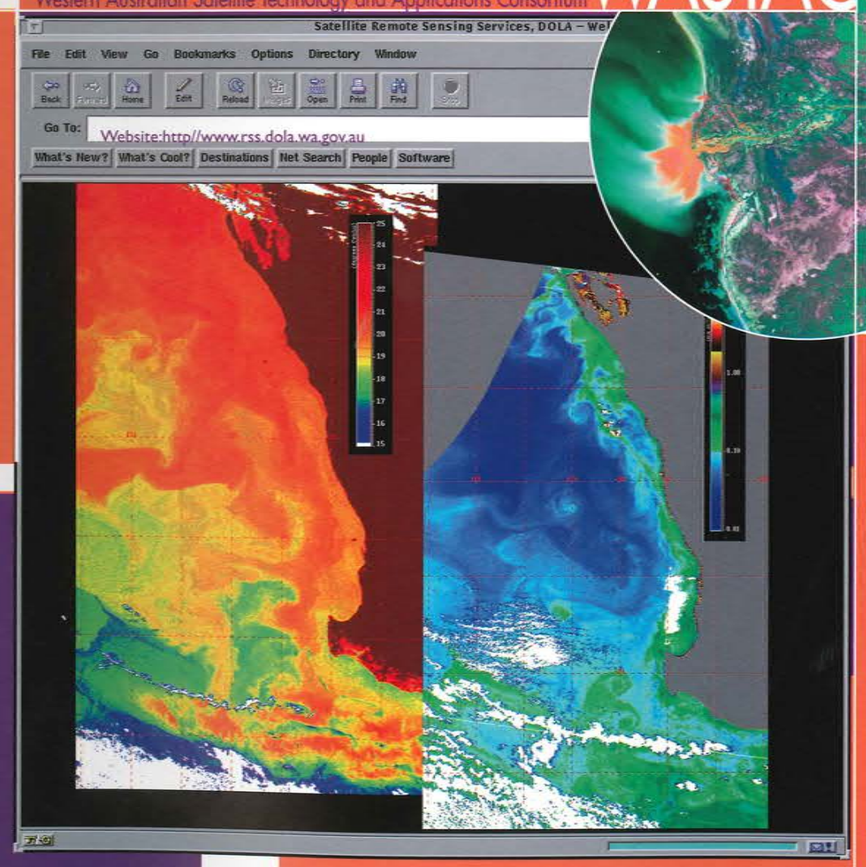
Department of Land Administration
Leeuwin Centre for Earth Sensing Technologies
65 Brockway Road
Floreat WA 6014

DOLA
Department of LAND ADMINISTRATION

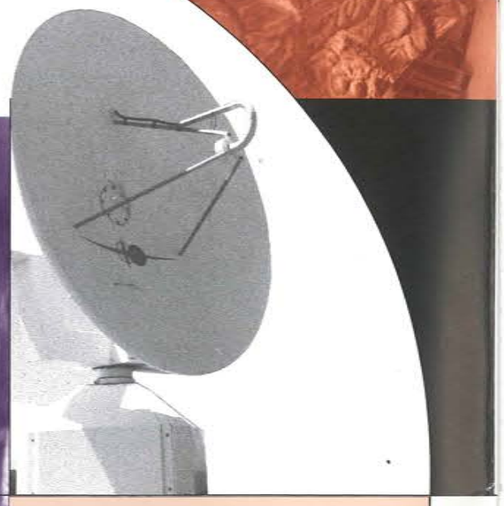
WASTAC

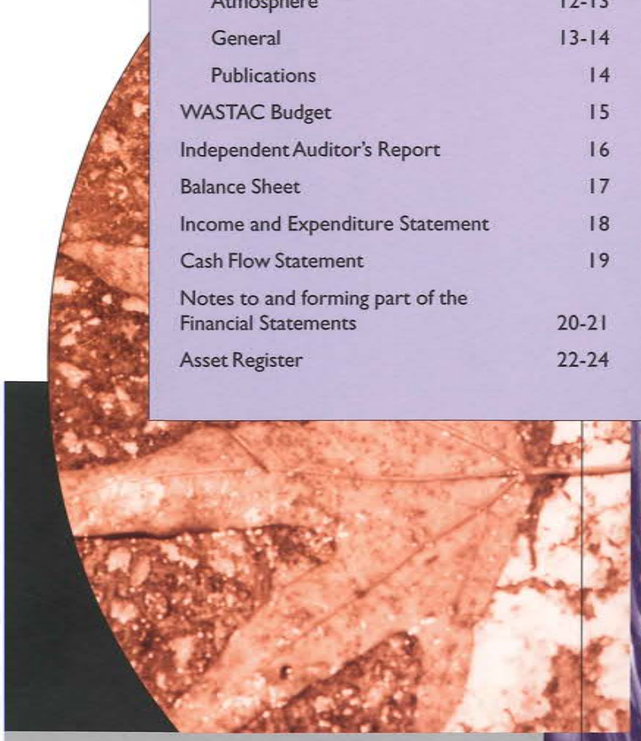
Western Australian Satellite Technology and Applications Consortium

Annual Report 1997



CONTENTS





Postal:

The Secretary WASTAC

PO Box 471 WEMBLEY 6014

Western Australia

65 Brockway Road

FLOREAT 6014

Western Australia

Telephone: (08) 9340 9330

Facsimile: (08) 9383 7142

International: (+618)

E-mail: stovold@uranus.dola.wa.gov.au

WEB: http://www.rss.dola.wa.gov.au

Editors: Richard Stovold - DOLA

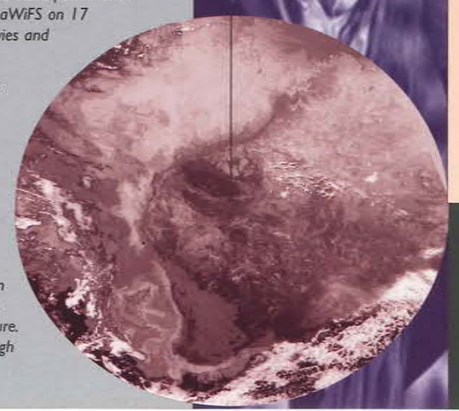
Alan Pearce - CSIRO

Front Cover Captions:

Satellite images showing (left) sea surface temperature from NOAA-AVHRR and (right) surface chlorophyll from SeaWiFS on 17 November 1997. Images prepared by Jim Davies and Peter Fearns, Curtin University of Technology.

Left: The Leeuwin Current is the band of warm (red) water moving southwards down the Western Australian coast, with characteristic meanders and eddies, and a cooler countercurrent (yellow) pushing northwards closer inshore. Note the strong warm feature in the centre of the picture.

Right: The chlorophyll-rich water (green) is largely restricted to coastal waters, although entrainment by the Leeuwin Current has drawn filaments of this shelf water offshore, including into the warm feature in the centre of the picture. Chlorophyll concentrations are also relatively high south of Cape Leeuwin.



WASTAC - 1997
CHAIRMAN'S REPORT

In 1997 the Western Australian Satellite Technology and Applications Consortium (WASTAC) made significant progress in the reception of S-band satellite data, value added products and on-line delivery. A record 4500 National Oceanographic and Atmospheric Administration (NOAA) satellite overpasses were archived during the year. All the TIROS Operational Vertical Sounder (TOVS) data were used by the Bureau of Meteorology (BOM) in weather forecasting and the Advanced Very High Resolution Radiometer (AVHRR) data from over 1000 of the overpasses were processed by the Department of Land Administration (DOLA) into value added products for vegetation and bush fire management and the fishing industry.

Data from the recently launched SeaWiFs ocean colour scanner was successfully received and archived in October 1997, and when the SEADAS software is complete, maps of ocean chlorophyll will be available.

An on-line digital quick look of archived NOAA-AVHRR that automatically updates every three hours was introduced in March 1997 followed by the Bush Fire Hot Spot Detection, Fire Scar and Normalised Difference Vegetation Index (NDVI) archives in July and August. The process of hot spot detection was fully automated by December 1997 leading to a puzzled Manager of Bush Fire Services in Kununurra asking "who on earth at DOLA is getting up so early in the morning so that this information is available before we arrive at work in the morning". These on-line initiatives were in response to regional fire control officers in remote localities of WA and the Northern Territory requesting faster and easier access to hot spot information.

NOAA-AVHRR is fast becoming an integral part of bush fire management in remote areas with the Cooperative Research Centre (CRC) for Sustainable Development of Tropical Savannas making extensive use of this information to coordinate bush fire control across Northern Australia.

In late 1997, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), BOM and DOLA began testing CAPS (Common AVHRR Processing Software), new software to improve the processing of NOAA-AVHRR data that will significantly enhance geometric and radiometric quality.

WASTAC is considering the need for an additional station to minimise the risk of receiving dish failure, reduce conflicts between alternative satellites and provide flexibility for further development. At the beginning of 1997 WASTAC was receiving data from NOAAs 10,12 and14. By the end of 1998 the number of S-band satellites will have significantly increased with SeaWiFs, NOAA-K and FENYUNG - IC also being available.

The progress and achievements in 1997 are a tribute to the commitment and professionalism of staff within the Curtin University of Technology, BOM, CSIRO and Satellite Remote Sensing Services DOLA (SRSS) who have demonstrated the benefits of research and development collaboration and coordination in providing improved client services.

Richard Smith

Chairman

WASTAC BOARD FOR 1997

Dr Richard Smith	(Chairman) Department of Land Administration
Mr Richard Stovold	(Secretary) Department of Land Administration
Assoc. Prof. Merv Lynch	Curtin University of Technology
Dr Doug Myers	Curtin University of Technology
Dr Brian Embleton	CSIRO, Office of Space Science and Applications
Mr Jeff Kingwell	CSIRO, Office of Space Science and Applications
Mr Bruce Neal	Bureau of Meteorology
Mr Len Broadbridge	Bureau of Meteorology

WASTAC STANDING COMMITTEE AND PROXY TO THE BOARD

Dr Richard Smith	(Chairman) Department of Land Administration
Mr Richard Stovold	(Secretary) Department of Land Administration
Assoc. Prof. Merv. Lynch	Curtin University of Technology
Dr Doug Myers	Curtin University of Technology
Mr Allan Scott	Bureau of Meteorology
Mr Don Ward	Bureau of Meteorology
Mr Alan Pearce	CSIRO, Marine Research
Mr Jeremy Wallace	CSIRO, Mathematics & Information Sciences

WASTAC STRATEGIC PLAN

VISION:

Improve the economy, society and environment through the acquisition of satellite observations of Western Australia and its oceans for research and near real-time applications.

MISSION:

The mission of WASTAC is to:

- provide high speed access to NOAA (TOVS and AVHRR) and SeaWiFS satellite data to members on a non-profit basis;
- contribute these data for national and international initiatives in remote sensing;
- adopt recognised data formats to ensure wide access to WASTAC data;
- maintain the integrity of archived data for research and operational applications;
- promote the development and calibration of value-added products; and
- ensure maximum use of NOAA and SeaWiFS data in the management of renewable resources.

FUTURE STRATEGIES:

- develop quick look access to archived data;
- update the communications, ingest and reception equipment by a process of planned asset replacement;
- review future satellite reception opportunities in both S- and X-band, and plan new assets (e.g. antenna) to capture these opportunities;
- expand acquisition of satellite data through high speed communication links;
- investigate the cost/benefits of an X-band consortium with Australian Centre for Remote Sensing (ACRES) and Tasmanian Earth Resources Satellite Station (TERSS) to provide full continental coverage of X-band reception;
- identify national and state initiatives in environmental monitoring for sustainable development using WASTAC satellite data; and
- identify areas of software (knowledge) deficiency limiting current exploitation of WASTAC satellite data and plan for upgrading.

FUTURE SATELLITE OPPORTUNITIES:

FENYUNG - 1C (1998) (S-band)

SPOT Vegetation Sensor (1998) (S-band)

NOAA-K (1998) (S-band)

MODIS EOS AM-1 (1999) (X-band)

MODIS EOS PM-1 (2000) (X-band)

METOP (Replaces NOAA in 2003) (X-band)

OPERATIONAL STATUS

Don Ward, Regional Computing Manager
Bureau of Meteorology (BOM); Perth.

WASTAC facilities consist of a 2.4 metre antenna and antenna controller at Curtin University of Technology, Bentley and ingest and display computers with hard disk storage and tape archive facilities, located at the BOM premises at 1100 Hay Street, West Perth. A low speed uni-directional microwave link connects the antenna to the ingest computers. A second high speed bi-directional microwave communications sytem was installed in June 1996 allowing the transmission of raw and processed satellite data between the Leeuwin Centre, Curtin University, and the WA Regional Office of BOM.

Colour and grey scale quicklook pictures are produced at SRSS in near real time for archive, indexing and distribution.

The raw data archive is produced on 4Gb DAT tape and a duplicate copy is currently produced for a national NOAA data archive program that is coordinated by CSIRO Office of Space Science and Applications (COSSA) in Canberra.

The new AVHRR ingest and display system developed by BOM became operational in September 1996. The system consists of two Hewlett Packard (HP) UNIX workstations, one provided by WASTAC and the other by BOM.

The ingest program runs on both workstations providing display, processing and backup facilities. The TOVS data, a subset of AVHRR, is automatically sent to the BOM in Melbourne so that atmospheric temperature retrievals can be included in the global numerical weather prediction models. Sea Surface Temperatures

(SST) are being produced by BOM and DOLA. DOLA is able to produce vegetation maps and monitor fire scars in near real-time and post NOAA and SeaWiFS archive information to the World Wide Web.

Equipment failures during the year resulted in the loss of two days of data.

Due to the dedicated efforts of DOLA and BOM staff, a total of 4509 satellite passes were recorded for the year.

DOLA is currently holding the archive on 8mm exabyte and recently on DAT tapes.

Orders for digital data can be provided on 8mm data tape, DAT tape, CD-ROM or 6250/1600bpi magnetic tape in raw format.

FUTURE DIRECTIONS

WASTAC has entered a new era with the implementation of a HP UNIX ingest and archive system that provides high levels of automation and system integrity. Further upgrades to the system will provide Year 2000 compliance. A proposal has been tabled to provide another antenna and reception system allowing for additional data streams and antenna backup.

WASTAC DATA ARCHIVE

The WASTAC archive of NOAA and SeaWiFS satellite passes, managed and maintained by SRSS, is held at the Leeuwin Centre.

DOLA actively manages the daily archive and management systems which have been installed to ensure rapid and reliable delivery of WASTAC satellite data for research and wider community use.

WASTAC is continuing to supply NOAA passes as part of the Australian contribution of data to the global one kilometre data set which is being administered for CSIRO by COSSA.

The WASTAC duplicate set of NOAA passes which commenced in March 1994, is still stored at the Earth Observation Centre at Gungahlin, Canberra, and is specifically for research use by CSIRO and collaborative partners. The global one kilometre data set dates back to April 1992.

A total of 4367 NOAA passes were recorded for 1997 on 107 4mm tapes comprising 264Gb of information. Passes comprised data from the NOAA 10, NOAA 12 and NOAA 14 satellites.

Copying of the WASTAC Computer Compatible Tape (CCT) archive of early NOAA passes has been completed with the exception of a few unreadable or damaged tapes. As of 22 May 1997, all 2562 passes had been copied from the original WASTAC CCT archive, which commenced on 9 September 1987 and finished on 25 May 1991. The CCT archive of 1282 tapes was copied to 44 8mm data tapes.

The archiving of SeaWiFS data onto 4mm data tapes commenced on 31 October 1997. To the end of 1997, 142 SeaWiFS passes had been archived to three 4mm data tapes.

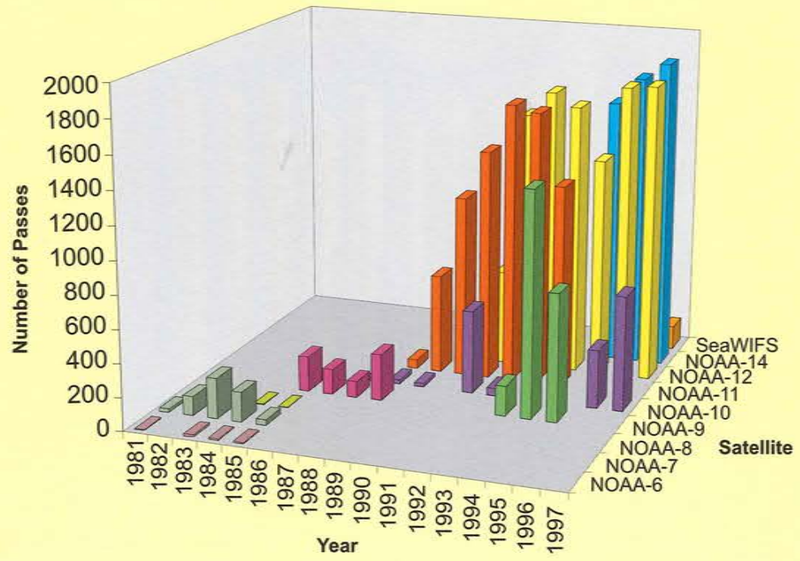
DIGITAL QUICKLOOK ARCHIVE

At the beginning of 1997, a near real-time digital quicklook archive of NOAA-AVHRR data was developed by SRSS for the World Wide Web (WWW). Currently, the digital archive holds data going back to 1994. After the launch of the SeaStar satellite in October 1997, an archive was developed for the SeaWiFS quicklook data. As of 10 February 1998, the SeaWiFS data has been encrypted. These two archives can be found at "http://www.rss.dola.wa.gov.au/noaaql/NOAAql.html" and "http://www.rss.dola.wa.gov.au/seawifsql/SeaWiFSql.html". The image below at right was taken from the NOAA-AVHRR digital quicklook archive and is from NOAA 14 dated 16/1/97 14:25 WST. The image below at left was taken from the SeaWiFS digital quicklook archive and is dated 8/12/97 11:39 WST.

Total number of satellite passes held in WASTAC archive at the Leeuwin Centre

	NOAA 6	NOAA 7	NOAA 8	NOAA 9	NOAA 10	NOAA 11	NOAA 12	NOAA 14	TOTAL	SeaWiFS
1981	5	22							27	
1982		115	1						116	
1983	12	244	12						268	
1984	7	179	4						190	
1985	7	33	4	212					256	
1986				151					151	
1987				97	18				115	
1988				280	25	53			358	
1989					21	601			622	
1990						1103			1103	
1991					506	1399	575		2480	
1992					47	1693	1571		3311	
1993				183		1656	1720		3559	
1994				1362		1227	1641		4230	
1995				770			1326	1615	3711	
1996					354		1780	1776	3910	
1997					694		1797	1876	4367	142
TOTAL:	**31**	**593**	**21**	**3055**	**1665**	**7732**	**10,410**	**5267**	**28774**	

Held as: 57 Curtin University archive 8mm tapes 1282 WASTAC archive 6250 bpi tapes (copied to 44 8mm tapes)
835 WASTAC archive 8mm tapes 140 WASTAC archive 4mm tapes



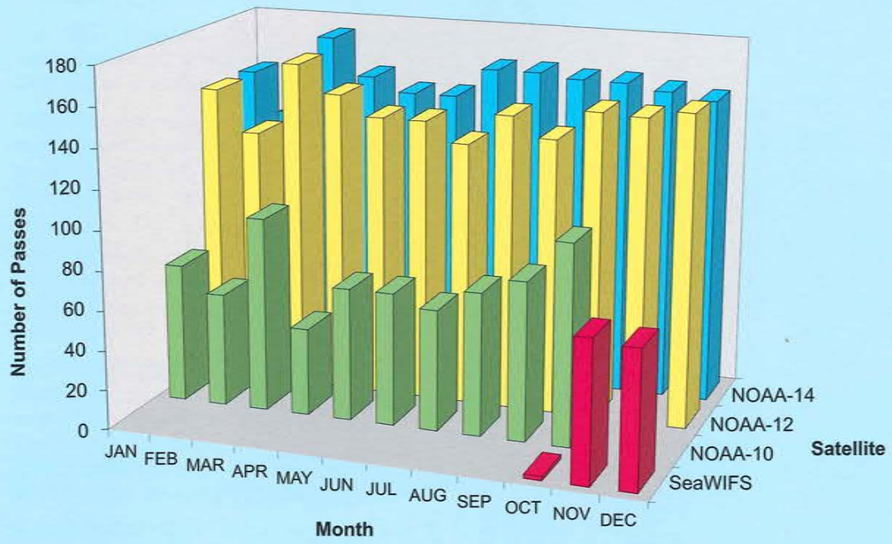
Total number of satellite passes held in WASTAC archive at the Leeuwin Centre

1997 satellite data archive held by WASTAC

	NOAA 10	NOAA 12	NOAA 14	TOTAL	SeaWiFS
JAN	70	151	152	373	
FEB	57	130	132	319	
MAR	98	167	173	438	
APR	44	153	154	351	
MAY	44	147	163	354	
JUN	67	143	147	357	
JUL	61	133	162	356	
AUG	72	149	162	383	
SEPT	80	154	160	394	
OCT	101	160	160	421	2
NOV	-	153	157	310	71
DEC	-	157	154	311	69

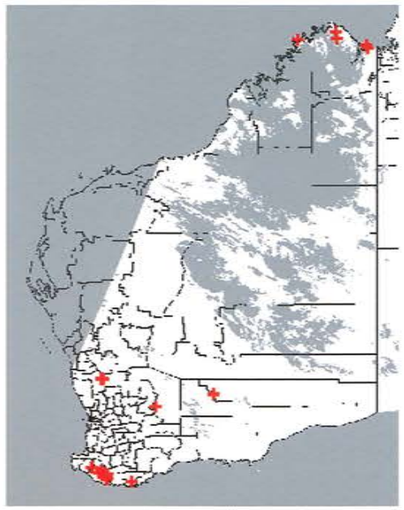
	NOAA	SeaWiFS
4mm Tapes:	4367 passes on 105 tapes	142 passes on 3 tapes
Total data archived:	264 gigabytes	8 gigabytes

1997 satellite data archive held by WASTAC



RESEARCH AND OPERATIONAL APPLICATIONS

In a change of format from previous editions of the WASTAC Annual Report, we are presenting the research and applications material thematically (rather than organisationally) under the broad headings of Land, Oceans, and Atmosphere.



LAND

Fire detection-

Satellite Remote Sensing Services DOLA

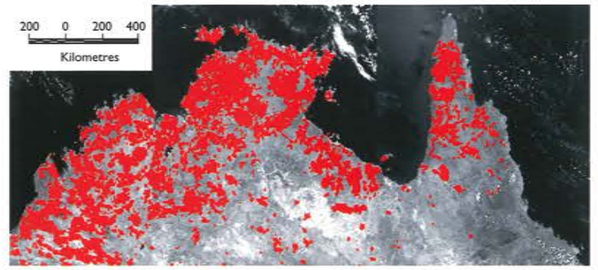
Since 1990 SRSS has been locating fires in Western Australia using WASTAC NOAA-AVHRR data. Since 1995 this locating has been undertaken every working day. In 1996 the coverage was enlarged to include the Northern Territory. It takes one staff member up to three hours every day to list all possible fires in these two states, and send faxes to the local fire officers. In August of 1997 this information was made available on the WWW. This archive can be found at "http://www.rss.dola.wa.gov.au/noaafd/NOAAfd.html". By December 1997 an automated system was in place. This system provides fire information every day of the year. During 1998, when CAPS software is installed at SRSS, the geometric correction of NOAA-AVHRR data will be more accurate and this system will replace the manual method of fire spotting. Currently, location maps are produced as part of the automatic system. These maps show each state with red crosses for fires and grey areas for cloud/sea/no data. The example shown was taken from the fire detection archive and is dated 26/3/98 1:24 WST.

Firescar mapping-

Satellite Remote Sensing Services DOLA

Since 1990, staff at SRSS have been involved in the mapping of firescars. These scars are what remains after fire has spread throughout an area and are easily observed using satellite imagery.

Every nine days thermal imagery from the NOAA AVHRR sensor is used to map new scars from fires which burned in the previous days. Maps are made available at our WWW site at "http://www.rss.dola.wa.gov.au/firescarmap.html" Hardcopies are sent to the offices of the Bushfires Service WA, the Bushfires Council NT and the Department of Conservation and Land Management (CALM).



Western Australia, Northern Territory and Queensland Fire History 1997.

The 1997 fire season in the north-west of Western Australia was a particularly 'bad' season with significant late season fires burning in the West Kimberley and Central Pilbara. The Thangoo fire in early October burned over 1 million hectares including valuable pastoral property south of Broome while large fires burned through Karajini National Park in the Pilbara.

The extent of the fires across the Tropical Savanna is shown above. The areas in red are those which burned in 1997.

Flood monitoring-

Bureau of Meteorology, Melbourne

BOM is developing the use of Normalised Difference Vegetation Index (NDVI) data for flood monitoring in an operational environment. The system, although still being developed has produced many useful images for BOM's hydrological services. BOM currently produces *ad hoc* NDVI images to assist in the national monitoring of flooded areas.

OCEANS

SeaWiFS and ocean colour sensing

Jim Davies*, Peter Fearns*, Mark Marinelli*, Mervyn Lynch*, Alan Pearce+ and John Parslow#

* Remote Sensing and Satellite Research Group, School of Physical Sciences, Curtin University.

+ CSIRO Marine Research, Marmion, WA.

CSIRO Marine Research, Hobart, Tasmania.

The SeaWiFS sensor was launched on the SeaStar platform in August 1997. Since that time it has operated successfully. WASTAC, after some initial problems related to the downlink antenna receiver's performance, has been capturing and archiving SeaWiFS data on a daily basis. Presently, SeaWiFS is being down-linked in Australia at Perth (WASTAC), Hobart (CSIRO Marine Research) and the Townsville Australian Institute for Marine Science (AIMS). These three stations are sufficient to provide coverage from the Australian coastal zone (excluding Heard Island) to the outer extent of the Extended Economic Zone (EEZ). These three reception centres, together with the CSIRO Earth Observation Centre (EOC), have formed the Australian Ocean Colour Working Group (AOCWG) which is affiliated with the International Ocean Colour Coordinating Committee (IOCCC).

As planned, after some three months of transmission, the SeaWiFS data stream was encrypted to prevent other than authorised users being able to use the data. WASTAC is an approved decryption agent, and in due course was provided with a decryption processor (SGP) by Orbimage, the corporation that undertook joint development of the SeaStar platform.

Data sets from the pre-encryption period have been processed using the SeaDAS software package provided through NASA Goddard Space Flight Centre (GSFC). Particular attention has been given to those data recorded for the dates of the Hillarys Transect. The initial scientific interest has been in validating the so-called Level 2 products from the SeaDAS processing suite. Prime Level 2 SeaWiFS products for validation are the spectral water leaving radiance, in-water chlorophlyll (Chl a) concentration and atmospheric aerosol optical depth. This process is continuing, supported by a monthly cruise off Hillarys Marina for measuring the Chl a and water leaving radiance, and the operation of a multiple spectral solar photometer to independently measure the aerosol optical thickness. The expectation is that some adjustments to the SeaWiFS algorithms will be required at least at the regional level.

Application of SeaWiFS to the study of both coastal zone productivity and to environmental management has been initiated. Three regions, namely Perth waters, Geographe Bay through to the Capes, and the North-West Shelf have been identified for intensive investigation, particularly for seasonal and interannual variability of Chl a.

Hillarys transect surveys

Alan Pearce+, Merv Lynch*, Peter Fearns*, Brendon McAtee* and Simon Braine+

* Remote Sensing and Satellite Research Group, School of Physical Sciences, Curtin University.
+ CSIRO Marine Research, Marmion, WA.

As part of a national study largely funded by the Fisheries Research and Development Corporation (FRDC), monthly surveys have been undertaken since October 1996 to measure the physical, chemical and bio-optical properties of the continental shelf waters due west of Hillarys Marina just north of Perth. The transects, which comprise both underway sampling and nine profiling stations out to 40 km offshore, include surface temperature and fluorescence, temperature and salinity profiles, depth-integrated chlorophyll and nutrients, light measurements, and both phyto- and zoo-plankton trawls. These data are being used in surface validation of SeaWiFS-derived chlorophyll estimates and the development/ refinement of chlorophyll algorithms (see above), as well as validation of satellite surface temperatures.

Transect-averaged chlorophyll concentrations indicate the high degree of both temporal and spatial variability in our coastal waters. As may be expected, the greatest variability tends to be near the coast with chlorophylls approaching (and occasionally exceeding) 1 µg/l, or an order of magnitude greater than those further offshore.

We are grateful to the Perth Diving Academy for their collaboration in chartering the dive-boat *Lionfish 2* and in technical assistance during the surveys.

Mesoscale features of the Leeuwin Current in AVHRR imagery

Alan Pearce

CSIRO Marine Research, Marmion, WA.

Sea surface temperature images are being used in on-going research into variability of the Leeuwin Current, the major (southward) flowing ocean current off WA. Following earlier studies of current patterns off the Houtman Abrolhos Islands and the south-western corner of the State (described in previous Annual Reports), an analysis was undertaken of SST imagery in the Kalbarri area covering the period 1990 to1996.

Current observations had shown anomalously high current speeds near the edge of the continental shelf, and the satellite imagery suggested that onshore flow in large-scale meanders interacted with the shelfbreak to accelerate the currents there. Generally, the Leeuwin Current flows along the edge of the shelf much of the time, but tends to drift a little offshore when it weakens during the summer months. In all seasons, there is a high degree of variability in current patterns over a range of length scales.

The AVHRR SST imagery has also been used in a study of currents off Western Australia during the time of the mass mortality of pilchards which occurred in autumn 1995. The images showed that the southward-flowing Leeuwin Current was close inshore between Cape Naturaliste and Cape Leeuwin at the time the mortality "wave" moved from the South Coast to the West Coast, so there was no current path allowing movement up the West Coast to explain the mortality as far north as Geraldton.

SST algorithm development and validation

Matt Boterhoven*, Brendon McAtee*, Andrew Rodger*, Mervyn Lynch*, Alan Pearce+ and Bob Griffiths+.

* Remote Sensing and Satellite Research Group, School of Physical Sciences, Curtin University.

+ CSIRO Marine Research, Marmion, WA.

The estimation of sea surface temperature (SST) from satellite sensor-derived spectral radiances or brightness temperatures requires application of an algorithm. There are a number of algorithms available from which to select, and, in its own way, each attempts to correct or compensate for the effect of the intervening atmosphere. The atmosphere, because it is warm, emits radiance toward the satellite. It also emits radiance downward, some of which is reflected at the sea surface toward the satellite sensor. The atmosphere is not a perfect transmitter, mainly because of water vapour, and its transmittance is dependent upon the wavelength of observation. If we consider just the imaging satellite sensors (such as NOAA/AVHRR but not ATSR or AATSR) these various radiative terms will vary in magnitude with a satellite off-nadir view. Further, because the atmosphere itself varies with time (hourly through to seasonal scales), these corrections are intrinsically complex to apply if best use of data from the sensor is to be assured.

Research presently being undertaken uses a line-by-line radiative transfer model (LBLRTM) code to calculate the spectral radiances (or brightness temperatures) that a specific sensor would detect for a given set of surface conditions (temperature and emissivity) and a selected atmospheric thermodynamic profile. These synthetic radiances are used to develop regression relationships and hence algorithm coefficients for retrieving SSTs from satellite data.

This approach permits the evaluation of the magnitude of the various terms in the radiative transfer equation as well as allowing for regionally and seasonally dependent algorithms to be created. The work to date has explored the use of regional climatology (taken from a 20 year radiosonde database) to specify the thermodynamic properties of the atmosphere.

Accordingly, algorithms for Albany, Perth, Geraldton, Broome and Darwin have been developed for the four seasons of the year. The approach has also permitted so-called linear and second order algorithms to be determined.

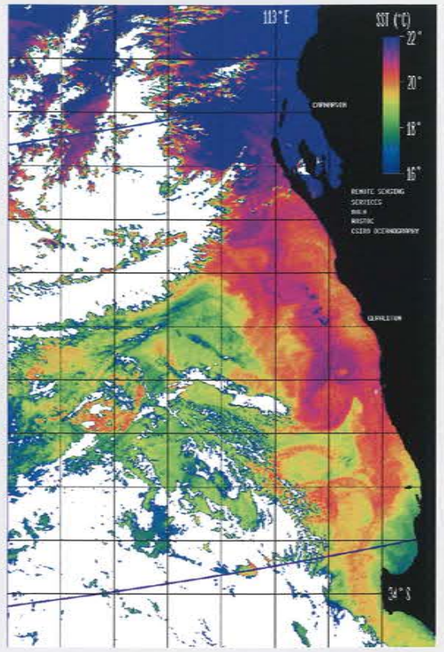
Using synthetic data, the performance of these algorithms has been compared with several of the more widely used algorithms that are global in application. The data sets from the Hillarys Transect (described above), which is essentially time coincident with NOAA satellite overpasses, and from the Exmouth cruise program (conducted by AIMS, Townsville) allow the performance of algorithms to be evaluated against the in-situ data.

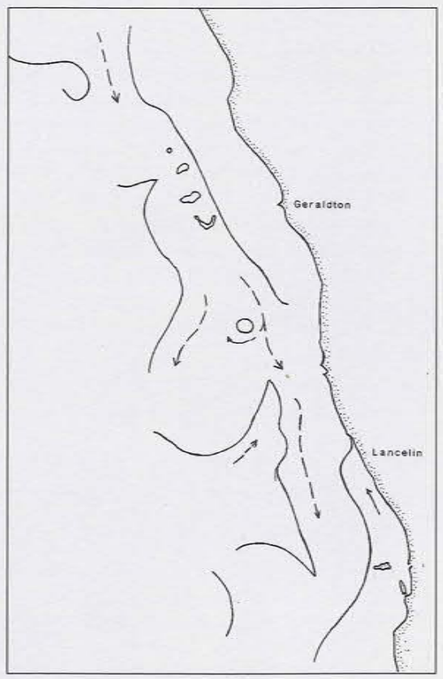
The research is being extended by applying the

same methodology to the development of SST algorithms for MODIS and ASTER - new sensors on the EOS AM platform due for launch late 1998. It is also planned to extend to using the advanced microwave sounding unit (AMSU) on the NOAA 15 platform to define the atmospheric thermodynamic state (profile of temperature and moisture) above the sea surface pixel. The appropriate algorithm to use may then be selected and applied to the satellite radiometry. This research is in part a cooperative initiative with CIMSS/SSEC, University of Wisconsin, Madison, Wisconsin, supporting a contribution to the MODIS calibration and product validation program.

As a separate initiative, an intake temperature sensor and a radiometer have been installed on the Rottnest ferry which plies between the Hillarys Marina, Fremantle and Rottnest Island (off the coast of Perth) several times a day. The temperatures are logged only when the vessel is travelling faster than five knots, to eliminate collecting data while the vessel is in harbour. After downloading onto computer, the 10-second samples are averaged over 1.1 km intervals (approximating the AVHRR pixel size) and divided into track segments between Hillarys, Fremantle and Rottnest Island.

In addition to providing regular surface temperature data for validation of the satellite-derived products, the ferry measurements allow us to examine relationships between the "skin" (radiometer) and "bulk" (intake sensor) temperatures, and also to monitor changes in cross-shelf temperature gradients on the continental shelf off Perth. We appreciate the cooperation of Boat Torque Cruises, operators of the Rottnest ferry, for their collaboration in this project.





Sea surface temperature images for marine users

Mike Steber* and Alan Pearce+
*Satellite Remote Sensing Services, DOLA.
+CSIRO Marine Research, Marmion.

The collaborative project between SRSS and CSIRO's Division of Marine Research continued throughout 1997. The aim of the project is to deliver SST products to the WA fishing industry. Data from the AVHRR sensor on board the NOAA satellite are received by WASTAC in Perth, SST charts are produced using DISIMP software and a Calcomp colour plotter. These hardcopy plots are then sent by courier to the client, usually within 12 hours of acquisition. In order to satisfy some clients' needs for quicker turnaround, the digital files can now be sent, where possible, *via* the Internet, and in most cases, the client can be looking at the SST image within five hours of the satellite data being received. Besides a personal computer, the only necessary hardware required by the client is a modem and access to the Internet. No special software is required except for Microsoft Windows which comes with most IBM compatible personal computers today.

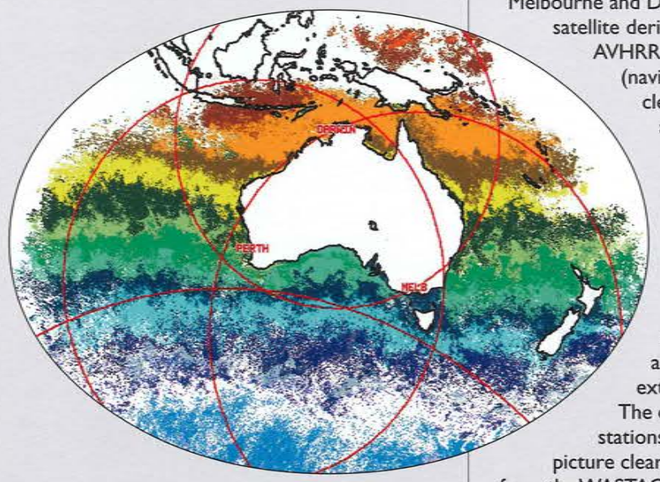
The images are sent using the file transfer protocol (ftp) program to the client's chosen Internet Service Provider (ISP). An electronic mail message confirms the arrival of an image on the ISP's computer and they can then download the image onto their own computer and view it using Microsoft Windows Paintbrush. During the year, 20 SST images were produced for 11 different clients from Perth, Fremantle, Geraldton and Dongara. This also included the crew from the "EF Learn a Language" yacht which competed in the Whitbread yacht race.

Daily imagery was produced for the CSIRO Division of Marine Research throughout the year. As a community service SST images and associated current interpretations were provided to the participants in the Fremantle to Lombok yacht race held in May and the Perth to Geraldton yacht race held in October. Shown on the bottom of p. 10 is the current interpretation for the NOAA-AVHRR image, top of p. 10. This image is dated 14/10/97 15:15 WST.

Sea Surface Temperatures: Application for climate

Bureau of Meteorology, Melbourne

BOM, by combining data from WASTAC with similar NOAA AVHRR data from its Casey, Melbourne and Darwin stations, calculates satellite derived SSTs nationally. The AVHRR data is processed locally (navigated, calibrated, cloud cleared) in near real-time and is available within an hour after the completion of the orbit.



The resulting SSTs for a particular orbit are then sent to Melbourne for inclusion into a national data set. These data are mainly in support of internal and defence operations but are also potentially available for external users via the WWW. The coverage from the four stations can be seen to the left. The picture clearly shows the contribution from the WASTAC station in Perth. Red lines are approximate extremities of sub-satellite points.

ATMOSPHERE

AVHRR data satellite estimation of maritime atmospheric aerosol optical thickness from NOAA

Jackie Marsden*, Mervyn Lynch*, Ross Mitchell# and Bruce Forgan+

* Remote Sensing and Satellite Research Group, School of Physical Sciences, Curtin University.

CSIRO Atmospheric Research, Aspendale, Victoria

+ Bureau of Meteorology, Melbourne, Victoria

Satellites may be used to estimate atmospheric aerosol optical thickness (AOT) over the oceans. At wavelengths greater than 0.7 of a micrometre the ocean's reflectance decreases and it approximates what is known as a dark target. This condition is not satisfied if there are significant whitecaps on the ocean surface.

In this work we have applied the radiative transfer equation to derive an algorithm for the estimation of the AOT. NOAA AVHRR data sets are analysed, and an aerosol product retrieved. These are compared to the equivalent product measured by solar photometry at the Cape Grim Baseline Air Pollution Station (CGBAPS) located in north-western Tasmania.

More recently the project has incorporated an extension to handle multiple scattering to second order (Mie-Mie, Rayleigh-Rayleigh, Rayleigh-Mie, Mie-Rayleigh). Presently, the modified algorithm is being tested against data sets recorded at CGBAPS during the Mt Pinatubo volcanic eruption when aerosol levels over Australia were abnormally high.

During 1998, a solar photometer is to be installed at Rottnest Island to sample maritime aerosol properties. This instrument will enable comparisons with NOAA AVHRR-derived AOTs and also with SeaWiFS's level 2 AOT products.

Estimation of tropical cyclone intensity using microwave radiometry from the NOAA MSU sensor

Len van Burgel*, Mervyn Lynch*, John Le Marshall# and Fred Prata+.

* Remote Sensing and Satellite Research Group, School of Physical Sciences, Curtin University.

BMRC, Bureau of Meteorology, Melbourne, Victoria

+ CSIRO Atmospheric Research, Aspendale, Victoria

Microwave emissions from the atmosphere are transmitted through non-precipitating clouds and may be detected by sensors on orbiting satellites. Channels 3 and 4 on the Microwave Sounding Unit (MSU) sensor on board the NOAA polar orbiting satellite series is useful to estimate the temperature anomaly that develops in the upper levels of tropical cyclones.

The bulk of tropical cyclones that have traversed the WA coast over the last 15 years have been analysed using MSU data, and the magnitude of the temperature anomaly determined. Corrections have been applied for the impact on the temperature anomaly of off-nadir viewing. Additional corrections have been applied for the effect of the MSU spatial sampling and sensor footprint (IFOV). The temperature anomalies have been compared to the post-analysis estimate of the central pressure provided by the BOM. A regression relationship has been developed and compared to theoretical expectations.

The launch of the Advanced Microwave Sounding Unit (AMSU) on NOAA 15 will provide a significant advance in this research because of the much reduced sensor IFOV, the increased number of spectral channels in the microwave region and the higher vertical resolution (*via* the spectral weighting functions) that this new sensor provides.

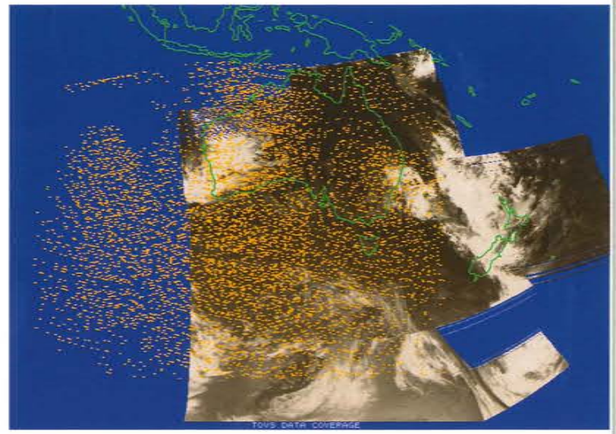
Weather modelling

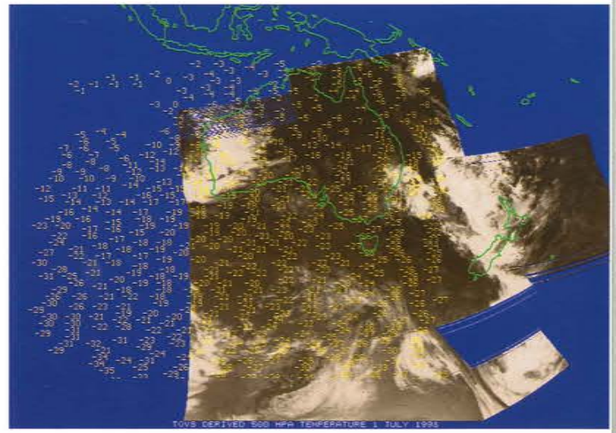
Bureau of Meteorology, Melbourne

BOM has produced locally derived TIROS Operational Vertical Sounder (TOVS) data for a number of years. This data provides valuable information on vertical profiles of atmospheric temperature and moisture. With the increased resolution of the numerical weather prediction (NWP) models, data analysis and assimilation has become increasingly important.

The standard observational network (ground and balloon based) has been supplemented by the inclusion of TOVS data into the analysis and assimilation schemes. It has been shown (Le Marshall *et al*, 1997 - two references) that assimilation of TOVS data into the Local Area Prediction System (LAPS) NWP model improves the overall skill scores of the prognosis for +6, +12, +24 and +36 hours. The data received from the WASTAC system greatly improves the coverage of the data to the west of the continent and hence improves the overall accuracy of the models. The figures (right) show the coverage of TOVS data for one day from the BOM system and an example of output in the form of 500 hPa temperatures.

TOVS coverage from WASTAC and the BOM's Melbourne NOAA station, overlayed on Melbourne AVHRR images. The contribution from the WASTAC reception system is evidenced by the lack of AVHRR data underlying same.





500 hPa temperatures from TOVS. These data are input into the Local Area Prediction System Model.

Volcanic ash monitoring

Bureau of Meteorology, Darwin

Bureau of Meteorology uses AVHRR (and GMS-5) data to monitor volcanic ash plumes from active volcanoes.

Even though the Volcanic Ash Advisory Centre is located in Darwin, the AVHRR data from Perth is reviewed for a full coverage of Darwin's area of responsibility. In 1996/97 Darwin issued a total of 267 advices covering the area south of 10°N between longitudes 100°E to 160°E.

Cyclone monitoring

Bureau of Meteorology, Perth

BOM WA Regional Forecasting Centre in Perth provides warnings from its Tropical Cyclone Warning Centre of tropical cyclones whenever the need arises . The last season was a particularly busy one with the region experiencing seven tropical cyclones, four of which occurred off the north-west coast. The AVHRR data is used to assist in the monitoring of fine details of tropical cyclones and supplements the positioning of these large systems by radar, GMS-5 imagery and NWP analysis.

GENERAL

Data collection platforms

Bureau of Meteorology, Melbourne

As part of an international commitment, BOM provides Tiros Information Processor (TIP) data to Argos (Collected Localisation Satellites) for input into its tracking system. The TIP data stream has embedded data from the Argos instrument which is on board the NOAA series satellites. The instrument allows the collection of data from remote platforms or transmitters on board ships, yachts, ocean buoys, animals, birds, cargo, etc. The Perth data gives Argos enhanced capabilities of receiving and using the data in

real-time (within 15 minutes of the end of the orbit) rather than having to wait one to three hours for the recorded data.

PUBLICATIONS

Publications and reports which have made use of WASTAC AVHRR and/or SeaWiFS data (or contributed to their validation and application) during 1997 were:

Fletcher,W.J., Jones,B., Pearce,A.F. and Hosje,W. (1997). *Environmental and biological aspects of the mass mortality of pilchards (autumn 1995) in Western Australia.* WA Fisheries Department Research Report 106, p. 102.

Le Marshall, J., Seecamp, R., Blank, D., Clark, J., Choi, B. and Magari, K. (1997). *Improving weather forecasts in the Australian region by continuous assimilation of direct readout data.* Technical Proceedings of the 9th International TOVS Study Conference, Ingls, Austria, pp. 20-26 Feb 1997.

Le Marshall, J., Leslie, L.M., Pescod, N., Spinoso, C. and Morrison, R. (1997). *The importance of direct readout satellite data in sub-synoptic scale data assimilation and numerical weather prediction.* Advances in Space Research Vol. 19 No.3, pp. 413 - 422.

McMillan, C., Craig, R., Steber, M., Adams, J., Evans, F. and Smith, R. (1997). *Fire history mapping in the Kimberley region of Western Australia 1993 to 1996 - methodology and results.* Proceedings of Australian Bushfire Conference, July 8-10, Darwin NT. CSIRO Tropical Ecosystems Research Centre, Winnellie, NT, Australia pp. 257-262.

Pearce, A.F. (1997). *The Leeuwin Current and the Houtman Abrolhos Islands.* In: Wells, F. E. (editor), *The marine flora and fauna of the Houtman Abrolhos Islands, Western Australia.* Proceedings of the 7th International Marine Biology Workshop, Western Australian Museum, Volume 1, pp. 11-46.

Pearce, A.F. and Way, A.M. (1997). *Classification of surface current patterns off Kalbarri from NOAA/AVHRR thermal images:* 1990-1996. Contract report prepared for Seafield Resources, p. 12.

Pearce,A.F. and Cresswell,G.R. (1997). *The Leeuwin Current - yachtsman's friend or foe?* In: Ross Brown, *Western Australian cruising: A yachting guide,* Fremantle Sailing Club, pp. 15-17.

Pearce,A.F. and Pattiaratchi,C.B. (1997). *Applications of satellite remote sensing to the marine environment in Western Australia.* Journal of the Royal Society of Western Australia 80, pp. 1-14.

Smith, R.C.G. and Pearce,A.F. (1997). *A bibliography of research into satellite remote sensing of land, sea and atmosphere conducted in Western Australia.* Journal of the Royal Society of Western Australia 80, pp. 29-39.

Smith, R.C.G. (1997). *Applications of satellite remote sensing for mapping and monitoring land surface processes in Western Australia.* Journal of the Royal Society of Western Australia, 80: pp. 15-28.

Smith, R.C.G., McMillan, C., Craig, R., Adams, J. and Steber, M. (1997). *Satellite monitoring of bush fires in Western Australia.* Proceedings of Desert Technology International Conference, 22-26 September 1997, Kalgoorlie, Western Australia. Curtin University of Technology - Kalgoorlie Campus.

Snyder W., Lynch,M. and Wan,Z. (1997). *The International Land-Surface Temperature Workshop.* The Earth Observer 9, pp. 10-14.

WASTAC BUDGET 1998

Estimated expenditure for the year January 1998 - December 1998

		PER ANNUM $ 1998	$ 1997
1.	Telstra Rental	3,400	3,000
2.	DAT Tapes	4,800	4,000
3.	System maintenance/repairs	6,000	6,000
4.	Telecommunications licence of facility	2,000	1,200
5.	Ink jet quick look costs	3,730	3,100
6.	Consultants-Archive/product generation assistance	16,500	16,500
7.	Sundries, consumables	1,000	2,000
8.	Travelling - airfares	4,500	4,500
9.	Provision for major equipment	2,500	2,000
10.	Annual Report	4,000	4,500
11.	WWW site development software (BOM)	0	3,000
	Total:	**$48,430**	**$49,800**

Estimated income/revenue for the year January 1998 - December 1998

1.	Contributions received ($10,000 each member)	40,000	40,000
2.	Sundry income (data replication)	0	1,000
3.	Interest	4,000	4,000
	Total Income:	**$44,000**	**$45,000**

Extra-ordinary expenditure January 1998 - December 1998

1.	Capital Reserve:		
1.1	Antenna replacement and componentry	40,000	
1.2	SeaWiFS reception/development	5,000	

INDEPENDENT AUDITOR'S REPORT

I have audited the attached financial statements and in my opinion they fairly represent the transactions of the Centre during the 1997 calendar year, the financial status as at 31 December 1997, and associated cash flows. The statements are based on proper accounts and records.

P J Perriam

Manager Internal Audit

Curtin University of Technology

30 April 1998

BALANCE SHEET AS AT 31 DECEMBER 1997

	NOTE	1997	1996
		$	$
Current Assets			
Cash at Bank		97,674	95,091
Prepayments		-	2,911
Total Current Assets		**97,674**	**98,002**
Non-Current Assets			
Computer Equipment	2a	41,307	55,076
Other Equipment	2b	59,440	67,968
Total Non-Current Assets		**100,747**	**123,044**
Total Assets		**198,421**	**221,045**
Current Liabilities			
Creditors and Borrowings		-	-
Accrued Expense		-	-
Total Current Liabilities		-	-
Non-Current Liabilities			
Creditors and Borrowings		-	-
Total Non-Current Liabilities		-	-
Total Liabilities		-	-
Net Assets		**198,421**	**221,045**
Shareholders Equity			
Asset Revaluation Reserve	3	129,997	129,997
Retained Profits/(Losses)	4	68,424	91,048
Total Shareholders Equity		**198,421**	**221,045**

INCOME AND EXPENDITURE STATEMENT FOR THE PERIOD 1 JANUARY 1997 TO 31 DECEMBER 1997

	NOTE	1997 $	1996 $
Income			
Contributions Received	5	40,000	40,000
Sundry Income		-	-
Interest Received		-	12,846
Income		**40,000**	**52,846**
Expenditure			
Salaries and Wages		6,813	14,235
Outsourced Work		250	-
Student Scholarship		10000	-
Conference		-	4,035
Telephone		3,572	3,129
Travel		-	750
Consumables		5,113	6,432
Printing, Stationery and Photocopying		3,620	3,971
Depreciation		22,296	40,248
Maintenance of Equipment		8,526	1,993
Equipment < $1,000		-	606
Computer Equipment Purchases		2,435	29,404
Feasibility Study		-	-
Total Expenditure		**62,624**	**104,803**
Net Surplus (Deficit)		(22,624)	(51,957)
Extraordinary Items		Nil	Nil
Net Surplus (Deficit) and Extraordinary items		(22,624)	(51,957)
Transfers to Asset Revaluation Reserve		Nil	Nil
Net Surplus (Deficit) transferred to Retained Profits/(Losses)		(22,624)	(51,957)

CASH FLOW STATEMENT FOR THE YEAR ENDED 31 DECEMBER 1997

Balance of Cash as at 1 January 1997		**95,091**	**Credit**
Receipts			
	Contributions Received		
	CSIRO	10,000	
	Bureau of Meteorology	10,000	
	Department of Land Administration	10,000	
	Curtin University of Technology	10,000	
Total Contributions Received		40,000	
Sundry Income			
Interest Received		0	
Total Sundry Income		**0**	
Total Receipts for 1997		**40,000**	
Payments			
	Salaries and Wages	6,813	
	Outsourced Work	250	
	Student Scholarship	10,000	
	Accommodation	-	
	Travel	-	
	Printing	3,620	
	Telephone	3,572	
	Consumables	5,113	
	Equipment < $1,000	-	
	Equipment Maintenance Contracts	5,615	
	Computer Equipment Purchases	2,435	
	Other Equipment Purchases	-	
Total Payments for 1997		**37,417**	
Excess of Receipts over Payments for 1997		**2,583**	
Balance of Cash as at 31 December 1997		**97,674**	**Credit**

NOTES TO AND FORMING PART OF THE FINANCIAL STATEMENT FOR THE PERIOD 1 JANUARY 1997 TO 31 DECEMBER 1997

1. Statement of Accounting Policies

The following accounting policies have been adopted in the preparation of financial statements.

1a. General Methodology

The financial statements, prepared in accordance with the provisions of approved Australian Accounting Standards Reporting are on the accrual basis of accounting and the accounts have been prepared under the historical cost convention.

1b. Valuation of Fixed Assets

In the years preceding 1990, the Curtin University of Technology operated on a cash accounting basis and consequently all fixed asset purchases were expensed in the year of acquisition. During 1990, all fixed assets were introduced into the financial statements at cost or valuation as an extraordinary item. This value was subsequently transferred to an Assets Revaluation Reserve.

In accordance with relevant Treasurer's Instructions, items costing less than $1000 which were purchased during 1990 have been expensed in 1990. Items of plant purchased prior to 1 January 1990 which cost less than $1000 have been excluded from the group of assets introduced during 1990.

1c. Depreciation

Plant and equipment presented in these financial statement is depreciated in accordance with the following methodology.

Desktop computer equipment	100%
Other Computer equipment	25% reducing balance method
Other Equipment	12.5 % reducing balance method

		1997 $	1996 $
2. Non Current Assets			
2a.	Computing Equipment (at cost)	243,849	243,849
	Accumulated Depreciation	(202,542)	(188,774)
	Total Computing Equipment	**41,307**	**55,076**
2b.	Other Equipment (at cost)	194,820	194,820
	Accumulated Depreciation	(135,380)	(126,852)
	Total Other Equipment	**59,440**	**67,968**
	Total Non-Current Assets	**100,747**	**123,044**
3. Asset Revaluation Reserve			
	Opening Balance	129,997	129,997
	Movement During the Year	Nil	Nil
	Closing Balance	**129,997**	**129,997**

4. Retained Profits/(Losses)			
	Opening Balance	91,048	143,005
	Net Surplus (Deficit) for the year	(22,624)	(51,957)
	Closing Balance	**68,424**	**91,048**
5. Contributions Received			
	Department of Land Administration	10,000	10,000
	Curtin University of Technology	10,000	10,000
	Bureau of Meteorology	10,000	10,000
	COSSA Canberra	10,000	10,000
	Total	**40,000**	**40,000**

ASSET REGISTER AT 31 DECEMBER 1997

Asset Number	Description	Original Cost	Accumulated Depreciation	Written Down Value
		$	$	$
Computing Equipment				
1358800	System Tracking Station	110,000.00	110,000.00	
2478800	2.3Gb 8mm Exabyte	6,272.00	6,272.00	
2494500	PS/2 25MHz 4/320MBhd and Monitor	16,686.00	16,686.00	
2494501	Memory Expansion Board 4Mb	1,911.00	1,911.00	
2494503	PS/2 Dual Asynch Adaptor	233.50	233.50	
2494504	PS/2 Dual Asynch Adaptor	233.50	233.50	
2494505	5.25 External Diskette Adaptor	204.00	204.00	
2494506	PS/2 Card Option SCSI	142.00	142.00	
2494507	OS/2 Extended Edition V1.2	700.00	700.00	
2494508	320Mb Hd Drive	4,739.00	4,739.00	
2494509	Maths Co-processor Intel 25MHz	726.00	726.00	
2494510	4-16Mb Memory Board 4Mb	1,501.00	1,501.00	
2494511	Etherlink mc Card	590.00	590.00	
2494512	Monitor Display Cable	120.00	120.00	
2494513	MS Macro Assembler V5.1	174.00	174.00	
2494514	Microsoft C Compiler V6	448.00	448.00	
2494515	Microsoft OS/2 Pm Toolkit	488.00	488.00	
2494516	Fortran V2.0	754.00	754.00	
2494517	Local Area Network Tech Manual	70.00	70.00	
2494518	PS/2 Mouse	109.00	109.00	
2552700	Tape Drive 2 Gb X801a	6,840.00	6,840.00	
2553701	Acqnr	3,800.00	3,800.00	
2585200	Paint-jet XL C1602a	2,425.00	2,425.00	
2587000	PS/2 20MHz 2/320MB hd VGA+SCSI	9,392.00	9,392.00	
2587001	Mouse	109.00	109.00	
2587002	Dual Asynch Adaptor	233.50	233.50	
2587003	Dual Asynch Adaptor	233.50	233.50	

Asset Number	Description	Original Cost	Accumulated Depreciation	Written Down Value
		$	$	$
2587004	OS/2 Extended Edition V1.2	700.00	700.00	
2587005	2Mb Main Memory Expansion	953.00	953.00	
2587007	Maths Co-processor Intel 20mhz	570.00	570.00	
2587008	2-8Mb Memory Expansion	1,450.00	1,450.00	
2587009	2Mb Memory Module	475.00	475.00	
2587010	2Mb Memory Module	475.00	475.00	
2587011	2Mb Memory Module	475.00	475.00	
2587012	Etherlink MC Card	590.00	590.00	
2587013	Future Domain	450.00	450.00	
2587014	Monitor Display Cable	120.00	120.00	
2587100	Ultra 1000 20" Monitor	2,870.00	2,870.00	
2587200	Ultra 1000 20" Monitor	2,870.00	2,870.00	
2587300	5.25 Diskette	501.00	501.00	
2629700	Cartridge System 2.5 G Byte 8M	4,950.00	4,950.00	
3914000	Microwave Communication System	57,266.00	15,959.37	41,306.63
		243,849.00	**202,542.37**	**41,306.63**
Desktop Computer				
3904000	Hewlett Packard 715/64 Workstation	25,208.00	25,208.00	
3923700	Lynxpack 6000E DDS2 4/8Gb Tape	2,098.00	2,098.00	
3923800	Lynxpack 6000E DDS2 4/8Gb Tape	2,098.00	2,098.00	
4085100	9Gb Disk Drive	2,435.00	2,435.00	
		31,839.00	31,839.00	
Total Computing Equipment		**275,688.00**	**234,381.37**	**41,306.63**
Other Equipment as at 31 December 1997				
Other Equipment				
1358700	Satellite Station Tracking	140,000.00	105,490.22	34,509.78
1948500	Power Conditioner	2,000.00	1,363.12	636.88
2009000	MA 23 CC	20,365.00	13,734.04	6,630.96
2552600	SCSI Host Adaptor 598A	1,900.00	1,136.64	763.36

Asset Number	Description	Original Cost	Accumulated Depreciation	Written Down Value
		$	$	$
2553700	Receiver NOAA I/F Format	19,500.00	11,665.58	7,834.42
3852500	Cx-FSIP4 CISCO 4 Port S/Inter	7,440.00	1,339.09	6,100.91
3852501	Pa-7kf-e1/75 CISCO Dual E1 G70	3,400.00	611.95	2,788.05
3852502	Cab E1 Bnc FSIP Mip-ce1 Bnc 75	215.00	38.69	176.31
Total	**Other Equipment**	**194,820.00**	**135,379.33**	**59,440.67**
	Total Equipment	**470,508.00**	**369,760.70**	**100,747.30**