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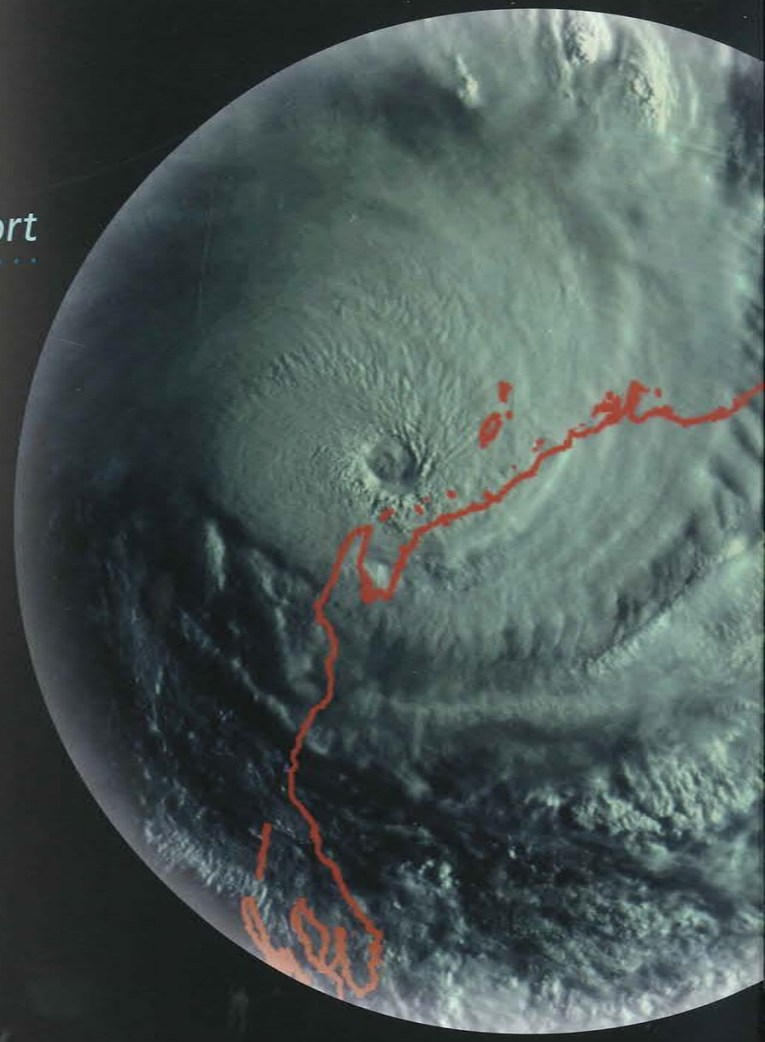
GOVERNMENT OF WESTERN AUSTRALIA

DOLA
Department of LAND ADMINISTRATION

WASTAC Annual Report



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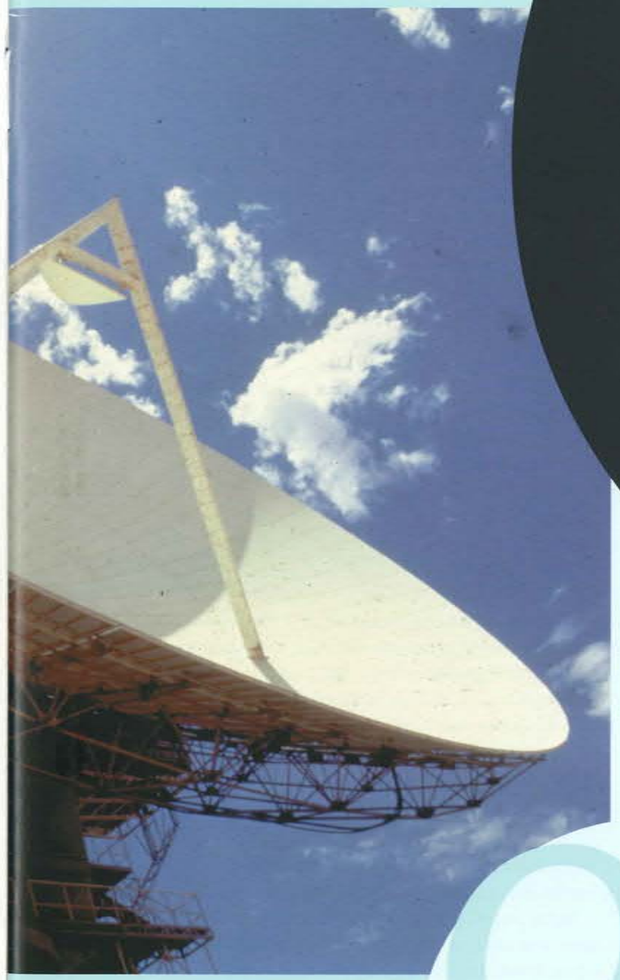
Western Australian Satellite Technology and Applications Consortium

Front cover:

Satellite image showing the advancing eye of tropical cyclone Vance just north east of the Western Australian coastline near Exmouth. The image is derived from NOAA15-AVHRR data and was taken on 22 March 1999 at 7:27 am WA standard time.

Satellite data, including WASTAC NOAA 15 passes, assisted emergency response units and weather forecasting agencies to accurately track the position of this devastating cyclone and enabled them to manage preparedness, response and recovery operations.

The NOAA 15 pass was provided by WASTAC and the image produced by the Satellite Remote Sensing Services section of the Department of Land Administration, Leeuwin Centre, Perth W.A.



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Western Australian Satellite Technology and Applications Consortium

WASTAC Annual Report 1998

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WASTAC 1998 CHAIRMAN'S REPORT

Our second five year Deed of Agreement has ended the Western Australian Satellite Technology and Applications Consortium's (WASTAC) first 10 years. In this period we have achieved significant benefits from the operational application of sensors on the American polar orbiting meteorological NOAA satellite series. These sensors include the TIROS Operational Vertical Sounder (TOVS) now routinely used for long term weather forecasting and the Advanced Very High Resolution Radiometer (AVHRR) routinely used for understanding the Leeuwin Current and monitoring the environment, vegetation, bush fires and agricultural cropping yields. AVHRR is also periodically used for cyclone and flood monitoring.

The ready supply of high quality data has stimulated on-going research by the Curtin University of Technology and CSIRO. WASTAC has contributed to the standardisation of NOAA receiving stations in Australia which has enabled AVHRR data from Darwin, Perth and Melbourne to be used continentally for vegetation and bush fire monitoring. We started receiving NOAA-9 and by 1998 were receiving NOAA-15, indicating the outstanding success of this satellite series in increasing our understanding of the meteorological, oceanic and land surface conditions impacting Western Australia's prosperity and environment.

WASTAC's strategic planning in 1998 focused on NASA's proposed direct broadcast in X-band from the MODerate-resolution Imaging Spectroradiometer (MODIS), when the EOS-AM1 satellite is launched in 1999. MODIS, a super AVHRR instrument, could significantly enhance existing applications and open up new opportunities with its 36 spectral bands and a resolution of 0.25km in the visible and near infrared. On EOS-PM1 there will be the Atmospheric Infrared Sounder (AIRS) which will significantly increase the accuracy of weather forecasts from improved vertical sounding data over the Southern and Indian oceans. WASTAC needs to enroll support for a new Consortium to fund and operate an X-band receiving station to capture the economic, social and environmental benefits of direct broadcast from MODIS and AIRS.

Tribute to the success of the past year goes to the active participation of all the WASTAC members. To Ron Craig, Department of Land Administration (DOLA), who has worked tirelessly with the Bureau of Meteorology technical staff in Melbourne and Perth, and Richard Stovold, DOLA, who has maintained the smooth running of the WASTAC Board and Standing Committee and Curtin University for sound financial management, go particular thanks.

Richard Smith
Chairman,

Western Australian Satellite Technology and Applications Consortium

WASTAC BOARD FOR 1998

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 Graeme Pearman	CSIRO, Atmospheric Research
Dr David Jupp	CSIRO, Earth Observation Centre
Dr David Griersmith	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 Alan Scott	Bureau of Meteorology
Mr Don Ward	Bureau of Meteorology
Mr Alan Pearce	CSIRO, Marine Research
Mr Jeremy Wallace	CSIRO, Mathematics & Information Sciences

WASTAC TECHNICAL COMMITTEE:

Mr Don Ward	(Chairman) Bureau of Meteorology
Assoc. Prof. Merv Lynch	Curtin University of Technology
Dr Doug Myers	Curtin University of Technology
Mr Ronald Craig	Department of Land Administration

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 ACRES and 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:

- Fengyun – 1c (1999) (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 2.4m antenna and antenna controller at the Curtin University of Technology, Bentley and ingest and display computers with hard disk storage and tape archive facilities, located at the Bureau of Meteorology premises at 1100 Hay Street, West Perth. A low speed uni-directional microwave link connects the antenna to the ingest computers. A high speed microwave communications system was installed in June 1996, allowing the transmission of raw and processed satellite data between the Leeuwin Centre, Curtin University, and the WA office of the BOM.

Colour and grey scale quicklook pictures are produced at Satellite Remote Sensing Services(SRSS) in near realtime 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 (COSSA) in Canberra.

The AVHRR ingest and display system, developed and installed by the Bureau of Meteorology in June 1996, consists of two 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 the BOM and DOLA. DOLA is able to produce vegetation maps and monitor fire scars in near realtime. NOAA and SeaWiFS archive information are posted to DOLA's World Wide Web page.

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

Due to the dedicated efforts of DOLA and BOM staff, a total of 4882 passes were recorded for the year.

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

An ongoing archive copy program has successfully copied 1980's NOAA passes from reel tape to 8mm data cartridges.

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 this year will provide Year 2000 compliance. A proposal is being prepared that will provide another antenna and reception system allowing access to X-band and other data streams as well as providing a backup NOAA reception facility.

WASTAC DATA ARCHIVE

The WASTAC archive of NOAA and SeaWiFS satellite passes, managed and maintained by the DOLA SRSS group, 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, continues to be 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 1998 on 107 4mm tapes comprising 264 gigabytes of information. Passes comprised data from the NOAA-10, NOAA-12 and NOAA-14 satellites.

Copying of the WASTAC 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 9 September 1987 and finished 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. During 1998, 859 SeaWiFS passes had been archived to fourteen 4mm data tapes.

DIGITAL QUICKLOOK ARCHIVE

At the beginning of 1997 a near real time digital quick-look archive of NOAA-AVHRR data was developed by Satellite Remote Sensing Services(SRSS) –DOLA for the World Wide Web. 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".

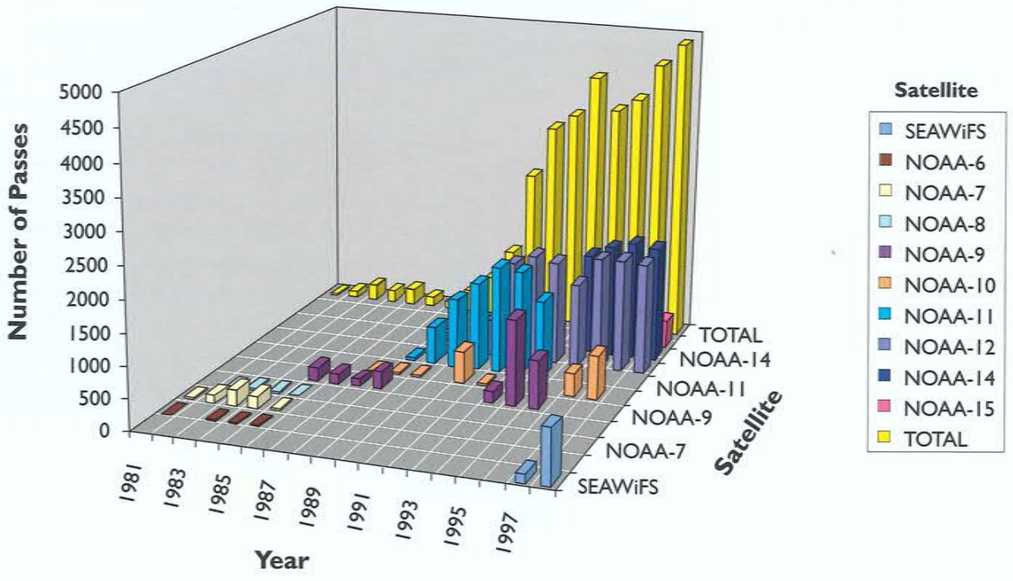
TOTAL NUMBER OF SATELLITE PASSES HELD IN WASTAC ARCHIVE AT THE LEEUWIN CENTRE

	NOAA-6	NOAA-7	NOAA-8	NOAA-9	NOAA-10	NOAA-11	NOAA-12	NOAA-14	NOAA-15	SeaWiFS	Total
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		142	4509
1998							1763	1828	432	859	4882
TOT AL:	31	593	21	3055	1665	7732	12173	7095	432	1001	33798

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

835 WASTAC archive 8mm tapes 269 WASTAC archive 4mm tapes

WASTAC NOAA/AVHRR and SeaWiFS ARCHIVED DATA



1998 SATELLITE DATA ARCHIVE HELD BY WASTAC

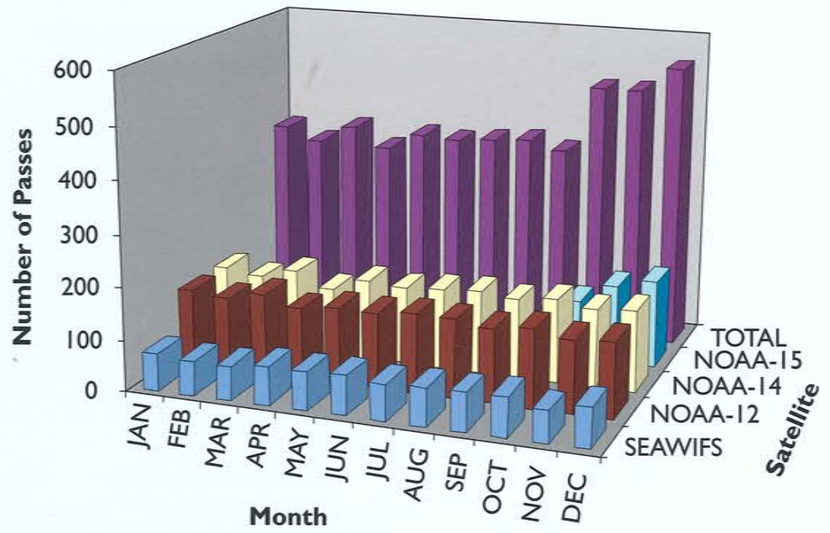
	NOAA-12	NOAA-14	NOAA-15	SeaWiFS	TOTAL
JAN	149	152	-	71	372
FEB	140	141	-	66	347
MAR	157	159	-	65	381
APR	138	133	-	74	345
MAY	147	156	-	75	378
JUN	147	150	-	76	373
JUL	153	157	-	70	380
AUG	152	161	-	73	386
SEPT	143	152	-	75	370
OCT	151	160	113	76	500
NOV	140	150	150	61	501
DEC	146	157	169	77	549

NOAA
4mm Tapes: 4023 passes on 112 tapes

SeaWiFS
859 passes on 14 tapes

Total data archived: 243 gigabytes 49 gigabytes

WASTAC 1998 NOAA/AVHRR and SeaWiFS ARCHIVED PASSES



RESEARCH AND OPERATIONAL APPLICATIONS

CSIRO

Marine surveys along the Hillarys transect

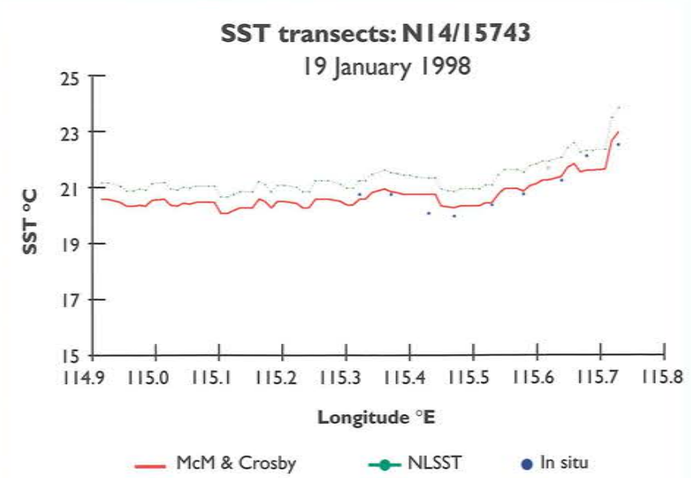
Alan Pearce+, Merv Lynch*, Luke Twomey^.
+ CSIRO Marine Research, Marmion, WA.
* Remote Sensing and Satellite Research Group, School of Physical Sciences, Curtin University.
^ School of Biological Sciences, Curtin University.

The monthly field surveys undertaken as part of the Fisheries Research and Development Corporation (FRDC) project measuring physical, chemical and bio-optical properties of the continental shelf waters off Perth have been completed. The dates of the full set of 27 transects were:
1996: 8 October, 11 November, 10 December.
1997: 13 January, 17 February, 19 March, 21 April, 21 May, 16 June, 21 July, 20 August, 17 September, 14 October, 18 November, 15 December.
1998: 19 January, 16 February, 17 March, 21 April, 19 May, 23 June, 15 July, 26 August, 23 September, 20 October, 10 November, 9 December.

On each transect, surface temperature and salinity, temperature and salinity profiles, depth-integrated chlorophyll and nutrients, light measurements, and both phyto- and zoo-plankton trawls were measured at nine stations out to 40 km offshore (the station positions are shown in the 1996 WASTAC Annual Report), and underway measurements of surface temperature, salinity and fluorescence were logged throughout. These data are being used in surface validation of SeaWiFS-derived chlorophyll estimates and the development/refinement of chlorophyll algorithms, as well as validation of satellite-derived sea surface temperature (SST).

The SST and chlorophyll results are outlined here; more detailed results on the other measurements are given in the Curtin University section of this report. Surface temperatures were measured using a calibrated mercury thermometer in a bucket of surface water, a thermal profiler, a continuous underway logger, and a TASCO radiometer.

Surface temperatures derived from the NOAA-AVHRR generally compare well with the in situ bucket temperatures, both in summer and winter (Figure 1). The NLSST algorithm, which takes account of the satellite zenith or scan angle, often (but not always) yields higher temperatures than the older McMillin and Crosby, and our preliminary analysis of the results from the Hillarys transect suggests that the latter may in fact give better comparisons with the surface measurements, at least off southwestern Australia. Analysis of the full dataset indicates that the satellite-derived values can be almost 2°C higher on occasion in summer, and we are investigating the vertical thermal profile and wind speed at each station.



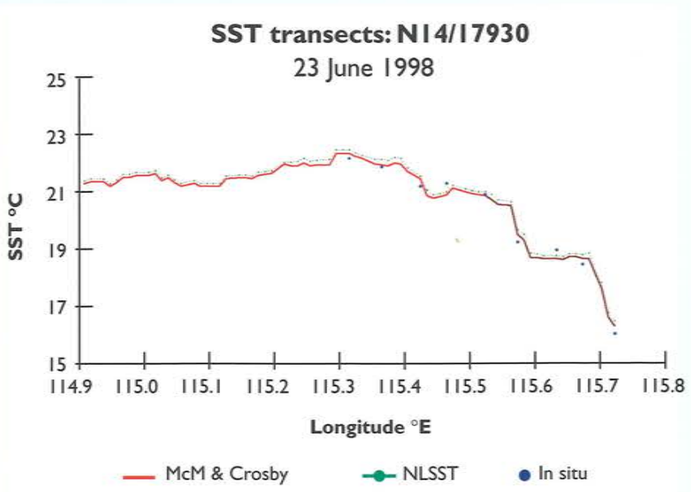


Figure 1: SST transects out from the coast to 114°54'E, extracted from the NOAA14-AVHRR using the McMillin and Crosby (solid line) and NLSST (dotted) in January (upper panel, representing summer) and June (lower panel, winter). The surface temperatures measured in situ using a calibrated mercury thermometer in a bucket at the nine Hillarys transect stations are shown as filled circles

Chlorophyll concentrations at each station were sampled from the upper 18 m water depth. There is (as anticipated) a high degree of both temporal and spatial variability in chlorophyll concentrations in our coastal waters. The greatest variability tends to be near the coast with chlorophylls approaching (and occasionally exceeding) 1 µg/l, whereas further offshore the concentrations are less than half this value and the variability is correspondingly lower (Figure 2). Seasonally, peak chlorophylls occur during the winter as found in other local studies, with a particularly strong peak in June.

Acknowledgements:

Perth Diving Academy for their collaboration in chartering the dive-boat *Lionfish 2* as well as technical assistance during the surveys. Simon Braine (CSIRO) assisted in the field and with the chlorophyll analyses, while Stuart Helleren (DALCON) analysed the chlorophyll data. AVHRR satellite imagery was acquired from WASTAC.

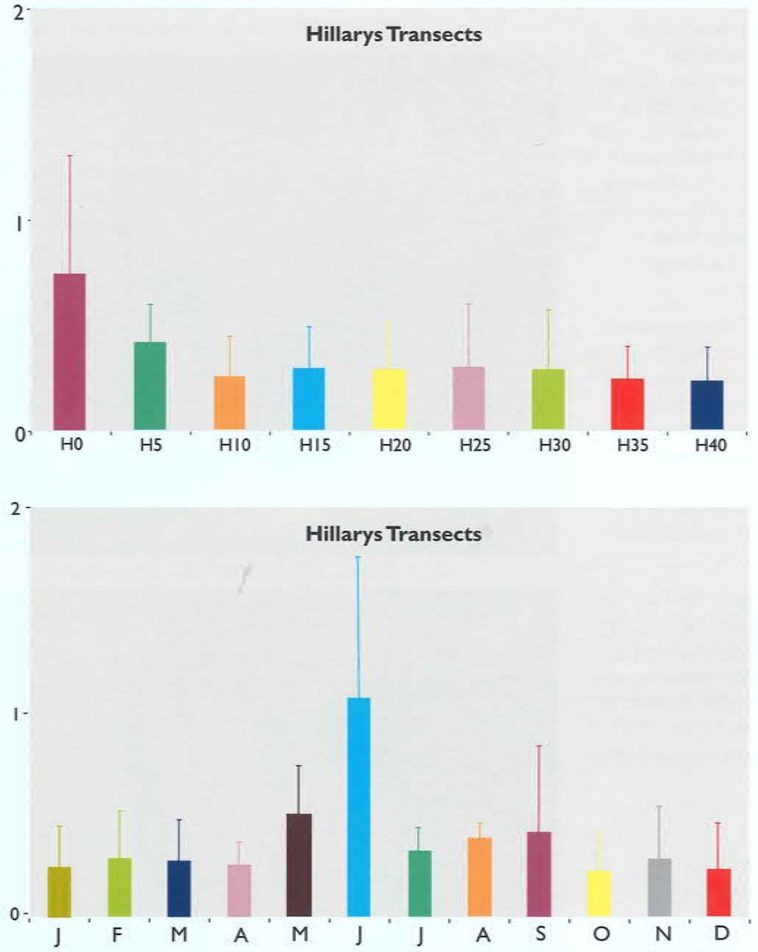


Figure 2: (Upper panel) Mean depth-integrated chlorophyll concentrations along the Hillarys transect H0 to H40. (Lower panel) Monthly mean depth-integrated chlorophyll concentrations for the whole transect. The thin bars show the standard deviations (from Pearce, A.F., S.K.R. Helleren & M. Marinelli (in prep). Review of productivity levels of Western Australian coastal and estuarine waters for mariculture planning purposes. Fisheries WA Research Report).

Mesoscale features of the Leeuwin Current in AVHRR imagery

Alan Pearce+
+ CSIRO Marine Research, Marmion, WA.

An analysis of AVHRR SST images of the southwestern coast of Western Australia has been undertaken to examine oceanic processes in and around Geographe Bay during 1998.

During the summer months, the warm Leeuwin Current is relatively weak because of the strong northwards (opposing) wind stress, and the Current tends to move offshore. The cooler Capes Current flows northwards along the inner continental shelf past Cape Leeuwin and Cape Naturaliste, usually continuing beyond Rottnest Island.

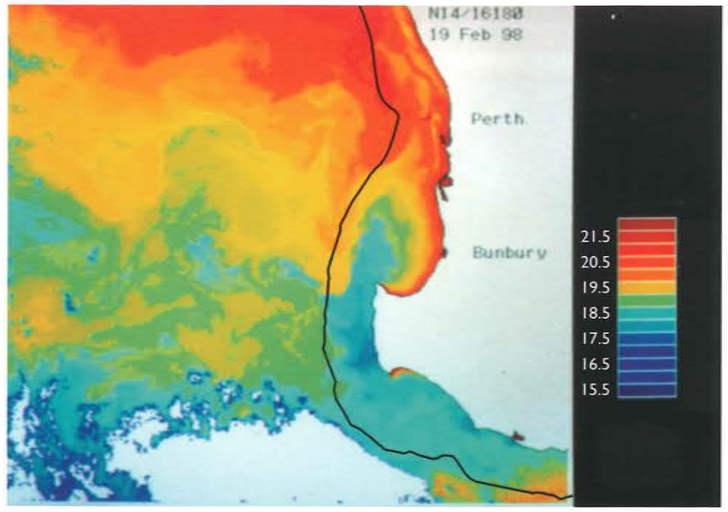
With autumn, the net northward wind stress eases, the Capes Current dies away, and the Leeuwin Current begins to strengthen and move closer inshore again. Large meanders and eddies associated with the Leeuwin Current can carry the warm tropical water over 100 km offshore. The Current continues to flow strongly until late spring when it weakens, tends to move offshore, and the Capes Current re-commences.

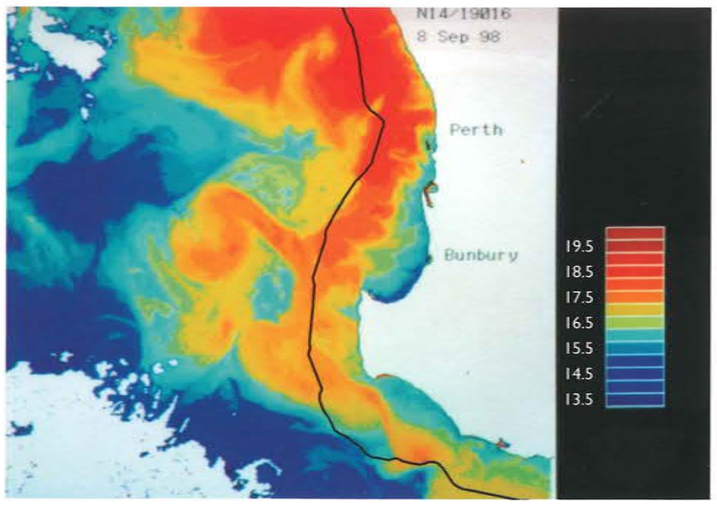
Tongues of Leeuwin Current water are often seen penetrating across the continental shelf towards the coast, representing an active exchange of inshore and Leeuwin Current water. This clearly has implications for marine larvae which can be transported either towards or away from the coast by these cross-shelf mixing processes.

The seasonal change in net heat flux into the ocean (in summer) and net heat loss from the ocean (winter) results in a seasonally-reversing cross-shelf temperature gradient. In summer, the shallow coastal water warms, so the temperature falls with increasing distance from the coast into the cool Capes Current, then rises again into the Leeuwin Current. In winter, by contrast, the coastal water in Geographe Bay cools dramatically and there is a strong temperature rise into the Leeuwin Current.

Acknowledgements:

The NOAA-AVHRR satellite imagery was acquired from WASTAC, from funding partly provided by the Fisheries Research and Development Corporation (FRDC). Jeremy Colman (CALM, now Woodside) initiated the Geographe Bay project, and Jodi Cake processed the images.





Colour images: NOAA SST images of the Geographe Bay region in February (representing summer) and September (winter) of 1998. The warmest water is shown in red, cooling through yellow and green to the coolest water in blue. Clouds are shown in white or mottled blue. The black line shows the 200 m isobath, marking the approximate edge of the continental shelf.

Sea Surface Temperature (SST) Validation

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

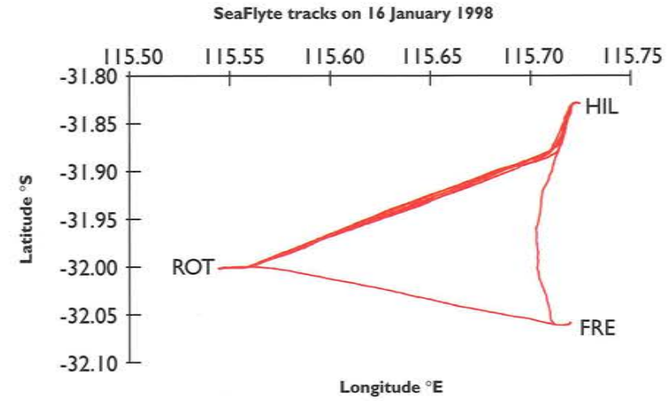
Despite some "teething problems" which have delayed the full implementation of routine SST logging on the Rottnest ferry (as described in the *1997 WASTAC Annual Report*), the results obtained during 1998 have confirmed the potential value of this project as part of a national SST validation program. The temperatures from the vessel's engine intake and the surface-viewing radiometer are being used for validation of satellite-derived temperatures from the NOAA-AVHRR and the ATSR on the ERS-1 and -2 satellites, as well as for examining relationships between the "skin" (radiometer) and "bulk" (intake sensor) temperatures and monitoring variations in cross-shelf temperature gradients on the continental shelf off Perth.

The ferry intake temperatures clearly show the variable cross-shelf thermal structure between the three sites of Hillarys, Rottnest and Fremantle (Figure 3). The water is warmest against the coast at Hillarys and Fremantle, and there is a temperature drop across the cool Capes Current before the water warms at Rottnest Island again.

There are plans to install a fluorometer on the ferry so that the surface chlorophyll distribution of Perth coastal waters can also be monitored on a daily basis to provide "surface truth" data for remotely-sensed chlorophylls from ocean colour satellites.

Acknowledgements:

Boat Torque Cruises, operators of the Rottnest ferry, for their collaboration in allowing SST sensors to be fitted to the *SeaFlyte* ferry for this project. NOAA-AVHRR satellite imagery was acquired from WASTAC. Funding support from the CSIRO Earth Observation Centre is gratefully acknowledged, as is Ian Barton's (CSIRO Marine Research) guidance during this project.



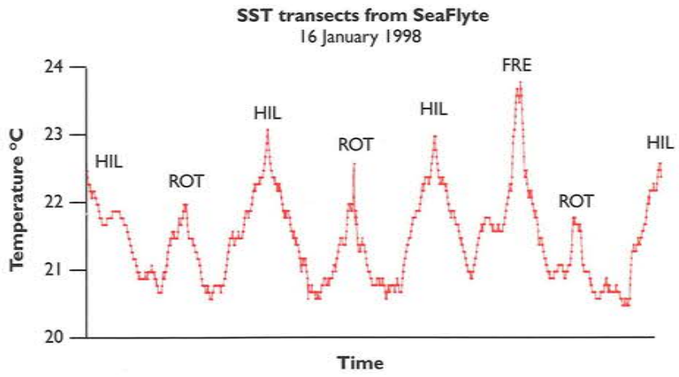


Figure 3: The track of the Rottnest ferry SeaFlyte between Hillarys HIL, Rottnest Island ROT and Fremantle FRE on 16 January 1998 (upper panel). The lower panel shows the intake water temperature along transects between the three sites for that day.

The Common AVHRR Processing Software (CAPS)

Harvey Davies, CSIRO Atmospheric Research

To improve the consistency of Advanced Very High Resolution Radiometer products from different satellite processing facilities around Australia (including WASTAC), the CSIRO Earth Observation Centre initiated the Common AVHRR Processing Software project (CAPS). Its objective is to produce accurate standard calibrated and geolocated AVHRR data products.

The primary functions of CAPS are:

- reading AVHRR data from HRPT (High Resolution Picture Transmission) files;
- geolocation (calculating the latitude and longitude of AVHRR image pixels);
- calibration (conversion of radiometer counts to radiance, reflectance and brightness temperature);
- array processing (including arithmetic, graphics and input/output);
- projecting data (to any map projection); and
- reading and writing HDF (Hierarchical Data Format) files.

The raw HRPT data come from the NOAA/TIROS series of polar orbiting satellites. CAPS can read most HRPT file formats used in Australia and supports the new channel 3a which was introduced on the NOAA-15 satellite launched in 1998. CAPS can also read Along Track Scanning Radiometer (ATSR) data. Geolocation can be done using either the well known Brouwer-Lyddane orbital propagator (giving errors of about 3 pixels), or the CSIRO Clift orbital propagator with attitude correction (giving errors of about 1 pixel).

Current users and hence potential beneficients of CAPS include:

- Department of Land Administration, Perth, Western Australia.
- Australian Institute of Marine Science, Townsville.
- Department of Natural Resources, Queensland.
- Bureau of Meteorology, Melbourne.
- Institute of Antarctic and Southern Ocean Studies, Tasmania.
- Various divisions of CSIRO.

The experience of these users with early versions of CAPS has led to significant improvements. The "CAPS Developer Group" is intended to break down the barriers between users and developers and promote further development in a cooperative manner. Source code is available to organisations which join this group, while documentation and binary executable files are freely available to all on the World Wide Web.

Summary of the Direct Broadcast meeting held in Canberra, December 1998.

Ian Barton, CSIRO Marine Research, Hobart.

A joint Australia/NASA meeting on the direct broadcast of data from EOS platforms to national and foreign ground stations was held at CSIRO Headquarters in Canberra, Australia during December 1998. This (edited) summary of the meeting is included here as indicating the direction of future direct-broadcast satellites relevant to WASTAC and local users.

Following a welcome by Dr David Jupp, Head of CSIRO's Office of Space Science and Applications (COSSA), the meeting commenced with a NASA review on the status of their EOS Program including plans for the direct broadcast of data to ground reception stations. For the AM-1 platform only data from the MODIS instrument would be available, but for the PM-1 satellite earth observation data from all instruments would be available via direct broadcast. Currently NASA is planning for four national reception sites, but many foreign stations in Europe, Asia, South America and Australia are also planning direct reception of these data. There is a commitment by NASA to the concept of an international user community which shares information on data reception, processing algorithms, calibration and validation, and NASA's policy is to support free exchange of EOS data for approved scientific, operational public good uses, and educational users.

The introductory talk was followed by speakers giving examples of the importance of real-time data in different applications. Richard Smith of DOLA Western Australian gave examples of the use of AVHRR data in the management of agricultural areas with special emphasis on the detection of areas affected by salinity and by grass fires. DOLA currently operate an automated near real-time fire monitoring program for northern Australia based on NOAA AVHRR data. A consortium in Western Australia is planning to develop Australia's third X-band reception station in Perth over the next year, ensuring that a range of new data, including possibly real-time EOS direct broadcast data could be made available to applications in Western Australia.

Among other speakers who demonstrated the application of satellite data products to the management of agriculture, land use, and environmental studies, Ian Barton of CSIRO Marine Research described the many benefits of the use of real-time satellite data in the management and research of Australia's Marine Exclusive Economic Zone. He stressed the need for the development of a suitable processing package which would allow foreign direct broadcast reception stations to obtain Level 1B data products (geo-located geophysical quantities) from the raw data stream. Graham Harris of CSIRO Land and Water talked about a new program to address and reverse salinity and erosion problems in the Murray-Darling Basin.

Following a brief summary of the meeting by Ian Barton there was wide ranging debate about issues relating to processing software and the distribution of data products. NASA reconfirmed its policy of free exchange of data for approved research, operational public good activities and educational applications.

CURTIN UNIVERSITY OF TECHNOLOGY

Remote Sensing and Satellite Research Group, School of Physical Sciences

SST Algorithm Development and Validation

Matt Boterhoven*, Brendon McAtee*, Andrew Rodger*, Brian Osborne*, Mervyn Lynch* and Alan Pearce+.
* Remote Sensing and Satellite Research Group, School of Physical Sciences, Curtin.
+ 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 these all in their own way mainly attempt to correct or compensate for the effect of the intervening atmosphere. The atmosphere is primarily thought of as an absorber of radiation. However, because it is warm, it also emits radiation toward the satellite. In fact, it emits in all directions including downwards and some of this radiation is reflected at the sea surface back toward the satellite sensor. The atmosphere is not nearly 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) the various radiative terms noted above will vary in magnitude with satellite off-nadir view. Further, because the atmosphere itself varies with time (hourly through to seasonal scales), these corrections are intrinsically complex to apply but essential if the best use of radiometric data from the satellite 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. We are able to include the various emission and absorption processes mentioned above. The synthetic radiances that are produced from the model are used to develop regression relationships and hence algorithm coefficients for more accurately 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 (see elsewhere in this Report), which are 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 measurements.

The above 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 mid-1999. It is also planned to use 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 by the observational data itself and applied without user intervention to the satellite radiometry to produce the SST product.

Of particular importance, and directly related to the ocean bulk and skin temperature, is the ocean heat flux (OHF). How the heat flux will be measured from satellite presently remains unclear. However, research is in progress using synthetic data from line-by-line transmittance code (LBLRTM) and ship observations using a high spectral resolution infrared interferometric radiometer. Data from this latter instrument, the Marine Atmospheric Emitted Radiance Interferometer (MAERI), has been acquired under a cooperative research program with the University of Wisconsin, USA. The plan is to extend this ocean heat flux research during 1999 with in situ measurements in the Indian Ocean and to use NOAA/AVHRR to assess oceanic SST - particularly its regional uniformity.

This research is, in part, a cooperative initiative with CIMSS/SSEC, University of Wisconsin, Madison, Wisconsin, USA supporting a contribution to the MODIS calibration and product validation program.

SeaWiFS and Ocean Colour Sensing

Jim Davies*, Peter Fearns*, Marc Marinelli*, Helen Chedzey*, Norm Santich*, Mervyn Lynch*, Alan Pearce+and John Parslow$
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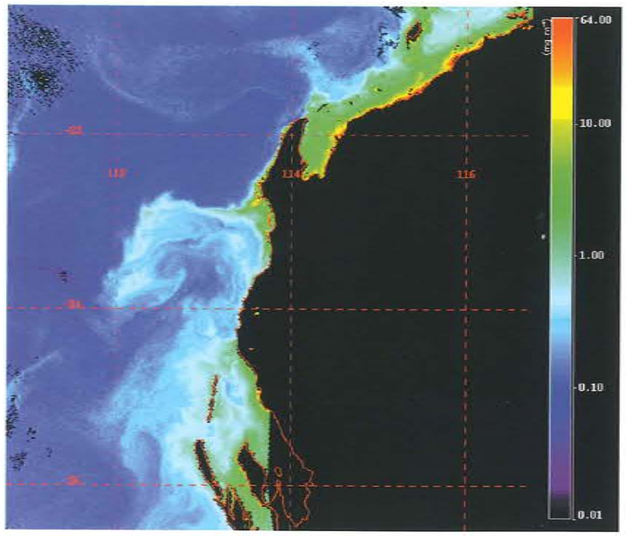
+ CSIRO Marine Research, Marmion, WA.
$ CSIRO Marine Research, Hobart, Tasmania.

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 downlinked in Australia at Perth (WASTAC), Hobart (CSIRO Marine Research) and Townsville (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).

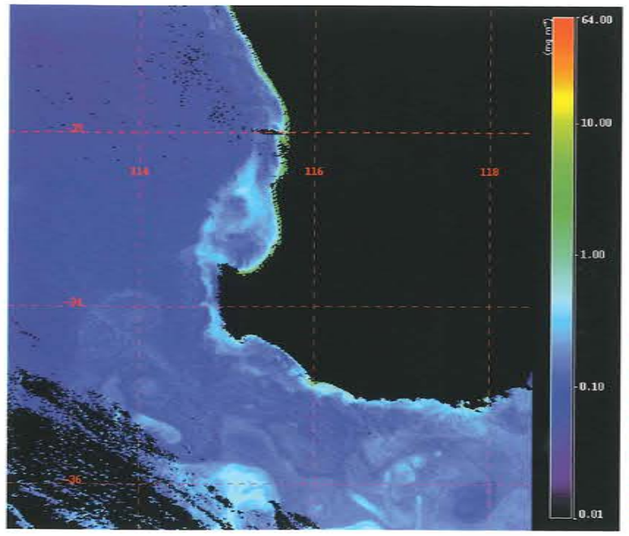
Figure 1.

SeaWiFS chlorophyll concentration image for the 1 November 1997. This shows the high concentration of chlorophyll along the NW of WA. An interesting feature is the inshore current running north at 113E 23S, counter to the southerly flowing Leeuwin Current. The northward flowing current turns westward at Point Cloates. This anomalous current scours the phytoplankton rich waters from the southern half of the Ningaloo Marine Park, carrying them offshore. The phytoplankton poor waters of the northern half of the marine park are in stark contrast to the majority of the NW coast at this time of year.



As planned, after some three months of transmission, the SeaWiFS data stream was encrypted to prevent other than authorised users being able to utilise 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 GSFC. Particular attention has been given to those data recorded for the dates of the Hillarys Transect. The initial scientific interest has been to validate the so-called Level 2 products from the SeaDAS processing suite. Key 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 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 have 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.



The major research topics using SeaWiFS data are (i) aerosol optical depth and size distribution determination, using an alternate scheme to the SeaDAS software, (ii) Chl a retrieval algorithms and in situ validation and (iii) application of data to study coastal processes.

Figure 2.

SeaWiFS chlorophyll concentration image for the 18 November 1997. The waters of the SW are clearly phytoplankton poor when compared to the northern half of WA (see Fig. 1), an indication of the nutrient depleted state of the ocean. Eddy structures to the South of the State show mixing of coastal waters with the Southern Ocean. The high chlorophyll concentration in Geographe Bay may indicate the presence of the northerly flowing Capes Current.

Satellite Estimation of Maritime Atmospheric Aerosol Optical Thickness from NOAA AVHRR Data

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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 micrometer 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 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 northwestern 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 was installed at Rottnest Island (off the coast near Perth) to sample maritime aerosol properties. This instrument has enabled comparisons with NOAA AVHRR-derived AOTs and also with SeaWiFS's level 2 AOT products.

Solar Photometry Field Site on Rottnest Island for Validation of Oceanic Atmospheric Correction to Satellite Data

Jim Davies, Brian Osborne, Luigi Renzullo, Norm Santich and Mervyn Lynch
Remote Sensing and Satellite Research Group, School of Physical Sciences, Curtin

A multi-filter rotating shadow band radiometer (a Yankee Environmental Systems MFRSR solar photometer) was installed on Rottnest Island during 1998. The data are downloaded daily via the mobile phone network and archived in a data base at the Leeuwin Centre. The primary purpose of the instrument is to provide aerosol optical depths for validating the atmospheric correction applied to satellite data. This is particularly important over oceanic regions because atmospherically scattered radiation frequently can comprise 80 to 90% of the signal detected by a satellite sensor viewing the ocean in the visible portion of the spectrum. A 10% error in the atmospheric correction may well be equal to the total signal attributable to ocean colour. Accordingly, the atmospheric correction is a key factor in obtaining accurate ocean colour products (e.g. chlorophyll).

The data from the solar photometer presently are being used to investigate the aerosol correction applied to data from the SeaWiFS ocean colour sensor by the NASA supplied SeaDAS processing code. The independent ability to validate the aerosol and hence the atmospheric correction provides confidence in the derived product the SeaWiFS water leaving radiance.

A further use of solar photometry data is in the validation of satellite-derived land surface spectral reflectance. The Rottnest site has a varied land cover and is a suitable site for making in situ measurements of land surface spectral reflectance and the associated bidirectional reflectance distribution function (BRDF). The derivation of land spectral reflectance from SeaWiFs and NOAA/AVHRR requires the determination of the atmospheric contribution to the satellite-detected radiance. The atmospheric contribution includes both a molecular and aerosol component. It is this aerosol contribution that may be validated against the independent solar photometer measurements. A validated atmospheric correction scheme gives confidence in the quality of the land surface reflectance product which, as indicated above, is subject to independent in situ validation.

Acknowledgement: The MFRSR solar photometer was provided under a FRDC grant. The installation and servicing of the instrument were supported by an ARC Small Grant awarded to Curtin University.

Satellite Validation Field Site at Broome, Western Australia

Brendon McAtee, Norm Santich, Luigi Renzullo, Frank Yu, Mervyn J Lynch, Fred Prata#, Graeme Rutter# and Bob Cechet#
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#CSIRO Atmospheric Research, Aspendale, Victoria.

During 1998 a field site for satellite validation research was established on Thangoo Station, Roebuck Bay near Broome in Western Australia. The site completes a national network of radiation measuring Continental Integrated Ground Site Network (CIGSN) sites initiated by CSIRO Atmospheric Research. The site is suitable for several important validation and research programs using satellite data. The site was surveyed in 1998 as a preliminary to installation of a suite of radiometric instruments. Instruments include up and down viewing pyranometers and pyrgeometers for earth radiation budget (ERB) studies. A set of five 5 metre high towers has been fitted with in situ calibrated scanning infrared radiometers. A multi-filter rotating shadow band radiometer (a Yankee Environmental Systems MFRSR solar photometer) was installed during 1998.

Primarily, the site has been established to provide validation for the ASTER instrument on the EOS AM-1 platform (Terra) when launched in 1999. For these applications the in situ measurements will provide validation for surface temperature and surface emissivity. The site currently is being used to validate land temperature estimates from NOAA/AVHRR and the ATSR2 instrument on ERS1. The multi-filter rotating shadow band radiometer (MFRSR) is providing validation for atmospheric correction to SeaWiFS derived products produced from imagery of the NW Shelf coastal zone (see SeaWiFS project above). The pyranometers and pyrgeometers are being installed to provide direct measurement of ERB. These in situ surface measurements are to be compared with estimates of ERB made from satellite radiometers (NOAA/AVHRR, SeaWiFS(over land), ATSR2, MODIS and CERES radiometer). Additionally, the MFRSR is to be used to assess the impact of aerosol on the ERB.

Estimation of Tropical Cyclone Intensity Using Microwave Radiometry from the NOAA MSU Sensor

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

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BMRC, Bureau of Meteorology, Melbourne, Victoria

+CSIRO Atmospheric Research, Aspendale, Victoria

Microwave emission from the atmosphere is 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 the NOAA polar orbiting satellite series are 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 Bureau of Meteorology. 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.

DEPARTMENT OF LAND ADMINISTRATION (DOLA)

Satellite Remote Sensing Services (SRSS)

Frost Image

Mike Steber, DOLA

In October 1998, SRSS was asked by the Australian Wheat Board (AWB) to assist in the battle against frost. In September severe frosts affected an area of 30,000 sq km in the Great Southern and Wheatbelt, resulting in a loss of crops conservatively estimated at $350 million. The AWB asked SRSS to prepare maps of the South West indicating the areas most likely to be frost affected. Because of the lack of a Land Surface Temperature (LST) algorithm within the software available at SRSS a Sea Surface Temperature algorithm was used. The two days when the temperature was at its lowest were on 19 and 23 September. The early morning NOAA-12 images for these two days were about 90 % cloud free. The images showed that temperatures in most of the agricultural region were dropping below 0° Celcius. SRSS's images will be used to develop strategies to combat future frosts. The prepared images were also provided to Agriculture Western Australia. It is also hoped that SRSS's software can be updated to include a LST algorithm.

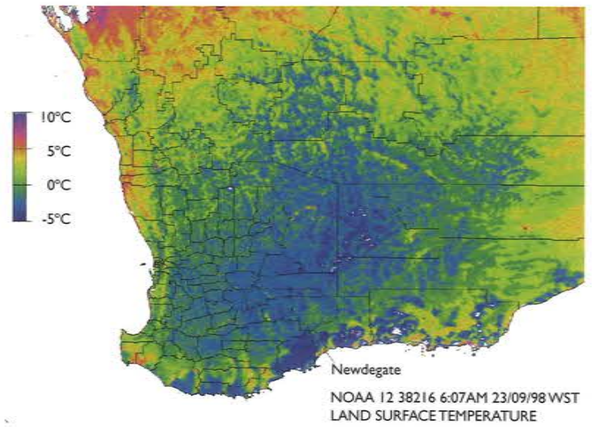


Figure 1. Land Surface Temperature image derived from NOAA-12 38216 dated 23/09/98 06:07 WST.

Sea Surface Temperature (SST)

Mike Steber, DOLA

SRSS and CSIRO Marine Research continued their collaborative project producing Sea Surface Temperature images for the WA fishing industry. During the year 106 separate SST images were produced for clients. These clients included other government departments like CALM and also commercial fishermen from Perth, Fremantle, Albany, Dongara, Geraldton and Onslow. The vast majority of the images are sent over the Internet and the turnaround is now within two hours of the satellite data being received. During 1999 SRSS is hoping to develop an online service providing 24 hour access. As a community service SST images and a current interpretation were placed on the SRSS web site for the Naturaliste Game and Sports Fishing Club.

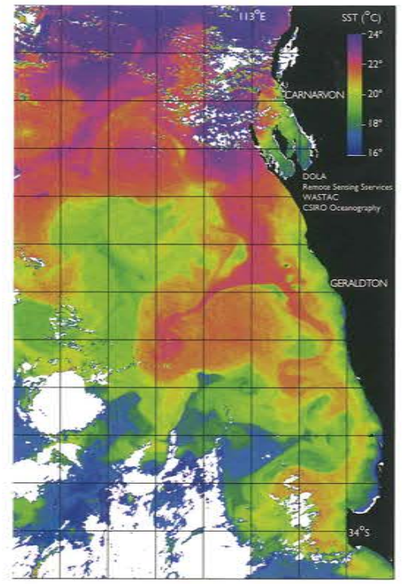


Figure 1. Sea Surface Temperature image derived from NOAA-14 18995 dated 07/09/98 02:50 WST.

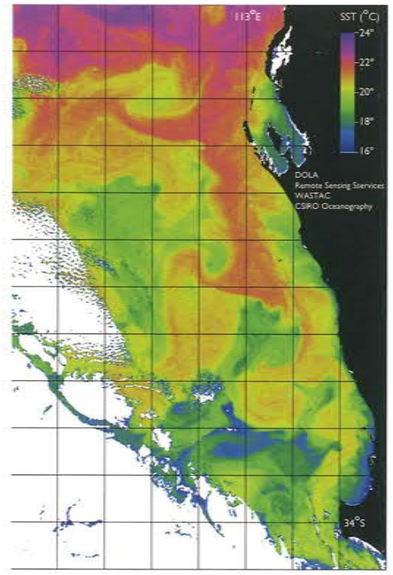


Figure 2. Sea surface Temperature image derived from NOAA-14 19221 dated 23/09/98 03:13 WST.

Continental Mapping of Fires across Australia

Jackie Marsden, et al., DOLA

In 1996 the release of 'State Environment Australia 1996' highlighted the dearth of information which existed about the fire regimes of Australia. Indeed, this report grossly underestimated the true extent of burning which occurs across Australia each summer season. In 1998, Satellite Remote Sensing Services (SRSS) DOLA was charged with the task of mapping the fire history of the Australian continent for the period April 1998 to June 1999, a period spanning both the northern and southern fire seasons. This is an extension of the work which has been continuing across northern Australia.

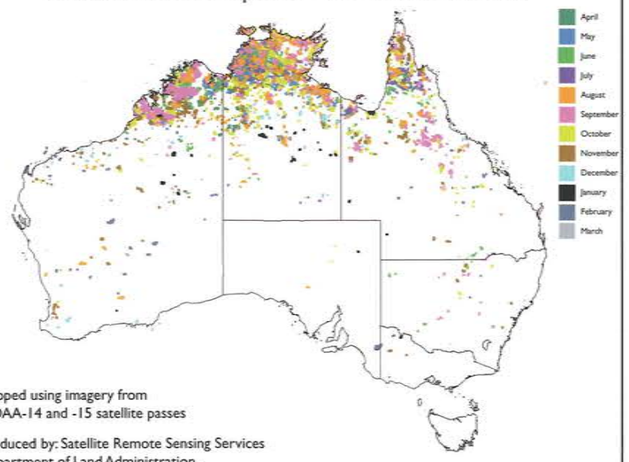
The annual cycle of burning which occurs across Australia is a relatively natural process. Indeed much of the diversity of plant species seen in the tropical savanna owes its existence to the continual renewal of vegetation associated with fire. The onset of pastoralism and farming practices has brought a new dimension to the way people relate to fire and the management of fire in these areas. Fire, used in the same manner as the traditional Aborigines is an important tool in the management of wildfires which threaten communities and wipe out many hectares of pastoral land each year. Knowledge of the fire regimes of these areas and how they vary from year to year may be used as a preventative measure against the spread of large wild fires.

The fire regimes of Australia may be separated into two seasons:

- the northern season which follows the passage of the monsoon usually begins in March with the cessation of the monsoon rains and subsequent curing of the vegetation,
- and the southern season which begins around October with the onset of the mid-latitude summer.

Continental coverage of Australia using NOAA AVHRR data is obtained using data from Perth, Melbourne and Darwin receiving stations. The maps presented below show the extent of fire across Australia from April 1998 to March 1999. The colours are indicative of the month in which the burn occurred. The first map shows the fire hotspots detected over the period. These are the fires which were burning as the satellite passed over the area and are detected using channels 3 and 4 of the AVHRR sensor. The following map shows the fire-affected area (FAA) which is the area burnt during the passage of the fire. Small fires may not leave a scar which is visible from the NOAA AVHRR sensor.

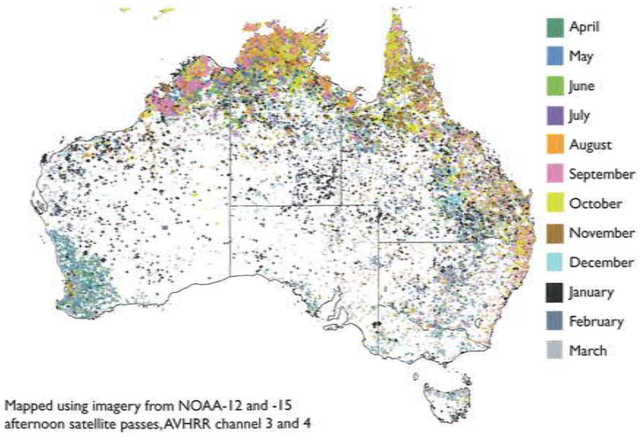
Fire Affected Areas - April 1st 1998 to March 31st 1999



Mapped using imagery from
NOAA-14 and -15 satellite passes

Produced by: Satellite Remote Sensing Services
Department of Land Administration,
Leeuwin Centre, Perth, WA

Fire Hotspots - April 1st 1998 to March 31st 1999



Mapped using imagery from NOAA-12 and -15
afternoon satellite passes, AVHRR channel 3 and 4

Vegetation Watch:

Robert Shaw, John Adams DOLA.

The vegetation watch project supplies state government agencies within Western Australia and the Northern Territory with hard copy NOAA NDVI greenness images on a monthly basis. These images are a fortnightly composite, and are distributed monthly.

Agencies who benefit from this data include;

10 Agriculture WA offices

7 Bush Fire Service offices

5 CALM offices

1 Conservation Commission office in NT.

These agencies have been receiving regular images since 1992. This has allowed agencies to build up a sizable catalogue of images as a record for monitoring vegetation change trends throughout the year. These images can be accessed on DOLA's web page.

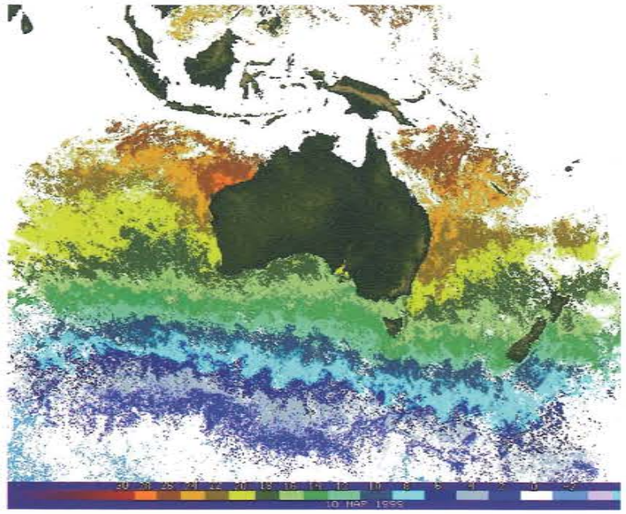


Figure 1

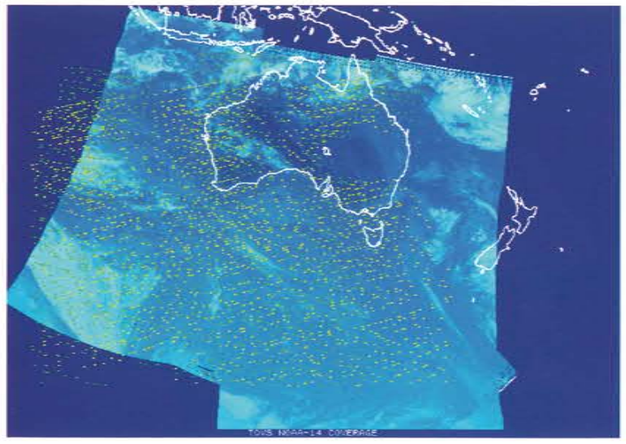


Figure 2: TOVS coverage from WASTAC and the Bureau's Melbourne NOAA station, overlayed on a mosaic of WASTAC and Melbourne AVHRR data.

BUREAU OF METEOROLOGY

Mike Willmott, et al., Bureau of Meteorology Melbourne.

Sea Surface Temperature

The BOM, by combining data from WASTAC with similar NOAA AVHRR data from its Casey, Melbourne and Darwin stations calculates satellite derived sea surface temperatures (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 (e.g. assimilation into BOM numerical weather prediction models) and are also available for external users via the World Wide Web. The coverage from the four stations can be seen in figure 1, which clearly shows the contribution from the WASTAC station.

SST products are now available for external users via BOM's "Weather by Fax" service in addition to subscription services on the WWW.

Weather Modelling/forecasting

The 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 enabled via the new BOM-CSIRO joint supercomputer facility (NEC SX-4), 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, 1999 - three references) that assimilation of TOVS data into the Limited 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 skill of the models. Figure 2 shows the coverage of TOVS data for one day from the BOM system, whilst Figure 3 shows an example of output in the form of 500 hPa temperatures.

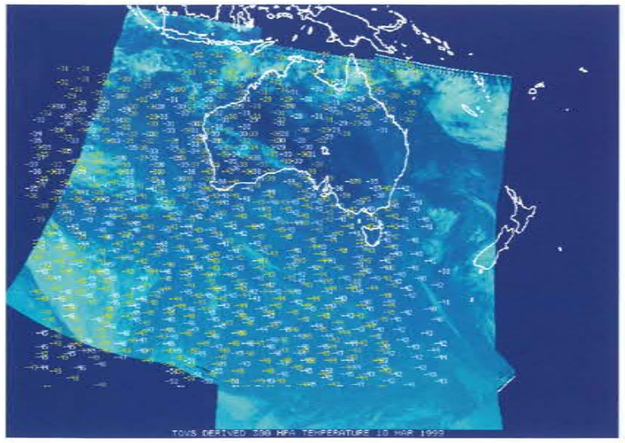


Figure 3: 500 hPa temperatures from TOVS. These data are input into BOM's Limited Area Prediction System (LAPS) NWP model.

Flood Monitoring

BOM is developing the use of NDVI data for flood monitoring in an operational environment. The system although under development 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.

Volcanic Ash

BOM uses AVHRR (and GMS-5) data to monitor volcanic ash plumes from active volcanoes which are extremely hazardous to aviation. The most active volcanic region in the world lies just to the North of Australia where international air traffic to and from Australia is concentrated. 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. By way of example, in 1996/97 Darwin issued a total of 267 advices covering the area South of 10° N between longitudes 100° E to 160° E.

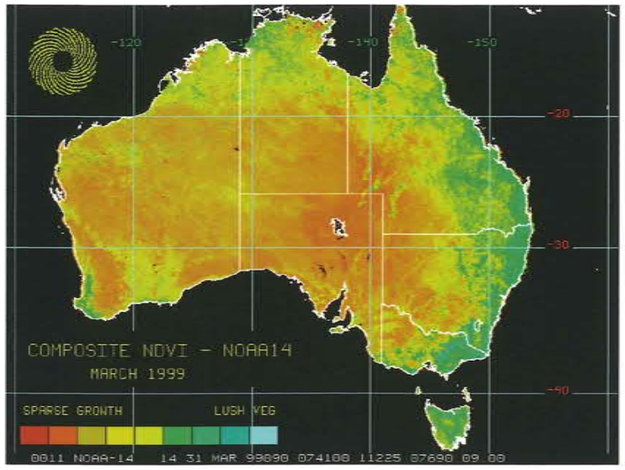


Figure 4: Example of a current operational NDVI product using Melbourne AVHRR data only.

Cyclone Monitoring

The BOM WA Regional Forecasting Centre in Perth provides warnings of tropical cyclones whenever the need arises from their Tropical Cyclone Warning Centre (TCWC). The AVHRR data is used to assist in the monitoring of fine detail of tropical cyclones and supplements the positioning of these large systems by radar, GMS-5 imagery and NWP analysis. It is also a critical back-up to GMS-5 imagery.

Fire Hot Spots

BOM has developed algorithms for fire detection and although focussed on the southern States will, in the future, use WASTAC AVHRR data operationally in support of its statutory obligations to supply fire weather forecasting and warning services for Western Australia.

NDVI and Relative green-ness index

BOM currently produces NDVI products using Melbourne AVHRR data and plans to complement this using WASTAC data to give more comprehensive coverage in support of Bureau services, climate studies and research. The data is mosaiced using a Maximum value composite approach and the WASTAC data is needed for a more complete coverage. The current product (Figure 4) is available to internal BOM users via the WWW.

Data Collection Platforms (DCP)

As part of an international commitment, BOM provides Tiros Information Processor (TIP) data to Argos (Collecte Localisation Satellites) for input into their tracking system. The TIP data stream has embedded data from the Argos instrument which is onboard 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 real-time (within 15 minutes of the end of the orbit) rather than having to wait 1 to 3 hours for the recorded data. In addition, BOM extracts and processes DCP data from the WASTAC TIP data to provide observations of meteorological variables such as pressure and temperature over data sparse ocean areas.

AVHRR Access Service

BOM now provides a real-time ftp subscription service to AVHRR data.

PUBLICATIONS

Bower, N and Lynch M. J. 1998. *High Spectral Resolution Land Surface Emissivity Investigations*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Cureton, G. P., Lynch, M. J. and McGann, B.T. 1998. *Retrieval of Sea-State Information from Sunglint*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Davies, J. E. and Lynch, M. J. 1998. *Use of the Navy Aerosol Model in Atmospheric Correction of Satellite Observations of Ocean Colour*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Davies, J. E., Osborne, B., Santich, N. and Lynch, M. J. 1998. *Solar Photometer Data for Perth Region*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Fearns, P.R.C.S. and Lynch, M. J. 1998. *Modelling Ocean Colour*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Fearns, P., Lynch, M. J., Davies, J., Boterhoven, M., Rodger, A., McAtee, B., Vincent, W., Pearce, A. and Braine, S. 1998. *Remote Sensing Validation Data from the Hillarys Cross-Shelf Transect*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Kelly, G., Harris, B., Saunders, R., McNally, A. and Le Marshall, J. 1999. *High resolution AMSU-A retrievals using an NWP first guess and comparison with the TL 639 resolution (~30km) model*. The Technical Proceedings of the Tenth International TOVS study Conference, Boulder, Colorado 27 January - 2 February 1999.

Le Marshall, J., Kelly, G., Mills, G., Leslie, L., Blank, D., Choi, B., Steinle, P. and Seecamp, R. 1999. *Recent advances in the application of TOVS, ATOVS, S-VISSR and advanced sounder data for Australia*. The Technical Proceedings of the Tenth International TOVS study Conference, Boulder, Colorado January 27 - February 2 1999.

Leslie, L. and Le Marshall, J. 1999. *High resolution 4-D variational assimilation of satellite data*. The Technical Proceedings of the Tenth International TOVS study Conference, Boulder, Colorado 27 January - 2 February 1999.

Marinelli, M.A., Lynch, M. J. and Pearce, A. F. 1998. *An Ocean Colour Remote Sensing Study of the Phytoplankton Distribution off the Western Australian Coast*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

McAtee, B. K., Boterhoven, M., Rodger, A., Lynch, M. J. and Pearce, A. F. 1998. *Investigations into a Radiance Equation for Satellite Sea Surface Temperature Estimation*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Newnham, G. J., Lynch, M. J. and Boterhoven, M.A. 1998. *Optical Detection of Soil Acidity Induced Stress in Agricultural Crops*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Osborne, B., Lynch, M.J. and Knuteson, R.O. 1998. *Temperature Micro-Sounding of the Lower Atmosphere Through High Spectral Resolution Infra-red Interferometry*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Renzullo, L. J., Lynch, M. J. and Campbell, N.A. 1998. *Change Detection in Multitemporal, Multispectral Satellite Image Data*. Abstracts, 13th National Congress, Australian Institute of Physics, Fremantle, WA 27 September, 1998.

Smith, R.C.G., Craig, R.L., Steber, M.T., Marsden, A.J., McMillan, C.E. and Adams, J 1998. *Use of NOAA-AVHRR for fire management in Australia's Tropical Savannas*. Presented at 9th Australian Remote Sensing and Photogrammetry Conference, volume 1, paper no. 123 CD-ROM.

Smith, R.C.G., McMillan, C.E., Craig, R.L., Adams, J. and Steber, M. 1998. *Satellite monitoring of bush fires in Western Australia*. Journal of Arid Land Studies 75, 27-30.

Willmott, M.C., Griersmith, D.C. and Tuddenham, W.G. 1998. *Remote Sensing and the Bureau of Meteorology - Where to Now?* Proceedings of the Land AVHRR Workshop, 9th Australasian Remote Sensing Conference 24 July 1998, Sydney, Australia.

Willmott, M.C., Griersmith, D.C. 1999. *Country and Scientific Report from the Bureau of Meteorology*. Meeting on Asia-Pacific Satellite Data Utilisation and Exchange, 2 to 4 February 1999, Tokyo, Japan.

WASTAC BUDGET 1999

Estimated expenditure for the year January 1999 – December 1999

	PER ANNUM $ 1999	$ 1998
1. Telstra Rental	4,980	3,400
2. DAT Tapes	4,800	4,800
3. System maintenance/repairs	6,000	6,000
4. Telecommunications licence of facility	1,858	2,000
5. Ink jet quick look costs	500	3,730
6. Consultants (X-band proposal)	12,000	16,500
7. Sundries consumables	1,500	1,000
8. Travelling – airfares	4,500	4,500
9. Provision for major equipment	7,500	2,500
10. Annual Report	4,000	4,000
Total:	**$47,638**	**$48,430**

Estimated income/revenue for the year January 1999 – December 1999

1. Contributions received ($10,000 each member)	40,000	40,000
2. Sundry income (data replication)	5,000	0
3. Interest	4,500	4,000
Total Income:	**$49,500**	**$44,000**

Extra-ordinary expenditure January 1999 – December 1999

1. Capital Reserve:	
1.1 Antenna replacement and componentry	50,000

INDEPENDENT AUDITOR'S REPORT

I have audited the attached financial statements and in my opinion they fairly represent the transactions of the Cost Centre during the 1998 calendar year, the financial status as at 31 December 1998, and associated cash flows. The statements are based on proper accounts and records.

P J Perriam

DIRECTOR INTERNAL AUDIT

CURTIN UNIVERSITY OF TECHNOLOGY

11 March 1999

Balance Sheet as at 31 December 1998

	NOTE	1998 $	1997 $
CURRENT ASSETS			
Cash at Bank		127,873	97,674
Prepayments		-	-
TOTAL CURRENT ASSETS		**127,873**	**97,674**
NON - CURRENT ASSETS			
Computer Equipment	2a	30,980	41,307
Other Equipment	2b	52,011	59,440
TOTAL NON - CURRENT ASSETS		**82,991**	**100,747**
TOTAL ASSETS		**210,864**	**198,421**
CURRENT LIABILITIES			
Creditors and Borrowings		-	-
Accrued Expense		-	-
TOTAL CURRENT LIABILITIES		**-**	**-**
NON - CURRENT LIABILITIES			
Creditors and Borrowings		-	-
TOTAL NON - CURRENT LIABILITIES	-	-	
TOTAL LIABILITIES		**-**	**-**
NET ASSETS		**210,864**	**198,421**
SHAREHOLDERS EQUITY			
Asset Revaluation Reserve	3	129,997	129,997
Retained Profits/(Losses)	4	80,867	68,424
TOTAL SHAREHOLDERS EQUITY		**210,864**	**198,421**

Income and expenditure statement

For the period 1 January 1998 to 31 December 1998

	NOTE	1998 $	1997 $
INCOME			
Contributions Received	5	40,000	40,000
Sundry Income		-	-
Interest Received		8,947	-
TOTAL INCOME		48,947	40,000
EXPENDITURE			
Salaries and Wages		-	6,813
Outsourced Work		-	250
Student Scholarship		-	10,000
Telephone		1,360	3,572
Travel		1,797	-
Consumables		1,241	5,113
Printing, Stationery and Photocopying		112	3,620
Depreciation		17,757	22,296
Maintenance of Equipment		2,415	8,526
Equipment < $1,000		1,365	-
Computer Equipment Purchases		10,458	2,435
Feasibility Study		-	-
TOTAL EXPENDITURE		**36,504**	**62,624**
NET SURPLUS (DEFICIT)		12,443	(22,624)
EXTRAORDINARY ITEMS		Nil	Nil
NET SURPLUS (DEFICIT) AND EXTRAORDINARY ITEMS		12,443	(22,624)
TRANSFERS TO ASSET REVALUATION RESERVE		Nil	Nil
NET SURPLUS (DEFICIT) TRANSFERRED TO RETAIN PROFITS/(LOSSES)		12,443	(22,624)

Cash flow statement for the year ended 31 December 1998

	$
BALANCE OF CASH AS AT 1 JANUARY 1998	**97,674 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	8,947
Total Sundry Income	8,947
TOTAL RECEIPTS FOR 1998	**48,947**
PAYMENTS	
Travel	1,797
Printing, Stationery and Photocopying	112
Telephone	1,360
Consumables	1,241
Equipment < $1,000	0
Equipment Maintenance contracts	2,415
Computer Equipment Purchases	10,458
Furniture	1,365
TOTAL PAYMENTS FOR 1998	**18,748**
EXCESS OF RECEIPTS OVER PAYMENTS FOR 1998	**30,199**
BALANCE OF CASH AS AT 31 DECEMBER 1998	**127,873 CREDIT**

Notes to and forming part of the Financial Statement

For the period 1 January 1998 to 31 December 1998

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 University 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 $1,000 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 statements 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

	1998 $	1997 $
2. NON CURRENT ASSETS		
2a Computing Equipment (at cost)	243,849	243,849
Accumulated Depreciation	(212,869)	(202,542)
TOTAL COMPUTING EQUIPMENT	**30,980**	**41,307**
2b Other Equipment (at cost)	194,820	194,820
Accumulated Depreciation	(142,809)	(135,380)
TOTAL OTHER EQUIPMENT	**52,011**	**59,440**
TOTAL NON - CURRENT ASSETS	**82,991**	**100,747**
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	68,424	91,048
Net Surplus (Deficit) for the year	12,443	(22,624)
CLOSING BALANCE	**80,867**	**68,424**
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
	40,000	**40,000**

ASSET REGISTER AS AT 31 DECEMBER 1998

Asset Number	Description	Original Cost	Accumulated Depreciation	Written Down Value
		$	$	$
COMPUTING EQUIPMENT				
1358800	SYSTEM SATELLITE TRACKING STATION	110,000.00	110,000.00	-
2478800	2.3GB 8MM EXABYTE	6,272.00	6,272.00	-
2494500	PS2 25MHZ 4/320MBHD & 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 TO 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	590	-
2494512	MONITOR DISPLAY CABLE	120	120	-
2494513	MS MACRO ASSEMBLER V5.1	174	174	-
2494514	MICROSOFT C COMPILER V6	448	448	-
2494515	MICROSOFT OS/2 PM TOOLKIT	488	488	-
2494516	FORTRAN V2.0	754	754	-
2494517	LOCAL AREA NETWORK TECH MANUAL	70	70	-
2494518	PS/2 MOUSE	109	109	-
2552700	TAPE DRIVE 2 GBYTE X801A	6,840.00	6,840.00	-
2553701	ACQNR	3,800.00	3,800.00	-
2585200	PAINTJET XL C1602A	2,425.00	2,425.00	-
2587000	PS/2 20MHZ 2/320MBHD VGA+SCSI	9,392.00	9,392.00	-
2587001	MOUSE	109	109	-
2587002	DUAL ASYNCH ADAPTOR	233.5	233.5	-
2587003	DUAL ASYNCH ADAPTOR	233.5	233.5	-
2587004	OS/2 EXTENDED EDITION V1.2	700	700	-
2587005	2MB MAIN MEMORY EXPANSION	953	953	-
2587007	MATHS CO-PROCESSOR INTEL 20MHZ	570	570	-
2587008	2-8MB MEMORY EXPANSION	1,450.00	1,450.00	-
2587009	2MB MEMORY MODULE	475	475	-
2587010	2MB MEMORY MODULE	475	475	-
2587011	2MB MEMORY MODULE	475	475	-
2587012	ETHERLINK MC CARD	590	590	-
2587013	FUTURE DOMAIN	450	450	-
2587014	MONITOR DISPLAY CABLE	120	120	-
2587100	ULTRA 1000 20"	2,870.00	2,870.00	-
2587200	ULTRA 1000 20"	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	26,286.02	30,979.98
TOTAL COMPUTER EQUIPMENT		**243,849.00**	**212,869.02**	**30,979.98**
OTHER EQUIPMENT				
1358700	SATELLITE STATION TRACKING	140,000.00	109,803.94	30,196.06
1948500	POWER CONDITIONER	2,000.00	1,442.73	557.27
2009000	MA 23 CC	20,365.00	14,562.91	5,802.09
2552600	SGSI HOST ADAPTOR 598A	1,900.00	1,232.06	667.94
2553700	RECEIVER NOAA I/F FORMAT	19,500.00	12,644.88	6,855.12
3852500	CX-FS1P4 CISCO 4 PORT S/INTER	7,440.00	2,101.70	5,338.30
3852501	PA-7KF-E1/75 CISCO DUAL E1 G70	3,400.00	960.45	2,439.55
3852502	CAB E1 BNC FSIP MIP-CE1 BNC 75	215	60.72	154.28
TOTAL OTHER EQUIPMENT		**194,820.00**	**142,809.39**	**52,010.61**
DESKTOP EQUIPMENT				
3904000	HEWLETT PACKARD 715/64 WORKSTATION	25,208.00	25,208.00	-
4085100	9GB DIS DRIVE	2,435.00	2,435.00	-
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	-
	AMSU CARD*	6,765.00	6,765.00	-
	WIDE DISK DRIVE**	2,164.00	2,164.00	-
TOTAL DESKTOP EQUIPMENT		**40,768.00**	**40,768.00**	**0.00**
TOTAL EQUIPMENT		**479,437.00**	**396,446.41**	**82,990.59**

* Note: These desktop purchases are in the process of being registered and will appear in the 1999 register with an asset number.

** Editor's note: Items to be written off in 1999 which are currently of no further operational use:- Asset ID 2494500 to 2494518(incl) and 2552600. Asset ID 2587000 to 2587014(incl), 2587100, 2587200, 2587300 and 2553701.