WASTAC
WESTERN AUSTRALIAN SATELLITE TECHNOLOGY
and APPLICATIONS CONSORTIUM

ANNUAL REPORT 2002

www.wastac.wa.gov.au

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FRONT PAGE: A MODIS true colour image merged with a thermal sea surface temperature image over Western Australia. Merged and processed by Jackie Marsden of the Satellite Remote Sensing Group from WASTAC supplied data.
The data assists in the management of land and ocean processes and supports decision making for land and ocean managers

EDITORS: R. Stovold DOLA, SRSS
A.F. Pearce CSIRO

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WASTAC CHAIRMAN'S REPORT 2002

"MODIS DATA HAVE BEEN IN HIGH DEMAND FOR OCEAN COLOUR, FIRE HOT SPOTS, BURNT AREA MAPPING AND DROUGHT ASSESSMENT"

During 2002, WASTAC achieved the routine processing of MODIS data to level 1b (geometric and radiometric correction) using the International MODIS/AIRS Processing Package (IMAPP) by providing DOLA with the computer hardware required for this task. Computer hardware was also provided to CSIRO Marine Research to implement the NASA Ocean code. On May 4th another MODIS sensor was successfully launched on the AQUA satellite, but the current version of IMAPP has not provided satisfactory geometric correction of the AQUA data. In November 2002, it was a pleasure to welcome Dr Stefan Maier from the German Remote Sensing Centre (DLR) to lead the MODIS development team within Satellite Remote Sensing Services, DOLA.

MODIS data have been in high demand for ocean colour, fire hot spots, burnt area mapping and drought assessment and for an innovative product that creates a virtual Landsat Normalised Difference Vegetation Index when Landsat is obscured by cloud.

WASTAC received significant support from the University of Wisconsin IMAPP development team during the year, including a training workshop in November, run by IMAPP project leader Liam Gumley with the support of Curtin University of Technology. WASTAC members also participated in two national MODIS workshops leading to agreement to develop IMAPP to a level where it will generate a standard NADIR Surface Reflectance product for the Australian continent. This requires the incorporation of additional algorithms into IMAPP for atmospheric correction, along with their validation and calibration. WASTAC is currently considering a proposal to fund work that would accelerate this development through the transition of key NASA institutional code into the IMAPP environment.

WASTAC has three MODIS development groups focusing on Land, Ocean and Atmospheric products, headed by Satellite Remote Sensing Services DOLA, CSIRO Marine Research and Curtin University's Remote Sensing and Satellite Research Group respectively. Through this interaction we hope to stimulate collaboration on implementation, validation and calibration of key MODIS algorithms.

For the Atmospheric group, the IMAPP cloud mask with significant errors over the Australian Continent is in need of local calibration to be useful.

Other strategic issues facing the WASTAC board are the future upgrade of the X-band facility for the National Polar Orbiting Environmental Satellite System (NPOESS) Preparatory Project (NPP) due for launch in 2006, which has on-board the Visible/InfraRed Imager/Radiometer Suite (VIIRS) as replacement for MODIS. The other issue is the L-band antenna for reception of NOAA and SeaWiFs data which after 16 years of near trouble free operation could be nearing the end of its life.

Much time has been spent negotiating a new Deed of Agreement to underpin the X-band facility. We expect it to be concluded during 2003. However in the interim, WASTAC-X is functioning well and achieving the outcomes required.

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

Richard Smith

Chairman

29 May 2003

WASTAC BOARD FOR 2002

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Bureau of Meteorology

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Bureau of Meteorology

Mr Don Ward
Bureau of Meteorology

Mr Alan Pearce
CSIRO, Marine Research

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CSIRO, Exploration and Mining

Professor Tom Lyons
Murdoch University

WASTAC TECHNICAL COMMITTEE

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Dr Doug Myers

Mr Ronald Craig

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

FUTURE STRATEGIES

- develop internet quicklook and promote archived data.
- update the communications, ingest and reception equipment by a process of planned asset replacement
- review future satellite reception opportunities in both L- and X-band and plan new assets (e.g. antenna) to capture these opportunities
- expand acquisition and distribution of satellite data through high speed communication links
- investigate the cost/benefits of an X-band consortium with ACRES and TERSS to provide improved national coverage of X-band reception
- identify new national and state opportunities in environmental monitoring for sustainable development utilising WASTAC satellite data
- identify new requirements for improved exploitation of WASTAC data.

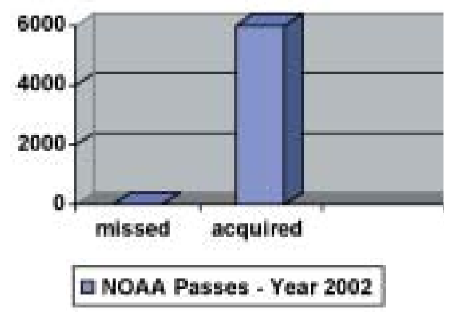
FUTURE SATELLITE OPPORTUNITIES

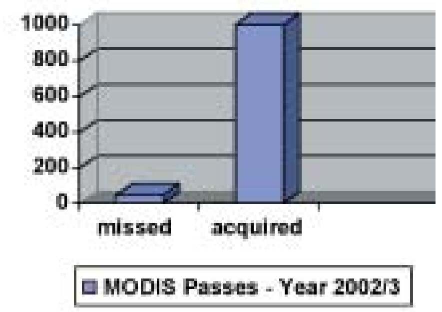
- METOP (Replaces NOAA in 2003) (X-band)

OPERATIONAL STATUS

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

WASTAC FACILITIES NOW EMBRACE BOTH L BAND AND X BAND RECEPTION. THE X BAND FACILITY AT MURDOCH UNIVERSITY WAS COMMISSIONED ON THE 21st NOVEMBER 2001.





WASTAC L

WASTAC L Band facilities consist of 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 BOM{Bureau of Meteorology}.

Colour and grey scale quicklook pictures are produced at the Department of Land Administration (DOLA) -Leeuwin Centre for Earth Sensing Technologies (LCEST) in near realtime for archiving, indexing and distribution. The raw data archive is produced on 4GB dat tape and a duplicate copy is currently produced for a national NOAA data archive program that is coordinated by CSIRO Office of Space Science and Applications (COSSA) in Canberra.

The 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 BOM. Software systems were 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 being produced by 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 7 days of data.

Due to the dedicated efforts of DOLA and BOM staff, a total of 6508 passes were recorded for the year.

WASTAC X

WASTAC X Band facilities consist of a 3.6m domed antenna and antenna controller computer at the Environmental Science building at Murdoch University, ingest and display computers with hard disk storage and tape archive facilities, located at DOLA in Floreat Park, Perth. A microwave link connects the antenna to the Bureau of Meteorology computers. The X band reception facility is directly connected to the high speed PARNET at the Murdoch node which allows data transfer to DOLA and via the internet to other members of WASTAC.

Quicklook pictures are produced at LCEST in around 1 hour for archive, indexing and distribution. The raw data archive is produced on 35 GB DLT tape.

The X band ingest and display system, developed and installed by SeaSpace Corp. in September 2001 consists of a Sun Sparc 400 workstation, antenna and reception hardware at Murdoch and a dual CPU LINUX processing computer at DOLA.

Due to the dedicated efforts of DOLA, Murdoch University and BOM staff, a total of 2444 X band MODIS passes were recorded for the year of which 734 passes were from the Aqua sensor.

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

Orders for digital data can be provided via the internet www.wastac.wa.gov.au on 8mm data tape, DAT tape, DLT tape, CD-ROM or 6250/1600bpi magnetic tape.

FUTURE DIRECTIONS:

A proposal is being prepared to provide a backup NOAA L Band reception facility as an add on to the X Band ingest facility at Murdoch University.

WASTAC DATA ARCHIVE

The WASTAC archive of NOAA and SeaWiFS satellite passes, managed and maintained by the Department of Land Administration (DOLA) Satellite Remote Sensing Services (SRSS) group, is held at the Leeuwin Centre in Floreat, W.A.

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.

A total of 6508 NOAA passes were archived for 2002. Passes comprised data from the NOAA 12, NOAA 14, NOAA 15, NOAA 16 and NOAA 17 satellites. All passes were stored on 20 DLT tapes.

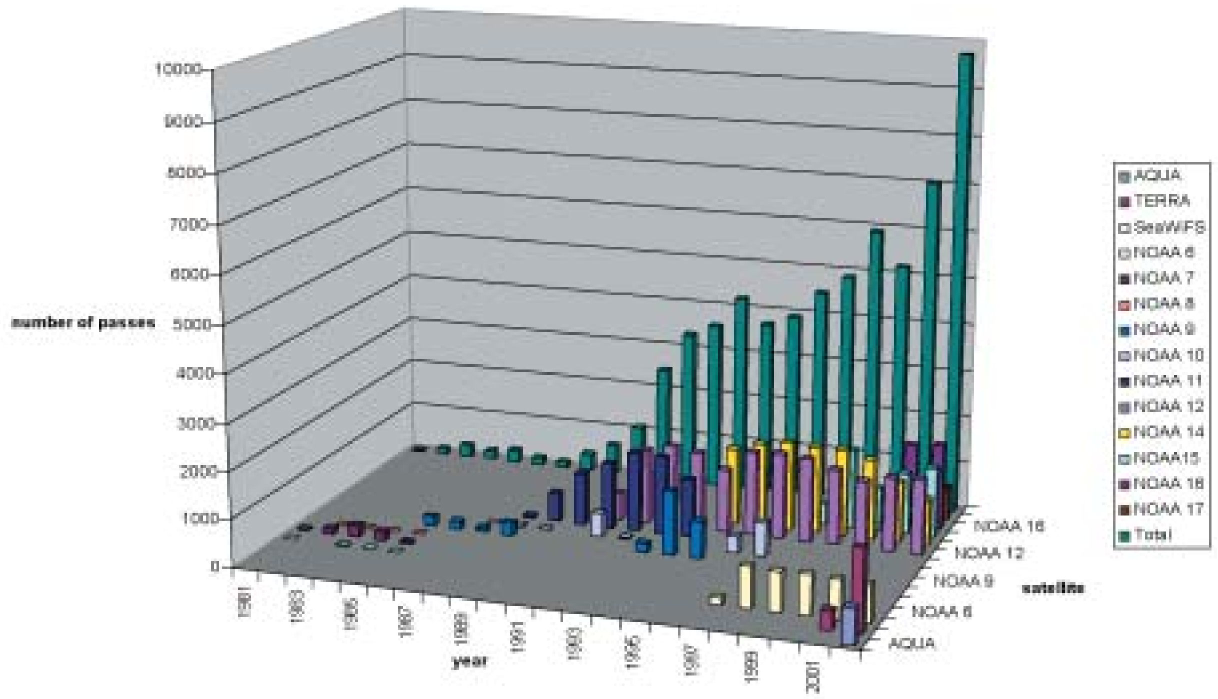
The archiving of SeaWiFS data onto 4mm data tapes commenced on 31 October 1997. During 2002, 780 SeaWiFS passes had been archived to 6 data tapes.

Following the successful installation of the X Band receiving facility at Murdoch 2444 TERRA and AQUA passes have been archived on 63 DLT tapes comprising 2005 gigabytes of information.

DOLAcontinues 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.

Email address to view this archive of MODIS, NOAA and SeaWiFS data is:
http://www.rss.dola.wa.gov.au/noaaql/NOAAql.html

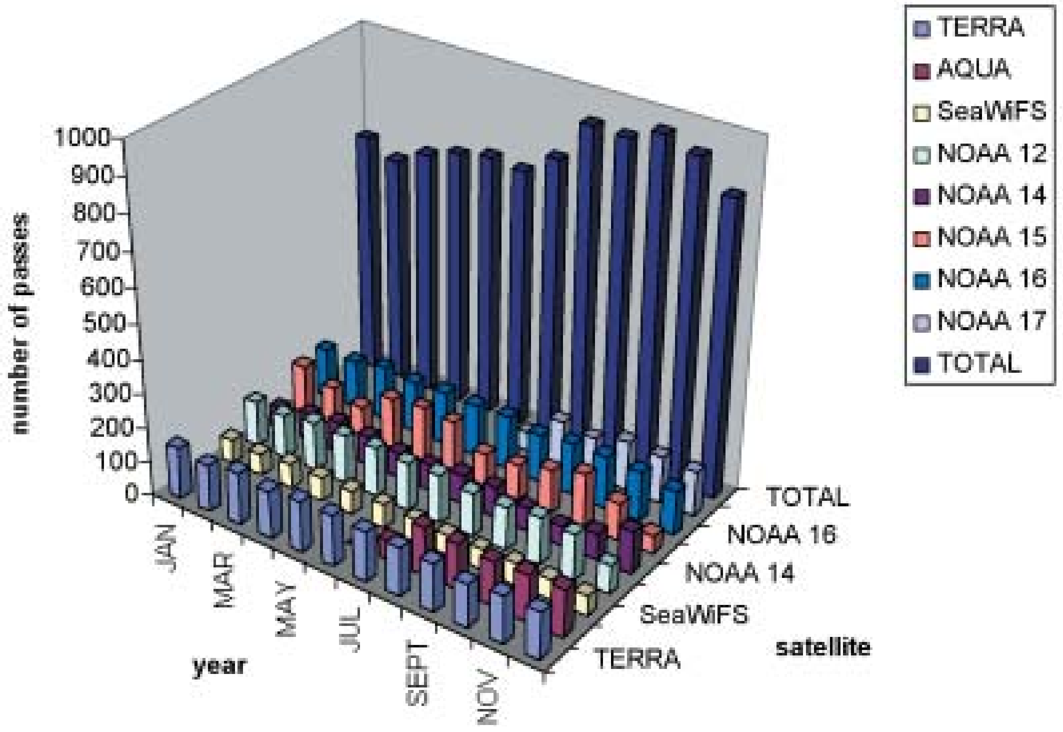
TOTAL NUMBER OF PASSES HELD IN THE WASTAC ARCHIVE - LEEUWIN CENTRE



	AQUA	TERRA	SeaWiFS	NOAA 6	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		178	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

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

WASTAC SATELLITE DATA ARCHIVE 2002



	TERRA	AQUA	SeaWiFS	NOAA 12	NOAA 14	NOAA 15	NOAA 16	NOAA 17	TOTAL
JAN	150		68	132	62	143	148		703
FEB	137		64	128	81	112	143		665
MAR	154		70	143	92	89	161		709
APR	141		70	141	86	151	151		740
MAY	153		69	144	76	160	157		759
JUN	153	1	70	138	76	155	154		747
JUL	147	57	65	143	88	97	157	56	810
AUG	142	141	59	128	89	103	139	127	928
SEPT	138	135	61	127	68	127	152	115	923
OCT	125	127	63	141	56	155	152	143	962
NOV	134	135	62	132	79	109	146	137	934
DEC	136	138	59	82	123	54	129	131	852

Tapes
6508 NOAA passes on 20 DLT tapes
780 SeaWiFS passes on 6 4mm tapes
2444 MODIS passes on 63 DLT tapes

DATA ARCHIVED:
NOAA 404 gigabytes
SeaWiFS 43 gigabytes
MODIS 2005 gigabytes

RESEARCH AND OPERATIONAL APPLICATIONS

BUREAU OF METEOROLOGY

Compiled by Agnes Apostolou & David Griersmith

SEA SURFACE TEMPERATURES

The sea-surface temperature (SST) algorithms used by the Commonwealth Bureau of Meteorology use a combination of NOAA HRPT data from WASTAC, Casey and Darwin for each orbit of NOAA -16, -15 and -12. The algorithms were developed from empirical relationships (originally based on McClain et al. 1985) between satellite observed brightness temperatures and temperatures measured directly on the sea surface. Surface values can be from ship inlet sensors, floating buoys or manually-taken measurements.

Different algorithms are used for SST calculation during the day and night, day and night being determined by the solar zenith angle at the observed point. If the solar zenith angle is less than or equal to 75° then the day time algorithm is used, otherwise the night time algorithm is used. The system computes SSTs at the full sensor resolution, resulting in a sub-satellite resolution of approximately 1 km.

Both algorithms first check that the satellite zenith angle is less than 53°. Experience has shown that the SST retrievals degrade as the sensor zenith angle increases therefore pixels that are greater than 53° from nadir are excluded. A land/sea test is then performed and land regions removed from further processing. The algorithms then check the solar zenith angle: if it is less than 1° then the daytime algorithm does not proceed. If the solar zenith angle is greater than 75° and if channel 2 reflectance is less than one percent, then the night-time algorithm is used. A gross IR test is then performed, where if the channel 4 temperature is less than -5°C then SST is not computed. Pixels which are affected by cloud contamination are also rejected. Corrections are applied to the day time algorithm for reflected solar radiation and to both algorithms for intervening atmospheric absorption.

The mean of three separate multi channel algorithms is used to compute SST at night time and all three algorithms must be within 2 °C otherwise the pixel is rejected. Only one algorithm is used during the day as channel 3 contains reflected sunlight and cannot be used.

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 the test 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 January 2003) of -0.35 (NOAA-16), 0.11 (NOAA-15), -0.01 (NOAA-12) degrees.

SST products produced by the Bureau are available to the general public for free (via the browse service at http://www.bom.gov.au/nmoc/archives/SST/) and by subscription (for higher resolution data). Examples of both products are given in Figures 2 and 3.

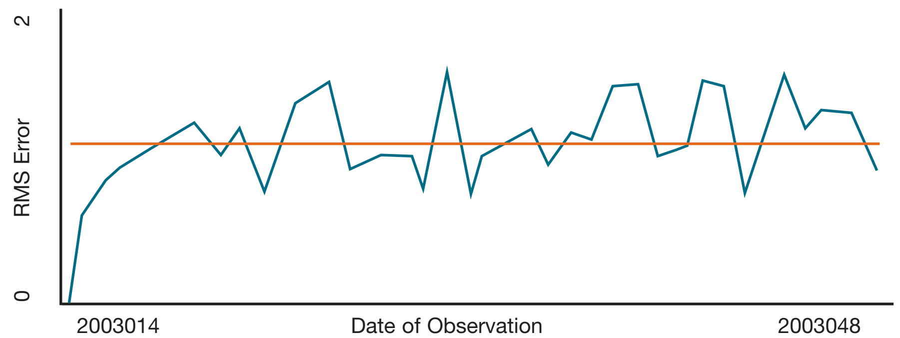


FIGURE 1
Average RMS error computed by taking the sum of the squares of the SST errors, dividing by the number of observations, subtracting the square of the bias, and taking the square root. The red line on the graph represents an RMS error of 1.0 degrees Kelvin.

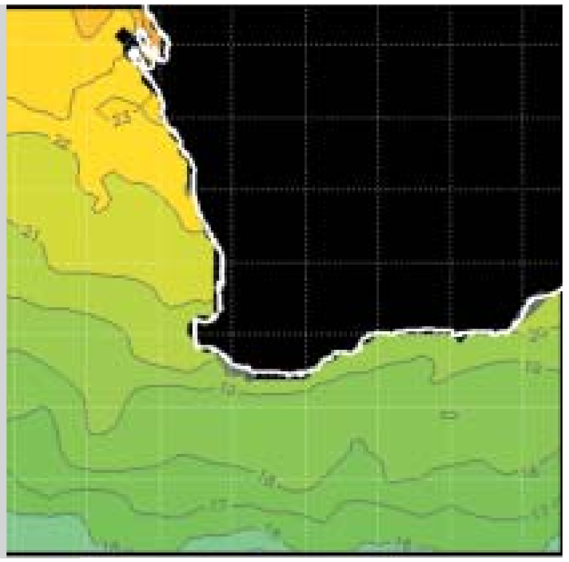


FIGURE 2
Daily regional contour map of satellite-derived SSTs in degrees Celsius, on a 0.25 degree grid. This product is available to the public by subscription.

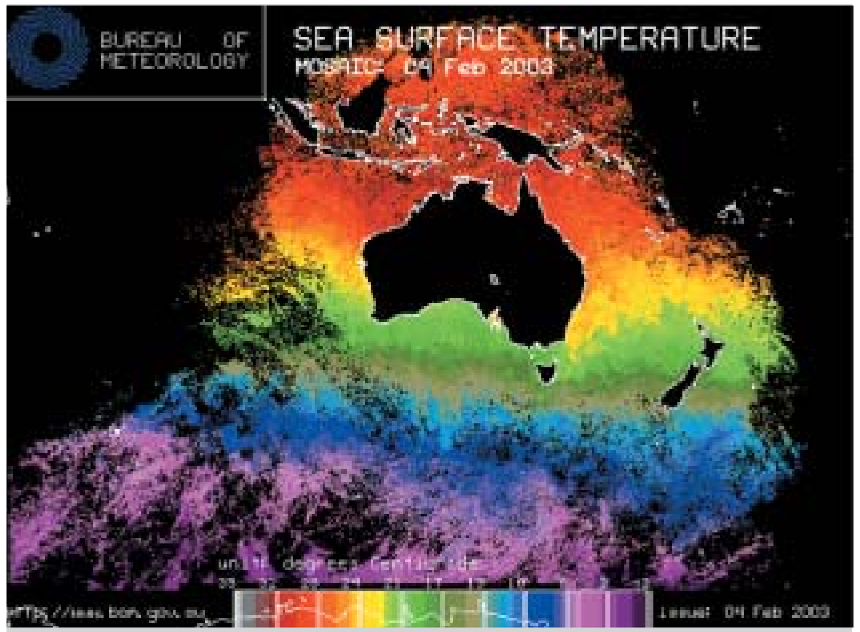


FIGURE 3
SST product available free to the public via a browse service on the Bureau web site. The image shows SSTs at 1:5 resolution.

WEATHER MODELLING / FORECASTING

The Bureau's present operational global assimilation system utilises a 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 online 1D-VAR ATOVS radiance retrieval scheme, implemented operationally within the global 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 the local and global 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.

NDVI

Normalised Difference Vegetation Index (NDVI) products are produced by the Bureau of Meteorology for the Australian region using measurements from channels 1 and 2 of the AVHRR instrument on board the NOAA-16 satellite. The differential reflectance in these bands provides a means of monitoring 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.

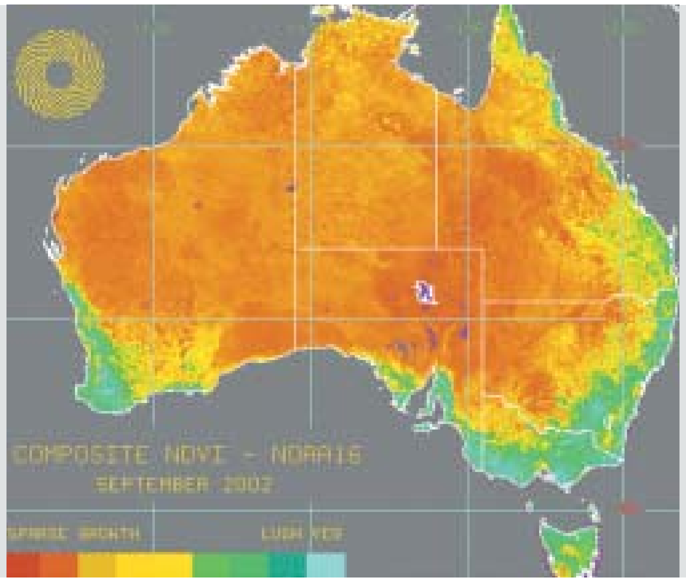


FIGURE 4
An example of the Bureau's Maximum Value Composite NDVI product.

VOLCANIC ASH

The Volcanic Ash Advisory Centre (VAAC) in Darwin provides warnings on volcanic ash for the aviation industry for an area that extends over much of the Southeast Asia region. Data from WASTAC are used to complete the 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 10ºN between longitudes 100ºE to 160ºE.

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.

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, which is 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 -16 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 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 -16 data. Emittance of low 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 was also improved to better detect low cloud pixels. See Figure 5 for an example of a cloud mask.

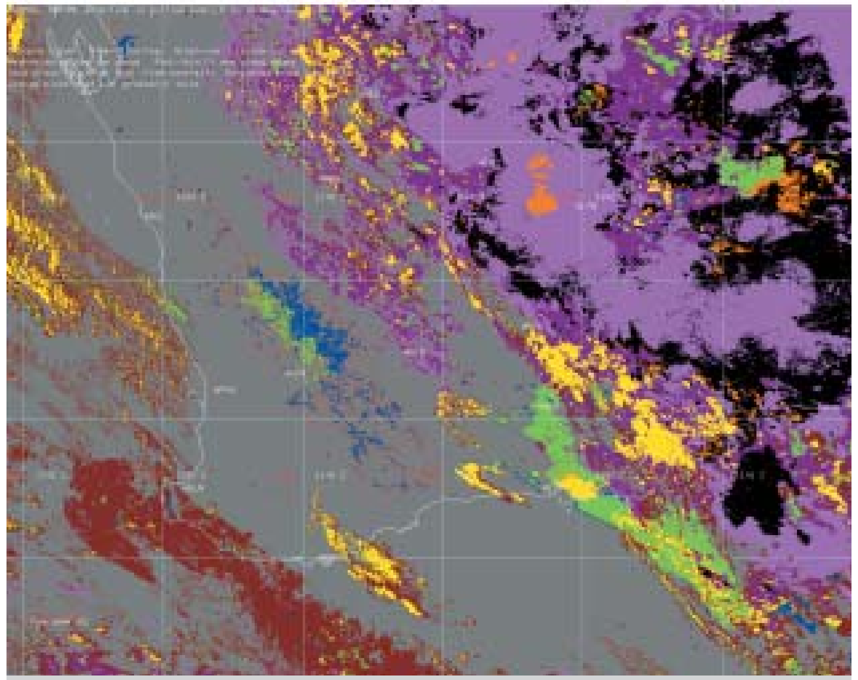


FIGURE 5
Cloud mask of the southern portion of Western Australia, 4 February 2003. Colours on the cloud mask mean: gray no cloud detected; red rejected fog / low cloud; blue very low cloud/fog; green low cloud; yellow low cloud but tops clearly distinct from ground (ex ch3-ch4); brown dull cloud - low 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 - probable ice.

CYCLONE MONITORING

The Bureau’s Western Australian Regional Forecasting Centre in Perth provides warnings of tropical cyclones whenever the need arises from its 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 noting that GMS-5 is now beyond its design life and is producing reduced observations to maximise its life until a replacement is launched (MTSAT-1R in late 2003). As an example, Figure 6 shows a tropical cyclone near Western Australia.

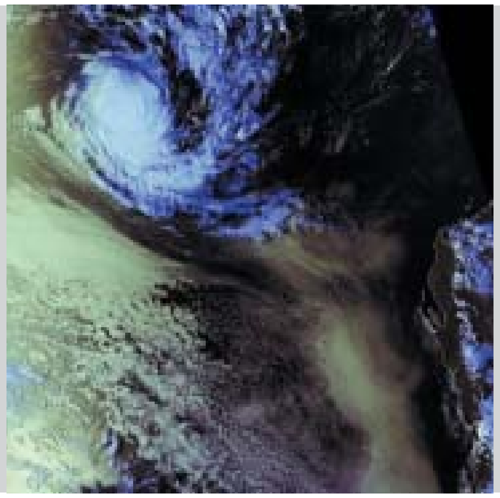


FIGURE 6
NOAA-12 image of Tropical Cyclone Fiona off the north-west coast of Western Australia (9 February 2003). TC Fiona sustained maximum winds of 90 knots and gusts of up to 110 knots.

FIRE WEATHER FORECASTING

The Bureau issues Fire Weather warnings as part of its free weather forecast, warnings and observations 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 Figure 7 for a hotspot image of fires near Perth in early 2003.

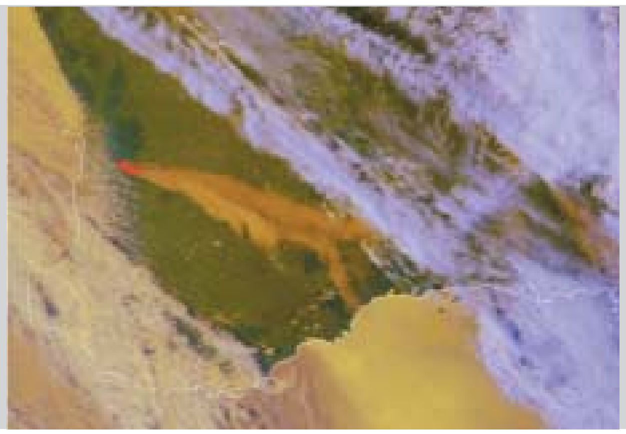


FIGURE 7
A NOAA-12 image of fire hotspots (coloured red) near Perth on 11 January 2003.

REFERENCES

McClain E.P., Pichel W.G. and Walton C.C. (1985). Comparative Performance of AVHRR-Based Multichannel Sea Surface Temperatures. Journal of Geophysical Research, Vol 90(C6) pp 11587-11601.

Weymouth, G.T. (2002). National fog and low cloud analyses. Proceedings of the 9th National Conference for the Australian Meteorological and Oceanographic Society (AMOS), University of Melbourne, 18-20 February.

CSIRO MARINE RESEARCH

BIOPHYSICAL SURVEYS OFF TWO ROCKS

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

The Biophysical Oceanography Project associated with the Strategic Research Fund for the Marine Environment (SRFME) project is studying the seasonality and cross-shelf variability of the productivity and food-chain succession in southwestern Australian coastal and offshore waters. A series of monthly transects (the so-called "Two Rocks Transect") commenced in February 2002, comprising three oceanographic stations between the coast and the outer continental shelf off the coastal settlement of Two Rocks some 50 km north of Fremantle. On every third (quarterly) survey, two additional stations are worked out to a total water depth of 1000 m.

Satellite remote sensing is being used to complement the conventional oceanographic and biological sampling, setting the Transect measurements into a broader context and also attempting to provide some temporal continuity between the monthly surveys. To date, AVHRR sea-surface temperature (SST) images have been processed for each day that the vessel was at sea, and digital SST transects extending to twice the distance offshore of the boat stations have been analysed. These show the expected seasonal patterns: little distinctive cross-shelf surface thermal structure during the summer months when the Leeuwin Current is generally weak, and a more pronounced SST profile across the Current while it is flowing more strongly in winter (Figure 1).

Both the images and the digital transects have been used to distinguish between the nearshore waters (which are subject to strong heat gains/losses and hence show large annual temperature ranges), the north-flowing Capes Current along the mid-shelf region in summer, and the southerly Leeuwin Current which usually flows southwards along the shelf-break but can on occasion meander closer to (or further away from) the shore. This classification may assist in determining the source and distribution of phyto- and zooplankton species sampled from the boat.

Future work involves extracting the digital AVHRR-SST transects for every cloud-free day between 1997 and the end of the project in 2005, then deriving monthly mean SST statistics across the shelf for the full period, and finally deriving a surface temperature climatology of the continental shelf. When the satellite ocean colour processing facilities have been fully implemented (see the accompanying article), SeaWiFS images will be similarly analysed to derive a chlorophyll climatology and also assist in interpreting the in situ productivity samples from the monthly surveys. MODIS SST and chlorophyll data will likewise be utilised when the MODIS data processing software has been implemented.

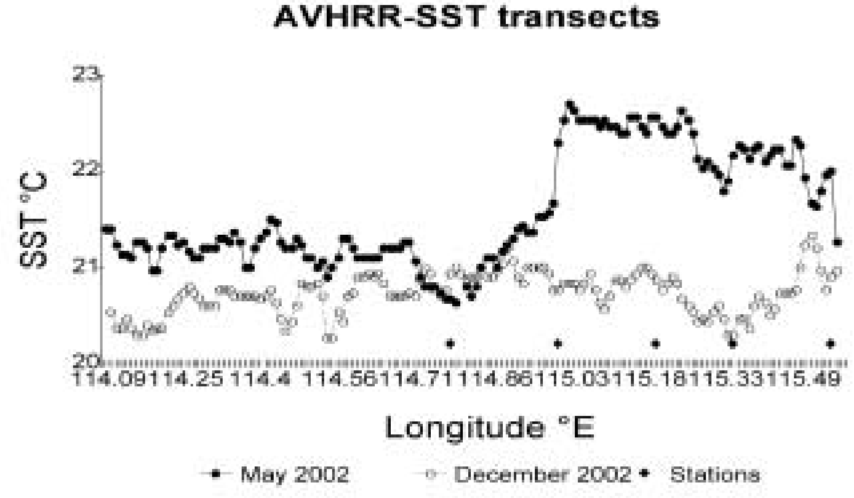


FIGURE 1
AVHRR-SST transects across the continental shelf off Two Rocks in May (filled circles) and December 2002 (open circles) representing typical winter and summer situations respectively - note the large SST gradient across the offshore boundary of the Leeuwin Current at 115.03°E in May. The diamonds denote the research vessel station positions. The coast is on the right.

ROTTNEST ISLAND TEMPERATURE CLIMATOLOGY

Alan Pearce (CSIRO Marine Research, Floreat), Fabienne Faskel and Glenn Hyndes (both Edith Cowan University)

Despite the large amount of research that has been undertaken over the past 3 decades in the waters surrounding Rottnest Island (some 20 km west of Fremantle), there has been no long-term monitoring of the water temperature. As an Edith Cowan Honours project, AVHRR-SST data have been used to derive monthly mean temperatures close inshore at 3 sites (Geordie Bay, Thompson's Bay and Parker Point) on the eastern shores of the Island. The period covered was 1995 to 2001, yielding a 7-year climatology.

Because the satellite temperatures were required as close to the Island as possible, it was especially important to avoid land-contaminated pixels; accordingly, much of the analysis was undertaken by visual selection of the required pixels at each site using the AVHRR Channel 2. Cloud screening was also undertaken visually using the same Channel. The SSTs were derived using both the earlier McMillin and Crosby algorithm, and the more recent NLSST (Non-Linear SST, which takes into account scan-angle effects).

To validate the method, the satellite-derived SSTs were compared with in situ measurements using self-recording TidBit temperature loggers between May and December 2001; while 8 months of data were acquired from the two northern sites, no loggers were recovered from the Parker Point so no data are available from that site. In simple terms, the proportion of the satellite SSTs which fell within 0.5°C and 1°C of the Tlogger measurements were:

Site	**±0.5°C**		**±1.0°C**	
	McM&Cr	**NLSST**	**McM&Cr**	**NLSST**
Geordie Bay	47%	78%	79%	97%
Thompson's Bay	35%	68%	78%	92%

The NLSST was clearly superior to the older algorithm, which tended to show a warm bias.

The 7-year AVHRR climatology showed peak mean temperatures of about 22.8°C between February and April (as the warm Leeuwin Current strengthened). The coolest month was August with a mean temperature of 18.5° to 19°C, with a small variation between the three sites. The study has demonstrated that AVHRR satellite data can be used to derive nearshore water temperatures to better than 1°C provided pixel selection and cloud screening are carefully carried out.

Acknowledgements: The rangers at Rottnest Island kindly assisted with logger deployment and recovery.

QUANTIFYING SOME UNCERTAINTIES IN SATELLITE SEA-SURFACE TEMPERATURE VALIDATION

Alan Pearce (CSIRO Marine Research, Floreat)

One of the uncertainties in comparing satellite-derived SSTs (such as provided by the AVHRR) with in situ validation measurements from a boat is the mis-match between the areal (1 km pixel) satellite average and the spot measurement from a boat.

During the Hillarys Transect surveys, described in previous WASTAC Annual Reports, continuous underway sea surface temperature measurements were made using a recording thermograph. Sampling was at 5-second intervals and 1 km averages were subsequently derived (approximating to the AVHRR or ATSR pixel size); with a vessel speed of say 16 knots, there were about 24 samples per kilometre. The differences between the 1-km mean temperature and the maximum and minimum individual samples gives some indication of the “errors” which can be expected between satellite 1-km pixel SSTs and the spot measurements from a boat.

Using the data from the 12 surveys in 1998, and excluding measurements within 5 km of the coast, it was found that 66% of the average-extreme differences were less than 0.1°C and 92% were less than 0.2°C. This effectively sets an upper limit of about 0.2°C as the expected “error” in comparing boat and satellite sea temperature measurements.

Underway fluorescence was also sampled during the Hillarys surveys using a Wetstar fluorometer, and a similar analysis to the above (which will be useful for SeaWiFS and MODIS) was undertaken for surface chlorophylls. It was found that 85% of the within-pixel chlorophyll differences were less than 0.04 µg/l.

Other analyses being undertaken include (a) a study of the vertical temperature difference between the surface “skin” (observed by the satellite) and the “bulk” temperature at 1-m depth typically sampled from a boat; (b) temporal variability while a boat is sampling; and (c) temperature differences resulting from the time-lag between a boat measurement and a satellite overpass (the diurnal temperature cycle), in both shallow and deep waters off Perth.

Acknowledgements: Jodie Koehler (work experience student) and Dianne Krikke (CSIRO Postgraduate Research Student) assisted with data analysis.

SST VALIDATION FROM THE ROTTNEST FERRY

Alan Pearce (CSIRO Marine Research, Floreat) and Ian Barton (CSIRO Marine Research, Hobart)

One of the main difficulties in satellite SST validation is acquiring reliable in situ measurements on a regular basis. Surface temperature measurements have been made using the Rottnest ferry SeaFlyte over the past few years, but there were many datagaps because of a lack of adequate resources. During 2002, however, a completely re-designed system was installed on the ferry, and good data have been obtained since October 2002.

The “bulk” water temperature is measured using a Platinum Resistance Thermometer (PRT) installed in the engine intake strainer box down in the engine room, and the signals are fed to a DataTaker logger where they are recorded at 10-second intervals. The vessel’s position is continuously monitored using a GPS, and a roll sensor records the ferry’s roll angle.

In addition, a TASCO radiometer has been installed over the wheelhouse pointing down to the water surface at an angle of 45°, to measure the “skin” temperature. Some difficulties resulting from sea spray have caused jamming of the radiometer shutter, so modifications are being made to improve the reliability of the radiometer measurements. Sky radiance corrections can be made using radiometer measurements from the CSIRO Laboratories at Floreat Park, a few kilometres from the coast. It is planned that regular PRT and TASCO calibrations will be undertaken once the facility is deemed fully operational.

A comparison of the ferry PRT and AVHRR data for February shows that the NLSST seems to perform better than the older McMillin and Crosby algorithm (Figure 2), and this is confirmed by the statistics for that month: the bias and RMS difference are respectively 0.24°C/0.75°C for the NLSST compared with 0.52°C/1.12°C for McMillin and Crosby.

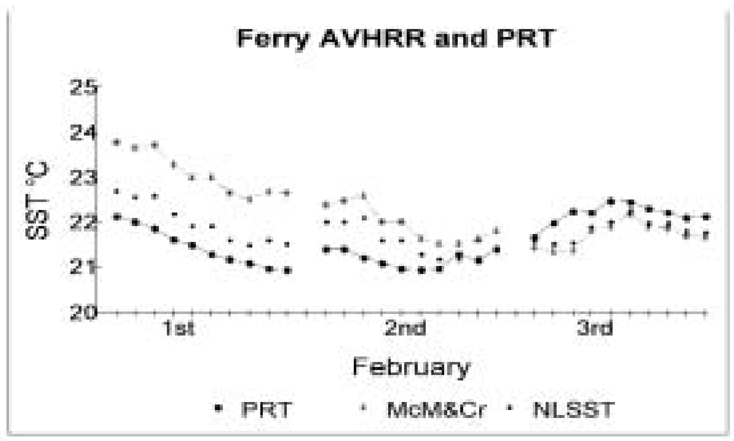


FIGURE 2
Daily ferry transects between Hillarys Marina (on the left of each segment) to Rottnest Island (on the right) for three days in early February. The ferry intake PRTs are plotted as filled-joined circles, the AVHRR-NLSST are the small dots, and the McMillin and Crosby algorithm is the dotted line joining the asterisks.

Acknowledgements: The cooperation of the Manager and crew of the SeaFlyte ferry in this project is greatly appreciated; Ian Helmond and Jeff Cordell (CSIRO Marine Research, Hobart) designed and implemented the new system; Nick Mortimer (CSIRO Marine Research, Floreat) and Leon Majewski (Curtin University) helped with maintenance and repair; and Kate Fitzgerald (CSIRO Postgraduate Research Student) assisted with data analysis and sensor calibration.

OCEAN COLOUR DATA PROCESSING

Peter Fearns (CSIRO Marine Research, Floreat)

The aim of the remote sensing tasks in SRFME is to establish an operational remote sensing facility for routinely acquiring, processing, analysing, validating and archiving satellite data in support of specific marine projects, as well as research and develop improved, and new, remotely sensed products for monitoring the WA coastal zone.

CSIRO Marine Research has taken on the responsibility of coordinating the development of software used in producing MODIS marine products. A WASTAC purchased computer will be used to support this process. The computer will regularly produce SeaWiFS, AVHRR and MODIS data. Linkages with the Curtin University Remote Sensing and Satellite Research Group and the Space Science and Engineering Centre (University of Madison) will contribute to development of the capability.

Field programmes run as part of the SRFME project have been initiated. Three key sites along the coast of WA will serve as the focus for intensive field campaigns involving water column sampling, benthic habitat studies, genetic investigations, nutrient dynamics measurements and optical measurements. These field campaigns will provide ground truthing data for SST and ocean colour remotely sensed products, as well as provide inputs to optical models used in algorithm development.

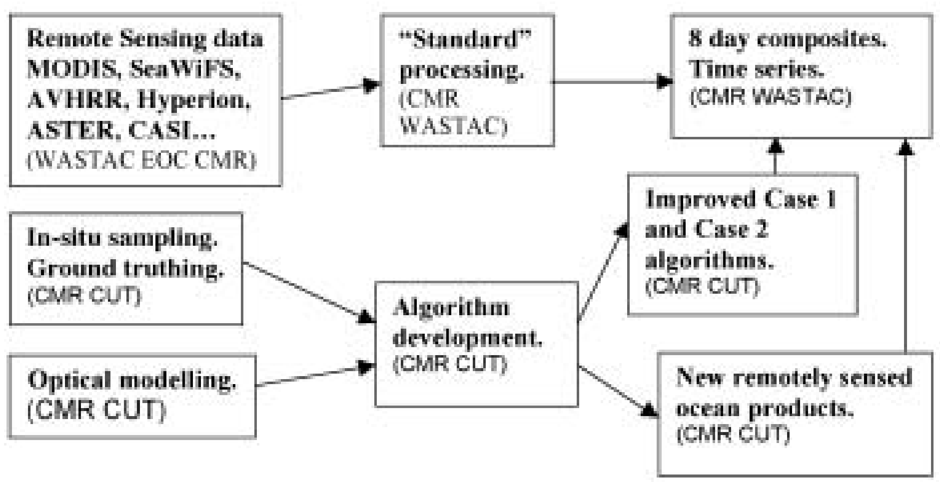


FIGURE 3
Remote sensing data flow. Remote sensing data are processed to "standard" products on a routine basis. Various statistics may be derived from the data (time series and spatial/temporal averages). New and improved products may be developed through combinations of in-situ sampling and modelling. [EOC - Earth Observation Centre. CMR - CSIRO Marine Research. CUT - Curtin University of Technology].

REFERENCES

Faskel,F. (2001). The assessment of satellite remote sensing as a tool for determining sea surface temperatures in nearshore environments. Unpublished Honours thesis, Edith Cowan University, 67pp.

Pearce,A.F. (in preparation). Quantifying some uncertainties in satellite SST validation. To be submitted to Remote Sensing of Environment.

Pearce,A.F., F.Faskel and G.Hyndes (in preparation). Derivation of a coastal sea temperature climatology using AVHRR satellite data. To be submitted to the International Journal of Remote Sensing.

CURTIN UNIVERSITY OF TECHNOLOGY

(REMOTE SENSING AND SATELLITE RESEARCH GROUP)

REMOTELY SENSING SEASONAL AND INTERANNUAL OCEANIC PRIMARY PRODUCTION FOR WA WATERS

Leon Majewski, Mervyn Lynch, Lesley Clementson[1] and Arnold Dekker [2]
[1] CSIRO Marine Research, Hobart [2] CSIRO Land and Water, Canberra

Primary production is a fundamental measure of the ability of oceanic waters to sequester atmospheric carbon and convert it, through the process of photosynthesis, into new organic compounds. Primary production may be considered a function of the bio-optical properties of phytoplankton and the physical properties in the surrounding environment. As such, primary production is an important data set that can be related to ecosystem health and consequently the management of the marine environment.

A number of algorithms have been developed that permit estimates of oceanic primary production from locally received (WASTAC) SeaWiFS, AVHRR and MODIS data. Data collected on SRFME validation voyages is being used in the refinement of these algorithms.

MODIS DIRECT BROADCAST SOFTWARE IMPLEMENTATION

Leon Majewski, Mervyn Lynch, Brendon McAtee, Helen Chedzey, Paul Menzel* and Liam Gumley*
* Cooperative Institute for Meteorological Satellite Studies (CIMSS), Space Science and Engineering Center, University of Wisconsin, Madison.

Under a long-standing arrangement with the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin, Curtin University has been engaged in the cooperative development and implementation of a suite of Direct Broadcast (DB) products. The emphasis to date has been on the generation of at sensor radiances (L1B).

The key issue for DB users who wish to work with data collected by the WASTAC X-band satellite downlink is to implement a software package and derive an associated suite of geophysical products that are both validated and available in near real-time. The development and validation of such products has now been distributed among the WASTAC MODIS atmosphere, ocean and land groups.

Variants on the standard MODIS products may be generated using alternative algorithms and, additionally, new products may be developed that are of local interest. The intention is that all products will be validated to ensure that the algorithms used are applicable in Australian conditions.

REMOTE SENSING OF OCEAN-OPTICAL PARAMETERS FOR RAPID ENVIRONMENTAL ASSESSMENT

Brendon McAtee, Mervyn Lynch and Alexei Kouzoubov
*DSTO Maritime Operations Division, Edinburgh, South Australia

Satellite remote sensing can be used to estimate a range of ocean-optical parameters (eg. chlorophyll concentration, diffuse attenuation coefficient, and particulate backscattering coefficient among others). This study begins to apply satellite-derived estimates of such parameters to Rapid Environmental Assessment (REA) for selected regions in Australian waters. Such REA may be important in many different maritime operations, from assessing periodic environmental phenomena such as algal blooms, to ongoing monitoring of the health of the marine environment, through to defence applications.

For this work, a five year time series of ocean-optical parameters for the south eastern Indian Ocean region was derived from the WASTAC and Remote Sensing and Satellite Research Group (RSSRG) archives of SeaWiFS data. The Perth Ocean Colour Intercomparison Experiment (POCIE), a multidisciplinary oceanographic cruise, bringing together expertise (DSTO, CSIRO divisions of Marine Research and Land and Water) and ocean-optical instruments from around Australia, was also conducted as part of this work in order to validate the estimates of the parameters derived from SeaWiFS imagery.

In the future, this project may shift focus to other regions of interest, such as the waters of northern Australia, and include a modelling component with the aim of linking radiative transfer theory within the maritime environment to an improvement in the quality of remotely sensed ocean products.

DETECTION OF CORAL SPAWNING EVENTS USING SEAWIFS.

Helen Chedzey, Brendon McAtee and Mervyn Lynch

Different methods were investigated in order to accurately detect the annual mass spawning of coral reefs along the Western Australian coastline during 1998. Seven to nine nights after the full moon in March (sometimes February or April), coral gametes are strewn into the surrounding reef waters. After egg and sperm unite, the newly formed planula larvae travel in surface slicks, weather permitting, for up to five days. If there are strong winds, the slick will break up in a shorter period of time. Reefs investigated for evidence of coral spawning included Ashmore Reef, Scott and Seringapatam Reefs and the three reefs comprising the Rowley Shoals (Mermaid, Clerke and Imperieuse).

Detection of coral spawning through remote sensing satellite technology involves examining various Level 1 and Level 2 products. The products used in this search included waterleaving radiances, normalized water leaving radiances, chlorophyll-a concentrations and diffuse attenuation coefficient values. The results of this investigation were inconclusive though research into other years is ongoing.

SEAWIFS APPLICATION TO MONITORING MARINE PARKS

Mervyn Lynch, Peter Fearns and Alan Pearce*
*CSIRO Marine Research, Marmion.

By the end of 2002, this 3-year research project (which was supported under the NHT Coasts and Clean Seas programme — see the WASTAC Annual Report for 2001) had run to completion. Its primary goal was to apply remote sensing to monitor marine park water quality, which required that the proposed water quality indicators that can be remotely sensed are accurate. The latter, in turn, required that a field program of in situ sampling be undertaken to validate the satellite products.

The project demonstrated the potential of remote sensing for monitoring coastal waters, leading to further collaborative work with CSIRO using higher spatial resolution hyperspectral sensors such as Hyperion.

THE EFFECT OF TROPICAL CYCLONES ON THE NUTRIENT LEVELS IN THE WATERS OFF THE NORTH WEST COAST OF AUSTRALIA

Carly Rossbach and Mervyn Lynch

Tropical cyclones are a frequent occurrence in the oceans off the North-West coast of Western Australia. Surface waters in this region are known to be typically nutrient and hence chlorophyll deficient. It has been suggested that deep water upwelling driven by summer tropical cyclones is the major process by which nutrients from depth are driven to the surface.

This project aims to verify the significance of the role which tropical cyclones play in the process of nutrient regeneration in this area, by investigating several past cyclonic events. Analysis of SeaWiFS images was completed to observe the chlorophyll-a changes that occur in the region preceding and following a cyclone. The data collected from the processed images show the expected chlorophyll-a increase after a cyclonic event.

DETECTION OF OIL FILMS ON OCEAN SURFACES

Jim Davies, Helen Chedzey, Peter Fearns, Pamela Rogal and Mervyn Lynch

There are a number of sources of oil on the Earth's ocean surfaces. Oil migrates from deposits deep below the ocean floor, releasing oil known as seeps. These seeps offer clues as to where oil deposits may be located in ocean basins. Other sources are accidental and non-accidental spills from ocean-going vessels.

A review of the literature pertaining to oil seep and slick detection via remote sensing methods was conducted as a preliminary stage for future projects. The literature consulted indicates that unambiguous detection of oil on the ocean surface by remote sensing can't be achieved through the use of a single remote sensing technology. An integrated approach is required, in terms of wavelength regions employed and in the use of both passive and active systems. Satellite-borne sensors are appropriate for the identification of possible active oil seeps but aircraft-borne sensors will generally be required to confirm satellite observations. With the advent of higher spectral resolution hyperspectral remote sensing instruments, the possibility of using the absorption spectra of volatile gases associated with active oil seeps presents itself. Further work utilizing satellite data is scheduled for subsequent projects.

SOME INTERESTING WEB LINKS FOR OCEAN COLOUR

SeaWiFS Homepage
http://seawifs.gsfc.nasa.gov

NASA Ocean Colour Information
http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/OB_main.html

NASA Ocean Primary Production Homepage
http://opp.gsfc.nasa.gov

Earth Observatory Homepage
http://www.earthobservatory.nasa.gov

Fisheries WA Homepage
http://www.wa.gov.au/westfish/

International Ocean Color Coordinating Group (IOCCG)
http://www.ioccg.org/

REFERENCES

Coleman J and Lynch M J. (2002). Seasonal and interannual characteristics of the Ningaloo current. Australian Marine Sciences Association (AMSA) Conference, Fremantle, WA, July 10 - 12.

Davies J. (2002). Atmospheric correction of satellite observations of ocean colour with the Navy aerosol model. Ph.D thesis, Curtin University of Technology, Perth, WA.

Fearns P R C (2002). Modelling ocean colour, Ph.D. Thesis, Curtin University of Technology, Perth, WA.

Fearns P R C, Chedzey H, Lynch M J, Hick P and Wilson J, (2001). Assessment of the offshore environment using remotely sensed data relating to development in the Timor Sea. International Geoscience and Remote Sensing Symposium (IGARSS 2001), Sydney, July 9 - 13.

Klonowski W and Lynch M J. (2002). The development and validation of algorithms for remotely sensing case II waters. Australian Marine Sciences Association (AMSA) Conference, Fremantle, WA, July 10 - 12.

Lynch M J, (2002). Satellite applications in the eastern Indian Ocean. First Conference of the Indian Ocean Global Ocean Observing System (IOGOOS), Grand Bay, Mauritius, November 4 - 9.

Lynch M J, (2002). Remote sensing data issues for IOGOOS. First Conference of the Indian Ocean Global Ocean Observing System (IOGOOS), Grand Bay, Mauritius, November 4 - 9.

Lynch M J, Chedzey H, Davies J E, Fearns P R C and Rogal P, (2002). Detection of oil films using remote sensing data. Report to Woodside Petroleum, September 2002.

Lynch M J and Fearns P R C (2002). Development of Satellite-Based Regional Water Quality Management Program . Final Report on Coasts and Clean Seas Project 9814.

Lynch M J, Fearns P R C and Chedzey H, (2001). Remotely sensed estimates of the extent of spatial and temporal variations in sea surface temperature, chlorophyll concentration and light attenuation in the Timor Sea. Joint CSIRO/Curtin University report to BBG, Environmental Management Consultants, July 2001.

Lynch M J, McGann B, White B, Fearns P R C, Davies J, Marsden J, McAtee B, Zakiyah U, Marinelli M, Chedzey H, Majewzki L, Klonowski W, Slivkoff M and Coleman J. (2002). Remote sensing of Western Australian case 1 and case 2 waters. Italian-Australian Technological Innovations Conference and Exhibition 2002, Melbourne, Victoria, March 25 - 28.

Majewski L and Lynch M J. (2002). Remotely sensing seasonal and interannual oceanic primary production for WA waters. Australian Marine Sciences Association (AMSA) Conference, Fremantle, WA, July 10 - 12.

Marinelli M, (2002). An ocean colour remote sensing study of the phytoplankton cycle off Western Australia, M.Sc. Thesis, Curtin University of Technology, Perth, WA.

Slivkoff M, Majewski L and Lynch M J. (2002). Prospects for the extraction of ocean eddy dynamical information from satellite imagery. Australian Marine Sciences Association (AMSA) Conference, Fremantle, WA, July 10 - 12.

DEPARTMENT OF LAND ADMINISTRATION
(SATELLITE REMOTE SENSING SERVICES)

MODIS LEVEL 1B PROCESSING
Stefan Maier

Figure 1 shows the flow diagram of the MODIS reception, quick-look generation and Level 1B processing. The raw data received at Murdoch University, the so-called CADU (Channel Access Data Unit) packages, are stored on DLT for archiving. For further processing, transmission artefacts have to be removed by a process called frame synchronisation. This process delivers the Level 0 data or Production Data Set (PDS). For each instrument transmitting via direct broadcast there is generated a separate PDS file. The PDS format is the international format to exchange MODIS Level 0 data.

The MODIS PDS files are directly ingested into the quick-look processor to produce quick-look images in JPEG format. Two-line-elements (TLE) describing the orbit of the satellite are sent from SeaSpace Corporation to the receiving computer. These are used by the quick-look processor to generate coastlines and map grid overlays. The quick-looks are accessible on DOLA's website (http://www.rss.dola.wa.gov.au/newsite/modisql/MODISql.html) approximately 20min after the overpass.

For further processing and distribution the PDS files are sent to a computer located at the Leeuwin Centre. MODIS/TERRA PDS files include spacecraft attitude/ephemeris information and are directly ingested into the IMAPP (International MODIS/AIRS Processing Package) Level 1B processor. AQUA attitude/ephemeris information are transmitted as GBAD (Ground Based Attitude Determination) packets. Using the TLEs these GBAD packages are converted to attitude/ephemeris files before ingestion into the IMAPP Level 1B processor. The IMAPP L1B processor does the geometric and radiometric calibration of MODIS data. It requires some auxilliary data: "utcpole.dat" describes the Earth's variable and slowing rotation with respect to Coordinated Universal Time (UTC), "leapsec.dat" contains a record of leap seconds which are designated by the International Earth Rotation Service (IERS), a digital elevation model (DEM) for precise geolocation and a land/sea mask which is made available in sensor projection for higher level processors.

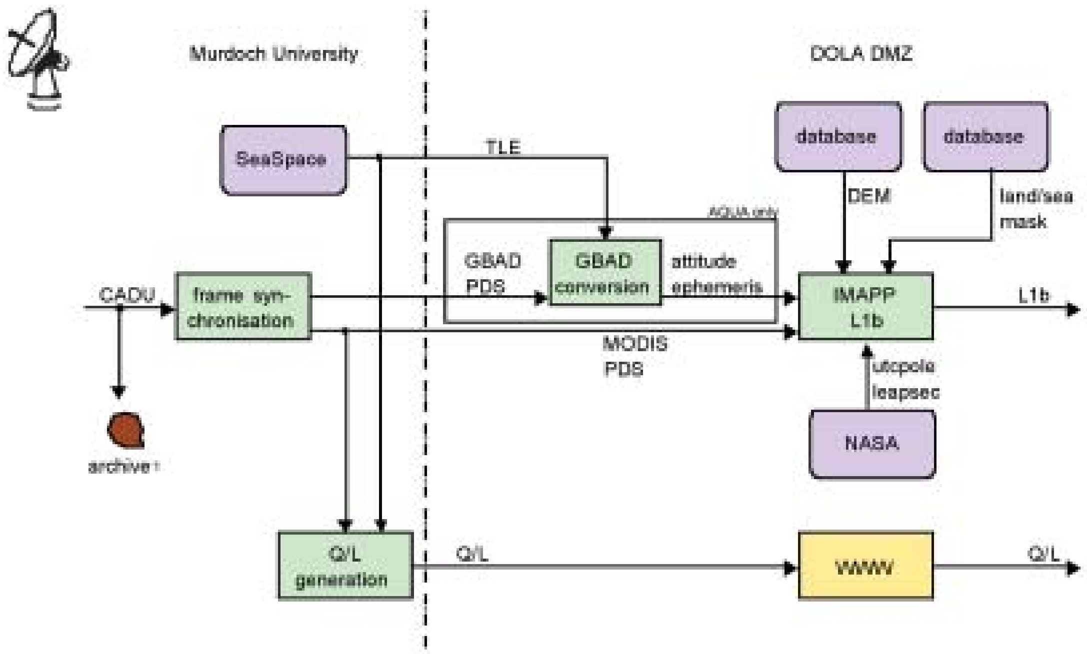


FIGURE 1
MODIS reception, quick-look generation and Level 1b processing flow diagram

CONTINENTAL NDVI FROM MODIS
Jackie Marsden

Satellite Remote Sensing Services (SRSS) routinely provides maximum value, continental Normalised Difference Vegetation Index (NDVI) composites to both Environment Australia (ERIN) and Agriculture Western Australia. These composites are based on NOAA-AVHRR satellite data with a 1 km spatial resolution. The MODIS sensor on the Terra and Aqua satellites provides several advantages over NOAA-AVHRR. Firstly, it has a spatial resolution of 250 metre in the visible giving better detail. It also has on-board visible channel calibration which may account for the sensor drift which was routinely seen with the NOAA-AVHRR over time.

During 2001/2002 NDVI composites have been generated solely from data received in Perth from the TERRA satellite using the WASTAC X-band antenna. The coverage over Australia was limited by the antenna horizon (Figure 2). As can be seen, most of Queensland is not visible using Perth data. New South Wales, Victoria and Tasmania are only observed on approximately 8 of the 16 days which make up the orbital repeat cycle of the satellite.

Data from Geoscience Australia's X-band receiver located at Alice Springs is easily ingestable into the operation processing stream being developed by SRSS. Combining this data with that received in Perth, continental coverage is achieved (Figure 3).

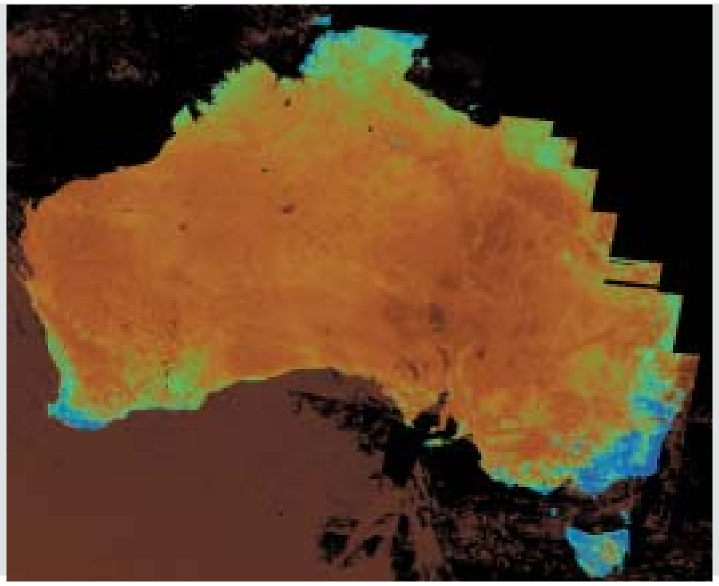


FIGURE 2:
MODIS NDVI composite at 250 m resolution using data from the WASTAC X-band receiver in Perth.

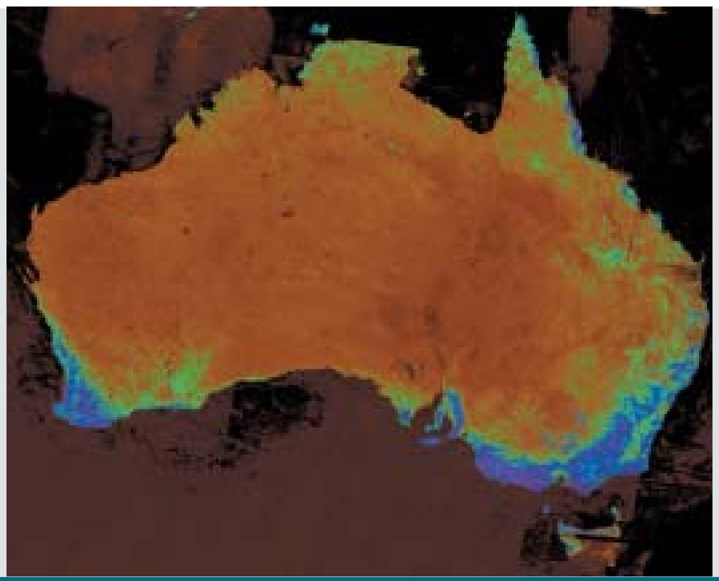


FIGURE 3:
MODIS NDVI composite at 250 m resolution using data from the WASTAC X-band receiver in Perth together with data from the Geoscience receiver located in Alice Springs.

FIRE HOTSPOTS AND FIRESCARS FROM MODIS

Jackie Marsden and Miquel Tovar

The MODIS sensor on the TERRA and AQUA satellites has been designed to include spectral and sensitivity characteristics suited to active fire detection and provides an enhanced capability over existing satellite sensors in terms of fire location and monitoring.

The MODIS fire products use the 1 km fire channels at 3.9 and 11 µm. Fire observations are made four times a day, twice daily (10:30am WST and 10:30pm WST) from the TERRA MODIS sensor and twice daily (1:30am WST and 1:30pm WST) using the AQUA MODIS sensor. The MODIS (MOD14) fire products provide information on the location of a fire and its emitted energy.

Satellite Remote Sensing Services uses direct-broadcast MODIS data from the WASTAC X-band antenna to implement the MOD14 algorithm and provide real-time information on the location of fires. The MODIS sensor offers advantages over the AVHRR sensor with the capability to more accurately determine the location of fires during both day and night. This information is provided to the community via the internet within 3 hours of the satellite overpass.

When combined with a 500m resolution true colour image as a backdrop, the firescar is often visible along with any smoke which is emanating from the fire. An example of the MOD14 product is shown below. The first image (Figure 4), using MODIS data from the 9th December 2002, shows a fire in the Pilbara region of Western Australia. The fire hotspots are shown in red. The firescar appears dark when compared to its surrounds and smoke appears white. The second image (Figure 5) is from the 14th November 2002 of the south-west of Western Australia.

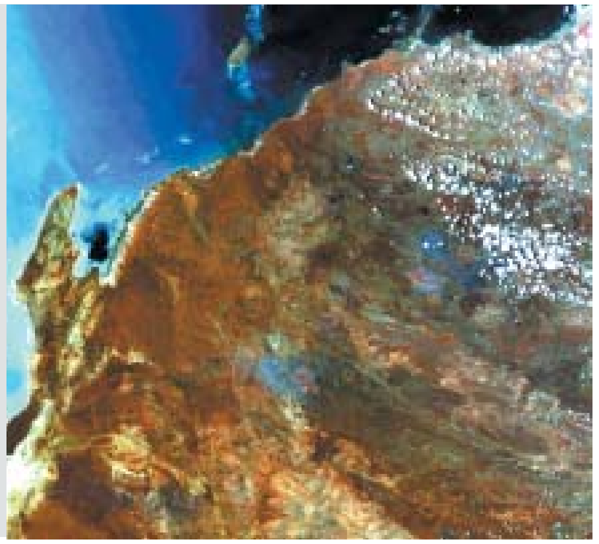


FIGURE 4
The MODIS image of 9th December 2002 of the Pilbara region of Western Australia. Fire hotspots appear red. Smoke is seen emanating from the fires.

FIGURE 5
A MODIS image of 14th November 2002 of the south-west of Western Australia. Fire hotspots appear red. Smoke is seen emanating from the fires.

Often large fires can cause immense smoke plumes which may affect densely populated areas. The fire at Mt Cooke in the Shire of Wandering (Figure 6) depicts a large smoke plume affected by south easterly winds.

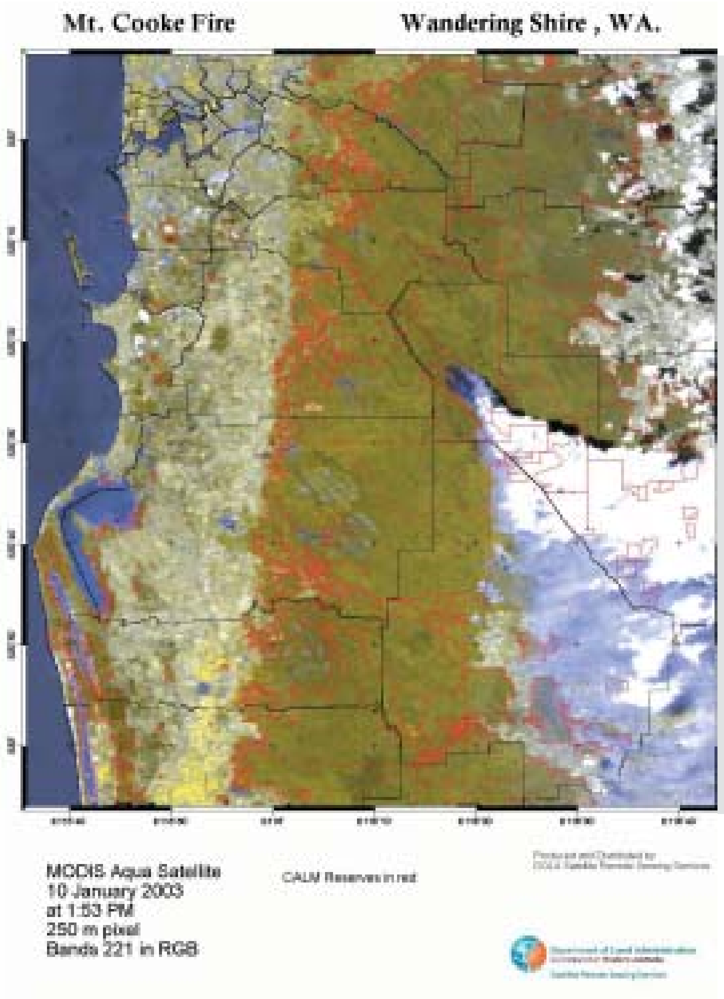


FIGURE 6
Firescar with large smoke plume affected by south easterly winds at Mt Cooke in the Shire of Wandering.

FIRE SCAR MAPPING

Belinda Heath

Satellite Remote Sensing Services have mapped fire scars from NOAA-AVHRR since 1993. The first continental mapping project commenced in 1998, on behalf of Environment Australia for the State of the Environment Report 2002. The ground resolution of NOAA-AVHRR is $1km^2$, thus fire scars less than 400 hectares are generally not visible and hence do not feature in this dataset. The fire scars are manually digitised every nine days when the satellite is close to nadir, which limits the atmospheric effects and geolocation errors associated with the extreme off-nadir view of the sensor. The fire scar vectors are imported into a GIS where they are analysed against various spatial datasets and the area burnt is calculated.

The fire history map (Figure 7) shows the number of times an area has burnt in six years. There is a high frequency of burn in the tropical savannas, some regions burn every year. There is a high level of prescribed burning in the Northern Territory and Kimberley region of Western Australia in the early dry season, which promotes pasture growth and manages the risk of late season wildfire.

The frequency of burn in southern regions of Australia is low when compared to the north. Many of the fire scars in the south are less than 400 hectares; thus they are not included in the dataset. Fuel load builds very slowly in the south thus return burns are limited. The tropical savannas in comparison have rapid fuel build up due to the monsoonal rains assisting vegetation growth; thus return burn time is swift.

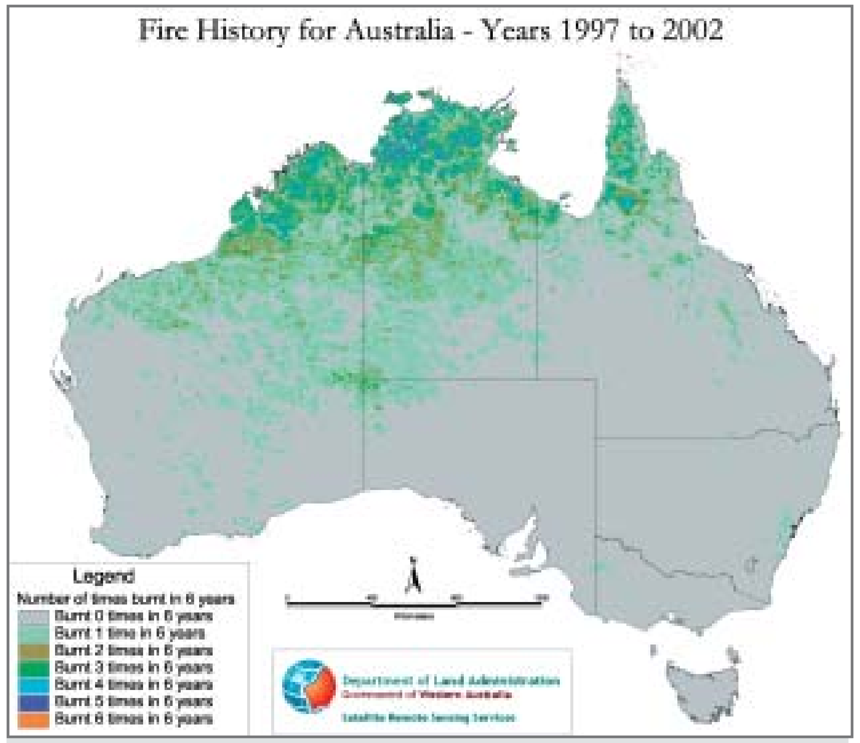


FIGURE 7
Fire scar history Map of Australia for the period 1997-2002.

FIRE FAX

Mike Steber

Although many pastoralists in the Kimberley region of WA use the SRSS website to view the fire hotspot information, the slow connection speeds and high access costs limit the type of information and services that can be provided over the Internet at present. Fire information is most valuable when it is viewed in near real time. Most pastoralists with a computer will only have it switched on for a short time each day and most probably at night. Visiting the website at this time is of little benefit as most of the updates to the SRSS website occur during the early hours of the morning.

SRSS decided that providing an automated fax service would reach a greater number of pastoralists and be cost effective to both SRSS and the end user. Nearly all pastoralists have fax machines and these are likely to be on most of the day.

DOLA had previously purchased software called RightFax which allowed DOLA staff to send faxes from their PC. The fire hotspot locations are automatically produced each morning on a UNIX workstation at SRSS and all of the 1:250000 map sheets for the Kimberley region had been converted to digital form. Computer scripts were written in IDL (Interactive Data Language) and DOS to combine these two datasets together and produce output that RightFax can read. A registration form was drawn up outlining the specifics of our proposed service. The service provided to each pastoral station would be that each morning a fire hotspot is detected in the vicinity of the station, a fax map would be sent showing the fire hotspot. This form was distributed to pastoralists at two meetings in the Kimberley during March 2002. Over the next two months approximately 30 forms were returned to SRSS. As the majority of pastoralists had specified a time between 8:00am and noon the automated system was set to run at 8:00am each morning. Each station was contacted by phone and then sent a test fax of their station. If the test fax was satisfactory the pastoralist's details were added to the automated system. By the end of December 2002 over 1000 fax maps had been transmitted to 28 pastoral stations.

Feedback received by SRSS showed that many pastoralists were looking at broadband access to the Internet. An email service is therefore being investigated as an option to the original fax service. This has the added bonus of colour and a higher resolution.

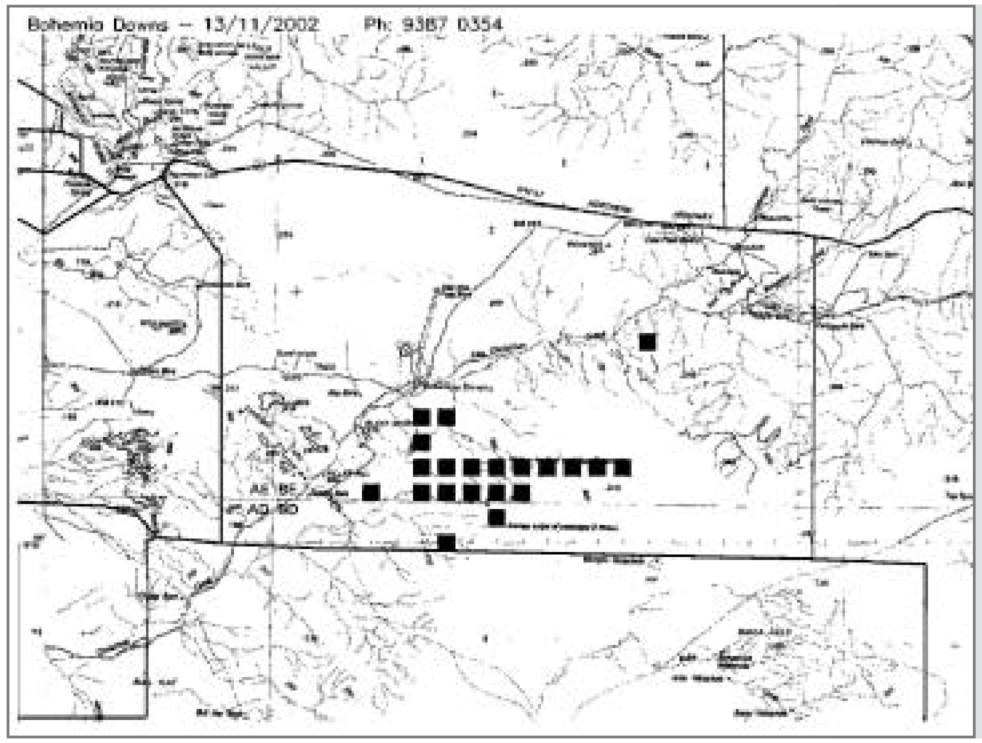


FIGURE 8
Firefax product for 13/11/02 showing fires on Bohemia Downs station.

SOIL MOISTURE

Mike Steber

SRSS has recently provided NOAA-AVHRR data to the University of Newcastle for a study into soil moisture. The aim of the study is to investigate for a number of study regions whether heating rates (the change in temperature over time) based on temporal changes in land surface temperature (LST) can be related to wetness, soil moisture status and surface resistance. Twenty NOAA 12 morning passes and NOAA 16 afternoon passes from 10 to 22 August 2001 were processed for LST over the Merredin region. This time period was chosen because of a rain event on 15 August and the cloud free conditions on either side of this date. Difference images for each day were determined.

SEA SURFACE TEMPERATURE (SST)

Mike Steber

SRSS and CSIRO Marine Research continued their collaborative project producing Sea Surface Temperature images for the fishing industry. During the year 61 customised SST images were produced for clients and 253 standard SST images were purchased through “Fishing Hotspots” on DOLA’s Land Online website (www.landonline.com.au/hotspots). Of the 61 customised SST images, 22 were produced for a study of dugongs around Shark Bay by the Department of Conservation and Land Management (CALM).

Work is underway to update the SST algorithm. Currently the McMillin and Crosby SST algorithm is being used, however, studies by CSIRO Marine Research have shown that the Non-Linear SST (NLSST) algorithm is more accurate off the coast of Western Australia. The NLSST algorithm differs from the McMillin and Crosby SST algorithm in that it requires a priori estimate of SST and also incorporates the satellite zenith angle.

Work is continuing on the production of SST imagery from the MODIS sensors onboard TERRA and AQUA.

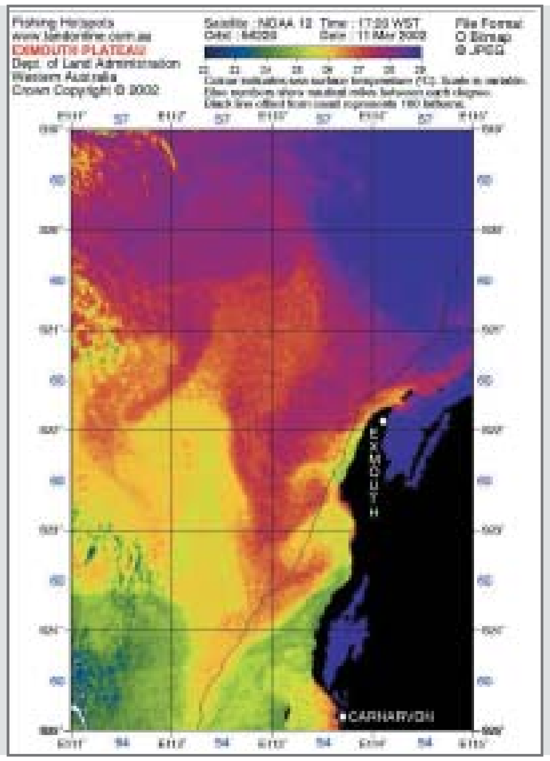


FIGURE 9
Fishing Hotspots product from NOAA 12/56220 dated 11/03/02 17:20 WST showing the northward-moving inshore current called the Ningaloo Current.

PASTURE GROWTH RATE MAPPING

Richard Stovold, ArjenTjalma and Adrian Allen

In a collaborative project between the Department of Land Administration, 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 Feed On Offer (FOO).

The PGR project provides farmers and decision makers with timely estimates of regional pasture growth rates for the south western corner of Western Australia. The Satellite Remote Sensing Services (SRSS) group’s role is to provide specialist services including data acquisition, image processing and web delivery. SRSS are accessing NOAA/AVHRR data at 1 km resolution and for season 2003, MODIS 250 metre resolution data, from the WASTAC archive in Perth and processing the data into fortnightly NDVI composites. The NDVI is a measure of the greenness of pastures. The NDVI composites are then combined with weekly climatic data supplied by the Bureau of Meteorology to give estimates of PGR within Local Government Areas (LGA) weekly as depicted in Figure 10. A new 7 day predicted PGR product has been developed for season 2003.

Improvements to the model development and testing are being undertaken by CSIRO Livestock Industries in conjunction with Agriculture Western Australia which is supplying field validating information.

To assist producers in more easily interpreting the data, a PC-based interpretation tool is being developed to chart weekly PGR for each pasture and compare it with forecasted PGR for the following week. This data will be regularly emailed to the client’s PC every week.

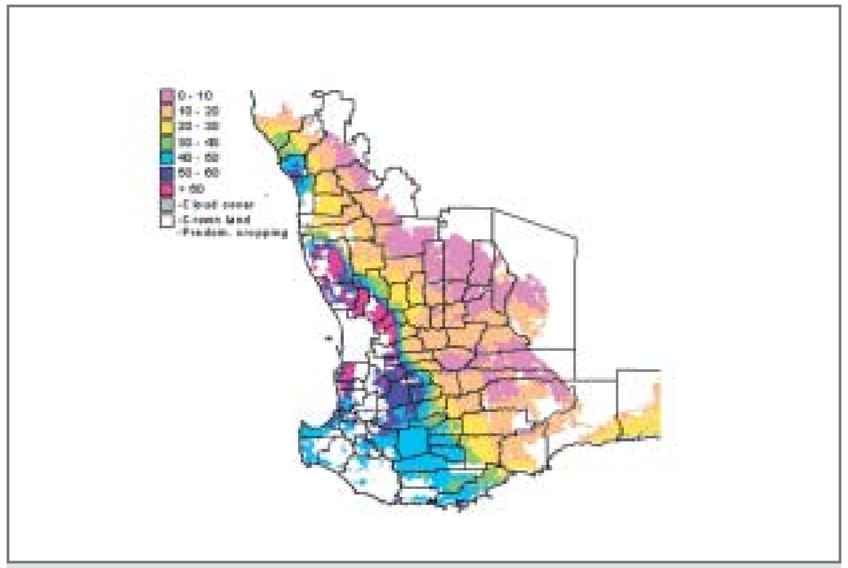


FIGURE 10
Map of south west Western Australia showing Pasture Growth Rate (PGR) on 18 September 2002 in kg/ha/day

The PGR files are posted to the website (www.pgr.csiro.au) every week throughout the pasture growing season. In addition to PRG maps at low and full resolution, a weekly mean PGR value per LGA is posted to the website for the farmer to assess. This provision of pasture information has assisted farmers to interpret the spatial and temporal variation of biomass and growth rates in paddocks. Using the PGR tool, the land manager is able to better manage fertiliser use and to target grazing to improve fine wool production and achieve more efficient feed conservation.

The PGR information also has important applications for agribusiness, regional shires, banking and finance sectors. Potential uses include rural strategic planning, insurance, land valuation and assessment and futures forecasting.

The pasture monitoring programme is currently being extended and verified across high winter rainfall areas of southern Australia as shown in Figure 11.

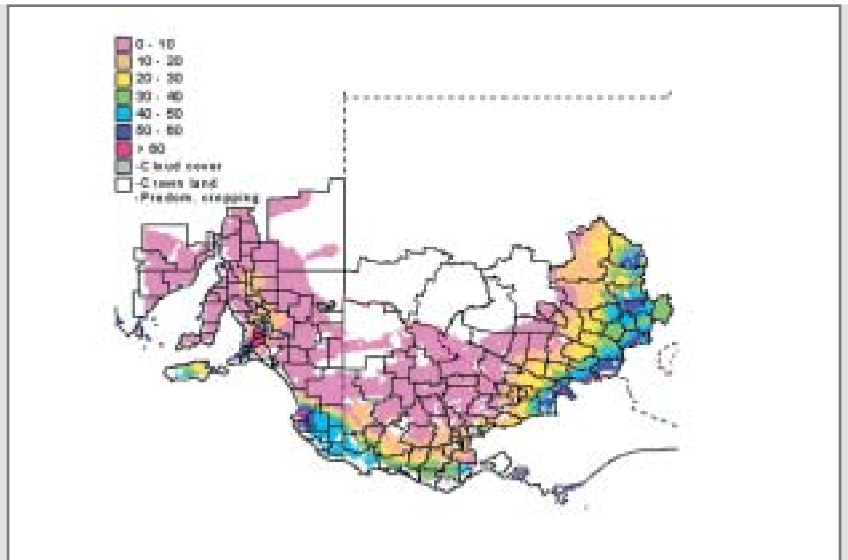


FIGURE 11
Map of south eastern Australia showing Pasture Growth Rate (PGR) on 11 September 2002 in kg/ha/day

Further improvements of PGR products are expected with the use of the new MODIS 250 m resolution data for season 2003. An updated web delivery “map server” site is being developed with zoom and navigation options down to paddock level. Further information is available from the websites www.pgr.csiro.au and www.agric.wa.gov.au.

FINANCIAL STATEMENTS

WASTAC L BAND BUDGET 2003

Estimated expenditure for the year January 2003 - December 2003

	$ PER ANNUM 2003	2002
1. Telstra Rental	7000	6000
2. Data Tapes	7000	4000
3. System maintenance/repairs	6000	6000
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	7000	12000
9. Annual Report	5000	4000
TOTAL	**$40,000**	**$40,000**

Estimated income/revenue for the year January 2003- December 2003

	2003	2002
1. Contributions received ($10,000 each member)	40000	40000
2. Sundry income (data replication)	-	1000
3. Interest	6000	5500
TOTAL INCOME	**$46,000**	**$46,500**

Extra-ordinary expenditure January 2003 - December 2003

	2003	2002
1. Capital Reserve:		
1.1 Antenna replacement and componentry	150000	110000
1.2 Purchase of microwave comms. system	-	30000
TOTAL	**$150,000**	**$140,000**

FINANCIAL STATEMENTS

WASTAC X BAND BUDGET 2003

Estimated expenditure for the year January 2003 - December 2003

	$ PER ANNUM 2003	2002
1. Data Tapes	10,000	10,000
2. System maintenance	20,000	20,000
3. System repairs	4,000	5,000
4. Telecommunications licence of facility	0	0
5. Consultants, product development	25,000	30,000
6. Sundry consumables	5,000	5,000
7. Travelling - Airfares	5,000	5,000
8. Provision for major equipment	15,000	15,000
TOTAL:	**$84,000**	**$90,000**

Estimated income/revenue for the year January 2003 - December 2003

	2003	2002
1. Annual Contributions ($20,000 each member BoM,DOLA,CSIRO,Geoscience Aust)	80,000	80,000
2. X-Band payments:		
BoM	-	100,000
Auslig	-	50,000
3. Interest	4,000	2,000
TOTAL INCOME:	**$84,000**	**$232,000**

Additional committed expenditure January 2003 - December 2006

	2003	2002
1. X-Band warranty period payment 13 Oct.2002	-	63,630(exl GST)
2. Withholding payment to SeaSpace Corp. 13 Oct.2006	31,815(exl GST)	31,815(exl GST)
3. Contract for Research and development	50,000	
TOTAL:	**$81,815**	**$95,445**

INDEPENDENT AUDITOR'S REPORT - L BAND

We have audited the attached financial statements for the year ended 31 December 2002 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 2002 and associated cash flows. The statements are based on proper accounts and records.

Joe Christopher CPA

Senior Financial & Operational Auditor
Curtin University of Technology

25 June 2003

INDEPENDENT AUDITOR'S REPORT - X BAND

We have audited the attached financial statements for the year ended 31 December 2002 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 2002 and associated cash flows. The statements are based on proper accounts and records.

Emphasis of Matter

Without qualification to the opinion expressed above, attention is drawn to the following matter:

Joint Venture Agreement for X-Band

A formal joint venture agreement for the operation of X-Band has not been signed yet at the time of audit. The audit of the attached financial statements was based on financial information and advice provided by the Consortium's agent (Curtin University of Technology) to report the financial performance and position of X-Band separately from those of L-Band.

Joe Christopher CPA

Senior Financial & Operational Auditor
Curtin University of Technology

25 June 2003

L BAND
EQUIPMENT AS AT 31 DECEMBER 2002

ASSET NUMBER	DESCRIPTION	ORIGINAL COST	ACCUMULATED DEPRECIATION	CLOSING W/DOWN VALUE
COMPUTING EQUIPMENT				
1358800	SYSTEM SATELLITE TRACKING STATION	110,000.00	110,000.00	-
24788002.	3GB 8MM EXABYTE	6,272.00	6,272.00	-
2552700	TAPE DRIVE 2 GB 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	-
2629700	CARTRIDGE SYSTEM 2.5 GB 8M	4,950.00	4,950.00	-
3914000	MICROWAVE COMMUNICATION SYSTEM	57,266.00	53,989.64	3,276.36
TOTAL COMPUTER EQUIPMENT		**191,553.00**	**188,276.64**	**3,276.36**
OTHER EQUIPMENT				
1358700	SATELLITE STATION TRACKING	140,000.00	122,299.63	17,700.37
1948500	POWER CONDITIONER	2,000.00	1,673.35	326.65
2009000	MA 23 CC	20,365.00	16,963.95	3,401.05
2553700	RECEIVER NOAA I/F FORMAT	19,500.00	15,481.63	4,018.37
3852500	CX-FS1P4 CISCO 4 PORT S/INTER	7,440.00	4,310.80	3,129.20
3852501	PA-7KF-E1/75 CISCO DUAL E1 G70	3,400.00	1,969.99	1,430.01
3852502	CAB E1 BNC FSIP MIP-CE1 BNC	75215.00	124.56	90.44
5132000	RADIO NETWORK BUREAU TO CURTIN	15,670.00		15,670.00
TOTAL OTHER EQUIPMENT		**208,590.00**	**162,823.91**	**45,766.09**
DESKTOP EQUIPMENT (expensed)				
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	-
4522800	WIDE DISK DRIVE	2,164.00	2,164.00	-
4536800	AMSU CARD FOR INST P/C	6,765.77	6,765.77	-
5131700	Linux PC	4,263.00	4,263.00	-
5131500	DLT4000	2,950.00	2,950.00	-
5131600	DLT4001	2,950.00	2,950.00	-
TOTAL DESKTOP EQUIPMENT		**50,931.77**	**50,931.77**	**-**
TOTAL EQUIPMENT		**451,074.77**	**402,032.32**	**49,042.45**

L BAND
CASH FLOW STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2002

	2002	2001
BALANCE OF CASH AS AT 1 JANUARY 2002	175,375CREDIT	164,577CREDIT
RECEIPTS		
Contributions Received		
Dept of Land Administration L Band	10,000	10,000
CSIRO Atmosphere research 2002	10,000	10,000
Bureau of Meteorology LBand	10,000	10,000
Curtin Contribution for 2001	10,000	
Curtin Contribution for 2002	10,000	
Total Contributions Received	**50,000**	**30,000**
SUNDRY INCOME		
Sundry income	36	0
Interest Received	5,947	7,380
Total Sundry Income	**5,983**	**7,380**
TOTAL RECEIPTS FOR 2002	**55,983**	**37,380**
PAYMENTS		
Data Tapes and Disks	2,413	4,288
Printing, Stationery & Photocopying	5,141	180
Telephone	6,532	3,275
System Maintenance Repairs	470	
Telecommunications License of Facility	1,030	1,225
Consultants	183	6,457
Major Equipment	26,468	4,818
Cargo Terminal Fee		869
Transfers fund to X-band		5,000
Aarnet charges	97	
TOTAL PAYMENTS FOR 2002	**41,864**	**26,582**
EXCESS OF RECEIPTS OVER PAYMENTS FOR 2002	**14,119**	**10,798**
BALANCE OF CASH AS AT 31 DECEMBER 2002	**189,494CREDIT**	**175,375CREDIT**

CURTIN UNIVERSITY OF TECHNOLOGY
WA SATELLITE TECHNOLOGY CENTRE

L BAND

STATEMENT OF FINANCIAL PERFORMANCE FOR THE PERIOD 1 JANUARY 2002 TO 31 DECEMBER 2002

	NOTE	2002	2001
	$	$	$
INCOME			
Contributions Received	4	50,000	30,000
Sundry Income		36	-
Interest Received		5,947	7,380
TOTAL INCOME		**55,983**	**37,380**
EXPENDITURE			
Data Tapes and Disks		2,413	4,288
Printing, Stationery & Photocopying		5,141	180
System Maintenance/Repairs			470
Telephone		6,532	3,275
Telecommunications License of Facility		1,030	1,225
Consultants		183	6,457
Major Equipment		10,798	4,818
Aarnet charges		97	-
Cargo Terminal Operators Fee			869
Transfers to X-Band			5,000
Depreciation Expenses		7,557	9,271
TOTAL EXPENDITURE		**33,751**	**35,853**
NET SURPLUS (DEFICIT)		22,232	1,527
EXTRAORDINARY ITEMS		Nil	Nil
NET SURPLUS (DEFICIT) AND EXTRAORDINARY ITEMS		22,232	1,527

CURTIN UNIVERSITY OF TECHNOLOGY
WA SATELLITE TECHNOLOGY CENTRE

L BAND

STATEMENT OF FINANCIAL POSITION AS AT 31 DECEMBER 2002

	NOTE	2002	2001
		$	$
CURRENT ASSETS			
Cash at Bank		189,494	175,375
TOTAL CURRENT ASSETS		**189,494**	**175,375**
NON - CURRENT ASSETS			
Computer Equipment	2a	9,811	13,070
Other Equipment	2b	45,766	34,394
TOTAL NON - CURRENT ASSETS		**55,577**	**47,464**
TOTAL ASSETS		**245,071**	**222,839**
CURRENT LIABILITIES		-	-
NON - CURRENT LIABILITIES		-	-
TOTAL LIABILITIES		-	-
NET ASSETS		245,071	222,839
SHAREHOLDERS EQUITY			
Retained Profits/(Losses)	3a	245,071	222,839
TOTAL SHAREHOLDERS EQUITY		**245,071**	**222,839**

CURTIN UNIVERSITY OF TECHNOLOGY
WA SATELLITE TECHNOLOGY CENTRE

L BAND
NOTES TO AND FORMING PART OF THE FINANCIAL STATEMENT FOR THE PERIOD 1 JANUARY 2002 TO 31 DECEMBER 2002

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

1b. Depreciation

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

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

	2002 $	2001 $
2. NON CURRENT ASSETS		
2a. Computing Equipment (at cost)	191,553	191,553
Accumulated Depreciation	(181,742)	(178,483)
TOTAL COMPUTING EQUIPMENT	**9,811**	**13,070**
2b. Other Equipment (at cost)	208,590	192,920
Accumulated Depreciation	(22,232)	(158,526)
TOTAL OTHER EQUIPMENT	**245,071**	**34,394**
TOTAL NON - CURRENT ASSETS	**55,577**	**47,464**

3. RETAINED PROFITS/(LOSSES)

Retained Profits B/fwd	222,839	221,312
Net Surplus (Deficit) for the year	(162,824)	1,527
CLOSING CASH BALANCE	**45,766**	**222,839**

4. CONTRIBUTIONS RECEIVED

	2002	2001
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 2001	10,000	-
Curtin University of Technology for 2002	10,000	-
	50,000	**30,000**

5. The accounts of L-band and X-band were combined together in the previous "year's financial statements. For comparation purposes, the financial position "and result for this year for both bands have been reported separetely. The comparative amounts for 2001 have been adjusted accordingly in their respective financial statements.

CURTIN UNIVERSITY OF TECHNOLOGY
WA SATELLITE TECHNOLOGY CENTRE

X BAND
EQUIPMENT AS AT 31 DECEMBER 2002

ASSET NUMBER	DESCRIPTION	ORIGINAL COST	ACCUMULATED DEPRECIATION	CLOSING W/DOWN VALUE
OTHER EQUIPMENT				
4857100	X-BAND SATELLITE RECEIVING STATION	553,283.00	72,991.99	480,291.01
TOTAL OTHER EQUIPMENT		**553,283.00**	**72,991.99**	**480,291.01**
DESKTOP EQUIPMENT (expensed)				
5131800	Linux PC -Comdek	4,818.00	4,818.00	-
5131900	DLT 8000	7,375.00	7,375.00	-
TOTAL DESKTOP EQUIPMENT		**12,193.00**	**12,193.00**	**-**
TOTAL EQUIPMENT		**565,476.00**	**72,991.99**	**492,484.01**

CURTIN UNIVERSITY OF TECHNOLOGY
WA SATELLITE TECHNOLOGY CENTRE

X BAND
CASH FLOW STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2002

	2002	2001
BALANCE OF CASH AS AT 1 JANUARY 2002	1,692 CREDIT	0
RECEIPTS		
Contributions Received		
AUSLIG Contribution	50,000	
Bureau of Meteorology Seaspace	100,000	200,000
Seaspace X Band Receiver Dept of Land Administration		300,000
Annual Membership Dept of Land Administration	20,000	
CSIRO - Seaspace		50,000
Annual Membership CSIRO	20,000	
Annual Membership Bureau of Metorology	20,000	
Annual Membership Geoscience Aust	20,000	
Total Contributions Received	230,000	550,000
SUNDRY INCOME		
Transfers From L Band		5,000
Total Sundry Income	-	5,000
TOTAL RECEIPTS FOR 2002	**230,000**	**555,000**
PAYMENTS		
Outsourced Work	987	25
Travel		4,156
Printing Stationery & Photocopying	774	
Mechanical and Equipment Maintenance	7,800	
Equipment purchase	17,142	553,283
Telecommunications License of Facility	2,358	
TOTAL PAYMENTS FOR 2002	**33,217**	**553,308**
EXCESS OF RECEIPTS OVER PAYMENTS FOR 2002	**196,783**	**1,692**
BALANCE OF CASH AS AT 31 DECEMBER 2002	**198,475 CREDIT**	**1,692 CREDIT**

CURTIN UNIVERSITY OF TECHNOLOGY
WA SATELLITE TECHNOLOGY CENTRE

X BAND
STATEMENT OF FINANCIAL PERFORMANCE FOR THE PERIOD 1 JANUARY 2002 TO 31 DECEMBER 2002

	2002 $	2001 $
INCOME		
Contributions Received	230,000	550,000
Sundry Income	-	5,000
TOTAL INCOME	**230,000**	**555,000**
EXPENDITURE		
Outsourced Work	987	25
Travel	4,156	
Printing, Stationery & Photocopying	774	
Depreciation	66,468	6,524
Maintenance of Equipment	7,800	
Equipment purchase	17,142	
Telecommunications License of Facility	2,358	
TOTAL EXPENDITURE	**99,685**	**6,549**
NET SURPLUS (DEFICIT)	130,315	548,451
EXTRAORDINARY ITEMS	Nil	Nil
NET SURPLUS (DEFICIT) AND EXTRAORDINARY ITEMS	130,315	548,451
TRANSFERS TO ASSET REVALUATION RESERVE	Nil	Nil
NET SURPLUS (DEFICIT) TRANSFERRED TO RETAINED PROFITS/(LOSSES)	130,315	548,451

X BAND
STATEMENT OF FINANCIAL POSITION AS AT 31 DECEMBER 2002

	NOTE	2002 $	2001 $
CURRENT ASSETS			
Cash at Bank		198,475	1,692
TOTAL CURRENT ASSETS		**198,475**	**1,692**
NON - CURRENT ASSETS			
Other Equipment	2	480,291	546,759
TOTAL NON - CURRENT ASSETS		**480,291**	**546,759**
TOTAL ASSETS		**678,766**	**548,451**
CURRENT LIABILITIES		-	-
NON - CURRENT LIABILITIES		-	-
TOTAL LIABILITIES		**-**	**-**
NET ASSETS		678,766	548,451
SHAREHOLDERS EQUITY			
Retained Profits/(Losses)	3	678,766	548,451
TOTAL SHAREHOLDERS EQUITY		**678,766**	**548,451**

X BAND
NOTES TO AND FORMING PART OF THE FINANCIAL STATEMENT FOR THE PERIOD 1 JANUARY 2002 TO 31 DECEMBER 2002

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. Depreciation

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

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

	2002 $	2001 $
2. NON CURRENT ASSETS		
Other Equipment (at cost)	553,283	553,283
Accumulated Depreciation	(72,992)	(6,524)
TOTAL OTHER EQUIPMENT	480,291	546,759
TOTAL NON - CURRENT ASSETS	**480,291**	**546,759**
3. RETAINED PROFITS/(LOSSES)		
Retained Profits B/fwd	548,451	-
Net Surplus (Deficit) for the year	130,315	548,451
CLOSING BALANCE	**678,766**	**548,451**

4. The accounts of L-band and X-band were combined together in the previous year’s financial statements. For comparation purposes, the financial position and result for this year for both bands have been reported separately. The comparative amounts for 2001 have been adjusted accordingly in their respective financial statements.