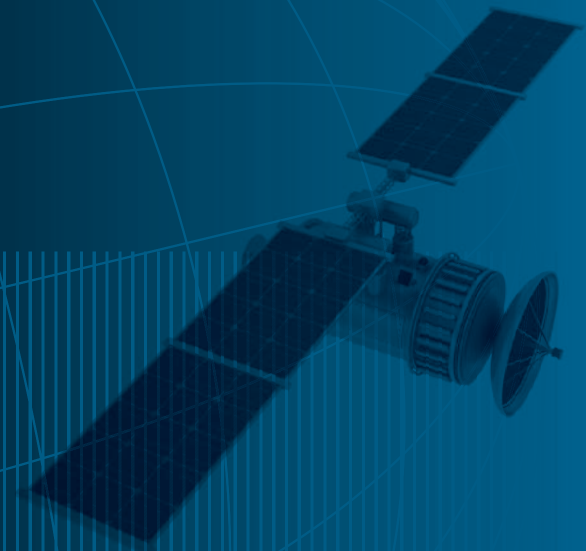
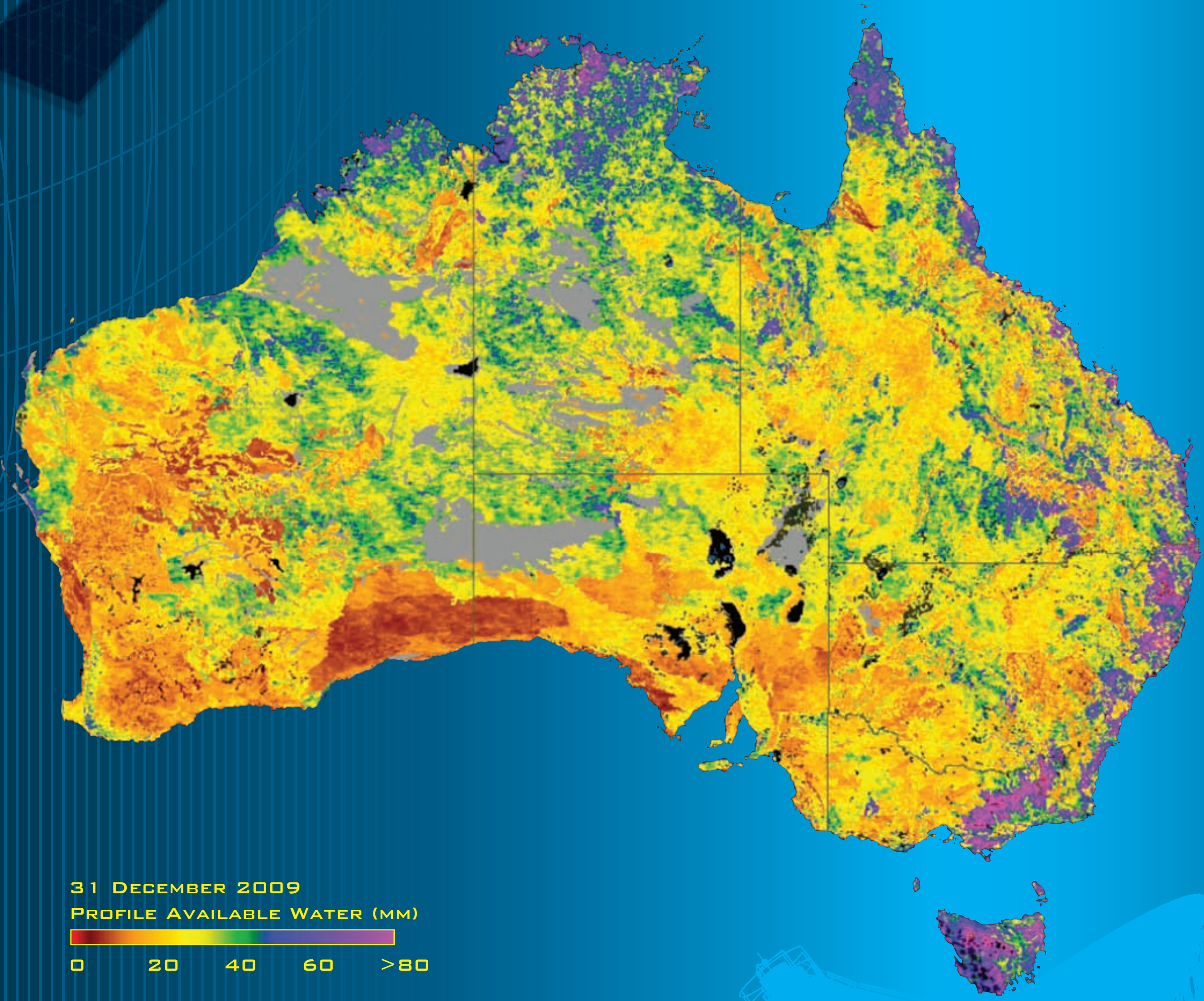
WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM

WASTAC

2009 ANNUAL REPORT





Satellite-Based Monitoring Of Soil Moisture In Australia

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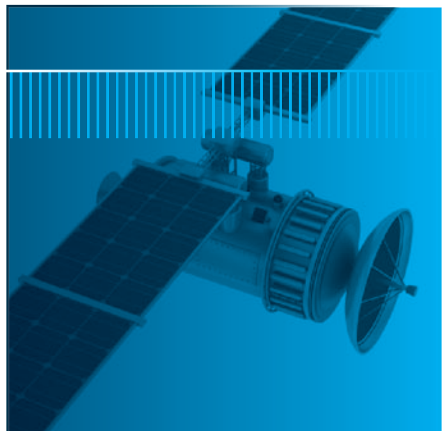
WASTAC MEMBERS



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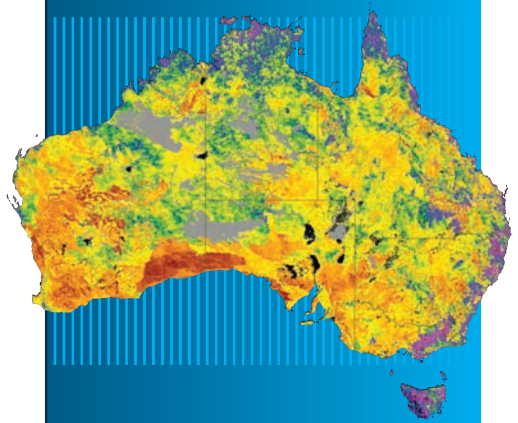

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Front Page:

The Profile Available Water (PAW) reflects the soil capacity to hold water calculated for the soil profile to a depth of 1 meter and expressed as millimetres of water. It can be estimated from the knowledge of the Soil Moisture Saturation Index (SMSI) and soil properties.

The cover image depicts the Profile Available Water at 31 December 2009 from the computed SMSI convoluted with soil data (A-Horizon + B-Horizon). Areas in grey have no soil data. Further details are contained in the Operational Applications section of this report titled "Satellite- Based Monitoring Of Soil Moisture In Australia" by Mario Ferri and Dave Foster.

Notes

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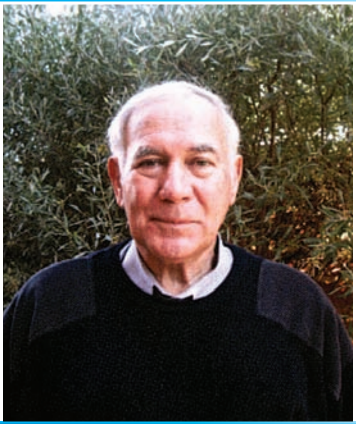
WASTAC CHAIRMANS REPORT



Professor Mervyn Lynch

A number of developments have impacted the deliberations at the WASTAC Board and its Standing Committee in recent times.

WASTAC itself being unincorporated cannot take the lead in responding to national opportunities but with three national and 3 State partners opportunities for collaborative ventures can be canvassed.

A welcome initiative taken by the Australian Government in the 2009-10 budget was the establishment of the Australian Space Policy Unit (ASPU). A total allocation of $48.6 million was appropriated with $40 million to be applied to the Australian Space Research Program (ASRP) over 4 years.

A web-based presentation, http://www.innovation.gov.au/Industry/Space/Documents/Australian_Space_Science_Program.ppt#1 , overviews the role of the ASPU and reveals a broadly-based thrust aimed at stimulating the rather unimpressive role of Australia in space and related technologies over past decades. While the Program also recognises the importance of education and training, the view of the community generally is that the current level of resources will need to ramp up significantly if Australia's role is to make any impact both nationally, in a socio-economic sense, and internationally.

The report, "*Australia's Place in Space: Toward a National Space Policy*" published by the Kokoda Foundation in May 2010 and authored by Biddington and Sach *http://www.kokodafoundation.org.Kokoda-papers* identified both the vulnerability of Australia's dependence on the technologies of others and also stressed the importance of the role of space research and associated technologies be seen as a key part of the Australian national infrastructure. The call to "fast-track" our national capability remains a challenge. It is also true that the neglect of past decades will require some time to consider the most effective way forward, to identify the niche areas and to get the settings right before significant funds are applied.

On the local scene, the Board has been occupied to ensure the security of supply of data to its partners involving the planning of a parallel microwave link (parallel to the AARNET fibre optics link) from the X-band antenna at Murdoch to the Bureau of Meteorology in Perth. There is increasing evidence of locally generated RF interfering with satellite data reception from the Curtin-based antenna. If WASTAC pursues the ACMA recommendation of relocating reception facilities remotely from the City centre, the key concern is the significant data communication cost.

We have seen a significant shift in the international space participation and capability over the last decade. The US space program is still struggling with the LANDSAT and MODIS follow-on missions which are having difficulty getting back on track.
In our region, Australia has shown significant interest in collaboration with both Chinese and Indian space programs with India's Oceansat2 being a recent achievement. It is interesting that the first geostationary ocean colour satellite is being built by Korea and is expected to launch in 2010.

In conclusion, WASTAC continues to function with efficiency and a high level of good will among partners. It would be remiss of me not to pay tribute to the impressive local support that Landgate contributes to the smooth operation of WASTAC and that the Bureau of Meteorology provides in the area of system support and maintenance.

Mervyn J Lynch

Mervyn Lynch
WASTAC Chairman 2009

BOARD MEMBERS 2009

WASTAC BOARD FOR 2009

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 Alan Scott / 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 Alan Scott/Mr Andrew Burton	Bureau of Meteorology
Mr Don Ward	Bureau of Meteorology
Mr Stuart Barr	Geoscience Australia
Professor Tom Lyons	Murdoch University

WASTAC SECRETARY

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

WASTAC TECHNICAL COMMITTEE

Mr Don Ward (Chairman)
Professor Merv Lynch
Dr Doug Myers
Mr Ronald Craig

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 the CSIRO Office of Space Science and Applications (COSSA) 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 SSRS 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.

WASTAC DATA ARCHIVE

The WASTAC archive of NOAA, MODIS and SeaWiFS satellite passes is managed and maintained by Landgate's 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 14,188 NOAA passes were archived at Curtin and Murdoch in 2009. Passes included data from the NOAA 15, 16, 17 ,18 and 19 satellites. NOAA 14 was turned off on 23 May 2007 and NOAA 12 on 10 August 2007. The number of SeaWiFS passes totalled 687.

There were 1411 TERRA, 1327 AQUA and 1132 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.

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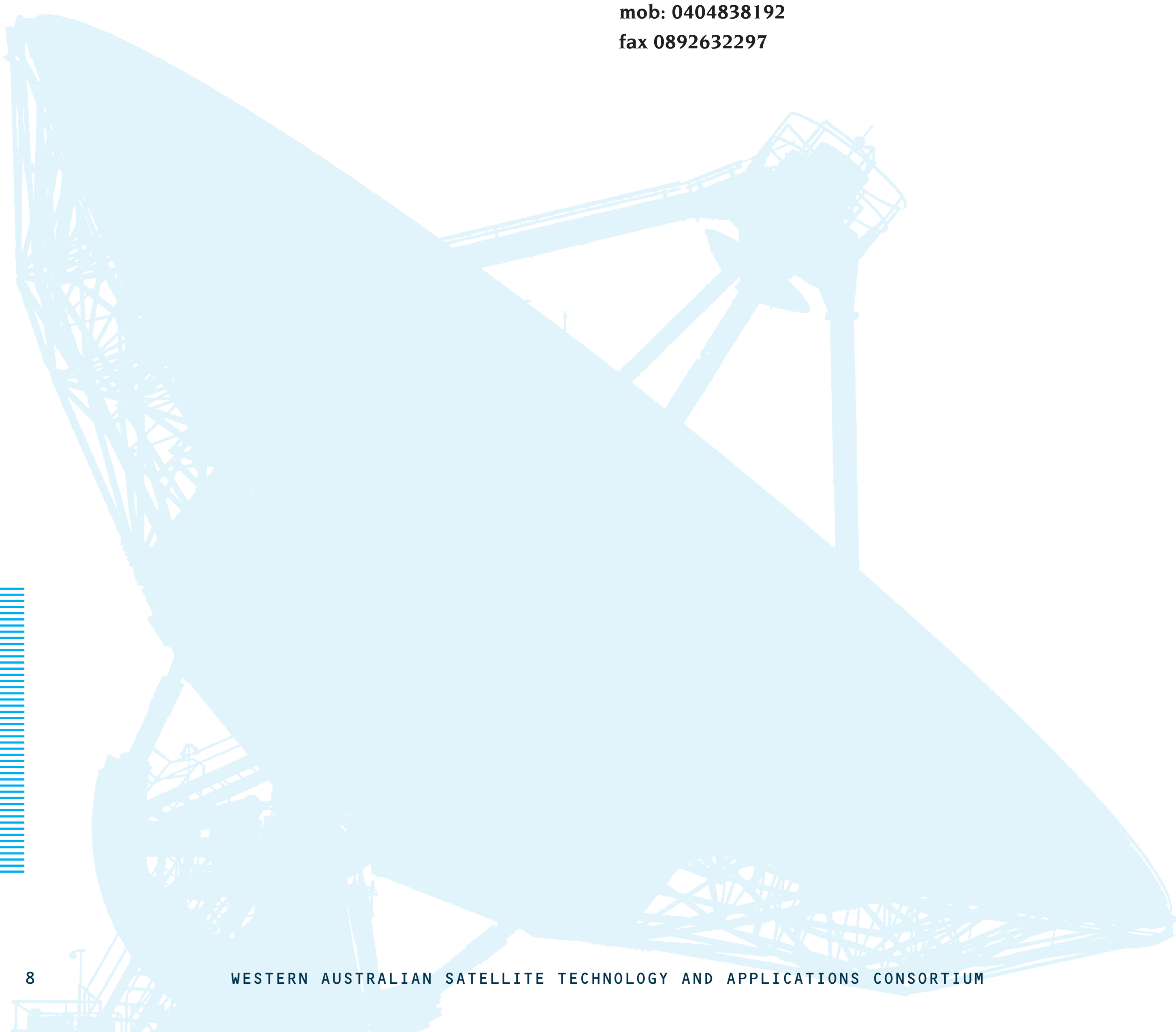
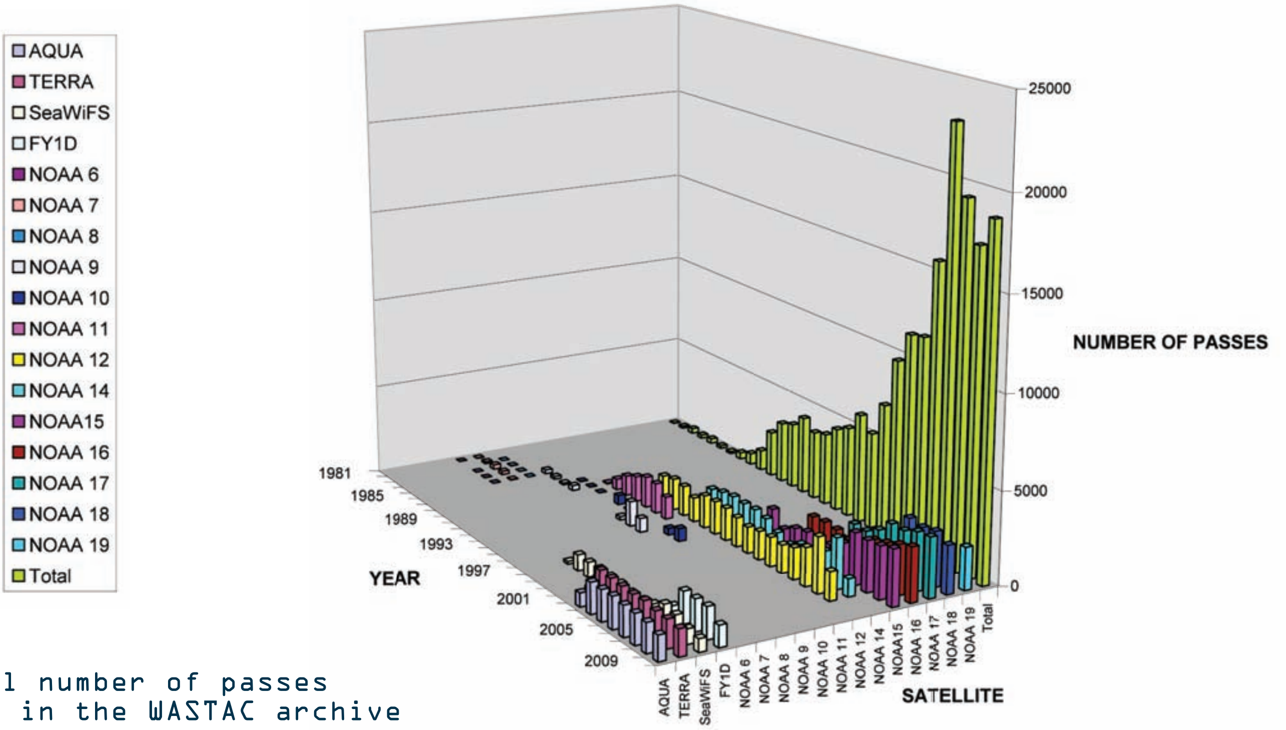
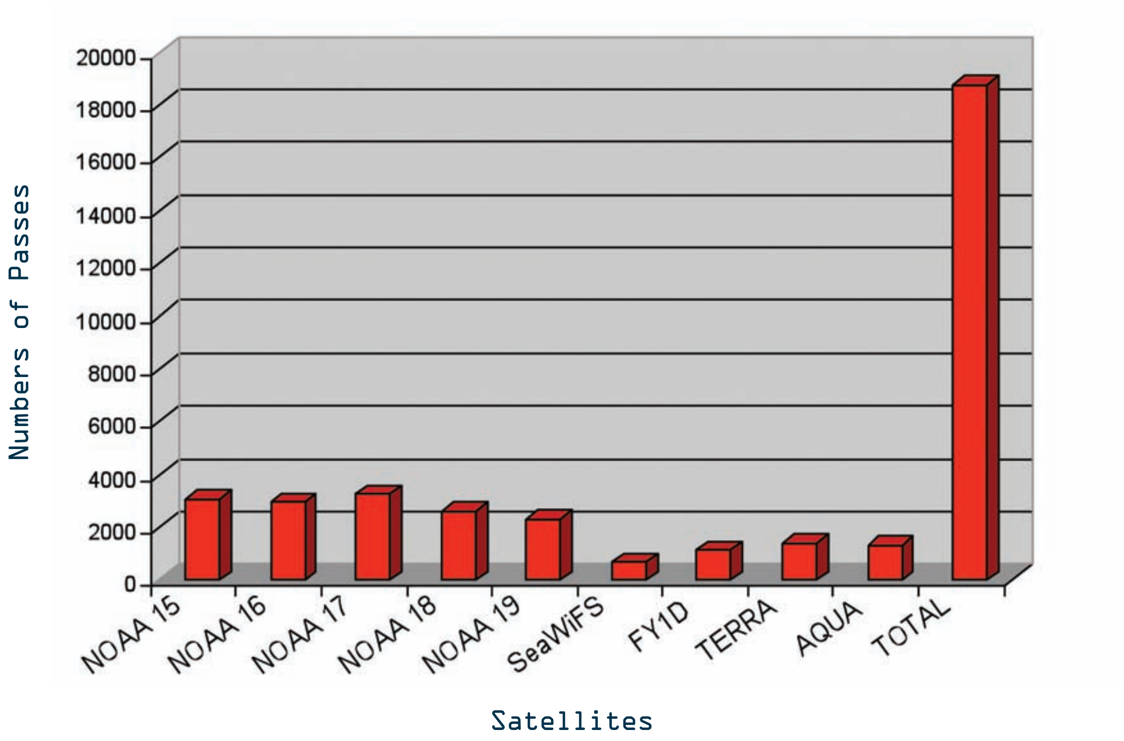




Total number of passes held in the WASTAC archive

	AQUA	TERRA	SeaWiFS	FY1D	NOAA 6	NOAA 7	NOAA 8	NOAA 9	NOAA 10	NOAA 11	NOAA 12	NOAA 14	NOAA15	NOAA 16	NOAA 17	NOAA 18	NOAA 19	Total
1981					5	22												27
1982						115	1											116
1983					12	244	12											268
1984					7	179	4											190
1985					7	33	4	212										256
1986								151										151
1987								97	18									115
1988								280	25	53								358
1989									21	601								622
1990										1103								1103
1991									506	1399	575							2480
1992									47	1693	1571							3311
1993								183		1656	1720							3559
1994								1362		1227	1641							4230
1995								770			1326	1615						3711
1996									354		1780	1776						3910
1997			142						694		1797	1876						4509
1998			859								1763	1828	432					4882
1999			822								1589	1839	1663					5912
2000			843								1427	1681	905	341				5197
2001		390	811								1548	1271	1292	1733				7045
2002	734	1710	780								1579	976	1455	1789	709			9732
2003	1651	1645	696								1521	1351	1200	1728	1827			11388
2004	1665	1602	680								1727	1058	1481	1524	1797			11534
2005	1705	1577	863	553							2101	1706	1904	1743	2212	1339		15703
2006	1635	1639	1239	1683							3030	2761	2823	2240	2883	2989		22922
2007	1615	1512	1092	1678							1571	952	2777	2442	2869	2839		19347
2008	1553	1495	787	1673									2844	2711	3165	2985		17213
2009	1327	1411	687	1132									3055	2951	3254	2622	2306	18745

Archived Satellite Passes for 2009 from Murdoch and Curtin



			NOAA 15	NOAA 16	NOAA 17	NOAA 18	NOAA 19	SeaWiFS	FY1D	TERRA	AQUA	TOTAL
JAN	2009	C	137	100	142	145	-	41				565
		M	126	145	127	109	-	53	93	128	126	907
FEB	2009	C	125	83	133	131	-	53				525
		M	106	141	138	114	53	58	116	7	7	740
MAR	2009	C	135	105	145	149	74	51				659
		M	123	147	137	134	136	65	103	117	64	1026
APR	2009	C	130	101	138	144	106	37				656
		M	115	148	123	117	118	34	79	127	128	989
MAY	2009	C	137	93	144	147	116	-				637
		M	127	163	135	134	140	-	89	134	133	1055
JUN	2009	C	134	95	141	144	114	23				651
		M	116	128	124	114	121	18	84	126	115	946
JUL	2009	C	119	94	133	128	68	17				559
		M	132	162	132	122	126	26	104	132	132	1068
AUG	2009	C	134	100	149	86	69	51				589
		M	117	146	123	81	97	45	96	126	126	957
SEP	2009	C	131	91	139	2	138	2				503
		M	128	157	130	99	37	2	114	128	128	923
OCT	2009	C	136	99	147	13	132	1				528
		M	128	163	135	93	117	1	96	136	130	999
NOV	2009	C	128	98	142	65	143	21				597
		M	126	145	122	89	123	21	85	125	120	956
DEC	2009	C	135	98	146	138	148	32				697
		M	130	149	129	124	130	35	73	125	118	1013
			3055	2951	3254	2622	2306	687	1132	1411	1327	18745

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM

WASTAC

OPERATIONAL APPLICATIONS 2009

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

Edward King

NOAA STITCHING

NOAA HRPT data acquired at both the Curtin and Murdoch reception stations is moved to the CSIRO supercomputing centre located in Melbourne as soon as possible after an overpass is completed (usually 15-20 mins). There it is combined with matching and overlapping data acquired at other Australian reception stations (Alice Springs, Darwin, Hobart, Melbourne and Townsville), to create a single data set spanning the Australian region, including the Southern Ocean. The method used to combine the multiple overpasses is designed to choose between the different data streams to produce a "best quality" output product, a process which eliminates a significant fraction of the transmission and reception noise associated with individual reception stations. These data are then made directly 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.

The data set output from this system is being used as the basis of a number of higher level data streams produced by other agencies. In particular, it forms the foundation data set for the high quality Sea Surface Temperature data set that is being created by the Bureau of Meteorology under the auspices of the Integrated Marine Observing System (IMOS). A second product is a national Normalised Difference Vegetation Index product that is also being produced in the Bureau in partnership with CSIRO. This data set will be a contribution to the AusCover project, the remote sensing component of the Terrestrial Ecosystem Research System.

This combined base data set (and the two product streams mentioned) is an example of the improvement in efficiency and quality that can be achieved through partnering and cooperation, in which WASTAC is a vital participant.

BUREAU OF METEOROLOGY, MELBOURNE

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

SEA SURFACE TEMPERATURE (SST)

The Australian Bureau of Meteorology (the Bureau) has been producing 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 since the early 1990's. The POES data is captured using the network of L-band receivers around the country, including the WASTAC L-band receivers.

The locally received AVHRR SST products are currently included in regional (1/12° spatial resolution) SST analyses (Beggs, 2007) that are used operationally in ocean forecasting and numerical weather prediction, including the prediction of tropical cyclones and severe weather events. These regional analyses have been made available to the wider research community as part of the Bureau's commitment to reduce barriers to data access.

In 2009, comparisons between temperature measurements from drifting buoys and locally received AVHRR data were used to generate improved SST algorithms. As part of this process, a quality level was assigned to each observation based on proximity to cloud and sensor view angle. Separate algorithms and quality levels were developed for night and day observations. Summary statistics describing the performance of the derived SST algorithms are provided in Table 1. Data with a quality index of 5 (highest quality) has a standard deviation of ~0.3°C and ~0.4°C for night and day, respectively. The standard deviation increases as the quality level reduces.

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). These re-processed data sets have been provided to the AO-DAAC on a trial basis in preparation for a roll out in 2010. The Bureau continued to supply the AO-DAAC with cloud-cleared SST data in the form of a mosaic of the weighted-average SST from observations within the past 14 days.

By allowing users to retrieve data from their area of interest, rather than the full dataset, download requirements are reduced, improving data accessibility. With this greater accessibility, users may find new applications for the Bureau's SST products.

Table 1: 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 (°C); and S.D. = standard deviation (°C).

Quality	NOAA 17			NOAA 18			NOAA 19		
Index	N	Bias	S.D.	N	Bias	S.D.	N	Bias	S.D.
	NIGHT								
2	1680	-0.20	0.50	1592	-0.21	0.56	1019	-0.29	0.62
3	965	-0.09	0.35	872	-0.10	0.46	605	-0.15	0.39
4	731	-0.03	0.32	693	-0.03	0.31	464	-0.13	0.51
5	2548	0.02	0.24	2535	0.02	0.28	1604	0.00	0.29
	DAY								
2	1330	-0.28	0.57	1631	-0.20	0.59	1024	-0.29	0.57
3	540	-0.17	0.41	664	-0.14	0.54	400	-0.19	0.53
4	493	-0.17	0.42	549	-0.09	0.48	327	-0.12	0.55
5	1751	-0.03	0.41	2476	0.01	0.40	1578	-0.03	0.39

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-1R imagery and Numerical Weather Prediction (NWP). AVHRR data is also a critical back-up to MTSAT-1R imagery.

For the Period 1 January 2009 to 31 December 2009, there were five tropical cyclones that entered or formed within Perth TCWC's area of responsibility (Table 2). Of these the most severe were Tropical Cyclone Ilsa and Tropical Cyclone Laurence.

Table 2: List of Tropical Cyclones for the Period January 2009 to December 2009.

Tropical Cyclone	Period (2009)	Max Intensity	Impact on Coast
Dominic	24 – 27 January	Category 2	Minimal
Freddy	3 – 13 February	Category 1	Nil
Gabrielle	28 Feb – 6 March	Category 0	Nil
Ilsa	17 – 24 March	Category 4	Nil
Laurence	13 – 23 December	Category 5	Minor

Tropical Cyclone Dominic 24-27 January 2009

A low moved off the Kimberley coast during 24 January. This system moved steadily west and intensified into Tropical Cyclone Dominic by 0900 WDT 26 January (Figure 1). Dominic turned southwest and reached category 2 intensity before crossing the west Pilbara coast near Onslow at 0600 WDT 27 January. Wind gusts to 133 km/h (72 knots) were recorded at Onslow Airport and there was some minor structural damage and power lines brought down. Dominic weakened quickly over land although the remains of the system caused heavy rainfall and flooding in many parts of southern Western Australia. The Gascoyne River inundated many parts of Carnarvon. A train was derailed east of Kalgoorlie on 30 January, reportedly due to flowing water. Flash flooding was also reported in the wheat-belt including York and Quairading.

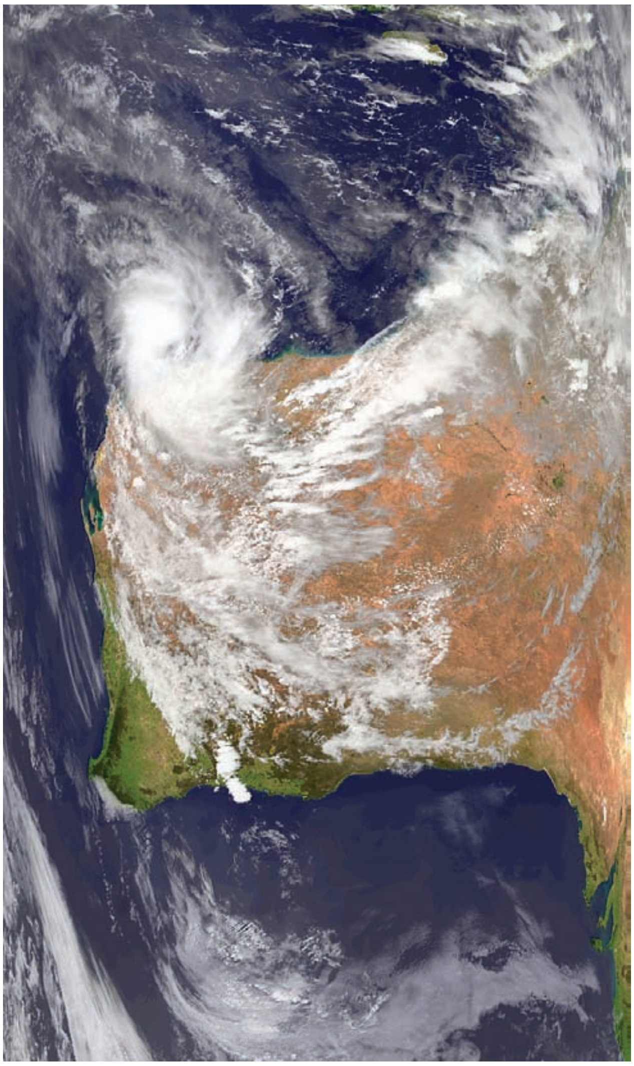


Figure 1: Tropical Cyclone Dominic observed from NOAA-18 as it nears the coast at 05:42 UTC on 26 January 2009.

NORMALISED DIFFERENCE VEGETATION INDEX (NDVI)

The Normalised Difference Vegetation Index (NDVI) is used to monitor the greenness of vegetation, and is an indication of its coverage and vigour. The NDVI anomaly quantifies the vegetation state relative to its long-term average and variability for a particular month of the year. Maps of NDVI and NDVI anomaly, as well as the underlying data grids, are available on the climate pages of the Bureau's website (Figure 2). In 2009 the Bureau continued to supply NDVI anomaly data to the Bureau of Rural Sciences for use in its National Agricultural Monitoring System (NAMS). NAMS provides decision makers with a variety of climatic and other data on the state of agricultural land, and in particular on the impact of drought to support decisions on Exceptional Circumstances compensation. In 2009 the Bureau also commenced supplying NDVI and NDVI anomaly data to the Environmental Resource Information Network (ERIN) within the Department of Environment, Water, Heritage and the Arts.

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, together 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 detrending is by the method of invariant semi-arid sites developed by 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 in all years in the record.

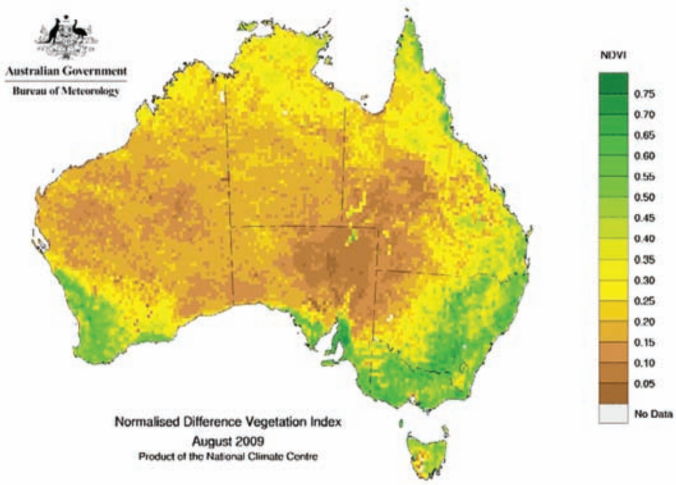


Figure 2: The national AVHRR NDVI map for August 2009 available at the Bureau of Meteorology's climate web pages. State maps and data grids are available at a finer resolution.

A notable application of NDVI is as an indicator of the dryness of bushfire fuels. The Bureau presents NDVI maps at the two annual Seasonal Bushfire Assessment Workshops that are held in the period leading up to the northern Australian and southern Australian bushfire seasons. These workshops bring state fire managers together to consider the available data and forecasts on fuel and weather conditions and produce a consensus national map of severe fire potential for the coming season.

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

Figure 3: AP-RARS sites.

ATMOSPHERIC PROFILES FOR NUMERICAL WEATHER PREDICTION

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. Modern weather forecasting, in turn, relies heavily upon this modelling. Global ATOVS coverage is provided from the United States and Europe, but with delays of up to 6 hours, which is too late for optimal use by NWP. In 2009, local ATOVS reception from WASTAC, Darwin, and Crib Point provided Australian Region NOAA-15, -17, -18 and -19 coverage to Melbourne within 30 minutes from the start of acquisition. The 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.The global need for ATOVS data in NWP centres has stimulated the development of rapid ATOVS dissemination through the European, South American and Asia-Pacific (AP) Regional ATOVS Retransmission Services (RARS). In addition to contributing data from five local ATOVS reception facilities, including WASTAC, the Bureau also coordinates the Asia-Pacific component of the international RARS initiative (AP-RARS). By the end of 2009, fifteen international AP-RARS reception sites were operational, including sites in Australia, New Zealand, Singapore, China, Japan, Hong Kong and Korea. The coverage provided by AP-RARS stations is depicted in Figure 3 (see http://www.bom.gov.au/weather/satellite/RARS/index.shtml).

MODIS AND AIRS DATA

The large number of spectral bands carried by MODIS enables the derivation of a large range of image products that diagnose the state of the atmosphere and surface. These include information on the spatial distribution of water vapour, temperature, cloud phase (ice or water) and cloud top properties (pressure, temperature, particle size). The Bureau is using the International MODIS and AIRS Processing Package (IMAPP) software from the University of Wisconsin to generate these products, and has a developmental web-based system to deliver them to the Bureau's forecasters. Figures 4 and 5 show MODIS data from WASTAC.

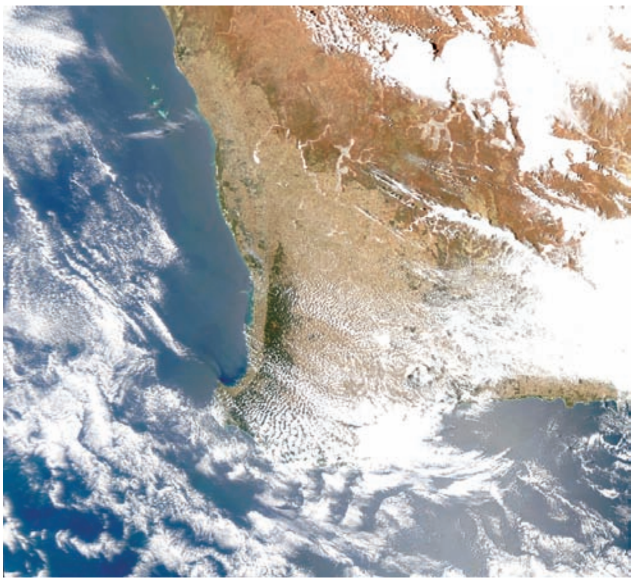


Figure 4: 500 km "True Colour" MODIS image received at WASTAC on 7th December 2009 at 05:42 UTC.

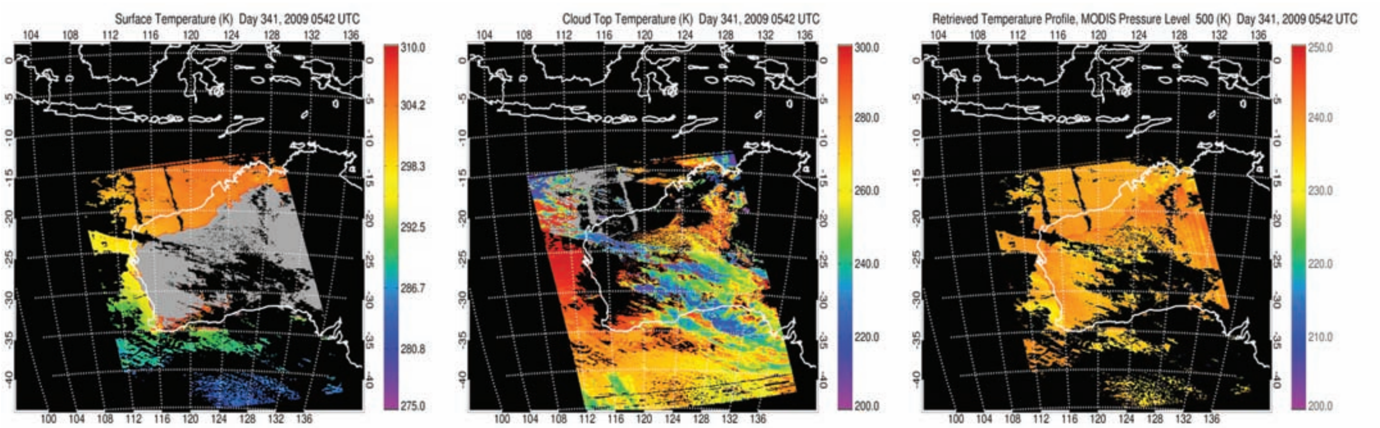


Figure 5: MODIS derived Temperatures for Surface, Cloud Top and 500 hPa respectively.

The Aqua satellite carries, besides MODIS, the Advanced Infrared Sounder (AIRS), which offers atmospheric profile data of unprecedented accuracy. Image products describing the temperature and moisture structure of the atmosphere will also be produced by IMAPP software for delivery to forecasters. AIRS data have shown major positive NWP impact, and are being assimilated on a trial basis into the Bureau's new NWP system "ACCESS", which is heavily based on the United Kingdom Met Office model. Figure 6 shows AIRS data received by WASTAC, after processing through IMAPP.

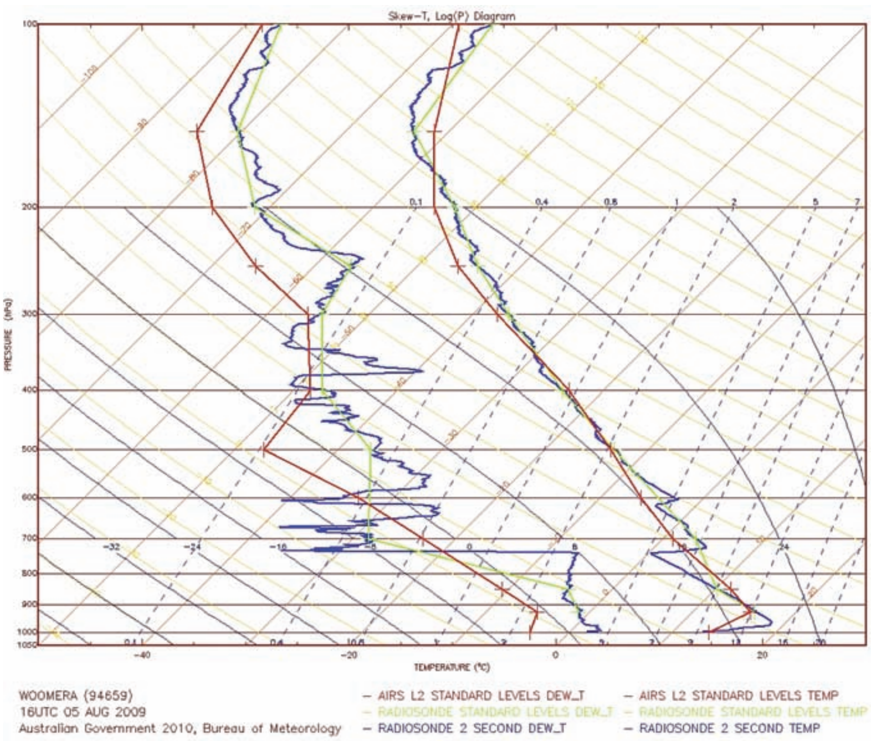


Figure 6: A comparison of the vertical profiles of standard and dew point temperatures from AIRS and from a radiosonde flight on the 5th August 2009 at 1600 UT.

FOG / LOW CLOUD

The fog/low cloud program developed by the Centre for Australian Weather and Climate Research (CAWCR) is aimed at improving our understanding and forecasting capability for fog. Accurate and timely fog forecasts are critical to efficient and safe aircraft operations. The low cloud software uses near real-time NOAA-15 to -18 satellite data received at WASTAC, Darwin and Melbourne. Products are available within 10 minutes of the satellite pass being received, and are geometrically located to within one pixel (1 km).

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

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

Figure 7 is a fog/low cloud image from NOAA-15. Blue areas represent the lowest cloud tops (as estimated from thermal contrast with nearby cloud-free surface), with lighter shades representing a stronger signal (due to smaller droplet size and/or thicker cloud). Slightly higher cloud tops are denoted by olive-green shades. Sharp boundaries in height assignment occasionally result from dividing up low cloud masses into local areas for comparison against local surface temperatures, where cloud top temperatures are borderline between those for low and very low cloud.

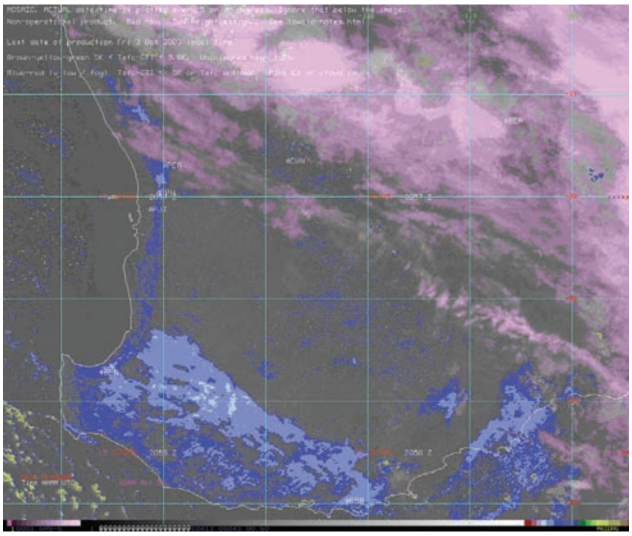


Figure 7: Fog and Low Cloud image from NOAA-15 ON 5 April 2007. Fog at Perth Airport lasted from 19:55 to 23:43 UTC. Fog is shown in blue along the plain on the coastal side of the escarpment, with a larger area on the southwest corner.

REFERENCES

Beggs, Helen (2007) A High-Resolution Blended Sea Surface Temperature Analysis over the Australian Region, BMRC *Research Report*, *Bureau of Meteorology*, *Melbourne*, *Australia*, 43 *pp*.

(http://www.bom.gov.au/bmrc/pubs/researchreports/RR130.pdf).

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

SST Publications

Beggs, H (2010) Use of TIR from Space in Operational Systems. In: Oceanography from Space, Revisited, *ed*. V. *Barale*, J.F.R. *Gower and* L. *Alberotanza*, pub. Springer Science+Business Media, in press.

Beggs, H., Verein, R. and Paltoglou, G. (2010) Calibration and Validation of AVHRR Sea Surface Temperature using Observations from Ships of Opportunity. Extended abstract, *Oceans from Space* 2010 *Symposium*, Venice, Italy, 26-30 April 2010.

Beggs Helen, Leon Majewski and George Paltoglou (2009) New Australian High Resolution AVHRR SST Products from the Integrated Marine Observing System, GHRSST 2009 *International Users Symposium Conference Proceedings*, Santa Rosa, USA, 29-30 May 200, p. 29-32. (http://www.ghrsst.org/modules/documents/documents/IGUS_Extended_Abstracts.pdf).

Van der Linden L. T. M. (2009) "Field and remote sensing observations of transient upwelling along Ningaloo Reef", Data Report, School of Environmental Systems Engineering, UWA, 65 pp.

Baird Mark, Helen MacDonald, Moninya Roughan and Peter Oke (2009) Downscaling an eddy-resolving global ocean model for the continental shelf off South-East Australia, Submitted to *Ocean Modelling*.

Maynard J, P. Turner, K. Anthony, A. Baird, R. Berkelmans, C. Eakin, J. Johnson, P. Marshall, G. Packer, A. Rea and B. Willis (2008) An interactive monitoring system for coral bleaching using high-resolution SST and improved stress predictors, *Geophys*. *Res*. *Let*., 35, 5.

LANDGATE, SATELLITE REMOTE SENSING SERVICES, FLOREAT

FIREWATCH - 21 years of Fire Scar Maps
Tim Nielsen

Satellite Remote Sensing Services (SRSS) routinely produces fire scar maps for Australia. The information produced has been primarily used by organisations and departments such as the Fire & Emergency Services Authority (FESA) of WA, the Western Australia Department of Environment and Conservation, and the Northern Territory Bush Fires Council who use the maps to identify the most recent fires and fire frequency for specific areas, and contribute to the development of fire management plans.

The mapping of fire scars for Western Australia and the Northern Territory has been undertaken since 1989. However, while fire scars have been routinely mapped since 1996, the archive between 1989 and 1996 has some periods where the record is incomplete.

SRSS is currently in the process of rectifying this situation. Fire scar maps for the missing periods have recently been completed for Western Australia, and in coming months this will also be the case for the Northern Territory. At the end of the project there will be a complete set of fire scar maps for the 21 years since July 1989.

Fire scars are identified and located using channels on day time NOAA images (Figure 8). For the purpose of this project, data collected by NOAA 9, NOAA 11 and NOAA 14 has been used.

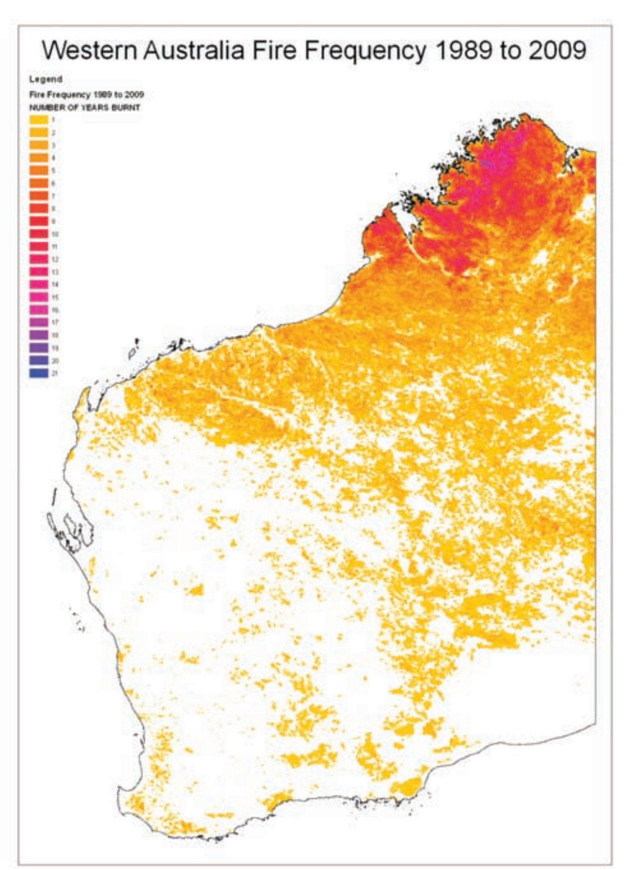


Figure 8: Fire frequency map of WA from 1989 to 2009 derived from NOAA 9,11,and 14.

INDOFIRE – FireWatch Indonesia Project

Ken Dawbin

Indofire is a browser-based system based on Landgate's FireWatch system. It was customized and transferred to Indonesia under the AusAID funded FireWatch Indonesia Project. Indofire may be accessed from the following addresses:
http://indofire.dephut.go.id
http://indofire.lapanrs.com
http://indofire.landgate.wa.gov.au

Indofire is an innovative, state of the art, online, graphical, fire monitoring system, developed in Western Australia by Landgate, that detects and monitors forest fires, peatland fires, hot spots and smoke haze, and provides accurate data on point-of-origin and fire speed and direction (Figure 9).

Indofire grew from Landgate's world-class FireWatch satellite technology, which was developed and perfected over 15 years, to assist wildfire early detection and management across Australia. Using a MODIS satellite sensor onboard Terra and Aqua satellites, Indofire generates invaluable fire monitoring information for the whole of Indonesia.

This enables early detection of fires, leading to their suppression, and minimising the spread of fires into Indonesia's forests, peatland habitats and commercial and subsistence farmlands. Indofire also provides near-real-time monitoring of active fires. The satellite data appears on the Indofire website within an hour, speeding up fire detection and allowing local fire brigades to respond more quickly.

Indofire provides free and open access to all stakeholder groups, including public and private sector agencies at all levels. Indofire is designed to Integrate with Indonesia's developing Forest Resource Information Systems (FRIS), to further enhance its usefulness.

Indofire technology is vitally important for those living in poorer, remote communities, who have little ability to battle major fires, and consequently suffer the most from loss of life, destruction of crops, topsoil and animals, and from pollution of their water systems.

Figure 9: Screen snapshot from the IndoFire website depicting fires in parts of Indonesia

PASTURES FROM SPACE®

Norm Santich, Richard Stovold

The Pastures From Space program continues to deliver weekly pasture growth rate (PGR®) and feed on offer (FOO®) data to agricultural producers in Western Australia and the eastern states of Australia. Of more recent times producers with very large holdings,often spread over many shires, are accessing the data to allow regular and consistent monitoring of their properties. The Pastures From Space product is providing on-farm efficiencies and assists to manage farms remotely.

Moderate Resolution Imaging Spectroradiometer (MODIS) Normalised Difference Vegetation Index (NDVI) data is being used in conjunction with climate data (rainfall, temperature, evaporation and solar radiation) to calculate weekly pasture growth rate (PGR®) information in the south western agricultural region of

Western Australia and south eastern Australia since 2003 (Figure 10). In eastern Australia the PGR footprint covers north to Rockhampton and south to include Tasmania. In 2008, the PGR model was further extended to calculate PGR at a continental scale. This information is available for producers to make pastoral management decisions based on the historical data.

The MODIS Feed On Offer (FOO®) model continues to be used in Eastern Australia. The MODIS FOO model was tested successfully on the Sundown Pastoral Company's Newstead farm. Tests indicate that pasture growth and available feed estimate accuracies are best suited to broader acre properties while dairy properties with smaller paddocks are not suited to accurate estimates of FOO® due to the resolution of the MODIS pixels.

Producers across Australia can subscribe to this weekly service through Fairport Technologies.

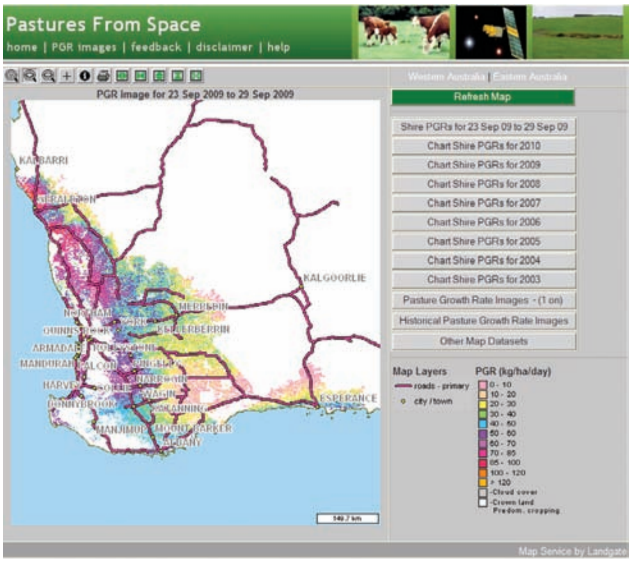


Figure 10. Weekly Pasture Growth Rate map of the South West of WA for week ending 29th September 2009 as viewed on the Pastures From Space website.

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

PLANT VIGOUR INDEX

Richard Stovold, Norm Santich

A plant vigour indicator has been generated from weekly processed MODIS NDVI data to give a seasonal update of plant growth in the South West wheatbelt of Western Australia. The images of the season growth patterns continue to be published every fortnight in the Countryman newspaper. Farmers and land managers can also access the data, which is posted every week, on the Agimage Landgate website under the farm Channel.

The imagery is assisting farmers determine the progress of their season and provide vital production information of 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 11).

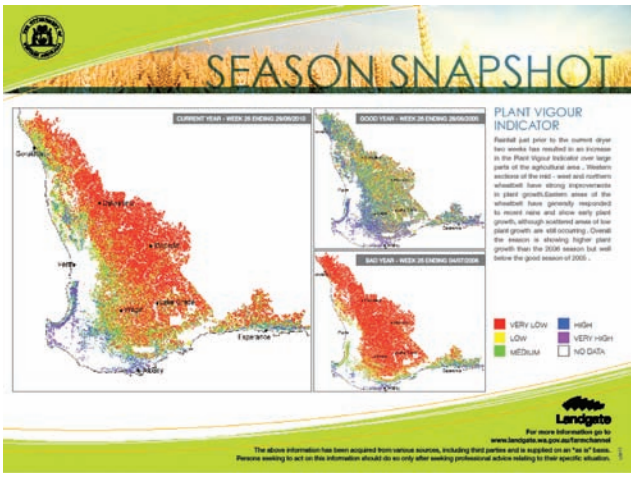


Figure 11. A comparison of the Plant Vigour Indicator for 29th June 2010 with the equivalent period in 2005 and 2006.

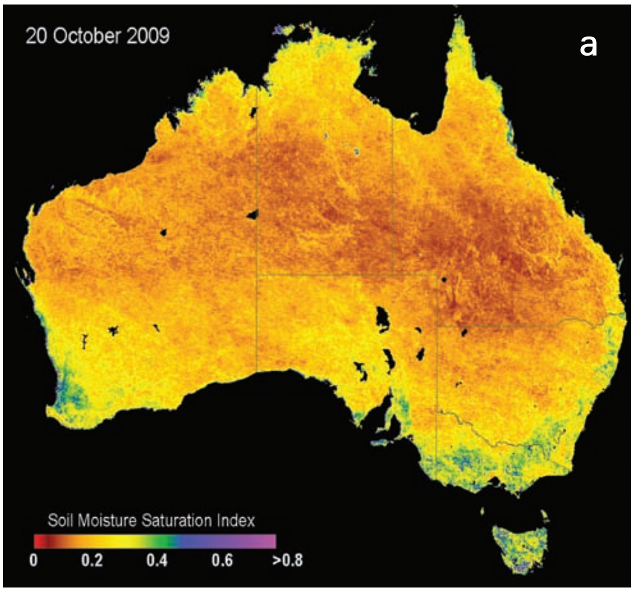
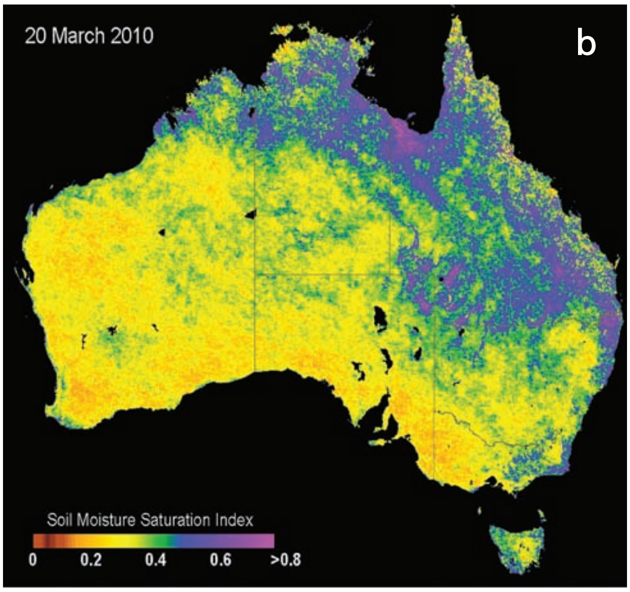
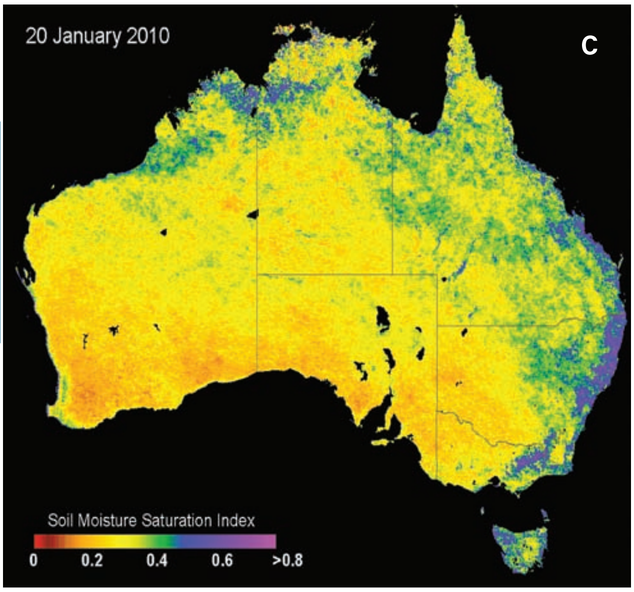
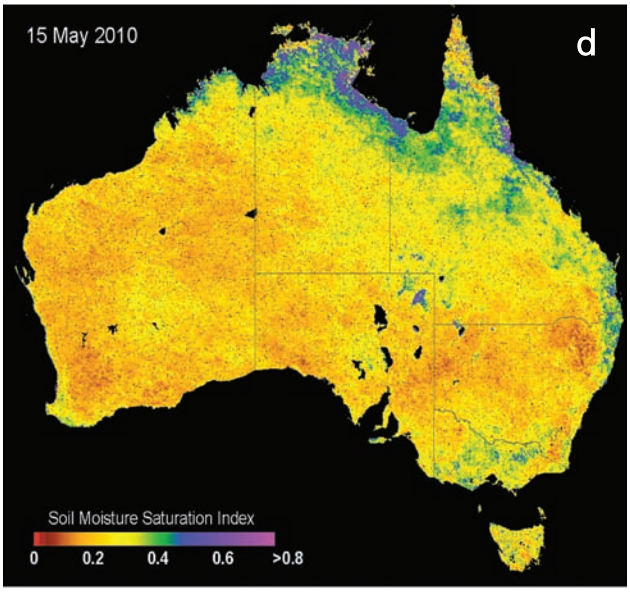


Figure12: – Estimated Soil Moisture Saturation Index maps of Australia for a 1 m soil profile generated from MTSAT data on four different dates: (a) 20 October 2009; (b) 20 March 2010; (c) 20 January 2010: (d) 15 May 2010.







SATELLITE-BASED MONITORING OF SOIL MOISTURE IN AUSTRALIA

Mario Ferri and Dave Foster

Monitoring of soil moisture from remote sensing is often carried out by using passive microwave systems. One of the problems with these systems is the relatively broad spatial resolution which is of the order of several tens of kilometres, depending on the frequency used. For example, with a wavelength of 2.8 cm (10.7 GHz) the mean spatial resolution is 38 km. Lower wavelengths, which should improve the spatial resolution, cannot be used because the depth of detecting soil moisture is about a tenth of the wavelength. Therefore, even with a wavelength of 2.8 cm, the moisture sensing depth is very modest (some mm). Using a wavelength of 5.6cm doubles the moisture sensing depth but the spatial resolution degrades to about 70 km.

An alternative method to retrieve information on soil water content is described in the WASTAC Annual Report 2007 (Ferri, 2007). The method makes use of the Apparent Thermal Inertia (ATI) generated from optical (1 km resolution) and thermal spectral data (4 km resolution) from the geostationary satellite MTSAT. This data is automatically processed at Landgate on daily basis to produce ATI images. Time series of previous 60 days of ATI are utilized to provide in near-real time the so-called Soil Moisture Saturation Index for a 1 m soil profile (SMSI). This index ranges from 0 to 1 corresponding to the degree to which the soil has water content between the minimum (residual) and maximum (saturation), respectively ((http://floodmap.landgate.wa.gov.au/).

Obviously the spatial and temporal changes of SMSI are related to variations in rainfall. As an example in Figure 12 the resulting SMSI maps for Australia are shown for four different dates. Map (a) shows a typical example during dry times, when the computed SMSI is generally very low everywhere.

On the contrary, March 2010 map (b) shows a typical example during wet periods: large areas, mainly in Queensland, are characterized by very high levels of SMSI. This can be interpreted due to the unusually heavy rainfall occurred in these areas between February and March 2010, causing also extensive water floods (Ferri and Foster, 2010). Map (c) and (d) show the SMSI distribution respectively before and after this period in map (b).

An application of SMSI is the possibility to obtain, at any day t of the year, the Profile Available Water (PAW) which reflects the soil's capacity to hold water calculated for the soil profile to a depth of 1 meter and expressed as millimetres of water. It can be obtained from the convolution of SMSI with the Water Storage Capacity (WSC):

$$PAW(t,\varphi,\lambda) = SMSI(t,\varphi,\lambda) \cdot WSC(\varphi,\lambda)$$

where φ and λ are the latitude and longitude, respectively (Ferri, 2007).

As described in Ferri (2007), the Water Storage Capacity of Australia can be estimated by using the "Available Water Capacity" and "Depth of the plant root zone" at 1 km grid cells, both available from ANDRL (Australian Natural Resources Data Library). As an example, the map in Fig 13 shows the *Profile Available Water* in Australia at 31 December 2009.

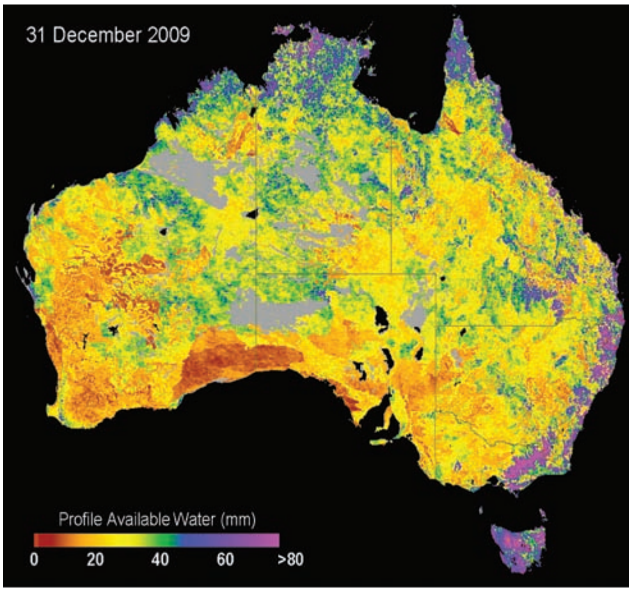


Figure 13. – Profile Available Water at 31 December 2009 from the computed SMSI convoluted with soil data (A-Horizon+B-Horizon). Areas in grey have no soil data.

The knowledge of spatial and temporal distribution of this kind of soil moisture features can be used for applications in several fields, such as applications to estimate grass growth by soil moisture, develop efficient irrigation schemes, plan pre-selections of crops and plantation, study global climate change through persistence and change of high or low soil moisture content, as well as to predict flood on the basis of the saturation condition of soils.

MONITORING FLOOD EXTENT IN QUEENSLAND USING MODIS DATA

Mario Ferri

Queensland, and some areas of the northern New South Wales and NNE of South Australia, received unusually heavy rainfall from February to March 2010. As a result, many rivers, such as Thomson River, Bulloo River, Barcoo River, Diamantina River and Cooper Creek among them, reached high levels causing extensive flooding to occur.

Using a specific algorithm applied to MODIS data, the extent of floodwaters between 10 February and 9 March 2010 has been derived at a ground resolution of 250 meters. This extent has been superimposed (coloured blue) on a Landsat colour composite image of the area (Figure 14). The total flooded area was about 80,000 km^2. Figure 15 clearly shows the river system in dry periods.

The map in Figure. 16 shows the flood hazard corresponding to the same area of Figure 14. This map , clipped from the Flood Hazard Map of Australia, is derived from a model based on a statistical-morphological approach.

It makes use of various topographic-morphometric parameters based on a Digital Elevation Model (SRTM at 90 meter resolution) and calibrated using the extent of flood events occurred in Australia since 2001from MODIS data. According to this model, the flood hazard in Australia has been classified in five categories: negligible (light gray in Figure 16), low (green), moderate (yellow), high (orange) and extreme (red). Figure 17 exhibits an excellent matching of the aforesaid inundation extents with areas classified as high and extreme flood hazard. This kind of information– which can be depicted on a daily basis via website (http://floodmap.landgate.wa.gov.au/) – are essential for Disaster and Emergency Management, especially in a country such as Australia where flooding is a recurring phenomenon causing a negative impact on the economy and, in some cases, loss of human lives.

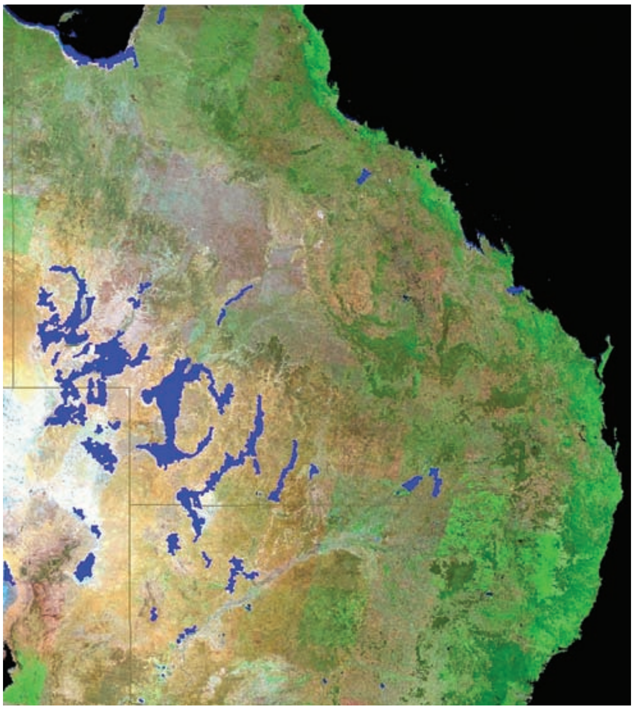


Figure 14. Extent of floodwaters occurred in Queensland, northern New South Wales and NNE of South Australia between 10 February and 9 March 2010.

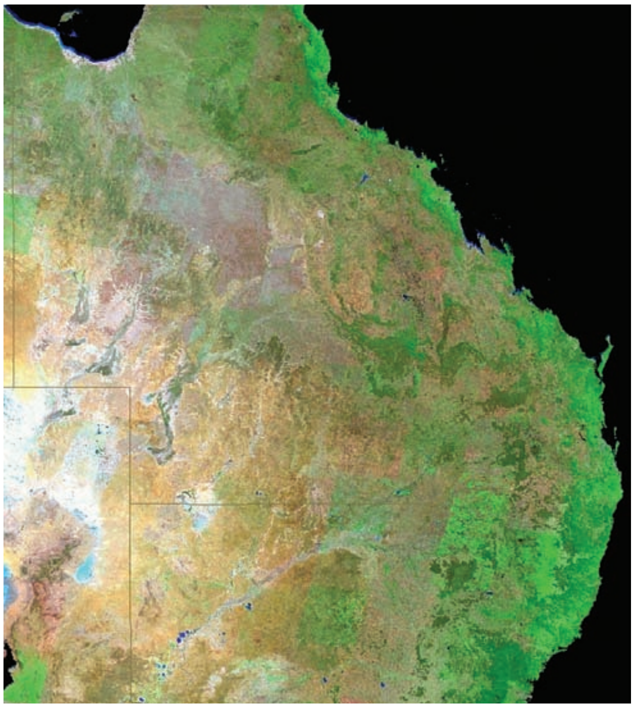


Figure 15. Landsat colour composite image in pre-flooding condition.

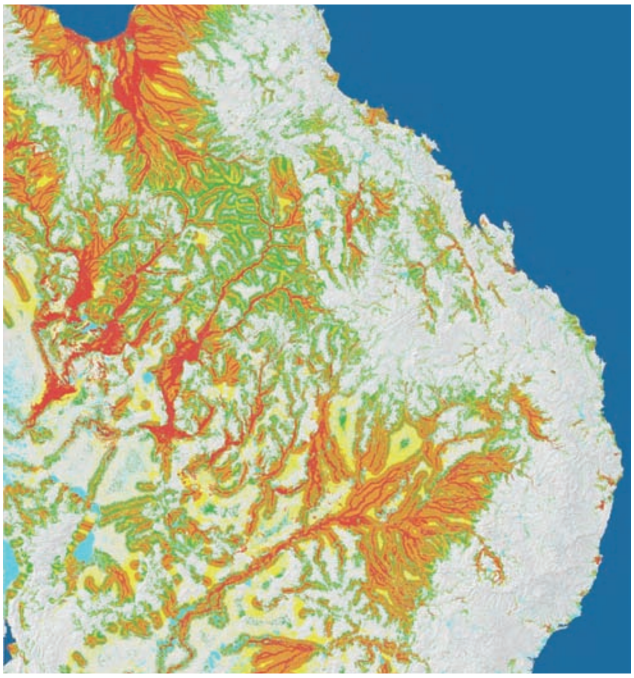


Figure 16. Flood hazard extracted from the Flood Hazard Map of Australia (http://floodmap.landgate.wa.gov.au/) which classifies Australia in five categories of flood hazard ranging from negligible to extreme hazard.

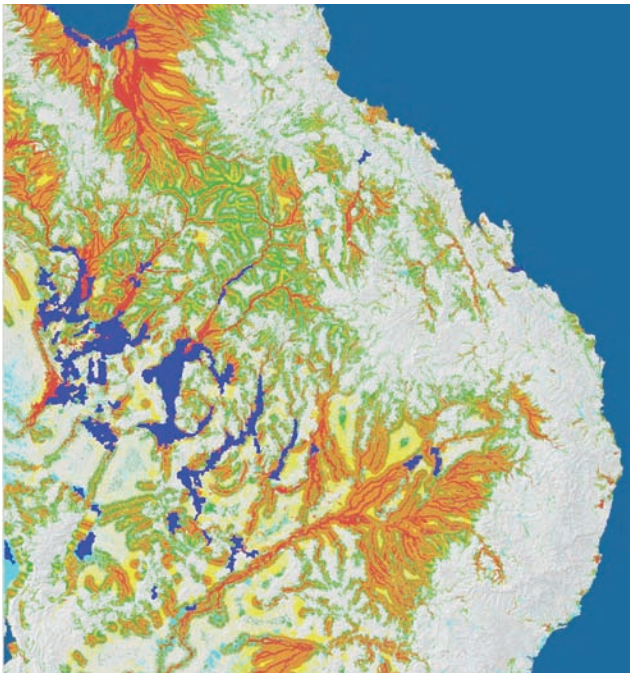


Figure 17. The extents of floodwaters in blue occurring between 10 February and 9 March 2010 falls entirely in areas classified as high and extreme flood hazard.

REMOTE SENSING FOR FORESTRY & CARBON ACCOUNTING

Brendon McAtee & Ricky van Dongen

The core of this work was to develop relationships between remotely sensed Normalised Difference Vegetation Index (NDVI) and the fraction of Absorbed Photosynthetically Active Radiation (fPAR) to facilitate the use of remotely sensed NDVI as an input to a biophysical model for the prediction of tree growth and biomass increase. As part of this work we conducted field measurements at a biosequestration field site near Kalannie, in the north east wheatbelt of Western Australia.

To measure fPAR we used multiple measurements of canopy reflectance to characterise radiative transfer through the canopy using an Analytical Spectral Device (ASD) spectroradiometer. From the top-of-canopy measurement we have simulated a Quickbird NDVI thereby relating remotely sensed NDVI with in situ measurements of fPAR.

As the rows of oil mallees were only 10m wide we used Quickbird (multispectral pixel size 1.6m) to get a good sample size within the rows (Figure 18). We geolocated trees which we measured in the field within the Quickbird imagery so we could relate observed NDVI in the field to the remotely sensed imagery and the in situ measurements of fPAR. Preliminary results suggest we may use Quickbird to estimate fPAR to within 20% using this methodology, however we believe this will be improved in the future after further analysis of the field data acquired.

As part of this work we used MODIS data to obtain the important atmospheric parameters to atmospherically correct the Quickbird imagery based on radiative transfer simulations run using MODTRAN. Within the wider modeling component of the work MODIS and AMSR-E data may also be employed to set environmental constraints such as temperature and available soil moisture.

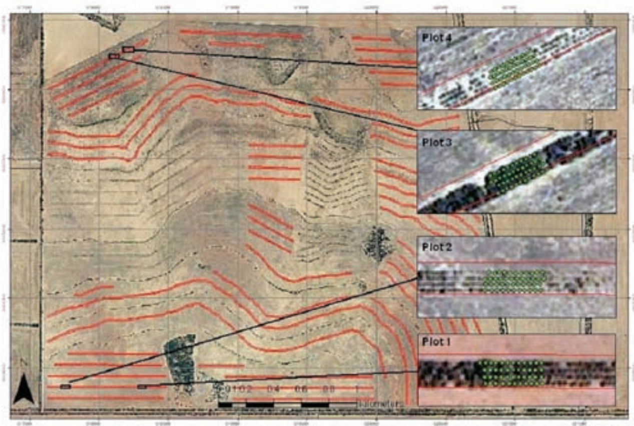


Figure 18. Biosequestration field site near Kalannie, Western Australia. 10m wide rows of oil mallee Eucalypts are shown in red. The insets show panchromatic Quickbird imagery of trees for which Analytical Spectral Device (ASD) and allometric measurements were recorded with actual tree locations superimposed on the imagery after GIS processing.

SEA SURFACE TEMPERATURE (SST)

Mike Steber

Landgate continued its successful partnership with Earthinsite in delivering SST and Chlorophyll data to the recreational and professional fishing industries. SST data derived from both MODIS and NOAA-AVHRR sensors and Chlorophyll data derived from MODIS are automatically generated for each satellite pass received from 6 stations located around Australia. These datasets are then forwarded to Earthinsite and placed on their website seasurface.com. A new addition to the website is the ocean currents layer. The ocean current information (Figure 19) appears as a series of black arrows over the top of the SST or Chlorophyll imagery. The direction of each arrow indicates the direction the current is running and the length of the arrow indicates its relative strength (ie. knots per hour). The current information is downloaded from NOAA each night and is a few days old. However, you can look at previous days' information and monitor the changes that are occurring daily.

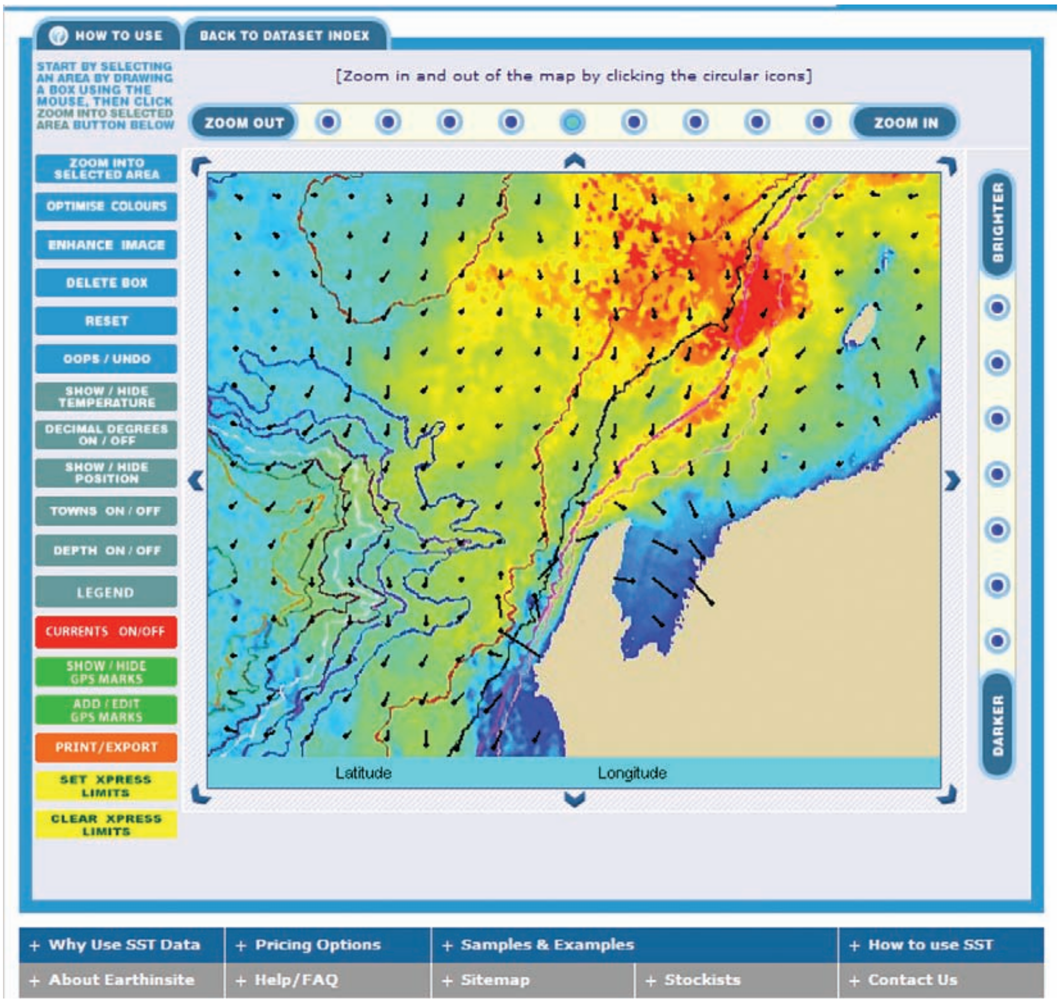


Figure 19. Screen snapshot from seasurface.com showing sea surface temperature and ocean currents on the north west coast of Australia.

VEGETATION WATCH

John Adams

The Vegetation Watch project continues to provide access to long-term NDVI (Normalised Difference Vegetation Index) time series data to clients such as the Dept of Agriculture and Food WA. In the two decades or so since the project began there have been several transitions between NOAA satellites as older satellites' components have failed and new satellites are brought online as replacements.

One such replacement was triggered at the end of 2009 as the AVHRR sensor on NOAA-17 developed scan motor problems, similar to the problems that afflicted NOAA-16 in early 2004. As well as occasional barcoding (Figure 20), the NOAA-17 AVHRR scan motor degradation led to scan-line surges, causing significant east-west distortion, worst near the start of the scan lines. Figure 21 shows the difference between georectified images only 2 days apart from NOAA-17 (left) and NOAA-19 (right) around Lake Barlee in WA. The distortion along the southern lake edges of the NOAA-17 image on the left is clearly visible when compared to the relatively smooth, straighter lake edges of the NOAA-19 image.

Therefore, to maintain the geometric accuracy of the NDVI timeseries, after cross-calibration between the two satellites to maintain NDVI consistency, NOAA-17 has now been replaced by data from NOAA-19.

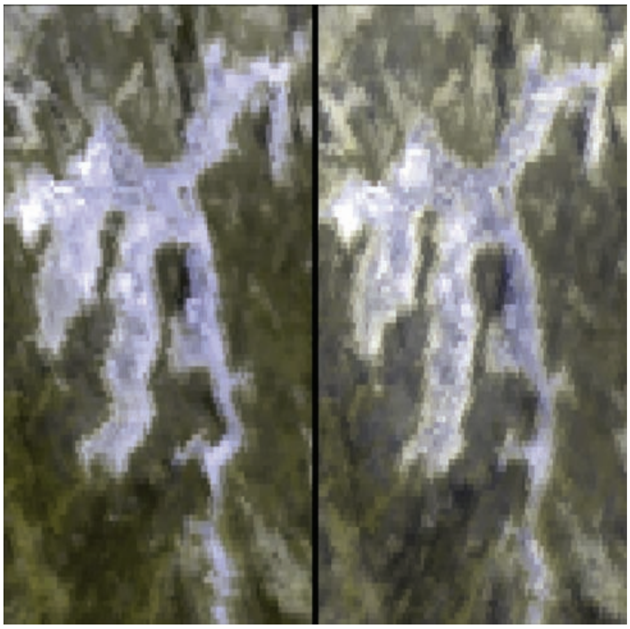


Figure 21. Images 2 days apart around Lake Barlee showing geometric distortion in the NOAA-17 AVHRR image on the left compared to the NOAA-19 AVHRR image on the right which shows no distortion.

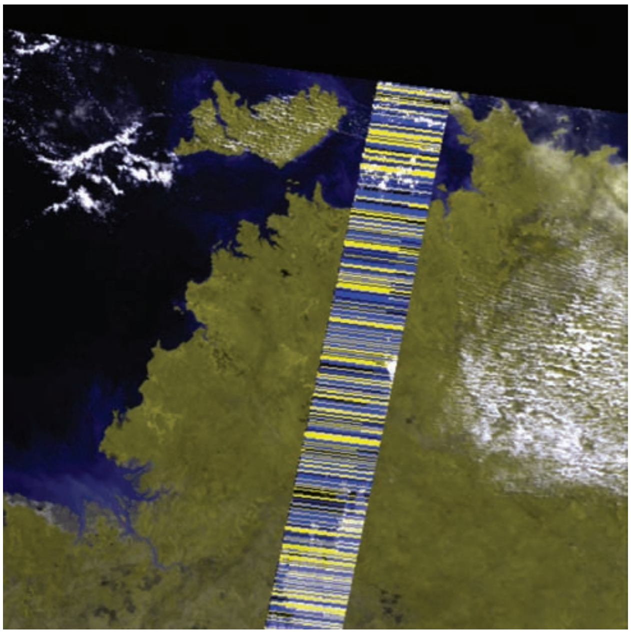


Figure 20. A NOAA-17 AVHRR image over the Northern Territory showing a typical barcoding problem.

USING MODIS IMAGERY TO MONITOR THE WEST ATLAS OIL SPILL

Carolyn McMillan

During the West Atlas Oil Spill in the Timor Sea, Moderate Resolution Imaging Spectroradiometer (MODIS) Imagery was used to assist with the detection and monitoring of the location and extent of the oil slick.

The West Atlas Rig was located in the Timor Sea (12°40'S 124°30'E), North West of the Kimberley coastline. After an explosion on the 21st August 2009, the rig caught fire and began leaking condensate, oil and gas into the Timor Sea.

The spill occurred in a very isolated location, but close to the environmentally sensitive reserves such as Ashmore Reef. Information about the extent of the oil spill was required, but sparse information was available.

MODIS satellite imagery, received at the WASTAC receiving station at Murdoch University was interpreted to determine if the sensor was able to locate and map the extent of the oil spill.

The MODIS satellite imagery, in particular, those images with sun glint over the area of interest, proved effective in determining the location of the spill (Figure 22). From these images Landgate was able to map the extent and movement of the oil slick, during the spill until after it was plugged on November 3rd, 2009.

These images were provided to Fisheries WA to assist with the assessment of the impact of the oil spill on the valuable demersal fishing zones.

The MODIS imagery provided by WASTAC has some distinct advantages over other satellites in detecting the oil slick. The area, on most days, had twice daily coverage, Terra in the morning and Aqua in the afternoon. MODIS imagery is available in near real time, each pass was available as a downloadable .tif image (MODIS bands 221 RGB enhancement) within 1 hour after the satellite had passed overhead.

The sheer scale of the oil slick meant that other sensors with a narrower swath were unable to map the entire extent off one overpass and the isolation of the spill site would prove expensive to fly airborne sensors.

References:

Ferri, M. 2007. Soil moisture in Australia from optical/thermal data. WASTAC Annual Report 2007.

Ferri, M and Foster D. 2010. Monitoring flood extent in Queensland using MODIS data. WASTAC Annual Report 2009 (this volume).

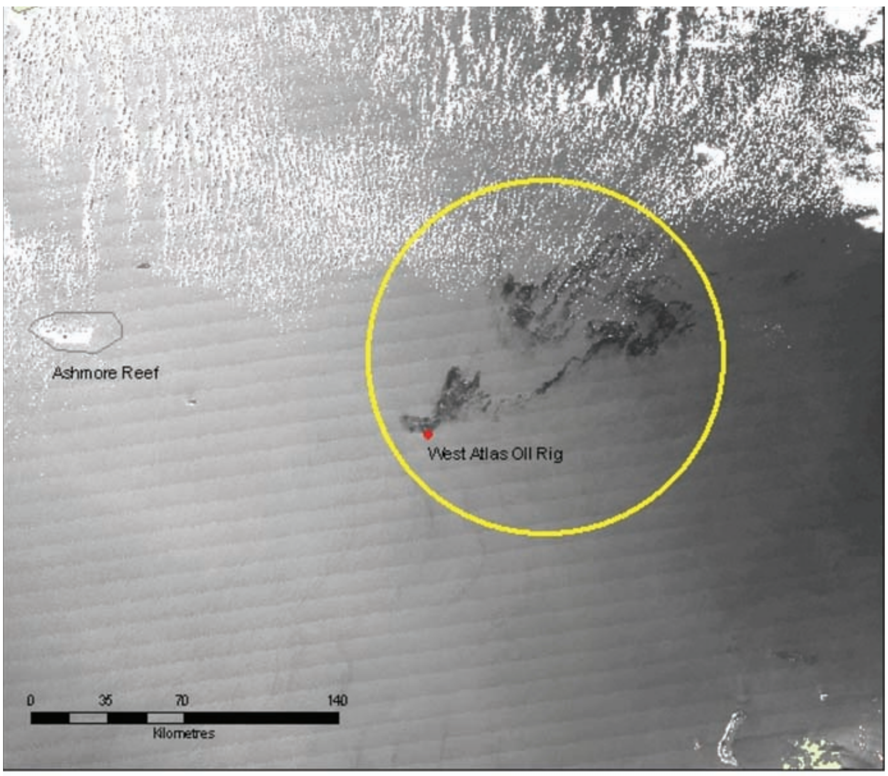


Figure 22: MODIS Imagery 30th August 2009 at 13:12 WST showing the extent of the oil spill from the West Atlas Oil Rig.

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM

WASTAC

RESEARCH DEVELOPMENTS 2009

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

CSIRO

Edward King

INTEGRATED MARINE OBSERVATION SYSTEMS

IMOS is a marine-focused capability of the National Collaborative Research Infrastructure Strategy. The Satellite Remote Sensing (SRS) facility within IMOS utilises several WASTAC data streams and expertise.

The Australian Oceans DAAC activity is incorporating MODIS Ocean Colour data sets produced by WASTAC and making them available to the marine research community on an experimental basis. This prototype data stream forms the basis of a plan within the IMOS Ocean Colour Sub-facility to develop a national ocean colour production system that will be operated at the National Computing Infrastructure located at the ANU in Canberra. A second area of contribution by WASTAC to the IMOS SRS is through the provision of data to the national NOAA/HRPT stitching system, operated by CSIRO, which produces a high-quality data set on a near-real time basis that is used to create a benchmark Sea Surface Temperature product stream for the Australian region. This SST product is a direct Australian contribution to the Global High Resolution SST project (GHRSST).

TERRESTRIAL ECOLOGICAL RESEARCH NETWORK (TERN)

The remote sensing facility of TERN, AusCover, is only just commencing operations in 2010 but already benefits from WASTAC data through existing data streams upon which it will build in future years. The national Normalised Difference Vegetation Index (NDVI) time series produced by the Bureau of Meteorology in partnership with CSIRO is based on WASTAC-acquired NOAA data. It is expected that the national MODIS processing facility that is planned for development within the IMOS Satellite Remote Sensing portfolio, based on the prototype developed at WASTAC, will also be a foundation data stream for AusCover and terrestrial products.

A new research activity being undertaken by CSIRO in partnership with Curtin University as a co-investment with TERN/AusCover and the National eResearch Architecture Taskforce (NeAT) is a project to develop a workflow system for processing satellite data within the national computing grid. This activity has been in the planning phase for much of 2009 and will exploit existing expertise developed in the context of WASTAC data processing streams to deploy a production environment in a modular and repeatable manner in an High Performance Computing environment. Although focused on TERN/AusCover data sets, a successful execution of this project will result in improvements to satellite data management, processing and utilisation in both the marine and atmospheric domains.

CURTIN UNIVERSITY OF TECHNOLOGY

Remote Sensing and Satellite Research Group

CLOUD CLIMATOLOGY FOR WESTERN AUSTRALIA

Helen Chedzey#, W Paul Menzel*, and Mervyn Lynch#
Curtin University of Technology, Perth, WA, Australia
* University of Wisconsin, Madison, Wisconsin, USA

Historically, Western Australia can be zoned into three different areas, each with its own distinctive rainfall pattern.

1. The Kimberley area has the 'wet' season during the Southern Hemisphere summer months, December to March.
2. Central WA receives rain from North West cloud bands typically observed between April and October.
3. The South West of WA is predominantly affected by cold fronts arising from the Indian and Southern Oceans where the majority of SWWA rainfall is received during the Southern Hemisphere winter months, June to August.

Since the 1970s there has been a significant decrease in annual rainfall (10%) in the SWWA region and as a result of this, also in the associated runoff from catchments into dams (40-65%) (IOCI, Climate Notes). During the same timeframe, there has been a marked increase in rainfall in the Kimberley region. What has happened to WA clouds? Have we suffered a serious shift in cloud cover in WA? Or has cloud cover remained consistent but the properties of the cloud systems changed, affecting how much they rain? Are there any trends discernable from 17 years of satellite data that can shed light on these questions?

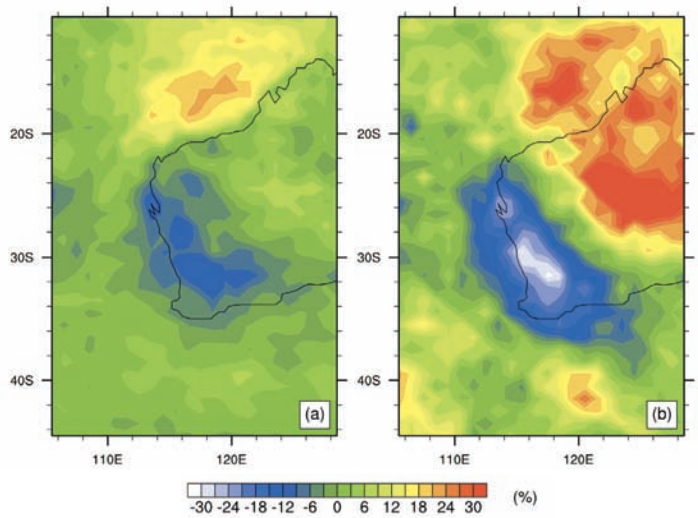


Figure 1: (a) Percentage change in all Cloud over Western Australia for two 8 year periods (1994 to 2001 –1985 to 1992). (b) Percentage change in high clouds (cloud top pressure less than 440 hPa) over Western Australia for two 8 year periods (1994 to 2001–1985 to 1992).

This study looks at the change in 8 year time periods of High Resolution Infrared Sounder (HIRS) IR data from the NOAA polar orbiting satellites over WA. The frequency of occurrence of upper tropospheric clouds has been extracted from the NOAA HIRS/2 data using the CO2 slicing method (Wylie et al, 2005) to infer cloud amount and height. Preliminary results show that there has been a decrease in total cloud amount over the South West regions of WA with an increase off the North West coast (Figure 1a). The effect is more dramatic when looking at the change in high-level clouds (clouds that are higher in the atmosphere than 440hPa). Figure 1b shows a significant decrease in high-level cloud cover over the South West regions of WA and a significant increase in high-level cloud seen off the North West coastline and over North West land areas and some central parts of WA.

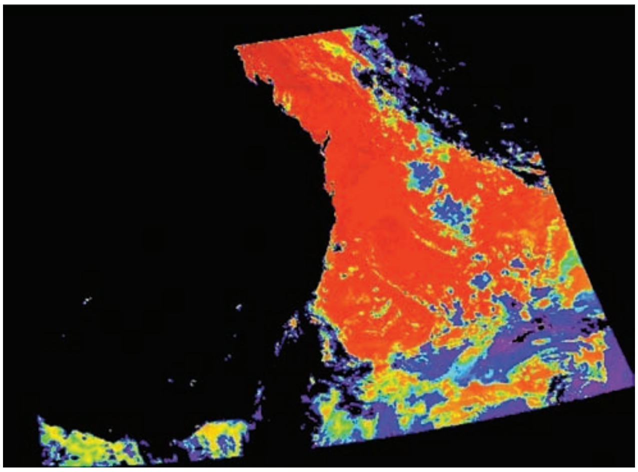


Figure 2: Example of a gridded sea surface temperature. All incoming MODIS granules are processed for common SeaDAS products and rendered to a standard grid. The grid used is equidistant and identical for all granules, as required for distribution through the IMOS AO-DAAC

IMOS DAILY MODIS GRIDDED PRODUCT GENERATION

Mark Gray

The aim of this project is to provide SeaDAS products generated from MODIS data ingested through the facilities of the Western Australian Satellite Technology and Applications Consortium (WASTAC). These SeaDAS products are gridded to a standard projection on a per-granule basis and made available via the THREDDS server in HDF4 format at the following address: http://opendap-ivec.arcs.org.au/thredds/catalog/IMOS/SRS/SeaDAS

Key milestones to date:

- Development of a production MODIS Swath To Grid (MS2GT) based gridding algorithm for MODIS grid data products for the Cylindrical Equidistant (CED) projection packaged with HDF4 using COARDS compliant metadata (as requested by SRS).
- Development of an environment for operational processing and publication of products at iVec.
- Complete processing of 2009 Aqua and Terra MODIS data.
- Processing of 2010 Aqua and Terra MODIS data (including leading edge data).

Data Publishing:

Daily Terra and Aqua MODIS granules are processed to produce a gridded product set (SST, K_490, Chlor_A) for each granule. Each gridded day of data is approx 4Gb and 2009-2010 gridded data holdings are currently approx 2.8Tb. The Aqua datastream started publishing in late 2009 with subsequent extension to 2010. The Terra 2010 and 2009 datastreams began in January 2010.

SeaDAS processing is underway for 2008 and earlier years with gridding and publication to the THREDDS server to be started once validation of the AODAAC product delivery is complete. An example of the SST product is shown in Figure 2.

The Algorithm:

MS2GT is a GPL licensed wrapper to the (also GPL licensed) mapx library. While the developed algorithm is currently set to produce the CED projection the underlying mapping toolkit supports a wide range of standard projects. The current code package can be easily adapted to re-grid any MODIS swath based dataset to any selected grid with appropriate metadata modifications.

DETECTION AND MAPPING OF FLOATING ALGAE USING MODIS 250 METRE DATA

Peter Fearns[1], Rodrigo Garcia[1,2], Dongyan Liu[3], John Keesing[2]

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[2] CSIRO Wealth from Oceans Flagship, Marine and Atmospheric Research, Private Bag 5, Wembley, 6913, Australia.
[3] Yantai Institute of Coastal Zone Research for Sustainable Development, Chinese Academy of Sciences, Yantai, Shandong, 264003, P.R. China.

Massive floating macro-algal blooms, green tides, have occurred in the Yellow Sea in recent years. The most notable event was the impact of the green tides on the 2008 Olympic Games sailing course with millions of tonnes of algae washing ashore along the Qindao coastline (China News, 2009; Liu et al. 2009). A recurrence of the massive green tide was observed in 2009(Liu et al., in press), with many expecting a similar event to occur in 2010. Recent studies based on morphological and phylogenetic analysis have confirmed the source of the green tides to be P*orhyra yezoensis* aquaculture rafts along the Jiangsu coastline (Keesing et al.submitted).

The development and magnitude of the green tide events has been observed using remote sensing techniques (Hu, 2009, Shi & Wang, 2009, Liu et al., in-press). The two 250 m resolution MODIS bands are sensitive to the spectral differences between floating algae and the surrounding water. Of interest is the ability to provide reliable estimates of the spatial extent and biomass of floating algae, however the highly variable spectral reflectance of the Yellow Sea, due to high turbidity, compounded with often hazy atmosphere, makes the delivery of reliable results difficult. To this end we have developed a Scaled Algae Index (SAI) algorithm which highlights the presence of floating algae (Figure3), even in the presence of a slightly hazy atmosphere and turbid water. Our aim is to provide reliable estimates of floating algae origin, extent, and estimates of total biomass.

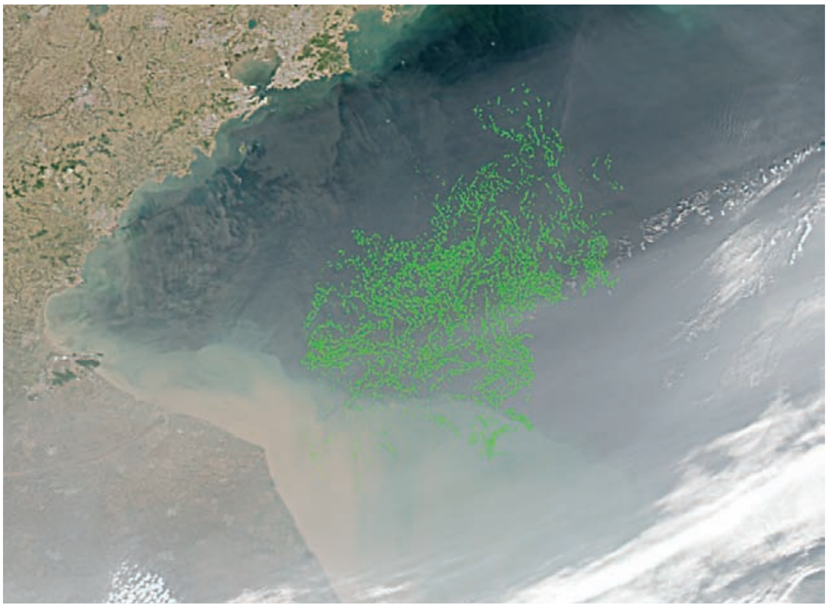

Figure 3. A 250 metre resolution Scaled Algae Index (SAI) image of the Yellow Sea.

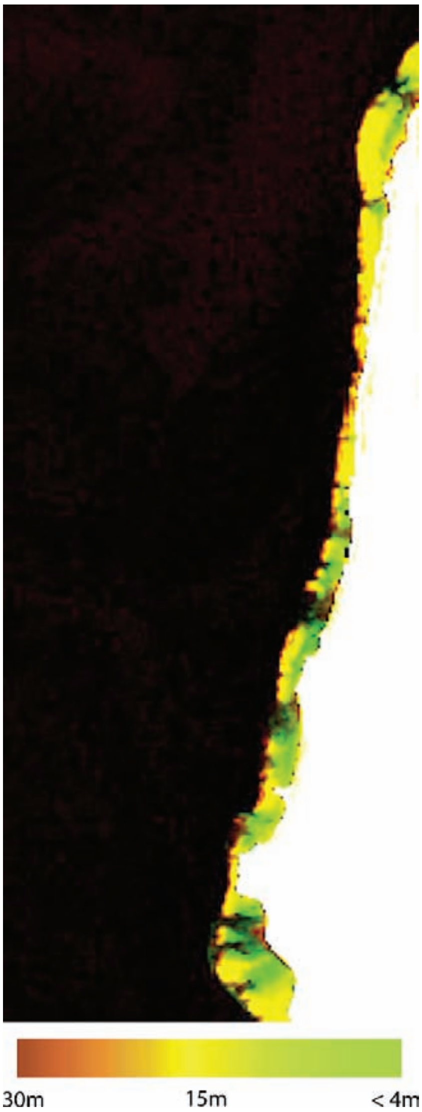

Figure 4. MERIS scene showing the Ningaloo Marine Park coastal region at 300m resolution for April 15, 2006.

DERIVING BATHYMETRY AND BENTHIC COVER FROM MODERATE AND HIGH RESOLUTION VISIBLE SENSORS

Mark Gray, Mervyn Lynch.

Full resolution MERIS data can be used to retrieve estimated bathymetry and benthic cover at 300m resolution using a physics-based retrieval scheme (Figure 4). This resolution is not sufficient to describe the coastal region for many purposes due to the natural variability of the underlying benthic habitat. Orbital sensors with higher spatial resolution (60m-3m) exist but do not have the spectral resolution to accurately observe changes in benthic cover or to completely distinguish between benthic cover changes and actual changes in bathymetry.

This work combines medium resolution observations of the shallow water coastal environment with co-incident high spatial resolution observations to derive bathymetry and benthic cover observations estimates at resolutions smaller than that offered through MERIS data alone (300m). Due to the inherent difficulty in collecting sufficiently overlapping data (in a temporal sense) hyperspectral observations of coastal water scenes have been used to simulate ideal and actual high spatial resolution short wavelength sensors. These simulated observations have been used with modeled and observed water properties and coincident moderate resolution observations (full resolution MERIS data) to derive bathymetry and coarse benthic habitat at various spatial resolutions within the moderate resolution footprint.

Current best case retrieval shows approximately 14% RMS error in comparison to full physical retrieval results derived from the 3m resolution hyperspectral bathymetry. Further work is underway to estimate the ideal combination of medium and high resolution observations for maximum information content.

WEST ATLAS OIL SPILL

Mark Gray

Oil spills that result in large quantities of oil appearing at the ocean surface are difficult to detect in typical visible satellite imagery. Thin layers of oil do not modify the visible properties of the water (such as colour) sufficiently to be easily distinguished from clear water. At the Remote Sensing and Satellite Group we hypothesised that the oil could modify the reflective properties of water so that oil regions might be viewable in highly reflective scenes. It follows that sun glint in the visible imagery provides the best opportunity to view surface oil regions in the data. In this image, Figure 5, the sun glint region in both the morning (Aqua) and afternoon (Terra) MODIS happen to overlap the West Atlas oil spill. This allows a very expansive view of the oil extent by combining both views in a single scene.

References:

http://www.china.com.cn/news/env/2009-06/16content_17954591.htm

Liu, D., J.K. Keesing, Q. Xing and P. Shi (2009), The world largest green-tide caused by *Porphyra* aquaculture. *Marine Pollution Bulletin* 58, 888-895.

Keesing, J.K., Liu, D., Fearns, P. (submitted) Inter-annual and intra-annual patterns of Enteromorpha (Ulva) macro-algal blooms and green-tides in the Yellow Sea during 2005-2009 and their relationship to the expansion of coastal Porphyra aquaculture, Journal of Geophysical Research - Oceans

Liu, D., Keesing, J.K., Dong, Z., Zhen, Y, Di, B., Shi, Y., Fearns, P., Shi, P. (in press) Recurrence of the world's largest green-tide in 2009 in Yellow Sea, China: Porphyra yezoensis aquaculture rafts confirmed as nursery for macroalgal blooms, Mar. Pollut. Bull. Doi:10.1016/j.marpolbul.2010.05.015

Hu, C., (2009) A novel ocean color index to detect floating algae in the global oceans, Remote Sensing of Environment, doi:10.1016/j.rse.2009.05.012

Shi, W., and M. Wang (2009), Green macroalgae blooms in the Yellow Sea during the spring and summer of 2008, J. Geophys. Res., 114, C12010, doi:10.1029/2009JC005513.

Wylie, D. P., D. L. Jackson, W. P. Menzel and J. J. Bates, 2005; Trends in Global Cloud Cover in Two Decades of HIRS Observations. J. Climate, Vol. 18, No. 15, pages 3021 - 3031.

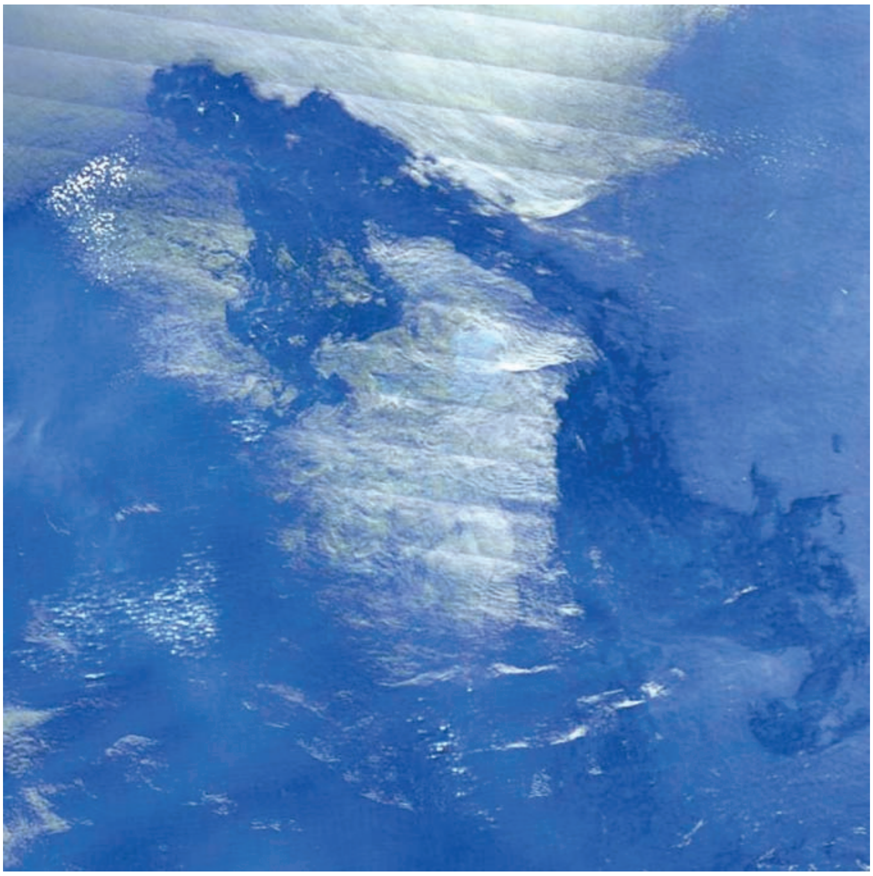

Figure 5 : West Atlas oil spill imaged in false colour (visible bands) derived from morning (Terra) and afternoon (Aqua), September 10 2009 polar orbiting satellite data.

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM

WASTAC

FINANCIAL STATEMENTS 2009

Liability limited by a scheme approved under Professional Standards Legislation.

COVER OF EXCELLENCE

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CPA

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INDEPENDENT AUDITORS' REPORT

The Members of the Board

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM

I have audited the accompanying special purpose financial report of the Western Australian Satellite Technology and Application Consortium – L Band which comprises the balance sheet as at 31 December 2008, the income statement and statement of cash flow for the year ended, a summary of significant accounting policies and other explanatory notes as attached.

Board Responsibility for the Financial Report

The Board is responsible for the preparation and fair presentation of the special purpose financial report. This responsibility includes establishing and maintaining internal controls relevant to the preparation and fair presentation of the financial report that is free from material misstatement, whether due to fraud or error and selecting and applying appropriate accounting policies.

Auditor's Responsibility

My responsibility is to express an opinion on the financial report based on my audit. I conducted the audit in accordance with Australian Auditing Standards. These Auditing Standards require that I 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 the entity's preparation and fair presentation 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 by the Board, as well as evaluating the overall presentation of the financial report.

I disclaim any assumption of responsibility for any reliance on this financial report to which it relates to any person other than the Board or for any purpose other than that for which it was prepared.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my audit opinion.

Auditor Independence

In conducting my audit, I have complied with the independence requirements of the Australian professional accounting bodies.

Auditor's Opinion

In my opinion, the financial report presents fairly, in all material respects, the financial position of the Western Australian Satellite Technology and Application Consortium – L Band as of 31 December 2008 and of its financial performance and its cash flows for the year then ended.

Santo Casilli CPA

Date: 31 March 2010

Perth

STATEMENT BY THE BOARD

In the opinion of the Board, the attached financial statements which form part of the special purpose financial report:

1. presents fairly the financial position of the Western Australian Satellite Technology And Application Consortium – L Band as at 31 December 2008 and the results and cash flows of the Western Australian Satellite Technology And Application Consortium for the year ended on that date; and
2. at the date of this statement there are reasonable grounds to believe that the Western Australian Satellite Technology And Application Consortium – L Band will be able to pay its debts as and when they fall due.

Prof Mervyn Lynch
Chairman

Richard Stovold
Secretary

WASTAC L-Band BUDGET 2009

Estimated expenditure for the year January 2009 – December 2009

	PER ANNUM	**$ 2008**	**$ 2009**
1.	Telstra Rental	4,000	0
2.	Data Tapes	2,000	2,000
3.	System maintenance/repairs	124,000	5,000
4.	Telecommunications licence of facility	3,500	3,500
5.	Consultants	72,000	5,000
6.	Sundry consumables	1,500	1,500
7.	Travelling – Airfares	3,000	3,000
8.	Provision for major equipment	12,000	12,000
9.	Annual Report	10,000	10,000
	TOTAL:	**$232,000**	**$42,000**

Estimated income/revenue for the year January 2009– December 2009

1.	Contributions received ($10,000 each)	40,000	40,000
2.	Interest	12,000	5,000
	TOTAL INCOME:	**$52,000**	**$45,000**

Extra-ordinary expenditure January 2009– December 2009

1.	Capital Reserve: No items		
	TOTAL:	**$0**	**$0**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATIONS CONSORTIUM

L-BAND

INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2009

	2009 $	2008 $
REVENUE		
Contributions Received	40,000	40,000
Interest Received	8,957	20,173
TOTAL REVENUE	**48,957**	**60,173**
EXPENDITURE		
Small Gift	100	
Telephone Rent & Calls	114	1,776
Service and Equipment Charges	-	-
Mobile Phone Services & Calls	-	851
Microwave Licenses	2,354	2,171
Minor New Works Charges	-	9,606
External Printing Costs	-	7,778
Other Computing Expenses	-	30,000
Other Equipment Maintenance	6,831	4,091
Depreciation Expenses	19,570	10,842
Cost of Other Equipment Sold	-	4,812
Photocopying	5,520	
Other Consumables	5,100	
TOTAL EXPENDITURE	**39,589**	**71,928**
Net Operating Result for the Year	**9,369**	**(11,755)**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATIONS CONSORTIUM

L-BAND

BALANCE SHEET AS AT 31 DECEMBER 2009

	Notes	2009	2008
		$	$
CURRENT ASSETS			
Cash at Bank		241,491	214,188
Prepayments		6,885	5,250
TOTAL CURRENT ASSETS		248,375	219,438
NON - CURRENT ASSETS			
Property, plant and equipment	2	67,569	87,138
TOTAL NON - CURRENT ASSETS		67,569	87,138
TOTAL ASSETS		**315,944**	**306,576**
CURRENT LIABILITIES			
Accrued expenses		-	-
TOTAL CURRENT LIABILITIES		-	-
TOTAL LIABILITIES		-	-
NET ASSETS		**315,944**	**306,576**
EQUITY			
Retained Funds	4	315,944	306,576
TOTAL EQUITY		**315,944**	**306,576**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATIONS CONSORTIUM

L-BAND

CASH FLOWS FROM OPERATING ACTIVITIES

	Notes	2009	2008
		$	$
Receipts			
Contributions Received:			
Department of Land Information		10,000	10,000
CSIRO		10,000	10,000
Bureau of Meteorology		10,000	10,000
Curtin University of Technology		10,000	10,000
Interest Received		8,957	20,173
Total Receipts		48,957	60,173
Payments			
Payments to suppliers		(21,654)	(60,928)
Total Payments		(21,654)	(60,928)
Net cash provided by operating activities	**3**	**27,303**	**(755)**

CASH FLOWS FROM INVESTING ACTIVITIES

Payments for property, plant and equipment		-	(73,835)
Net cash used in investing activities		-	**(73,835)**
Net increase/(decrease) in cash		**27,303**	**(74,589)**
Cash at the beginning of the year		214,188	288,777
Cash at the end of the year		**241,491**	**214,188**

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 has been prepared in accordance with Australian Accounting Standards including Australian Accounting Interpretations, other authoritative pronouncements of the Australian Accounting Standards Board and Urgent Issues Group Consensus Views.

Compliance with AIFRS

Australian Accounting Standards set out accounting policies that the AASB has concluded would result in a financial report containing relevant and reliable information about transactions, events and conditions to which they apply. Compliance with Australian Accounting standards ensures that the financial statements and notes comply with International Financial Reporting Standards.

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 is shown at cost or fair value, less subsequent depreciation and 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 Income Statement.

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's assets are not primarily dependent on the assets' ability to generate net cash inflows.

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

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 circumstances 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.

2. PROPERTY, PLANT AND EQUIPMENT

	2009	**2008**
Computer Equipment		
At cost	151,468	151,468
Accumulated depreciation	(130,056)	(118,291)
	21,413	33,177
Other Equipment		
At cost	222,806	233,861
Accumulated depreciation	(176,650)	(179,900)
	46,156	53,961
Total Property, Plant and Equipment	**67,569**	**87,138**

Reconciliations

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

	Computer Equipment	**Other Equipment**	**Total**
Carrying amount at start of year	33,177	53,961	87,138
Additions	-	-	-
Depreciation expense	(11,765)	(7,805)	(19,570)
Adjustment due to change in asset policy	-	-	-
Carrying amount at end of year	**21,412**	**46,156**	**67,568**

3. Notes to the Cash Flow Statement

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

	2009	2008
Net operating result	9,369	(11,755)
Depreciation expense	19,570	10,842
Cost of Other Equipment Sold	-	4,812
Movement in Current Liabilities	-	-
Movement in Current Assets	(1,635)	(4,654)
Net cash provided by operating activities	**27,303**	**(755)**

4. Retained Earnings

	2009	2008
Balance at beginning of the year	306,576	318,332
Adjustment due to change in asset policy	-	-
Operating surplus/(deficit) for the year	9,369	(11,756)
Balance at end of the year	**315,945**	**306,576**

5. Changes in accounting policy

With restropective effective from 1 January 2006, the University's asset capitalisation threshold was increased to $5,000 from previous amount of $1,000. Property, plant and equipment with cost below the capitalisation threshold is expensed in the year of purchase. The increase in threshold was introduced in order to simplify administration of the University's asset, enabling, in particular, more reliable and relevant information from fixed asset stock takes.

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Certified Practising Accountant

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INDEPENDENT AUDITORS' REPORT

The Members of the Board

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATIONS CONSORTIUM

I have audited the accompanying special purpose financial report of the Western Australian Satellite Technology and Application Consortium – X Band which comprises the balance sheet as at 31 December 2008, the income statement and statement of cash flow for the year ended, a summary of significant accounting policies and other explanatory notes as attached.

Board Responsibility for the Financial Report

The Board is responsible for the preparation and fair presentation of the special purpose financial report. This responsibility includes establishing and maintaining internal controls relevant to the preparation and fair presentation of the financial report that is free from material misstatement, whether due to fraud or error and selecting and applying appropriate accounting policies.

Auditor's Responsibility

My responsibility is to express an opinion on the financial report based on my audit. I conducted the audit in accordance with Australian Auditing Standards. These Auditing Standards require that I 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 the entity's preparation and fair presentation 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 by the Board, as well as evaluating the overall presentation of the financial report.

I disclaim any assumption of responsibility for any reliance on this financial report to which it relates to any person other than the Board or for any purpose other than that for which it was prepared.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my audit opinion.

Auditor Independence

In conducting my audit, I have complied with the independence requirements of the Australian professional accounting bodies.

Auditor's Opinion

In my opinion, the financial report presents fairly, in all material respects, the financial position of the Western Australian Satellite Technology and Application Consortium – L Band as of 31 December 2008 and of its financial performance and its cash flows for the year then ended.

Santo Casilli CPA

Date: 31 March 2010

Perth

STATEMENT BY THE BOARD

In the opinion of the Board, the attached financial statements which form part of the special purpose financial report:

1. presents fairly the financial position of the Western Australian Satellite Technology And Application Consortium – X Band as at 31 December 2008 and the results and cash flows of the Western Australian Satellite Technology And Application Consortium for the year ended on that date; and
2. at the date of this statement there are reasonable grounds to believe that the Western Australian Satellite Technology And Application Consortium – X Band will be able to pay its debts as and when they fall due.

Prof Mervyn Lynch
Chairman

Richard Stovold
Secretary

WASTAC X-Band BUDGET 2009

Estimated expenditure for the year January 2009 – December 2009

		$ PER ANNUM 2008	2009
1.	Data Tapes	3,000	3,000
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	8,000
7.	Provision for major equipment	60,000	255,000
	TOTAL:	**$112,000**	**$307,000**

Estimated income/revenue for the year January 2009 – December 2009

1.	Annual Contributions $20,000 each	80,000	80,000
2.	Interest	8,000	5,000
	TOTAL:	**$88,000**	**$85,000**

Additional committed expenditure January 2009– December 2010

1.	Receiver upgrade for NPP/NPOESS satellites	80,000	150,000
2.	Microwave Murdoch to BoM		85,000
	TOTAL:	**$80,000**	**$235,000**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATIONS CONSORTIUM

X-BAND

INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2009

	2009	2008
	$	$
REVENUE		
Contributions Received	80,000	80,000
Interest Received	13,008	29,774
TOTAL REVENUE	**93,008**	**109,774**
EXPENDITURE		
Hospitality	367	164
Fringe Benefit Tax Paid	177	264
Other Computing Expense	-	57
Maintenance	145,323	1,933
Depreciation	98,721	94,172
TOTAL EXPENDITURE	244,588	96,590
NET OPERATING RESULT FOR THE YEAR	**(151,580)**	**13,184**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATIONS CONSORTIUM

X-BAND

BALANCE SHEET AS AT 31 DECEMBER 2009

	NOTE	2009	2008
		$	$
CURRENT ASSETS			
Cash at bank		337,085	382,785
Prepayments		-	7,159
TOTAL CURRENT ASSETS		337,085	389,944
NON-CURRENT ASSETS			
Property, plant and equipment	2	53,492	152,213
TOTAL NON-CURRENT ASSETS		53,492	152,213
TOTAL ASSETS		**390,577**	**542,157**
TOTAL LIABILITIES		-	-
NET ASSETS		**390,577**	**542,157**
EQUITY			
Retained Funds	4	390,577	542,157
TOTAL EQUITY		**390,577**	**542,157**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATIONS CONSORTIUM

X-BAND

CASH FLOW AS AT 31 DECEMBER 2009

	Note	2009	2008
31 DECEMBER 2009		**$**	**$**
Receipts			
Contributions Received:			
Landgate (Formerly the Department of Land Information)		20,000	20,000
CSIRO		20,000	20,000
Bureau of Meteorology		20,000	20,000
Geoscience Australia		20,000	20,000
Interest Received		13,008	29,774
Total Receipts		93,008	109,774
Payments			
Payments to suppliers		(138,708)	(9,577)
Total Payments		(138,708)	(9,577)
Net cash provided by operating activities	3	**(45,700)**	**100,197**
CASH FLOWS FROM INVESTING ACTIVITIES			
Payments for property, plant and equipment		-	(42,162)
Net cash used in investing activities		**-**	**(42,162)**
Net increase/(decrease) in cash		**(45,700)**	**58,035**
Cash at the beginning of the year		382,785	324,750
Cash at the end of the year		**337,085**	**382,785**

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 has been prepared in accordance with Australian Accounting Standards including Australian Accounting Interpretations, other authoritative pronouncements of the Australian Accounting Standards Board and Urgent Issues Group Consensus Views.

Compliance with AIFRS

Australian Accounting Standards set out accounting policies that the AASB has concluded would result in a financial report containing relevant and reliable information about transactions, events and conditions to which they apply. Compliance with Australian Accounting standards ensures that the financial statements and notes comply with International Financial Reporting Standards.

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 is shown at cost or fair value, less subsequent depreciation and 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 Income Statement.

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's assets are not primarily dependent on the assets' ability to generate net cash inflows.

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

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 circumstances 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.

2. PROPERTY, PLANT AND EQUIPMENT

	2009	**2008**
Computer Equipment		
At cost	14,408	14,408
Accumulated depreciation	(14,408)	(14,408)
	-	-
Other Equipment		
Equipment - work in progress	-	-
At cost	789,767	789,767
Accumulated depreciation	(736,275)	(637,554)
	53,492	152,213
Total Property, Plant and Equipment	**53,492**	**152,213**

Reconciliations

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

	Computer Equipment	**Other Equipment**	**Total**
Carrying amount at start of year	-	152,213	152,213
Additions/(Disposals)	-		-
Accumulated Depreciation on Disposals	-	-	-
Depreciation expense	-	(98,721)	(98,721)
Carrying amount at end of year	**-**	**53,492**	**53,492**

3. Notes to the Cash Flow Statement

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

	2009	2008
Net operating result	(151,580)	13,184
Depreciation expense	98,721	94,172
Movement in Current Assets	7,159	(7,159)
Net cash provided by operating activities	**(45,700)**	**100,197**

4. Retained Earnings

Balance at beginning of the year	542,157	528,973
Operating surplus/(deficit) for the year	(151,580)	13,184
Balance at end of the year	**390,577**	**542,157**

5. Changes in accounting policy

With restropective effective from 1 January 2006, the University's asset capitalisation threshold was increased to $5,000 from previous amount of $1,000. Property, plant and equipment with cost below the capitalisation threshold is expensed in the year of purchase. The increase in threshold was introduced in order to simplify administration of the University's asset, enabling, in particular, more reliable and relevant information from fixed asset stock takes.