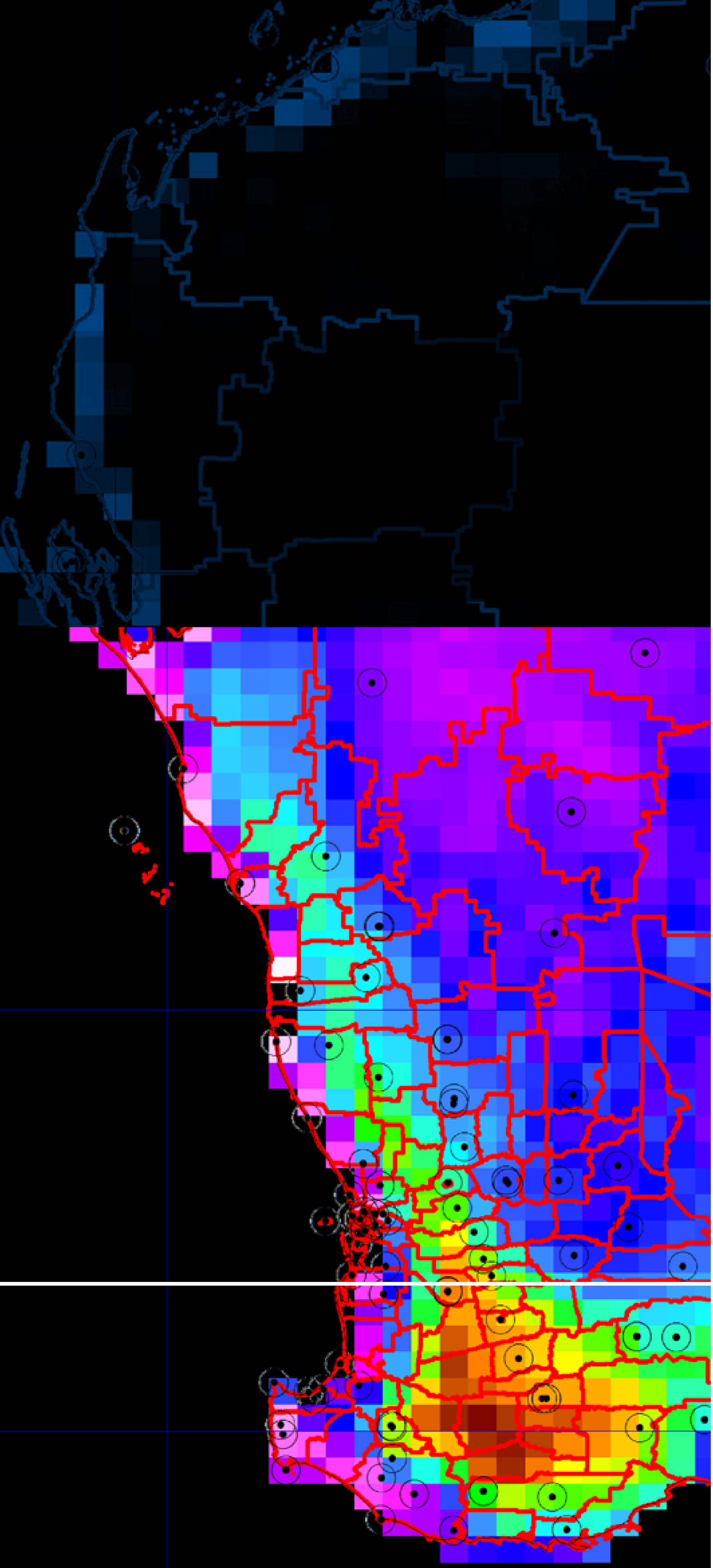

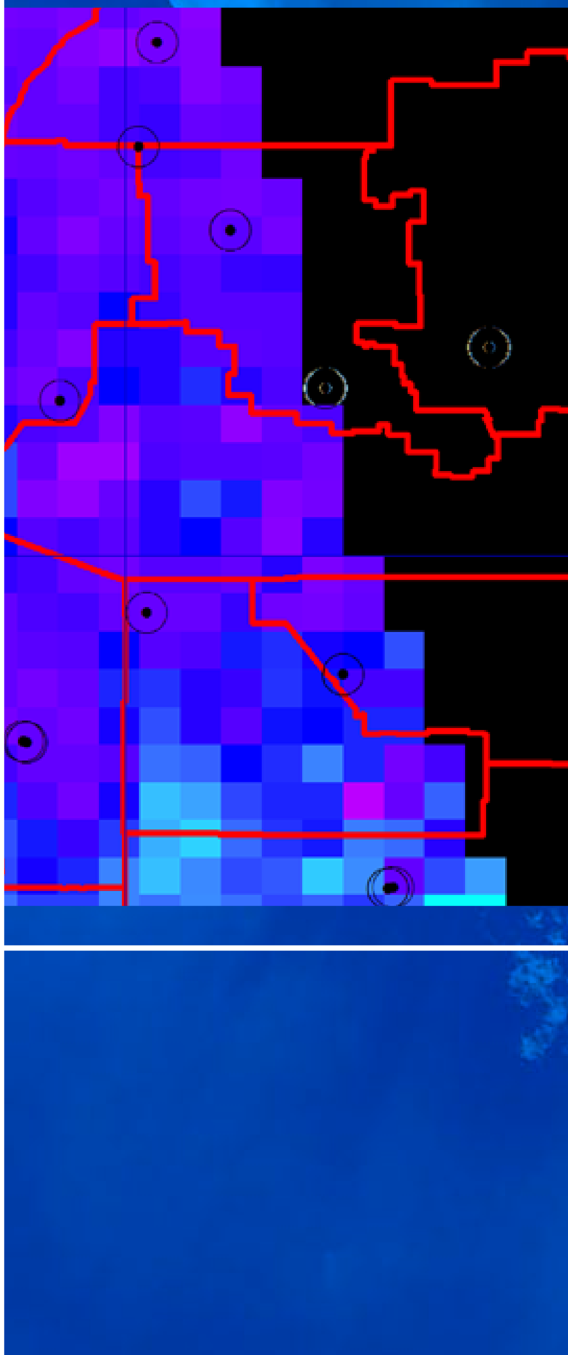

WASTAC

Annual Report 2006

Western Australian Satellite Technology and Applications Consortium

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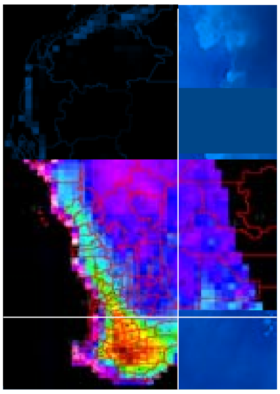
COVER IMAGE



The soil moisture image of a portion of southern Western Australia, with shire boundary overlay, was imaged after a significant rainfall event occurred signalling the break of the season for agricultural cropping and grazing land. The soil moisture product is derived from the AMSR-E sensor on board the Aqua satellite. Pixel resolution is 28 kilometres. Investigations are underway to determine the uses of the soil moisture measurements for use by rural land owners and resource and environmental management agencies. Reference to the project is made in the Operational Application, Department of Land Information, section of the report.

EDITORS
R. Stovold DLI, SRSS and A.F. Pearce

ACKNOWLEDGEMENTS:

CONTENTS Page

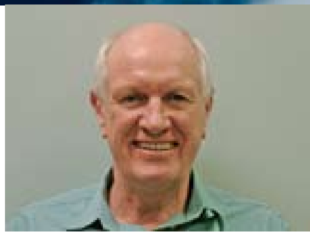
WASTAC CHAIRMAN'S REPORT 2006

Increasing evidence much of it from earth observing satellites makes it apparent that human activity is changing our climate at an unprecedented rate. Such climate changes previously occurred over many thousands of years allowing species to adapt. The current changes are occurring within the space of a few hundred years. Many species will not be able to adapt and Homo Sapiens' adaptability will be severely tested, particularly the sharing of expertise and finite resources.

From WASTAC's imagery we observe diminished pasture and crop growth from declining rainfall in the south, while grass and shrub growth, wild fires, tropical storms and floods are observed to be increasing with changing rainfall patterns in the north. In Indonesia extensive fires are observed as part of the harvesting of tropical rainforests to make way for oil palms and agricultural crops. These observations provide a powerful tool to understand and manage climate change into the future.

To maintain our capacity to receive and archive these observations, WASTAC continued upgrading its facilities during 2006 by:

- Finalising the upgrade of our 3.6m SeaSpace X-band system to a Dual L/X Linux System to provide redundancy and enhanced capacity for conflict resolution.
- Planning the upgrade of the SeaSpace L/X-band ground station for the reception of METOP in 2007.
- Installation of a new antenna mount for the Curtin University 2.4m L band tracking antenna after 20 years of continuous operation.
- Planning the upgrade of the Curtin University L-band ground station for the reception of METOP and FY1 in 2007.
- Developing the long term archiving of WASTAC's data using the iVEC super computing facility at Bentley Technology Park.
- Planning to access data from the new X-band facility being installed by the Bureau of Meteorology in Darwin.



WASTAC's interest has evolved over the years to include coverage of the whole of Australia, Indonesia and Papua New Guinea. This results from the continental and global scales at which climate change is occurring. This has resulted in WASTAC members assisting neighboring states and third world countries. Initially these requests came from the Northern Territory and Queensland. More recently they have come from Indonesia and Vietnam for assistance in fire detection and forest protection, also for monitoring tropical storms and flooding where use of direct readout sensors is vital. The importance of these developments was highlighted by the Australian Government's recently announced $200 million "Global Initiative on Forests and Climate" to promote reforestation, limit the destruction of rainforest, promote sustainable management and encourage contributions from other countries. WASTAC looks forward to contributing to this initiative.

I wish to compliment the many contributors who have compiled reports for the 2006 Annual Report. Persons who shouldn't go without mention are Richard Stovold in his role as Secretary and editor-in-chief, Ron Craig who continues to build the number of satellite orbits captured and Professor Merv Lynch who pioneered access to iVEC for the long term archiving of WASTAC's data. Following his retirement, Alan Pearce who contributed many years of service to the WASTAC Standing Commitee is sadly missed.

Richard Smith
Chairman, WASTAC
July 13, 2007

WASTAC BOARD FOR 2006

Dr Richard Smith (Chairman)	Department of Land Information
Dr Stefan Maier	Department of Land Information
Professor Merv Lynch	Curtin University of Technology
Dr Doug Myers	Curtin University of Technology
Dr Alex Held	CSIRO, Earth Observation Centre
Dr David Griersmith	Bureau of Meteorology
Mr Alan Scott	Bureau of Meteorology
Mr Adam Lewis	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
Professor 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
Dr Halina Kobryn	Murdoch University

WASTAC SECRETARY

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

WASTAC TECHNICAL COMMITTEE:

Mr Don Ward (Chairman)
Professor Merv Lynch
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:
- provide high speed access to Aqua, Terra, NOAA (TOVS and AVHRR), SeaWiFS and FY1D 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 and research uses of WASTAC data
- ensure maximum use of Aqua, Terra, NOAA, SeaWiFS and FY1D data in the management of renewable resources.

FUTURE STRATEGIES:
- Upgrade reception and processing capabilities for METOP (including AVHRR), NPP (including VIIRS) and FY3 (including MERS).
- Advance MODIS processing from Level 1b to Level 2 (Below-atmosphere NADIR reflection) through introduction of atmospheric and view angle (BRDF) corrections.
- Advance the processing of AIRS data from Aqua and Terra.
- Improved management of the archive through collaboration with iVEC (Interactive Virtual Environment Computing Facility).
- Network access to other Earth Observation Satellite receiving stations in Australia.
- Facilitate reception and processing of data from the Chinese ZY3 photogrammetric satellite.

FUTURE SATELLITE RECEPTION OPPORTUNITIES:
- National Polar Orbiting Environmental Satellite System (NPOESS)
- Landsat Continuity Data Mission.
- Chinese FY3 (MODIS type sensor) and ZY3.

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. The X Band facility at Murdoch University was commissioned on the 21 November 2001.

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 pictures 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.

WASTAC X

The WASTAC X band facilities at the Environmental Science building at Murdoch University were supplied and installed by SeaSpace Corp 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 the WASTAC.

The X band computer has been upgraded by SeaSpace to incorporate ingest for new X band satellites and a L band ingest facility has been added to provide backup and help resolve pass conflicts.

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

ARCHIVE STORAGE

DLI is currently holding the archive on 8mm exabyte and DAT tapes. 20Gb 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.

Data is also fed to the iVEC data management facility in Perth.

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

RECENT DEVELOPMENTS AND FUTURE DIRECTIONS

A project is underway that will upgrade the existing L band station at Curtin to match similar Bureau facilities. WASTAC is also progressing a data warehouse proposal from IVEC who will manage and provide online access to the WASTAC to the extensive archive.

Future plans include upgrading for ingest of METOP, NPP and FY3 satellite data streams as well as the processing of MODIS data to level2 and processing of AIRS data from Aqua and Terra.

WASTAC DATA ARCHIVE

The WASTAC archive of NOAA, MODIS and SeaWiFS satellite passes, managed and maintained by 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 16,726 NOAA passes were archived at Curtin and Murdoch in 2006. Passes include data from the NOAA 12, NOAA 14, NOAA 15 ,NOAA 16 ,NOAA 17 and NOAA 18 satellites. All passes were stored on DLT tapes.

The archiving of SeaWiFS data continued during 2006 with 1239 passes being archived.

During 2006 1639 TERRA ,1635 AQUA and 1683 FY1D 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.

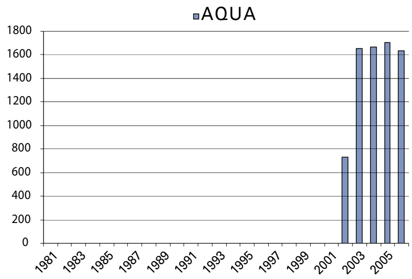
Web addresses to view this archive of MODIS, NOAA and SeaWiFS data online are:

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

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

TOTAL NUMBER OF PASSES HELD IN THE WASTAC ARCHIVE

	AQUA	TERRA	Sea WiFS	FY1D	NOAA 6	NOAA 7	NOAA 8	NOAA 9	NOAA 10	NOAA 11	NOAA 12	NOAA 14	NOAA 15	NOAA 16	NOAA 17	NOAA 18	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
2005	1705	1577	863	553							2101	1706	1904	1743	2212	1339	15703
2006	1635	1639	1239	1683							3030	2761	2823	2240	2883	2989	22922


AQUA
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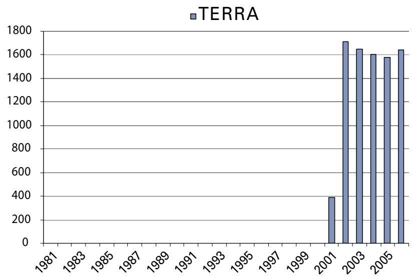
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005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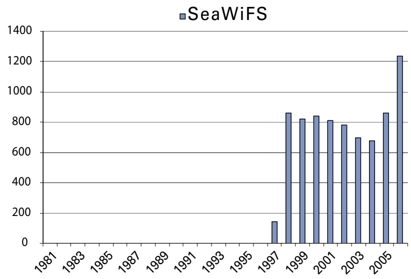
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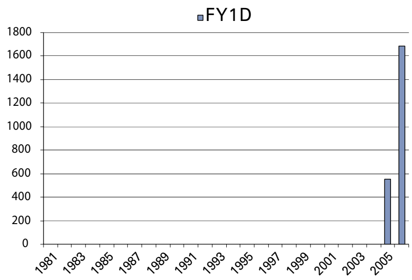
FY1D
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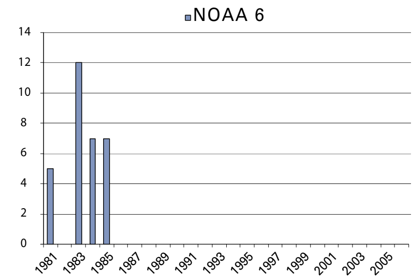
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005


NOAA 6
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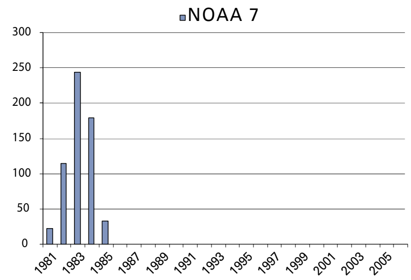
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005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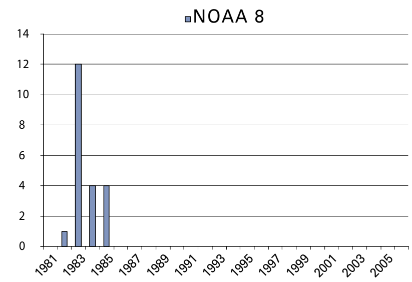
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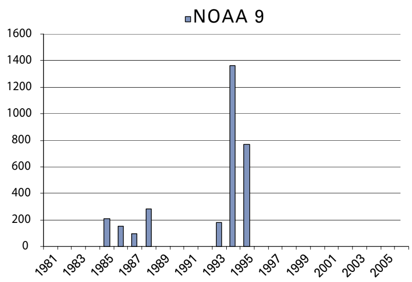
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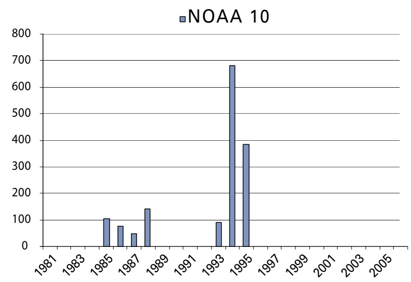
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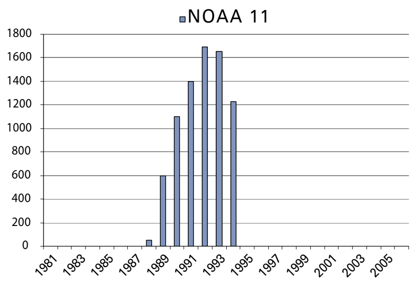
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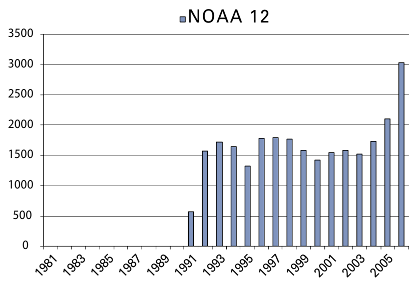
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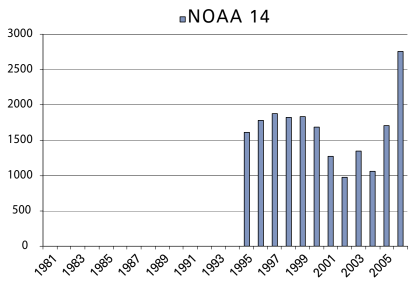
NOAA 14
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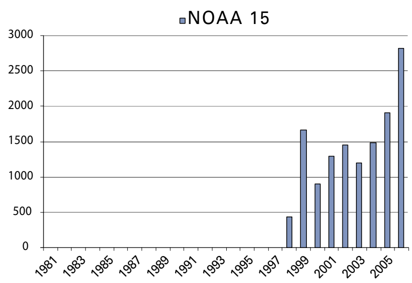
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005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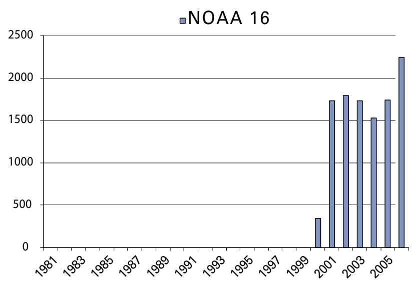
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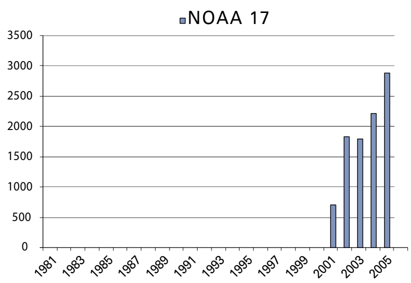
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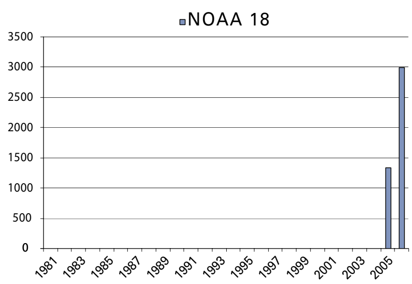
NOAA 18
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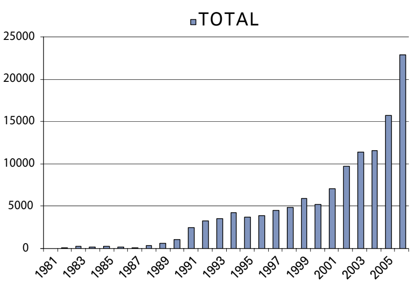
TOTAL
0 5000 10000 15000 20000 25000
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005

WASTAC SATELLITE DATA 2006

	TERRA	AQUA	FY1D	SeaWiFS	NOAA 12	NOAA 14	NOAA 15	NOAA 16	NOAA 17	NOAA 18	TOTAL
JAN	132	146	139	107	299	236	283	189	247	257	2037
FEB	114	105	103	85	236	205	209	136	208	198	1599
MAR	143	136	136	109	195	228	156	266	252	276	1897
APR	138	132	137	91	272	228	239	145	229	216	1826
MAY	141	142	155	110	291	241	286	228	251	283	2128
JUN	137	130	140	100	231	228	211	184	235	233	1824
JUL	141	138	141	115	231	242	171	211	245	269	1906
AUG	145	134	148	113	285	233	279	206	248	259	2050
SEPT	132	134	147	90	265	225	280	169	242	237	1921
OCT	139	137	142	99	195	247	218	236	247	257	1917
NOV	138	132	140	111	271	224	181	155	255	255	1914
DEC	137	139	155	99	259	220	228	295	223	249	1944

OPERATIONAL APPLICATIONS 2006

A variety of operational marine, terrestrial and atmospheric products have been developed using locally-received satellite data from the AVHRR, SeaWiFS and MODIS sensors. The principal agencies involved are the Bureau of Meteorology and the Satellite Remote Sensing Services group in the WA Department of Land Information (DLI).

BUREAU OF METEOROLOGY, MELBOURNE

Compiled by Ian Grant, Anthony Rea & Mike Willmott.

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 (Rea, 2004). The algorithms currently in use are the Non-Linear SST (Walton, 1998) using coefficients derived by NOAA/NESDIS.

Within 30 minutes of reception, the regional AVHRR data is fed into the SST processing system, located in the Bureau's Head Office, where it is cloud cleared and the SSTs calculated. Navigation to an accuracy of around 1 km or better is achieved with the Common AVHRR Processing System (CAPS), using the Clift navigation model and orbital information from CSIRO Marine Research (Hobart).

Individual passes are combined into a national SST map and are also forwarded on for use in the Bureau's ocean analysis systems. Daily SST maps are available to external users at reduced resolution through the Bureau's website at http://www.bom.gov.au/nmoc/archives/SST/ (Figure 1).

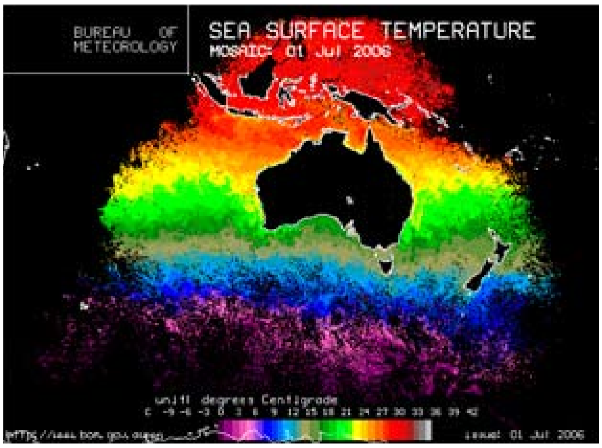

Figure 1: SST product available free to the public via a browse service on the Bureau's web site (www.bom.gov.au).

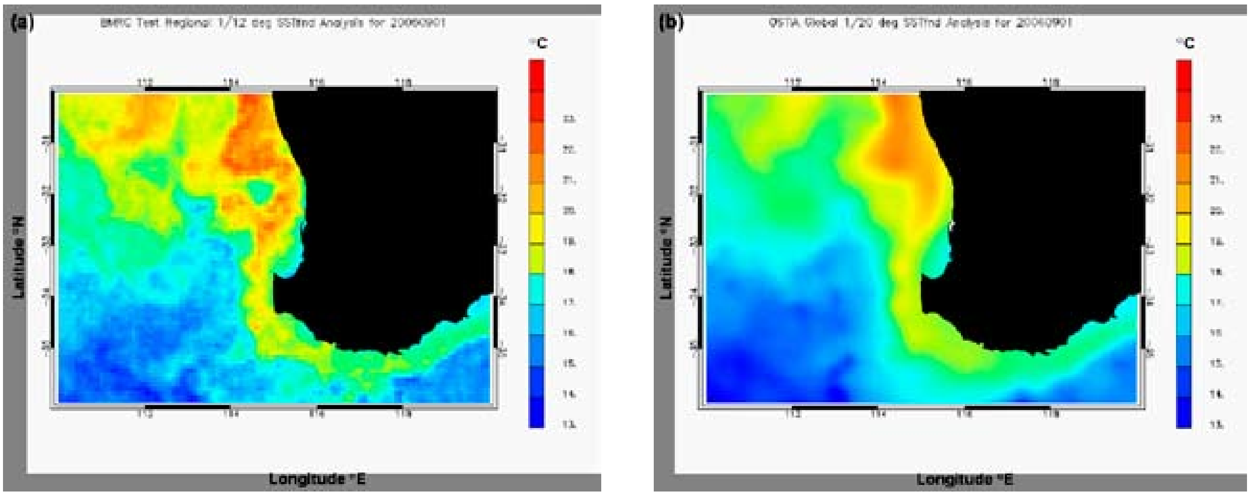

Figure 2: An example of the (a) BLUElink> regional daily 1/12° resolution SST analysis, and (b) UK Met Office Operational SST and Sea Ice Analysis (OSTIA) global daily 1/20° resolution SST analysis for 1 September 2006 over the oceans south-west of Australia (110°E to 120°E, 30°S to 36°S).

Verification of the satellite-derived SST fields is carried out automatically after each individual orbit is processed. The SSTs are compared to in situ measurements from ships and buoys which are co-located and coincident. 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. During 2006, a comparison of ship and buoy matchups demonstrated that the ship observations are significantly less accurate than the buoys and, since August 2006, only buoy data has been used to measure the accuracy of the satellite SSTs. This reduced the typical RMS error in the satellite measurements from 1.0 degrees to 0.6 degrees.

These SST data are used by the Bureau/CSIRO/Navy collaborative BLUElink> Ocean Forecasting Australia project as input to the high-resolution regional SST analysis system (Beggs, 2007) which BLUE¬link> is developing for ocean nowcasting and forecasting applications. While this system uses global SST data from a variety of satellite sensors, the AVHRR data from WASTAC and the other Australian sites are particularly valuable because of their timeliness and fine resolution. Figure 2 shows the advantage of including the locally received HRPT AVHRR SST data in the 1/12° resolution regional SST analysis in the Perth region, compared with the new 1/20° resolution global SST analysis from the UK Met Office which includes GAC AVHRR SST data from the NOAA-17 and NOAA-18 satellites but no HRPT AVHRR SST data from this region.

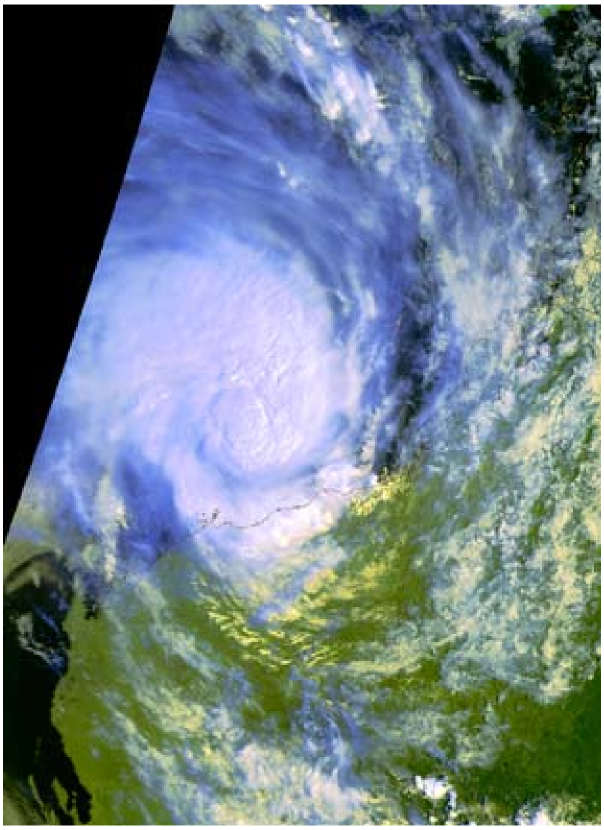

Figure 3: Tropical Cyclone Clare bears down on the Pilbara region of Western Australia. Image taken from NOAA-14, 9 January 2006 00 UTC.

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, MTSAT-1R imagery and NWP analysis. It is also a critical back-up to MTSAT-1R imagery.

For the Period 1 January to 31 December 2006, there were 6 Tropical Cyclones that impacted on the Western Australian Coast. The most significant of these were Clare in January and Glenda in March. During Clare, downed power lines and flooding disrupted power and telecommunication to many parts of the Pilbara including Dampier and Karratha. Heavy rains during Clare (Figure 3) caused widespread flooding over many parts of the state including areas well to the south. Glenda was a small and intense system that initially threatened Karratha and Dampier before weakening and moving to the southwest, crossing the coast near Onslow. Damage at Onslow was generally minor.

Tropical Cyclone Emma was a weak category 1 system but it did generate considerable rainfall across the Pilbara, Gascoyne and Murchison regions and in particular produced a significant flood on the Murchison River (Figure 4).

Figure 4: Image taken from NOAA-17 on 15 March 2006 at 02 UTC using channels 1, 4 and 5 depicting areas of flooding (blue). This event was the direct result of the passing of Tropical Cyclone Emma.

NORMALISED DIFFERENCE VEGETATION INDEX (NDVI)

The Normalised Difference Vegetation Index (NDVI) monitors the greenness of vegetation, and is an indication of its coverage and vigour. The Bureau currently produces NDVI products from the AVHRR on NOAA-17. After the AVHRR data is geolocated and calibrated, it is remapped into a daily composite covering Australia. Each daily composite is manually inspected and may be rejected if degraded, for instance, by reception noise. The NDVI calculated from the red and near-infrared top-of-atmosphere reflectances is composited by maximum value over 9-day periods. The 9-day composites are further composited into monthly national maps (Figure 5) which are distributed via the world wide web.

Vegetation greenness reflects the broadscale dryness of bushfire fuels, and so is a critical parameter to consider in assessing fire danger. Bureau NDVI products were presented to the inaugural national Seasonal Bushfire Assessment Workshop, held at the Bureau of Meteorology Head Office in June 2006. Both monthly maps of NDVI and monthly maps of change in NDVI from the previous month or year are generated. The change from the previous year (Figure 6) highlights regions of anomalous growth with respect to the previous year. The change from the previous month highlights recent trends in growth or senescence. The maps are used as a broad-scale summary of the state of vegetation and regions of anomalies, and as one input to the process of formulating a national map of fire potential.

The Bureau provides an experimental Grassland Curing Index (GCI) product derived from NOAA AVHRR data to fire agencies in Victoria, South Australia and the ACT to assist with fire danger assessment. The Bureau currently produces GCI, which is derived from NDVI, from NOAA-18 data using an algorithm and software developed by CSIRO. While the product covers only south-eastern Australia, the Bureau is a partner in a Bushfire Cooperative Research Centre project to develop a satellite curing assessment technique that is robust and validated across Australia.

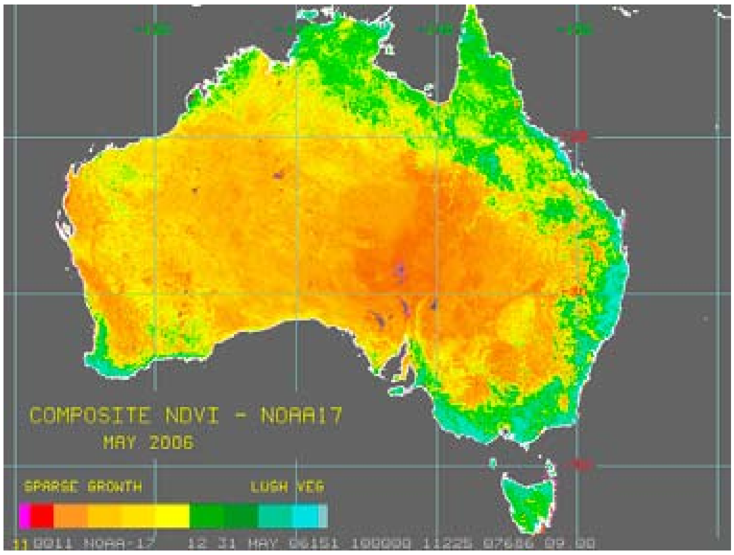

Figure 5: An example of the Bureau's monthly Maximum Value Composite NDVI product.

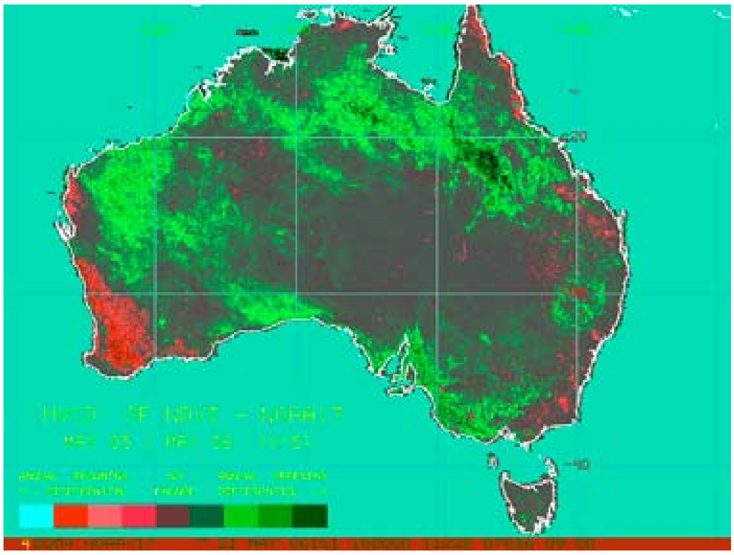

Figure 6: Annual (May 2006 – May 2005) NDVI difference produced by the Bureau of Meteorology.

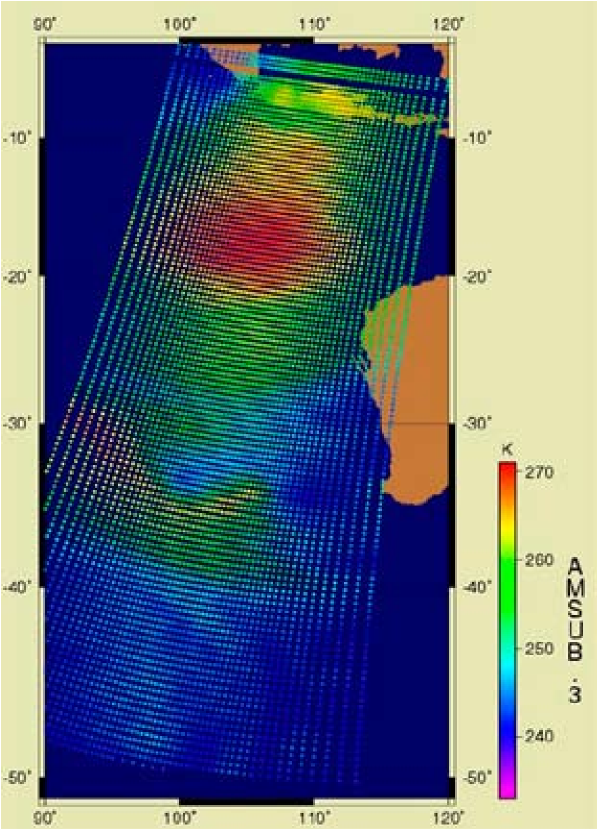

Figure 7: ATOVS data (microwave brightness temperature from channel 3 of the AMSU-B instrument) from a 13 July 2006 pass of NOAA-18, received by WASTAC and processed by the Bureau of Meteorology.

ATMOSPHERIC PROFILES FOR NUMERICAL WEATHER PREDICTION

The Advanced TIROS Operational Vertical Sounder (ATOVS) suite of instruments on board the NOAA satellites provides information on the vertical profiles of temperature and moisture in the atmosphere. This information on the state of the atmosphere has complete daily spatial coverage from each satellite and is important input into the computer models of the atmosphere that underpin numerical weather prediction. Modern weather forecasting, in turn, relies heavily upon this modelling. The Bureau sends ATOVS data from NOAA-15, -17 and -18 received at WASTAC, Darwin and Crib Point (south-east of Melbourne) to its Head Office in Melbourne within half an hour of the end of the overpass. There it is processed through the internationally standard ATOVS and AVHRR Pre-processing Package (AAPP). Figure 7 shows an example of microwave brightness temperatures from the Bureau's AAPP processing system. The data has been used experimentally in the newest version of the Bureau's NWP model, and the data will become operational in 2007.

The global nature of the atmospheric system drives a need for global ATOVS data to serve the NWP requirements of nations all over the world. This has stimulated the establishment of systems for the rapid international exchange of ATOVS products. Following the successful example of Europe, nations in Australia's region are establishing the Asia-Pacific Regional ATOVS Retransmission Service (AP-RARS). The Bureau is the coordinator and a major exchange node for AP-RARS. Test exchanges commenced in the middle of 2006, and by the end of 2006 ten sites were routinely exchanging data. Thus, for instance, data received by WASTAC, as well as three other Australian sites, is routinely being assimilated into the Japan Meteorological Agency's weather model, with positive impact.

MODIS AND AIRS DATA

The large number of spectral bands carried by MODIS enables the derivation of a large range of image products that diagnose the state of the atmosphere. These include the spatial distribution of water vapour, temperature as a function of pressure level, cloud phase (ice or water), and cloud top properties (pressure, temperature, particle size). The Bureau is using IMAPP (International MODIS and AIRS Processing Package) software from the University of Wisconsin to generate these products, and has a developmental web-based system to deliver them to the Bureau's forecasters. Figure 8 is a sample of the web-page through which the forecasters in the Bureau's Western Australia Regional Office can access products derived from MODIS data received by WASTAC.

The Aqua satellite carries, besides MODIS, the Advanced

Infrared Sounder (AIRS), which offers atmospheric profile data of unprecedented accuracy. Image products describing the temperature and moisture structure of the atmosphere will also be produced by IMAPP software for delivery to forecasters. Ultimately, AIRS will constitute another key input to the Bureau's numerical weather prediction models.

VOLCANIC ASH

Work is continuing on the use of AVHRR (and MTSAT-1R) 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 MTSAT-1R 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.

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.

LOW CLOUD / FOG

The fog/low cloud program developed by the 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 to -18 satellite data received at WASTAC, Darwin and Melbourne. Products are available within 10 minutes of the satellite pass being received, and are geometrically located to within one pixel (1 km).

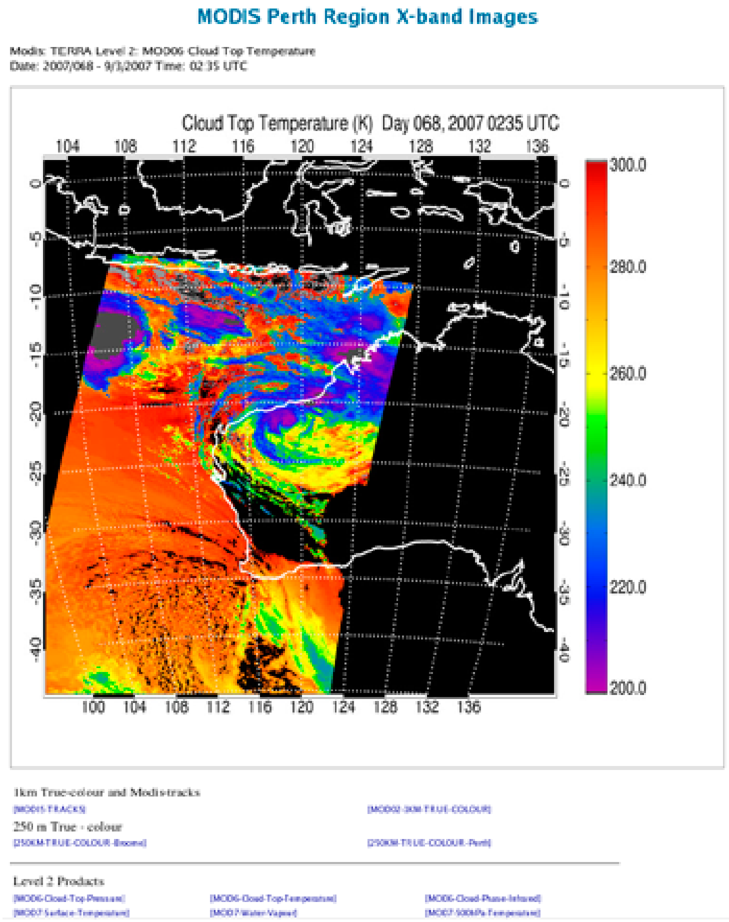

Figure 8: A sample of the web page to present MODIS products to Bureau forecasters. The links at the bottom give access to other parameters and high resolution true colour images.

Nighttime low cloud detection is performed using 3.7 micron and 11 micron IR NOAA data. Low altitude small-droplet water cloud emissivity at nighttime approximates that of a blackbody at 11 micron, but not 3.7 micron, leading to the apparent blackbody temperature being lower in the 3.7 micron band than the 11 micron band. Clouds composed of large droplets and/or ice crystals are not detected. The software provides cloud top height assignment with the use of topography and a land-sea mask.

The imagery (Figure 9) is used in conjunction with MTSAT imagery, which provides lower spatial resolution (and hence sometimes fewer detections) than NOAA, but higher temporal resolution, with imagery every 15 minutes to one hour enabling image loops to determine cloud movement and help identify false detections.

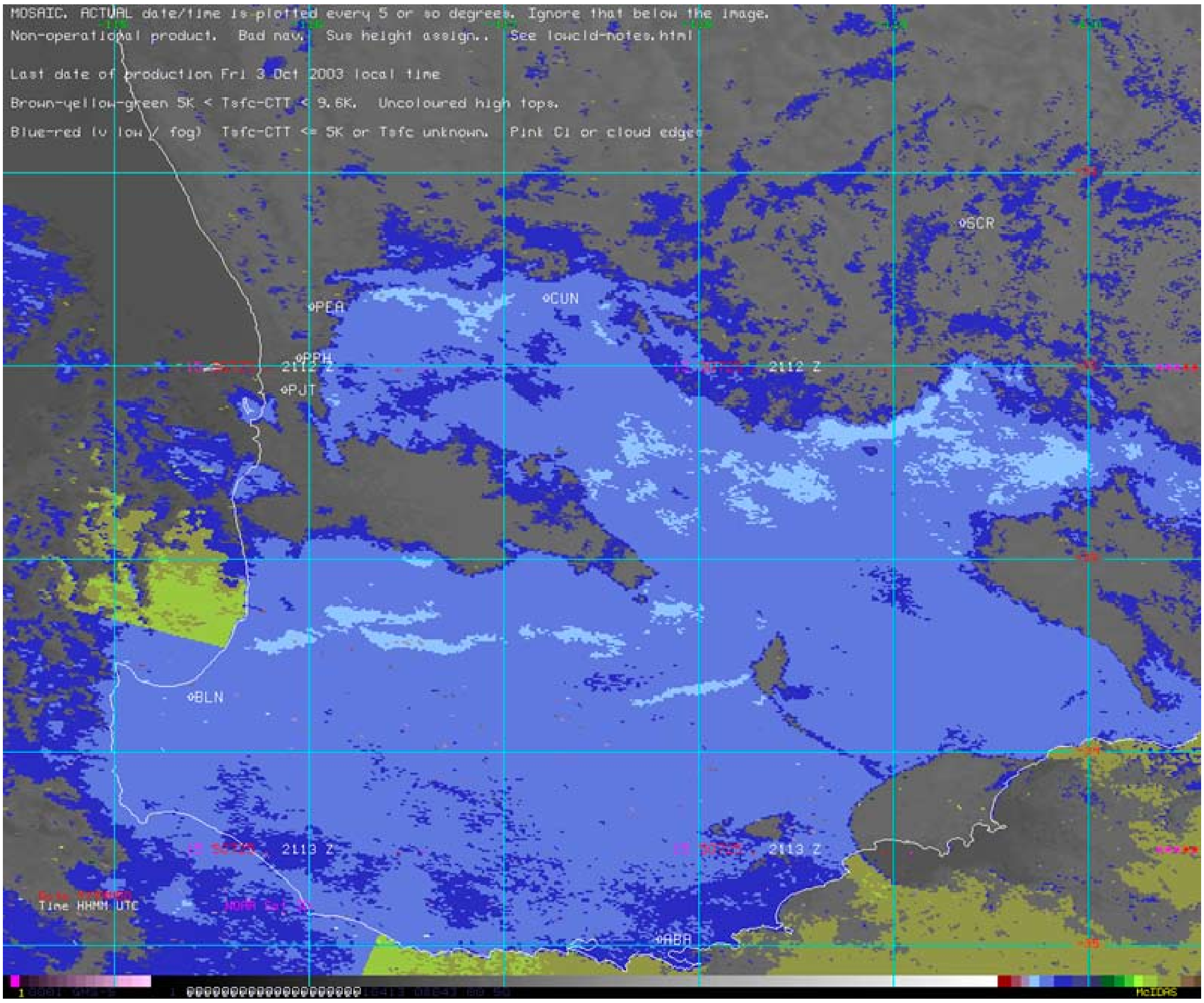

Figure 9: Fog and Low Cloud image from NOAA-15 data of the southwest corner of WA on the morning of a fog affecting Perth Airport, 26 July 2005. Blue areas represent the lowest cloud tops (as estimated from thermal contrast with nearby cloud-free surface), with lighter shades representing a stronger signal (due to smaller droplet size and/or thicker cloud). Slightly higher cloud tops are denoted by olive-green shades. Sharp boundaries in height assignment occasionally result from dividing up low cloud masses into local areas for comparison against local surface temperatures, where cloud top temperatures are borderline between those for low and very low cloud.

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DEPARTMENT OF LAND INFORMATION

(Satellite Remote Sensing Services)

SEA SURFACE TEMPERATURE (SST)

John Adams

SST data derived from both MODIS and NOAA-AVHRR sensors are routinely generated for each satellite pass received from 6 stations located around Australia (including both WASTAC receiving stations). These datasets are then forwarded to a partner agency in Canberra called Earthinsite. They have developed a website at seasurface.com which features continental SST imagery for the past week. Clients can access data by Single Purchase, Multiple Purchase Packs and by Unlimited Use Packs (Weekly, Quarterly or Annual). Clients can further refine their requirements for Multiple Purchase and Unlimited Use Packs for a small additional fee by nominating their area of interest under the SST Express service. This then allows the user to be taken straight to images which have data covering their specified area and optionally processed in a way suited to the client. Other options available cover slow internet connections and group discounts for fishing cooperatives. SST data is also supplied to the Royal Australian Navy who assist in improvement of this service. Chlorophyll data from the MODIS sensor is currently being trialled to enhance SST-related information (Figure 1).

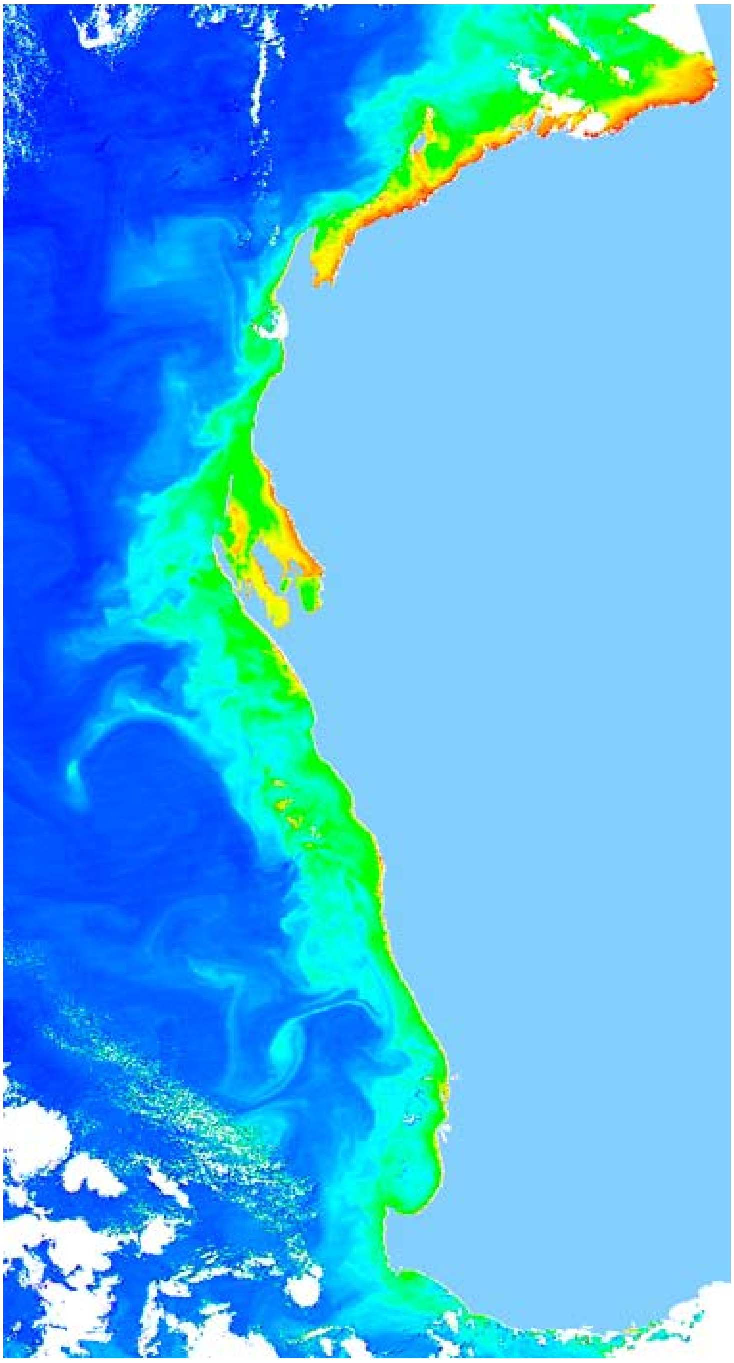


Figure 1: Example MODIS chlorophyll image from the 29th of March 2007.

VOLUMETRIC SOIL MOISTURE FROM AMSR-E

Norm Santich, Jackie Marsden, Andrew Buchanan, Mario Ferri, Richard Stovold

The use of satellite microwave radiometry offers the possibility to remotely measure the volumetric moisture content of soils. The amount of moisture contained within the topsoil is one of the major factors that determines the growth rate of crops and pastures. It is also a useful parameter for predicting flood and drought events.

It is anticipated that the soil moisture product as derived from AMSR-E will be used as an input to the Pasture Growth Rate (PGR) model. Volumetric soil moisture is also of interest to the Crops From Space project. The soil moisture content is currently inferred by rainfall data supplied by the Bureau of Meteorology.

2006 was one of Perth's driest years on record. This changed in 2007 when a cold front brought much needed rain to the south west corner of Western Australia on April 15. Volumetric soil moisture data derived from remotely sensed AMSR-E data shows the change in the soil moisture content before and after April 15 in the south western corner of WA.

Figure 2 shows the generally dry conditions across the south west on April 14. On April 16 it can be seen that this has changed below a line from Jurien Bay to Bremer Bay. The soil moisture in this region has increased significantly as a result of the rainfall brought by the passage of the cold front on the previous day.

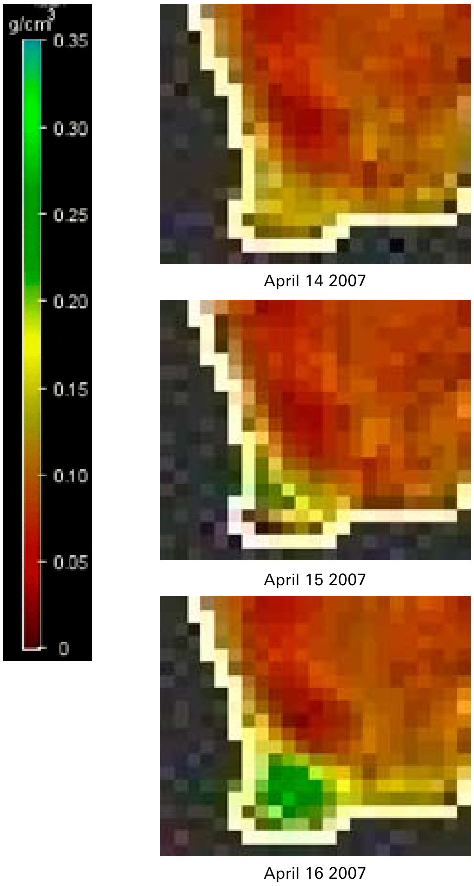


Figure 2: Soil moisture data derived from AMSR-E showing the effect of a passing cold front on soil moisture content in the south west of WA.

CROPS FROM SPACE

Richard Smith, Richard Stovold, Stefan Maier, Norm Santich, Matt Adams

Within the new Department of Land Information initiative "Crops from Space", a commercial platform is created where users (farmers or advisors) can access paddock or farm NDVI values. This project aims to deliver near real-time Crop Area and Crop yield estimation from MODIS time series data (Figure 3). This product uses weekly measures of vegetation greenness to separate crops from pastures at field scale. Landgate is supportive to include add-on products to this platform, such as the improved wheat yield and production forecasting products. Collaborating Crops From Space farmers were contacted recently with a request to provide paddock usage data dating back to 2002. This data has started coming in and will be used for validation of remote sensing algorithms developed for the Crops From Space project.

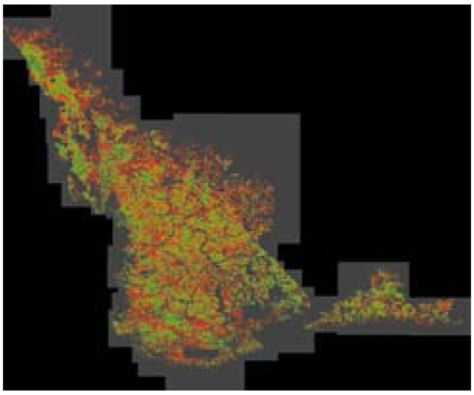


Figure 3: Classified MODIS crop (in red) and pasture (green) image of South West WA in June 2006.

PASTURES FROM SPACE

Richard Stovold, Matthew Adams, Sarfraz Khokhar, Norm Santich

MODIS satellite derived Pasture Growth Rate (PGR) data is routinely being used by farmers to give a weekly measurement of their PGR within paddocks. The PGR information is delivered every week as a subscription service over the internet. The information is being delivered through Fairport Technologies Pasture Watch software to producers in southern Australia Figure 4).

Farmers in Western Australia and the Eastern States are now using this new technology to assist them improve their management decisions resulting in higher profitability. Farmers are achieving increased pasture utilization using Pasture Growth Rate and Feed On Offer maps resulting in more wool and profit per hectare.

Figure 4: PastureWatch software used to deliver Pasture Growth Rate information to farmers PC.

Following on from new research at SRSS farmers are getting more accurate pasture growth rates and feed on offer measurements following the addition of two new tools to Pasture Watch software.

A new variable rainfall tool now lets farmers input rainfall values for their farms; and they can also now input a constant value to account for local differences between the modelled and the observed feed on offer on the farm.

The new tools mean that farmers get a predicted pasture growth rate and feed on offer value that's more in line with actual growth rates on their land.

They can now more confidently predict stocking rates and feed budgets and rotate livestock to get the best possible fit for their farms.

The Department of Land Information who process the satellite information to PGR measurements based on the CSIRO Livestock Industries PGR model and Department of Agriculture ground data, have set up a new web site within the Farm Channel of their Landgate service with free publicly viewable Pastures From Space information.

To view the Pastures From Space information visit http://www.pasturesfromspace.csiro.au

To visit the Department of Land Information website http://www.landgate.com.au
(go to the Farm channel)

For information on the Fairport subscription service visit http://www.fairport.com.au/pasturewatch.

New subscribers to Pastures from Space will get the latest 4.0 version of Pasture Watch which comes with the new tools. Existing subscribers can download the latest version.

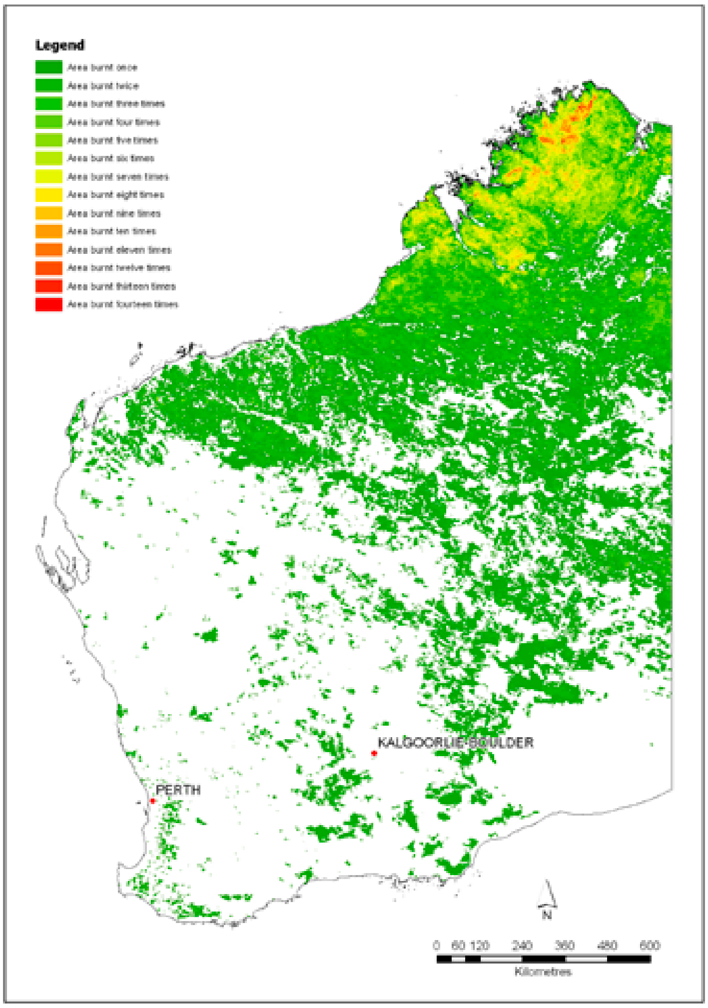


Figure 5: Fire frequency map for Western Australia from 1993 to 2006. Most of the northern half of Western Australia has burnt at least once within the last fourteen years. In the Kimberley region, some areas burn every year

FIRE FREQUENCY FOR WESTERN AUSTRALIA FROM 1993 TO 2006

Agnes Khristina, Jackie Marsden

FireWatch has digitised fire burnt areas in WA (Figure 5) since 1993; as a result, the fire frequency can be determined over Australia. Fire frequency map indicates the number of times an area has been burnt within specific time, in this case from 1993 to 2006.

The fire frequency map is created by adding annual burnt areas on top of each other. The burnt area itself is derived from 9 day cycle NOAA AVHRR imagery and using band 2, 3 and 5 as well as the NDVI (Normalised Difference Vegetation Index). Later, burnt area is converted to a 1 kilometre by 1 kilometre grid. Burnt areas are labelled as 1 whereas non-burnt areas are labelled 0. By adding the burnt area grids, frequency of an area burnt is known. See Example 1.

Burnt areas in 2000

1	1	1
0	1	1
0	0	0

+

Burnt areas in 2001

0	0	1
0	1	1
0	1	1

=

Fire frequency from 2000 to 2001

1	1	2
0	2	2
0	1	1

Example 1. Calculation of fire frequency map

MODIS LAND PROCESSING SYSTEM AT DEPARTMENT OF LAND INFORMATION

Stefan Maier

Figure 6 shows an overview of the MODIS land processing system at Department of Land Information. Data received by the WASTAC receiver at Murdoch University and from other receiving stations in Australia is geometrically and radiometrically calibrated using the SeaDAS MODIS L1DB code and auxiliary data from NASA.

The calibrated, level 1 data (called L1b) then gets fed into the fire hotspot detection algorithm. This process provides fire locations as vector information as well as backdrop images to indicate cloud coverage and to highlight burnt areas. L1b data is also used by the Normalised Difference Vegetation Index (NDVI) generation subsystem. It generates NDVI composites from individual overpass NDVIs with a number of compositing periods and frequencies. These NDVI composites are used by a higher level product called pasture growth rate (PGR) which also uses meteorological information from the Bureau of Meteorology (BoM). NDVI composites are also used as input for the feed on offer (FOO) and crop map products.

In a different data stream level 2 (L2) cloud mask and atmospheric water vapour data sets are being generated and the reflective bands 1-7 are being atmospherically corrected.

The L2 cloud mask utilises an algorithm developed by Landgate-SRSS and is specifically tuned for the Australian continent.

The atmospheric water vapour retrieval is based on an algorithm which utilises the near infrared absorption of water vapour. This information is fed into the atmospheric correction module together with mean sea level pressure and stratospheric ozone data provided by BoM. An aerosol retrieval module is currently under development. The atmospheric correction module utilises the Simplified Method for Atmospheric Correction (SMAC).

Atmospherically corrected data is used by the flood mapping module, which generates maps of water inundated areas. It is also used by a module which determines the Bi-directional Reflectance Factor (BRF) for bands 1-5 and 7. The BRF describes the reflectance as a function of illumination and observation directions. In order to determine the BRF the last seven cloud free observations are being used by the BRF module. In the future the BRF information will be the input for modules for land cover classification and vegetation parameter retrieval.

With the BRF information from previous observations the reflectance factor for the observation geometry of the current observation is predicted. The difference between predicted and actual reflectance is stored as an intermediate product herein referred to as the reflectance change data set.

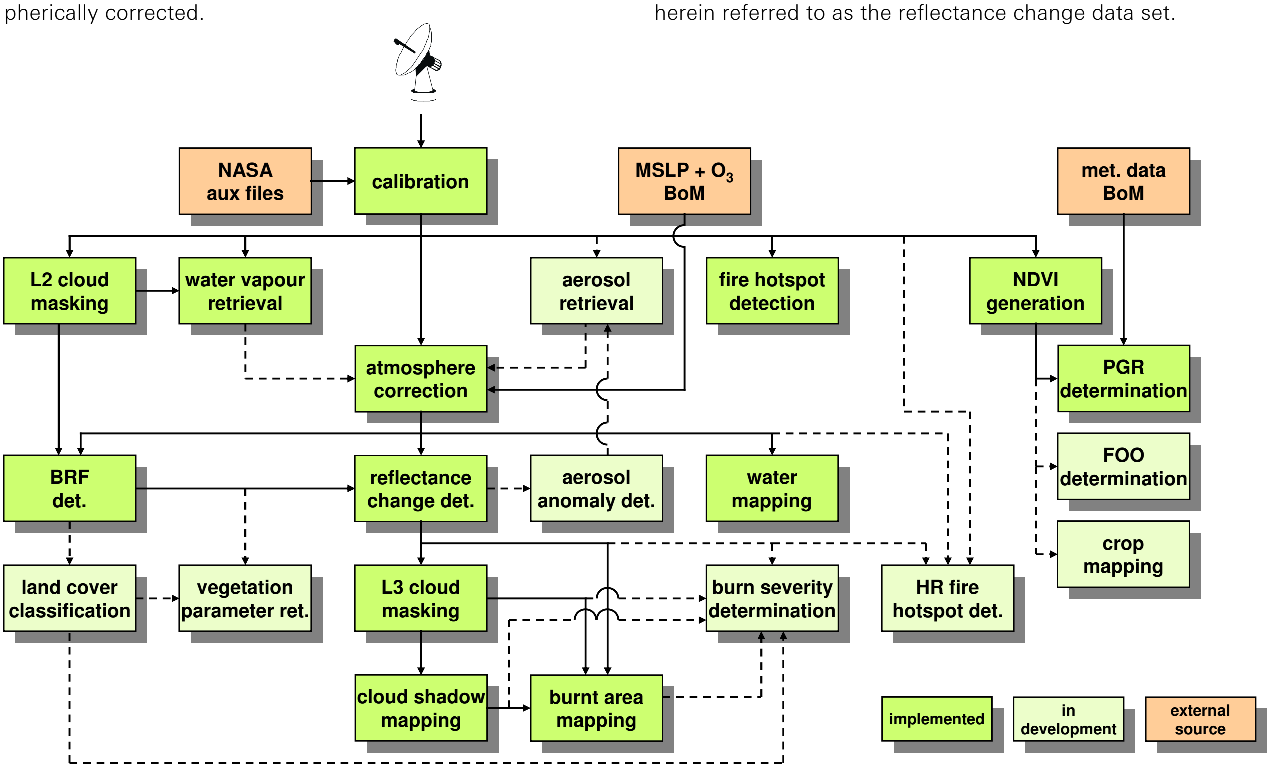


Figure 6: MODIS land processing system at Landgate

The reflectance change data is used by the level 3 (L3) cloud masking and the burnt area detection module. These modules utilise the fact that different changes on the ground or the atmosphere cause different changes in reflectance in different parts of the spectrum. The L3 cloud mask is much more accurate than the L2 cloud mask because it has *a priori* information about the surface reflectance available. This L3 cloud mask and the observation geometry are used to produce a map of possible cloud shadow affected areas. The possible cloud shadow maps are important for the burnt area detection module as cloud shadows have similar spectral properties as burnt areas.

The reflectance change data sets are also used by modules currently under development which generate aerosol anomaly maps, fire hotspot information at 500m resolution and burn severity maps.

VEGETATION WATCH 2006

Richard Smith

Comparison of the NDVI imagery of 2005 and 2006 from MODIS in Figure 7 clearly highlights the drought affected areas in south western Australia in mid August when the biomass of crops and pastures are usually near their maximum. The imagery is a Maximum Value composite of all MODIS overpasses from Terra and Aqua in the preceding week.

The very low level of green vegetation cover in August 2006 in south western Australia was a result of some of the lowest rainfall on record, while in the north and far west of Western Australia some of the highest rainfall ever was recorded. For example in the south west Geraldton had total rainfall of 197mm compared with the previous low of 225 mm in 1948. At Wyndham and Eucla in the North and far West the highest ever rainfalls of 1506 and 440mm were recorded in 2006 compared with previous highs of 1429 and 434mm in 1992 and 2000 respectively.

These NDVI products were used to generate Pasture Growth Rate (PGR) and Feed on Offer (FOO) for over 70 farms in southern Australia through Department of Land Information's Pastures from Space service. These products are also supplied to the Australian Government's National Agricultural Monitoring System (NAMS).

FEED ON OFFER (FOO) FROM MODIS NDVI

Richard Smith, Richard Stovold and Matthew Adams

During the early growth of Mediterranean annual pastures in southern Australia, farmers adopt grazing strategies aimed at carrying as many sheep as possible in this period. This is to ensure a high level of grass utilisation and hence profitability of wool production during the rest of the season. Knowledge of the dynamics of the Feed on Offer (FOO) in this period is important for these grazing strategies, but its measurement in near real-time is not easy, therefore satellite based techniques were investigated.

Cloud cover limited the near real-time use of Landsat and SPOT for estimating FOO from the Normalised Difference Vegetation Index (NDVI). The problem of cloud was overcome by using daily coverage of the MODIS sensor on the Terra and Aqua satellites at 250m (6.3ha) resolution. For paddocks over 10ha in size covering 98% of the area, mean paddock NDVI from MODIS was closely correlated (R^2 = 0.80) with that from SPOT. With average paddock sizes of 40ha, MODIS has 6 to 7 pixels per paddock.

Measures of MODIS NDVI at paddock scale (c. 40ha) were related by regression to visual estimates of FOO that were

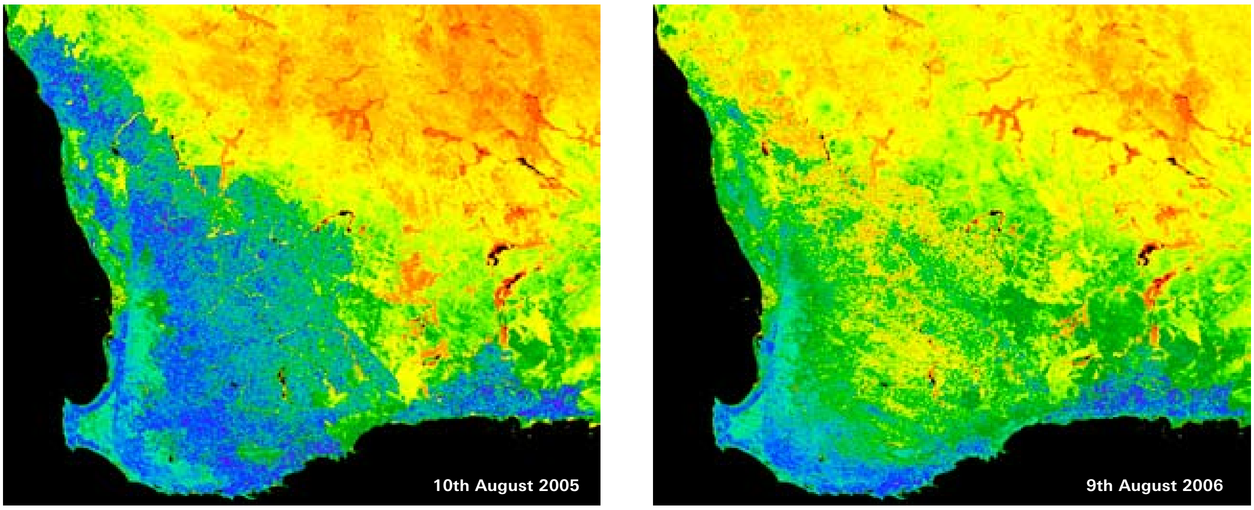
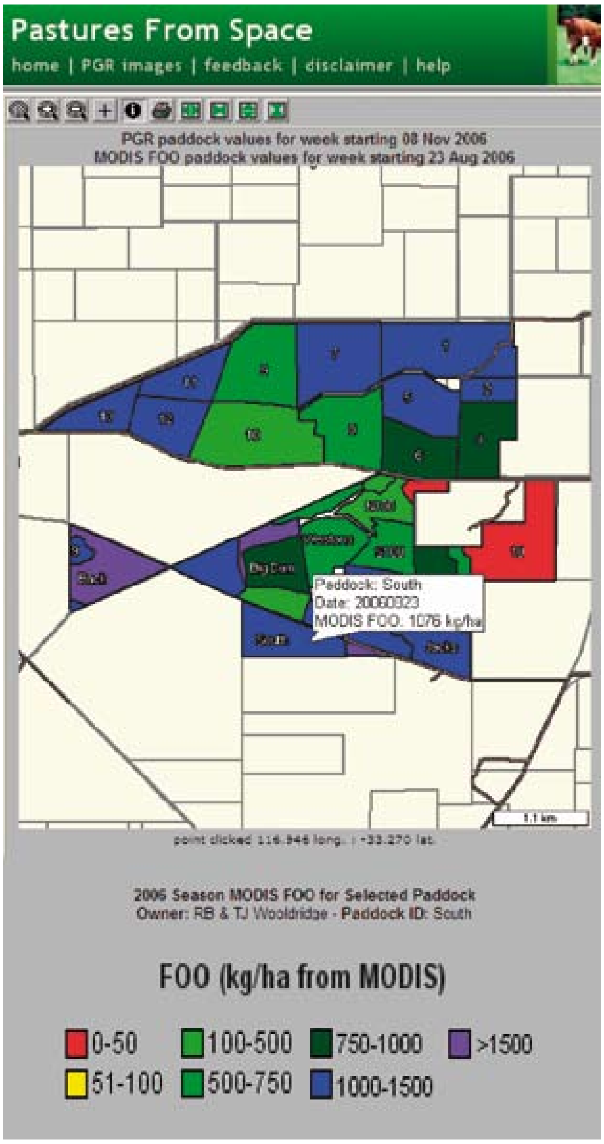


Figure 7: Comparison of the NDVI imagery of 2005 and 2006 from MODIS highlighting the drought affected areas in south western Australia in mid August when the biomass of crops and pastures are usually near their maximum

calibrated against 1m^2 cut and dried FOO samples. A predictive relationship derived in 2004 and early 2005 was tested in late 2005 and 2006 using 72 paddocks from eighteen farms distributed over the higher rainfall area of south-western Australia. Over all paddocks and farms visual FOO from 0 to 1500kg/ha was significantly related to MODIS NDVI during vegetative growth (R^2 = 0.71 to 0.75). For an individual farm this correlation often exceeded R^2 of 0.90. The MODIS NDVI saturates above a FOO of 1500 kg/ha which limits its predictive value to the critical period of early season grazing management.

The MODIS FOO predictions have apparent errors of ± 600kg/ha (P<.1) when compared to visual estimates. However it was concluded that much of this error would be associated with the visual estimation technique, NDVI atmospheric and cloud effects and the single relationship covering all farms. A survey of farmers given near real-time access to the information via the internet in 2006 indicated that the high apparent error did not invalidate the value of the information for their early season grazing decisions. Therefore the MODIS FOO product will be available through the Pastures from Space service while additional research continues to reduce error due to cloud and atmospheric effects on the NDVI.

Near real-time access to MODIS FOO predictions was made accessible to subscribing farmers (example in Figure 8) in 2006 using the Pastures from Space (PFS) Web Site (http://www.pasturesfromspace.csiro.au/) and to minimise bandwidth limitations Fairport Technologies provides their Pasture Watch Service (http://www.fairport.com.au/PastureWatch). The Fairport Pasture Watch Software enables farmers to automatically download an XML file of paddock PGR (Kg/ha/day) and FOO (kg/ha) from the PFS server via the internet to graphically display on their own Personal Computers.



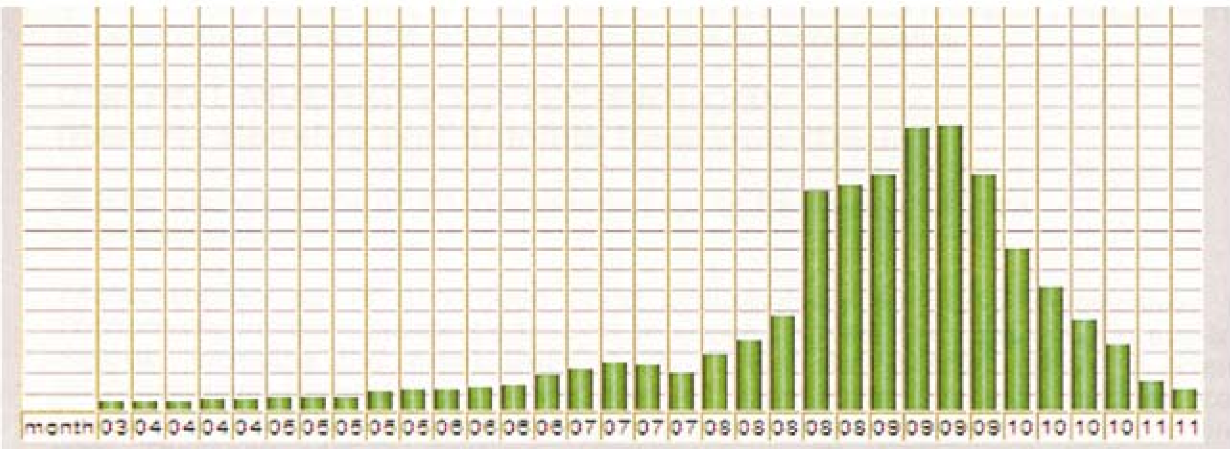


Figure 8: Example of MODIS FOO map of a farmers property for the week commencing 23rd August 2006(top) and the weekly FOO values for "South" paddock in graph format for the 2006 season.

Research Developments 2006

Investigations of new techniques for processing and applying satellite data are under way at Curtin University and DLI, and this section outlines some the research being undertaken to underpin and improve the operational products described earlier.

CURTIN UNIVERSITY OF TECHNOLOGY (Remote Sensing and Satellite Research Group)

MODIS OBSERVATIONS OF TRICHODESMIUM SP. IN EXMOUTH GULF, WA

Leon Majewski

Trichodesmium sp. is a nitrogen fixing cyanobacteria of global significance. Filaments of Trichodesmium are consistently present in water samples from tropical and sub-tropical ocean regions, including the north west shelf of Australia (NWS). When a great density of Trichodesmium filaments are present, they join together to form large, buoyant, colonies which (under calm conditions) float to the sea surface, and are observed as an extensive brown/red slick. The scale of these features, combined with the unique absorption and backscattering coefficients of Trichodesmium allow the presence of the cyanobacteria to be detected within sea surface reflectance imagery provided by SeaWiFS and MODIS.

By chance, a Trichodesmium bloom was encountered during a field experiment within Exmouth Gulf. The wind field and oceanographic conditions channelled the Trichodesmium into long rows, extending 1-10 m across and 10-100 m in length. These wind-rows of Trichodesmium were encountered for over 1 km along the cruise track.

A bio-optical model with a Trichoidesmium specific component was applied to MODIS-Aqua imagery obtained concomitant with the field survey (Figure 1). The algorithm detected high concentrations of Trichodesmium at the inshore location (where high concentrations were observed) but did not detect the low concentrations observed at the offshore site.

A more comprehensive observation regime is required to determine the effectiveness of the algorithm as well as the frequency and extent of bloom events along the NWS.

BIO-OPTICAL PROPERTIES OF THE NORTH WEST SHELF, WA

Leon Majewski and Robyn Conmy[1]

[1] College of Marine Science, University of South Florida, USA

In June/July 2003 a multidisciplinary ocean research voyage was undertaken on the North West Shelf, WA (NWS). The voyage (WHOI-VANC11, Figure. 2) investigated the physical properties and oceanographic processes present on the continental slope and shelf. Additionally, biological and optical properties were measured opportunistically.

High Performance Liquid Chromatography (HPLC) measurements of phytoplankton pigments indicate that the offshore community is dominated by pico- and nano-phytoplankton. Measurements of phytoplankton and CDOM absorption demonstrate that CDOM is the major light absorbing constituent present in offshore waters. Analysis of CDOM fluorescence spectra indicate that CDOM present in offshore waters has characteristics of new CDOM, while CDOM present in inshore waters has undergone photo-bleaching.

Underway subsurface measurements (obtained through the use of a towed, undulating, vehicle) show that in 88% of measurements the deep chlorophyll maximum (DCM) occurred between 40-90 m with an average depth of 67 m (±12 m), far below the depths that contribute to the remotely sensed reflectance. Thus, estimates of column integrated chlorophyll-a derived from remotely sensed products (assuming a uniform profile) are likely to underestimate the measured value by 10-20%.

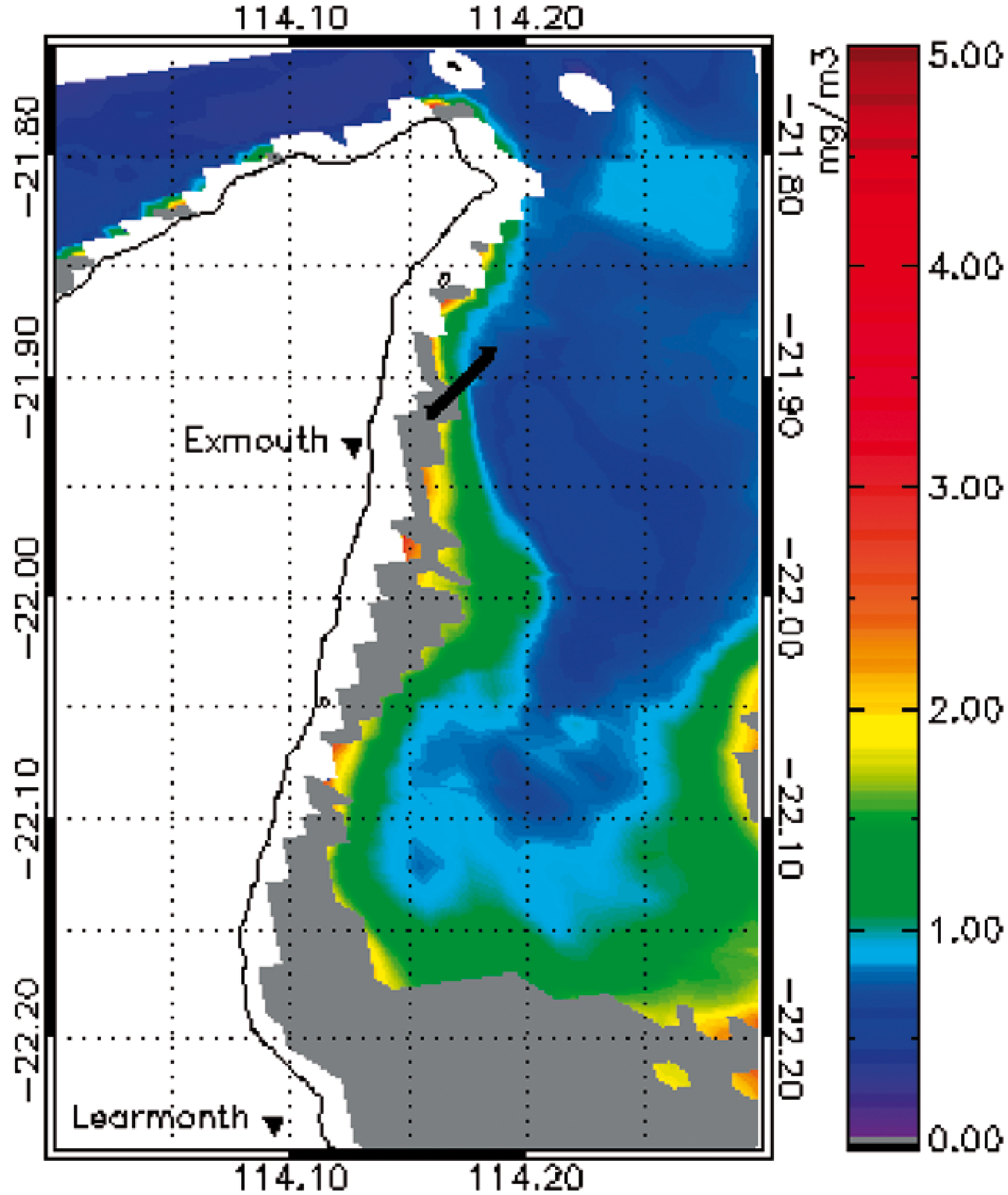


Figure 1: MODIS-Aqua chlorophyll a product (mg Chl a m^{-3}) for 22/4/2006 with positive Trichodesmium retrievals overlaid (grey blotches). Field measurements were undertaken along the cruise path which extended offshore (from high concentrations to low concentrations).

MAPPING KEY BENTHIC COVER TYPES FROM HYPERSPECTRAL IMAGERY

Wojciech Klonowski, Peter Fearns, and Mervyn Lynch

The spatial distribution of benthic cover in coastal waters is of key importance in managing and monitoring our coastal water environments. Currently very little of the Western Australian shallow coastal water habitats are mapped, and for those maps that do exist, the spatial resolution is poor and the information is dated. Aircraft and space-borne hyperspectral sensors have been shown to be useful in imaging substrate features in shallow coastal waters.

This study explores a method for quantitatively estimating benthic cover in shallow waters from hyperspectral imagery. The method incorporates a shallow water reflectance model which accounts for the water column absorption and backscattering, water depth and substrate reflectance. The model was tested against simulated reflectance data (Hydrolight), demonstrating the model's ability to retrieve appropriate fractional coverage of sand, green seagrass and brown algae for depths ranging from 1m - 12m. The model was applied to a HyMap image encompassing a portion of the Jurien Bay Marine Park off the coast of Western Australia. The retrieved benthic cover products were compared to under-water video observations sampled within the image scene. The comparison results show the method's great potential for classifying key benthic cover types from remotely sensed hyperspectral data.

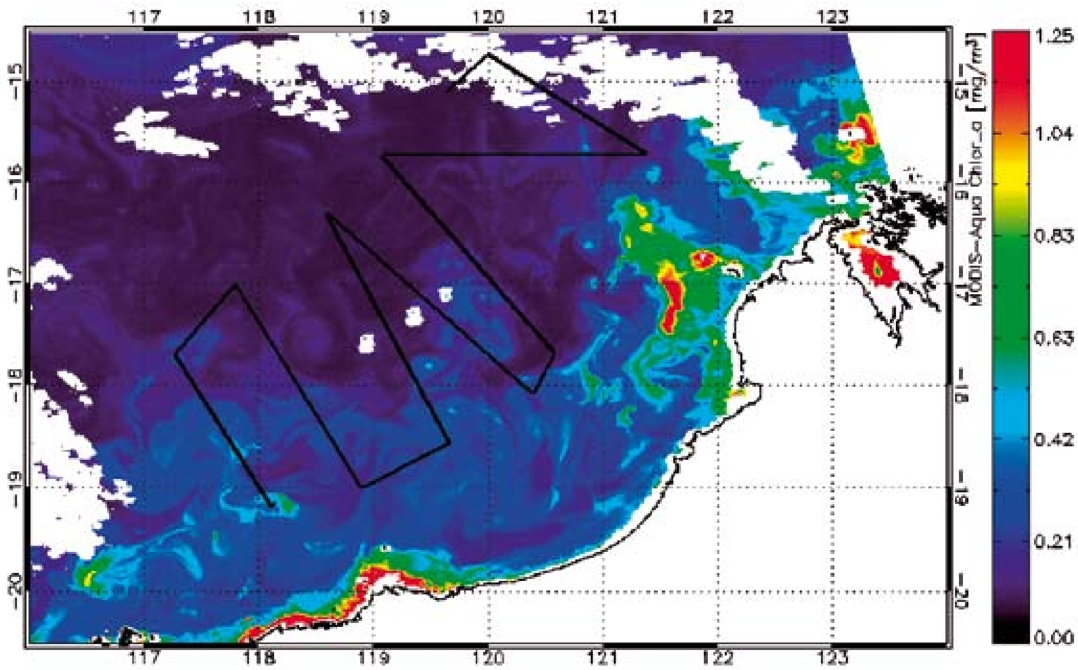


Figure 2: Cruise track of WHOI-VANC11 overlaid on MODIS-Aqua chlorophyll a product (mg Chl a m^{-3}) for 10/7/2003.

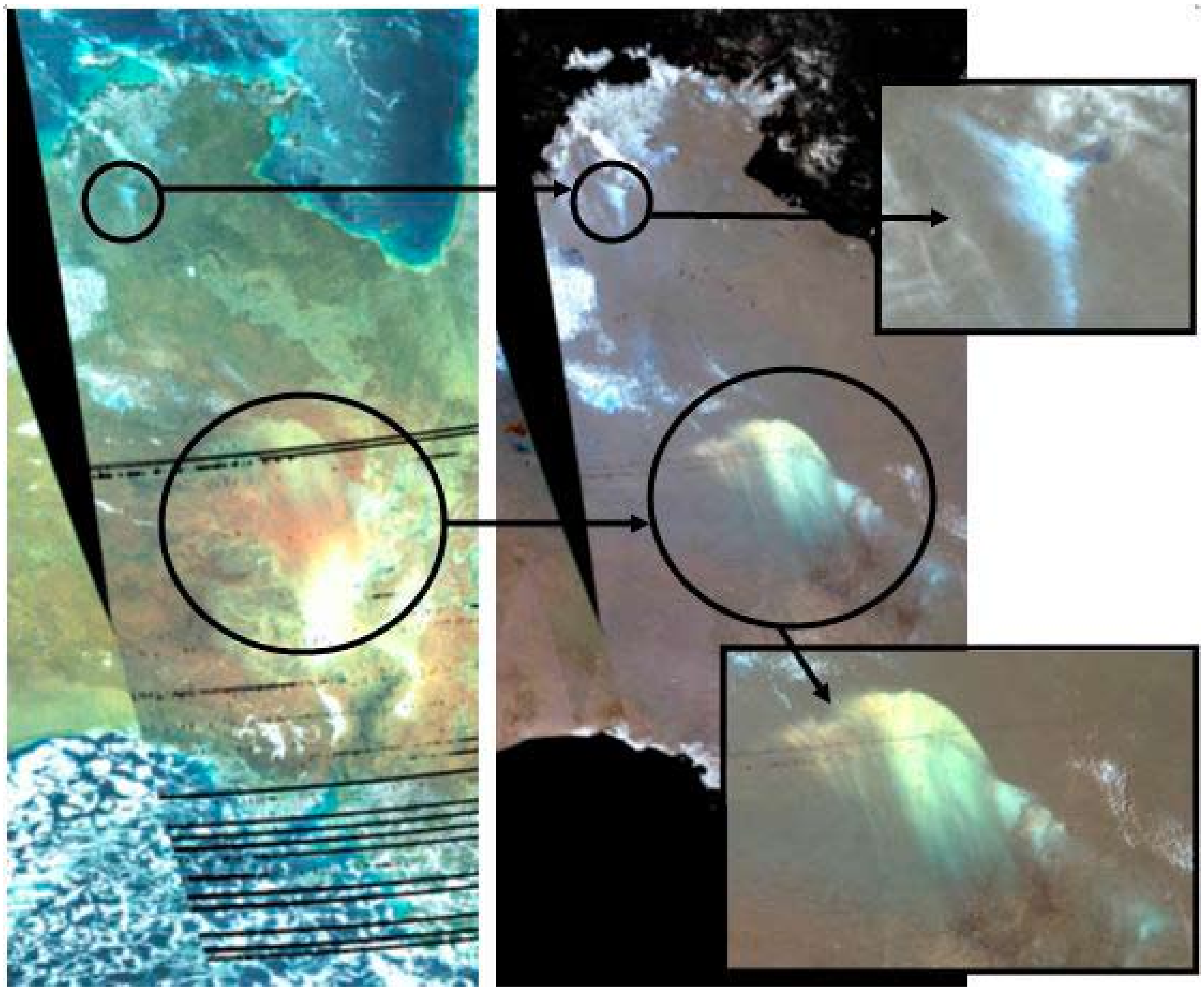


Figure 3: MODIS Aqua Reflectance RGB comprised of bands 1,4,3 respectively (left) and Reflectance change RGB comprised of bands 1,4,3 respectively (right and insets) for the 24th of September, 2006.

AEROSOL OPTICAL DEPTH RETRIEVAL USING TIME-SERIES BI-DIRECTIONAL REFLECTANCE FACTOR DATA FOR NEAR REAL-TIME ATMOSPHERIC CORRECTION OF MODIS REFLECTANCE DATA

Mark Broomhall, Brendon McAtee, Stefan Maier

The images in Figure 3 show a very large dust storm in central Australia and smoke from significant biomass burning in northern Australia. While these features are clearly visible in the reflectance image, they really stand out in the reflectance change in MODIS bands 1,4 and 3. These bands in the reflectance change images show not only the large dust and smoke plumes within the circles and inset areas but hazy areas within the images that are not clearly visible in the reflectance image. The hazy appearance is due to aerosol loading within the atmosphere.

The reflectance change is determined using time-series Bidirectional Reflectance Factor (BRF) data and current observational data. BRF is used to compensate for the apparent change in reflectance due to the variation of position of the sun and the satellite between scans. This effect can be seen in the reflectance image in Figure 3 which shows 2 scans from MODIS Aqua which were performed 2 hours apart. The BRF requires at least 7 scans over a particular area in a 14 day period to construct. This is a running process with data used coming from the previous 14-day period so that new observations are included and old observations are removed from the determination. Once the BRF is constructed, predictions can be made as to the apparent reflectance for the next MODIS scan.

The reflectance change is determined by comparing the forward-predicted apparent reflectance and the actual reflectance observed for the current MODIS scan. The signal received at the satellite is due to light reflected from the surface and scattered by the atmosphere. If the atmosphere or surface changes significantly from the conditions over which the BRF was constructed for the current MODIS scan, then a reflectance change will be identified.

Using different MODIS bands it is possible to identify where the reflectance changes have taken place, either on the surface or in the atmosphere. The surface reflectance in MODIS band 3 and 8 is generally very low and changes to the surface, such as removing vegetation, do not change the reflectance in this band appreciably. Conversely, the type and amount of aerosol in the atmosphere produces large changes in the amount of scatter in these bands. The effect of atmospheric aerosols decreases as the wavelength of light decreases to the point where it is almost non-existent in the infrared region.

Radiative transfer modelling of the reflectance change process is being undertaken to identify a scheme to extract information on the aerosol loading of the atmosphere. This will produce modelled reflectance change data for particular sets of parameters which will mimic the actual parameters at the time of the scan by the MODIS sensor. These will include apparent reflectance, view and solar zenith angles, relative azimuth between the sun and sensor, and the average aerosol conditions.

The plots in Figure 4 show the modelled reflectance change for such a set of parameters. Each graph included 8 plots of modelled change in reflectance for a change in the Optical Depth (OD) at 550 nm. The primary input to the radiative transfer program for altering the OD, and thus the Aerosol Optical Depth (AOD) across the visible spectrum is the OD at 550 nm. The OD at other parts of the spectrum is scaled to this value.

The plots are scaled integers and show the reflectance change from an original plot with OD of (In_τ). The changes in OD from this original value are shown for each plot by (Δτ). The plots show how the reflectance change varies over the relative azimuth angle for set values of apparent surface reflectance (ρ), solar zenith angle (Θ_s) and view zenith angle (Θ_s).

The data used to produce Figure 4 are for a rural aerosol model. The same approach is used to produce data for dust and smoke models to capture a majority of the expected atmospheric conditions over the Australian continent.

It is hoped that this work will progress in 2007 to the level where it can be used to extract AOD information for use in the atmospheric correction of MODIS data. This process is designed to be able to work over bright surfaces where the NASA-derived aerosol extraction algorithms are either unreliable or fail completely.

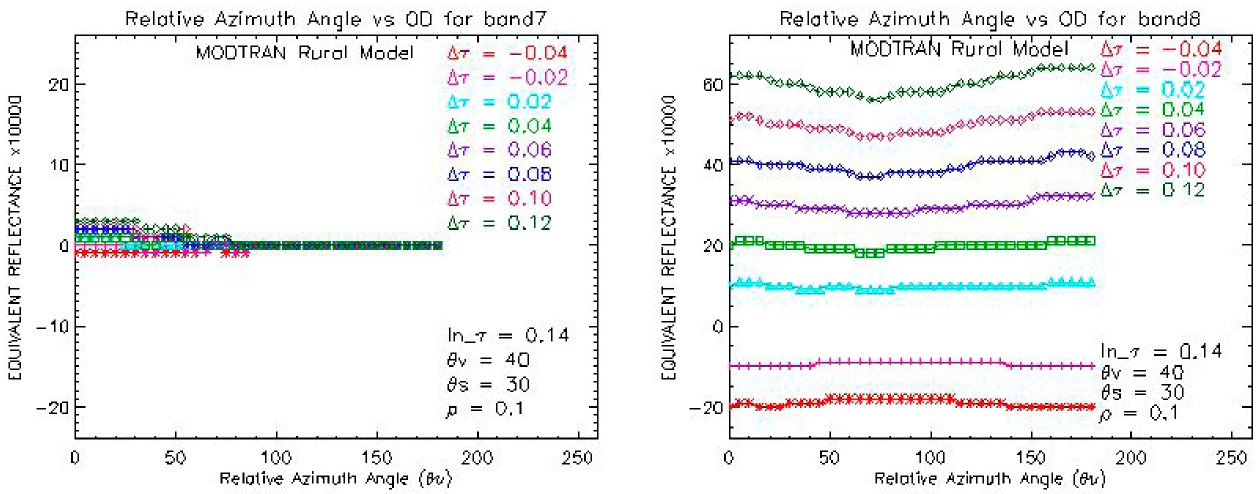


Figure 4: Reflectance change plots for bands 7 and 8 of MODIS. These plots are the result of comparing the band averaged reflectance output from MODTRAN for various Optical Depths (OD). In the plots In_τ and Δτ are OD's or change in OD at 550 nm as this is the wavelength used to specify OD in MODTRAN. In the plots the band averaged figures for an optical depth of In_τ are used to determine the change in reflectance for other OD's.

HIGHER RESOLUTION FIRE DETECTION FROM MODIS

Florian Goessmann

Algorithms to detect active fires from MODIS traditionally utilised channels working in the thermal range of the electromagnetic spectrum. On MODIS, those channels are available at 1 km resolution (nadir).

In continuation of the work commenced in 2005, a new algorithm based on the 2.1 micron channel of MODIS which is available at 500 m resolution was developed. The new algorithm was successfully applied to MODIS observations of Australia.

Figure 5 shows fire detections of three different detection methods applied to fire complex in northern Australia in 2004. It shows high resolution fire detections from ASTER, fire detections of the standard MODIS fire product MOD14 and the detections of the new algorithm. This figure illustrates the capabilities and limitations of the new algorithm in comparison to MOD14. Due to physical properties, the new algorithm is capable of providing more detailed spatial information of intense fire complexes but fails to detect smaller fires.

The combination of MOD14 and the new algorithm, however, can potentially provide fire management authorities with more detailed information without compromising MODIS coverage and revisit rate.

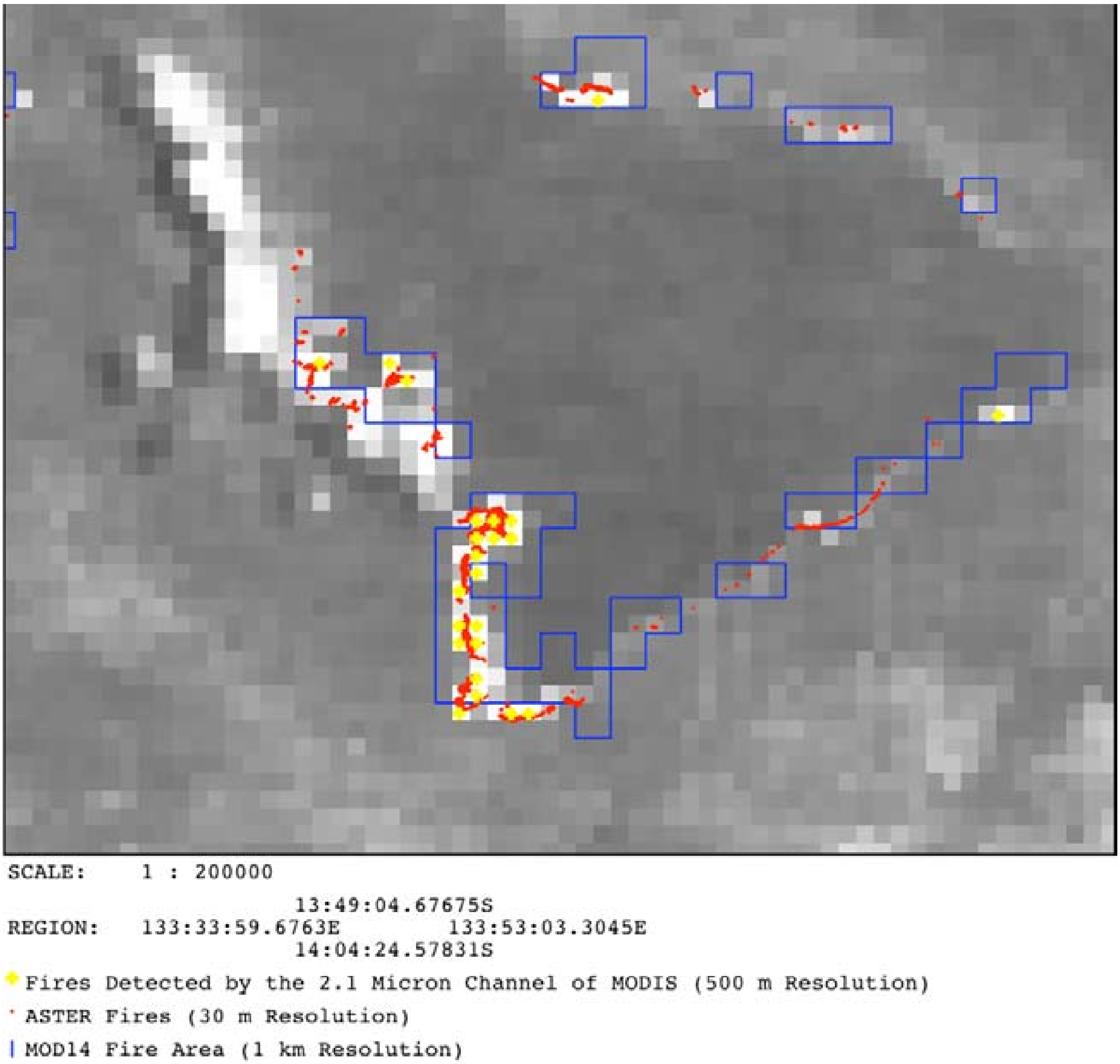


Figure 5: Fire detections of three different detection methods applied to fire complex in northern Australia in 2004.

DEPARTMENT OF LAND INFORMATION

(Satellite Remote Sensing Services)

VALIDATION OF THE MODIS ATMOSPHERICALLY CORRECTED SURFACE REFLECTANCE (MOD09) PRODUCT

Brendon McAtee

In situ surface reflectance data for validating the NASA MOD09 algorithm for the atmospheric correction of spectral surface reflectance data from MODIS were acquired at a field site in Merredin using an Analytical Spectral Devices (ASD) field spectrometer. Figure 1 shows that there is good agreement between the in situ and remotely sensed data. Table 1 shows that in the majority of cases the MOD09 algorithm is performing within the theoretical limits specified in the Algorithm Theoretical Basis Document for MOD09 (Vermote and Vermeulen, 1999). This analysis will be extended to include the near-real time algorithm for atmospheric correction used by Landgate Satellite Remote Sensing Services in the near future.

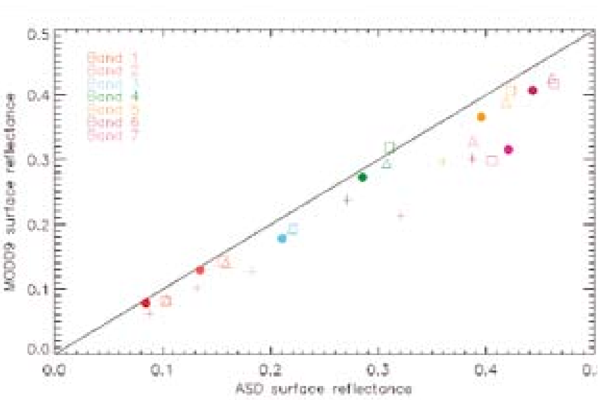


Figure 1: MOD09 validation results.

Table 1: Comparison of Merredin validation results with theoretical limits presented in the MOD09 ATBD.

Band	MOD09 ATBD	Merredin Experiment
1	10-33 %	30%
2	3-6 %	7 %
3	50-80 %	11 %
4	5-12 %	11 %
5	3-7 %	9 %
6	2-8 %	8 %
7	2-8 %	5 %

REFERENCES

Vermote, E. and A. Vermeulen (1999). *"Atmospheric Correction Algorithm: Spectral Reflectances (MOD09)." MODIS Algorithm Technical Background Document Version 4.0, Department of Geography, University of Maryland, USA.*

MTSAT COMPLEMENTS MODIS FOR NEAR – REAL TIME SURFACE WATER MAPPING.

Andrew Buchanan, Mario Ferri and John Adams

MODIS data (via the WASTAC consortium) is being routinely used by Department of Land Information's Satellite Remote Sensing Services (SRSS) section for mapping surface water across Australia (Figure 3). MODIS Terra and Aqua sensors provide morning and afternoon coverage at 250m spatial resolution in the visible red and infrared spectral bands. If cloud obscures visual identification of the land surface on one of these MODIS passes then the user may have from three to twelve hours before another look becomes available. The MTSAT_1R geostationary satellite, which is used extensively within the Bureau of Meteorology to assist in real time weather analysis and forecasting, provides hourly updates of the entire surface of Australia in the visible red portion of the spectrum at 1km spatial resolution. SRSS is now using MTSAT-1R data (Figure 2) in their surface water mapping project (FloodMap) to complement the MODIS Terra and Aqua sensors for this reason. The MTSAT_1R serves as a visual aid to target extensive flooding where cloud cover permits surface water mapping.

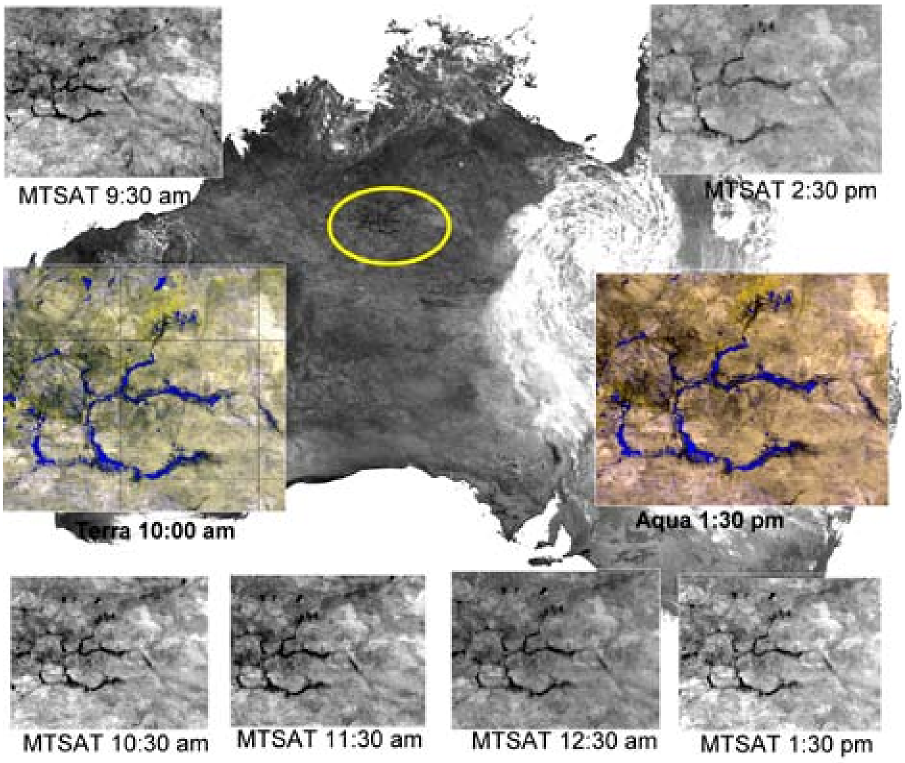


Figure 2: Flooding in central Australia as seen from the MTSAT geostationary satellite and the MODIS Terra and Aqua sensors. Insets show the multiple looks that MTSAT provides at 1km spatial resolution

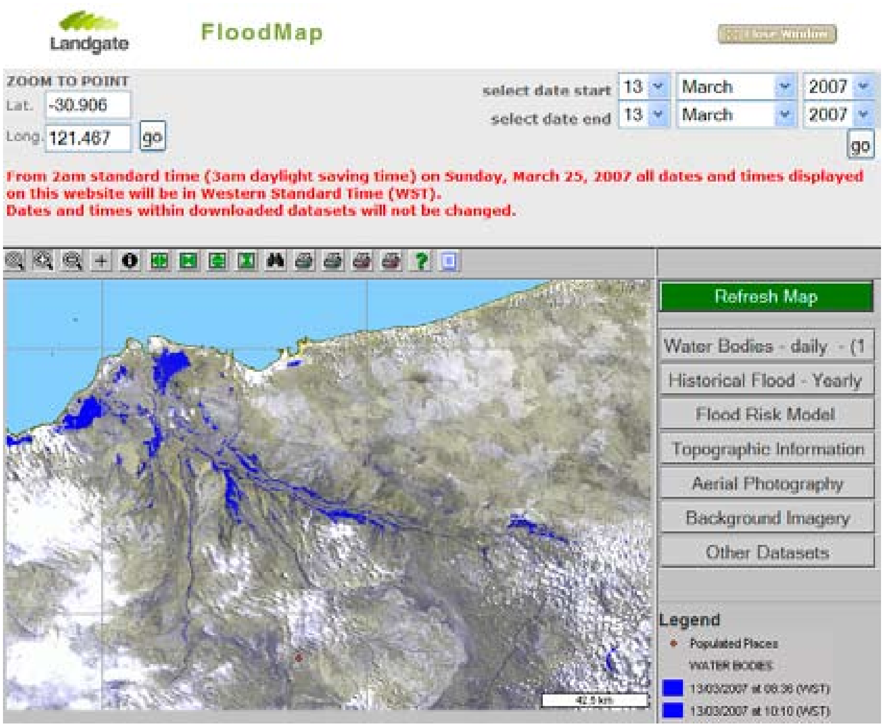


Figure 3: An example of the automated surface water mapping as seen through the FloodMap webpage.

WASTAC

Financial Statements 2005-2006

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WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM L BAND

INDEPENDENT AUDITOR'S REPORT

We have audited the attached financial statements for the year ended 31st December 2006 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 31st December 2006 and associated cash flows The statements are based on proper accounts and records

STAN PALASSIS
Managing Partner
Stamfords Advisors Consultants

14th May 2007

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WASTAC L - BAND BUDGET 2007

ESTIMATED EXPENDITURE FOR THE YEAR JANUARY 2007 – DECEMBER 2007

		PER ANNUM $ 2006	PER ANNUM $ 2007
1.	Telstra Rental	4000	4000
2.	Data Tapes	2000	2000
3.	System maintenance/repairs	112000	90,000
4.	Telecommunications licence of facility	1500	1500
5.	Consultants	2000	57,000
6.	Sundry consumables	1500	1500
7.	Travelling – Airfares	3000	3000
8.	Provision for major equipment	12000	12000
9.	Annual Report	10000	10000
	TOTAL:	**$148,000**	**$181,000**

ESTIMATED INCOME/REVENUE FOR THE YEAR JANUARY 2007– DECEMBER 2007

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

EXTRA-ORDINARY EXPENDITURE JANUARY 2007 – DECEMBER 2008

1.	Capital Reserve:		
1.1	Antenna replacement and componentry	80,000	
1.2	iVEC phase2 implementation		30,000
	TOTAL:	**$80,000**	**$30,000**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM L BAND INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2006

	2006 $	2005 $
REVENUE		
Contributions Received	50,000	30,000
Interest Received	13,319	10,824
TOTAL REVENUE	**63,319**	**40,824**
EXPENDITURE		
Outsourced Work	3,200	-
Telephone Rent & Calls	965	4,311
Service and Equipment Charges	-	1,608
Microwave Licenses	-	1,685
Freight Costs	737	-
Network Software/Licence	976	-
Computer Maintenance Costs	-	334
Application Software	-	5,578
External Printing Costs	6,550	6,694
Other Consumables	-	1,032
Other Equipment Maintenance	45,991	-
Depreciation Expenses	2,112	2,105
TOTAL EXPENDITURE	**60,531**	**23,347**
NET OPERATING RESULT FOR THE YEAR	**2,788**	**17,477**

James Lindsay
Deputy Chief Financial Officer
Financial Services

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM BALANCE SHEET AS AT 31 DECEMBER 2006

	NOTE	2006 $	2005 $
CURRENT ASSETS			
Cash at Bank		315,002	262,868
TOTAL CURRENT ASSETS		**315,002**	**262,868**
NON - CURRENT ASSETS			
Property, plant and equipment	2	9,050	11,162
TOTAL NON - CURRENT ASSETS		**9,050**	**11,162**
TOTAL ASSETS		**324,051**	**274,030**
CURRENT LIABILITIES			
Accrued expenses		48,216	982
TOTAL CURRENT LIABILITIES		**48,216**	**982**
TOTAL LIABILITIES		**48,216**	**982**
NET ASSETS		**275,836**	**273,048**
EQUITY			
Retained Funds	4	275,836	273,048
TOTAL EQUITY		**275,836**	**273,048**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM
L - BAND CASH FLOW STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2006

CASH FLOWS FROM OPERATING ACTIVITIES	NOTE	2006 $	2005$
Receipts			
Contributions Received:			
Department of Land Information		10,000	10,000
CSIRO		10,000	10,000
Bureau of Meteorology		10,000	10,000
Curtin University of Technology for 2005		10,000	
Curtin University of Technology for 2006		10,000	
Interest Received		13,319	10,824
TOTAL RECEIPTS		**63,319**	**40,824**
Payments			
Payments to suppliers		(11,186)	(20,260)
Total Payments		(11,186)	(20,260)
Net cash provided by operating activities	3	**52,133**	**20,564**
CASH FLOWS FROM INVESTING ACTIVITIES			
Payments for property, plant and equipment		-	-
Net cash used in investing activities		-	-
Net increase/(decrease) in cash		52,133	20,564
Cash at the beginning of the year		262,868	242,304
Cash at the end of the year		**315,002**	**262,868**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM
L - BAND NOTES TO THE FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2006

1 SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

The principal accounting policies adopted in the preparation of the financial report are set out below. These policies have been consistently applied to all the years presented unless otherwise stated.

(A) BASIS OF PREPARATION

The Western Australian Satellite Technology and Application Consortium (WASTAC) financial report has been prepared in accordance with Australian equivalents to International Financial Reporting Standards (IFRS), other authoritative pronouncements of the Australian Accounting Standards Board and Urgent Issues Group Consensus Views.

COMPLIANCE WITH AIFRS

Australian Accounting Standards include Australian equivalents to International Financial Reporting Standards (AIFRS). Compliance with AIFRS ensures that the financial statements and notes comply with IFRS.

HISTORICAL COST CONVENTION

These financial statements have been prepared on the accrual basis of accounting using the historical cost convention.

(B) ACQUISITION AND DISPOSAL OF ASSETS

"In accordance with AASB 116 ""Property, Plant & Equipment"", all property, plant and equipment is shown at cost, less subsequent depreciation and impairment. Cost includes expenditure that is directly attributable to the acquisition of the items. Subsequent costs are included in the asset carrying amount or recognised as a separate asset, as appropriate, only when it is probable that future economic benefits associated with the item will flow to the entity and the cost of the item can be measured reliably.

All other repairs and maintenance expenditures are charged to the Income Statement during the financial period in which they are incurred.

Gains and losses on disposals are determined by comparing the disposal proceeds with the carrying amount and are included in the Income Statement."

(C) DEPRECIATION OF NON-CURRENT ASSETS

All non-current assets having a limited useful life are depreciated or amortised over their estimated useful lives, in a manner which reflects the consumption of their future economic benefits.

Depreciation is calculated on a straight-line basis from the time the asset becomes available for use. Estimated useful lives are as follows:

- Computing equipment 3 years
- Other equipment 8 years

"Assets' residual values and useful lives are reviewed, and adjusted if appropriate, at each balance sheet date.

A class of asset's carrying amount is written down immediately to its recoverable amount if the class of asset's carrying amount is greater than its estimated recoverable amount (see note 1(d))."

(D) IMPAIRMENT OF PROPERTY, PLANT AND EQUIPMENT

In accordance with AASB 136 "Impairment of Assets", at each reporting date, WASTAC reviews the carrying amounts of each class of asset within property, plant and equipment to determine whether there is any indication that those asset classes have suffered an impairment loss. If any such indication exists, the recoverable amount of the class of asset is estimated in order to determine the extent of the impairment loss. Where the asset does not generate cash flows that are independent from other assets, WASTAC estimates the recoverable amount of the cash-generating unit to which the asset belongs.

Recoverable amount is the higher of fair value less costs to sell and value in use. In assessing value in use, the depreciated replacement cost is used where the future economic benefits of WASTAC's assets are not primarily dependent on the assets' ability to generate net cash inflows.

If the recoverable amount of a class of asset is estimated to be less than its carrying amount, the carrying amount is reduced to recoverable amount. An impairment loss is recognised as an expense to the Income Statement immediately.

2 PROPERTY, PLANT AND EQUIPMENT

	2006	2005
COMPUTER EQUIPMENT		
At cost	121,222	121,222
Accumulated depreciation	(121,222)	(121,222)
	-	-
OTHER EQUIPMENT		
At cost	190,258	190,258
Accumulated depreciation	(181,208)	(179,096)
	9,050	11,162
Total Property, Plant and Equipment	**9,050**	**11,162**

RECONCILIATIONS

Reconciliations of the carrying amounts of property, plant and equipment at the beginning and end of the current financial year are set out below:

	COMPUTER EQUIPMENT	OTHER EQUIPMENT	TOTAL
Carrying amount at start of year	-	11,162	11,162
Additions	-	-	-
Depreciation expense	-	(2,112)	(2,112)
CARRYING AMOUNT AT END OF YEAR	**-**	**9,050**	**9,050**

3 NOTES TO THE CASH FLOW STATEMENT

Reconciliation of operating result from ordinary activities to net cash inflow from operating activities

	2006	2005
Net operating result	2,788	17,477
Depreciation expense	2,112	2,112
Movement in Current Liabilities	47,234	982
NET CASH PROVIDED BY OPERATING ACTIVITIES	**52,134**	**20,571**

4 RETAINED EARNINGS

Balance at beginning of the year	273,048	255,571
Operating surplus/(deficit) for the year	2,788	17,477
BALANCE AT END OF THE YEAR	**275,836**	**273,048**

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WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM X BAND

INDEPENDENT AUDITOR'S REPORT

We have audited the attached financial statements for the year ended 31st December 2006 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 31st December 2006 and associated cash flows The statements are based on proper accounts and records

STAN PALASSIS
Managing Partner
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14th May 2007

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WASTAC X - BAND BUDGET 2007

ESTIMATED EXPENDITURE FOR THE YEAR JANUARY 2007 – DECEMBER 2007

		$ PER ANNUM 2007	$ PER ANNUM 2006
1.	Data Tapes	3,000	3,000
2.	System maintenance	35,000	15,000
3.	System repairs	4,000	4,000
4.	Consultants, product development	20,000	20,000
5.	Sundry consumables	2,000	2,000
6.	Travelling – Airfares	8,000	8,000
7.	Provision for major equipment, plus with holding payment to SeaSpace $31,815 exc GST (2006 only)	52,000	60,000
	TOTAL:	**$124,000**	**$112,000**

ESTIMATED INCOME/REVENUE FOR THE YEAR JANUARY 2007 – DECEMBER 2007

1.	Annual Contributions $20,000 each	80,000	80,000
2.	Interest	6,000	6,000
	TOTAL INCOME:	**$86,000**	**$86,000**

ADDITIONAL COMMITTED EXPENDITURE JANUARY 2008– DECEMBER 2009

1.	Receiver upgrade for NPP/NPOESS satellites	80,000	80,000
	TOTAL:	**$80,000**	**$80,00**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM
X - BAND INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2006

	2006	2005
	$	$
REVENUE		
Contributions Received	80,000	70,000
Interest Received	9,955	10,213
TOTAL REVENUE	**89,955**	**80,213**
EXPENDITURE		
Outsourced Work	-	-
Hospitality	204	-
Visiting Specialist	-	-
Travel	-	-
Microwave Licenses	56	-
Venue Hire	-	-
Insurance Premium	-	2,205
Maintenance	-	12,620
Computer Equipment Purchase	-	-
Meeting Expenses	300	
External Printing Costs	-	2,650
IDM Media Costs	-	2,700
Other Consumables	-	709
Refund (cancellation of insurance policy)	(828)	-
Depreciation	102,308	157,437
TOTAL EXPENDITURE	**102,040**	**178,321**
NET OPERATING RESULT FOR THE YEAR	**(12,085)**	**(98,108)**

James Lindsay
Deputy Chief Financial Officer
Financial Services

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM X - BAND BALANCE SHEET AS AT 31 DECEMBER 2006

	NOTE	2006	2005
		$	$
CURRENT ASSETS			
Cash at Bank		234,715	167,554
TOTAL CURRENT ASSETS		**234,715**	**167,554**
NON-CURRENT ASSETS			
Property, plant and equipment	2	294,125	373,371
TOTAL NON-CURRENT ASSETS		**294,125**	**373,371**
TOTAL ASSETS		**528,840**	**540,925**
TOTAL LIABILITIES		-	-
NET ASSETS		**528,840**	**540,925**
EQUITY			
Retained Funds	4	528,840	540,925
TOTAL EQUITY		**528,840**	**540,925**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM X - BAND CASH FLOW STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2006

	NOTE	2006	2005
CASH FLOWS FROM OPERATING ACTIVITIES		$	$
RECEIPTS			
Contributions Received:			
Department of Land Information		20,000	20,000
CSIRO		20,000	20,000
Bureau of Meteorology		20,000	10,000
Geoscience Australia		20,000	20,000
Interest Received		9,955	10,213
TOTAL RECEIPTS		**89,955**	**80,213**
PAYMENTS			
Payments to suppliers		268	(20,884)
TOTAL PAYMENTS		**268**	**(20,884)**
NET CASH PROVIDED BY OPERATING ACTIVITIES	3	**90,223**	**59,329**
CASH FLOWS FROM INVESTING ACTIVITIES			
Payments for property, plant and equipment		(23,062)	(113,883)
NET CASH USED IN INVESTING ACTIVITIES		**(23,062)**	**(113,883)**
NET INCREASE/(DECREASE) IN CASH		**67,161**	**(54,554)**
Cash at the beginning of the year		167,554	222,108
CASH AT THE END OF THE YEAR		**234,715**	**167,554**

1 SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

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- Computing equipment 3 years
- Other equipment 8 years

"Assets' residual values and useful lives are reviewed, and adjusted if appropriate, at each balance sheet date.

A class of asset's carrying amount is written down immediately to its recoverable amount if the class of asset's carrying amount is greater than its estimated recoverable amount (see note 1(d))."

(D) IMPAIRMENT OF PROPERTY, PLANT AND EQUIPMENT

In accordance with AASB 136 "Impairment of Assets", at each reporting date, WASTAC reviews the carrying amounts of each class of asset within property, plant and equipment to determine whether there is any indication that those asset classes have suffered an impairment loss. If any such indication exists, the recoverable amount of the class of asset is estimated in order to determine the extent of the impairment loss. Where the asset does not generate cash flows that are independent from other assets, WASTAC estimates the recoverable amount of the cash-generating unit to which the asset belongs.

Recoverable amount is the higher of fair value less costs to sell and value in use. In assessing value in use, the depreciated replacement cost is used where the future economic benefits of WASTAC's assets are not primarily dependent on the assets ability to generate net cash inflows.

If the recoverable amount of a class of asset is estimated to be less than its carrying amount, the carrying amount is reduced to recoverable amount. An impairment loss is recognised as an expense to the Income Statement immediately.

2 PROPERTY, PLANT AND EQUIPMENT

	2006	2005
COMPUTER EQUIPMENT		
At cost	41,373	41,373
Accumulated depreciation	(28,487)	(15,080)
	12,886	26,293
OTHER EQUIPMENT		
Equipment - work in progress		
At cost		
Accumulated depreciation		
	281,239	347,078
TOTAL PROPERTY, PLANT AND EQUIPMENT	**294,125**	**373,371**

RECONCILIATIONS

Reconciliations of the carrying amounts of property, plant and equipment at the beginning and end of the current financial year are set out below:

	COMPUTER EQUIPMENT	OTHER EQUIPMENT	TOTAL
CARRYING AMOUNT AT START OF YEAR	26,293	347,078	373,371
Additions	-	23,062	23,062
Depreciation expense	(13,407)	(88,901)	(102,308)
CARRYING AMOUNT AT END OF YEAR	**12,886**	**281,239**	**294,125**

3 NOTES TO THE CASH FLOW STATEMENT

Reconciliation of operating result from ordinary activities to net cash inflow from operating activities

	2006	2005
Net operating result	(12,085)	(98,108)
Depreciation expense	102,308	157,437
NET CASH PROVIDED BY OPERATING ACTIVITIES	**90,223**	**59,329**

4 RETAINED EARNINGS

Balance at beginning of the year	540,925	639,032
Operating surplus/(deficit) for the year	(12,085)	(98,108)
BALANCE AT END OF THE YEAR	**528,840**	**540,925**

WASTAC

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