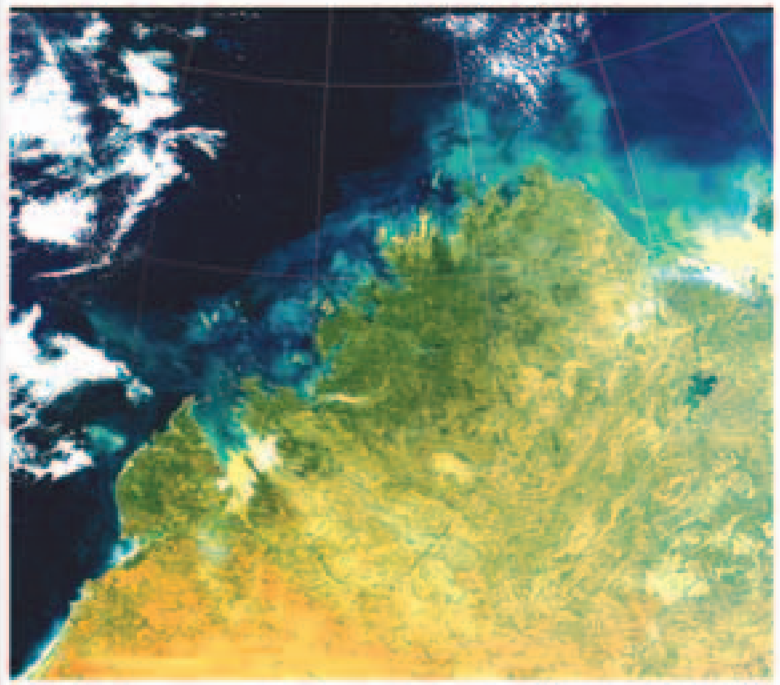
WASTAC

Western Australian Satellite Technology and Applications Consortium

Annual Report 2004



www.wastac.wa.gov.au

WASTAC members

Bureau of Meteorology
GPO Box 1289
Melbourne VIC 3001

Curtin University of Technology
GPO Box U1987
Perth WA 6845

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

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

Geoscience Australia
GPO Box 378
Canberra ACT 2601

Murdoch University
South Street
Murdoch
Western Australia 6150

POSTAL:

The Secretary WASTAC
PO Box 471
WEMBLEY 6913
Western Australia

LEEUWIN CENTRE
65 Brockway Road
FLOREAT 6014
Western Australia
Telephone:
(08) 9387 0330
Facsimile: (08) 9383 7142
International:
(+618)

Email:
Richard.Stovold@dli.wa.gov.au

Web site:
http://www.wastac.wa.gov.au

Front Page: Kimberley From Space
A Terra MODIS image acquired on August 24, 2002 by WASTAC and processed by Satellite Remote Sensing Services. The image shows the outflow of suspended sediments streaming into the King Sound from the Fitzroy River . Other notable features include reef formation, bathymetric detail and land systems.

Editors: R. Stovold DLI, SRSS
A.F. Pearce CSIRO

Acknowledgements

To Jackie Marsden, Ron Craig and Brendon McAtee for their proof reading assistance.

CONTENTS

WASTAC CHAIRMAN'S REPORT 2004

Using its access to real-time data from the MODIS sensor, WASTAC applied its resources and collaborative potential in 2004 to advance the frontiers of science. It also reviewed its strategic direction and made key decisions to upgrade our facilities for the next generation of environmental satellites.

Dr Brendon McAtee was supported to implement NASA software for Atmospheric Correction of MODIS data. This work was subsequently taken over by the Cooperative Research Centre for Spatial Information with a Research Fellow and two PhD studentships to work on this important topic. Already an algorithm for the measurement of total precipitable water is in an advanced stage of testing. Next we expect a product for Aerosol Optical Depth measurement.

Using its access to real-time data from the MODIS sensor, WASTAC applied its resources and collaborative potential in 2004 to advance the frontiers of science.

Dr Peter Fearns, CSIRO Marine Research has made important progress on the production of ocean products from MODIS data. Over the years sea surface temperature from NOAA-AVHRR has made a significant contribution to our understanding of the Leeuwin Current. With MODIS this understanding will be considerably advanced through our ability to measure the impact of the Leeuwin Current on photosynthesis in the ocean.

Dr Stefan Maier, DLI has developed the automatic detection of land cover change for the automatic mapping of burnt area from MODIS. This provides mapping at 6 ha resolution compared with 100 ha from NOAA-AVHRR. There is now recognition that the systematic mapping of landscape scale fire from NOAA-AVHRR has significantly increased our understanding of the significance of landscape scale fires particularly in Tropical Savannas. Based on these data it is estimated that landscape scale fires contribute about 16% of Australia's Greenhouse gas emissions and that MODIS will play a significant role in the future of our National Carbon Accounting system. This poses the challenge of measuring not only burnt area but also the Fire Intensity (Wm^{-2}) and Burn Severity (biomass reduction) of this area.

The WASTAC partners have contributed generously to the efficient running of WASTAC. Ron Craig and Sarah Foster, DLI along with Don Ward, BOM have kept the stations running with a high degree of reliability. CSIRO maintains the high speed data link needed for near real-time processing at the Leeuwin Centre.

Our secretary, Richard Stovold, DLI has kept the decision making on track and with Alan Pearce, CSIRO edits an excellent Annual Report. Curtin University continues to manage our accounts efficiently. Murdoch University maintains an excellent site for the X-band antenna and ACRES, Geoscience Australia have provided valuable national coordination and access to MODIS data from Alice Springs for WASTAC members.

As Chairman, I take pride in the major contributions WASTAC is making to advancing our understanding of land, ocean and atmospheric processes within Australia.

Richard Smith
Chairman

WASTAC BOARD FOR 2004

Dr Richard Smith
(Chairman)
Department of Land Information

Dr Stefan Maier
Department of Land Information

Assoc. Prof. Merv Lynch
Curtin University of Technology

Dr Doug Myers
Curtin University of Technology

Dr Greg Ayres
CSIRO, Atmospheric Research

Dr Alex Held
CSIRO, Earth Observation Centre

Dr David Griersmith
Bureau of Meteorology

Mr Alan Scott
Bureau of Meteorology

Mr Shanti Reddy
Geoscience Australia

Professor Tom Lyons
Murdoch University

Exec. Dean Yianni Attikiouzel
Murdoch University

WASTAC STANDING COMMITTEE AND PROXY TO THE BOARD

Dr Richard Smith
(Chairman)
Department of Land Information

Dr Stefan Maier
Department of Land Information

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 Peter Fearns
CSIRO, Marine Research

Professor Tom Lyons
Murdoch University

WASTAC TECHNICAL COMMITTEE:

Mr Don Ward (Chairman)

Assoc Prof Merv Lynch

Dr Doug Myers

Mr Ronald Craig

WASTAC SECRETARY

Mr Richard Stovold
Secretary to the WASTAC Board
and Standing Committee.

WASTAC STRATEGIC PLAN

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 MODIS , 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
- promote educational uses of WASTAC data
- ensure maximum use of MODIS, NOAA and SeaWiFS data in the management of renewable resources.

FUTURE STRATEGIES:

- Upgrade reception capabilities for METOP (replacement for AVHRR) and NPP (replacement for MODIS).
- Advance MODIS processing from Level 1b to Level 2 (Below-atmosphere NADIR reflection) through introduction of atmospheric and View angle (BRDF) corrections.
- Develop real-time access to Bureau of Meteorology data on Total Column Ozone, Total Column Water Vapour and Surface Pressure for the Atmospheric correction of MODIS data.
- Network access to other MODIS receiving stations in Australia.

FUTURE SATELLITE OPPORTUNITIES:

- METOP (Replacement for NOAA) (X-band)
- NPP (Replacement for MODIS).

OPERATIONAL STATUS:

Don Ward, Regional Computing Manager
Bureau of Meteorology Perth (www.bom.gov.au)

WASTAC FACILITIES INCLUDE BOTH L BAND AND X BAND RECEPTION:

WASTAC L

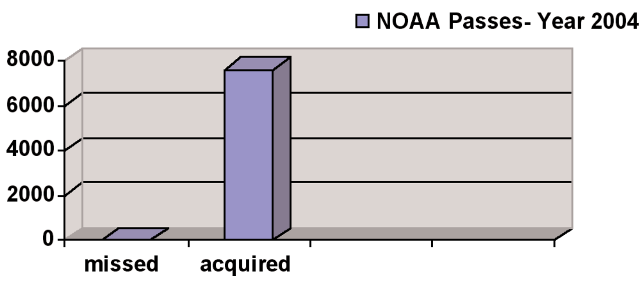
WASTAC L band facilities consist of a 2.4m antenna and antenna controller at Curtin University of Technology and ingest and display computers with hard disk storage and tape archive facilities located at the Bureau of Meteorology premises at 1100 Hay Street, West Perth. A low speed uni-directional microwave 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 Regional Office of the Bureau of Meteorology.

Colour and grey scale quicklook files are produced at the Department of Land Information's (DLI) Satellite Remote Sensing Services (SRSS) at the Leeuwin Centre for Earth Sensing Technologies at Floreat in near realtime for archiving, indexing and distribution. The raw data archive is produced on 20Gb DLT tape and a duplicate copy is currently produced for a national NOAA data archive program that is coordinated by the CSIRO Office of Space Science and Applications (COSSA) in Canberra.

The AVHRR ingest and display system, developed and installed by the Bureau of Meteorology in September 1996 consists of two HP UNIX workstations, one provided by WASTAC and the other by the Bureau. The software was upgraded late in 1999.

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 Bureau of Meteorology in Melbourne so that atmospheric temperature retrievals can be included in the global numerical weather prediction models. Sea Surface temperatures (SST) are produced by the Bureau and DLI. DLI also produces vegetation maps and monitors fire scars in near realtime. NOAA and SeaWiFS archive information are posted to DLI's World Wide Web page.

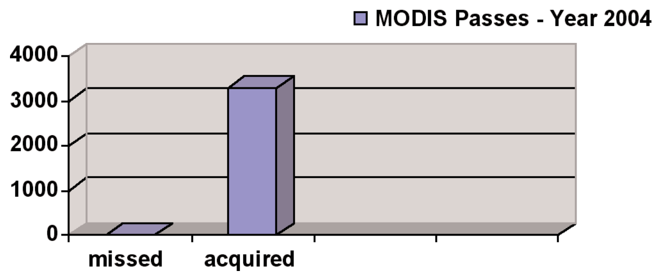
Equipment failures during the year caused the loss of 6 days of data but the dedicated efforts of DLI and Bureau staff resulted in a total of 7587 NOAA passes being recorded during the year.



WASTAC X

The WASTAC X band facilities at the Environmental Science building at Murdoch University were supplied and installed by SeaSpace Corporation in September 2001 and consist of a 3.6m diameter antenna mounted in a fibreglass dome and a Sun Sparc 400 antenna control computer. The separately acquired ingest and display computers with hard disk storage and tape archive facilities as well as a dual CPU LINUX processing computer are located at SRSS at the Leeuwin Centre. The X band reception facility is directly connected to the high speed PARNET wide area network at the Murdoch node. This allows data transfer to DLI and via the internet to other members of WASTAC.

Quicklook files are produced at SRSS in around one hour for archiving, indexing and distribution.



Equipment failures during the year resulted in the loss of no data but a total of 3267 X band MODIS passes were recorded for the year.

ARCHIVE STORAGE

DLI is currently holding the archive on 8mm exabyte and DAT tapes. 20 Gb DLT tape was introduced as the archive media late in 2000 for the L band data and since its commencement in 2001, X band data have been archived to 35 Gb DLT tape.

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

Recent Developments and Future Directions

A project is underway that will provide a backup NOAA L Band reception capability as an add-on to the X band facility at Murdoch University. Another will upgrade the existing L band station at Curtin to match similar Bureau facilities.
The second L band system will allow better resolution of pass tracking conflicts and access the next generation of satellites such as MTSAT-IR, FY-1D, FY-2C as required.

WASTAC DATA ARCHIVE

The WASTAC archive of NOAA, MODIS and SeaWiFS satellite passes, managed and maintained by the Department of Land Information (DLI) Satellite Remote Sensing Services (SRSS) group, is held at the Leeuwin Centre in Floreat, Western Australia.

DLI 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.

A total of 7587 NOAA passes were archived in 2004. Passes include data from the NOAA 12, NOAA 14, NOAA 15 ,NOAA 16 and NOAA 17 satellites. All passes were stored on DLT tapes.

The archiving of SeaWiFS data continued during 2004 with 680 passes being archived.

During 2004 1602 TERRA and 1665 AQUA passes have been archived.

We continue to maintain the near real time quick-look archive of MODIS and NOAA-AVHRR data on the world wide web. The digital archive holds data from the present time back to 1983. A similar archive of SeaWiFS quick-look data is also held on the world wide web.

Web addresses to view this archive of MODIS, NOAA and SeaWiFS data online are:

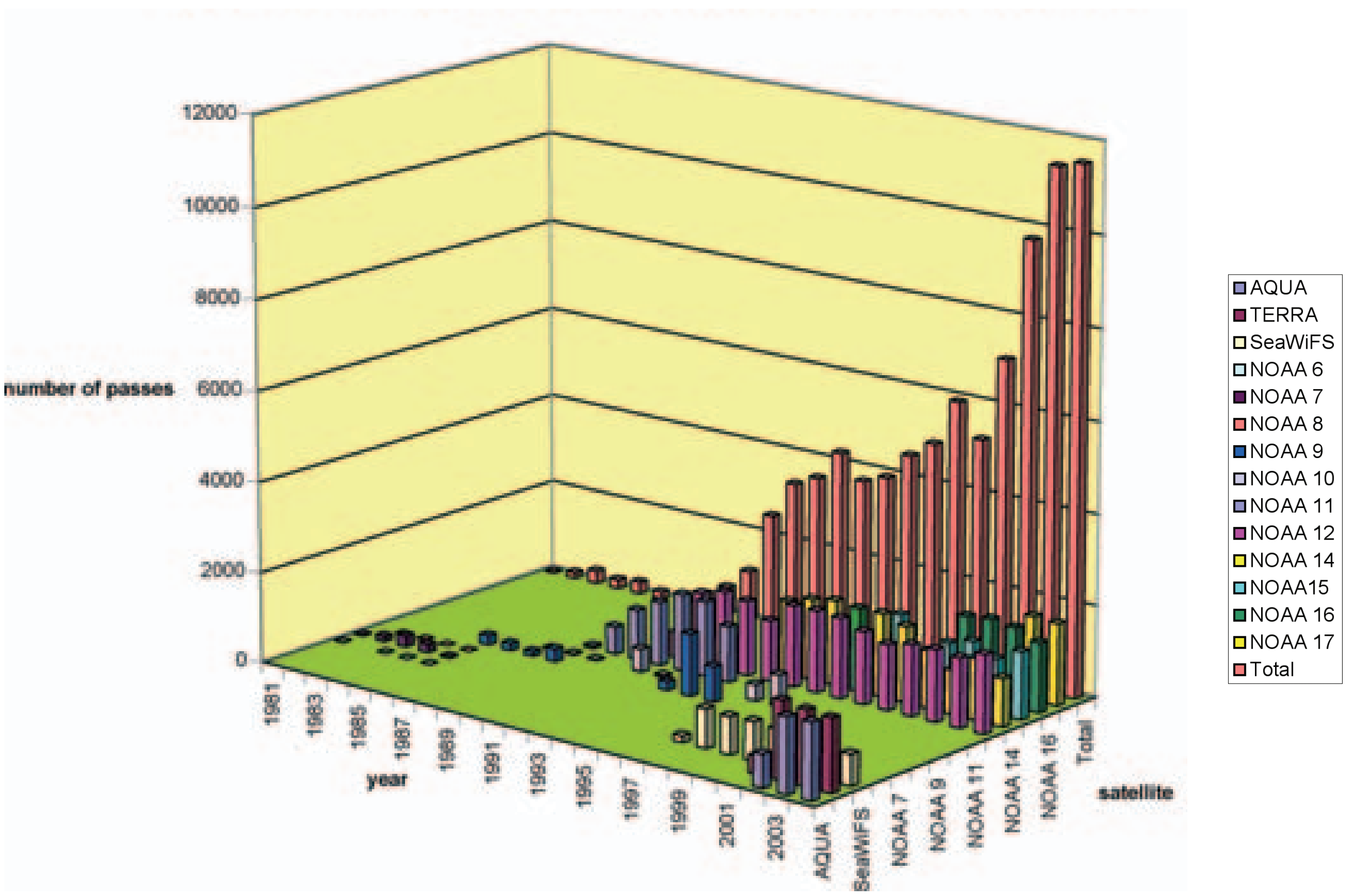
http://www.rss.dola.wa.gov.au/noaaql/NOAAql.html
http://www.rss.dola.wa.gov.au/modisql/MODISql.html

DLI 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.

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

	AQUA	TERRA	SeaWiFS	NOAA6	NOAA 7	NOAA 8	NOAA 9	NOAA 10	NOAA 11	NOAA 12	NOAA 14	NOAA15	NOAA 16	NOAA 17	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	-	-	142	-	-	-	-	694	-	1797	1876	-	-	-	4509
1998	-	-	859	-	-	-	-	-	-	1763	1828	432	-	-	4882
1999	-	-	822	-	-	-	-	-	-	1589	1839	1663	-	-	5912
2000	-	-	843	-	-	-	-	-	-	1427	1681	905	341	-	5197
2001	-	390	811	-	-	-	-	-	-	1548	1271	1292	1733	-	7045
2002	734	1710	780	-	-	-	-	-	-	1579	976	1455	1789	709	9732
2003	1651	1645	696	-	-	-	-	-	-	1521	1351	1200	1728	1827	11388
2004	1665	1602	680	-	-	-	-	-	-	1727	1058	1481	1524	1797	11534

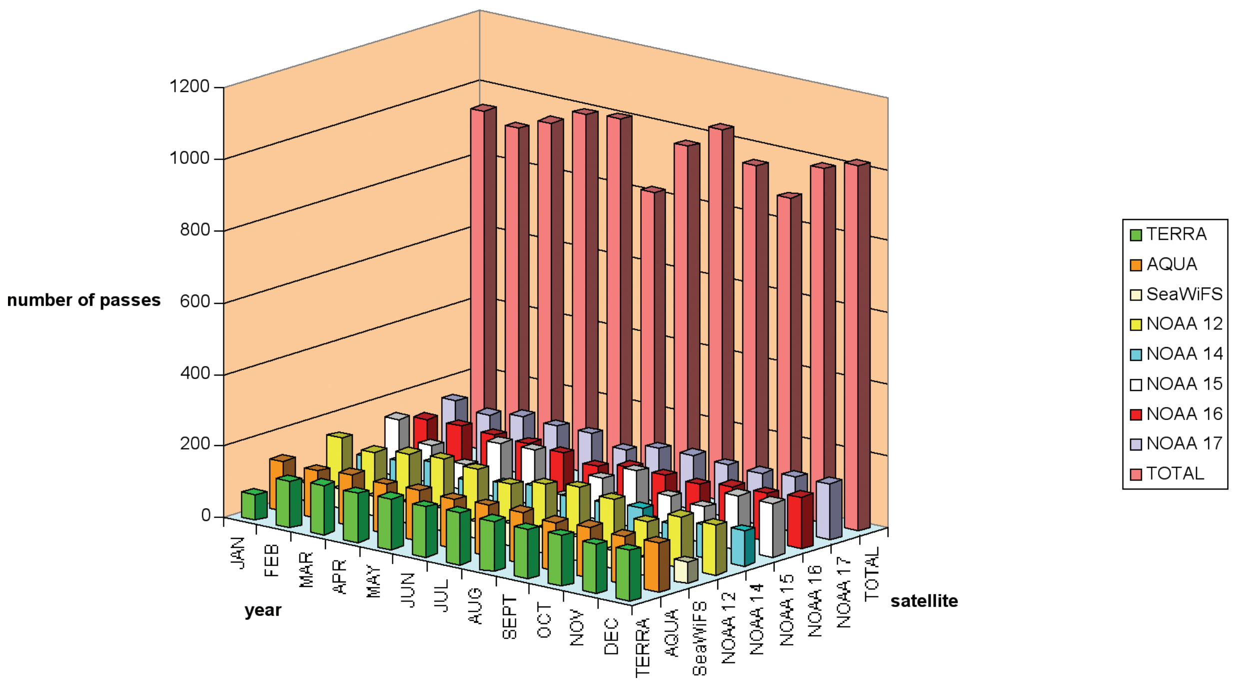
TOTAL NUMBER PASSES HELD IN THE WASTAC ARCHIVE - LEEUWIN CENTRE



WASTAC SATELLITE DATA FOR YEAR 2004

	TERRA	AQUA	SeaWiFS	NOAA 12	NOAA 14	NOAA 15	NOAA 16	NOAA 17	TOTAL
JAN	71	140	51	154	79	158	133	161	947
FEB	129	132	54	136	84	107	136	142	920
MAR	139	144	56	152	101	73	131	159	955
APR	136	138	59	158	74	154	128	151	998
MAY	142	142	61	149	84	156	121	152	1005
JUN	139	136	45	130	95	47	105	126	823
JUL	144	140	60	149	87	118	124	151	972
AUG	142	142	70	161	92	158	122	153	1040
SEPT	138	134	65	150	100	108	117	146	958
OCT	142	142	50	106	74	100	132	145	889
NOV	138	137	49	142	90	151	132	154	993
DEC	142	140	60	140	98	151	143	157	1021

WASTAC SATELLITE DATA ARCHIVE 2004



OPERATIONAL APPLICATIONS

The AVHRR, SeaWiFS and MODIS datasets are being increasingly used for a variety of operational products and applications, which are summarised in this section.

BUREAU OF METEOROLOGY, MELBOURNE

Compiled by Mike Willmott, David Griersmith, Anthony Rea, Graham Warren

Sea Surface Temperatures (derived from NOAA data)

The Bureau of Meteorology calculates satellite derived sea surface temperatures (SSTs) for the Australian region by combining data from the WASTAC Perth station with similar NOAA AVHRR data from its Casey, Crib Point (Melbourne) and Darwin stations. The algorithms currently in use are the Non-Linear SST (NLSST) algorithms derived by NOAA/NESDIS (see for example http://coastwatch.noaa.gov/poes_sst_algorithms.html). The Bureau AVHRR data is navigated, calibrated, cloud cleared in real time and the processed orbit is available within an hour after the completion of the ingest. The resulting SSTs for a particular orbit are then sent to Melbourne for inclusion into the Bureau's national data set. The data is then quality controlled against SST data collected from ships and drifting buoys prior to being mosaiced into a national map. These data are mainly used in support of internal and defence operations (e.g. assimilation into Bureau numerical weather prediction models) but are also available to external users as metadata and browse images of daily mosaics (since November 1998) via the world wide web at http://www.bom.gov.au/nmoc/archives/SST/. The SST grid data are archived as part of Australia's National Climate Record, and are also input in to the Bureau/CSIRO/Navy collaborative BlueLink Oceanography project.

The experimental implementation of the Common AVHRR Processing System (CAPS) for navigation is still being assessed. The CAPS system, using the Clift navigation model and orbital information from CSIRO Marine Research (Hobart), is impressive since it consistently provides a navigational accuracy of around 1 pixel.

Verification of the computed SST fields is carried out automatically after each individual orbit is processed. SST temperatures are compared to ship and buoy sea-temperature observations which are co-located in both space and time. Observations within 3 hours of the nominal AVHRR image time are accepted. The results of the comparisons are produced in both graphical and tabular formats and are accessible via the Bureau internal web. Statistics for this verification system have been kept since July 1999. Typical RMS errors (usually around 1K) for the satellite-observed minus ship/buoy observed SSTs are shown in Figure 1, with a typical bias (for September 2004 to March 2005) of -0.14 (NOAA-17), 0.03 (NOAA-15) and -0.16 (NOAA-12) degrees. (Note: NOAA-16 performance was affected by an AVHRR scan motor failure and is no longer processed operationally).

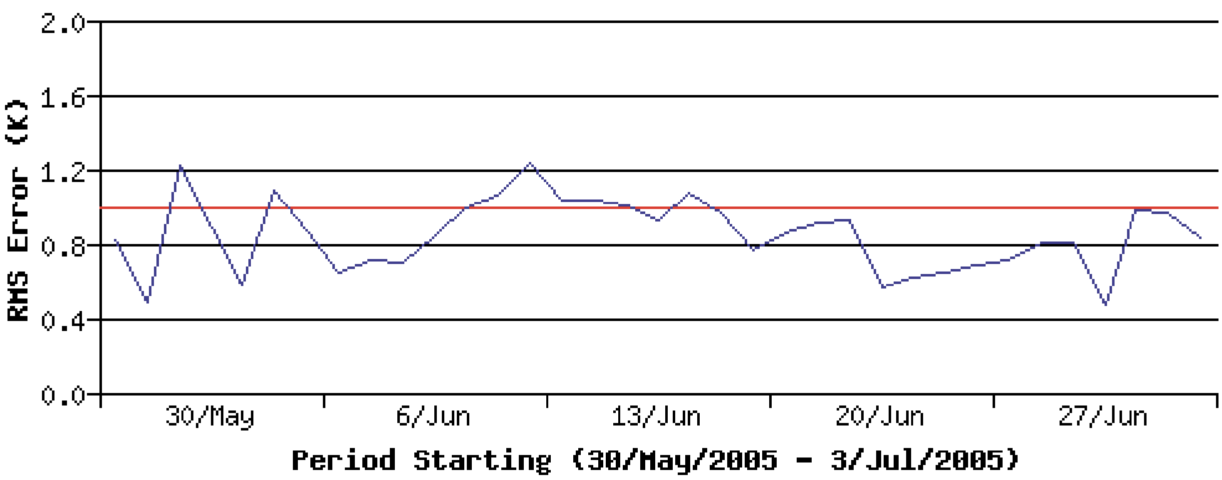


Figure 1. Average RMS error computed by taking the sum of the squares of the SST errors (Satellite versus ground truth), dividing by the number of observations, subtracting the square of the bias and taking the square root. The red line on the graph represents an RMS error of 1.0 degrees Kelvin.

OPERATIONAL APPLICATIONS (continued)

Automation and precise navigation corrections are still being performed using the Common AVHRR Processing Package (CAPS) developed by CSIRO Atmospheric Research.

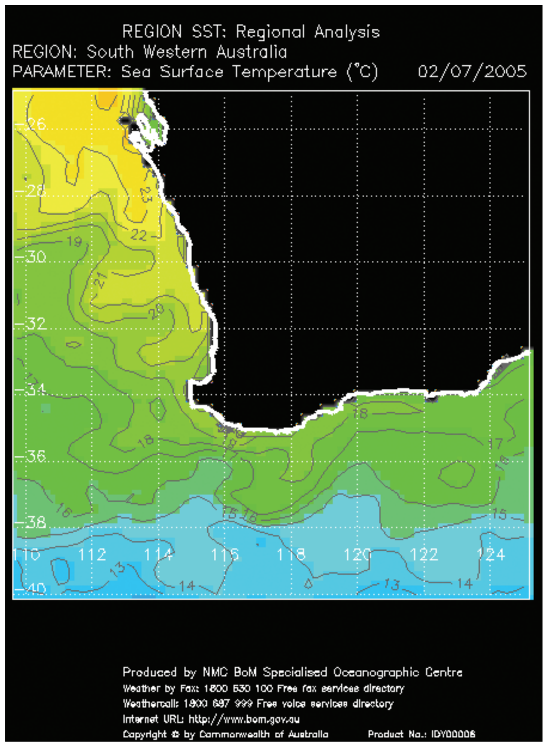


Figure 2. Daily regional contour map of satellite-derived SSTs in degrees Celsius, on a 0.25 degree grid. This product is available to the public via a registered subscription service.

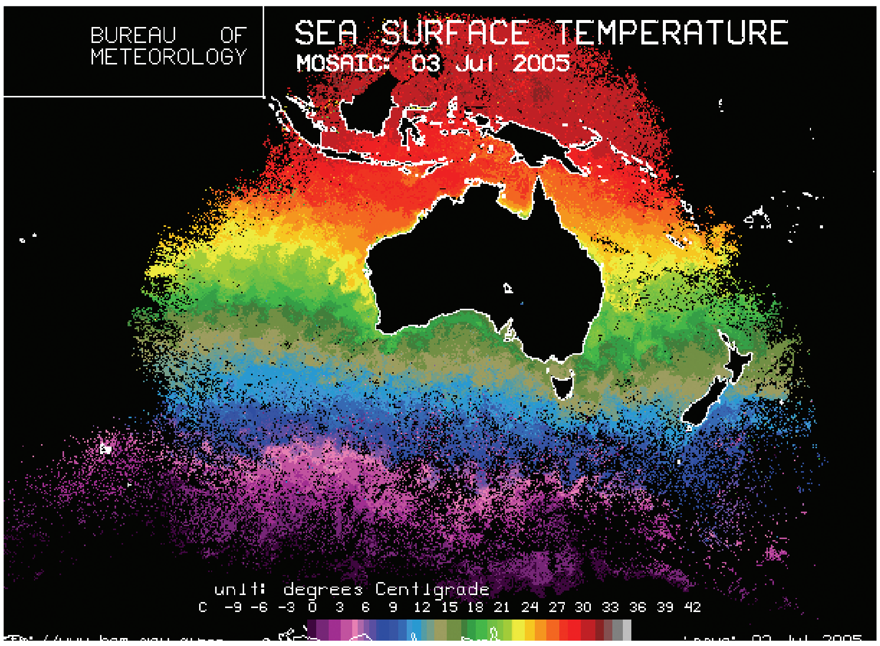


Figure 3. SST product available free to the public via a browse service on the Bureau's web site (www.bom.gov.au). The image shows SSTs at 10 km resolution.

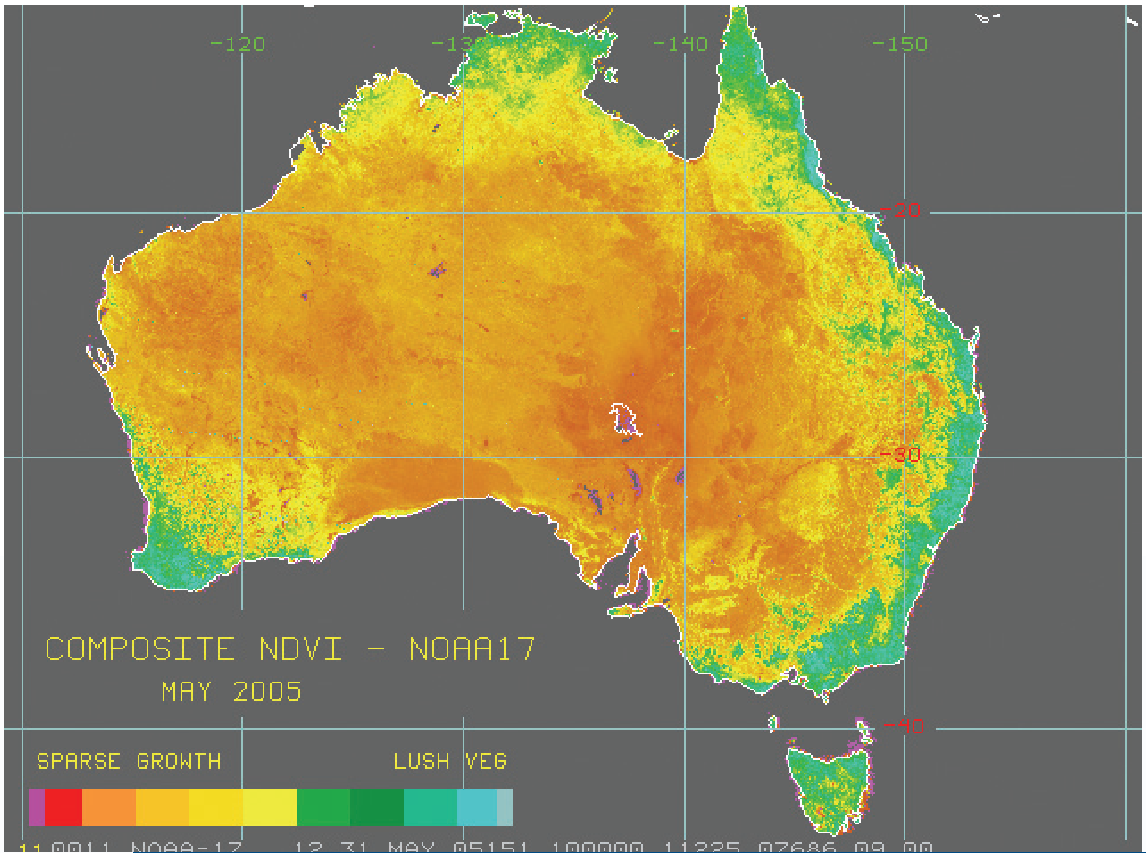


Figure 4. An example of the Bureau's Maximum Value Composite NDVI product.

Normalised Difference Vegetation Indices (NDVIs)

The Bureau currently produces NDVI products using AVHRR data based on Melbourne and Perth WASTAC data. Data are used to monitor monthly changes in vegetation and other drought/climate related matters, floods, fire scars and as input in fire weather forecasting via generation of grassland curing indices.

Differential reflectance measurements from channels 1 and 2 of the AVHRR instrument on board the NOAA-17 satellite provides a means of monitoring the density and vigour of green vegetation growth using the spectral reflectivity of solar radiation.

Typically two sequential daytime orbits covering most of Australia are available for processing in near real time each day. Monthly Maximum Value Composite (MVC) NDVI maps in Mercator projection are produced by taking the highest value for each pixel for the month from all the daily composites created from the individual orbits. This minimises data gaps in any particular composite due to cloud interference or missing data and overcomes some of the systemic errors that reduce the index value. See figure 4 for an example of the Bureau's NDVI product.

Automation and precise navigation corrections are still being performed using the Common AVHRR Processing Package (CAPS) developed by CSIRO Atmospheric Research.

OPERATIONAL APPLICATIONS (continued)

The Bureau also provides a Grassland Curing Index (GCI) product derived from NOAA AVHRR data. The product was developed at CSIRO Atmospheric Research. The result is a high-quality product which is of great use to a range of customers including regional fire services and various power generation and distribution companies. The product is currently available for Victoria and for South Australia. An example of the Victorian product is given in figure 5.

The Victorian GCI imagery is produced as part of a cooperative agreement involving the CSIRO, the Bureau of Meteorology and the Country Fire Authority. CSIRO has provided the software. The Bureau runs it via its Central Computing Facility and relevant operational staff and the CFA provides validation data and other support.

The product is generated once per day from an afternoon pass of the NOAA-17 satellite, between 04 and 06 UTC (around 3-5pm EDST). In cases where a single NOAA pass does not completely cover the target area (a 'split pass') the product is not generated. Due to the orbital characteristics of the satellite this will happen once every 9 days for each region.

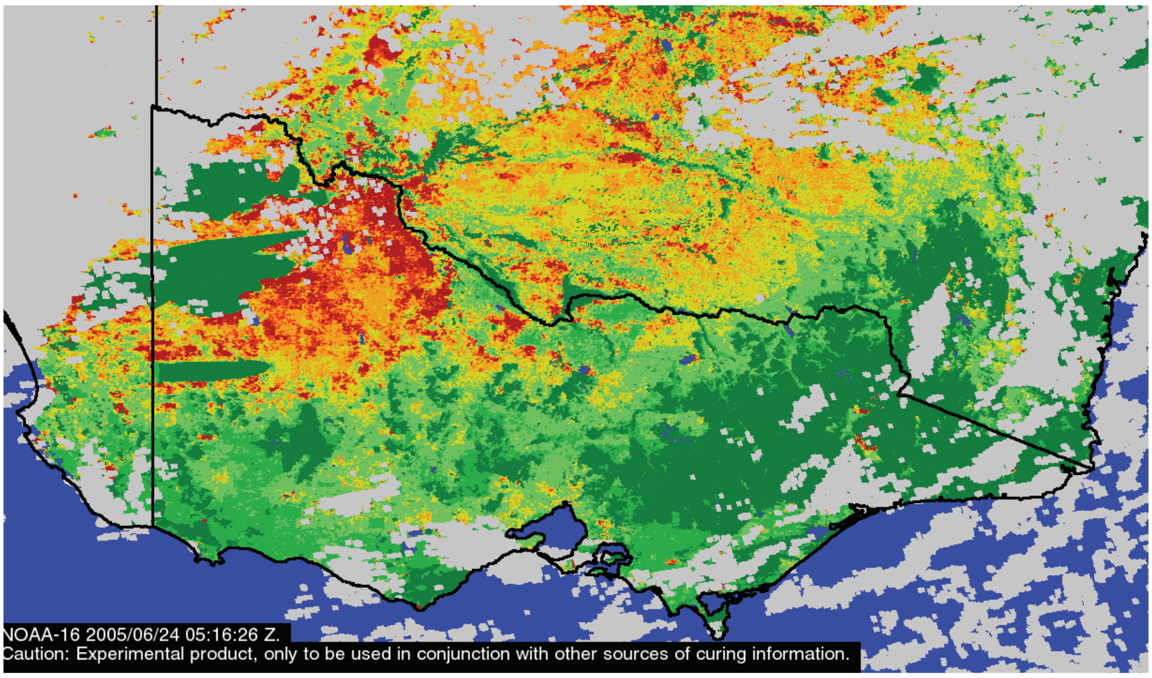


Figure 5. An example of the Bureau's Grassland Curing Index (GCI) product.

Weather Modelling/Forecasting

The Bureau's present operational global assimilation system utilises a One-Dimensional Variational (1D-VAR) retrieval of both NOAA-15 and NOAA-16 AMSU-A and HIRS radiances, utilising 1D radiances as available from NESDIS. An extended version of this global system allows the full forward calculation of ATOVS radiance first guess values in the 1D-VAR retrieval scheme still using level 1D ATOVS radiances. In the immediate future, use of 1C radiances will be examined where each instrument (HIRS or AMSU-A or B) in the ATOVS instrument package will be treated as a separate observation. Processing of locally-derived data can deliver both 1C and 1D radiances which are desirable in support of early cut-off regional assimilation. The Bureau is currently implementing operational processing of HRPT data received at WASTAC, Darwin, Casey and Crib Point (south of Melbourne) to level 1C/1D using the ATOVS and AVHRR Processing Package (AAPP) from EUMETSAT. AAPP is now running operationally with the Crib Point data.

The online 1D-VAR ATOVS radiance retrieval scheme, implemented operationally within the Bureau's global numerical weather prediction system (GASP), has also been integrated with the Bureau's Limited area Assimilation and Prediction System (LAPS), as part of the effort to unify the data assimilation component of these forecasting systems. The 1D-VAR retrievals are used over the sea and at pressures < 100 hPa over land. Work is underway to test the 1D-VAR system in an extended version of LAPS with an increased number of vertical levels and the model top raised to 0.1 hPa, following similar extensions to GASP. This eliminates the need for NESDIS retrievals and will facilitate the use of locally received and processed ATOVS radiances whose timeliness will improve the amount of data available to the operational LAPS system.

Volcanic Ash

Work is continuing on the use of AVHRR (and GOES-9) satellite data for the discrimination of volcanic ash clouds from water/ice clouds and reduction in the incidence of false alarms. The Bureau's Volcanic Ash Advisory Centre (VAAC) in Darwin provides advice on volcanic ash clouds within its area of responsibility for the aviation industry. The advisory messages are based on advice from aircraft, vulcanological authorities, NOAA and GOES-9 satellite imagery and a volcanic ash trajectory forecast model. Even though the Volcanic Ash Advisory Centre is located in Darwin, the AVHRR data from Perth is used for full coverage of Darwin's area of responsibility. By way of example, in 2002 Darwin issued a total of 224 advices covering the area south of 10°N between longitudes 100°E and 160°E. The Bureau is planning to use MODIS data from WASTAC in further R&D efforts to monitor ash clouds.

The Volcanic Ash Advisories (VAAs) issued are based on an initial report or detection of a volcanic eruption or ash cloud, an analysis of satellite data to identify and track the ash cloud, and a short term forecast of the ash movement based on upper level winds and a numerical dispersion model. In the event of a volcanic eruption the provision of timely warnings is critical if the risk of an aircraft encounter with the ash is to be minimised.

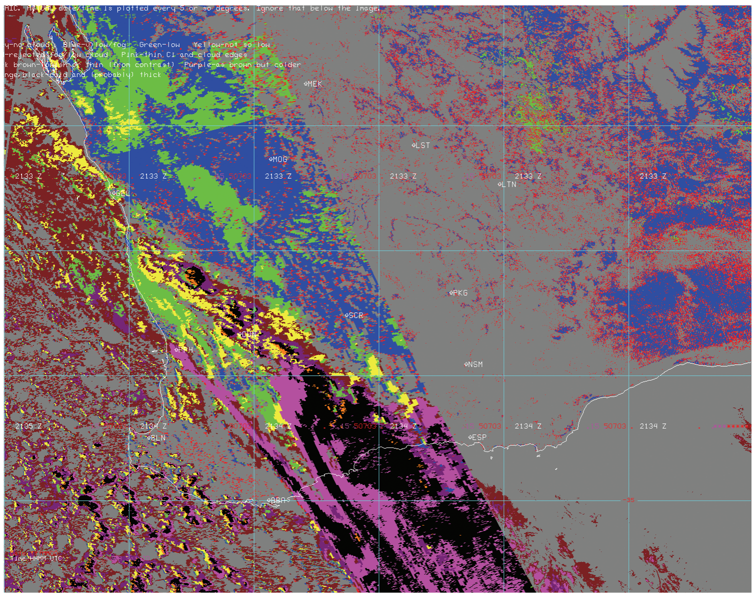


Figure 6. Cloud mask of the southern portion of Western Australia, 2 July 2005. Colours on the cloud mask mean: gray – no cloud detected; red – rejected fog/low cloud; blue – very low cloud/fog; green – low cloud; yellow – low cloud but tops clearly distinct from ground (ex ch3-ch4); brown – dull cloud, low and/or thin (ex neighbouring pixel check); purple – bright cloud, mid and/or thick (ex neighbouring "surface" check); magenta/pink – cirrus and cloud edges; orange – cold cloud, ice or large water droplets; black – cold cloud, probably ice.

Fog/low cloud

The fog/low cloud program developed by Bureau of Meteorology Research Centre is aimed at improving our understanding and forecasting capability for fog. These forecasts are critical to efficient and safe aircraft operations. The low cloud software mosaics AVHRR infrared imagery onto a latitude-longitude grid, using near real-time NOAA-15 and -17 satellite data received at WASTAC and Melbourne. Products are available within 10 minutes of the satellite pass being received, and are geometrically calibrated to within one pixel (1 km).

Daytime low cloud detection is produced using NOAA-15 data. Daytime detections are obtained by taking advantage of the high reflectivity of water clouds in the 3.7 micron channel compared to the lower reflectivity and higher emissivity of the ground. If the 3.7 micron channel is warmer than the 11 micron channel by approximately 14K, then cloud is flagged. Subsequent checks eliminate cloud that is too cold or (where the ground is visible) too high off the ground.

Nighttime low cloud detection is performed using channels 3 and 4 from NOAA-15, and 17 data. Emittance of low altitude water clouds (with small droplets) at nighttime approximates blackbody emittance in NOAA channel 4, but not in channel 3, therefore $T3 < T4$. Clouds composed of large droplets and/or ice crystals are not detected.

Recent improvements to the software include improved cloud height assignment with the use of topography and a land-sea mask, use of temperature rather than brightness values (for greater thermal resolution) and better quality control. For example, nominally low cloud pixels (from ch3 - ch4 test) are rejected, and shown in red on the cloud mask. The cloud mask has also been improved to better detect low cloud pixels. See Figure 6 for an example of a cloud mask.

OPERATIONAL APPLICATIONS (continued)

Cyclone Monitoring

The Bureau's Western Australian Regional Forecasting Centre in Perth provides warnings of tropical cyclones from its Tropical Cyclone Warning Centre (TCWC) whenever the need arises. 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, MTSAT-1R imagery and NWP analysis. It is also a critical back-up to MTSAT-1R imagery. As an example, Figure 7 shows tropical cyclone Ingrid approaching the northwest coast of Western Australian on 15 March 2005 at 0145 UTC.

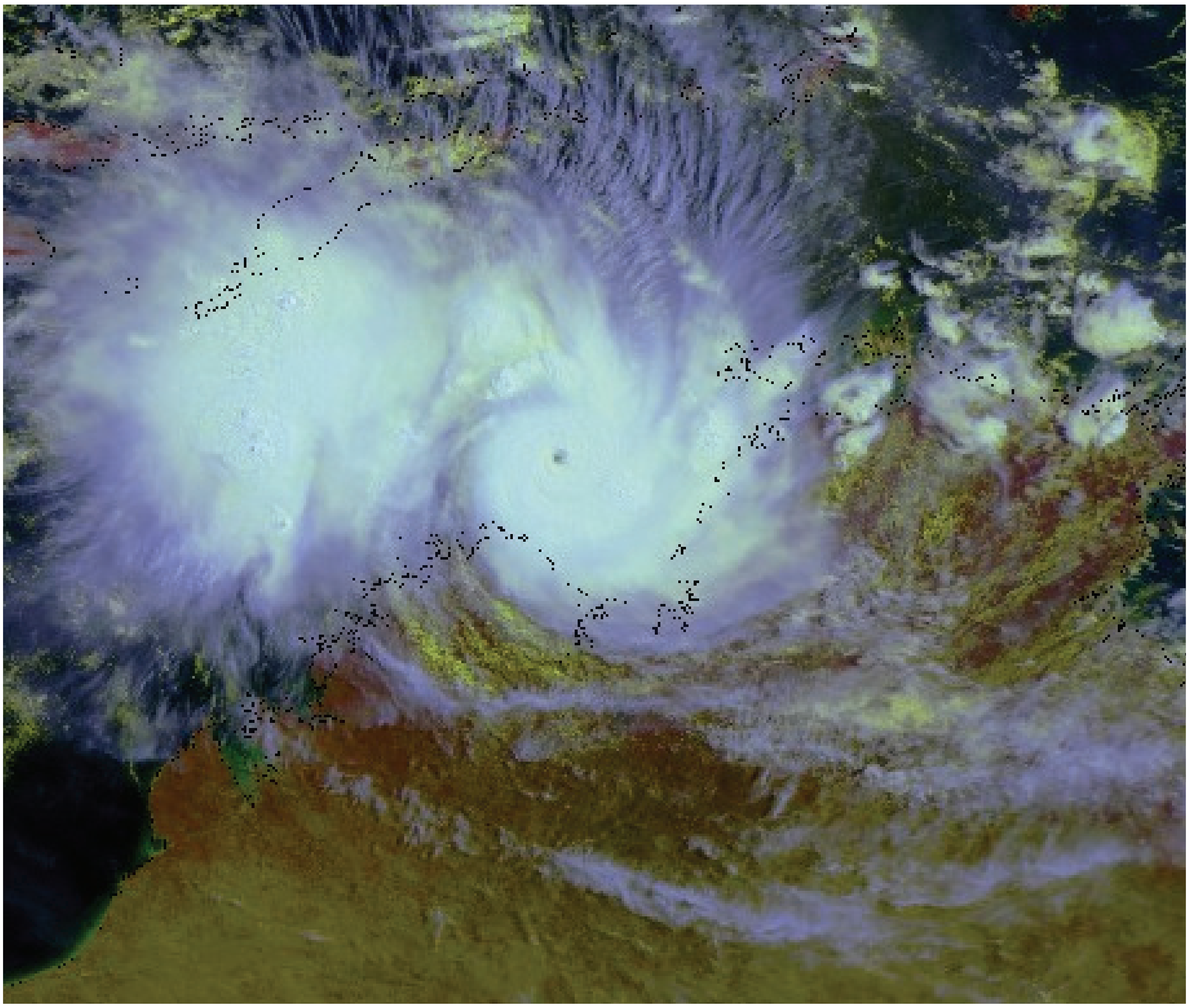


Figure 7. Tropical Cyclone Ingrid bears down on the northwest coast of Western Australia. Image taken from NOAA-17, 15 March 2005 0145 UTC using channels 1, 4 and 5.

Fire Weather Forecasting

The Bureau issues Fire Weather forecasts and warnings as part of its public weather forecast and warning service. In support of this service the Bureau has developed fire detection algorithms for use with AVHRR data. The data received from WASTAC provides coverage for Western and South Australia. See Figures 8 and 9 for hotspot images of fires near Perth in early 2005.

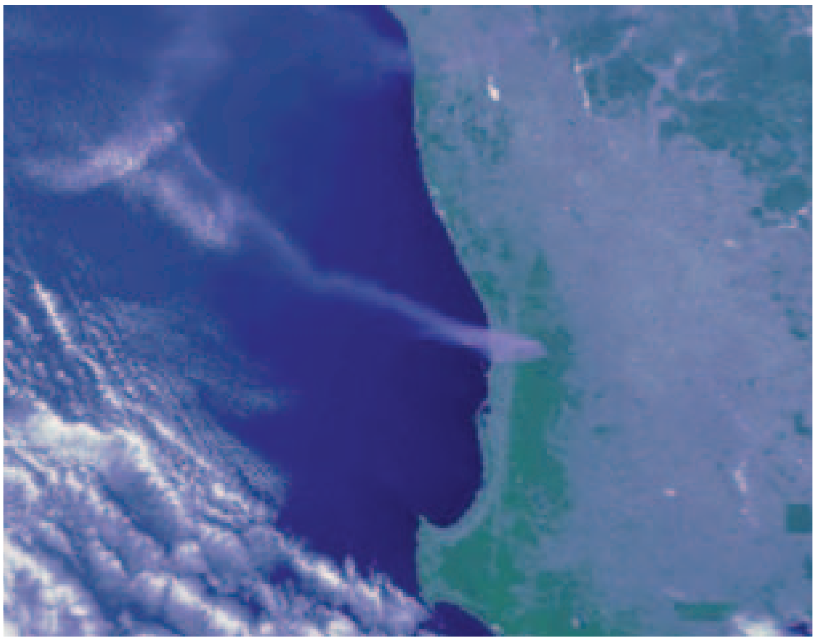


Figure 8. Fires near Perth taken from NOAA-17 on 19 January 2005 at 0247 UTC. This false colour image has been derived using channels 1, 4 and 5.

MODIS and AIRS data

The Bureau is using IMAPP (International MODIS and AIRS Processing Package) software from University of Wisconsin for developmental processing of AIRS sounder data and MODIS high resolution imagery from Hobart, and is near to establishing operational systems which will use the WASTAC X-band antenna MODIS data in real time. The Bureau will use the operational products produced in support of its forecasting requirements. These products will include fog/low cloud detection and cyclone intensity monitoring.

Figure 9. A similar image to that in Figure 8 but from NOAA-16 a few hours later. (19 January 2005 at 0644 UTC). The hot spots can be seen as the red pixels which are derived from channels 3, 4 and 5.

OPERATIONAL APPLICATIONS (continued)

DEPARTMENT OF LAND INFORMATION (SATELLITE REMOTE SENSING SERVICES)

Sea Surface Temperature (SST)

Mike Steber

Over the past year SRSS has been providing NOAA SST images to a Canberra based company Earthinsite. Earthinsite has developed a website named seasurface.com which features SST imagery for the entire continent for the last week (Figure 1). Clients can access and purchase this data from the website in three ways:

- Single Purchase
- Multiple Purchase Subscriptions
- Unlimited Use Subscription

The NOAA-AVHRR data are collected from 3 receiving stations (including WASTAC), processed at SRSS using the CAPS software, and then retrieved by Earthinsite. The time between the satellite pass being received and the SST image appearing on the website can be as short as 1 hour. SRSS has also started processing MODIS data for SST, using IMAPP and locally written software, and is planning to start providing Chlorophyll data from the MODIS sensor.

Figure 1. Earthinsite's web site.

FireWatch

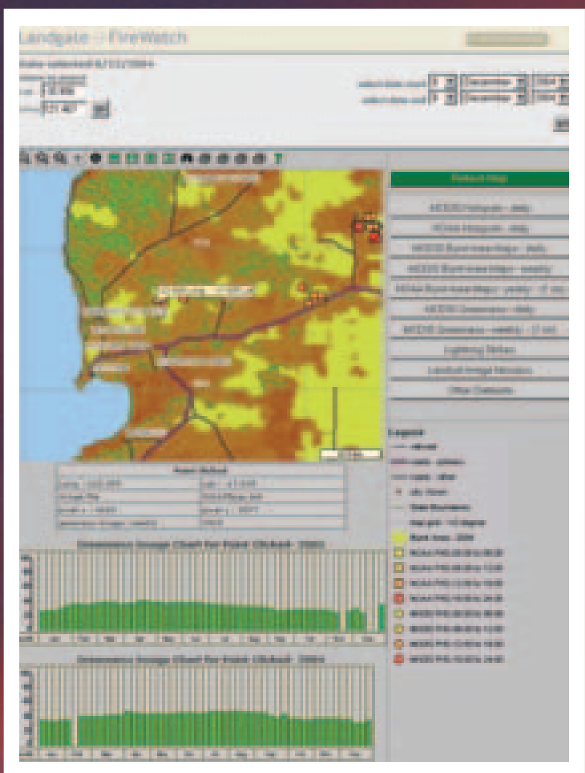
Miquel Tovar

Improvements in the Firewatch Internet Map Service provide the user with more detailed and timely fire information. Firewatch is becoming an essential tool in emergency management across Australia.

Access to the service is via subscription (currently free of charge). It is now used by more than 300 users including the Fire and Emergency Services Authority (FESA) of Western Australia, Conservation and Land Management WA (CALM), the Bushfires Council Northern Territory (BFCNT) and the Country Fire Service, South Australia. Other users include local government agencies, pastoralists and government organisations such as the Departments of Defence, Police and Transport. Western Power, Water Corporation, tourism operators and mining companies across WA have also subscribed to the service.

The service provides daily continental MODIS coverage from receiving stations at Perth, Alice Springs and Hobart. Updates of fire hot spot information are available up to 6 times a day when data from both the MODIS TERRA and AQUA sensors are included with data from NOAA AVHRR. These data are downloadable in both text and shape file format. Additional datasets complement the fire hotspot information. These include burnt area maps (accumulated over daily or weekly time periods), near real-time lightning strike information, and daily and weekly composites of the NDVI, which may be used as a measure of vegetation greenness. Users are able to produce time series plots of the NDVI while online (Figure 2). All information may be viewed and printed by the user.

Users are also able to access a 100 metre Digital Elevation Model (SRTM), a LANDSAT mosaic of Australia, cadastral information, topographic maps, and road and rail location information.



Fiqure 2: Example from the FireWatch website firewatch.dli.wa.gov.au, showing the fire hotspots (shown in red symbols), burnt area (green) and NDVI time series. The image backdrop is the NDVI from the corresponding MODIS overpass. The graphs allow the user to compare the change of NDVI across and between seasons.

Drought Assessment in the Pilbara Using a MODIS greenness index.

Miquel Tovar

Rainfall anomaly maps from the Bureau of Meteorology indicate that while the rainfall from 1998 to 2004 was above the 1960-1991 mean (with extensive flooding along parts of the Fortescue River in 2002), the Pilbara precipitation in 2005 was 300 mm less than the mean. This rainfall information can be verified by comparison with the MODIS greenness time series images. The greenness for most of the central Pilbara for the month of April 2005 registered a 56 % decrease from the mean annual rainfall: the MODIS greenness time series in Figure 3 shows the widespread drought conditions in the Pilbara region.

The current drought has large implications for the migrant bird population and the pastoral enterprises which depend on summer monsoonal rains. These drought events are a reminder to the pastoral owners to adjust the carrying capacity to a planned long-term average season rather than based on a number of good years. The MODIS greenness time series represents a more reliable tool when monitoring the responses to rainfall and flooding than rainfall maps alone.

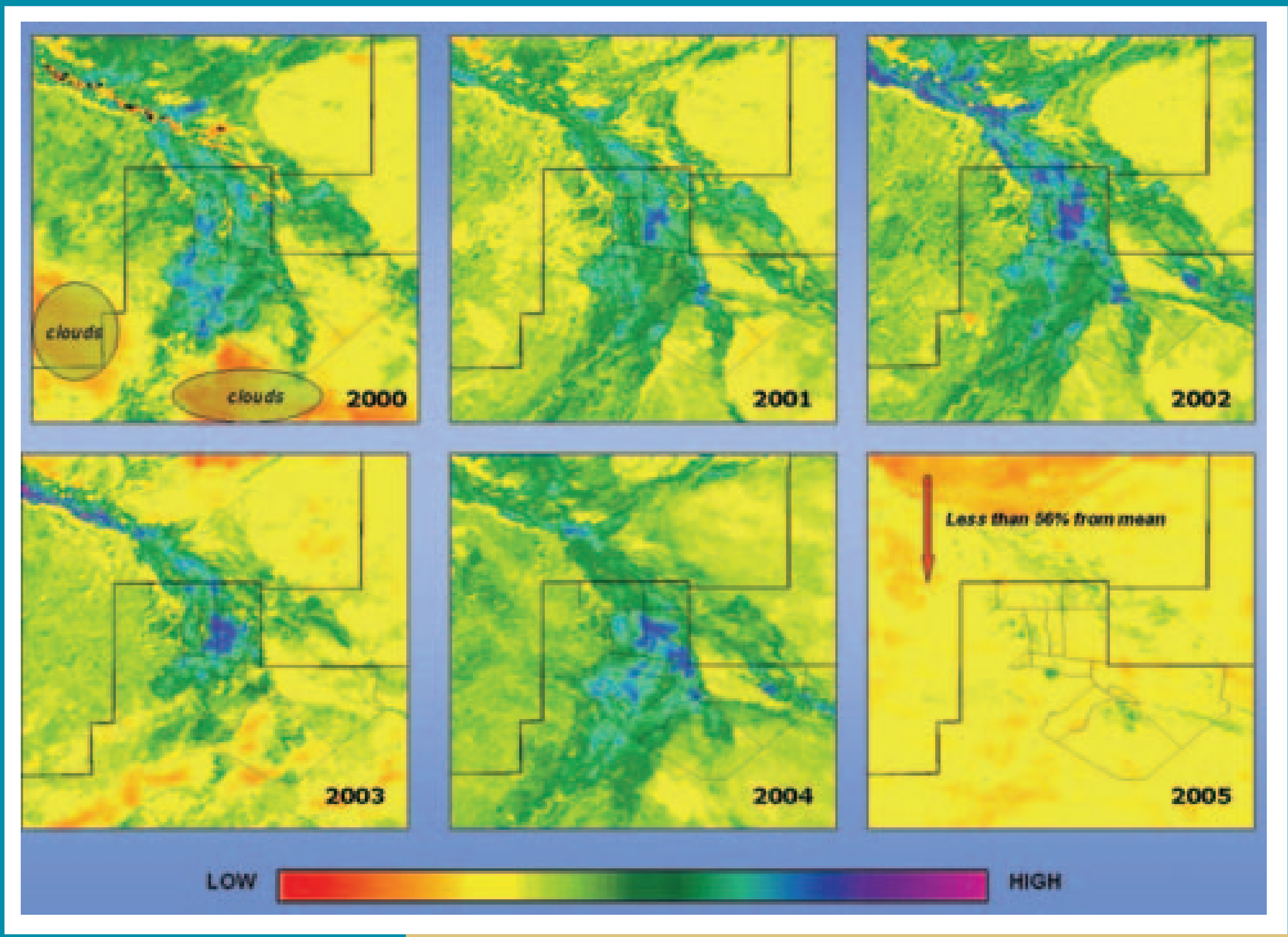


Figure 3: MODIS Greenness composites for the Fortescue River Valley for the month of April between 2000 and 2005.

OPERATIONAL APPLICATIONS (continued)

Pasture Growth Rate Mapping

Richard Stovold, Matthew Adams, Sarfraz Khokhar, Adrian Allen, Graham Donald [1]
[1] CSIRO Livestock Industries.

In a collaborative project between the Department of Land Information, CSIRO Livestock Industries and Agriculture Western Australia, two satellite-based measurement tools have been developed to measure the growth rate and amount of feed on offer within agricultural pastures. The tools are Pasture Growth Rate (PGR) and Food On Offer (FOO).

Using the new improved MODIS satellite data, farmers are accessing weekly PGR measurements of their paddocks. The PGR information is delivered every week as a subscription service over the internet through Fairport Technologies Pasture Watch software.

Farmers in Western Australia and the Eastern States have been using this new technology for over 3 years to assist them to improve their management decisions resulting in higher profitability. They are achieving increased pasture utilisation using PGR and FOO maps resulting in more wool and profit per hectare.

Kojonup farmer Bill Webb (who has been a pioneer in the use of PGR) claims to have increased his overall sheep gross margin by $25/hectare by using feed lots to increase sheep production and pasture utilisation. The satellite derived PGR data which he is using as part of his production risk management can detect degrees of pasture growth rates not detectable by the eye and gives him 2-3 weeks lead time and improves confidence levels in stock management decisions. He also uses the information to decide on his grazing rotation, stocking rates, feed budgeting and fertiliser applications .

Department of Land Information processes the satellite information to PGR measurements based on the CSIRO Livestock Industries PGR model and Department of Agriculture ground data, and has set up a new web site within the Farm Channel of their Landgate service which provides free publicly viewable Pastures From Space information (Figure 4). Recent improvements have been made to the PGR model including the 7 day MODIS cloud free composite. A new MODIS FOO model providing weekly values is being tested in season 2005.

The PGR information can assist agribusiness, regional shires, banking and finance sectors. Potential uses include rural strategic planning, insurance, land valuation and assessment and futures forecasting.

To view the information visit http://www.pasturesfromspace.csiro.au
or visit the DLI Landgate farm channel http://pfs.dli.wa.gov.au

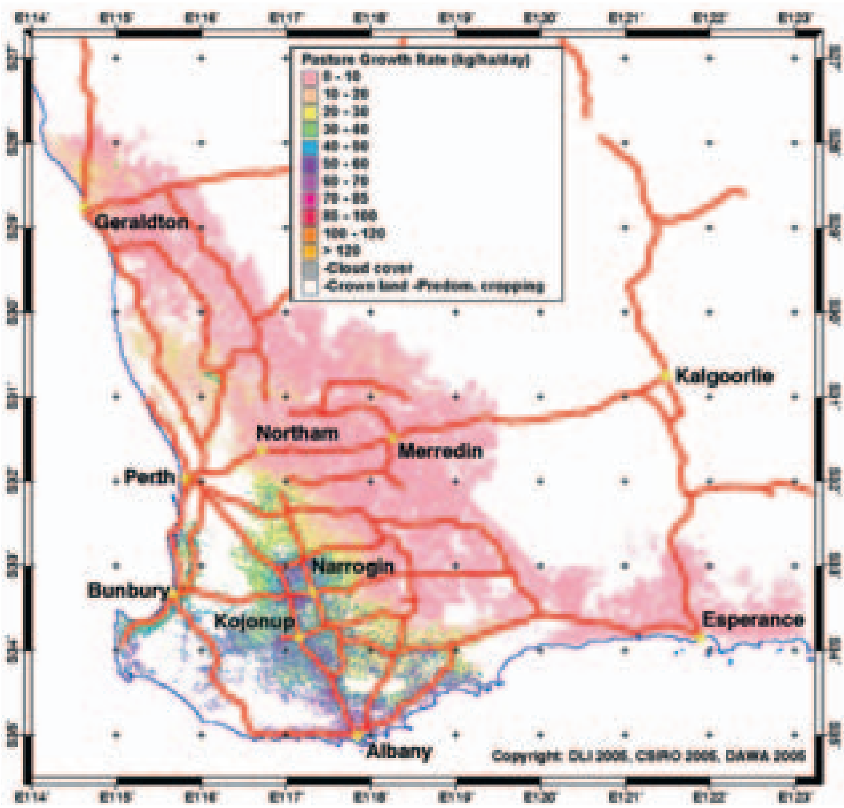


Figure 4: Map of south west Western Australia showing Pasture Growth Rate (PGR) on 27th April 2005 in kg/ha/day.

RESEARCH DEVELOPMENTS

The operational applications described in the previous section are underpinned by ongoing research developments, and this section highlights some of the research activities being undertaken by the WASTAC partners.

CSIRO MARINE RESEARCH

Temperature and chlorophyll images along the Two Rocks Transect

Alan Pearce, Peter Fearns and Tony Koslow (CSIRO Marine Research, Floreat)

NOAA-AVHRR satellite data received by WASTAC are being used to complement water temperature and salinity sampling from surface vessels along a transect off Two Rocks, north of Perth. One of the objectives of the Strategic Research Fund for the Marine Environment (SRFME) is to examine relationships between oceanographic processes (such as water currents, temperature and nutrients) and biological productivity across the continental shelf. Satellite images of sea-surface temperature (SST) show the structure and position of the Leeuwin Current for each of the monthly Transect surveys, and so assist in defining the currents and water masses in relation to the distribution of phyto- and zooplankton.

Because of meandering and eddy processes, the position of the Leeuwin Current is highly variable. It tends to flow along the outer continental shelf and upper slope, but can meander onto the shelf or well offshore in the form of large loops. These meanders or offshoots (Figure 1) transport the tropical waters up to 200 km offshore, while smaller-scale tongues of Leeuwin Current can penetrate across the continental shelf towards the coast, providing an effective mechanism for the cross-shelf exchange of planktonic larvae.

Chlorophyll images derived from the SeaWiFS sensor also reveal a high degree of both spatial and temporal variability associated with patchiness in the abundance of phytoplankton. Many of these features match current structures evident in the SST imagery, but there are also regions of elevated chlorophyll which can apparently develop and propagate independently of SST features.

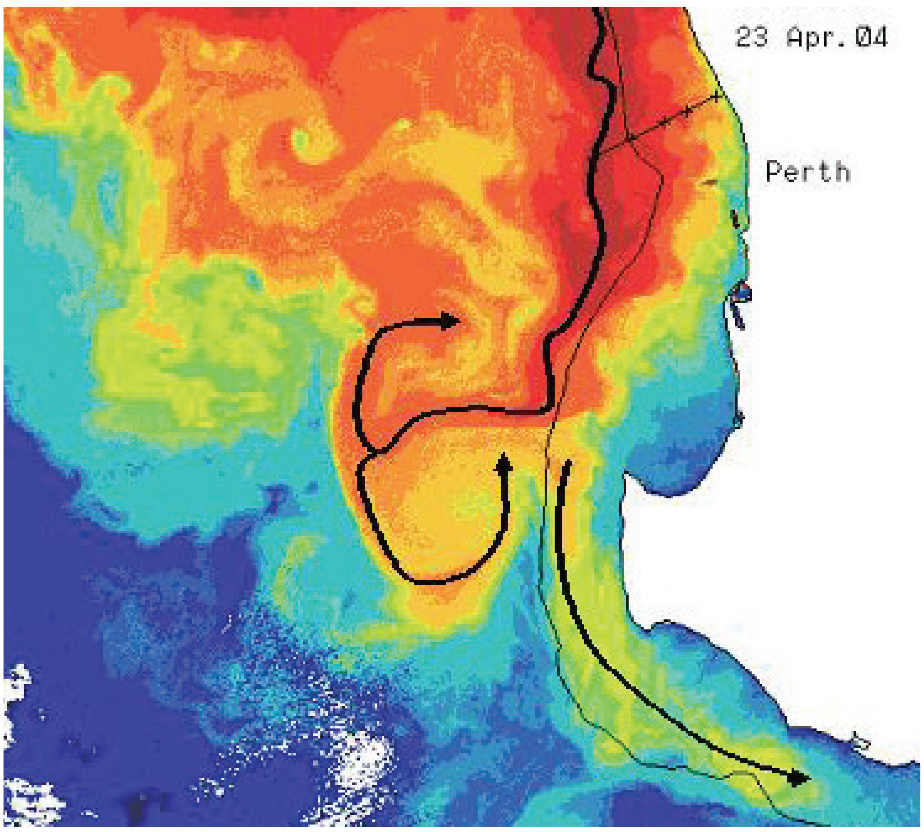


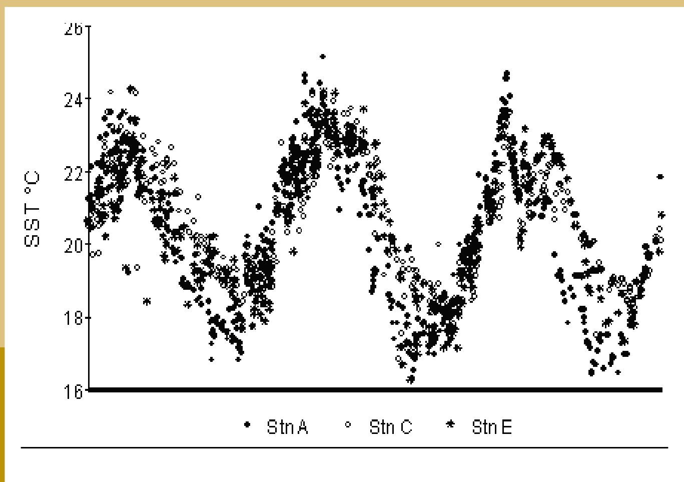
Figure 1: NOAA-SST image of the Leeuwin Current in April 2004. Warmest water is shown in red/orange, cooling through yellow/green to the coolest water in blue. The black line marks the approximate edge of the continental shelf, and the 5 Two Rocks station positions are marked with x's. Note the comparatively cool water in Geographe Bay, and the large offshoot heading offshore into a bipolar eddy.

RESEARCH DEVELOPMENTS (continued)

Sea-surface temperature and chlorophyll time-series
Peter Fearns and Alan Pearce (CSIRO Marine Research, Floreat)

To assist in interpreting the individual monthly boat surveys and to examine the shorter-term variability, daily SSTs have been extracted from all cloud-free afternoon AVHRR passes between 2002 and 2004 at the five boat station positions A (inshore) to E (offshore). For each overpass, the mean and standard deviation of a 3*3 pixel array centred on the stations has been derived. Simple cloud screening has been accomplished using 3 basic tests:
a) SST below 14°C (absolute threshold test);
b) Standard deviation of the near-infrared band (AVHRR Band 2) above 4 counts (spatial coherency test);
c) Standard deviation of the brightness temperature in AVHRR Band 4 above 0.4°C (spatial coherency test).

Despite the high variability, the seasonal cycle is clearly demonstrated with distinctly different amplitudes from inshore to offshore (as discussed for just a single year in the 2003 WASTAC Annual Report). Summer temperatures peak at 23°C in February in the shallow nearshore waters and at 22°C between February and May in the Leeuwin Current (Figure 2). In winter, coastal temperatures drop to 17°C in August (a summer-to-winter range of 6°C) but only to 19°C in the Leeuwin Current in September/October (an annual range of 3°C).



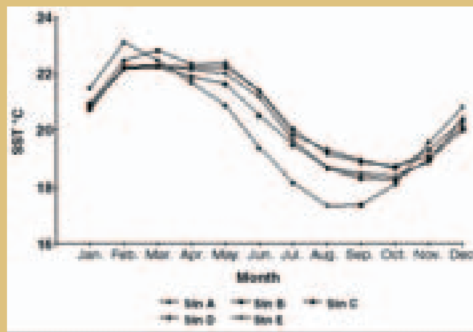
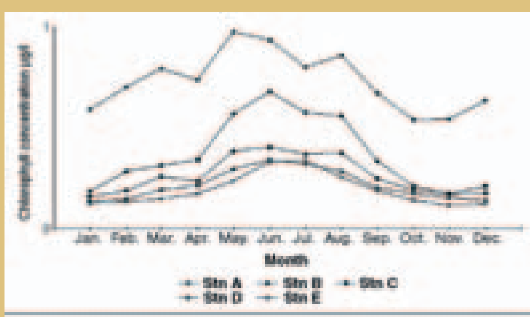


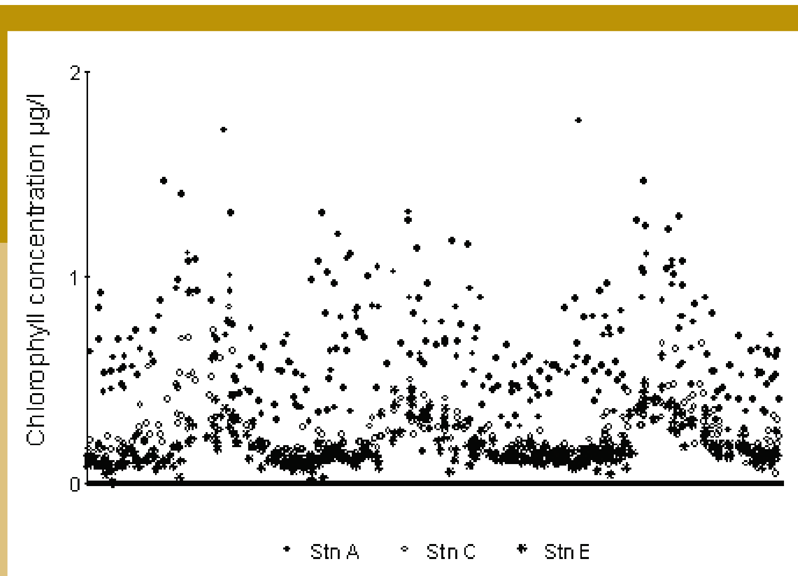
Figure 2: (left) Daily AVHRR sea-surface temperatures (cloud permitting) at the Two Rocks Transect stations A (close inshore) to E (in 1000 m water depth) over the 3-year SRFME period 2002 to 2004. **(above)** The mean annual SST cycle at the 5 Two Rocks Transect stations derived from the daily values 2002 to 2004.

Daily near-surface chlorophyll concentrations derived from SeaWiFS using the standard SEADAS algorithms have also been analysed for the Two Rocks stations (Figure 3, right). Although there is much more scatter than for SST, a clear seasonal pattern emerges with elevated chlorophyll concentrations during the winter period (matching results from the earlier Hillarys Transects). The concentrations are highest at station A near the coast, although as this station is in only 20 m water depth, there may be some degree of bottom reflection or suspended sediments ("Case 2" waters) artificially increasing the upwelling radiances.

Both the seasonal and cross-shelf patterns are clear in the monthly means (Figure 3, below), with the chlorophyll levels being highest between May and August right across the Transect, and the highest values being near the coast.

Figure 3: (right) Daily SeaWiFS chlorophyll concentrations (cloud permitting) at the Two Rocks Transect stations A (close inshore) to E (in 1000 m water depth) over the 3-year SRFME period 2002 to 2004. **(below)** The mean annual chlorophyll concentration cycle at the 5 Two Rocks Transect stations derived from the daily values 1998 to 2004.





SST validation

Alan Pearce, Peter Fearns and Nick Mortimer (CSIRO Marine Research, Floreat)

To have confidence in the satellite-derived temperatures described above, their accuracy must be assessed using "surface-truth" measurements. The near-surface temperatures from the Conductivity/Temperature/Depth (CTD) profiler used at each of the SRFME Two Rocks stations over the 3-year period have been compared with the satellite estimates from the AVHRR sensors on NOAA-16 (2002 and 2003) and NOAA-17 (2004). Cloud-screening has been accomplished using the methods described above.

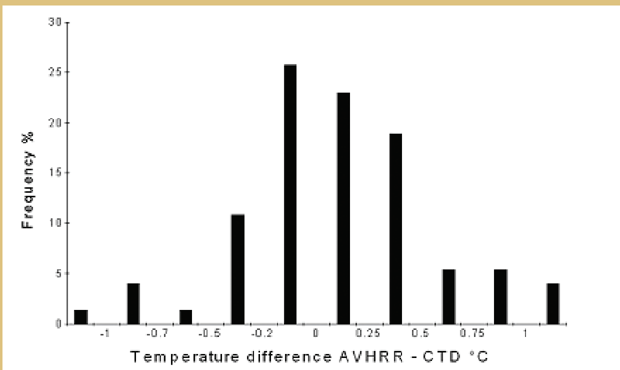


Figure 4: Histogram of the AVHRR-CTD temperature differences over the 75 match-ups along the SRFME Two Rocks Transect between 2002 and 2004.

The mean and standard deviation of 3*3 pixel arrays centred on the CTD station positions have been derived for all the cloud-free stations on the same day as the satellite overpass. Over 75 match-ups, the bias (AVHRR - CTD) was 0.09°C and the RMS difference 0.48°C. The analysis showed that 78% of the match-ups were within 0.5°C and 95% within 1°C (Figure 4).

Acknowledgements

CSIRO and the WA Government for the 5-year funding of SRFME. WASTAC for NOAA-AVHRR, SeaWiFS and MODIS satellite imagery. Marco Marinelli and Dianne Krikke for assistance with data processing and analysis.

Common AVHRR Processing Software (CAPS) Developments

Peter Turner and Ken Suber (CSIRO Marine Research, Hobart)

There have been some significant developments in both interactive and batch functionality in CAPS over the past 12 months. The batch processing system for AVHRR and other data called AllModCons has undergone some major changes to simplify and enhance its operation. Support for NOAA 18 has been added to the batch processing system.

A new module for sea surface temperature is undergoing operational trials at CSIRO Marine Research. An algorithm to process MODIS level 1b data to true colour spatially enhanced geographically projected images has also been developed, as in the example showing Shark Bay (Figure 5).

The HDF/netCDF browser has been significantly enhanced with a new interactive drag box feature to select sub-areas of an image. This greatly improves the investigative capabilities of CAPS. It is envisaged that these facilities will be further enhanced to allow analysis of selected regions of an image.

An OpenDap library to access netCDF files is also being included in an experimental version of CAPS. OpenDap provides a means of accessing data in a variety of formats including HDF and netCDF across the Web as though the data are resident on a local disk.

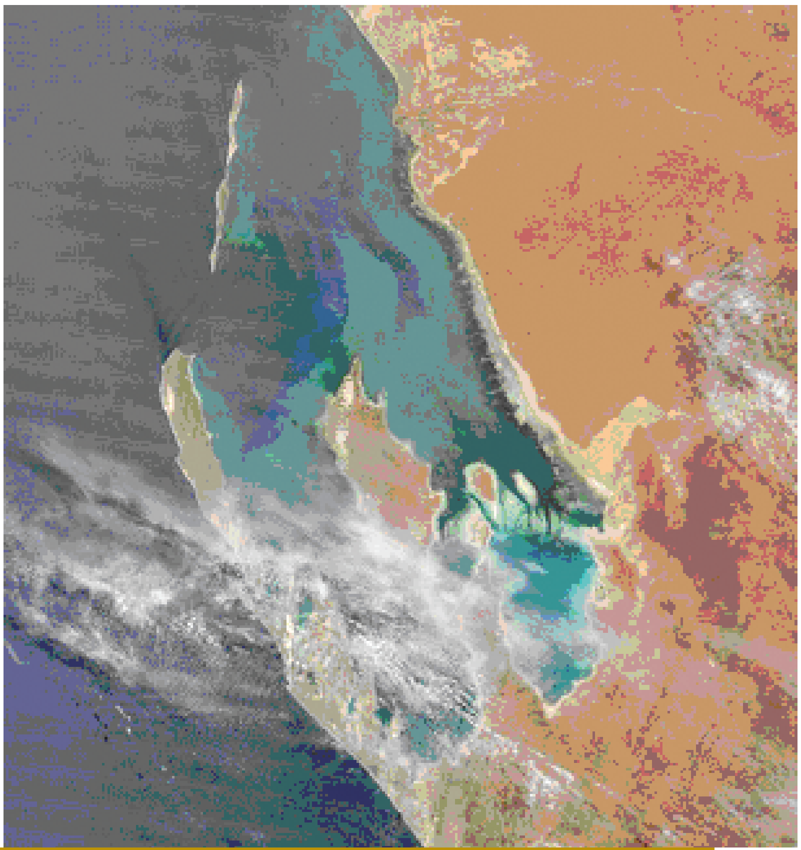


Figure 5: MODIS TERRA image showing ocean colour variability in the Shark Bay area on 19 March 2003: 250 metre enhanced colour image from MODIS channels 1, 3 and 4 processed by CAPS.

RESEARCH DEVELOPMENTS (continued)

CURTIN UNIVERSITY OF TECHNOLOGY
REMOTE SENSING AND SATELLITE RESEARCH GROUP

Regional Trends in Cloud Properties from NOAA TOVS and MODIS Sensors

Helen Chedzey, Paul Menzel1, Mervyn Lynch and Brendan McGann
1 Cooperative Institute of Meteorological Satellite Studies, University of Wisconsin-Madison.

The study of cloud properties has recently been enhanced with the additional spectral information available on the MODIS sensor. Nevertheless, the less sophisticated earlier generation satellites provide longer-term observations of cloud properties which may give valuable insights into trends in cloud radiometric properties, cloud amount and cloud heights. The objective of this study therefore is twofold:

1) to analyse archival satellite data sets (e.g. from the NOAA TOVS instrument) over several decades to search for climate change signatures.
2) to use sensors such as MODIS to track changes in some of the cloud properties that we observe from these new sensors.

HIRS/2 (High resolution Infrared Radiation Sounder) data are available between 1979 (NOAA 5) and 2001 (NOAA 14). Subsets of the global dataset were made for Australia to compare the global trends with regional trends in cloud cover. Cloud observations have been categorised by cloud level and cloud density and collated in the tables below. The statistics corrected for available field of view are shown in brackets. Table 1 lists the global results and Table 2 lists the regional results for Australia.

Clouds forming over the Australian region have been detected by HIRS with an average frequency of 64%. This is a 12% reduction from the average global estimate of 76%. The main differences appear in the detection of high thick clouds (4%) and mid level thick and opaque clouds (3% each).

TABLE 1

GLOBAL	THIN	THICK	OPAQUE	ALL DENSITIES
HIGH	15% (15%)	16% (16%)	2% (2%)	33% (33%)
MID	5% (7%)	8% (12%)	5% (7%)	18% (26%)
LOW	0% (0%)	2% (4%)	23% (47%)	25% (51%)
TOTAL	20%	26%	30%	76%

CLEAR = 24%

TABLE 2

AUSTRALIA	THIN	THICK	OPAQUE	ALL DENSITIES
HIGH	14% (14%)	12% (12%)	1% (1%)	27% (27%)
MID	5% (7%)	5% (7%)	2% (3%)	12% (17%)
LOW	0% (0%)	2% (3%)	23% (38%)	25% (41%)
TOTAL	19%	19%	26%	64%

CLEAR = 36%

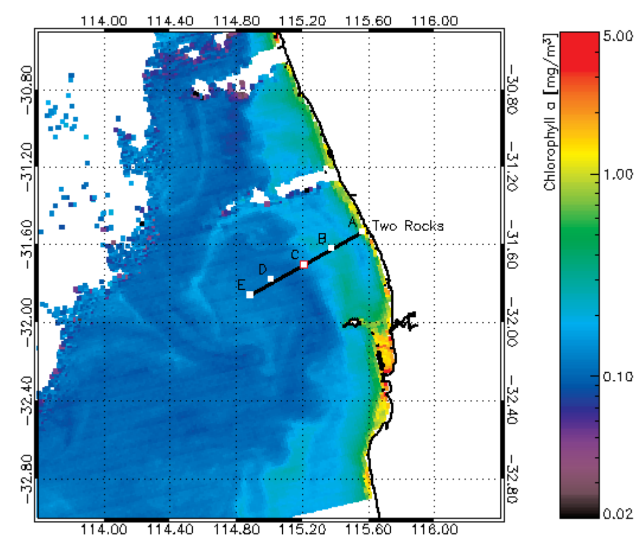


Figure 1: MODIS-Aqua derived chlorophyll a product (units of mg/m3) coincident with field observations located at 'Station C' offshore of Two Rocks (23/1/2004).

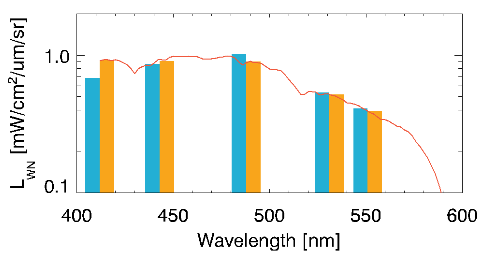


Figure 2: Comparison of MODIS-Aqua exact normalised water leaving radiance (aqua bars) with those obtained from measurements at 'Station C' offshore of Two Rocks (23/1/2004). The results from the hyperspectral profiler (red line) were convolved with the MODIS-Aqua band functions for comparison (orange bars).

Ocean colour product validation in Western Australian waters

L.J. Majewski, W.M. Klonowski, M.J. Lynch, P.R.C.S. Fearns[1], L.A. Clementson[1]
[1]CSIRO Marine Research

The applicability of bio-optical algorithms to a particular location can only be determined through a regional validation program. The Strategic Research Fund for the Marine Environment (SRFME) has enabled the implementation of such a program. Since 2003 measurements of physical, biological and bio-optical properties have been made on a monthly basis along a transect extending out from Two Rocks (Western Australia). The monthly sampling is generally limited to the continental shelf. Four times a year more extensive surveys encompassing deeper waters are conducted. These multi-disciplinary voyages aim to investigate the physical, chemical, bio-optical, bio-geochemical and biological structure along the Two Rocks transect.

Optical profiles were obtained at each station during field work aboard the RV Southern Surveyor (20-28 January 2004) and *Maritime Image* (18-20 July 2004) using a HOBILabs HydroRad-2. Ocean colour data products were acquired for near coincident MODIS-Aqua overpasses. The current version of the MODIS-Aqua ocean colour processing software (SeaDAS v4.6) includes options pertaining to BRDF correction. This functionality was used to obtain the exact, normalised water leaving radiance, L_{WN}^{ex}.

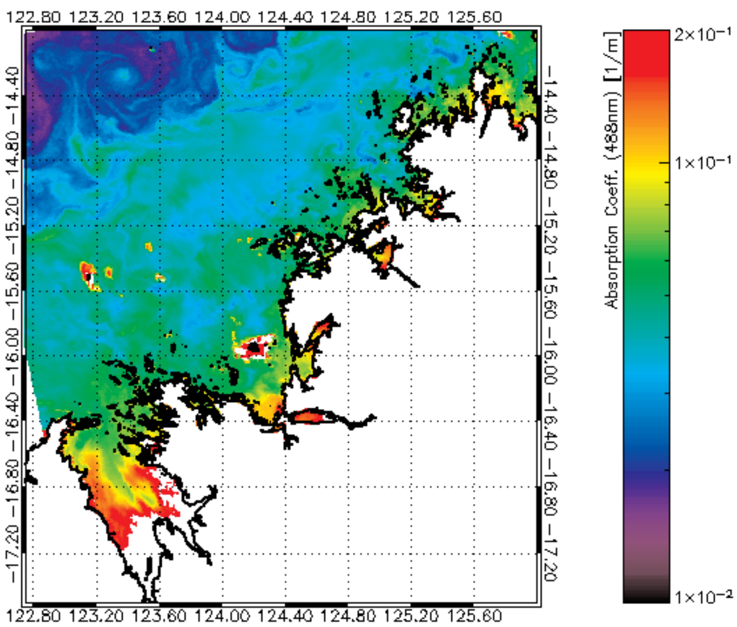
Estimates of chlorophyll *a* (Chl-a) from MODIS-Aqua have been compared to those retrieved when the OC-3 algorithm is applied to in-water measurements (Figures 1 and 2). Although the differences in L_{WN}^{ex} encountered are sometimes outside of specification, the effect on the bio-optical algorithm is less than 30%. In this case, the errors are negligible (less than 0.06 mg Chl-a/m3). While the sensitivity to the input L_{WN}^{ex} has been determined, the validity of the retrieved Chl-a must be compared to the HPLC measured Chl-a concentration before the applicability of the bio-optical algorithm can be fully assessed.

MODIS data for marine bioregion classification schemes
L.J. Majewski, M.J. Lynch

Bioregions are areas that have common biological, physical and/or chemical attributes. For classification purposes the marine environment may be thought of as two distinct but inter-related systems, namely, the water column and the benthic habitat. Information on both of these components (plus other knowledge e.g. marine fauna, populations and distributions etc.) is seen as essential for a robust bioregional classification scheme. The huge extent of the Australian coastline makes defining and monitoring these regions a difficult task. Space-based remote sensing can provide information on spatial and temporal scales that far exceed those of ship-based observations. Information from ocean colour sensors (MODIS and SeaWiFS) is potentially very useful in contributing to marine bioregion classification schemes.

Robust measures of water column properties are required. The inherent optical properties (IOPs) of an observed water column, such as the absorption and scattering coefficients (Figure 3), provide such a measure since they are concerned with the total (observed) water column rather than the concentration of spectrally unresolved constituents. The quasi-analytical algorithm (QAA) of Lee, Carder and Arnone [2002] was employed to obtain estimates of water column IOPs in a self-consistent manner. The QAA may be used in both case 1 and case 2 waters, enabling deployment in regions where little is known about the water chemistry. Additional research is required to refine and validate these algorithms to ensure their general applicability.

While the spatio-temporal coverage that remotely sensed products offer is unrivalled by any other observing system, they should be seen as complementary to other observing and in situ systems. Further, they have an important role in complementing the benthic information provided from other sources that is so crucial in bioregional classification systems. The appearance of new hyperspectral sensors, such as Hyperion, will continue to mature remotely sensed products to the point where the mapping of the shallow water benthic regions will produce valuable and complementary information.



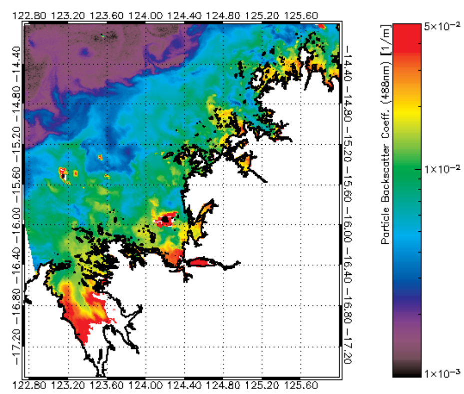


Figure 3: Absorption and particle backscattering coefficients at 488nm (units of m-1) retrieved from MODIS-Aqua using the quasi-analytical algorithm. High estimates of the backscattering coefficient occur near areas anticipated to be sediment dominated/turbid (e.g. King Sound; note the log scale). IOPs may be used as robust estimators of water column properties and can be used in bioregion classification schemes.

RESEARCH DEVELOPMENTS (continued)

Remotely sensing seasonal and interannual oceanic primary production
L.J. Majewski

Our knowledge of phytoplankton production in the southeast Indian Ocean near Western Australia is limited to the very few measurements of carbon uptake made in this area over the last 50 years. This data set is not sufficient to form an understanding of the seasonal or interannual variability present in production, a key variable in current global biogeochemical models.

Remote sensing provides a means of obtaining environmental data sets such as sea surface temperature and chlorophyll-a concentration at high spatial and temporal resolution. These and other high resolution data sets can be manipulated to form an estimate of primary production. To achieve an understanding of the variability of production and possible flow on effects, algorithms applicable to the area of interest must be devised and validated.

Various non-spectral, depth-integrated, remote sensing production models have been developed using data collected from regions with physical and biological characteristics different to those observed during the series of field experiments. Spectrally resolved algorithms reduce the number of empirically determined coefficients and as such provide a more generally applicable method for estimating production. Algorithms have been developed to estimate water column optical properties (including absorption and backscattering coefficients) from the remotely sensed water-leaving radiance at a number of wavelengths. The absorption coefficient can be separated into various components, including that part due to phytoplankton. Knowledge of the phytoplankton specific absorption coefficient allows an estimate of the energy absorbed by phytoplankton throughout the euphotic zone to be developed. If the quantum efficiency of production is known (or can be estimated) an estimate of production can be obtained.

The Determination of Aerosol Optical Thickness and Land Surface BRDF
Frank Yu, Mervyn Lynch and Brendan McGann

The initial activity undertaken on this project was to establish if spectral radiance observations corresponding to multiple views of a scene recorded over a daily cycle (or sequential days) could be inverted to yield the land surface bidirectional reflectance distribution function (BRDF) and simultaneously retrieve the aerosol optical depth. This segment of the project has been completed and it has shown that the approach works providing the scheme uses regularization to stabilise the solution. A validation of the products derived from geostationary data sets has been undertaken using helicopter field data sets and atmospheric aerosol data from solar photometers. Limitations do exist in accurately retrieving the BRDF where there is a high aerosol load in the atmosphere above a dark target or in accurately recovering the aerosol optical depth for the case of a low level of aerosol over a bright target.

Current effort is directed at investigating the feasibility of applying this simultaneous retrieval approach to polar orbiter satellite sensors such as MODIS. The relatively higher spatial resolution and additional spectral bands of MODIS are more appropriate to resource management applications. If the method proves feasible, we expect to validate using BRDF and aerosol data collected as part of a research program conducted by the Spatial Information CRC.

References

Lynch, M.J., and L.J. Majewski, 2004, The role of ocean colour products in bioregion classification schemes, in Ocean Optics XVII, SPIE, Fremantle.

Majewski, L.J., W.M. Klonowski, P.R.C.S. Fearns, L.A. Clementson, and M.J. Lynch, 2004, Ocean colour product validation in Western Australian Waters, in Ocean Optics XVII, SPIE, Fremantle.

Majewski, L.J., W.M. Klonowski, P.R.C.S. Fearns, L. Clementson, and M.J. Lynch, 2004, Validation of remotely sensed ocean colour products in Western Australian waters, in ASLO Ocean Research Conference, Honolulu.

Majewski, L.J., M.J. Lynch, B.T. McGann, P.R.C.S. Fearns, and L.A. Clementson, 2004, Remotely sensing seasonal and interannual oceanic primary production for WA waters, in 3rd SRFME Symposium, Floreat.

DEPARTMENT OF LAND INFORMATION (SATELLITE REMOTE SENSING SERVICES)

Near Real Time Burnt Area Mapping
Stefan W. Maier

The continuous reception via Direct Broadcast (DB) and the quality of the MODIS data make it possible to automatically map burnt areas in near real time (within a few hours of the satellite observation). This enables fire managers to monitor the progression of fires both for managing active fires and for post-event analysis. The near real time burnt area product complements the active fire hotspot product by providing a time-integrated view which fills the gaps in the active fire hotspot information due to overpass time and cloud coverage. In addition it is available at 250m spatial resolution.

The algorithm uses atmospherically-corrected surface reflectances and viewing geometry dependant reflectance factor information (BRDF) from previous overpasses to detect rapid changes in surface reflectance associated with rapid land cover changes.

Figure 1 shows the near real time burnt area maps and corresponding active fire hotspots over a couple of days for a region in the Northern Territory near Larrimah. The violet line represents the Stuart highway. The series of images show how the fire moved in a north-westerly direction (images a and b) and was stopped at the Stuart highway (c and d). Subsequently the fire moved north parallel to the highway (e). Images (f) to (i) show an attempt to stop the fire by a back-burn from a minor road. The back-burn was successful as images (j) to (m) illustrate. Eventually the movement of the fire to the East was probably stopped by a fire break in the North-South direction.

The near real time burnt area maps are being generated on an operational trial base over the whole continent. Future work will include the reduction of noise and other errors due to edge effects and senescence of vegetation. The burnt area maps are available for viewing and download on DLI's FireWatch web page (http://firewatch.dli.wa.gov.au).

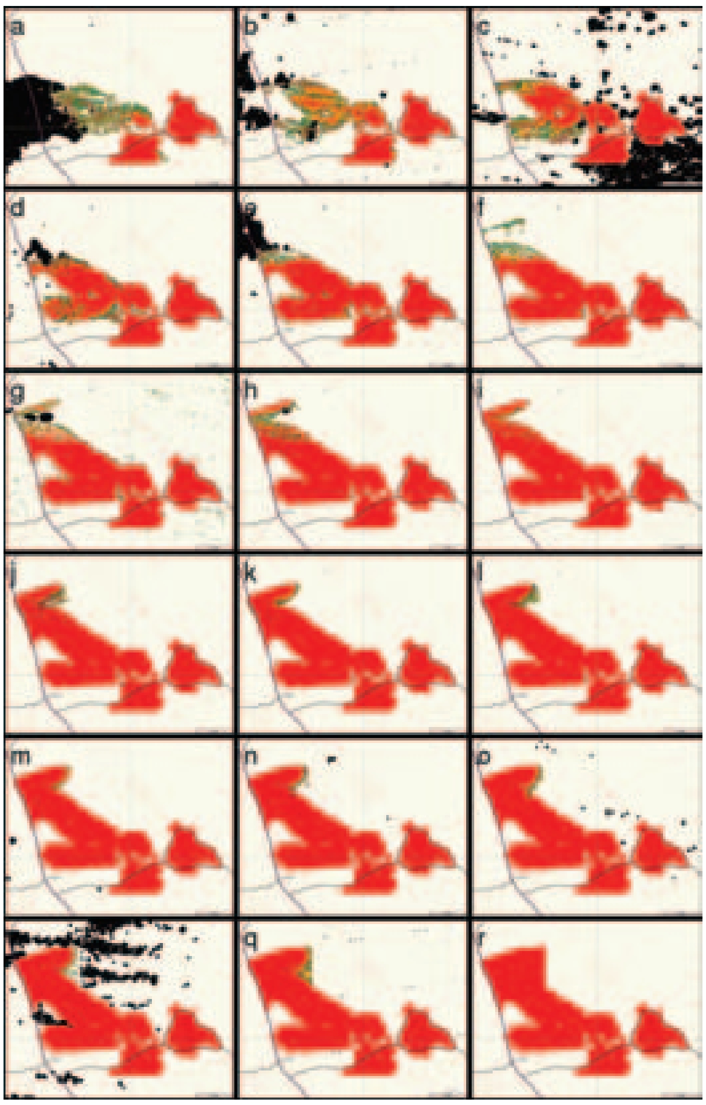
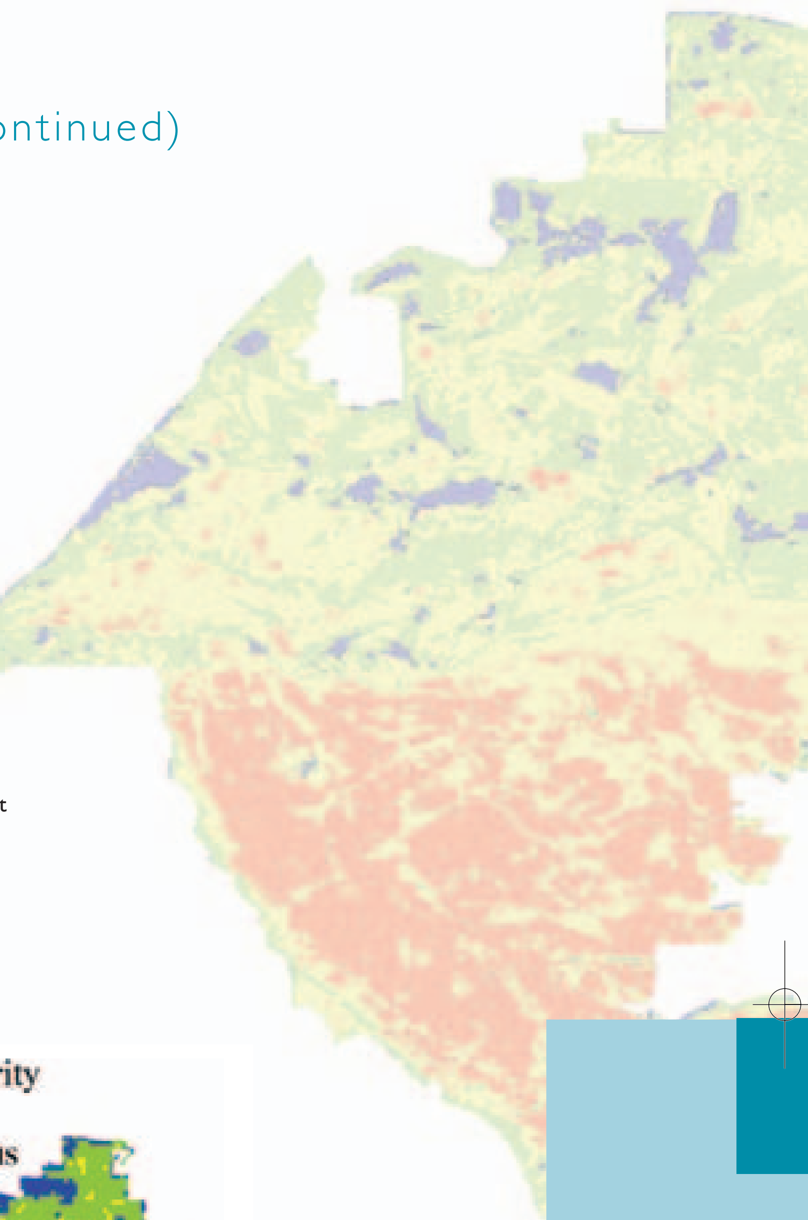


Figure 1: Near real time burnt area maps of a region near Larrimah (NT). Uncertain areas (first indication of burning) are marked in green, possibly burnt areas in orange and burnt areas in red. Corresponding active fire hotspots detected by AVHRR sensors are marked as squares whereas MODIS derived ones are marked as circles. Black areas have been masked out because of obscuring by cloud or smoke. Image dates/times:

a) 21/09/2004 10:03WST,
b) 21/09/2004 12:42WST,
c) 22/09/2004 09:09WST,
d) 23/09/2004 09:51WST,
e) 23/09/2004 12:30WST,
f) 24/09/2004 08:57WST,
g) 24/09/2004 13:11WST,
h) 25/09/2004 09:38WST,
i) 25/09/2004 12:18WST,
j) 26/09/2004 08:45WST,
k) 26/09/2004 12:59WST,
l) 27/09/2004 09:26WST,
m) 27/09/2004 12:04WST,
n) 28/09/2004 12:48WST,
o) 29/09/2004 09:14WST,
p) 30/09/2004 09:14WST

RESEARCH DEVELOPMENTS (continued)



Burn Severity Mapping

Stefan W. Maier

Whereas burnt area mapping gives information about the extent of a fire, burn severity mapping gives information about the "quality" of a fire. The burn severity product, which is currently in development at DLI, is a measure of the biomass reduction due to fire. Burn severity is important for estimates of greenhouse gas emissions and has ecological consequences. It is also a way of assessing the effectiveness of prescribed fuel reduction burns.

Figure 2 shows two burn severity maps of a forested area in the south-west of WA. The map on the left has been derived from Landsat-ETM+ data whereas the one on the right is derived from Terra/Aqua MODIS data. Both maps show a similar pattern with the Landsat-ETM+ derived image showing more spatial detail. The advantage of MODIS data, despite its lower spatial resolution, is its ability to provide burn severity information in near real time (within a few hours of the satellite observation) up to twice a day. This makes it an important tool for managing active fires and for investigating the dynamic behaviour of a fire. The upper part of the burnt area was subject to low intensity prescribed burning, expressed by the mainly green colours. In contrast, the lower part was subject to a wild fire with high intensities, reflected in the mainly red colours.

In future the algorithm, which has proved to be applicable in forested areas, will be adapted to other ecosystems like the tropical savannas.

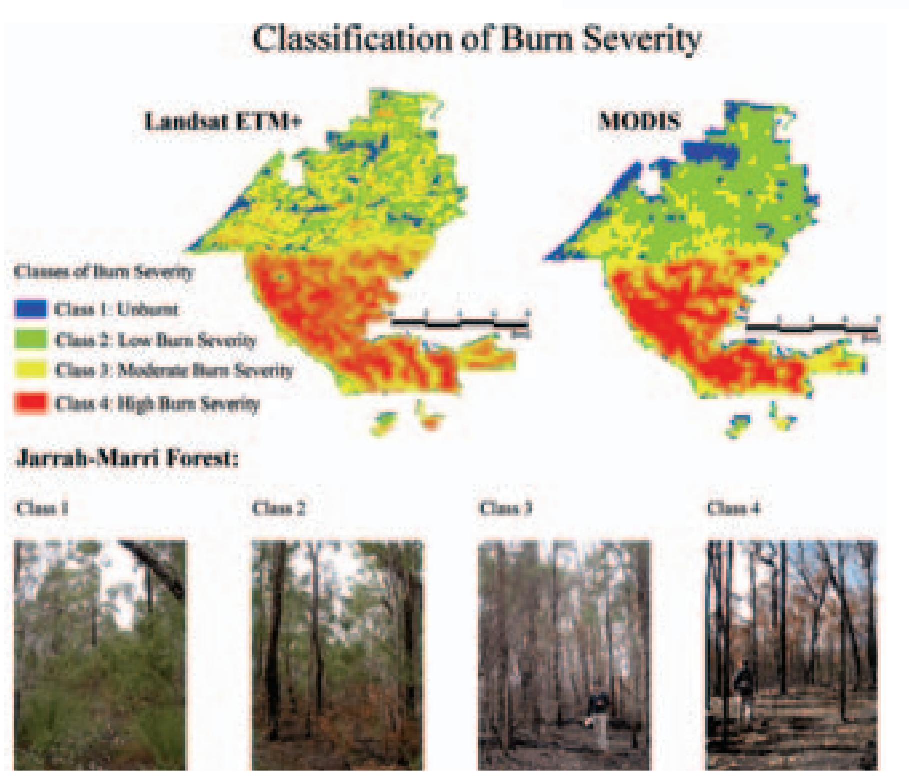


Figure 2: Burn severity classification of a forested area in the south-west of WA. Left: derived from Landsat-ETM+, Right: derived from Terra/Aqua-MODIS. blue: unburnt, green: low burn severity, yellow: moderate burn severity, red: high burn severity. Pictures show typical examples for the different classes in the Jarrah-Marri forest.

Water Vapour From MODIS in Near-Real Time

Brendon McAtee

During 2004, under funding from the CRC for Spatial Information (CRCSI), DLI began developing an operational system for the atmospheric correction of remotely sensed reflectance data from the MODIS satellite sensor in Near-Real Time (NRT). DLI has taken a modular approach to the construction of an atmospheric correction algorithm. An important input into such a system is an estimate of the total precipitable water (PW) in the atmosphere, and this has been the first stage of development. Two algorithms for the NRT retrieval of PW have been implemented and validated against both radiosonde data and the water vapour fields predicted from the Bureau of Meteorology's (BOM) LAPS model.

Figure 3 (a,b) compares the results from the NRT PW retrieval algorithm developed by Sobrino et al. (2003) and the IMAPP NRT PW retrieval algorithm (wvnir) against the LAPS PW data for December 2004, without any cloudmask applied. Figure 3(c,d) show the same comparison but using the cloudmask generated from International MODIS/AIRS Processing Package (IMAPP) software in Figure 3c and a DLI cloud mask in Figure 3d. It is apparent that after application of the cloudmask, the RMS error of the comparison between the two datasets is significantly reduced.

The importance of using an accurate cloudmask has been an important outcome of the work. Without the application of a cloudmask, accuracy is limited to between 0.9 and 1 g cm-^{2} (Figure 3, a,b). With a cloud mask applied, PW may be measured using MODIS data to an accuracy between 0.5 and 0.6 g cm^{-2} (Figure 3, c,d), which is comparable to that achieved by the BOM LAPS model over continental Australia. This evaluation and validation work has enabled selection of the best algorithm for NRT PW retrieval for use within the operational system for atmospheric correction of MODIS data in NRT.

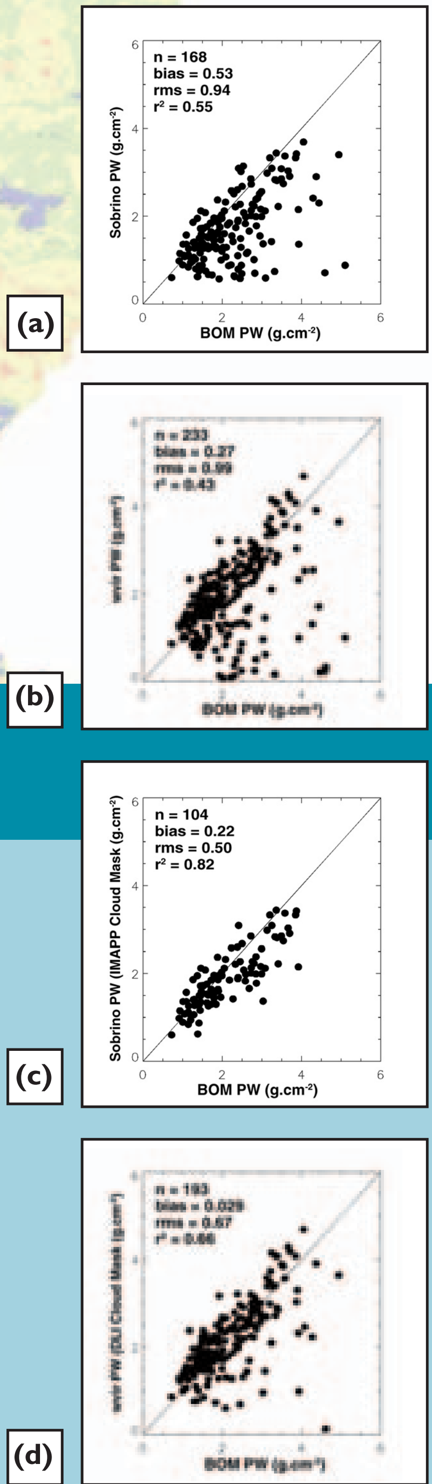


Figure 3: (a,b) Comparison of the Precipitable Water Vapour (PW) derived from the Sobrino et al. (2003) algorithm and the IMAPP algorithm against the Bureau of Meteorology LAPS model, without cloud-screening.
Figure 3 (c,d) Ditto, but with IMAPP cloud-screening applied in (c) and the DLI cloud mask in (d).

Reference:

Sobrino et al. (2003), Surface temperature and water vapour retrieval from MODIS data. International Journal of Remote Sensing, Vol. 24 (24)

MURDOCH UNIVERSITY

Marine reserve planning in data poor environments: a case study from north west Australian waters adjacent to the Kimberley coast

Nicola Fox and Lynnath Beckley

The primary objective of this study is to develop techniques for selecting marine reserve networks in areas with a paucity of biological survey data. A possible approach in such areas is to use environmental data derived from remote sensing and modelling. Satellite data will be combined with computer modelling to act as a surrogate for marine biodiversity in the poorly-studied coastal region between Broome and the Northern Territory border.

Weekly composites of MODIS sea surface temperature, chlorophyll concentration and light attenuation data will be analysed for the period 2000 to 2004 to estimate environmental dissimilarity along the coast and provide a base for the selection of priority areas for marine conservation.

WASTAC ANNUAL REPORT FINANCIAL STATEMENTS 2004

WASTAC L BAND BUDGET 2005

Estimated expenditure for the year January 2005 – December 2005

		PER ANNUM $ 2004	$ 2005
1.	Telstra Rental	7000	7000
2.	Data Tapes	2000	2000
3.	System maintenance/repairs	6000	86000
4.	Telecommunications lic/maint of facility	1500	1500
5.	Consultants	2000	2000
6.	Sundry consumables	1500	1500
7.	Travelling – Airfares	3000	3000
8.	Provision for major equipment	12000	12000
9.	Annual Report	5000	10000
	TOTAL:	$40,000	$125,000

Estimated income/revenue for the year January 2005– December 2005

1.	Contributions received ($10,000 each)	40000	40000
2.	Interest	6000	6000
	TOTAL INCOME	$46,000	$46,000

Extra-ordinary expenditure January 2005 – December 2005

1.	Capital Reserve:		
1.1	Antenna replacement and componentry	150,000	80,000
1.2	Receiver upgrade for METOP satellite	30,000	0
	TOTAL:	$180,000	$80,000

WASTAC X BAND BUDGET 2005

Estimated expenditure for the year January 2005 – December 2005

		PER ANNUM $ 2004	$ 2005
1.	Data Tapes	5,000	5,000
2.	System maintenance	15,000	145,000
3.	System repairs	4,000	4,000
4.	Consultants,product development	70,000	20,000
5.	Sundry consumables	2,000	2,000
6.	Travelling – Airfares	8,000	8,000
7.	Provision for major equipment	15,000	20,000
	TOTAL:	$119,000	$204,000

Estimated income/revenue for the year January 2005 – December 2005

1.	Annual Contributions ($20,000 each from DOLA,CSIRO,Geoscience Aust, $10,000 from BoM for 2005 year only)	80,000	70,000
2.	Interest	6,000	6,000
	TOTAL INCOME:	$86,000	$76,000

Additional committed expenditure January 2005 – December 2006

1.	Withholding payment to SeaSpace Corp. 13 Oct.2006	31,815(exl GST)	31,815(exl GST)
2.	Receiver upgrade for NPP/NPOES satellies	150,000	80,000
	TOTAL:	$181,815	$111,815

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY
AND APPLICATION CONSORTIUM L BAND

INDEPENDENT AUDITOR'S REPORT

We have audited the attached financial statements for the year ended 31 December 2004 and in our opinion they fairly represent the transactions of the Consortium pertaining to L-Band for the year then ended, the financial status as at 31 December 2004 and associated cash flows. The statements are based on proper accounts and records

Charlie Bertilone
Director of Internal Audit
Curtin University of Technology

31 May 2005

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY
AND APPLICATION CONSORTIUM X BAND

INDEPENDENT AUDITOR'S REPORT

We have audited the attached financial statements for the year ended 31 December 2004 and in our opinion they fairly represent the transactions of the Consortium pertaining to X-Band for the year then ended, the financial status as at 31 December 2004 and associated cash flows. The statements are based on proper accounts and records

Charlie Bertilone
Director of Internal Audit
Curtin University of Technology

31 May 2005

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY
AND APPLICATION CONSORTIUM L BAND

STATEMENT OF FINANCIAL PERFORMANCE FOR THE PERIOD 1 JANUARY 2004 TO 31 DECEMBER 2004

	NOTE	2004 $	2003 $
INCOME			
Contributions Received	4	50,000	30,000
Sundry Income		-	-
Interest Received		8,491	6,657
TOTAL INCOME		**58,491**	**36,657**
EXPENDITURE			
Data Tapes and Disks		-	6,250
Printing, Stationery & Photocopying		6,436	4,360
System Maintenance/Repairs		209	5,138
Telephone		6,482	7,595
Telecommunications License of Facility		2,635	1,058
Consultants		-	-
Major Equipment		-	-
Aarnet charges		-	-
Depreciation Expenses		13,724	6,473
Furniture		1,007	-
TOTAL EXPENDITURE		**30,493**	**30,874**
OPERATING SURPLUS / (LOSS)		**27,998**	**5,783**

Jocelyn Gan
Director
Financial Services

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM L BAND

STATEMENT OF FINANCIAL POSITION AS AT 31 DECEMBER 2004

	NOTE	2004 $	2003 $
CURRENT ASSETS			
Cash at Bank		242,304	201,750
TOTAL CURRENT ASSETS		242,304	201,750
NON - CURRENT ASSETS	2		
Computer Equipment	2a,5	-	7,100
Other Equipment	2b,5	36,549	42,004
TOTAL NON - CURRENT ASSETS		36,549	49,104
TOTAL ASSETS		278,853	250,854
CURRENT LIABILITIES		-	-
NON - CURRENT LIABILITIES		-	-
TOTAL LIABILITIES		-	-
NET ASSETS		278,853	250,854
SHAREHOLDERS EQUITY			
Retained Funds	3	278,853	250,854
TOTAL EQUITY		278,853	250,854

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM L BAND

CASH FLOW STATEMENT FOR THE TWELVE MONTHS TO 31 DECEMBER 2004

	2004 $	2003 $
INFLOWS		
Contributions Received	50,000	30,000
Sundry income	-	-
Interest Received	8,491	6,657
TOTAL INFLOWS	**58,491**	**36,657**
OUTFLOWS		
Purchase of Other Equipment	1,168	
Data Tapes and Disks	-	6,250
Printing, Stationery & Photocopying	6,436	4,360
Telephone	6,482	7,595
System Maintenance Repairs	209	5,138
Telecommunications License of Facility	2,635	1,058
Consultants	-	-
Major Equipment	-	-
Aarnet charges	-	-
Funiture	1,007	-
TOTAL OUTFLOWS	17,937	24,401
EXCESS OF INFLOWS OVER OUTFLOWS	40,554	12,256
CASH AT BEGINNING OF PERIOD	201,750	189,494
CASH AT END OF PERIOD	**242,304**	**201,750**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY
AND APPLICATION CONSORTIUM L BAND

NOTES TO AND FORMING PART OF THE FINANCIAL STATEMENTS FOR THE PERIOD 1 JANUARY 2004 TO 31 DECEMBER 2004

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. Where necessary, comparative figures for the previous year have been adjusted to conform with changes in presentation and classifications made in the current year.

1b. Depreciation

Equipment presented in these financial statements is depreciated in accordance with the following methodology.

Other Equipment	12.5 % reducing balance method
Computer Equipment	25% reducing balance method. Personal desktop computers are fully expensed in the month of purchase. This differs from Curtin University where only personal desktop computers costing less than $1,000 are expensed in the month of purchase.

		2004 $	2003 $
2	**NON CURRENT ASSETS**		
2a.	Computing Equipment (at cost)	121,222	191,553
	Accumulated Depreciation	(121,222)	(184,453)
	TOTAL COMPUTING EQUIPMENT	-	7,100
2b.	Other Equipment (at cost)	209,758	208,590
	Accumulated Depreciation	(173,209)	(166,586)
	TOTAL OTHER EQUIPMENT	36,549	42,004
	TOTAL NON - CURRENT ASSETS	36,549	49,104
3	**RETAINED PROFITS/(LOSSES)**		
	Retained Profits/(Losses) at beginning of period	250,854	245,071
	Net Surplus/Deficit for the period	27,998	5,783
	RETAINED PROFITS/(LOSSES) AT END OF PERIOD	278,853	250,854

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY
AND APPLICATION CONSORTIUM L BAND

NOTES TO AND FORMING PART OF THE FINANCIAL STATEMENTS FOR THE PERIOD 1 JANUARY 2004 TO 31 DECEMBER 2004

4 **CONTRIBUTIONS RECEIVED**	**2004**	**2003**
	$	**$**
Department of Land Administration	10,000	10,000
Bureau of Meteorology	10,000	10,000
CSIRO - Earth Observation Centre	10,000	10,000
Curtin University of Technology for 2003	10,000	-
Curtin University of Technology for 2004	10,000	-
	50,000	30,000

5 FIXED ASSET SCHEDULE

Computer Equipment	**2004**	**2003**
	$	**$**
Carrying amount at beginning of period	7,100	9,811
Additions	-	-
Disposal	(5,273)	-
Depreciation	(1,827)	(2,711)
Accumulated depreciation disposal	-	-
Carrying amount at end of period	-	7,100

Other Equipment	**2004**	**2003**
	$	**$**
Carrying amount at beginning of period	42,004	45,766
Additions	1,168	-
Depreciation	(6,623)	(3,762)
Carrying amount at end of period	36,549	42,004

CURTIN UNIVERSITY OF TECHNOLOGY
WA SATELLITE TECHNOLOGY CENTRE - L BAND

EQUIPMENT AS AT 31 DECEMBER 2004

Asset #	Description	Opening Cost	Accumulated Depn	Disposal of Assets	
COMPUTER EQUIPMENT					
01358800	SYSTEM SATELITE TRACKING STATI	110,000	110,000	-	-
02478800	2.3GB 8MM EXABYTE	6,272	6,272	-	-
02629700	CARTRIDGE SYSTEM 2.5 G BYTE 8M	4,950	4,950	-	-
02552700	TAPE DRIVE 2 GBYTE X801A	6,840	6,840	6,840	N/a
02553701	ACQNR	3,800	3,800	3,800	N/a
02585200	PAINTJET XL C1602A	2,425	2,425	2,425	N/a
03914000	MICROWAVE COMMUNICATION SYSTEM	57,266	57,266	57,266	N/a
TOTAL COMPUTER EQUIPMENT		191,553	191,553	70,331	-
OTHER EQUIPMENT					
01358700	SATELITE STATION TRACKING	140,000	126,448	-	13,552
01948500	POWER CONDITIONER	2,000	1,750	-	250
02009000	MA 23 CC	20,365	17,761	-	2,604
02553700	RECEIVER NOAA I/F FORMAT	19,500	16,424	-	3,076
03852500	CX-FS1P4 CISCO 4 PORT S/INTER	7,440	5,044	-	2,396
03852501	PA-7KF-E1/75 CISCO DUAL E1 G70	3,400	2,305	-	1,095
03852502	CAB E1 BNC FSIP MIP-CE1 BNC 75	215	146	-	69
05132000	RADIO NETWORK BUREAU TO CURTIN	15,670	3,257	-	12,413
05477100	TAPE STORAGE CABINET (NEW)	1,168	74	-	1,094
TOTAL OTHER EQUIPMENT		209,758	173,209	-	36,549
DESKTOP EQUIPMENT (EXPENSED)					
03904000	HEWLETT PACKARD 715/64 WORKSTA	25,208			
03923700	LYNXPACK 6000E DDS2 4/8GB TAPE	2,098			
03923800	LYNXPACK 6000E DDS2 4/8GB TAPE	2,098			
04085100	9GB DIS DRIVE	2,435			
04522800	WIDE DISK DRIVES	2,164			
04536800	AMSUCARD FOR INST P/C	6,765			
04619200	MONITOR	834			
05131500	DLT 4000 TAPE DRIVE	2,950			
05131600	DLT 4000 TAPE DRIVE	2,950			
05131700	LINUX PC	4,263			
TOTAL DESKTOP EQUIPMENT		51,765			

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY
AND APPLICATION CONSORTIUM X BAND

STATEMENT OF FINANCIAL PERFORMANCE FOR THE PERIOD 1 JANUARY 2004 TO 31 DECEMBER 2004

	NOTE	2004 $	2003 $
INCOME			
Contributions Received	4	80,000	80,000
Sundry Income		-	-
Interest Received		11,813	16,157
TOTAL INCOME		**91,813**	**96,157**
EXPENDITURE			
Outsourced Work		46,804	-
Visiting		3,000	-
Travel		1,374	874
Venue Hire		743	-
Maintenance		10,896	10,004
Computer Equipment Purchase		(21,783)	14,408
IDM Media Costs		3,200	9,250
Other Consumables		153	-
Depreciation		57,801	61,577
TOTAL EXPENDITURE		**102,188**	**96,113**
OPERATING SURPLUS / (LOSS)		**(10,375)**	**44**

Jocelyn Gan
Director
Financial Services

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM X BAND

STATEMENT OF FINANCIAL POSITION AS AT 31 DECEMBER 2004

	NOTE	2004 $	2003 $
CURRENT ASSETS			
Cash at Bank		222,108	196,466
TOTAL CURRENT ASSETS		222,108	196,466
NON - CURRENT ASSETS			
Computer Equipment	2a,5	14,974	-
Other Equipment	2b,5	431,353	482,344
TOTAL NON - CURRENT ASSETS		446,327	482,344
TOTAL ASSETS		668,435	678,810
CURRENT LIABILITIES		-	-
NON - CURRENT LIABILITIES		-	-
TOTAL LIABILITIES		-	-
NET ASSETS		668,435	678,810
SHAREHOLDERS EQUITY			
Retained Funds	3	668,435	678,810
TOTAL EQUITY		668,435	678,810

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY
AND APPLICATION CONSORTIUM X BAND

NOTES TO AND FORMING PART OF THE FINANCIAL STATEMENTS FOR THE PERIOD 1 JANUARY 2004 TO 31 DECEMBER 2004

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.
Where necessary, comparative figures for the previous year have been adjusted to conform with changes in presentation and classifications made in the current year.

1b. Depreciation

Equipment presented in these financial statements is depreciated in accordance with the following methodology.

Other Equipment	12.5 % reducing balance method
Computer Equipment	25% reducing balance method. Personal desktop computers are fully expensed in the month of purchase. This differs from Curtin University where only personal desktop computers costing less than $1,000 are expensed in the month of purchase.

2 NON CURRENT ASSETS

	2004	2003
	$	$
2a Computer Equipment (at cost)	**21,783**	**-**
Accumulated Depreciation - Computer Equipment	(6,809)	-
TOTAL COMPUTER EQUIPMENT	14,974	-
2b Other Equipment (at cost)	**616,913**	**616,913**
Accumulated Depreciation - Other	(185,560)	(134,569)
TOTAL OTHER EQUIPMENT	431,353	482,344
TOTAL NON - CURRENT ASSETS	446,327	482,344

3 RETAINED PROFITS/(LOSSES) AT THE END OF PERIOD

	2004	2003
	$	$
Retained Profits at the beginning of period	678,810	678,766
Net Surplus/(Deficit) for the period	(10,375)	44
Accumulated Funds at the end of the financial year	668,435	678,810

4 CONTRIBUTIONS RECEIVED

	2004	2003
	$	$
Annual Membership-Department of Land Information	20,000	20,000
Annual Membership-CSIRO	20,000	20,000
Annual membership-Bureau of Meteorology	20,000	20,000
Annual Membership-Geoscience Australia	20,000	20,000
TOTAL CONTRIBUTIONS RECEIVED	80,000	80,000

5 FIXED ASSETS SCHEDULE

Computer Equipment	2004	2003
	$	$
Carrying amount at beginning of period	-	-
Additions	21,783	-
Depreciation	(6,809)	-
Carrying amount at end of period	14,974	-

Other Equipment	2004	2003
	$	$
Carrying amount at beginning of period	482,344	480,291
Additions	-	63,630
Depreciation	(50,992)	(61,577)
Carrying amount at end of period	431,353	482,344

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM X BAND

CASH FLOW STATEMENT FOR THE TWELVE MONTHS TO 31 DECEMBER 2004

	2004	2003
INFLOWS		
Contributions Received	80,000	80,000
Sundry income	-	-
Interest Received	11,813	16,157
TOTAL INFLOWS	**91,813**	**96,157**
OUTFLOWS		
Outsourced Work	46,804	-
Visiting Specialist	3,000	-
Travel	1,374	874
Venue Hire	743	-
Maintenance	10,896	10,004
Computer Equipment Purchase	-	14,408
IDM Media Costs	3,200	9,250
Other Consumables	153	-
X Band Receiving Station Final Payment	-	63,630
TOTAL OUTFLOWS	**66,170**	**98,166**
(SHORTAGE)/EXCESS OF INFLOWS OVER OUTFLOWS	25,643	(2,009)
CASH AT BEGINNING OF PERIOD	196,466	198,475
CASH AT END OF PERIOD	**222,108**	**196,466**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM X BAND

EQUIPMENT AS AT 31 DECEMBER 2004

ASSET #	DESCRIPTION	ORIGINAL COST	ACCUMULATED DEPRECIATION	WRITTEN DOWN VALUE
OTHER EQUIPMENT				
4857100	X-BAND SATELLITE RECEIVING STATION	553,283	(185,560)	367,723
	FINAL PAYMENT ON X-BAND SATELLITE RECEIVING STATION	63,630	-	63,630
TOTAL OTHER EQUIPMENT		616,913	(185,560)	431,353
DESKTOP COMPUTER EQUIPMENT				
5131900	DLT 8000 TAPE DRIVE	7,375	(4,250)	3,125
5429500	DELL POWEREDGE 1600CC SERVER	7,204	(1,279)	5,925
5429600	DELL POWEREDGE 1600CC SERVER	7,204	(1,279)	5,925
TOTAL DESKTOP COMPUTER EQUIPMENT		21,783	(6,809)	14,974

ASSET REGISTER

Asset Number	Description	Cost Centre	Location	Area	Project . No	Asset Type	Serial No.	Commissioned	Current Cost	Accumulated Depreciation	Net Book Value
	E-101206-0010-16121										
1358800	SYSTEM SATELITE TRACKING STATI	E1012060010	204	500	E109201	D	---------------	1-Jul-87	$110,000.00	$110,000.00	$0.00
2478800	2.3GB 8MM EXABYTE	E1012060010	218	301	E109201	D	802548	1-Dec-90	$6,272.00	$6,272.00	$0.00
2629700	CARTRIDGE SYSTEM 2.5 G BYTE 8M	E1012060010	BLD	WASTAC	E109201	D	801491	1-Jul-91	$4,950.00	$4,950.00	$0.00
	E-101206-0010-16131										
1358700	SATELITE STATION TRACKING	E1012060010	204	600	E109201	E	0	1-Jul-87	$140,000.00	$140,000.00	$0.00
1948500	POWER CONDITIONER	E1012060010	204	500	E109201	E	7/83/132	1-Jun-89	$2,000.00	$2,000.00	$0.00
2009000	MA 23 CC	E1012060010	204	500	E109201	E	8910	1-Aug-89	$20,365.00	$20,365.00	$0.00
3852500	CX-FSIP4 CISCO 4 PORT S/INTER	E1012060010	NA	NA	E109201	E	0	1-Jul-96	$7,440.00	$7,440.00	$0.00
3852501	PA-7KF-E1/75 CISCO DUAL E1 G70	E1012060010	NA	NA	E109201	E	0	1-Jul-96	$3,400.00	$3,400.00	$0.00
3852502	CAB E1 BNC FSIP MIP-CE1 BNC 75	E1012060010	NA	NA	E109201	E	0	1-Jul-96	$215.00	$215.00	$0.00
5132000	RADIO NETWORK BUREAU TO CURTIN	E-101206-0010-16131	NA	NA	F135100	E	020225DOLA	20-Mar-03	$15,670.00	$4,002.05	$11,667.95
5477100	TAPE STORAGE CABINET - LOC: DLI FLOREAT	E-101206-0010-16131	NA	NA	F135100	E	0	29-Jun-04	$1,168.00	$133.12	$1,034.88
	E-101206-0010-72@@@										
3904000	HEWLETT PACKARD 715/64 WORKSTA	E1012060010	NA	NA	E109201	N	6619V30035	1-Oct-1996	$25,208.00	$25,208.00	$0.00
3923700	LYNXPACK 6000E DDS2 4/8GB TAPE	E1012060010	BLD	WASTAC	E109201	N	96360472314	2-Dec-1996	$2,098.00	$2,098.00	$0.00
3923800	LYNXPACK 6000E DDS2 4/8GB TAPE	E1012060010	BLD	WASTAC	E109201	N	96360472286	2-Dec-1996	$2,098.00	$2,098.00	$0.00
4085100	9GB DIS DRIVE	E1012060010	NA	NA	E109201	N	0	21-Oct-1997	$2,435.00	$2,435.00	$0.00
4522800	WIDE DISK DRIVES	E1012060010	NA	NA	E109201	N	LP343974	23-Sep-1999	$2,164.00	$2,164.00	$0.00
4901500	PENTIUM III - VIA COMPUTER SYSTEM	E-101206-0010-72377	NA	NA	F135100	N	9431608	18-Apr-2002	$4,818.18	$4,818.18	$0.00
5131500	DLT 4000 TAPE DRIVE	E-101206-0010-72322	NA	NA	F135100	N	0	20-Mar-2003	$2,950.00	$2,950.00	$0.00
5131600	DLT 4000 TAPE DRIVE	E-101206-0010-72322	NA	NA	F135100	N	0	20-Mar-2003	$2,950.00	$2,950.00	$0.00
5131700	LINUX PC	E-101206-0010-70200	NA	NA	F135100	N	0	20-Mar-2003	$4,263.00	$4,263.00	$0.00
	E-101206-0020-16131										
4857100	X-BAND SATELLITE RECEIVING STATION	E1012060020	NA	NA	E101200	E	0	27-Nov-01	$616,913.00	$211,751.71	$405,161.29
	E-101206-0020-16121										
5131900	DLT 8000 TAPE DRIVE	E-101206-0020-16121	NA	NA	F135100	D	0	20-Mar-03	$7,375.00	$5,267.10	$2,107.90
5429500	DELL SERVER - CSIRO MARINE FLOREAT	E-101206-0020-16121	NA	NA	F135100	D	FKTV71S	16-Apr-04	$7,204.00	$2,272.70	$4,931.30
5429600	DELL SERVER - DEPT OF LAND INFO, FLOREAT	E-101206-0020-16121	NA	NA	F135100	D	GKTV71S	16-Apr-04	$7,204.00	$2,272.70	$4,931.30
	E-101206-0020-72@@@										
5131800	LINUX PC - COMDEK	E-101206-0020-72377	NA	NA	F135100	N	0	20-Mar-2003	$4,818.00	$4,818.00	$0.00

This page is left blank intentionally