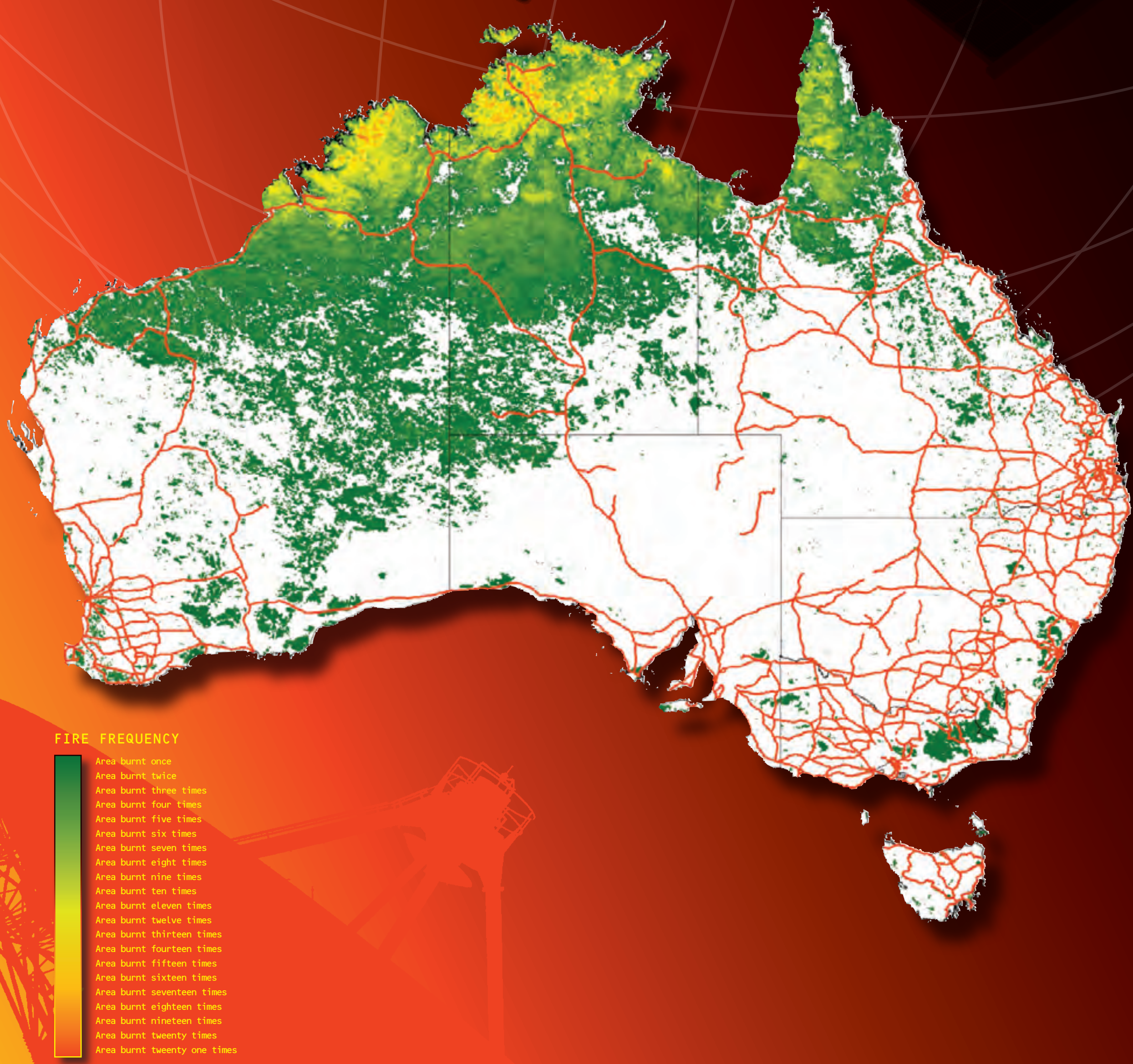
WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM

WASTAC

2010 ANNUAL REPORT



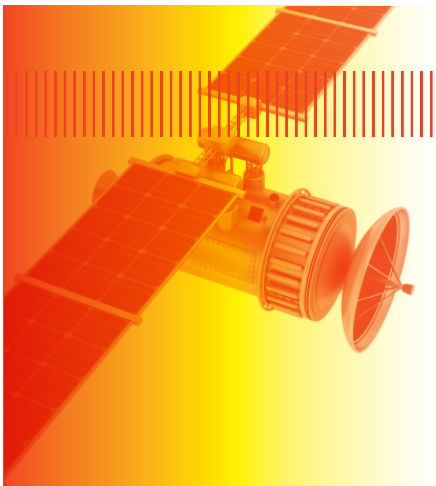
wastac.wa.gov.au

Satellite based monitoring of fire frequency in Australia

JULY 1989 – DECEMBER 2010

Satellite NOAA AVHRR 1 kilometre resolution

WASTAC MEMBERS



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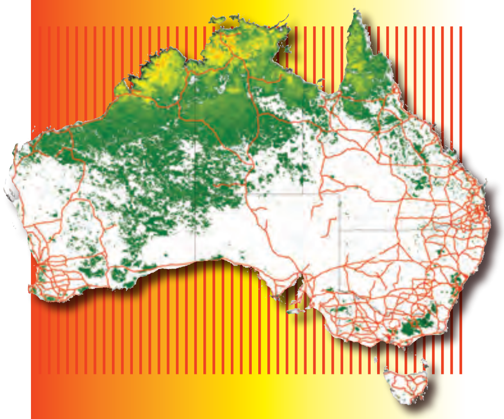

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Front Page:

"This map shows frequency of fire for Australia from July 1989 to December 2010. Fire frequency was derived from fire burnt areas mapped every 9 days and from satellite NOAA AVHRR with 1 kilometre resolution."
For further information relevant to the FireWatch program visit

www.firewatch.landgate.wa.gov.au

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WASTAC CHAIRMANS REPORT

Year 2010 was another very busy year for WASTAC as the record of our core business, that of downlinking and archiving satellite datasets, reveals.

During 2010 a number of important initiatives were progressed. The WASTAC microwave link from the X-band system at Murdoch University via Curtin University's Chemistry Centre Precinct to the Bureau of Meteorology (BoM) was progressed and should be completed in early 2011. The intention of this installation was to provide security of data supply to BoM.

The SeaSpace upgrade to the X-band antenna was completed and will enable the reception of METOP when the direct broadcast transmission is turned on.

WASTAC partners also provided input to the Space Policy Unit's consultant who was preparing a report on "*The Economic Value of Earth Observations*".

On the broader front it is pleasing to be able to report that there does appear to be a growing and quite serious interest at the Federal level in the area of monitoring and managing the Australian environment. A number of reports have been released over the 2009 and 2010 period and by end of 2010 still had not been well disseminated throughout the scientific community, including the remote sensing community. These reports cover many topics which are relevant to remote sensing and which indicate that there are many areas that may benefit from access to and application of remotely sensed information. The information that follows identifies a number of the key reports.

The Australian Space Council, for example, has recognised the importance of the space sector and the associated technologies to Australia and its potential impact on a wide range of activities including national security, climate change, weather, natural resource management, forestry , agriculture, and disaster management. For details see the Australian Government Space Portal http://www.space.gov.au.

The Department of Climate Change released a report in December 2009 "*Australian Climate Change Science: A National Framework*" which addressed the many issues that are of concern such as rising CO2 levels, sea level rise, severe weather etc. The web link is: http://www.climatechange.gov.au/~/media/publications/science/cc-science-framework.pdf.

With respect to ocean science, the Oceans Policy Science Advisory Group also issued a report in 2009 "*A Marine Nation: A National Framework for Marine Research and Innovation*" which coupled with the release by the Minister for Environment Protection, Heritage and the Arts of the "Australian Antarctic Science Strategic Plan 2011-12 to 2020-21" on 19 July 2010 laid out the key science issues and appropriate associated strategies. The relevant reports are at the links below:
http://www.climatechange.gov.au/~/media/publications/science/cc-science-framework.pdf
and http://www.antarctica.gov.au/__data/assets/pdf_file/0019/27307/AASSP_final-published-version_Apr-2011.pdf.

Remote sensing and earth observations are very dependent on developments in the ICT field. The Government has launched an initiative "*Strategic Vision for the Australian Government's use of ICT*" which is due to report in 2011. The creation of the Pawsey Centre in the West Technology Park adjacent to ARRC (where iVEC is located) was a major advance in the ICT capability in WA. The planning of this Centre has advanced significantly during 2010. Much of WASTAC's satellite data archive now resides on the iVEC supercomputer system.

The Australian Academy of Science released a document in 2010 based around the Earth System Science (ESS) concept titled "*To Live Within Earth's Limits: An Australian Plan to Develop a Science of the Whole Earth System*". This report addresses the so-called Anthropocene Period which we are now claimed to be in and which it is argued that human beings are profoundly changing the Earth's environment. The Report argues that ESS is required in order to understand and model our Earth System and to formulate predictions about consequences. See http://www.science.org.au/natcoms/nc-ess/documents/ess-report2010.pdf for details. Clearly, models need information in order to test and validate them and historical archives of remotely sensed information would seem the ideal resource to use in such evaluations.

In May 2010 the Minister for Environment Protection, Heritage and the Arts announced a new initiative to address the environmental information needs of the nation: "*The National Plan for Environmental Information*". The plan argues that we need to take the first step toward a long-term commitment to reform Australia's environmental information base and build an appropriate infrastructure for the future. The approach is to both coordinate and prioritise the way the Australian Government collects, manages and uses environmental information. Remotely sensed information will form a key part of the national environmental information system. For further details see -http://www.environment.gov.au/npei/pubs/npei-factsheet.pdf.

In October 2009, the House Standing Committee on Climate Change, Water, Environment and the Arts presented its report into climate change and environmental impacts on coasts titled "*Inquiry into climate change and environmental impacts on coastal communities*" which focused on managing our coastal zone in a changing climate. With some 36,000 km of coastline the role of remote sensing information in supporting the monitoring and managements of coastal systems is critical. See the following urls for further details: http://www.aph.gov.au/house/committee/ccwea/coastalzone/report/Final%20Report.pdf.
http://www.environment.gov.au/coasts/publications/framework/pubs/framework.pdf.

Capturing the issue of the global carbon cycle and, in particular, the concentrations, knowledge of locations of sources and sinks and the impact of greenhouse gases (GHG), is seen as fundamental to the projections of climate change and are important in international negotiations such as in the United Nations Framework Convention on Climate Change (UNFCCC): see http://unfccc.int/essential_background/convention/background/items/2853.php for details.

Finally, the Australian Academy of Science (AAS) and the Australian Academy of Technological Science and Engineering (ATSE) jointly prepared the report "*Australian Strategic Plan for Earth Observations from Space*" in July 2009 – see http://www.science.org.au/reports/documents/EOSfinal.pdf for details. This is a key document that presents a strategy for strengthening Australia's role in space-based observations of the Earth in order to address our expanding need for Earth observational data for the next 10 to 15 years.

It would be difficult to challenge the view that these reports do offer a significant challenge and an opportunity for remote sensing to address, both through promotion of its earth system science products and also the significant value of the long term record that earth observations from space have captured. The 2011 WASTAC Board may well react to aspects of these reports and documents in terms of what implications they might offer or actions that they might encourage.

Mervyn Lynch
WASTAC Chairman 2010

WASTAC BOARD FOR 2010

Professor Merv Lynch (Chairman)	Curtin University of Technology
Dr Doug Myers	Curtin University of Technology
Dr Matthew Adams	Landgate
Mr Richard Stovold	Landgate
Dr Kimberley Clayfield	CSIRO
Dr Edward King	CSIRO
Dr Anthony Rea	Bureau of Meteorology
Mr Andrew Burton	Bureau of Meteorology
Dr Adam Lewis	Geoscience Australia
Professor Tom Lyons	Murdoch University
Exec. Dean Yianni Attikiouzel	Murdoch University

WASTAC STANDING COMMITTEE AND PROXY TO THE BOARD

Professor Merv Lynch (Chairman)	Curtin University of Technology
Dr Doug Myers	Curtin University of Technology
Dr Matthew Adams	Landgate
Mr Richard Stovold	Landgate
Mr Andrew Burton	Bureau of Meteorology
Mr Don Ward	Bureau of Meteorology
Mr Stuart Barr, Mr Mike Pasfield	Geoscience Australia
Professor Tom Lyons	Murdoch University
Dr Thomas Cudahy	CSIRO

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, 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.
- Prepare for utilisation of information from new technically and scientifically advanced sensors.
- Promote educational and research uses of WASTAC data.
- Promote use of Aqua, Terra, NOAA, SeaWiFS and FY1D data in climate studies, environmental and renewable resource management.
- Encourage WASTAC to promote awareness of products.

CURRENT STRATEGIES:

- Upgrade reception and processing capabilities for METOP (including AVHRR), NPP (including VIIRS) and FY3 (including MERS).
- Continue to improve the products derived from MODIS sensors.
- Advance the processing of AIRS data from Aqua and Terra.
- Improve the management and access of the WASTAC archive through collaboration with iVEC (Interactive Virtual Environment Computing Facility).
- Provide network access to other Earth Observation Satellite receiving stations in Australia.

FUTURE SATELLITE RECEPTION OPPORTUNITIES:

- National Polar Orbiting Environmental Satellite System and NPP/NPOESS.
- Landsat Continuity Data Mission.
- Chinese HY3 and ZY3 satellites.
- Russian Meteor Satellites.

OPERATIONAL STATUS

WASTAC facilities have both L and X band reception capabilities. The L band archive commenced in 1983 however satellite tracking commenced at Curtin University of Technology (then the WA Institute of Technology) in the late 1970s. The X band facility was commissioned at Murdoch University on 21 November 2001.

WASTAC L

The L band facility consists of a 2.4m antenna and antenna controller at Curtin University of Technology and new ingest and display computers with hard disc storage and tape archive facilities at Curtin University at Bentley. The antenna pedestal was replaced in December 2006. A new high-speed bi-directional microwave unit was installed in late 2007. The bi-directional microwave continues to provide high-speed transmission of raw and processed data between Curtin University, the Bureau of Meteorology and Leeuwin Centre.

The AVHRR ingest and display system, developed by the Bureau and installed in April 2008 consists of two Linux workstations, one provided by WASTAC and the other by the Bureau. LNC upgrades have also allowed access to METOP data.

Colour and grey scale quicklook images are produced by Landgate's Satellite Remote Sensing Services (SRSS) at the Leeuwin Centre for Earth Sensing Technologies at Floreat. Quicklook production is undertaken in near realtime for archiving, indexing and distribution. The raw data archive is transferred to 20Gb DLT tapes and duplicate copies are produced for a national NOAA archive program that is coordinated by CSIRO in Canberra.

The ingest program runs on both workstations to provide display, processing and backup facilities. The TOVS data, a subset of the AVHRR, is automatically sent to the Bureau of Meteorology in Melbourne where the atmospheric temperature retrievals are ingested into global numerical weather prediction models. Sea Surface Temperature (SST) analyses are produced by the Bureau of Meteorology and Landgate. Landgate also produces vegetation maps and monitors fire scars in realtime.

WASTAC X

The WASTAC X band facilities at the Environmental Science Building at Murdoch University were supplied and installed by SeaSpace Corporation in September 2001 and consist of a 3.6m diameter antenna mounted in a fibreglass dome and a Sun Sparc 400 antenna control computer. The ingest and display computers with hard disc and tape archive storage as well as a dual CPU LINUX processing computer are located at Landgate's SRSS at the Leeuwin Centre. The X band station was upgraded to receive METOP(mid 2009), NPP and FY3 satellite data(due on stream 2010) as well as the processing of MODIS data to level2 and AIRS data from Aqua and Terra.

The X band reception facility is connected through the Murdoch node to the high speed PARNET wide area network which allows data transfer to Landgate and via the internet to other WASTAC consortium members.

The X band computer has been upgraded by SeaSpace to incorporate ingest for new X band satellites. An L band ingest facility has also been added to provide backup and help resolve pass conflicts at the L band facility at Curtin University.

RECENT DEVELOPMENTS AND FUTURE DIRECTIONS

WASTAC continues to be involved with the development of software which will allow easier on-line access to the data stored at the iVEC site in Technology Park, Bentley. A new Sun workstation has also been installed to provide processing of archive products and various metadata. A new MODIS software package and IPOP from NASA will be installed on a new processing computer at Landgate in Floreat,WA.

The BOM will install a new microwave link between the BOM in Perth to the Murdoch University via Curtin University which will allow direct access to Xband data for BOM and serve as a backup for existing PARNET links. Work to allow access to the Xband data via this link is continuing.

WASTAC DATA ARCHIVE

The WASTAC archive of NOAA, MODIS and SeaWiFS satellite passes is managed and maintained by Landgate's Satellite Remote Sensing Services (SRSS) group and held at the Leeuwin Centre at Floreat in Perth. The SRSS Group actively manages the daily archive and management systems that have been installed to ensure rapid and reliable delivery of WASTAC satellite data for research and wider community use.

A total of 14,635 NOAA passes were archived at Curtin and Murdoch in 2010. Passes included data from the NOAA 15, 16, 17, 18 and 19 satellites.

The number of SeaWiFS passes totalled 793.

There were 1516 TERRA, 1454 AQUA and 1040 FY1D passes archived.

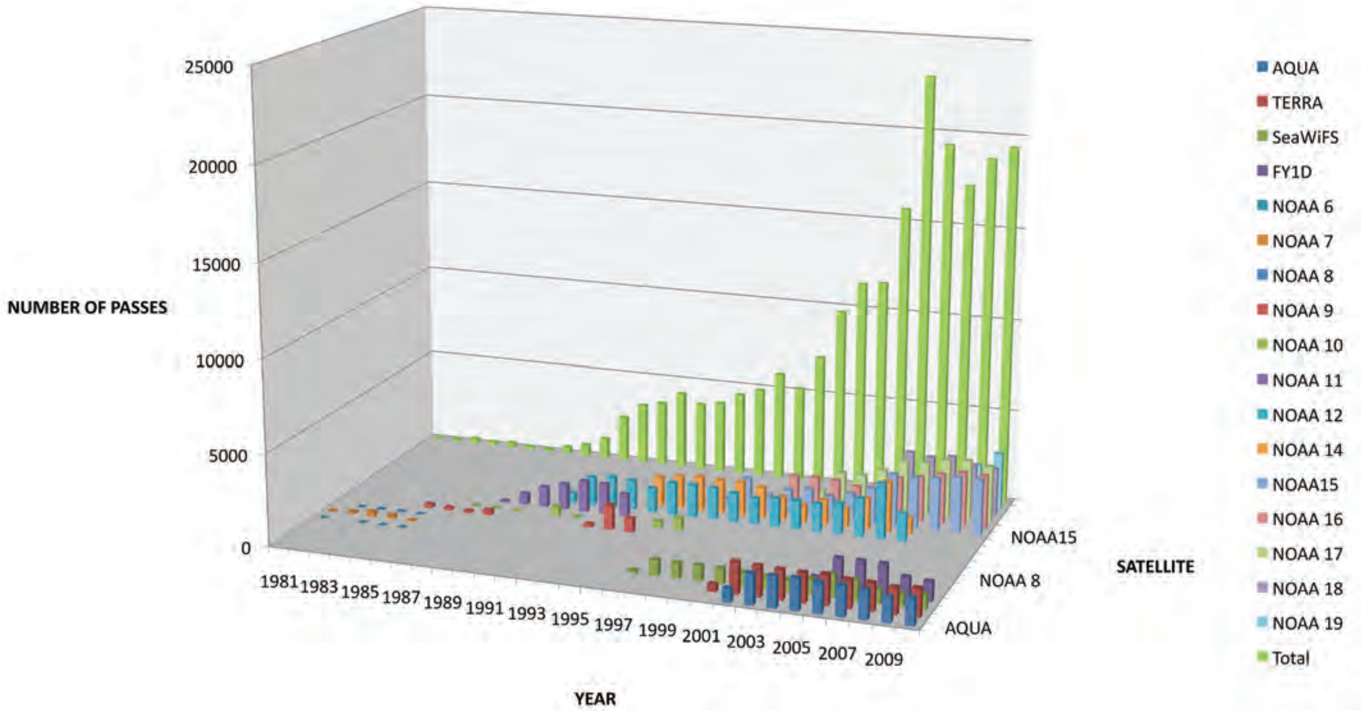
The near realtime quick-look archive of MODIS and NOAA-AVHRR data continues to be maintained on the world wide web. This digital archive extends back to 1983. A similar archive of SeaWiFS quick-look data is also held on the Web. The archive of MODIS, NOAA and SeaWiFS data can be viewed at:

http://www.rss.dola.wa.gov.au/noaaq/NOAAql.html
http://www.rss.dola.wa.gov.au/modisq/MODISql.html

Landgate currently holds the archive on 8mm exabyte and DAT tapes. 20Gb DLT tapes were introduced as the archive media in late 2000 for the L band data and since the commissioning of the facility in 2001, X band data has been archived on DLT 35Gb tapes.

Russell Steicke, Regional Computing Manager,
Bureau of Meteorology, WA

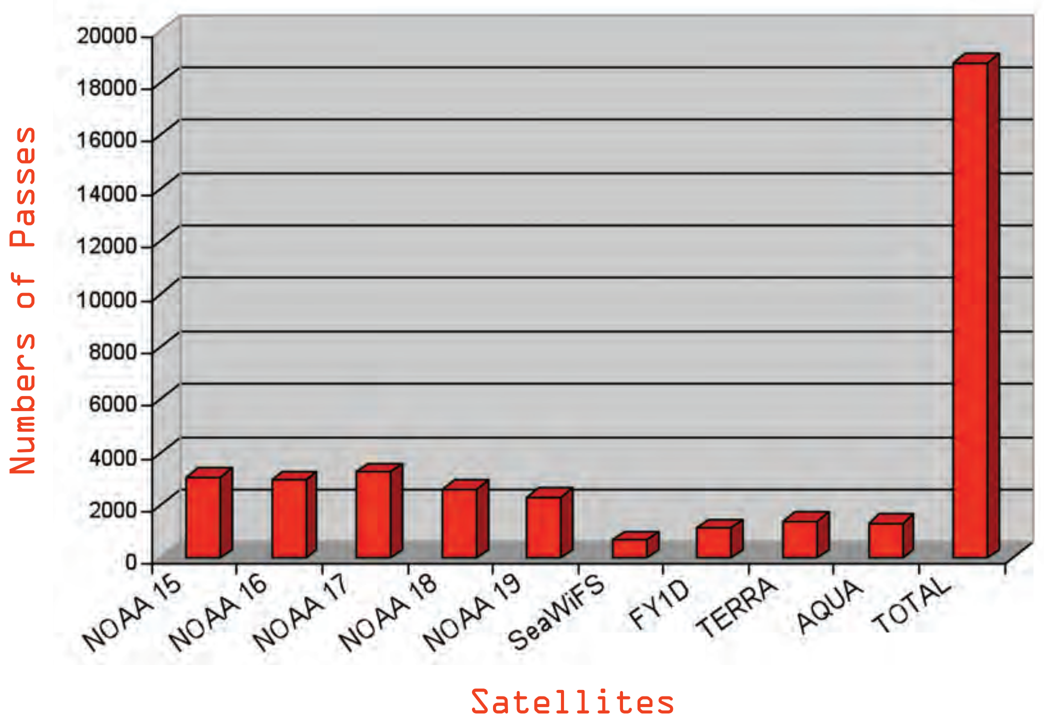
	AQUA	TERRA	SeaWiFS	FY1D	NOAA 6	NOAA 7	NOAA 8	NOAA 9	NOAA 10
1981					5	22			
1982						115	1		
1983					12	244	12		
1984					7	179	4		
1985					7	33	4	212	
1986								151	
1987								97	18
1988								280	25
1989									21
1990									
1991									506
1992									47
1993								183	
1994								1362	
1995								770	
1996									354
1997			142						694
1998			859						
1999			822						
2000			843						
2001		390	811						
2002	734	1710	780						
2003	1651	1645	696						
2004	1665	1602	680						
2005	1705	1577	863	553					
2006	1635	1639	1239	1683					
2007	1615	1512	1092	1678					
2008	1553	1495	787	1673					
2009	1327	1411	687	1132					
2010	1454	1516	793	1040					



Total number of passes held in the WASTAC archive

NOAA 11	NOAA 12	NOAA 14	NOAA15	NOAA 16	NOAA 17	NOAA 18	NOAA 19	TOTAL
								27
								116
								268
								190
								256
								151
								115
53								358
601								622
1103								1103
1399	575							2480
1693	1571							3311
1656	1720							3559
1227	1641							4230
	1326	1615						3711
	1780	1776						3910
	1797	1876						4509
	1763	1828	432					4882
	1589	1839	1663					5912
	1427	1681	905	341				5197
	1548	1271	1292	1733				7045
	1579	976	1455	1789	709			9732
	1521	1351	1200	1728	1827			11388
	1727	1058	1481	1524	1797			11534
	2101	1706	1904	1743	2212	1339		15703
	3030	2761	2823	2240	2883	2989		22922
	1571	952	2777	2442	2869	2839		19347
			2844	2711	3165	2985		17213
			3055	2951	3254	2622	2306	18745
			3061	2895	3054	2567	3058	19438

Archived Satellite Passes for 2010 from Murdoch and Curtin



		NOAA 15	NOAA 16	NOAA 17	NOAA 18	NOAA 19	SeaWiFS	FY1D	TERRA	AQUA	TOTAL
Jan	C	103	72	109	102	109	15				510
	M	118	141	126	119	126	16	68	127	115	956
Feb	C	122	89	133	123	136	29				632
	M	117	128	110	116	119	36	75	115	102	918
Mar	C	131	90	146	133	146	25				671
	M	134	148	133	130	123	51	104	129	129	1081
Apr	C	125	76	136	128	142	20				627
	M	131	136	125	113	124	26	75	122	122	974
May	C	134	104	147	136	150	27				698
	M	109	111	109	104	107	36	77	106	106	865
Jun	C	128	106	140	117	142	32				665
	M	125	130	122	103	121	38	16	118	112	885
Jul	C	128	88	143	19	144	36				558
	M	127	149	129	87	111	26	121	137	134	1021
Aug	C	133	104	147	9	141	46				580
	M	130	144	124	100	41	41	99	127	123	929
Sep	C	128	106	141	27	136	40				578
	M	129	138	128	135	114	37	113	133	125	1052
Oct	C	133	118	135	115	144	41				686
	M	143	147	126	133	132	56	91	136	128	1092
Nov	C	129	127	111	133	147	35				682
	M	138	149	120	127	132	55	92	133	123	1069
Dec	C	125	139	105	131	151	5				656
	M	141	155	109	127	120	24	109	133	135	1053
	TOTALS	3061	2895	3054	2567	3058	793	1040	1516	1454	19438

OPERATIONAL APPLICATIONS 2010

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, CSIRO and Satellite Remote Sensing Services group in Landgate.

CSIRO, CANBERRA

Edward King

National MODIS Processing System

CSIRO, in collaboration with Geoscience Australia, is establishing a national MODIS processing facility based at the National Computational Infrastructure (NCI) located in Canberra. The first stage of this system combines MODIS direct broadcast data received by the WASTAC Murdoch station with data from Townsville (AIMS), Melbourne (Bureau), Alice Springs and Hobart (both GA) to create a near real-time national direct broadcast Level-0 data set. Overlapping multi-station data from single orbits is stitched together to yield high-quality overpass data as 5-minute granules. Both Terra and Aqua MODIS sensors are included and the Level-0 data are immediately processed to Level-1B to support processing for both marine and terrestrial applications.

The second stage, currently under development, is seeking to use historical data from the NASA DAAC to establish comprehensive Level-0 whole-of-mission archives for both Terra and Aqua for the Australasian region on the NCI mass tape store. These data will then be able to be processed using the same software systems as the direct broadcast data set (Figure 1).

It is envisioned that once established the data sets and software tools within this system will be made available to researchers as part of the NCI toolset. This work is being supported by both TERN/AusCover and IMOS/SRS and staff from both Curtin and Charles Darwin Universities are contributing to build this national facility.

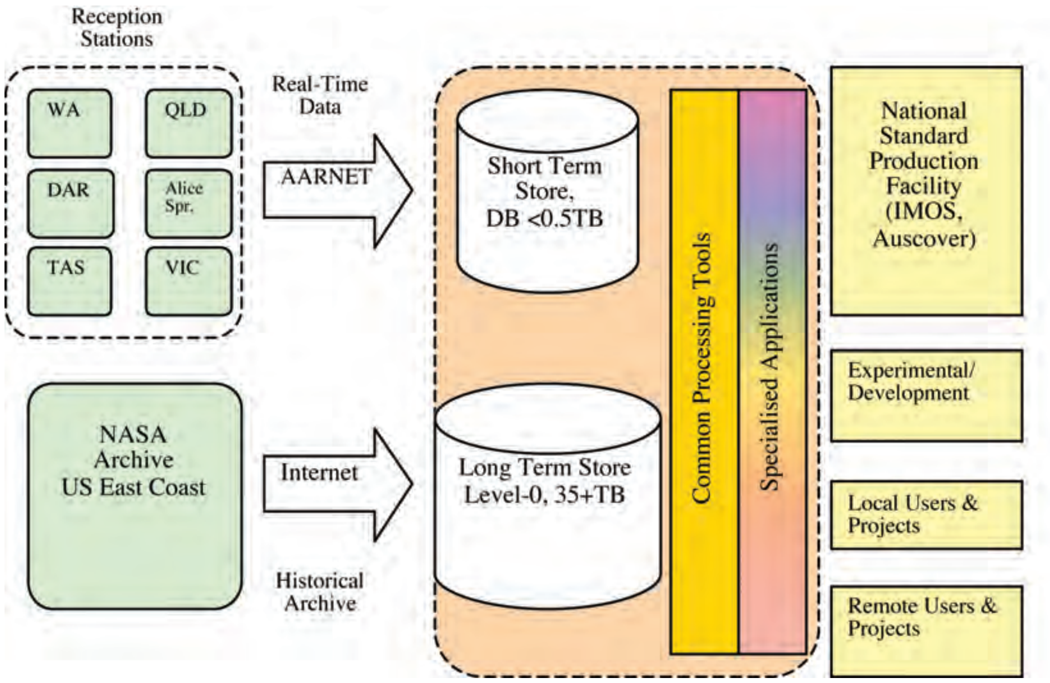


Figure 1. National MODIS processing facility brings together all near real time DB data and historical archives with the NCI processing system to efficiently support a wide range of applications and research uses.

BUREAU OF METEOROLOGY, MELBOURNE

Compiled by Ian Grant, Christopher Down, Leon Majewski, Mike Willmott & Staff of the Western Australian Severe Weather Section

The L-band and X-band reception systems operated by WASTAC form an integral part of the Bureau of Meteorology's satellite reception network. These systems provide important and timely coverage over the west of Australia and out over the Indian and Southern Oceans. Data from these systems are used in a range of application areas including, importantly, numerical weather prediction and the generation of forecasts and warnings.

ATMOSPHERIC PROFILES FOR NUMERICAL WEATHER

The Advanced TIROS Operational Vertical Sounder (ATOVS) suite of instruments on board the NOAA and MetOp satellites provides information on the vertical profiles of temperature and moisture in the atmosphere. The all-weather microwave component of ATOVS provides the biggest impact on Numerical Weather Prediction (NWP) skill of any single data type, adding several days of predictability in the southern hemisphere. Modern weather forecasting, in turn, relies heavily upon this modelling. Global ATOVS coverage is provided from the United States (for NOAA) and Europe (for MetOp), but with delays of three to six hours, which misses the cutoff for some operational NWP systems. In 2010, local ATOVS reception from WASTAC, Darwin, and Crib Point provided the Bureau with NOAA-15, -17, -18 and -19 coverage over the Australian region within 30 minutes of the start of acquisition. ATOVS data are processed through the internationally standard ATOVS and AVHRR Pre-processing Package (AAPP), and produce significant positive impact in the Bureau's NWP system.

Accurate regional NWP for any country requires global ATOVS data. This has stimulated the development of rapid ATOVS dissemination through European, South American and Asia-Pacific (AP) Regional ATOVS Retransmission Services (RARS). In addition to contributing data through five local ATOVS reception facilities, including WASTAC, the Bureau also coordinates the international AP-RARS initiative. By the end of 2010, fifteen international AP-RARS sites were operational, including Australia, New Zealand, Singapore, China, Japan, Hong Kong and Korea. The coverage of AP-RARS stations is provided in Figure 2. (see http://www.bom.gov.au/weather/satellite/RARS/index.shtml).

Figure 2: AP-RARS sites

MODIS AND AIRS DATA

The large number of spectral bands carried by MODIS instrument on the Terra and Aqua spacecraft enables the derivation of a range of atmosphere and surface products. These include information on the spatial distribution of water vapour, temperature, cloud phase (ice or water) and cloud top properties (pressure, temperature, particle size). Products are generated using the International MODIS and AIRS Processing Package (IMAPP) software from the University of Wisconsin and delivered to forecasters via a developmental web-based system. Figures 3, 4 and 5 show MODIS data from WASTAC for the 20th December 2010. The RGB composite highlights the storm front that caused evacuation warnings to be sent to the residents of Carnarvon for that day.

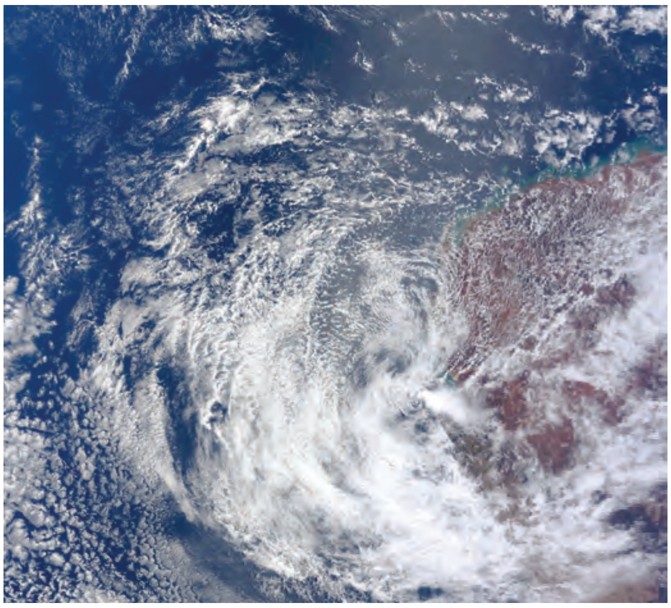


Figure 3: RGB composite image for the 20th December 2010

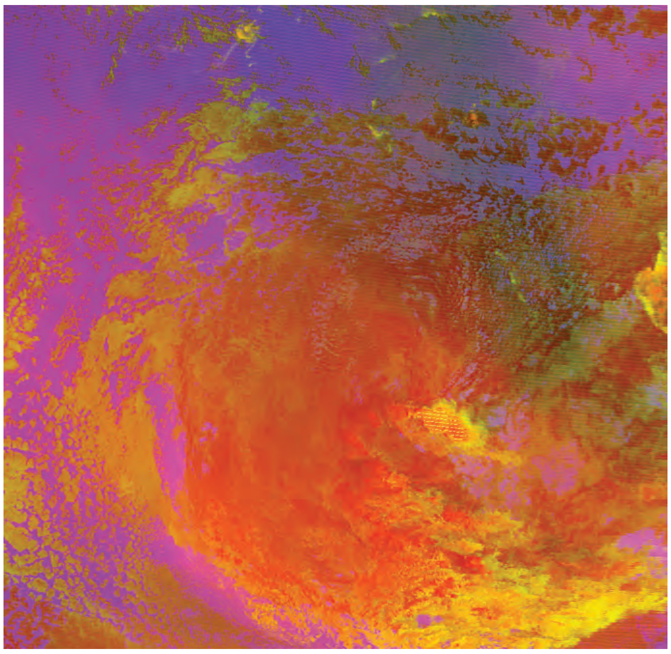


Figure 4. Convection/Severe

Figure 4 shows an image product which is aimed at identifying Convective Storm features. The red colour shows deep precipitating high level cloud composed largely of ice particles and the yellow colour shows again high level cloud but with associated strong updrafts and severe weather.

Figure 5 shows the relative air masses for the atmosphere. The green colour shows the cloud to be thick warm low level cloud, while the white and yellow highlights the cloud is still thick but is higher in the atmosphere. The red in the far bottom right is typical of a high level descending advection jet stream.

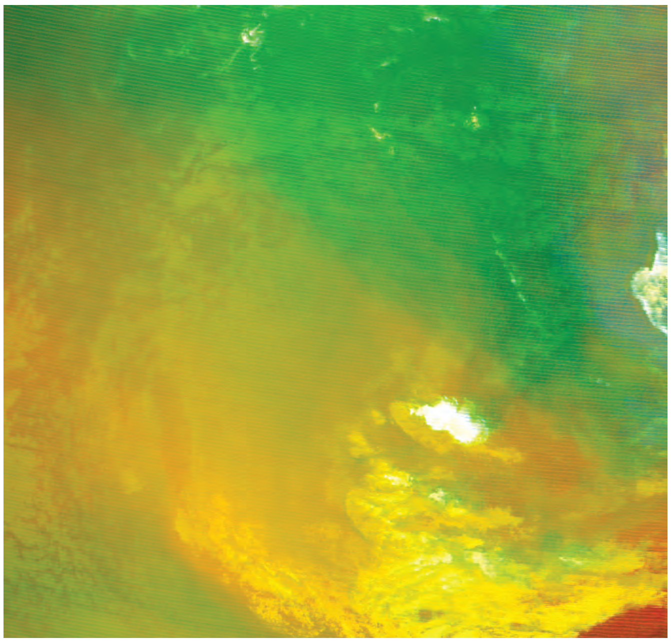


Figure 5. Air Mass RGB

The Aqua satellite also carries the Atmospheric Infrared Sounder (AIRS), which provides atmospheric profile data at high spectral resolution. Image products describing the temperature and moisture structure of the atmosphere are also produced by IMAPP software for delivery to forecasters. AIRS data have shown major positive NWP impact overseas, and are being assimilated on a trial basis into the Bureau's new NWP system, 'ACCESS' which is a local implementation of the United Kingdom Met Office Unified Model.

NORMALISED DIFFERENCE VEGETATION INDEX (NDVI)

The Bureau derives Normalised Difference Vegetation Index (NDVI) products from AVHRR data. NDVI is used to monitor the greenness of vegetation, and is an indication of its coverage and vigour. The NDVI standardised anomaly, defined as the number of standard deviations above or below the long-term mean, quantifies the vegetation state relative to its long-term average and variability for a particular month of the year. Maps of NDVI and NDVI standardised anomaly, as well as the underlying data grids, are available on the climate pages of the Bureau's website. In 2010, the Bureau started distributing NDVI data through the AusCover web portal which is under development as part of the Terrestrial Ecosystem Research Network (http://www.auscover.org.au/portal/index.htm).

The NDVI and NDVI anomaly production is based on data from the AVHRR on NOAA-18 that is acquired in near-real-time by the Bureau from WASTAC and other sites around Australia, and used in conjunction with historical AVHRR data supplied by CSIRO. These data are processed into national monthly maximum value composites. Geolocation and cloud masking are performed using the Common AVHRR Processing System (CAPS) software. Calibration de-trending is by the method of invariant semi-arid sites developed by the Environmental Resource Information Network (ERIN). The NDVI anomaly map for a given month is calculated from the NDVI for that month and the mean and standard deviation of the corresponding month over all years of the record.

The maps of NDVI and NDVI anomaly for October 2010 in Figure 6 show an exceptional degree of greenness for that time of year across central Australia and into the eastern states. This reflects the unusually high rainfall in those regions over the preceding several months.

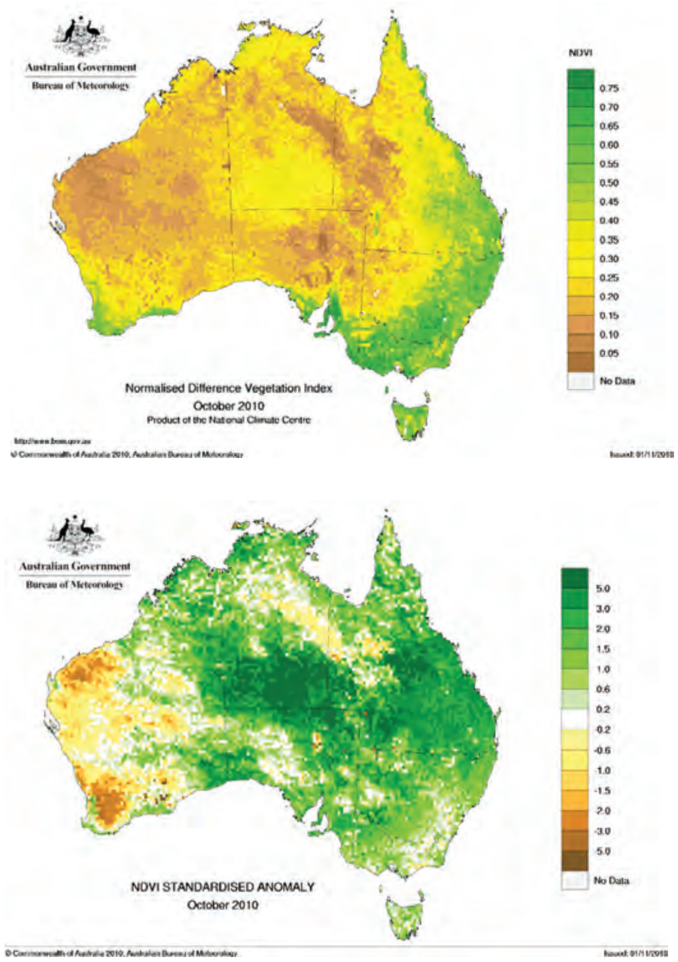


Figure 6: The national AVHRR NDVI (top) and NDVI standardised anomaly maps (bottom) for October 2010 available at the Bureau of Meteorology's climate web pages. State maps and data grids are available at a finer resolution.

TROPICAL CYCLONE MONITORING

The Bureau operates a Tropical Cyclone Warning Centre (TCWC) from its Western Australian Regional Forecasting Centre in Perth. Within the Centre, 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-2 imagery, Feng Yun 2 imagery and Numerical Weather Prediction (NWP).

For the period 1 January 2010 to 31 December 2010, there were five tropical cyclones that entered or formed within Perth TCWC's area of responsibility (See Table 1). Of these, the most severe tropical cyclone that threatened the Australian coastline was Tropical Cyclone M*agda*.

This 12 month period was significant in that none of the five Tropical Cyclones within Perth's Tropical Cyclone Warning Centre's area of responsibility caused any damage to members of the public or their property.

Tropical Cyclone Magda (19–23 January 2010)

A tropical low formed close to the Indonesian island of Roti (southwest of Timor) on 18 January and drifted slowly to the south-southwest, reaching cyclone intensity on 20 January. Magda developed rapidly during the overnight period, reaching category three intensity on the morning of 21 January close to Browse Island. It then weakened for a period during the day but regained intensity the following night. Magda again reached category three intensity as it crossed the Kimberley coast at Kuri Bay, about 210 km north northeast of Derby, at about 5am WST 22 January. Magda weakened below cyclone intensity late that day as it moved inland passing east of Derby.

Some minor damage to infrastructure occurred at Kuri Bay as Magda passed by. Vegetation near the coast was considerably defoliated. Fortunately, facilities at Koolan Island and Cockatoo Island only experienced the western peripheral gales and no damage was reported. (see figure 7).

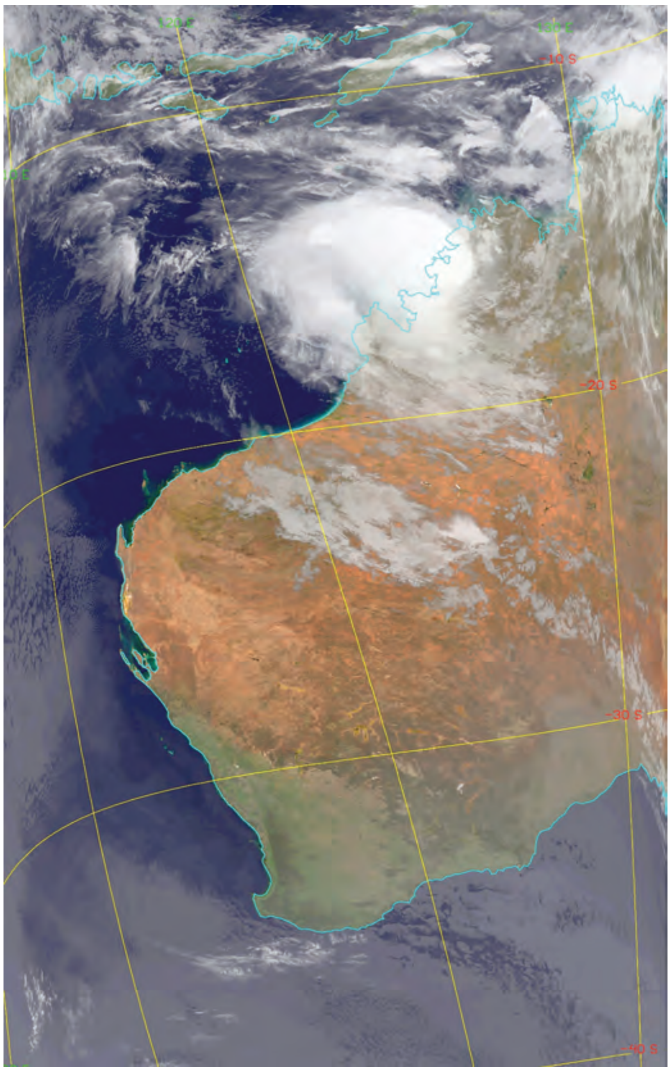


Figure 7. Tropical Cyclone Magda observed from NOAA-18 as it approached landfall at maximum intensity (Category 3) on 17:28 UTC on 21 January 2010

Table 1. List of Tropical Cyclones for the period January 2010 to December 2010

Tropical Cyclone	Period (2010)	Max Intensity	Impact on Coast or Other Aus. Territory	Means of Detection
Magda	19 – 23 January	Cat 3	Minor	Radar/Satellite
Robyn	1 – 7 April	Cat 2	Nil	Satellite
Sean	20 – 25 April	Cat 2	Nil	Satellite
Anggrek	31 Oct – 4 November	Cat 2	Nil	(Detected OAOR)*
Abele	29 Nov - 4 December	Cat 3	Nil	(Detected OAOR)*

* Detected OAOR – Detected Outside Area of Responsibility but tracked using satellite observations.

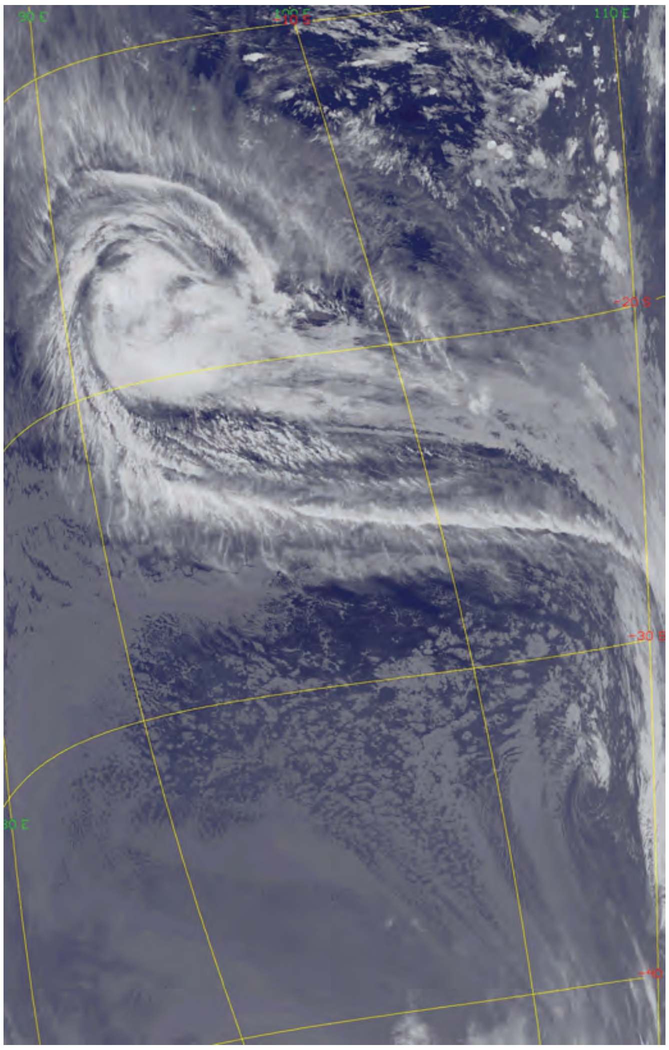


Figure 8. Tropical Cyclone Robyn observed from NOAA-18 at maximum intensity (Category 2) at 06:47 UTC on 8 February 2010.

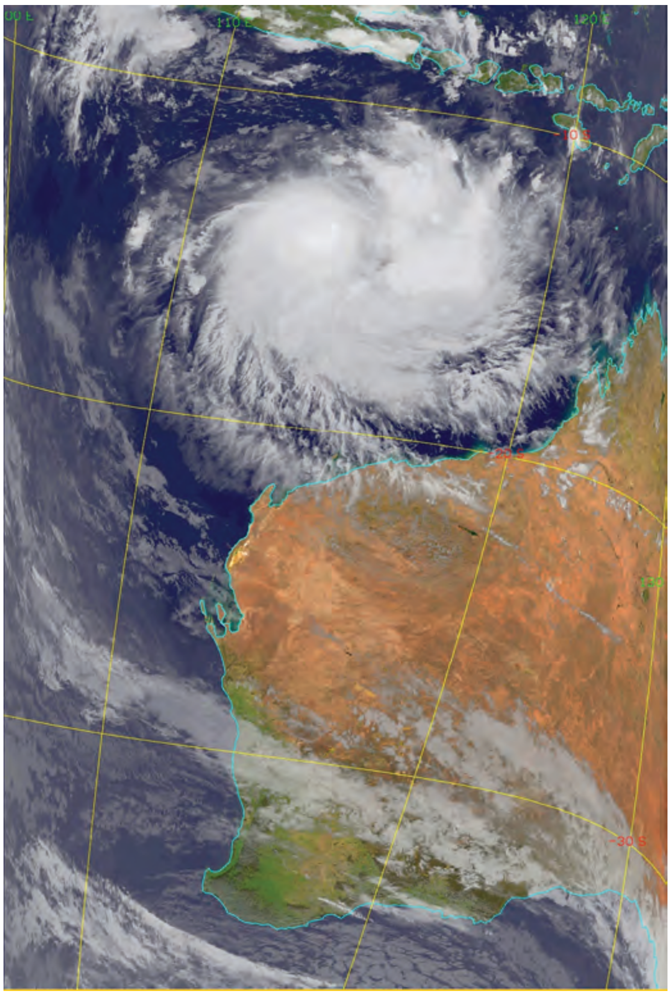


Figure 9. Tropical Cyclone Sean at maximum intensity (Category 2) on 23 April 2010. Image observed by NOAA-19 at 06:01 UTC on 23 April 2010.

Tropical Cyclone Robyn (1 to 7 April 2010)

Tropical Cyclone Robyn developed well to the northwest of the Cocos Islands in early April, reaching cyclone intensity at 0000 UTC on 3 April as it moved slowly to the south. Robyn peaked at 60 knot intensity at 0000 UTC 5 April but weakened rapidly later that day due to increasing north-westerly wind shear. Robyn is estimated to have weakened below cyclone intensity at 0600 UTC 6 April, by which stage it had begun tracking to the northwest. Shipping warnings remained current for easterly gales on the southern side until 0600 UTC 7 April because of westerly motion and a strong high to the south.

TC Robyn remained over open waters in the central Indian Ocean and had no known impact. (See Figure 8).

Tropical Cyclone Sean (20 to 25 April 2010)

Tropical Cyclone Sean developed south of Bali, well east of Christmas Island in late April and reached cyclone intensity at 1800 UTC 22 April as it moved to the southwest. Sean peaked at 55 knots intensity at 1800 UTC 23 April but subsequently weakened rapidly on 24 and 25 April due to increasing north-westerly wind shear. Sean is estimated to have weakened below cyclone intensity at 0000 UTC 25 April by which stage it had begun tracking to the west.

TC Sean remained over open waters in the Indian Ocean and had no known impact (See Figure 9).

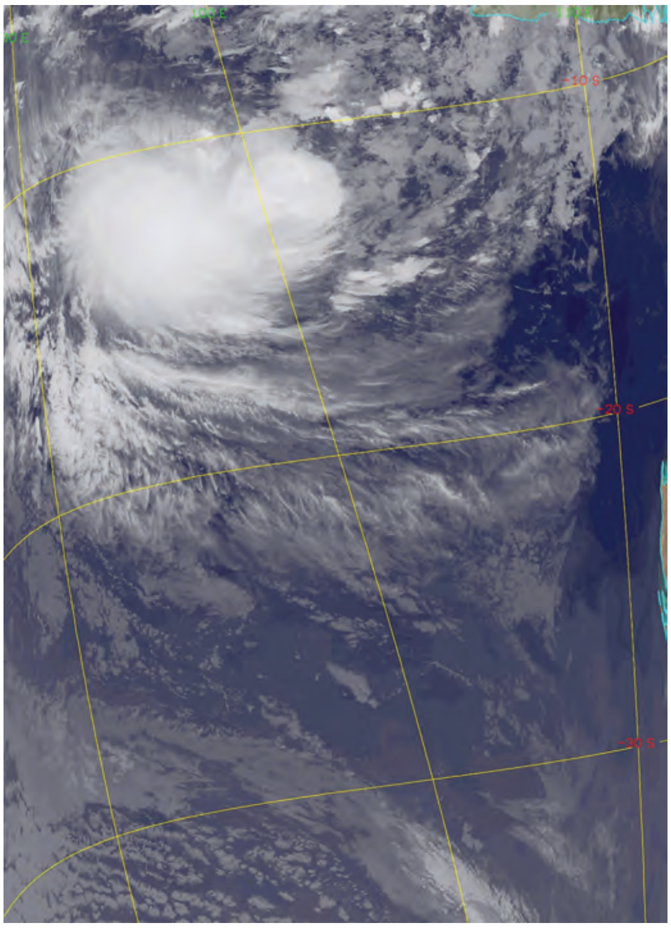


Figure 10. Tropical Cyclone Anggrek at maximum intensity on 1 November 2010. Image observed from NOAA-18 at 19:06 UTC on 1 November 2010. The Western Australian Coastline can just be seen on the extreme right of this image.

Tropical Cyclone Anggrek (31 October to 4 November 2010)

A tropical low formed to the southwest of Indonesia on 28 October and drifted slowly west before re-curving to the southeast and reaching cyclone intensity on 31 October. The system was named Anggrek by the Jakarta Tropical Cyclone Warning Centre. Anggrek developed slowly and reached category two intensity on 1 November, before weakening below cyclone intensity early on 4 November.

Anggrek passed to the east and then to the south of Cocos Island with the closest approach being about 140 km to the east south-east of the island during the afternoon of 2 November. Moderate rainfall occurred over Cocos Island during the passage of Anggrek with the maximum 24 hour rainfall being 56mm on 1 November. No damage was reported from the passage of Anggrek. (See Figure 10).

Tropical Cyclone Abele (29 November to 4 December 2010)

A tropical low formed in the central Indian Ocean on 29 November 2010 and drifted slowly to the south. It reached tropical cyclone intensity on 1 December and was named Abele while still in the area of responsibility of La Reunion Tropical Cyclone Centre. Abele was a small system that rapidly intensified into a category 3 cyclone late on 2 December. Abele moved into the Perth Tropical Cyclone Warning Centre's area of responsibility on 3 December. By this time it was a category 2 cyclone, having already begun weakening rapidly due to cold sea surface temperatures and increasing vertical wind shear. Abele weakened below cyclone intensity early on 4 December over open water.

Throughout its life, Abele posed no threat to the Cocos Islands or communities on the Australian mainland and observations from the WASTAC antenna were not obtained due to the fact that it was outside the range of the reception area.

SEA SURFACE TEMPERATURE (SST)

The Australian Bureau of Meteorology (the Bureau) produces moderate-resolution sea surface temperature (SST) products in near real time from Advanced Very High Resolution Radiometer (AVHRR) sensors on-board NOAA Polar Operational Environmental Satellite (POES) platforms. The POES data is captured using the network of L-Band receivers around the country, including the WASTAC L-Band receivers.

In 2010, the Bureau developed improved SST algorithms based on locally received POES data. The improved SST products have been formatted following the Group for High Resolution SST (GHRSST) Data Processing Specification (GDS) and are compatible with the Integrated Marine Observing System (IMOS) Australian Oceans Distributed Active Archive Centre (AO-DAAC). Multi-day and multi-sensor composites are now downloadable from the AO-DAAC and from the Bureau upon request. An example of a multi-day composite from NOAA-18 is displayed in Figure 11.

The performance of the Bureau's SST product is routinely monitored by observing the difference from contemporaneous *in situ* measurements provided by a network of drifting buoys. Summary statistics describing the performance of the derived SST algorithms are provided in Table 2. The standard deviation decreases as the quality level increases. During 2010, the performance of the AVHRR onboard NOAA-17 became degraded. As such, results from NOAA-17 are not displayed.

Buoy measurements are not error free. To remove the uncertainty associated with the buoy measurements a three-way comparison was conducted following O'Carroll. et al. (2008). The results of a three-way comparison using the AVHRR onboard NOAA-18, drifting buoys and MTSAT (Table 3) suggest that the standard deviation of the NOAA-18 SST product is less than that of the drifting buoy network during the day at wind speeds > 6 ms^{-1} (0.16 vs 0.20 K) and at night (0.13 vs 0.22 K).

These improved AVHRR SST products are currently included in global (1/4° spatial resolution) and regional (1/12° spatial resolution) SST analyses that are used operationally in ocean forecasting and numerical weather prediction, including the prediction of tropical cyclones and severe weather events (Beggs, 2008). http://www.bom.gov.au/bmrc/ocean/Bluelink/SST/GHRSST9/9th_GHRSST_PP_Meeting_GAMSSA_paper.doc

Table 2. Summary statistics for comparisons between satellite and drifting buoy temperature measurements, separated by quality level and time, for the period 2008-2009. N = number of coincident observations; Bias = Satellite - Buoy (K); and, S.D. = standard deviation (K).

Quality Index	NOAA 18			NOAA 19		
	N	Bias	S.D.	N	Bias	S.D.
Night (Wind > 2 ms^{-1})						
3	718	-0.09	0.37	723	-0.16	0.36
4	776	0.02	0.30	711	-0.08	0.33
5	1680	0.05	0.25	1882	-0.01	0.26
Day (Wind > 6 ms^{-1})						
3	451	-0.11	0.46	523	-0.15	0.42
4	565	-0.03	0.42	619	-0.08	0.44
5	1638	0.02	0.39	1711	0.01	0.37

Table 3. Summary statistics for a three-way comparison between the AVHRR onboard NOAA-18, drifting buoys and MTSAT, using matchups within 1 hour and 10 km, for the period 2008-2010. N = number of coincident observations.

Period	Wind Speed Criteria	N	Standard Deviation [K]		
			NOAA-18	Buoys	MTSAT-1R
Day	< 6 ms^{-1}	494	0.22	0.21	0.36
Day	> 6 ms^{-1}	573	0.16	0.20	0.32
Night		373	0.13	0.21	0.30

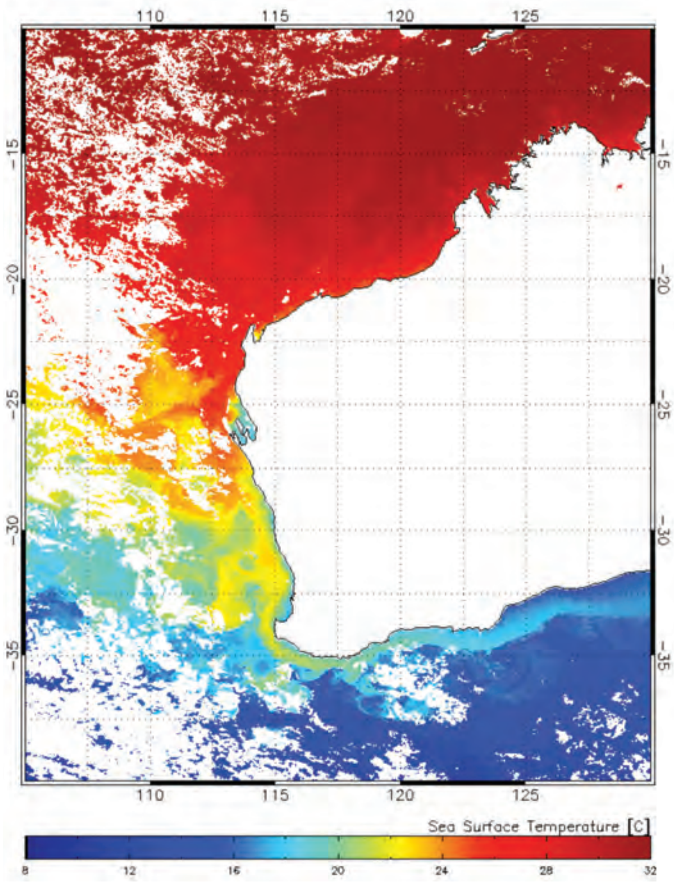


Figure 11: NOAA-18 AVHRR night time sea surface temperature for the period 20-29/08/2010. The Leeuwin Current is positioned off the west coast and can be observed rounding Cape Leeuwin.

References:

Beggs, H., 2008. GAMSSA – A New Global Australian Multi-Sensor SST Analysis,
Submitted to Proceedings of the 9th GHRSST–PP Science Team Meeting, Perros-Guirec, France, 9-13 June 2008.

O'Carroll, A.G. Eyre, J.R. Saunders, R.W., 2008.
Three-Way Error Analysis between AATSR, AMSR-E, and In Situ Sea Surface Temperature Observations.
Journal of Atmospheric and Oceanic Technology, v25, n7, p1197-1207.

LANDGATE SATELLITE REMOTE SENSING SERVICES, FLOREAT

BUSHFIRE SIMULATION

Gerrit van Burgel

Landgate Satellite Remote Sensing Services (SRSS) has been working in partnership with the University of Western Australia (UWA) and the Fire and Emergency Services Authority of Western Australia (FESA) on bushfire simulation and prediction.

A joint project, namely the National Bushfire Prediction, Detection, Simulation and Early Warning System, has been funded under the Digital Regions Initiative (DRI) of the Department of Broadband, Communications and the Digital Economy (DBCDE). The three year project commenced in mid 2010 and will run until June 2013. It will provide both the public and emergency services in rural, regional and remote Australia with bushfire alerts via SMS and email and instant access to bushfire simulation maps.

UWA have developed a bushfire simulation software engine which they are enhancing as part of this project. This core engine is used by two components developed by Landgate SRSS:

- An ArcGIS desktop interface (Figure 12) that will allow FESA to run its own real-time fire simulations and predictions.
- A website called Firewatch Early Warning which will display the real-time MODIS fire hotspots and their predicted spread over the next 24 hours.

Both components require as inputs satellite imagery derived datasets such as a Digital Elevation Model (DEM), vegetation maps, and fuel age maps. The fuel loads can be determined using the NOAA time since last burn (TSLB) dataset. The weather inputs come from a realtime FTP feed of their Access-A gridded forecasts from the Bureau of Meteorology (BOM).

FESA will be involved in validation of the simulations against both controlled burns and uncontrolled wildfires. This will make use of the fire scar mapping done by SRSS.

For more on the Digital Regions Initiative:

http://www.dbcde.gov.au/funding_and_programs/digital_regions_initiative

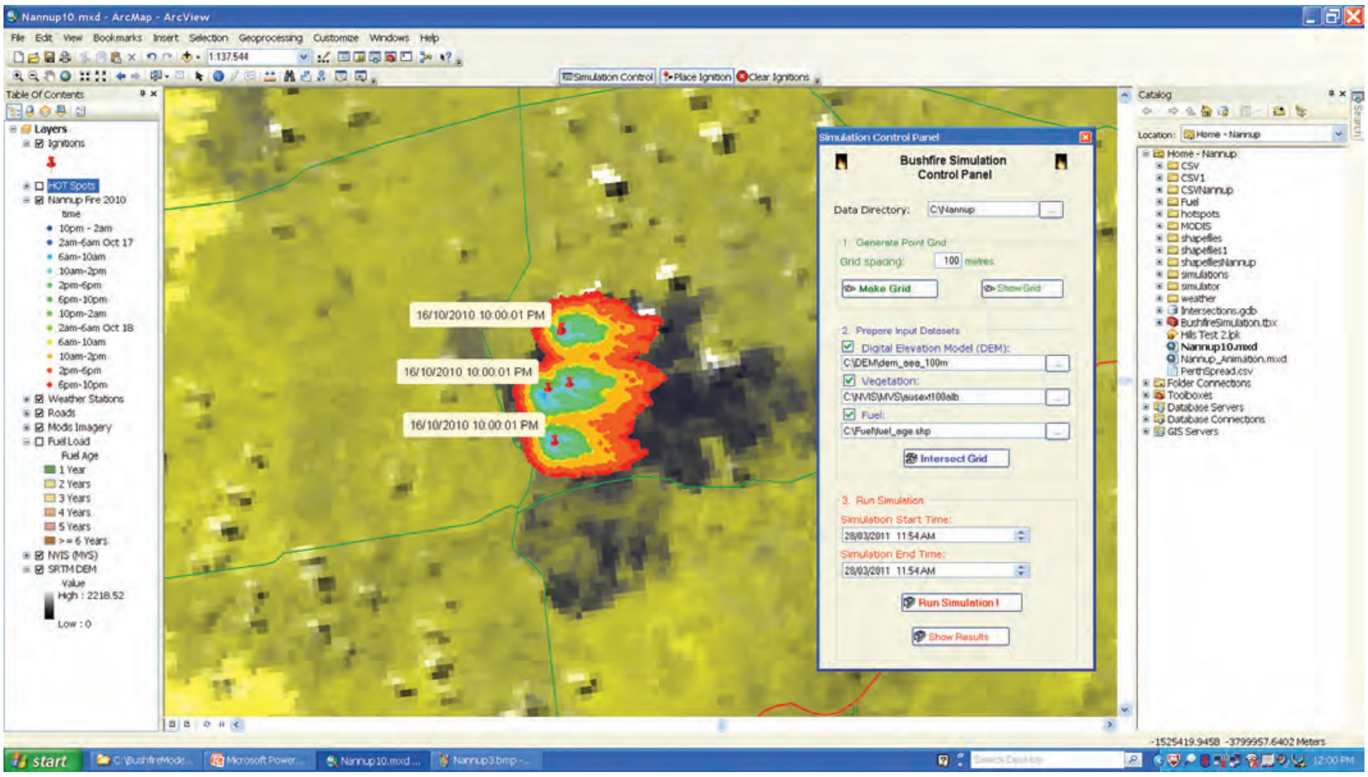


Figure 12: The ArcGIS desktop interface that will allow FESA to run its own real-time fire simulations and predictions.

CREATING AN EDUCATIONAL TOOL USING PASTURES FROM SPACE

Richard Stovold , Norm Santich, David Lamb (University of New England)

The Pastures From Space program continues to provide a web based delivery of Pasture Growth Rate (PGR) and Feed on Offer (FOO) information for farmers. The consortium partners comprising Landgate, CSIRO and Department of Food and Agriculture continue their support of the program which has been used by the agricultural market for over 6 years.

More recently, the value of Pastures From Space as a potential educational tool is being recognized. For example, a professional development workshop for Victorian secondary agriculture teachers was run by the University of New England at Dookie Agricultural College (Victoria, November 2010). Teachers worked through a number of simple scenarios to identify the differences between climate/rainfall zones (summer and winter dominant, Mediterranean and sub-tropical) and to look closely at their own local growing regions.

Special interest was shown by the teachers in the ability of the technology to provide comparisons of different pasture species and the seasonal growth variations provided by the NDVI .Valuable insights into the uses of the historical weekly PGR data in a spatial and temporal sense were demonstrated. The temporal comparison of PGR was demonstrated in the two images depicted in Figures 13 and 14. The reaction was very positive with many teachers seeking further information on product access and availability of 'teaching licenses'.

The Pastures From Space technology is also being adopted by the University of New England as part of the teaching program in the Graduate Certificate of Precision Agriculture (Precision Pasture Topic). Farmers across Australia can subscribe to Pastures From Space as a weekly web-based delivery service through Fairport Technologies.

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

To visit the Landgate website
http://www.landgate.com.au
(go to the Farm channel and select Pastures From Space).

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

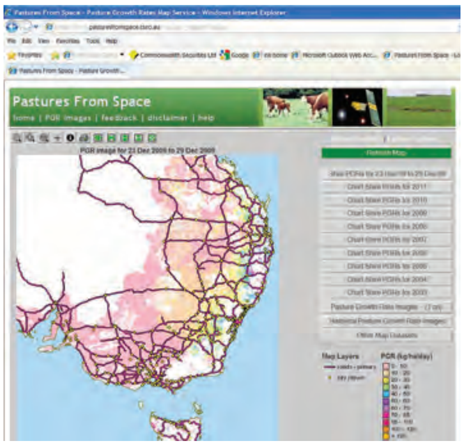


Figure 13: An image of regional Pasture Growth Rates over eastern Australian pastoral land for the week ending 29th December 2009. The lower rates of growth are in stark contrast to the record seasonal pastures growth in the same region and time in 2010 as indicated in Figure 14

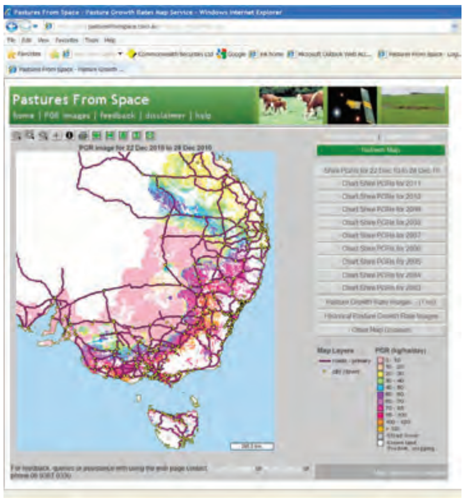


Figure 14: PGR data over the same area as Figure 13 for the week ending 28th December 2010 indicating very high levels of growth following record rains.

PLANT VIGOUR INDICATOR INDEX

Richard Stovold, Norm Santich

The Plant Vigour Indicator continues to be generated weekly from processed MODIS NDVI data providing a season update of plant growth in the South West wheatbelt of Western Australia. Landgate is providing farmers and land managers access to the data on the Agimage Landgate website under the farm channel. The information is published fortnightly in the Countryman newspaper.

The imagery (Figure 15) is assisting farmers to determine the progress of the season and provides vital production information for their properties.The data published in the Countryman compares the current season to the good season of 2005 and the bad season of 2006.

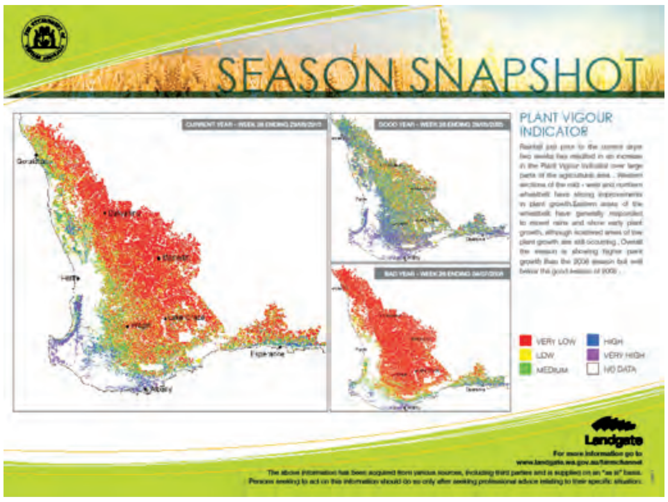


Figure 15: Comparison of the Plant Vigour Indicator for 29th June 2010 with the equivalent period in 2005 and 2006.

EARLY SEASON PREDICTIONS OF PASTURE GROWTH – TOTAL DRY MATTER CURVES

Norm Santich

The Western Australian Satellite Technology and Applications Consortium's (WASTAC) growing archive of historical Moderate resolution Imaging Spectroradiometer (MODIS) data is increasing in value to farmers who want an indication of what they can expect from the remainder of the growing season. MODIS data is used to generate weekly Normalised Difference Vegetation Index (NDVI) composites which are then used as an input to the Pastures From Space pasture growth rate (PGR) model. When the PGRs for a paddock or property are accumulated each week, it gives an indication of the Total Dry Matter (TDM) production for that paddock or property. The TDM can be plotted alongside the TDM curves for other growing seasons and this allows for a comparison with good and bad growing seasons.

Figure 16 gives an example of this. For a location in the shire of West Arthur, the weekly PGR values were accumulated to produce the TDM curves for each growing season between 2002 and 2009. The PGR values for 2010 up to week 35 were also included. It can be seen that by week 35, 2010 was on track to being one of the poorest seasons of the last decade and that by that time approximately 2000 kg/ha of dry matter had been produced. When using the previous seasons as a guide, it can be predicted from the data that if the season finished poorly, it could be expected to produce approximately 3000 kg/ha. If the season was to finish strongly then a total production of 5000kg/ha could be hoped for.

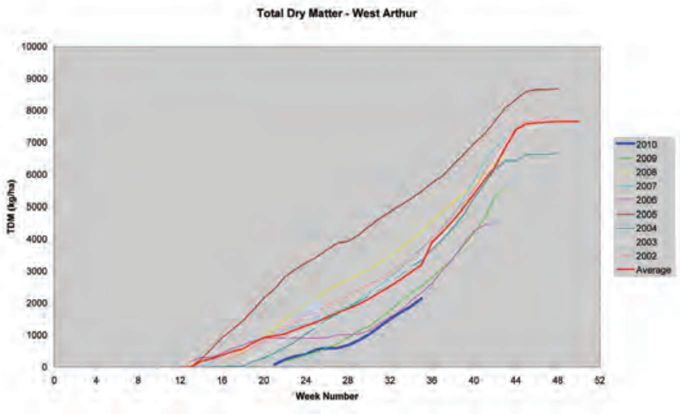


Figure 16: Total Dry Matter curves including 2010 season to week 35

At the end of the 2010 growing season the PGR values following week from 35 were added to the remainder of the 2010 season (Figure 17). It shows the actual final TDM production for 2010 as being approximately 4000 kg/ha, vindicating the earlier prediction of between 3000kg/ha and 5000 kg/ha. With this information, farmers can forecast their optimum stocking rates and increase or decrease the current stocking rates accordingly. If the current stocking rates are too high, then they also have the option to plan for future hand-feeding. This becomes valuable information, particularly in drought years, when stocking rates are often too high or the amount of available feed is insufficient for the current stocking rates.

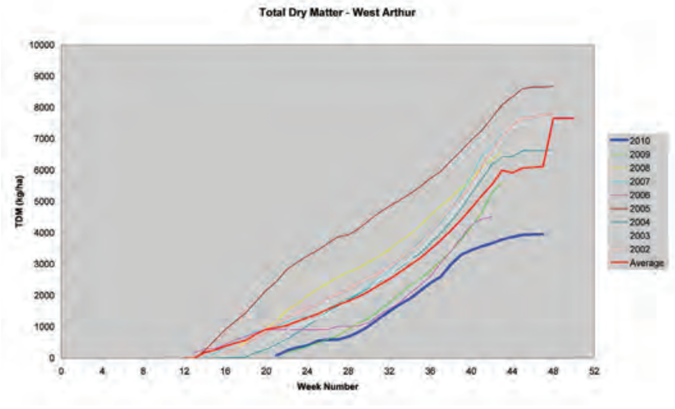


Figure 17: Total Dry Matter curves including all of the 2010 season

MAPPING THE GASCOYNE RIVER 2010/2011 FLOOD EVENT USING DIFFERENT REGIONS OF THE ELECTRO-MAGNETIC SPECTRUM.

Andrew Buchanan, Ron Craig, Carolyn McMillan, Mario Ferri

The Carnarvon Flood Event

Carnarvon is a coastal community located at the mouth of the Gascoyne River, some 900 kilometres north of Perth, Western Australia. Over Christmas 2010, Carnarvon experienced some of the worst flooding in 50 years and then in the second week of January 2011, the Gascoyne River again reached a peak. Emergency services required as much flood inundation information as possible over this period so that they could mitigate the effects of the flood and plan remediation activities.

Landgate's flood mapping service: Floodmap

As a result of federal and state funding through the National Disasters Mitigation Programme (NDMP), Landgate has been attempting to deliver a near real time satellite derived flood mapping service. This service has an internet presence and can be viewed at http://floodmap.dli.wa.gov.au/landgate_floodmap_public.asp.

For most of the Carnarvon flood event, constant cloud cover prevented most morning and afternoon MODIS passes to be of any assistance. When there was a chance to use the visible imagery the sun-glint effect rendered the daytime MODIS imagery ineffective. Figure 18 shows a typical cloud covered image with associated sun glint area most obvious in the ocean water adjacent to the coastline.

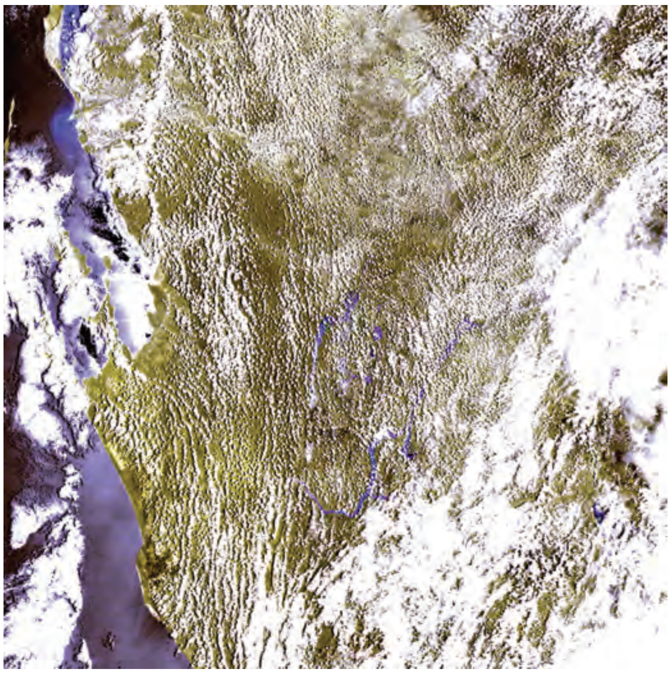


Figure 18: Typical cloud covered flood image with associated sun glint area.

Night Thermal Imagery

As the cloud cover passes over the flood affected region, "windows" eventually appear in the cloud cover that can be taken advantage of by sensors with high temporal resolution. In this respect the night thermal imagery (Figure 19) from both MODIS and AVHRR imagery were found to be useful sources of flood inundation information. Water has very dark to medium grey tones in day thermal-IR images and moderately light tones in night thermal imagery. This response is due in part to a rather high thermal inertia relative to typical land surfaces, as controlled by water's high specific heat. In these thermal night images flood water is warmer than land and is therefore represented as pixels with the highest digital count in the image while clouds are the coldest components of the imagery, possessing the lowest digital counts and appearing as darker grey tones.

Sensors that have thermal channels, are free to access and have high temporal resolution are in Table 4.

Table 4. Sensors with thermal-IR bands that have high temporal resolution.

Sensor	Band	Thermal Bandwidth (µm)	Spatial Resolution
MODIS	20	3.66 – 3.840	1km
MODIS	31	10.78 – 11.28	1km
MODIS	32	11.77 – 12.27	1km
AVHRR	3	3.55 – 3.930	1.1km
AVHRR	4	10.30 – 11.30	1.1km
AVHRR	5	11.50 – 12.50	1.1km
MTSAT-1R	2	10.30 – 11.30	4km
MTSAT-1R	3	11.50 – 12.50	4km

MODIS NIGHT THERMAL – GASCOYNE AND MURCHISON RIVERS

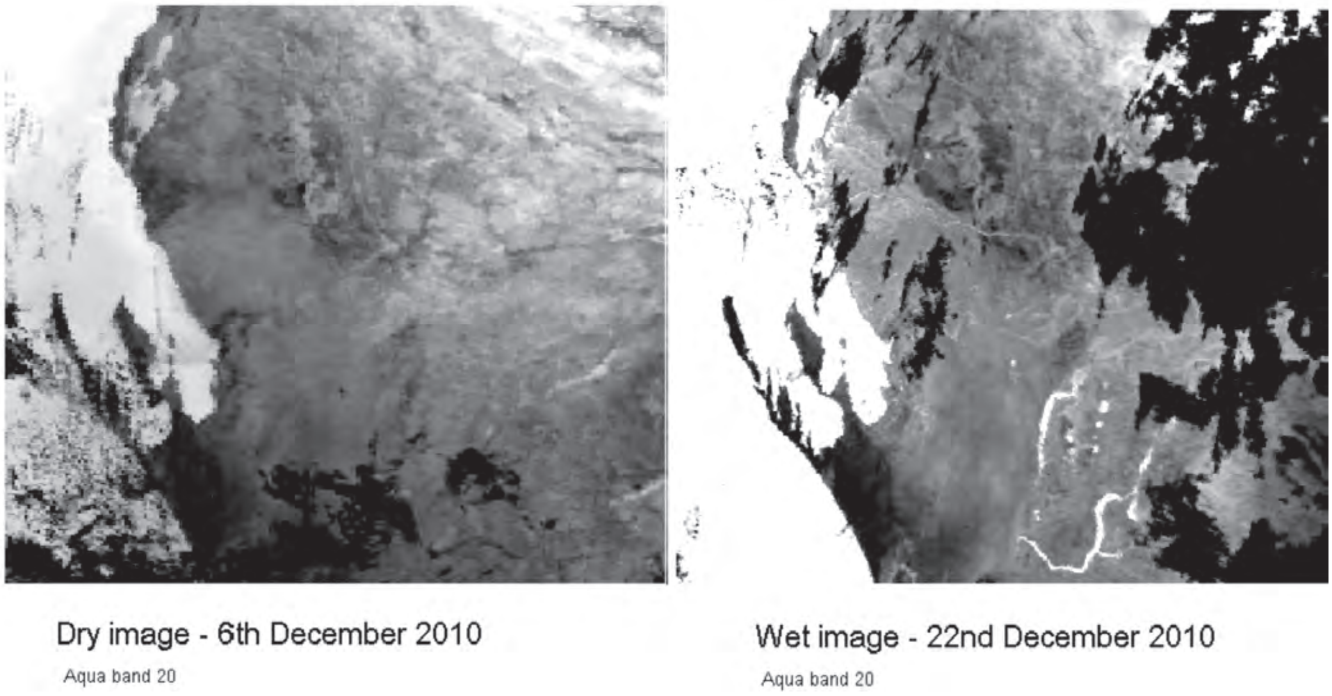


Figure 19: Night thermal imagery – dry and wet images.

Microwave Imagery

The University of New South Wales Geodesy and Earth Observing System Group has recently introduced the COSMO-SkyMed satellite constellation to Australia's flood mapping endeavours. COSMO-SkyMed is a constellation of four synthetic aperture radar satellites operating in the X band frequency range. The uniqueness of the COSMO-SkyMed constellation is manifested in the frequency of revisit (temporal resolution) which allows capture of the same area twice per day (at Australian latitudes) in all weather, day or night.

The size of the swath and the spatial resolution vary depending on the spatial detail and coverage required by the user. Generally spatial resolution degrades as the coverage increases (Table 5).

Table 5. COSMO-SkyMed spatial resolution and swath width

	Spotlight	**Stripmap**		**ScanSAR**	
		HIIMAGE	Ping Pong	Wide Region	Huge region
Polarization	Single	Single	Dual	Single	Single
Swath width (km x km)	10x10	40x40	30x30	100x100	200x200
Accessible swath	Approximately 620 km				
Geometric Resolution (m)	1	3	15	30	100

Figure 20: COSMO-SkyMed Strimap product for Carnarvon, Western Australia.

The COSMO-SkyMed image (Figure 20) captured for the Carnarvon flood was not collected on the optimum date (January 9th 2011) however it does demonstrate how useful this particular constellation of satellites will be for future Australian flood events.

Visible imagery

If the timing of the flood event is fortunate enough to co-incide with a medium to hi-resolution visible image and there are gaps in the cloud cover, then optimum imaging conditions are available. An example of this is the Landsat 5 image of Carnarvon townsite (Figure 21) which was captured immediately after the peak of the flood event on December 22nd 2010.

Figure 21: Landsat TM of the Carnarvon townsite 22nd December 2010.

Conclusion

Imaging flood events with near real time day visible imagery provides the user with the cheapest and most easily interpreted flood mapping information. Where cloud cover persists, masking substantial flood events, alternatives sources of information should be considered. These sources of information include night thermal imagery and microwave imagery.

GEOSCIENCE AUSTRALIA

Alla Metlenko

GEOSCIENCE AUSTRALIA TO LAUNCH ITS AUSTRALIAN GEOGRAPHIC REFERENCE IMAGE

Geoscience Australia (GA) will launch its 'Australian Geographic Reference Image' (AGRI) at the up and coming Surveying and Spatial Sciences Institute (SSSI) Conference in Wellington November 2011. AGRI is a 2.5 metre resolution national mosaic designed to provide a spatially correct reference image across Australia, including near-coastal waters (refer to Figures 22,23,and 24).

At relative positional accuracy of ± 2.5 metres, and with an absolute root mean square (rms) accuracy anticipated to be in the range of 2 to 5 metres, AGRI will provide a national benchmark for future geo-referencing of data over Australia and surrounding coastal islands and reefs. This will lead to significant improvements in mapping accuracy in remote areas and make possible monitoring through time at resolutions as high as 2.5 metres.

The mosaic is compiled using images from the *Panchromatic Remote-Sensing Imaging instrument for Stereo Mapping* (PRISM) on board the Japanese Advanced Land Observation Satellite (ALOS).

The mosaic is made possible by the recently developed *Barista* software, which allows correction of whole passes of imagery based on a limited number of control points.

GA's release of the AGRI product will comprise the national mosaic as well as all the Ground Control Points (GCP) used to orthorectify the PRISM images. Both the mosaic and GCP's will be made available to the public at cost of transfer under a Creative Commons – Attribution licence. This product will be accompanied by a technical report and all relevant metadata.

For more information contact earth.observation@ga.gov.au.

AGRI is being made possible through the contributions of Geoscience Australia which funded the work over a two year period (2009 -2011); the Cooperative Research Centre for Spatial Information (CRC-SI) which developed the *Barista* software; the Japanese Aerospace Exploration Agency (JAXA) which operated the ALOS satellite; and the capabilities of the Australian GIS, surveying and remote sensing industries which have provided spatial database design, field survey, and mosaicing services respectively.

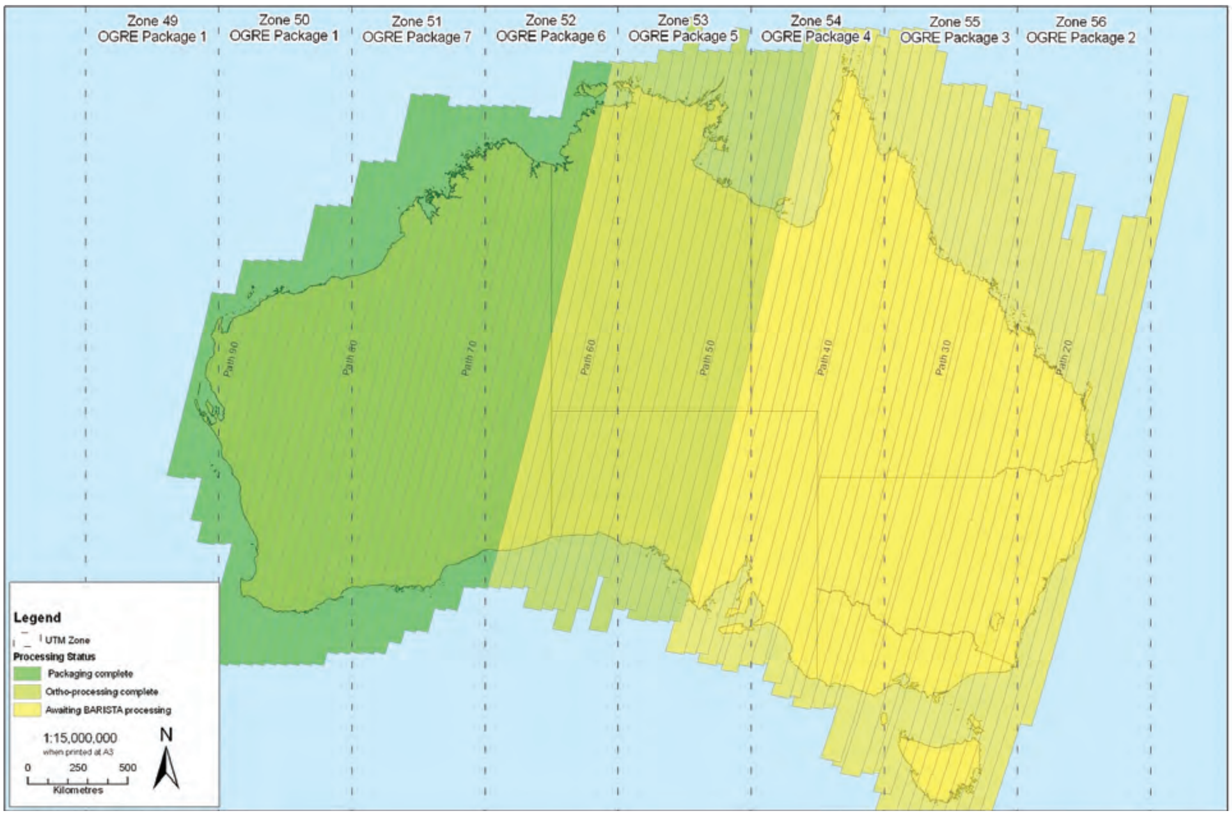


Figure 22: Building AGRI using full path processing of ALOS data using Barista.

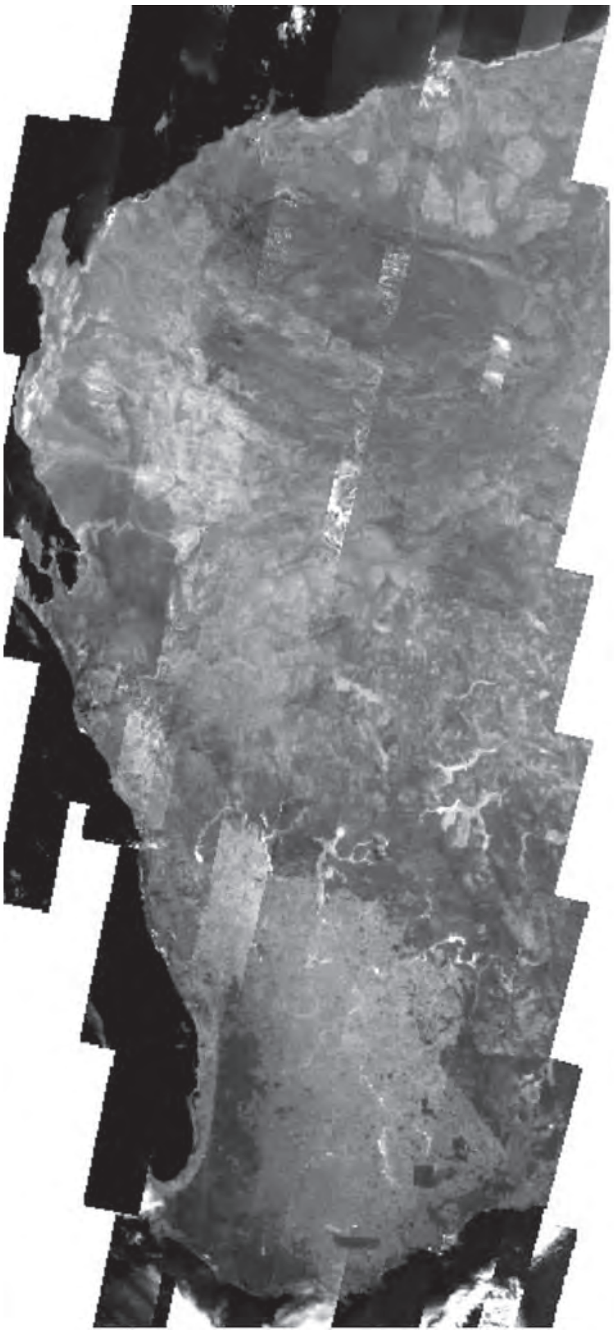


Figure 23: Part of AGRI mosaic Zone 50 UTM Western Australia.

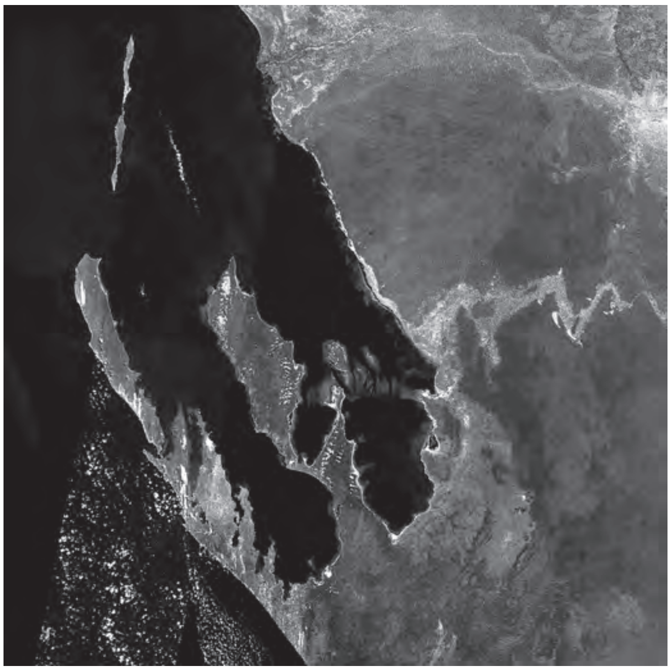


Figure 24: Part of AGRI mosaic Shark Bay Western Australia.

RESEARCH DEVELOPMENTS 2010

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

CSIRO

Edward King

TERN/AusCover

AusCover is the remote sensing facility of the NCRIS Terrestrial Ecosystems Research Network and is a partnership of 10+ agencies and institutions, led by CSIRO, with the common goal of providing Australian biophysical remote sensing data time-series and continental map products. AusCover commenced development in 2010 and is working to develop improved data access and processing systems, and coordinated Cal/Val activities for better Australian products.

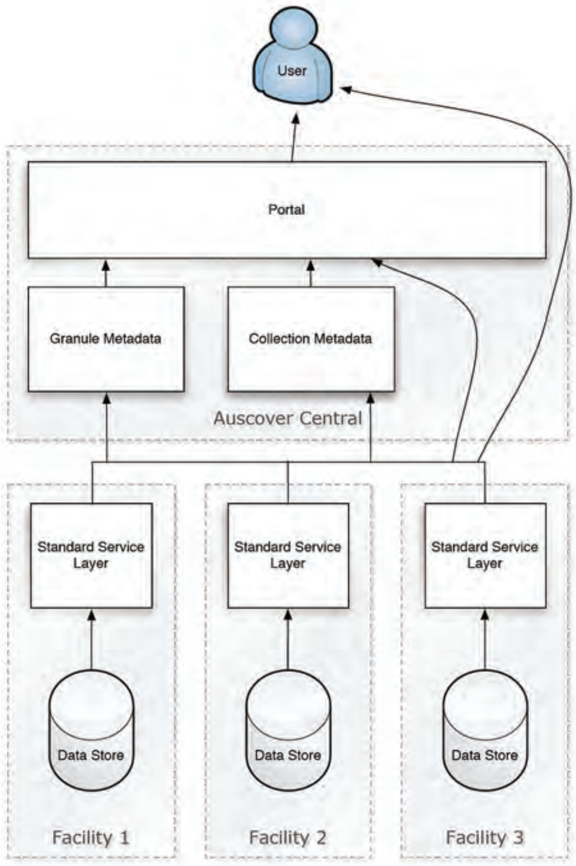


Figure 1: Distributed node design adopted by AusCover.

The development of a data storage and access system for national data sets underpins the AusCover deployment plan. The data systems team is led by CMAR in close partnership with Curtin University. The model adopted is that of a distributed data system with data exposed via open standards-based protocols and unified via a central portal that will provide search and discovery capabilities (Figure 1). Currently nodes are located at iVEC in Perth, the Bureau and VPAC in Melbourne, CSIRO and the NCI in Canberra, with another node at the University of Queensland imminent. Future nodes are planned for both Adelaide and Sydney (Figure 2).

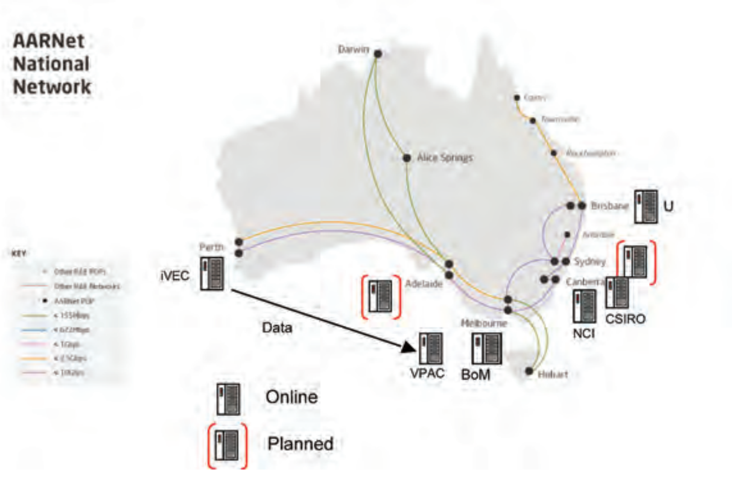
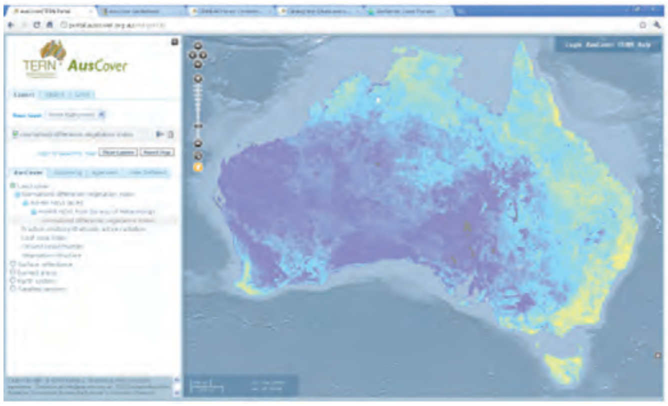


Figure 2: Location of data nodes in AusCover.

The central portal will maintain a searchable catalogue of metadata describing data sets held by AusCover. Where practical, indexes of individual scenes within data sets will be populated to enable fine grained searching by researchers. The portal itself is based on that developed for "Integrated Marine Observing System (IMOS)" which provides tight integration with the metadata search engine (the opensource Geonetworks) and the ability to visualise data layers (Figure 3.).



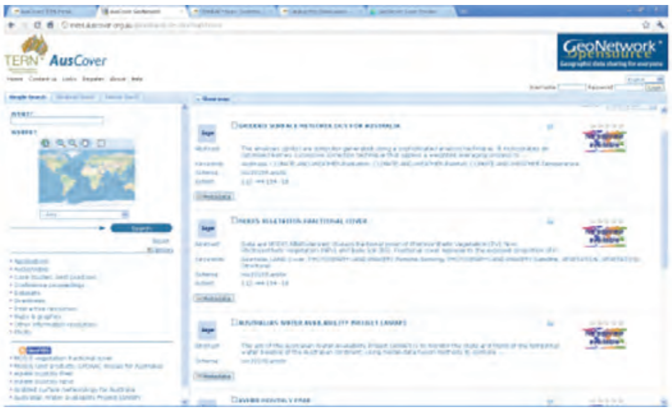


Figure 3: The AusCover portal (left) enables visualisation of multiple map layers and is tightly integrated with the Geonetworks metadata catalogue (right).

With the support of the National eResearch Architecture Taskforce (NeAT), and under the auspices of AusCover, CSIRO and Curtin University researchers are developing a workflow system for processing satellite data within the national computing grid. The aim of this system is to provide a relatively simple web-based interface to remote sensing processing tools to improve access to researchers who are not remote sensing specialists. By providing a means to codify multi-step processes, this system will also make it easier to consistently produce long time series data sets with accurate provenance metadata. While initially focussed on AusCover and MODIS, it is planned that this system will also support AVHRR processing and be applicable to processing streams for marine applications.

2010 also sees the creation of a new IMOS/SRS sub-facility, led by CSIRO Land & Water, to improve Ocean Colour products for the Australasian region. The three main activities in this sub-facility are:

- Creation of a bio-optical database of in-situ measurements for Australian waters to improve retrieval algorithm development;
- Deployment of radiometers on (research) ships of opportunity to better characterise open water ocean colour on an ongoing basis; and
- Establishment of a time series production system for ocean colour.

IMOS SATELLITE REMOTE SENSING

The Satellite Remote Sensing (SRS) facility within the Integrated Marine Observing System continues to sustain and develop improved data products for marine applications using WASTAC data.

The NOAA/AVHRR stitching system developed by CSIRO several years ago to support the Bureau's Sea Surface Temperature IMOS sub-facility continues to operate. It combines data from reception stations all round Australia to produce high quality overpasses which are made immediately available to the user community via the Internet. Although hosted within a CSIRO research environment, the system effectively runs operationally and has done so for the past two years. It produces approximately 40 combined overpasses per day, utilising about 145 individual acquisitions, 45 of which are derived from one of the two WASTAC sites in Perth. These data are also being taken up by AusCover to produce terrestrial products.

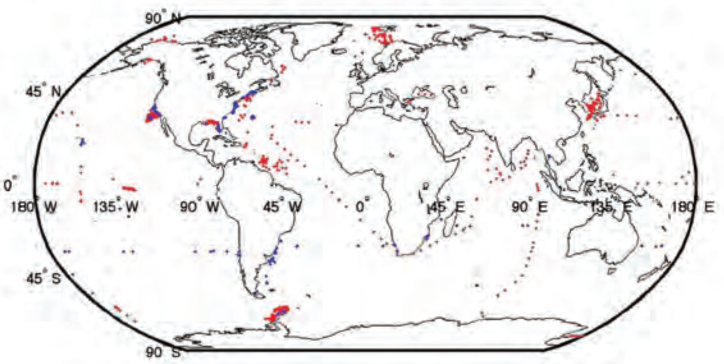


Figure 4: Geographic distribution of ocean colour validation data clearly indicating the need for improved Cal/Val data around Australia (from Moore et. al., RSE 113, 2009)

The database will contain bio-optical and in situ optical data collected by the Australian research community since 1997 and will seek to address the scarcity of validation data in the region (Figure 4). It will underpin the assessment of ocean colour products in the Australian region and be contributed to international space agencies to support the development of global algorithms with improved performance in Australian conditions.

Two spectro-radiometers are to be deployed on research vessels to acquire continuous measurements of the water leaving radiance in the Australian sector of the Indian, Pacific and Southern Oceans. These systems will provide ongoing Cal/Val for the open ocean to support the development of ocean colour products used for research into bio-geochemical modelling.

The ocean colour time series production system has already been described . It will initially provide processing for MODIS data followed later by SeaWIFS data. It is hoped that it will also provide a framework within which a national approach can be taken to managing data from the follow-on VIIRS sensor when NPP is launched in late 2011 or early 2012. WASTAC is one of the only sites currently equipped to receive these data.

Although the initial focus is on blue water ocean, the database and time series production system will both eventually support work in shallow and optically complex waters. In common with all IMOS data, all the Cal/Val data and ocean colour time series produced by this sub-facility will be freely available for research use.

References:

Timothy S. Moore, Janet W. Campbell, Mark D. Dowell, A class-based approach to characterizing and mapping the uncertainty of the MODIS ocean chlorophyll product, Remote Sensing of Environment, Volume 113, Issue 11, 16 November 2009, Pages 2424-2430, ISSN 0034-4257, 10.1016/j.rse.2009.07.016.

CURTIN UNIVERSITY OF TECHNOLOGY

Remote Sensing and Satellite Research Group

COMPARATIVE APPROACHES TO THE REMOTE SENSING OF DUST STORMS

Mark Broomhall

The advection of mineral dust has implications for crop lands, radiative forcing and public health. Satellite imagery is the only effective way to monitor dust storm events in remote regions and on a national or international basis.

Three detection algorithms which use MODIS data have been implemented within the new RS-YABI remote sensing workflow system. The dust plumes which streak these images from North west to South east are not readily identified in the true-colour image in Figure 5. Figure 6 shows the result of subtracting the temperature derived from one thermal infrared band from another. The algorithms that produce Figures 7 and 8 combine ratios of reflectance bands with the temperature difference in Figure 6 to provide further discrimination between dust, background surface, cloud and water.

Work to date suggests that there is not a single algorithm which performs best on every occasion Therefore running an ensemble of algorithms to generate a dust mask gives the greatest chance of identifying a dust event.

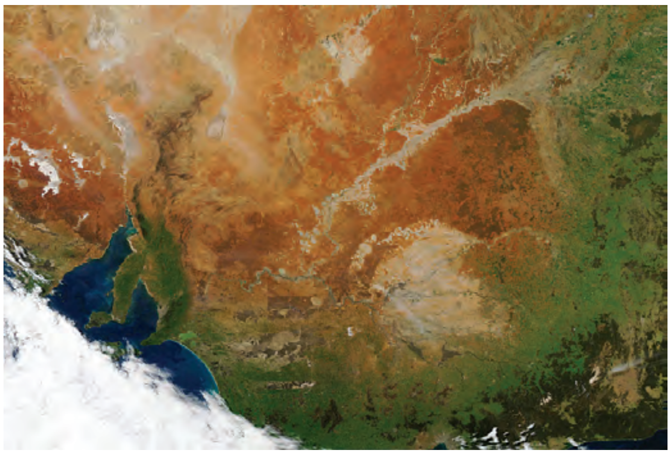


Figure 5: MODIS true colour image.

REMOTE SENSING DATA PROCESSING ON HIGH PERFORMANCE COMPUTING SYSTEMS IN A WORKFLOWS ENVIRONMENT.

Peter Fearns[1], Merv Lynch[1] , Helen Chedzey[1], Mark Broomhall[1], Edward King[2], Ziyuan Wang[2], Glenelg Smith[2]
[1] Remote Sensing and Satellite Research Group, Curtin University
[2] CSIRO Marine and Atmospheric Research

The National eResearch Architecture Taskforce (NeAT) funded an 18 month project to help enable researchers to process remote sensing data sets using the ARCS grid (or cloud) computing infrastructure or other High Performance Computing (HPC) resources that they have available. The intent was to hide the complexity of the underlying processing environment behind a straightforward user interface. The interface is based on the YABI workflows system developed by the Centre for Comparative Genomics at Murdoch University. The interface allows end users to customise their own workflow to process MODIS data from L0 to produce a suite of geophysical products and deliver data or images in various formats (Figure. 9). The NeAT project supported Curtin University and CSIRO Marine and Atmospheric Research staff to develop the Remote Sensing YABI (RS-YABI) system. This new system has been demonstrated to researchers from the WA Museum, Dept. of Environment and Conservation, Dept. of Food and Agriculture, and Fisheries WA. Output data included MOD14 fire products, suspended sediment, sea surface temperature, and chlorophyll concentration in formats including HDF, CSV, shape file and numerous image formats. Figure. 10 shows an example of different workflow paths available in RS-YABI.

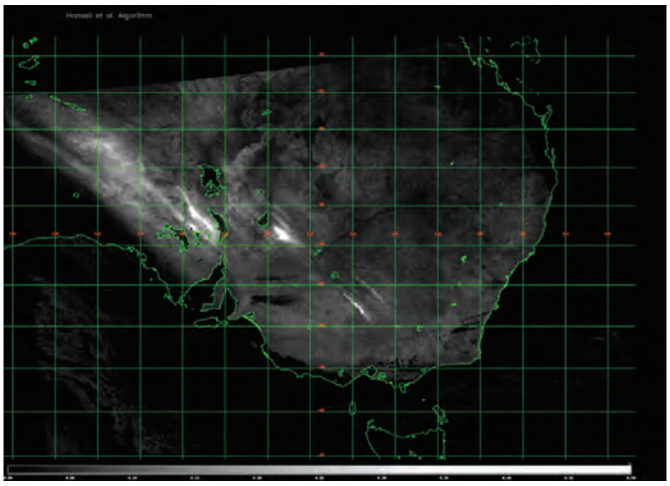


Figure 6: Dust plumes as a result of subtracting the temperature derived from one thermal infrared band from another.

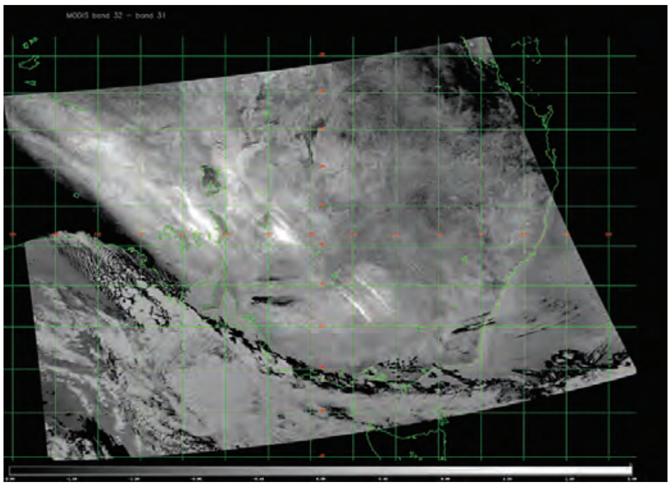


Figure 7: Ratios of reflectance bands with the temperature difference in Figure 6.

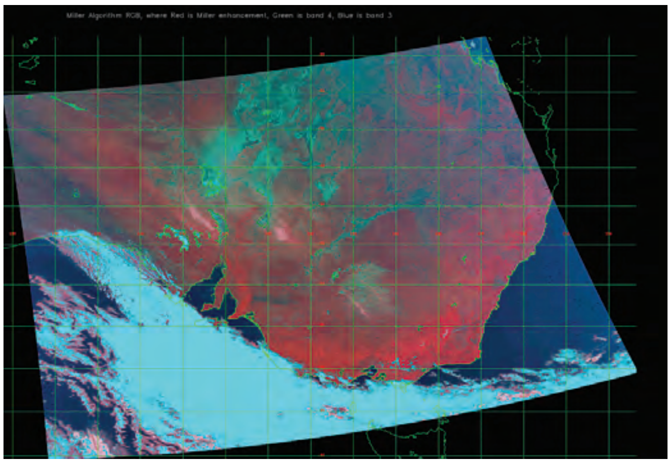


Figure 8: A different ratio of reflectance bands with the temperature difference in Figure 6.

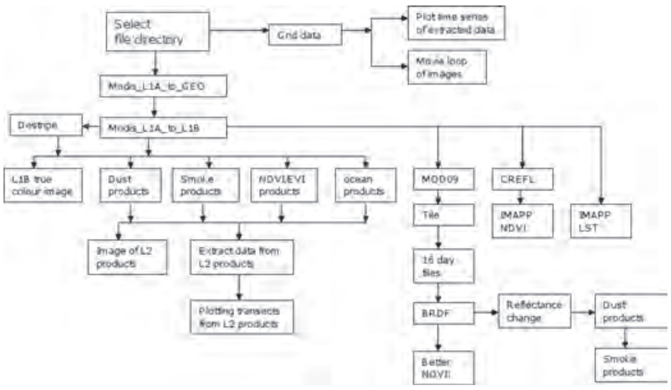


Figure 9: Users can customise their own workflows to process MODIS data

TERN/AUSCOVER – REMOTE SENSING DATA MANAGEMENT FOR TERRESTRIAL ECOSYSTEM RESEARCH

Mark Gray, Peter Fearns and Merv Lynch

The RSSRG at Curtin University and Landgate are leveraging WASTAC data to help AusCover build national satellite data products for distribution to the Australian research community. AusCover is a component organisation of the Terrestrial Ecosystem Research Network (TERN) and is tasked with the production of ecosystem science data products designed for Australian conditions. AusCover is a collaborative organization with nodes in each state and is coordinated by CSIRO's Marine and Atmospheric Research Division.

A primary responsibility under AusCover is the development of an atmospherically corrected national land surface MODIS time series dataset which can be used for product derivation and land and vegetation analysis by interested researchers. This product uses the Simple Method for Atmospheric Correction (SMAC) and will be extended to a Bidirectional Reflectance Distribution Function (BRDF) corrected reflectance data time series. Preliminary implementation of this algorithm is made available by Landgate as part of the RSSRG-Landgate partnership in the WA node of AusCover node.

AusCover data facilities will provide easy access to these (and other) remote sensing data products through the AusCover Distributed Data Archive and Access Capability (DAAC). RSSRG staff are actively collaborating in the design and implementation of this system with particular reference to whole-of-system metadata management and data export functionality for the Geographical Information Systems user community.

The AusCover SMAC MODIS (ASM) product currently being produced operationally at iVec for AusCover is available for validation purposes (example imagery, Figure 11).

Early comparison of the ASM results with MOD09 reflectance shows good agreement (Figure 12), although limited validation data is currently available. Further validation of MODIS reflectance (both SMAC and BRDF corrected) will be undertaken at RSSRG for AusCover as resources and facilities permit. Very preliminary work is underway to scope the construction of a 4m diameter goniometer in order to build a rigorous BRDF validation data set.

Figure 10: An example of different workflow paths available in RS-YABI.

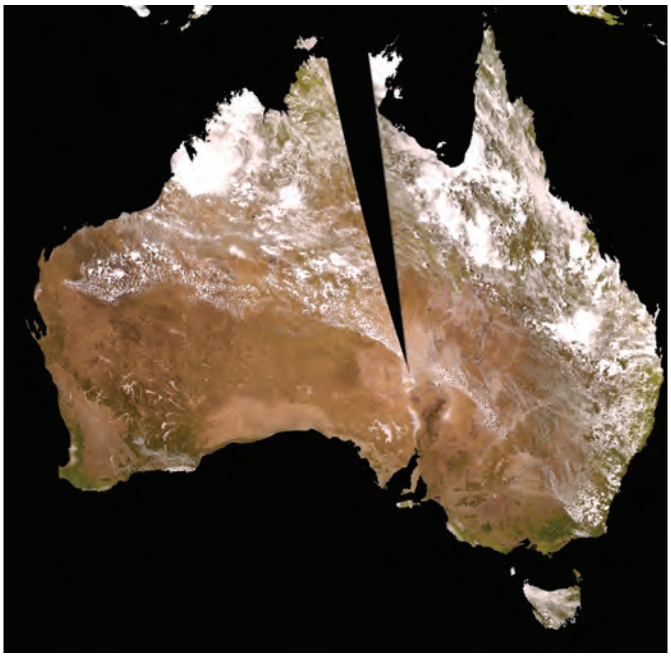


Figure 11: Example AusCover SMAC MODIS continental image for MODIS bands 1,4,3.

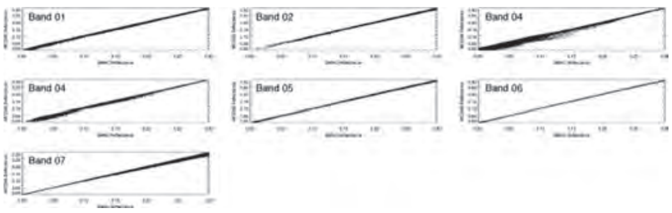


Figure 12: SMAC vs MOD09 comparison for Terra MODIS bottom of atmosphere reflectance bands 1-7. Scene processed with identical ancillary fields.

SMOKE PLUME PRODUCTS FROM THE MODERATE RESOLUTION IMAGING SPECTRORADIOMETER (MODIS)

Helen Chedzey [1], Mark Broomhall [1], Rodrigo Garcia [1], Peter Fearns [1], Mervyn Lynch [1], Edward King [3], Ziyuan Wang [2], Glenelg Smith [3]

[1] Curtin University, Perth, WA, Australia
[2] CSIRO Marine and Atmospheric Research, Canberra, ACT, Australia
[3] CSIRO Marine and Atmospheric Research, Hobart, TAS, Australia

During 2010, a collaboration between the Curtin Remote Sensing and Satellite Research Group, CSIRO and Murdoch University designed a remote sensing workflow system that can access and process on-demand, parts of the large, existing WASTAC satellite data archive. One of the many products made available in the workflow system is a smoke plume product. The smoke detection algorithm aims to differentiate bushfire derived particulates from other scene elements in a satellite image. Various threshold tests are used based on specific spectral bands that are sensitive to the presence of scene elements such as smoke, cloud, bright surface features, vegetation or water.

Preliminary work established a usable method but performance over some land features and discrimination with some clouds was poor and adequately detecting thin smoke was also an issue. Currently, every scene benefits from individual tuning of the test thresholds (Figure 13). Further testing is being conducted to devise a more robust automated detection scheme.

Figure 13 : (top) A true colour image taken from MODIS Terra on the 19th January 2005 (0255 UTC) showing the Pickering Brook bushfire smoke plume drift over the ocean before returning to pass over land. (bottom) A true colour image with the individually tuned, multi-threshold tested smoke plume mask overlaid in red.

LANDGATE SATELLITE REMOTE SENSING SERVICES, FLOREAT

USING TIME SERIES OF MULTISPECTRAL DATA TO MONITOR FOREST CHANGES

Mario Ferri & Brendon McAtee

The aim of this study is the development of remote sensing techniques for:

1. monitoring forest health, and
2. the early detection of forest decline due to drought impacts.

The results presented here are based on time series of the Normalised Difference Infrared Index (NDII). For surface reflectances from MODIS bands 2 and 6 ; NDII = $(R_2-R_6)/(R_2+R_6)$

The NDII may similarly be calculated for Landsat TM where Band 4 is used in place of MODIS Band 2 and TM Band 5 in place of MODIS Band 6, as in Figure 14.The NDII is a good indicator for vegetation liquid water since the amount of water available in the internal leaf structure controls the reflectance in the infrared. The NDII also exhibits a quicker response to drought conditions than other similar indices.

For this study we parameterised the NDII time series as

$$NDII = a \cdot \sin(2\pi t/T + \varphi) + (b + c \cdot t)$$

which describes the combination of the seasonal growth cycle of the forest with a linear trend superimposed upon it representing increase or decrease in health. We then analysed the parameters within the analytical description of the NDII to see which parameters may be useful predictors of forest decline.

Figure 14 shows a time series of the intercept (b) for a plantation pine forest east of Perth at Landsat scale where drought impacts have been recorded. In the Figure the time series of b is plotted for pixel number 16 in the matrix at the top right. Pixels in the matrix are colour coded to show decline and improvement. Here green is improvement and brown represents decline. Pixel 16 is brown since the time series show b to be significantly decreasing.

Such a pixel map tracks forest health and we believe the nature of the time series of b contains enough information to predict drought related forest decline early enough to allow for management intervention to preserve the forest integrity.

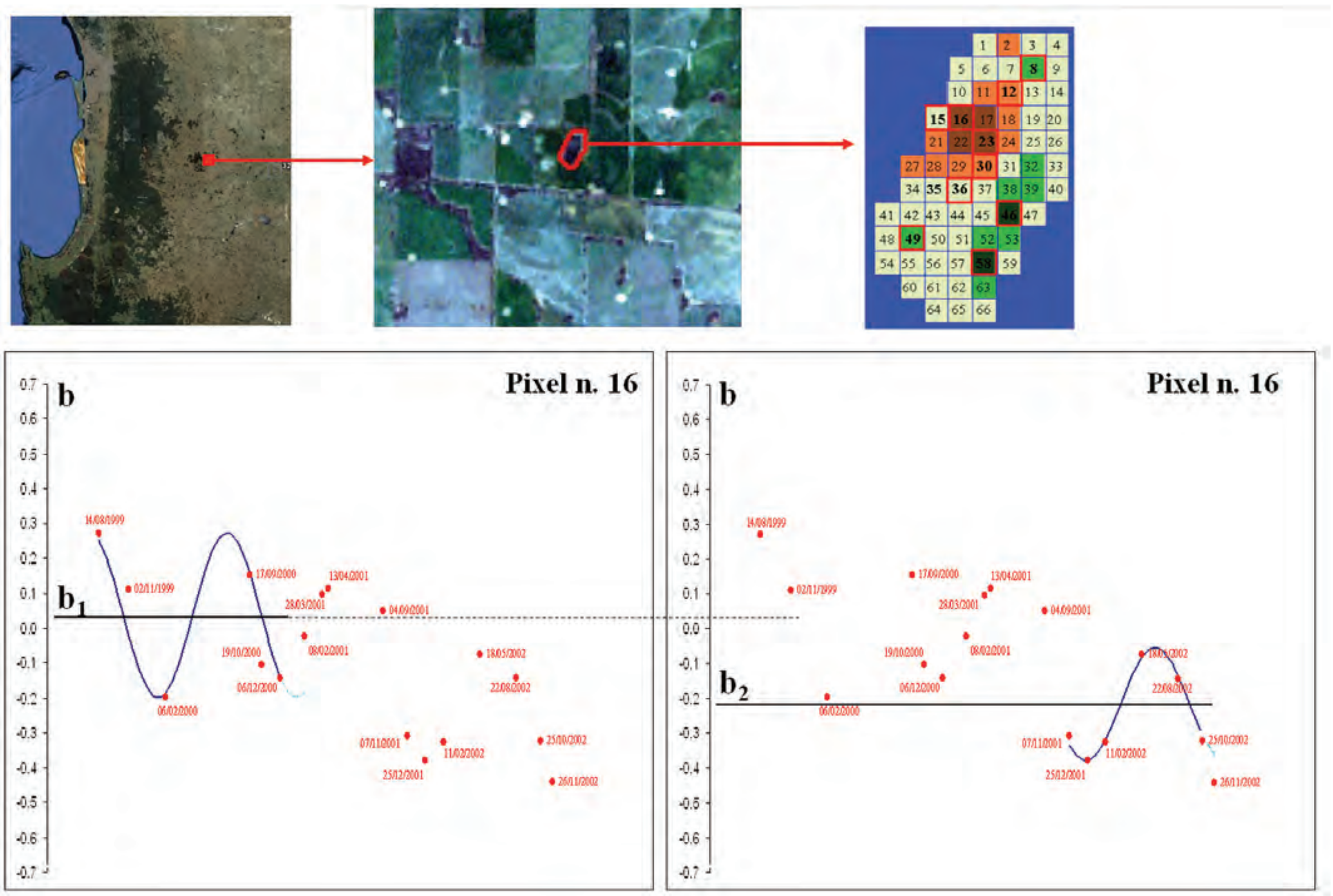


Figure 14: Depiction of forest health tracking based on NDII. The top images show a plantation pine field site and the health of trees within the site in matrix form based on the time series of b. The graphs below show the time series of b from which the matrix is derived.

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM
L – BAND

STATEMENT BY THE BOARD

In the opinion of the Board, the financial statements as set out on pages 6 to 12; is a special purpose financial report and has been prepared in accordance with the accounting policies described in Note 1 to the financial statements and;

1. presents fairly the financial position of the Western Australian Satellite Technology and Application Consortium – L band as at 31 December 2010 and the results and statement of cash flows of the Western Australian Satellite Technology And Application of Consortium for the year ended on that date; and

2. at the date of this statement there are reasonable grounds to believe that Western Australian Satellite Technology And Application of Consortium – L Band will be able to pay its debts as and when they fall due.

This statement is made and signed for and on behalf of the Board:

Prof Mervyn Lynch
Chairman

Richard Stovold
Secretary

Dated this day 3rd MAY of 2011.

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INDEPENDENT AUDITORS' REPORT

To The Members of the Board

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM - L BAND

We have audited the accompanying financial report, being a special purpose financial report, of the Western Australian Satellite Technology and Application Consortium – L Band which comprises the statement of financial position as at 31 December 2010, the statement of comprehensive income, statement of cash flows and statement of changes in equity for the period ended 31 December 2010, notes comprising a summary of significant accounting policies and other explanatory information and the Board's statement.

Officer's Responsibility for the Financial Report

The Board of the Western Australian Satellite Technology and Application Consortium – L Band is responsible for the preparation of the financial report information and has determined that the basis of preparation of this information described in Note 1, is appropriate to meet the reporting requirements of the Western Australian Satellite Technology and Application Consortium – L Band as per the existing joint venture agreement. The Board's responsibility also includes the establishment of internal control as the Board determines is necessary to enable the preparation of a financial report that is free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on the financial report based on our audit. We have conducted our audit in accordance with Australian Auditing Standards. Those standards require that we comply with relevant ethical requirements relating to audit engagements and plan and perform the audit to obtain reasonable assurance whether the financial report is free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial report. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial report, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to Western Australian Satellite Technology and Application Consortium – L Band's preparation of the financial report, in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control.

An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made, as well as evaluating the overall presentation of the financial report.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion, the financial report presents fairly, in all material respects, the financial position of Western Australian Satellite Technology and Application Consortium – L Band as at 31 December 2010 and its financial performance for the period then ended.

Emphasis of Matter

Without modifying our opinion, we draw attention to Note 1 to the financial report, which describes the basis of accounting. The financial report has been prepared to assist the Board and the joint venture participants of the Western Australian Satellite Technology and Application Consortium – L Band to meet the reporting requirements. As a result, the financial report may not be suitable for another purpose and should not be distributed to or used by parties other than the Board members and joint venture participants.

Santo Casilli CPA

Date: 18 April 2011

Perth

WASTAC L-BAND BUDGET 2010

Estimated expenditure for the year January 2010 – December 2010

		$ 2009	$ 2010
1.	Data Tapes	2000	2000
2.	System maintenance/repairs	5000	5000
3.	Telecommunications license of facility	3500	5000
4.	Consultants	5000	5000
5.	Sundry consumables	1500	1500
6.	Traveling – Airfares	3000	3000
7.	Provision for major equipment	12000	12000
8.	Annual Report	10000	8000
TOTAL:		**$42,000**	**$41,500**

Estimated income/revenue for the year January 2010– December 2010

1.	Contributions received ($10,000 each)	40000	40000
2.	Interest	5000	7500
	TOTAL INCOME:	**$45,000**	**$47,500**

Extra-ordinary expenditure January 2010– December 2010

1. **Capital Reserve: No items**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

L-BAND

STATEMENT OF FINANCIAL POSITION AS AT 31 DECEMBER 2010

	NOTE	2010 $	2009 $
CURRENT ASSETS			
Cash at bank		282,622	241,491
Prepayments		3,540	6,885
TOTAL CURRENT ASSETS		286,162	248,375
NON-CURRENT ASSETS			
Property, Plant and Equipment	2	48,031	67,569
TOTAL NON-CURRENT ASSETS		48,031	67,569
TOTAL ASSETS		**334,193**	**315,944**
TOTAL LIABILITIES		**0**	**0**
NET ASSETS		**$334,193**	**$315,944**
ACCUMULATED FUNDS			
Retained Earnings	4	334,193	315,944
TOTAL EQUITY		**$334,193**	**$315,944**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

L-BAND

STATEMENT OF COMPREHENSIVE INCOME FOR THE YEAR ENDED 31 DECEMBER 2010

	NOTE	2010 $	2009 $
Revenue		51,384	48,957
Depreciation expense	2	(19,537)	(19,570)
Equipment maintenance		(5,476)	(6,831)
Hospitality		(870)	(100)
Microwave license		(2,427)	(2,354)
Other operating expenditure		(4,825)	(10,733)
Profit/(Loss) for the year		18,249	9,369
Total other comprehensive income for the year		0	0
Total comprehensive income attributable to the entity		18,249	9,369

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

L-BAND

STATEMENT OF CASH FLOWS FOR THE YEAR ENDED 31 DECEMBER 2010

	NOTE	2010 $ Inflows/ (Outflows)	2009 $ Inflows/ (Outflows)
Cash flows from operating activities:			
Revenue from Contributions	5	40,000	40,000
Interest Received		11,384	8,957
Payments to suppliers		(10,253)	(21,654)
Net cash provided by operating activities	3	41,131	27,303
Cash flows from investing activities			
Payments for property, plant and equipment		0	0
Net cash used in investing activities		0	0
Net increase/ (decrease) in cash held	3	41,131	27,303
Cash at the beginning of the financial year		241,491	214,188
Cash at the end of the financial year		**$ 282,622**	**$ 241,491**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

L-BAND

STATEMENT OF CHANGES IN EQUITY FOR THE PERIOD ENDED 31 DECEMBER 2010

	Retained Earnings $
Balance at 30 June 2008	306,576
Profit/(Loss) attributable to the entity	9,369
Total other comprehensive income	0
Balance at 30 June 2009	315,944
Profit/(Loss) attributable to the entity	18,249
Total other comprehensive income	0
Balance at 31 December 2010	**$334,193**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

L-BAND

NOTES TO THE FINANCIAL STATEMENTS FOR THE FINANCIAL PERIOD ENDED 31 DECEMBER 2010

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 unless otherwise stated.

Basis of Preparation
The Western Australian Satellite Technology and Application Consortium (WASTAC) L Band financial report is a special purpose financial report and has been prepared in accordance with the accounting policies within Note 1 to the financial statements.

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

(a) Valuation of Property, Plant and Equipment

All property, plant and equipment are shown at cost, less subsequent depreciation and if any impairment losses. 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.

Any gains and losses on disposals are determined by comparing the disposal proceeds with the carrying amount and are included in the Statement of Comprehensive Income.

(b) Depreciation of non-current assets

All property, plant and equipment having a limited useful life are depreciated 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:

o Computing equipment 3 years
o 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(c))."

c) Impairment of property, plant and equipment

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 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.

d) Income Tax

The Board considers that its operations are exempt from income tax under the provisions of section 50-25 of the Income Tax Assessment Act (1997) as amended.

e) Goods and Services Tax (GST)

Revenues, expenses and assets are recognised net of the amount of GST, except where the amount of GST is not recoverable from the Australian Taxation Office. In these instances the GST is recognised as part of the cost of acquisition of the asset or as part of an item of the expense.

f) Income Recognition

The Board recognises income as it is received. All income is stated net of the amount of goods and services tax (GST). Interest is recognised on the effective interest rate method calculated by Curtin University on the cash at bank balances of the Curtin University main bank account and attributed twice yearly to the X Band project account.

2. Property, Plant and Equipment

	2010 $	2009 $
Computer Equipment		
At cost	151,468	151,468
Accumulated Depreciation	(141,788)	(130,056)
	9,680	21,413
Other Equipment		
At cost	222,086	222,806
Accumulated Depreciation	(184,455)	(176,650)
	38,381	46,156
Total Property, Plant and Equipment	**48,031**	**67,569**

Reconciliations

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

	Computer Equipment	Other Equipment	Total
Carrying amount at start of year	21,413	46,156	67,569
Depreciation expense	(11,732)	(7,805)	(19,537)
Carrying amount at end of year	9,681	38,351	48,031

3. Notes to the Cash Flow Statement

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

	2010 $	2009 $
Net operating result	18,249	9,369
Depreciation expense	19,537	19,570
Movement in Current Assets	3,345	(1,635)
Net cash provided/(used) by operating activities	**41,131**	**27,303**

4. Retained Earnings

Balance at beginning of the year	315,944	306,575
Operating surplus/(deficit) for the year	18,249	9,369
Balance at end of the year	**334,193**	**315,944**

5. Receipts

Contributions Received:

Landgate	10,000	10,000
CSIRO	10,000	10,000
Bureau of Meteorology	10,000	10,000
Curtin University	10,000	10,000
Balance at end of the year	**40,000**	**40,000**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONCONSORTIUM

X – BAND

STATEMENT BY THE BOARD

In the opinion of the Board, the financial statements as set out on pages 6 to 12; is a special purpose financial report and has been prepared in accordance with the accounting policies described in Note 1 to the financial statements and;

1. presents fairly the financial position of the Western Australian Satellite Technology and Application Consortium – X band as at 31 December 2010 and the results and statement of cash flows of the Western Australian Satellite Technology And Application of Consortium for the year ended on that date; and

2. at the date of this statement there are reasonable grounds to believe that Western Australian Satellite Technology And Application of Consortium – X Band will be able to pay its debts as and when they fall due.

This statement is made and signed for and on behalf of the Board:

Prof Mervyn Lynch
Chairman

Richard Stovold
Secretary

Dated this day ...2 April...of 2011.

Liability limited by a scheme approved under Professional Standards Legislation.

COVER OF EXCELLENCE

SANTO CASILLI
Accounting and Auditing Services
Certified Practising Accountant

CPA
Santo Casilli Accounting and Auditing Services is a CPA Practice

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INDEPENDENT AUDITORS' REPORT

To The Members of the Board

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM - X BAND

We have audited the accompanying financial report, being a special purpose financial report, of the Western Australian Satellite Technology and Application Consortium – X Band which comprises the statement of financial position as at 31 December 2010, the statement of comprehensive income, statement of cash flows and statement of changes in equity for the period ended 31 December 2010, notes comprising a summary of significant accounting policies and other explanatory information and the Board's statement.

Officer's Responsibility for the Financial Report

The Board of the Western Australian Satellite Technology and Application Consortium – X Band is responsible for the preparation of the financial report information and has determined that the basis of preparation of this information described in Note 1, is appropriate to meet the reporting requirements of the Western Australian Satellite Technology and Application Consortium – X Band as per the existing joint venture agreement. The Board's responsibility also includes the establishment of internal control as the Board determines is necessary to enable the preparation of a financial report that is free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on the financial report based on our audit. We have conducted our audit in accordance with Australian Auditing Standards. Those standards require that we comply with relevant ethical requirements relating to audit engagements and plan and perform the audit to obtain reasonable assurance whether the financial report is free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial report. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial report, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to Western Australian Satellite Technology and Application Consortium – X Band's preparation of the financial report, in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control.

An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made, as well as evaluating the overall presentation of the financial report.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion, the financial report presents fairly, in all material respects, the financial position of Western Australian Satellite Technology and Application Consortium – X Band as at 31 December 2010 and its financial performance for the period then ended.

Emphasis of Matter

Without modifying our opinion, we draw attention to Note 1 to the financial report, which describes the basis of accounting. The financial report has been prepared to assist the Board and the joint venture participants of the Western Australian Satellite Technology and Application Consortium – X Band to meet the reporting requirements. As a result, the financial report may not be suitable for another purpose and should not be distributed to or used by parties other than the Board members and joint venture participants.

Santo Casilli CPA

Date: 2 April

Perth

WASTAC X- Band BUDGET 2010

Estimated expenditure for the year January 2010 – December 2010

		$ 2009	$ 2010
1.	Data Tapes	3,000	5,000
2.	System maintenance	15,000	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	6,000
7.	Provision for major equipment	255,000	125,000
	TOTAL	**$307,000**	**$177,000**

Estimated income/revenue for the year January 2010 – December 2010

1.	Annual Contributions $20,000 each	80,000	80,000
2.	Interest	5,000	10,000
	TOTAL INCOME	**$85,000**	**$90,000**

Additional committed expenditure January 2010– December 2010

1.	Microwave Murdoch to BoM	85,000	85,000
	TOTAL	**$85,000**	**$85,000**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

X-BAND

STATEMENT OF FINANCIAL POSITION AS AT 31 DECEMBER 2010

	NOTE	2010 $	2009 $
CURRENT ASSETS			
Cash at bank		434,045	337,085
TOTAL CURRENT ASSETS		434,045	337,085
NON-CURRENT ASSETS			
Property, Plant and Equipment	2	39,236	53,492
TOTAL NON-CURRENT ASSETS		39,236	53,492
TOTAL ASSETS		**39,236**	**53,492**
TOTAL LIABILITIES			
NET ASSETS		**$473,281**	**$390,577**
ACCUMULATED FUNDS			
Retained Earnings	4	473,281	390,577
TOTAL EQUITY		**$473,281**	**$390,577**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

X-BAND

STATEMENT OF COMPREHENSIVE INCOME FOR THE YEAR ENDED 31 DECEMBER 2010

	NOTE	2010 $	2009 $
Revenue		96,839	93,008
Depreciation expense	2	(14,256)	(98,721)
Fringe benefits tax		121	(177)
Hospitality		(0)	(367)
Maintenance		(0)	(145,323)
Profit/(Loss) for the year		82,704	(151,580)
Total other comprehensive income for the year		0	0
Total comprehensive income attributable to the entity		82,704	(151,580)

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

X-BAND

STATEMENT OF CASH FLOWS FOR THE YEAR ENDED 31 DECEMBER 2010

	NOTE	2010	2009
		$	**$**
		Inflows/	Inflows/
		(Outflows)	(Outflows)
Cash flows from operating activities:			
Revenue from Contributions	5	80,000	80,000
Interest Received		16,839	13,008
Payments to suppliers		121	(138,708)
Net cash provided by operating activities	3	96,960	(45,700)
Cash flows from investing activities			
Payments for property, plant and equipment		0	0
Net cash used in investing activities		0	0
Net increase/ (decrease) in cash held	3	96,960	(45,700)
Cash at the beginning of the financial year		337,085	382,785
Cash at the end of the financial year		**$ 434,045**	**$ 337,085**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

X-BAND

STATEMENT OF CHANGES IN EQUITY FOR THE PERIOD ENDED 31 DECEMBER 2010

	Retained Earnings $
Balance at 30 June 2008	542,157
Profit/(Loss) attributable to the entity	(151,580)
Total other comprehensive income	0
Balance at 30 June 2009	390,577
Profit/(Loss) attributable to the entity	82,704
Total other comprehensive income	0
Balance at 31 December 2010	**$473,281**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM

X-BAND

NOTES TO THE FINANCIAL STATEMENTS FOR THE FINANCIAL PERIOD ENDED 31 DECEMBER 2010

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 unless otherwise stated.

Basis of Preparation
The Western Australian Satellite Technology and Application Consortium (WASTAC) X Band financial report is a special purpose financial report and has been prepared in accordance with the accounting policies within Note 1 to the financial statements.

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

(a) Valuation of Property, Plant and Equipment

All property, plant and equipment are shown at cost, less subsequent depreciation and if any impairment losses. 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.

Any gains and losses on disposals are determined by comparing the disposal proceeds with the carrying amount and are included in the Statement of Comprehensive Income.

(b) Depreciation of non-current assets

All property, plant and equipment having a limited useful life are depreciated 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(c))."

c) Impairment of property, plant and equipment

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 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.

d) Income Tax

The Board considers that its operations are exempt from income tax under the provisions of section 50-25 of the Income Tax Assessment Act (1997) as amended.

e) Goods and Services Tax (GST)

Revenues, expenses and assets are recognised net of the amount of GST, except where the amount of GST is not recoverable from the Australian Taxation Office. In these instances the GST is recognised as part of the cost of acquisition of the asset or as part of an item of the expense.

f) Income Recognition

The Board recognises income as it is received. All income is stated net of the amount of goods and services tax (GST). Interest is recognised on the effective interest rate method calculated by Curtin University on the cash at bank balances of the Curtin University main bank account and attributed twice yearly to the X Band project account.

2. Property, Plant and Equipment

	2010 $	2009 $
Computer Equipment		
At cost	14,408	14,408
Accumulated Depreciation	(14,408)	(14,408)
	0	0
Other Equipment		
At cost	789,767	789,767
Accumulated Depreciation	(750,531)	(736,275)
	39,236	53,492
Total Property, Plant and Equipment	**39,236**	**53,492**

Reconciliations

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

	Computer Equipment	Other Equipment	Total
Carrying amount at start of year	-	53,492	53,492
Depreciation expense	-	(14,256)	(14,256)
Carrying amount at end of year	-	39,236	39,236

3. Notes to the Cash Flow Statement

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

	2010 $	2009 $
Net operating result	82,704	(151,580)
Depreciation expense	14,256	98,721
Movement in Current Assets	-	7,159
Net cash provided/(used) by operating activities	**96,960**	**(45,700)**

4. Retained Earnings

Balance at beginning of the year	390,577	542,157
Operating surplus/(deficit) for the year	82,704	(151,580)
Balance at end of the year	**473,281**	**390,577**

5. Receipts

Landgate	20,000	20,000
CSIRO	20,000	20,000
Bureau of Meteorology	20,000	20,000
Geoscience Australia	20,000	20,000
Balance at end of the year	**80,000**	**80,000**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM

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