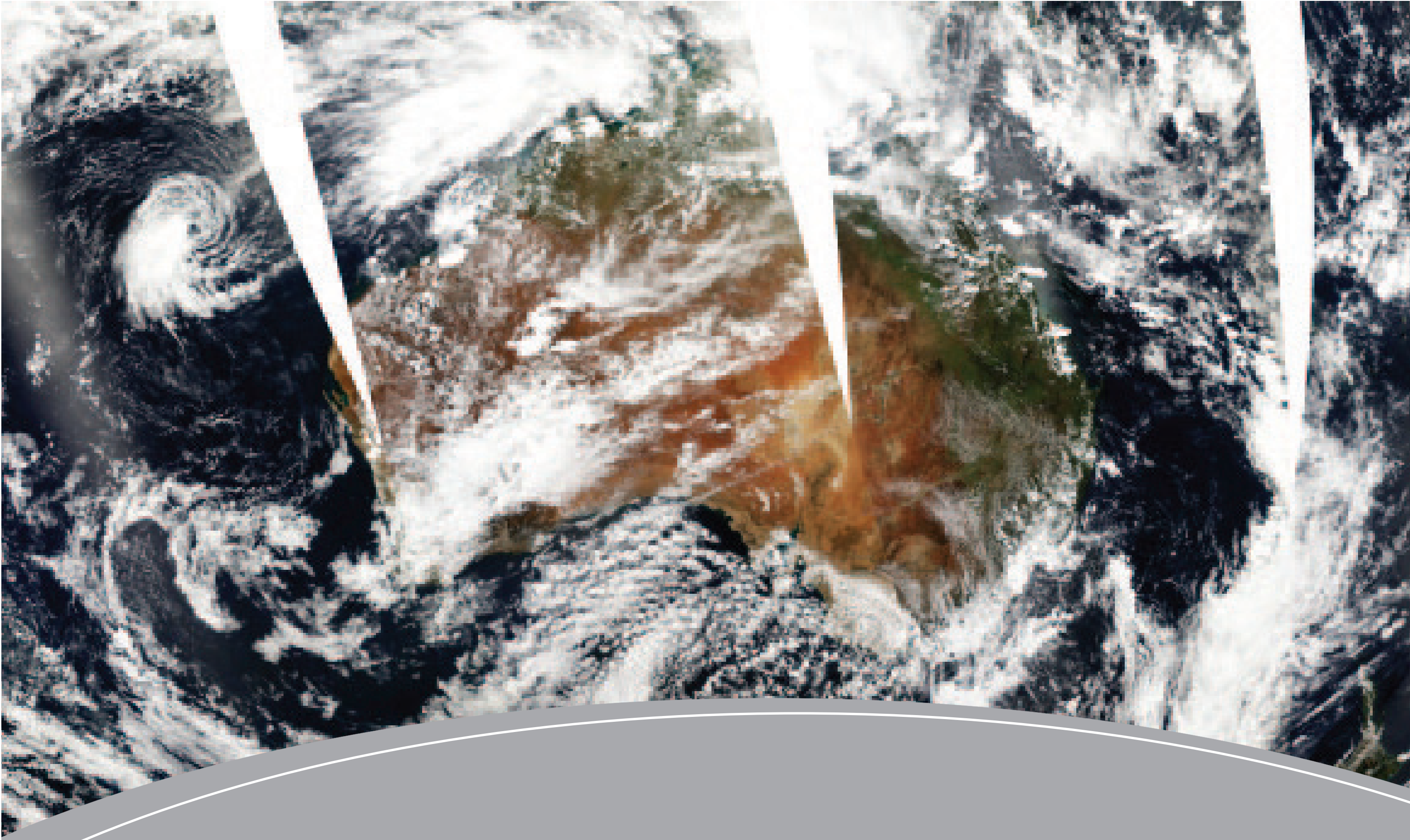


WASTAC

Western Australian Satellite Technology & Applications Consortium

Annual Report 2008

www.wastac.wa.gov.au

WASTAC members

Australian Bureau of Meteorology
GPO Box 1289
Melbourne VIC 3001

Curtin University of Technology
GPO Box U1987
Perth WA 6845

CSIRO
Space Sciences and Technology
PO Box 7109
Yarralumla ACT 2600

LANDGATE
Leeuwin Centre for Earth Sensing Technologies
65 Brockway Road
Floreat WA 6014

Geoscience Australia
GPO Box 378
Canberra ACT 2601

Murdoch University
South Street
Murdoch
Western Australia 6150

Postal:
The Secretary WASTAC
PO Box 471
WEMBLEY 6913
Western Australia

LEEUWIN CENTRE
65 Brockway Road
FLOREAT 6014
Western Australia

Telephone: (08) 9387 0330
Facsimile: (08) 9383 7142
International: (+618)

Email: Richard.Stovold@landgate.wa.gov.au
Web site: http://www.wastac.wa.gov.au

Front Page:
Australia and the surrounding region imaged by the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the NASA Aqua polar orbiting platform. This data was collected February 8, 2008 and forms part of a long term archive of satellite data collected and maintained by WASTAC. The image is a false-color image generated from atmospherically corrected 645nm, 553nm and 465nm observations combined to simulate the red, blue and green regions of the visible spectrum.

Mark Gray, Remote Sensing and Satellite Research Group, Curtin University of Technology
(mark.gray@postgrad.curtin.edu.au)

Editors: R. Stovold - Landgate
A.F. Pearce - Curtin University of Technology

Contents

WASTAC CHAIRMAN'S REPORT 2008

Professor M. J. Lynch

It is encouraging to witness the increasing role that remote sensing is contributing in addressing the more immediate interest of industry on the one hand and the longer term concern of the pressures of environmental change and, on the other, the consequences for terrestrial and marine ecosystems and biodiversity. Remote sensing not only offers an objective reporting scheme on the state of the environment but also offers the potential to dig deeper into processes and interactions that are the propagators of change in the environment.

More recently, the National Heritage Trust program has been replaced by Caring for our Country initiative. It is difficult to imagine that such a program as the latter could progress without a significant dependence on long term quantitative remote sensing information.

For decades we have been accustomed to remote sensing data from the meteorological satellites being assimilated into numerical forecast models in order to better constrain numerical model initial conditions. With enhanced information from the current generation of satellite sensors (such as MODIS, AIRS, MERIS) there has been a growth in the development of models to improve the prediction of a wider range of physical and biological systems – both terrestrial and oceanic. Terrestrial and oceanic primary production are two such cases in point where the ability to monitor the welfare or health of these systems in the longer term, to understand their functionality, and to predict their future sustainability is crucial.

We continue to see improvements in the sophistication and performance of on-orbit sensors. Whereas, just a decade ago, it was common to work with environmental satellites sensors with just a few spectral bands, we are now able to acquire data from on-orbit hyperspectral infrared sensors that have thousands of spectral bands coupled with on-orbit radiometric calibration systems. However, there is still a trade-off between spectral bands and spatial resolution which is slowly being eroded to our benefit. The precursors to advanced on-orbit instruments usually are the airborne systems. WASTAC needs to be vigilant and ensure it keeps abreast of the science, the algorithms and the processing systems that extract new information on the environment from these advanced technology sensors.

It is encouraging over more recent years to see WASTAC's archive of satellite data being migrated into larger and longer term studies such as SRFME, CRC Spatial Information, the Ningaloo Collaborative Flagship, WAMSI and the longer term Federal initiatives such as NCRIS IMOS and, more recently, NCRIS TERN. Additionally, WASTAC's almost 30 year archive of environmental satellite data is being migrated to on-line status at the State's high performance computing facility, iVEC.

There is no doubt that the heritage of WASTAC will be its foresight in maintaining a data record from those earlier years when the value of such information was likely underestimated and the tools and technology to maintain the record were certainly challenging. Are we doing sufficient with the information we have now? The challenge for WASTAC today is to have the foresight to define an ongoing utilisation of its information that will be equally significant when judged in 30 years time.

Professor M. J. Lynch

WASTAC BOARD FOR 2008

Professor Merv Lynch	(Chairman) Curtin University of Technology
Dr Matthew Adams	Landgate
Mr Richard Stovold	Landgate
Dr Doug Myers	Curtin University of Technology
Dr Alex Held	CSIRO, Earth Observation Centre
Dr David Griersmith	Bureau of Meteorology
Mr Alan Scott	Bureau of Meteorology
Mr Adam Lewis	Geoscience Australia
Professor Tom Lyons	Murdoch University
Exec. Dean Yianni Attikiouzel	Murdoch University

WASTAC STANDING COMMITTEE AND PROXY TO THE BOARD

Professor Merv Lynch	(Chairman) Curtin University of Technology
Dr Matthew Adams	Landgate
Mr Richard Stovold	Department of Land Information
Dr Doug Myers	Curtin University of Technology
Mr Alan Scott	Bureau of Meteorology
Mr Don Ward	Bureau of Meteorology
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

WASTAC STRATEGIC PLAN

VISION:

Improve the economy, society and environment through the acquisition of satellite observations of Western Australia and its oceans for research and near real-time applications.

MISSION:

- Provide high speed access to Aqua, Terra, NOAA (TOVS and AVHRR), SeaWiFS and FY1D satellite data to members on a non-profit basis.
- Contribute these data for national and international initiatives in remote sensing.
- Adopt recognised data formats to ensure wide access to WASTAC data.
- Maintain the integrity of archived data for research and operational applications.
- Promote the development and calibration of value-added products.
- Prepare for utilisation of information from new technically and scientifically advanced sensors.
- Promote educational and research uses of WASTAC data.
- Ensure maximum use of Aqua, Terra, NOAA, SeaWiFS and FY1D data in the management of renewable resources.

FUTURE STRATEGIES:

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

FUTURE SATELLITE RECEPTION OPPORTUNITIES:

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

OPERATIONAL STATUS

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 the Leeuwin Centre.

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

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

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

WASTAC X

The WASTAC X band facilities at the Environmental Science Building at Murdoch University were supplied and installed by SeaSpace Corporation in September 2001 and consist of a 3.6m diameter antenna mounted in a fibreglass dome and a Linux PC antenna control computer. The ingest and display computers with hard disc and tape archive storage as well as a dual CPU LINUX processing computer are located at Landgate's SRSS at the Leeuwin Centre. The X band 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.

Future plans include upgrading the X band station to receive METOP[mid 2009], NPP and FY3 satellite data as well as the processing of MODIS data to level2 and AIRS data from Aqua and Terra. The BOM will install a new microwave link between the BOM in Perth to Murdoch University which will allow direct access to X band 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 11,705 NOAA passes were archived at Curtin and Murdoch in 2008. Passes included data from the NOAA 15, 16, 17 and 18 satellites. NOAA 14 was turned off on 23 May 2007 and NOAA 12 on 10 August 2007.

The number of SeaWiFS passes totalled 787.

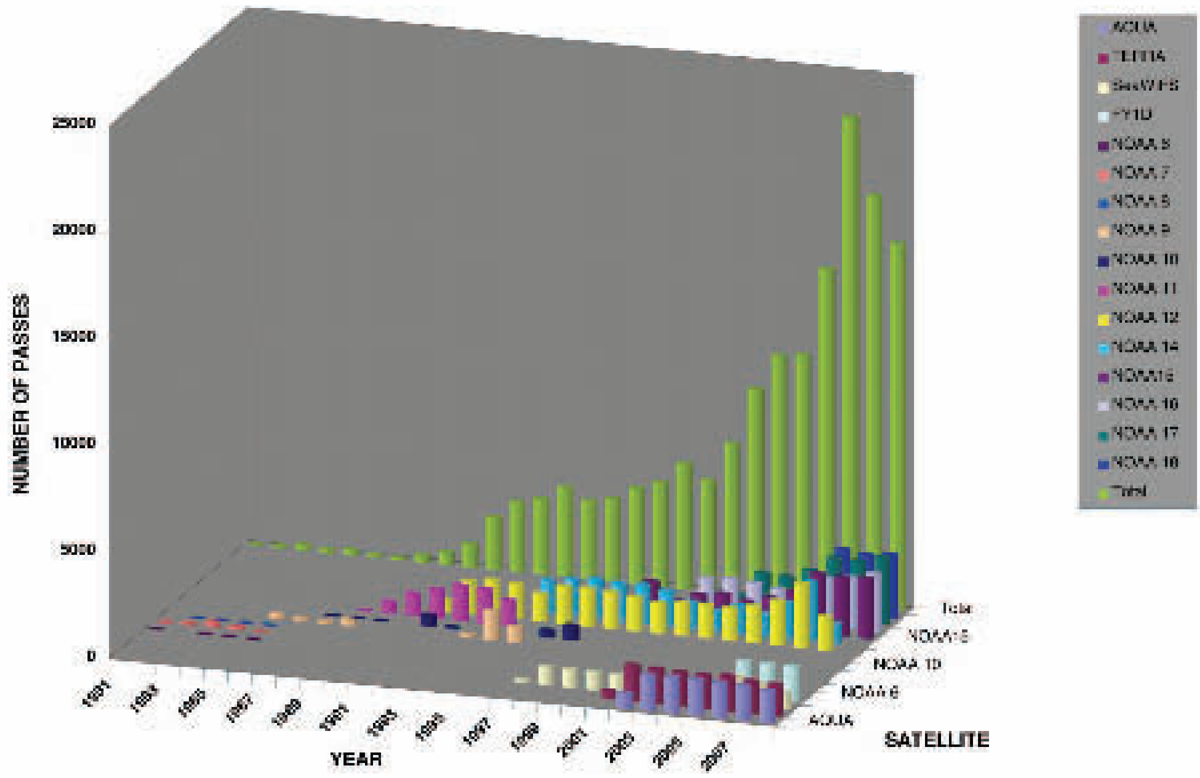
There were 1495 TERRA, 1553 AQUA and 1673 FY1D passes archived.

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

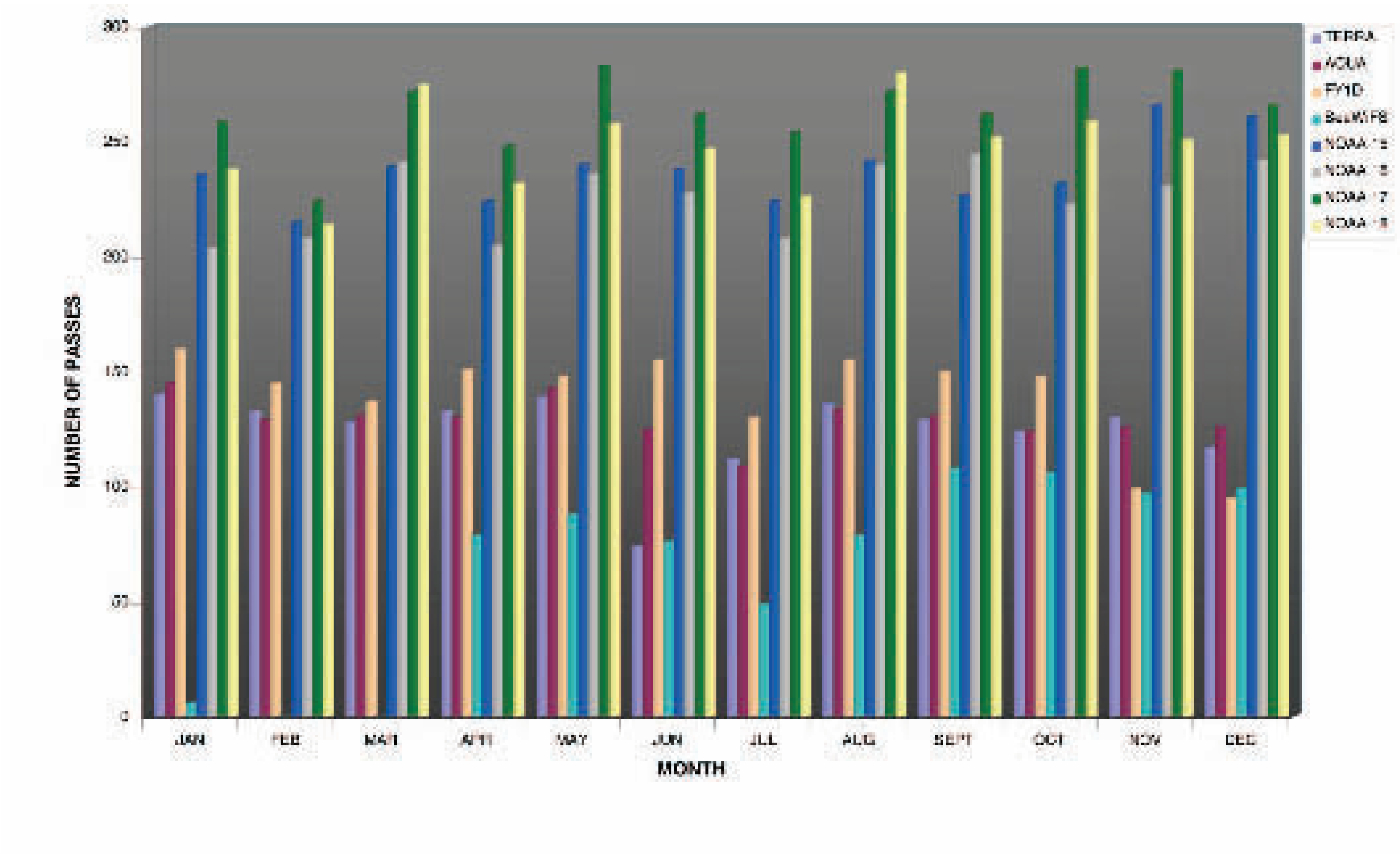
Landgate currently holds the archive on 8mm exabyte and DAT tapes. 20Gb DLT tapes were introduced as the archive media in late 2000 for the L band data and since the commissioning of the facility in 2001, X band data has been archived on 35Gb DLT tapes.

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	NOAA 15	NOAA 16	NOAA 17	NOAA 18	Total
1981					5	22											27
1982						115	1										116
1983					12	224	12										248
1984					7	179	4										190
1985					7	33	4	212									256
1986								151									151
1987								97	18								115
1988								200	25	55							280
1989									21	501							522
1990										1118							1118
1991									906	1399	175						2480
1992									47	1593	1571						3211
1993								133		1598	1720						3450
1994								1182		1271	1481						3934
1995								770			1326	1015					3111
1996									354		1780	1776					3910
1997			142						596		1707	1578					4023
1998			415								1763	1698	487				4363
1999			123								1709	1619	1701				5152
2000			843								1427	1391	925	541			5127
2001		330	811								1548	1271	1202	1488			6645
2002	728	1710	780								1779	876	1126	1798	739		9707
2003	1621	1045	690								1521	1331	1329	1738	1607		11282
2004	1588	1592	680								1727	1058	1481	1524	1727		11534
2005	1708	1577	490	660							2101	1708	1504	1488	2202	1550	16028
2006	1926	1939	1296	1920							2200	2001	2920	2290	2901	2988	23920
2007	1015	1512	1026	1679							1571	832	2777	2442	2029	2029	20047
2008	1593	1495	792	1673									2544	2711	3159	2588	17218

WASTAC Satellite Data for 2008



2008 Archived Data

	TERRA	AQUA	FY1D	SeaWiFS	NOAA 15	NOAA 16	NOAA 17	NOAA 18
JAN	140	145	160	6	236	204	259	238
FEB	133	129	145	0	215	208	224	214
MAR	128	131	137	0	239	241	272	275
APR	133	130	151	79	224	205	248	232
MAY	139	143	148	88	240	236	283	258
JUN	74	125	155	76	238	228	262	247
JUL	112	109	130	49	224	208	254	226
AUG	136	134	155	79	242	240	272	280
SEPT	129	131	150	108	227	245	262	252
OCT	124	124	148	106	232	223	282	259
NOV	130	126	99	97	266	231	281	251
DEC	117	126	95	99	261	242	266	253

Operational Applications

2008

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

Full resolution (1km) AVHRR data from the NOAA polar orbiters has been recorded since the early 1980s via direct broadcast at locations around Australia, including Perth, Darwin, Alice Springs, Townsville, Melbourne and Hobart. Data recorded at individual reception stations can be degraded by local radio interference, antenna tracking errors, directional transmission problems at the spacecraft and noise in the receiving system. For the last 9 years CSIRO in Canberra has been retrospectively, with a delay of months or years, combining the segments of each overpass recorded at multiple sites to produce a stitched archive of NOAA data which comprises continent-spanning passes using only the best data. The resulting data set is both more compact and of higher quality because it consists of only one file per overpass, and specially developed algorithms exploit the redundancy in the overlapping multiple acquisitions to select the highest quality data. Where three or more simultaneous acquisitions exist, it is normally possible to completely correct noise affected data. An example of the stitching process is shown in Figure 1.

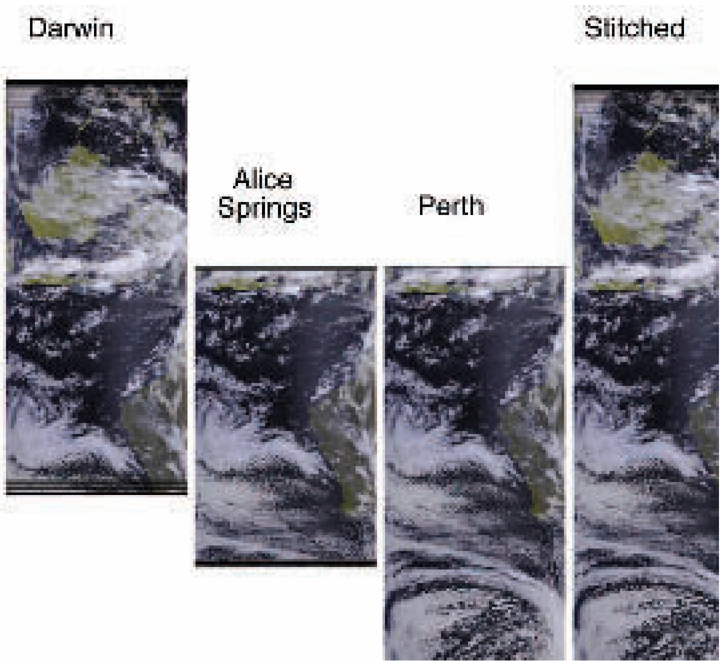


Figure 1. A stitched pass using NOAA-17 data from Darwin, Alice Springs and the WASTAC Murdoch reception station at 02:30GMT on 2006-01-26.

In late-2007 CSIRO Marine and Atmospheric Research and WASTAC arranged a direct network feed of NOAA data acquired at the two Perth reception sites into the CSIRO Advanced Scientific Computing (ASC) Centre collocated with the Bureau of Meteorology head office in Melbourne. CSIRO has rewritten the stitching software system with a view to running it at the ASC using the WASTAC data and other NOAA data brought onsite by CSIRO and the Bureau of Meteorology, to produce the stitched passes in near real time for use in time sensitive applications. A key use will be to support the generation of the GHRSST-PP sea surface temperature product being developed by the Bureau as part of the IMOS project.

The system has been operating since mid-2008 using the six reception sites shown in Figure 2. Approximately 40 stitched passes are produced every day from around 170 individual acquisitions at the contributing reception stations. The data is publicly available from the CSIRO web site within minutes of an overpass being received so all agencies using NOAA AVHRR data, including WASTAC, have access to the same high quality national base data set. This is a prime example of what can be achieved when multiple agencies cooperate to produce a combined data set. It is likely that the system will eventually be run operationally by the Satellite Section of the Observations Branch of the Bureau.

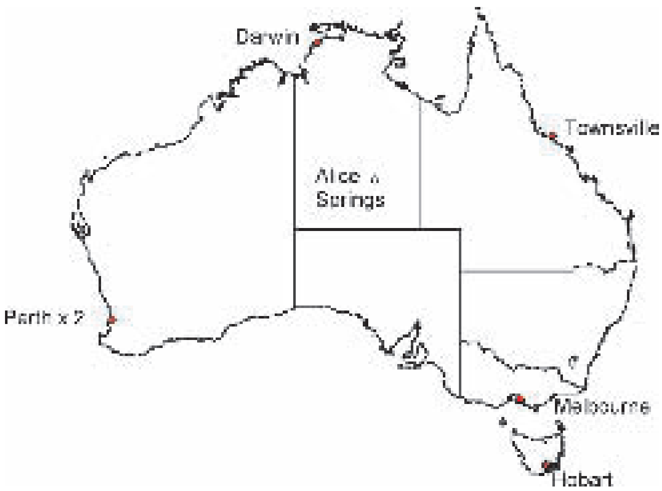


Figure 2. Australian reception stations contributing NOAA HRPT data to the near real time stitching data set.

CAPS GEOLOCATION SOFTWARE

The CAPS Geolocation software is used to automatically generate navigation state vectors for the NOAA spacecraft using AVHRR instrument data. These state vectors, comprising spacecraft position, velocity and orientation, can be used with the CAPS application software to geolocate AVHRR scanner data with sub-pixel accuracy across the whole Australian region without recourse to ground control points on a per-scene basis. As well as providing high quality navigation for contemporary data, the system could be applied to historical archives to enable consistent processing of multi-decadal time series. Depending on the details of the scanner models, it also has the potential to navigate data from other instruments, such as those carried on the Chinese polar orbiters (the VIRS on FY1 and forthcoming MERS on FY3). The state vector generation system was developed by CSIRO and is run operationally at the CSIRO Laboratories in Hobart.

The heart of the system is a numerical orbit propagator which integrates the satellite equations of motion to predict satellite location and orientation with high precision. The system operates automatically on a sequence of scenes, and uses the differences between the observed and predicted locations of coastline segments in a least squares fit to refine the state vector, which can then be used with the orbit predictor to accurately geolocate individual scenes (Figure 3).

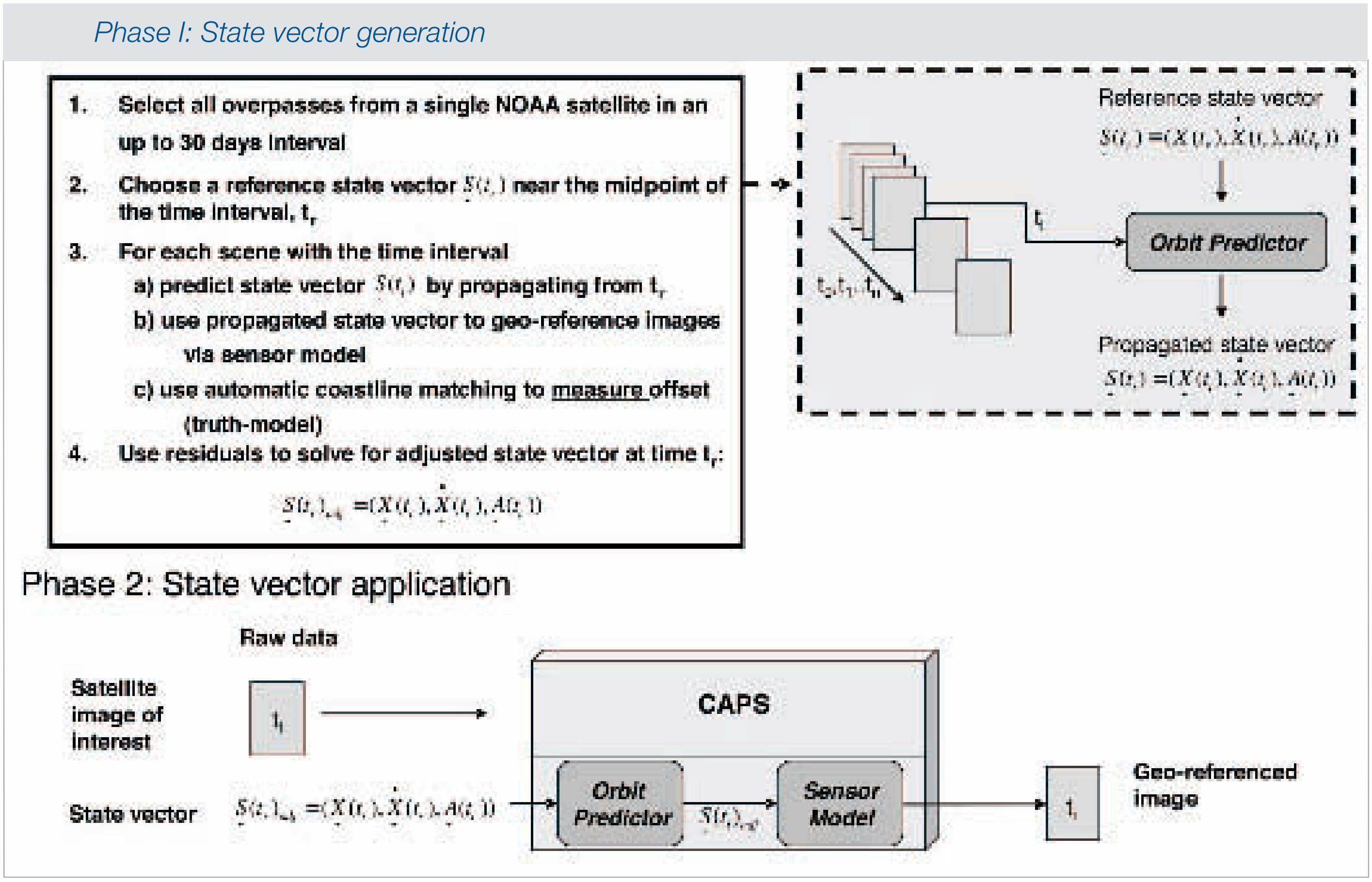


Figure 3. Schematic overview of the CAPS geolocation process (from Schmidt, et al. 2008).

The existing operational system consists of several thousand lines of Fortran 77 and runs only on Solaris operating system on the SPARC architecture. The code predates the development of modern software engineering practice and has several legacy software dependencies built into it, such as references to the DISIMP package libraries, and many other utilities that are either unmaintained, or whose authors have long since moved on. There is only one person with the skills and knowledge to run the system and the ability to recognise and diagnose faults. What little documentation exists is either incomplete or out of date. The automatic generation of state vectors relies on a coastline database that is over 25 years old, does not include many islands beyond the Australian continent (eg Indonesia, PNG), and that is superseded by a new higher quality publicly available coastline database (GSHHS).

Several years ago CSIRO began a project to update and modernise the code and to enable it to be run other than at the Hobart site. This project has achieved several milestones:

1. Switching from DISIMP to ASDA format image data.
2. Replacement of old Fortran orbital mechanics code with a modern and properly engineered CAPS implementation in C.
3. New operating script and portable environment definition.

As a result the system was able to be run on Solaris/SPARC architecture away from Hobart. However the conversions, particularly the first two steps, required some major architectural changes to the code and the new system did not produce results consistent with, or of as high a quality, as the existing operational system.

Recognising the value of this software, it's strategic potential, and the opportunity to contribute to the national remote sensing community, the WASTAC board voted in 2007 to provide up to $20K to help bring the conversion project to completion. The first stage was essentially exploratory and enabling, and was completed in November 2007 and used approximately one quarter of the funds to make the new system work on a Linux operating system, and to assess what the next step should be. The second stage, undertaken by CSIRO and the Bureau of Meteorology, is improving the documentation and developing tools and test cases in order to locate remaining issues and verify correct operation of the individual components on an ongoing basis. Once that is achieved, the third step would enable the system to work with the GSHHS coastline database. Although a significant change in its own right, comparable to the file format and orbital mechanics changes already made, this step should be much easier due to the improved documentation and tools developed in the previous stage.

Upon completion, the system should be able to be run independently by CSIRO in both Hobart and Canberra, WASTAC in Perth, and operationally by the Bureau of Meteorology in Melbourne. The code will be documented and maintainable, several people will understand it, and there will be no single points of failure. Its key ongoing role in the processing of AVHRR data, both contemporary and historical, will be protected, and there is a far greater likelihood that it will fulfil its potential for use with future scanner instruments.

References.

Schmidt,M. et al (2008). Assessing the geometric accuracy of AVHRR data processed with a state vector based navigation system. Canadian Journal of Remote Sensing, Vol. 34, No. 5, pp. 496-508

BUREAU OF METEOROLOGY, MELBOURNE

Compiled by Mike Willmott, Ian Grant, Leon Majewski, Gary Weymouth, David Howard & members of the Severe Weather Section of WA

SEA SURFACE TEMPERATURES (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 AVHRR SST products are currently included in global (1/4° spatial resolution) and regional (1/12° spatial resolution) SST analyses that are used operationally in ocean forecasting and numerical weather prediction, including the prediction of tropical cyclones and severe weather events (Beggs, 2008). These global and regional analyses have been made available to the wider research community as part of the Bureau's commitment to reduce barriers to data access.

Cloud-cleared SST data has been used to create a mosaic of the weighted-average SST from observations within the past 14-days. The weighting process places more emphasis on the most recently acquired cloud-free data. This method provides near-complete coverage of the Australian region.

Recently, the mosaic product has been converted into netCDF formatted data files, using the Group for High Resolution SST (GHRSST) Data Processing Specification (GDS) v1.7. The use of the GHRSST data format has allowed the mosaic to be included in the Integrated Marine Observing System (IMOS) Australian Oceans Distributed Active Archive Centre (AO-DAAC).

The AO-DAAC is built around a PostGIS/PostgreSQL spatial database that allows the determination (and subsequent extraction) of areas and regions that intersect with the data holdings (King et al., 2008). A Google-Maps interface to the AO-DAAC system has been provided (Figure 4; see http://www.eoc.csiro.au/aodaac).

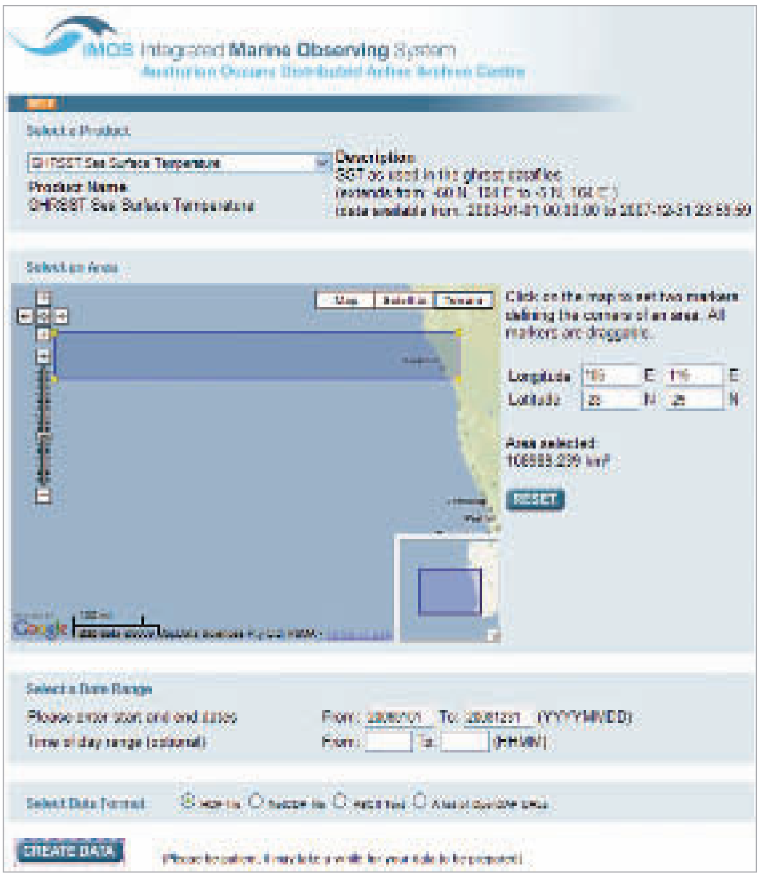


Figure 4. The AO-DAAC selection window. Coordinates can be entered using a Google-Maps interface. The AO-DAAC can be accessed from http://www.eoc.csiro.au/aodaac.

The requested data can be returned as a set of OPeNDAP URLs, ASCII text, or extracted into a single HDF file.

The value of the AO-DAAC is demonstrated in Figure 5. An area off the coast of Geraldton, WA (28.7°S, 114.6°E) of approximately 1 x 10° has been selected for the period 1/1/2006–31/12/2008 (inclusive) and a Hovmöller diagram created to display the variability along the longitude dimension over time. The diagram shows that in March 2008, the average SST between 108-114°E was 24.5±0.1°C; warmer than at the same in either 2006 or 2007 (23.7±0.3°C and 23.0±0.3°C, respectively). The warmer temperatures observed in 2008 were due to the influence of a strong Leeuwin Current associated with the La Niña event that persisted between September 2007 through May 2008.

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.

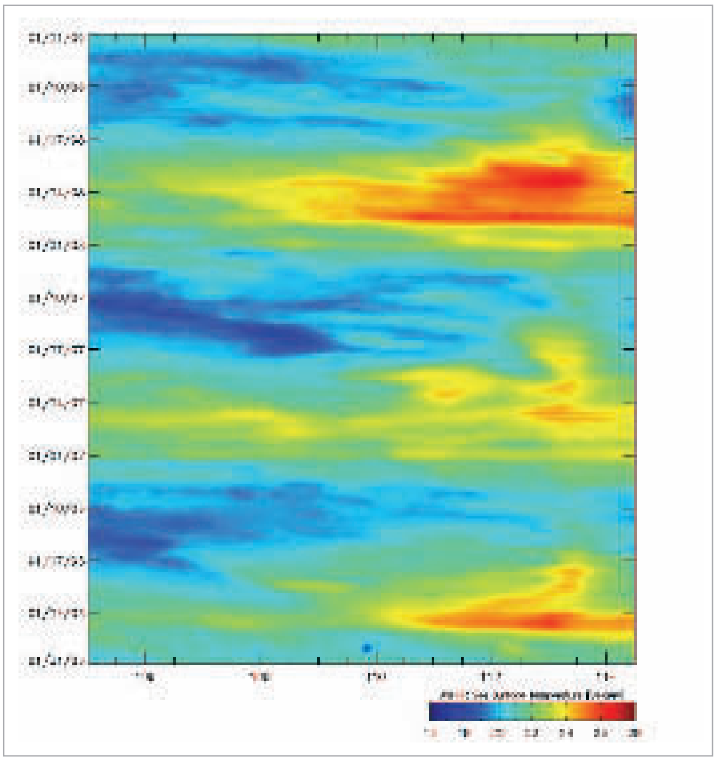


Figure 5. Hovmöller diagram of the average SST off the coast of Geraldton, WA (28.7°S, 114.6°E) between 28-29°S, 104-114.6°E for 2006 through 2008. The 2008 warming period has a greater magnitude, is longer and larger than the corresponding periods in 2006 and 2007.

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 3 January 2008 to 31 December 2008, there were seven tropical cyclones that entered or formed within the Perth TCWC's area of responsibility (See Table 1). Of these the most severe were Tropical Cyclones Nicholas, Pancho and Billy (Figure 6,7,and 8). It is interesting to note that Tropical Cyclone Rosie was the first tropical low monitored by the newly established Jakarta Tropical Cyclone Warning Centre and Tropical Cyclone Durga was the first tropical cyclone to be named by the same establishment.

Table 1. List of Tropical Cyclones for the period January 2008 to December 2008

Tropical Cyclone	Period (2008)	Max Intensity	Impact on Coast
Nicholas	11 – 20 February	Category 3	Significant
Ophelia	1 – 6 March	Category 2	Nil
Pancho	23 – 30 March	Category 4	Significant
Rosie	20 – 24 April	Category 2	(Christmas Island only)
Durga	20 – 26 April	Category 2	Nil
Anika	17 – 22 November	Category 2	Nil
Billy	15 – 28 December	Category 4	Significant

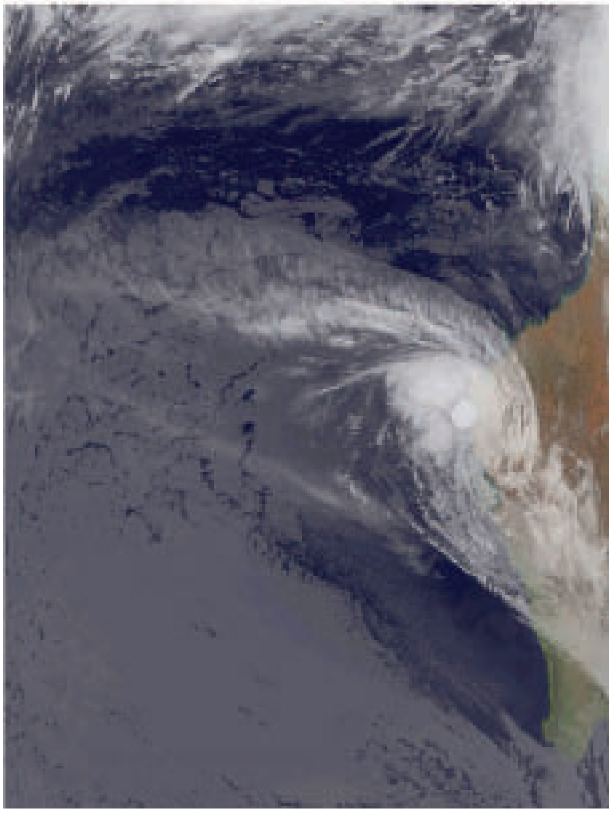


Figure 6. Severe Tropical Cyclone Nicholas crosses the coast approximately 60 kilometres south southwest of Coral Bay. Image taken from NOAA-18 on 19 February 2008 at 18:03 UTC.

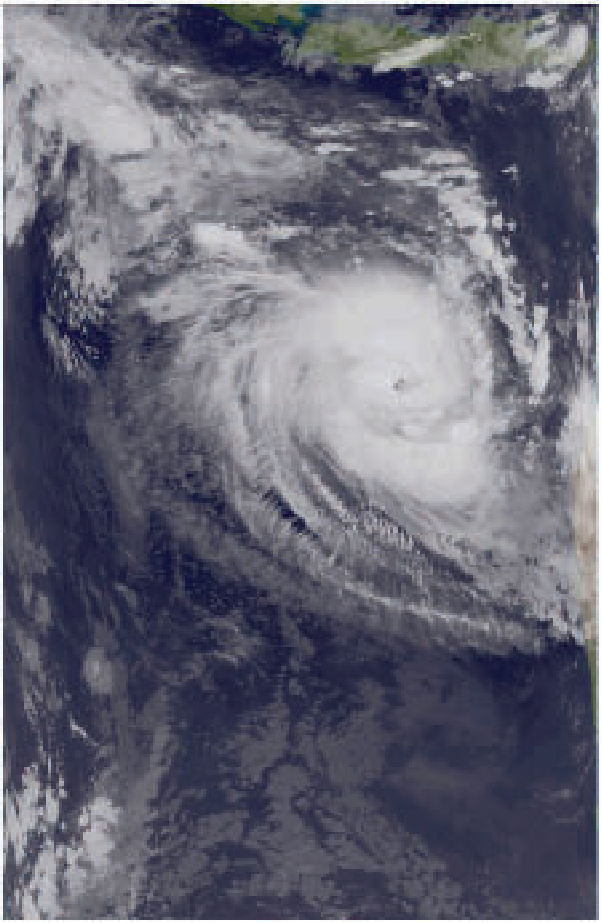


Figure 7. Severe Tropical Cyclone Pancho 975km NW of Learmonth at maximum intensity. Image taken from NOAA-18 on 26 March 2008 at 18:29 UTC.

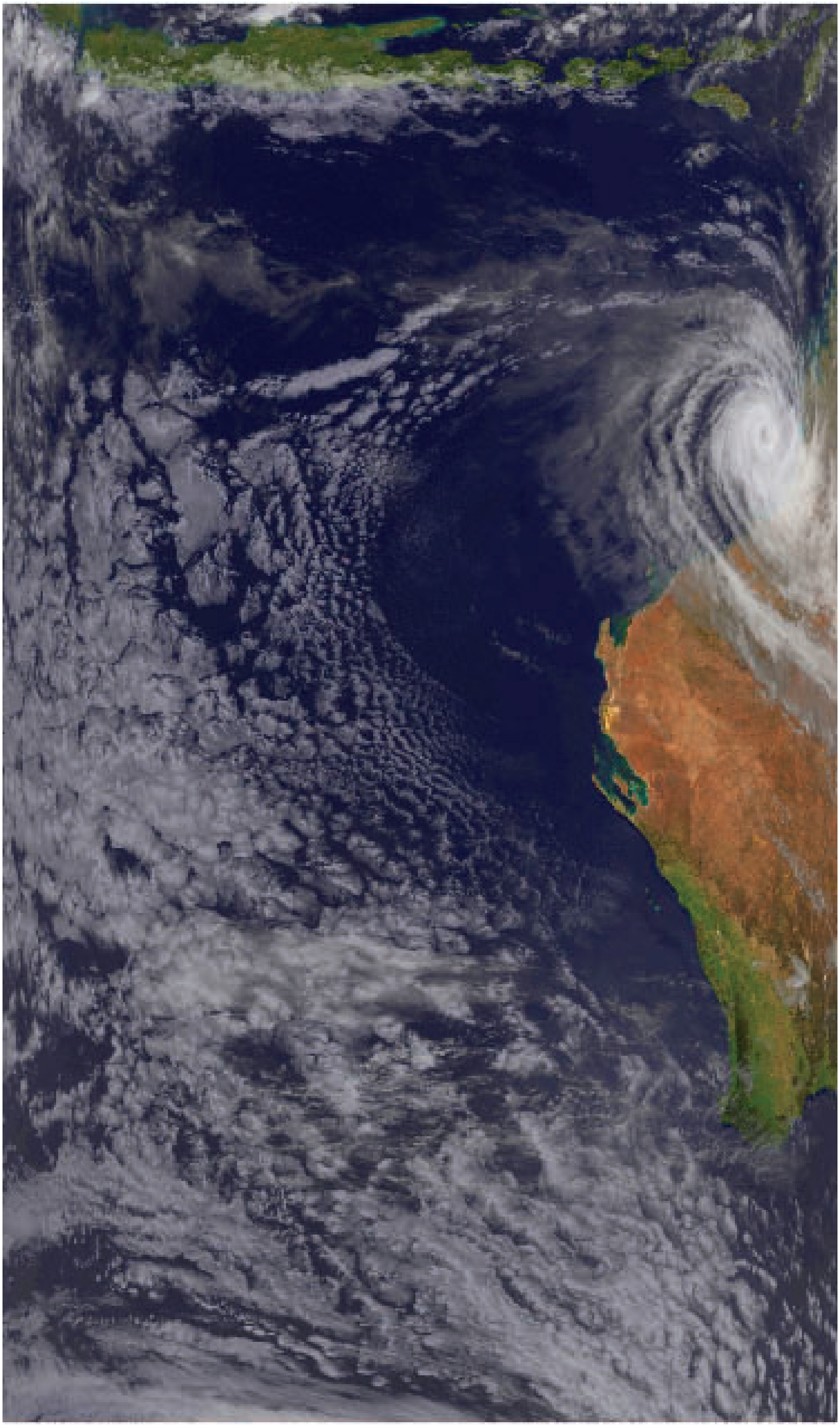


Figure 8. Severe Tropical Cyclone Billy about to make landfall near Wyndham. Image taken from NOAA-17 on 24 December 2008 at 02:00 UTC.

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 (see Figure 9). In 2008, the Bureau started supplying monthly 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.

The 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 the Environmental Resources Information Network (ERIN). The NDVI anomaly map for a given month is calculated from the NDVI for that month and the mean and standard deviation of the corresponding month in all years in the record.

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.

NDVI Anomaly February 2008

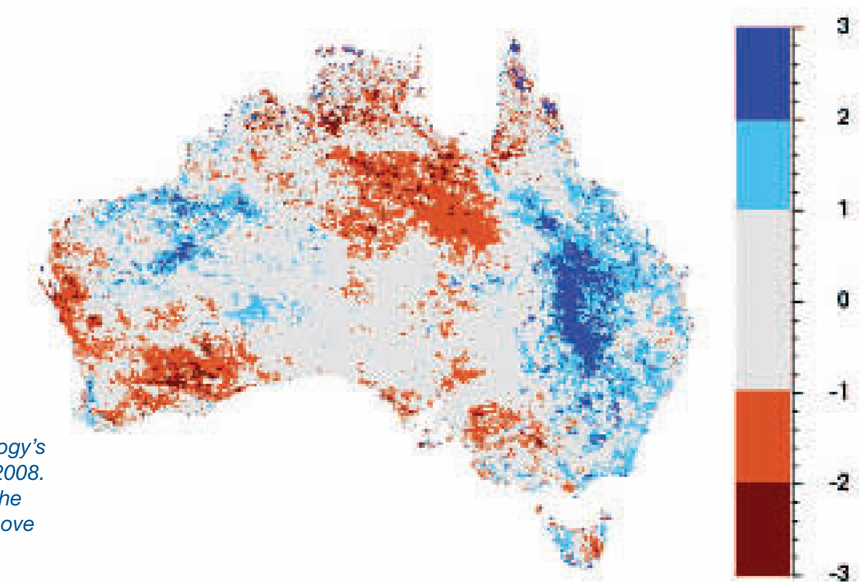


Figure 9. The Bureau of Meteorology's NDVI anomaly map for February 2008. The anomalies are expressed as the number of standard deviations above or below the long-term mean.

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, adding several days of predictability in the southern hemisphere compared to use of no satellite data. 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 2008, local ATOVS reception from WASTAC, Darwin, and Crib Point provided Australian Region NOAA-15, -17 and -18 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.

Accurate regional NWP for any country requires global ATOVS data. This has stimulated the development of rapid ATOVS dissemination through European, South American and Asia-Pacific (AP) Regional ATOVS Retransmission Services (RARS). In addition to contributing data through five local ATOVS reception facilities, including WASTAC, the Bureau also coordinates the international AP-RARS initiative. By the end of 2008, twelve international AP-RARS sites were operational, including Australia, New Zealand, Singapore, China, Japan, Hong Kong and Korea. An example of AP-RARS coverage is provided in Figure 10. Significant operational AP-RARS network expansion through 2009 is expected. (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 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.

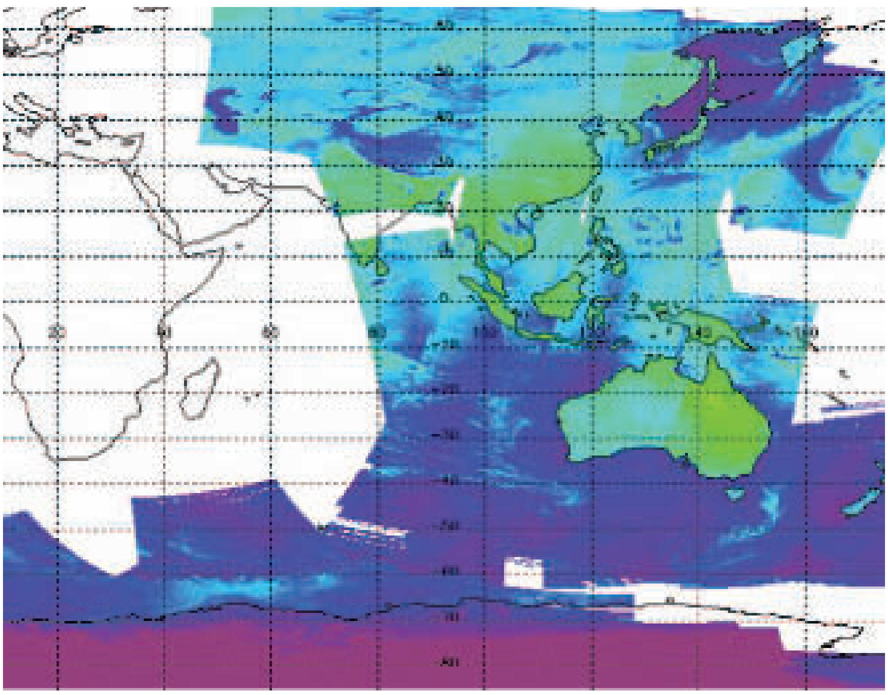


Figure 10. A 12-hour composite of AP-RARS microwave data coverage (incorporating data from WASTAC) in spring, 2007.

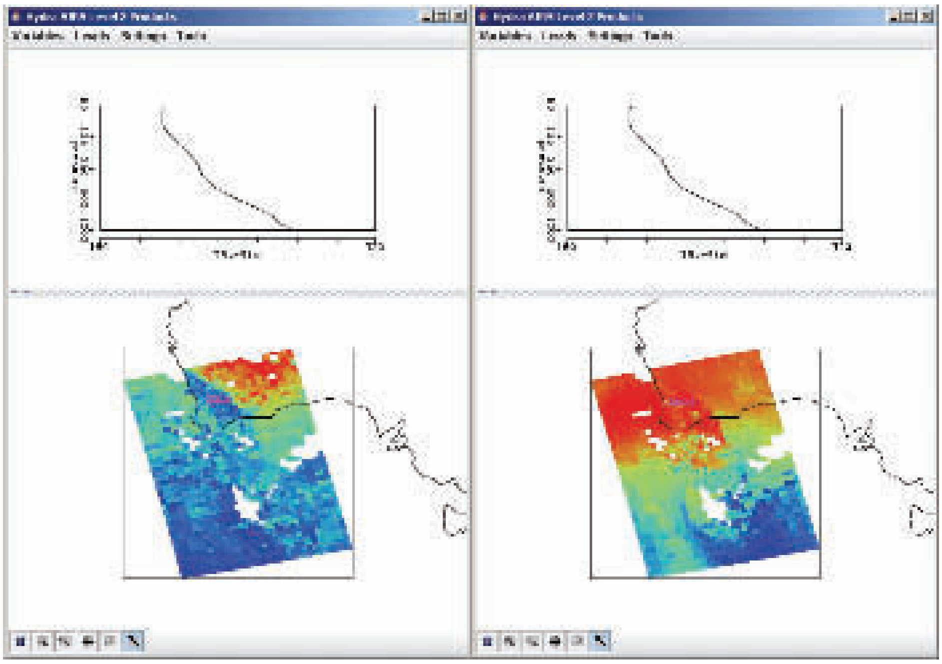


Figure 11. AIRS data received at WASTAC on 18 July 2008 at 05:57 UTC, viewed through the Hydra hyperspectral data viewer showing the temperature profile over Perth (upper left) and the corresponding thermal image below, and at 250hPa with its corresponding thermal image.

Figure 11 shows AIRS data received by WASTAC, after processing through IMAPP. Figure 12 shows MODIS data from WASTAC. The Aqua satellite carries, besides MODIS, the Advanced Infrared Sounder (AIRS), which offers atmospheric profile data of unprecedented accuracy. Image products describing the temperature and moisture structure of the atmosphere will also be produced by IMAPP software for delivery to forecasters. 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.

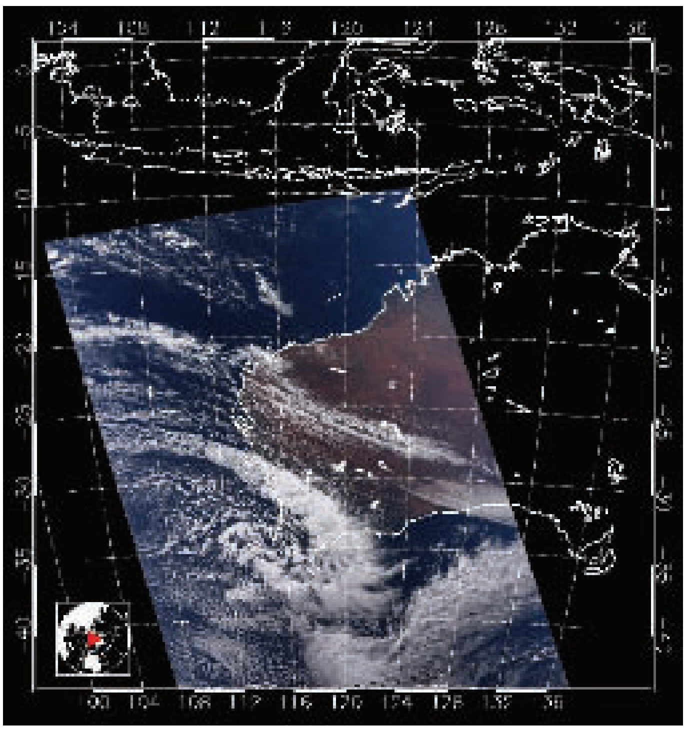


Figure 12. "True Colour" MODIS image received at WASTAC on 18 July 2008 at 05:57 UTC.

FOG / LOW CLOUD

The fog/low cloud program developed by the Bureau of Meteorology Research Centre (Weymouth, 2002) 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 IR NOAA data. Low altitude small-droplet water cloud emissivity at nighttime approximates that of a blackbody at 11 micron, but not 3.7 micron, leading to the apparent blackbody temperature being lower in the 3.7 micron band than the 11 micron band. Clouds composed of large droplets and/or ice crystals are not detected. The software provides cloud top height assignment with the use of topography and a land-sea mask.
The imagery 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. MODIS fog and low cloud imagery from WASTAC X-band reception will be produced by Autumn 2010.

Figure 13 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.

References.

Beggs, H. (2008). In GHRSST-PP 9th STM. Perros-Guirec, France.

E.A. King, P.P.Y. Mak, P.J. Turner, G.P. Smith, K.D. Suber, M.J. Paget, C. J. Jackett, P. Fearns, A.L. Rohl, F. Goessmann, L. Majewski, S. Reddy and C. Steinberg (2008). Distributed Gridded Data Delivery for Marine Research. In: Proceedings of eResearch Australasia 2008. eResearch Australasia 2008, Melbourne, Australia. 28 September - 3 October 2008

Weymouth, G. (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.

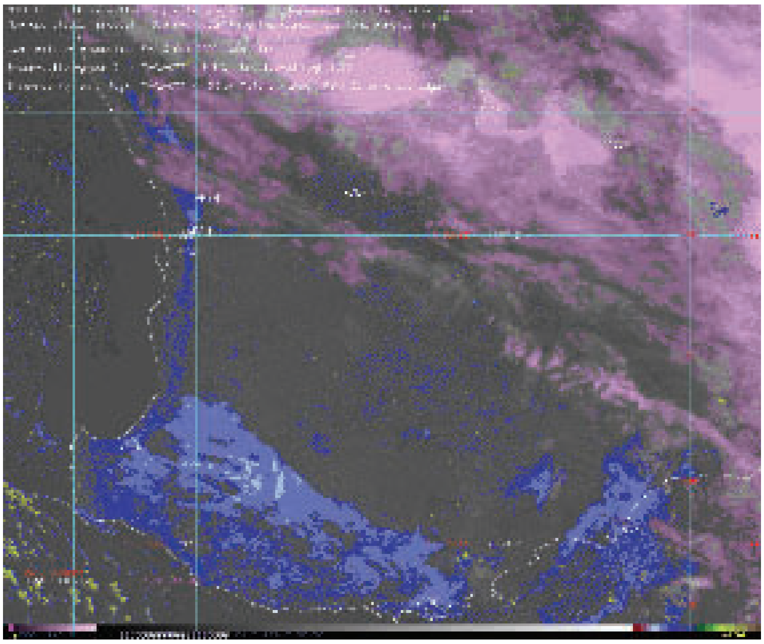


Figure 13. Fog and Low Cloud image from NOAA-15 on 5 April 2007. Fog at Perth Airport lasted from 19:55 to 23:43 UTC. Fog is shown in blue along the plain on the coastal side of the escarpment, with a larger area on the southwest corner.

LANDGATE , SATELLITE REMOTE SENSING SERVICES, FLOREAT

TEMPERATURE (SST)

Mike Steber

SST data derived from both MODIS and NOAA-AVHRR sensors and Chlorophyll data derived from just MODIS are routinely generated for each satellite pass received from 6 stations located around Australia. These datasets are then forwarded to a partner agency in Canberra called Earthinsite who have a website called seasurface.com (Figure 14) which features continental SST and Chlorophyll imagery. Clients can access data by Single Purchase, Multiple Purchase Packs and by Unlimited Subscription (Weekly or Annual). Clients can also display, add and edit GPS marks. These GPS marks show favourite fishing locations. The client can choose whether to keep their GPS marks private or open them up to other members of the service. The main users of this website are recreational and game fishermen from the east coast but more fishermen from the west coast are starting to use the website.

PASTURES FROM SPACE®

Norm Santich, Richard Stovold, Matthew Adams, Graham Donald

Moderate Resolution Imaging Spectroradiometer (MODIS) Normalised Difference Vegetation Index (NDVI) data has been 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. In eastern Australia the PGR footprint was then extended north to Rockhampton and south to include Tasmania in 2007.

In 2008, the PGR model was further extended to calculate PGR at a continental scale (Figure 15). The archive of national MODIS NDVI data as well as the climate data has been back-processed and PGR information now exists at a continental scale from the beginning of 2005. This information will enable producers to make pastoral management decisions based on the historical data. Data from the current season can be compared with previous years and this will aid producers when making decisions on carrying capacity and at mustering time.

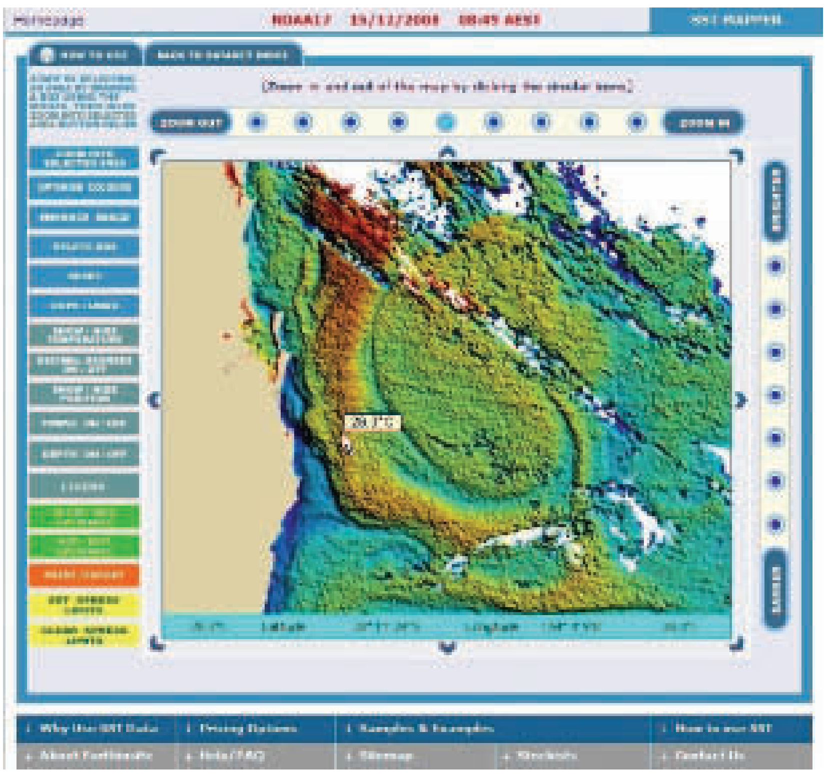


Figure 14. Screen snapshot from seasurface.com showing sea surface temperature on the east coast of Australia.

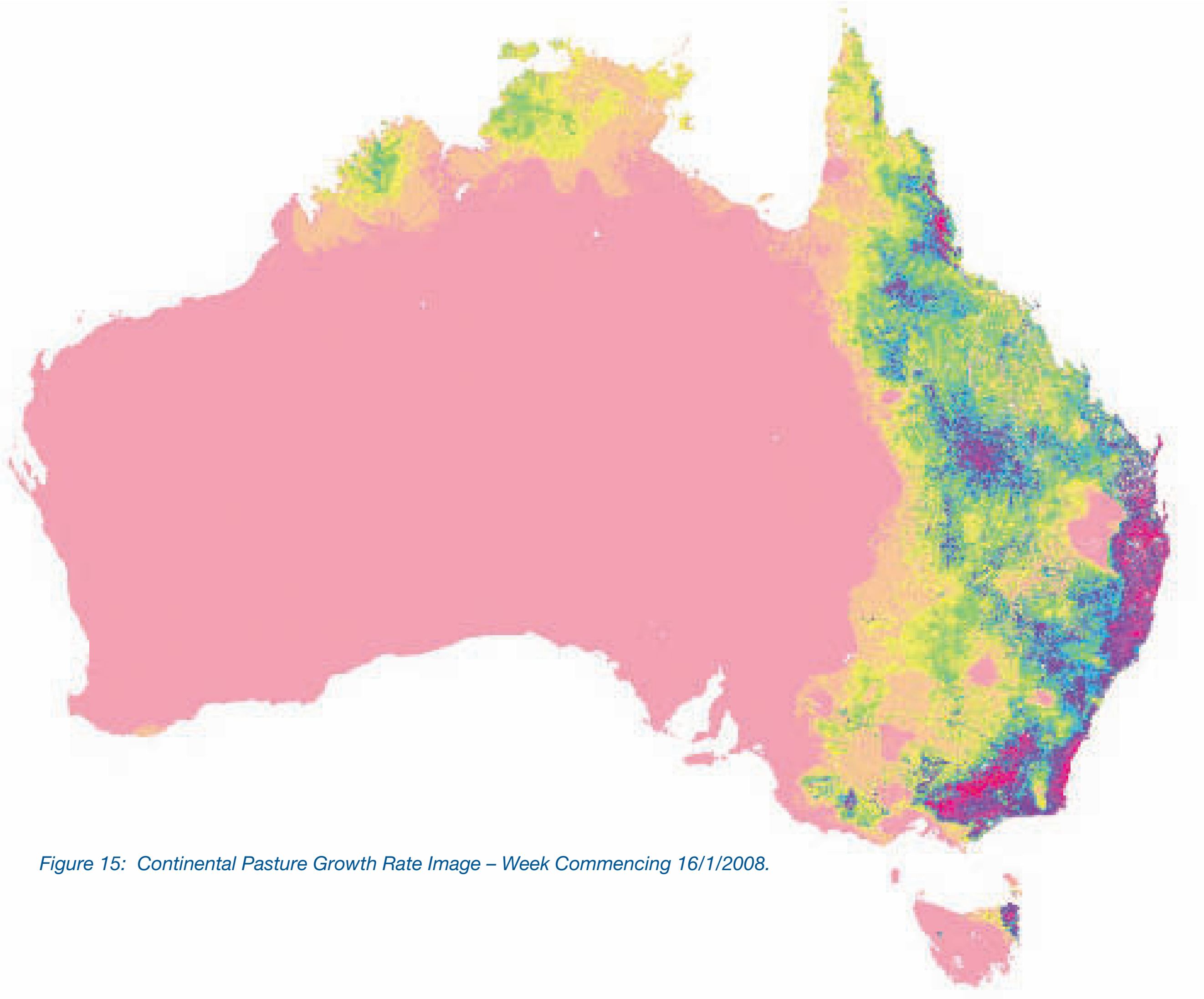


Figure 15: Continental Pasture Growth Rate Image – Week Commencing 16/1/2008.

The MODIS Feed On Offer (FOO) model has also been extended into Eastern Australia on a trial basis for the Sundown Pastoral Company and Warrnambool Vet Clinic. It is planned to improve and validate the MODIS FOO model for suitable agricultural regions in the eastern states with ground truth data from Sundown Pastoral Company's Newstead farm. Suitable regions include non dairy regions where intensive grazing isn't practised and regions where paddock sizes are typically larger than a 250 m MODIS pixel.

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, Matt Adams, Greg Walker

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 depicting growth patterns are viewable every fortnight during the current crop and pasture growing season in the Countryman newspaper with a commentary to assist rural producers. The imagery will assist them determine the progress of the season and provide vital production information for their properties.

A poster (Figure 16), similar to that being provided to the Countryman, describes the comparison of the 2009 season to 2005 and 2006 around the month of May corresponding to the start of the agricultural growing season.

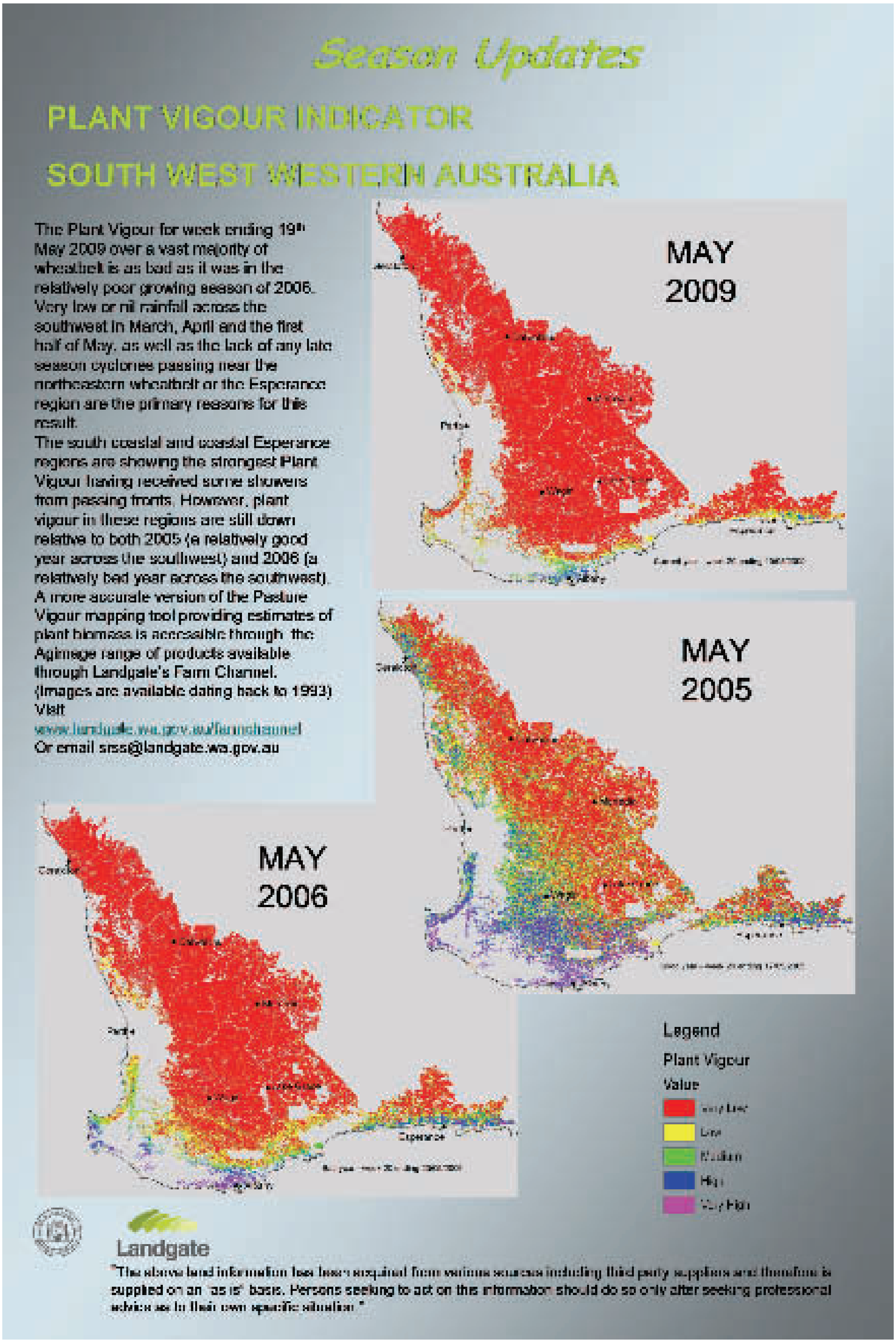


Figure 16. Comparison of the Plant Vigour Indicator for 19th May 2009 with the equivalent May period in 2005 and 2006.

DAILY MANUAL FIRE HOTSPOTS DETECTION FROM NOAA AVHRR

Agnes Kristina

The Advanced Very High Resolution Radiometer (AVHRR) sensor on the National Oceanic and Atmospheric Administration (NOAA) satellites views the earth's surface through 6 different wavelengths, several of which show the thermal characteristics of the earth's surface. Fires are mapped from these thermal layers of the image.

A fire hotspot is when an area has an extraordinarily high temperature when compared to its surrounding.

Landgate manually detects fire hotspots from the NOAA AVHRR imagery on a daily basis.
Using the geocoding wizard tool from spatial software, ERMAPPER, the locations of hotspots are produced and later manually faxed to clients and updated onto the Landgate - Firewatch website (Figure 17.)

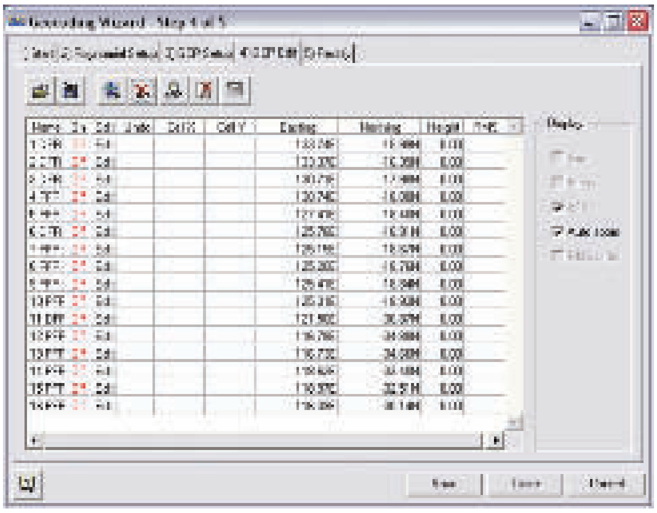


Figure 17. The location information of the fire hotspots in easting and northing faxed to clients.

Fire hotspots are derived from night time imagery, particularly from band 3B of the NOAA AVHRR sensor. The hotspots appear bright in intensity compared to their surroundings (Figure 18.) The margin of error for the spatial location of a fire hotspot is about +/- 1km.

SRSS – Landgate also provides daily automatic fire hotspots detection and information is updated within one hour of the satellite passing over. The website also provides access to the image data from where the fire hotspots were derived, so factors such as cloud cover and satellite overpass extents can be understood and considered when interpreting the fire hotspots displayed.

In addition, the manual detection method can only observe fire hotspots within Western Australia, Northern Territory and South Australia whereas the automatic detection system is nationwide. Fire hotspots information can be accessible from http://www.firewatch.landgate.wa.gov.au.

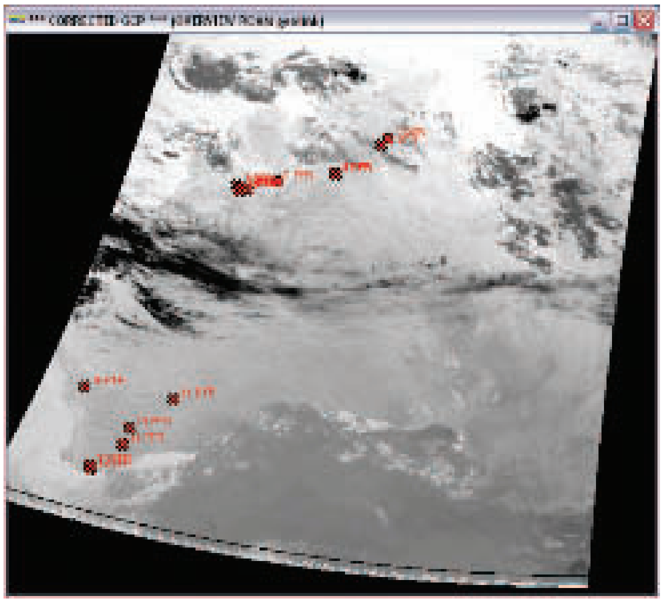


Figure 18. Geocoding window showing fire hotspots detection from night time imagery. Hotspots appear bright in intensity compared to their surroundings.

FIREWATCH WEBSITE USAGE - FROM 1/1/2009 TO 8/2/2009

Richard Smith, Adrian Allen

The Firewatch Online Mapping System has continued to support operational fire management activities throughout 2008 and continuing into 2009 with increased usage evident from web site statistics (Figure 19) during the fires in WA in mid January and a significant increase during the Victoria fires.

The extent of the February 2009 bushfires is evident in the MODIS Terra Satellite Imagery dated 9:16 WDST 9/2/2009 (Figure 20) and the detected fire hotspots in Figure 21.

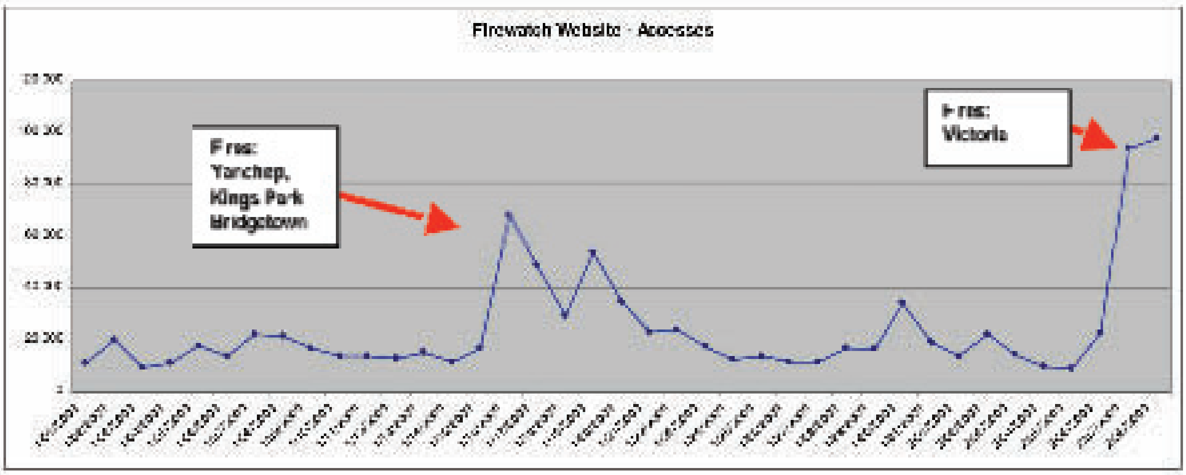


Figure 19. Firewatch website statistics depicting peaks of usage in January and February 2009.

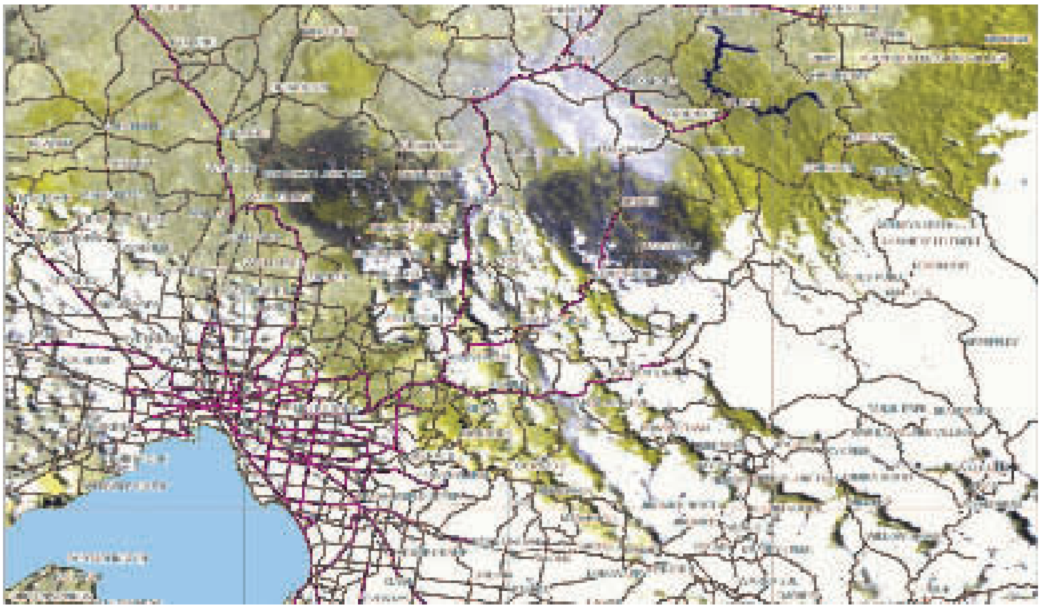


Figure 20 : MODIS Terra Satellite Imagery 9:16 WDST 9/2/2009 showing the Victorian fireburnt areas in black.

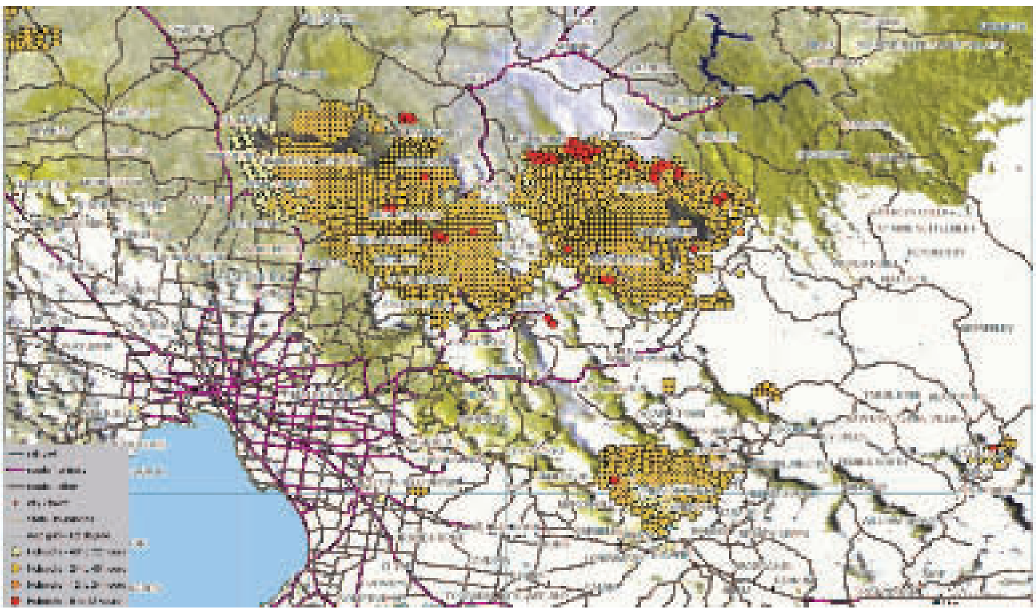


Figure 21 : MODIS Terra Satellite Imagery 9:16 WDST 9/2/2009 showing the Victorian fire hotspots.

Research Developments 2008

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

CSIRO

IMOS AO-DAAC

Edward King

The Integrated Marine Observing System (IMOS, http://imos.org.au) is a project funded as part of the National Collaborative Research Infrastructure Strategy. The three main components of the Satellite Remote Sensing Facility of IMOS are the development of a GHRSST-PP sea surface temperature product, installation of an X-band reception system in Townsville and an upgrade to the TERSS system in Hobart, and the creation of the Australian Oceans - Distributed Active Archive Centre, or AO-DAAC.

Data from environmental Earth observation satellites is already being acquired at a number of reception facilities around Australia. These data are being processed through to marine data products such as sea surface temperature and chlorophyll-a. Figure 1 shows a schematic of the national reception network expected to be in place in 2009 (Townsville and Darwin to come online). The purpose of the AO-DAAC is to improve sharing of marine remote sensing products amongst agencies by encouraging consistent processing standards and formats, supporting storage infrastructure and developing discovery and access tools.

Data from both the WASTAC L and X band reception systems and the associated iVEC infrastructure are important components of the AO-DAAC. Already NOAA data is being integrated into continental SST data sets, and WASTAC has always been a source of high quality MODIS data for ocean colour work. The IMOS project has co-funded, with iVEC, approximately 15TB of storage to enable WASTAC-derived marine product data to be placed online.

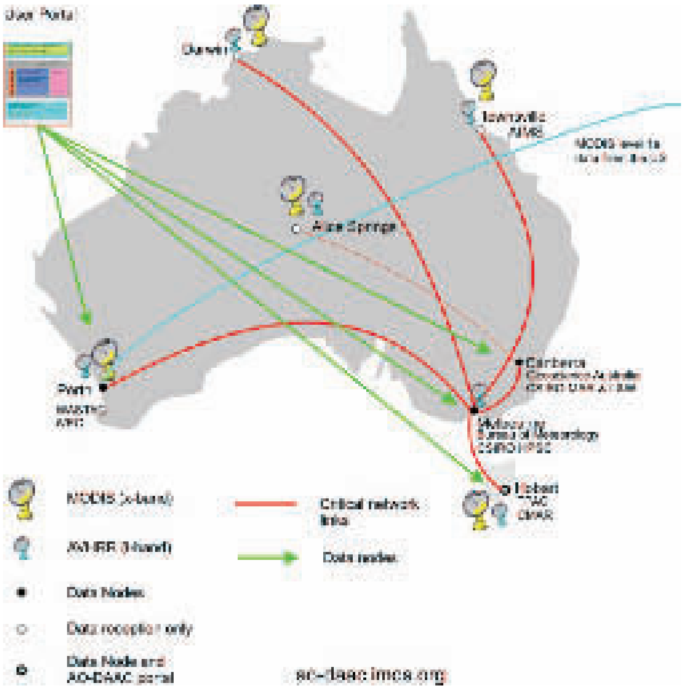


Figure 1. Schematic representation of AO-DAAC reception and dissemination architecture.

The AO-DAAC design is based on a tiered architecture (Figure 2) in which data and metadata are both accessed via OPeNDAP servers. The OPeNDAP protocol thus serves as a standard transfer protocol to enable interoperability (Figure 3). A major component of the AO-DAAC is the software and database infrastructure that sits behind the storage systems and OPeNDAP servers to facilitate discovery and access of the many data sets located all around the country. The project has based its work on the OPeNDAP crawler developed by TPAC, a web-robot that crawls OPeNDAP servers, searching for data sets and harvesting metadata. The AO-DAAC enhancements to the crawler permit more control over which data is harvested and on how it is represented in the database. The latter feature is crucial because it allows metadata nomenclature differences between otherwise identical data products to be invisibly resolved from the point of view of the end user. This, together with the database, enables the assembly of national data sets by aggregating data from multiple servers.

The first production OPeNDAP servers were deployed in 2008 and a prototype data system will be operational by the middle of 2009. A web portal providing access to the test data sets is online and a data aggregator application is being used to demonstrate and test the whole system (Figure 4). The AO-DAAC is an important piece of infrastructure that will reduce duplication of data, expedite access, and facilitate uniformly high standards of data management by all participating agencies. Although primarily a marine data system, the AO-DAAC has been designed so that it can be used in other domains using gridded spatial data, such as the forthcoming NCRIS Terrestrial Ecosystems Research Network Auscover platform.

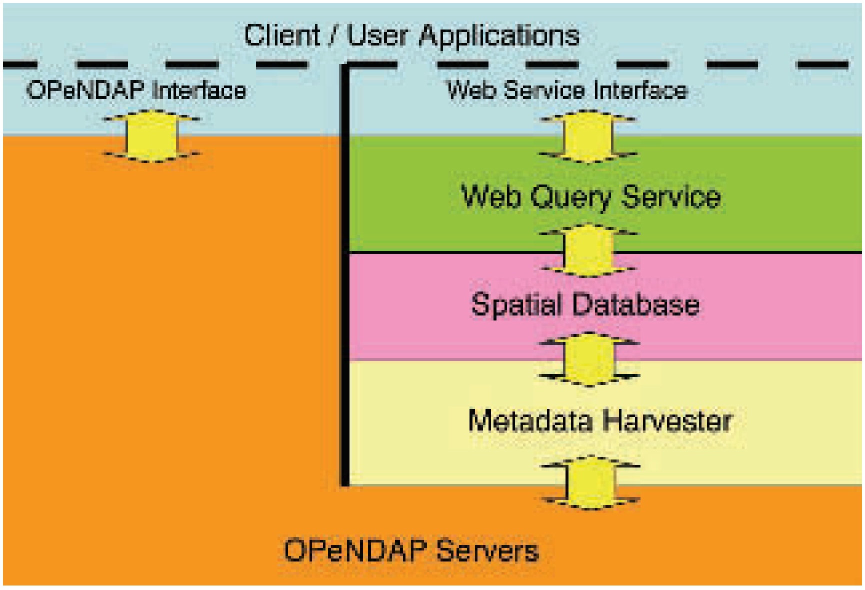


Figure 2. The tiered design of the AO-DAAC relies on OPeNDAP to provide access to both metadata and the data themselves.

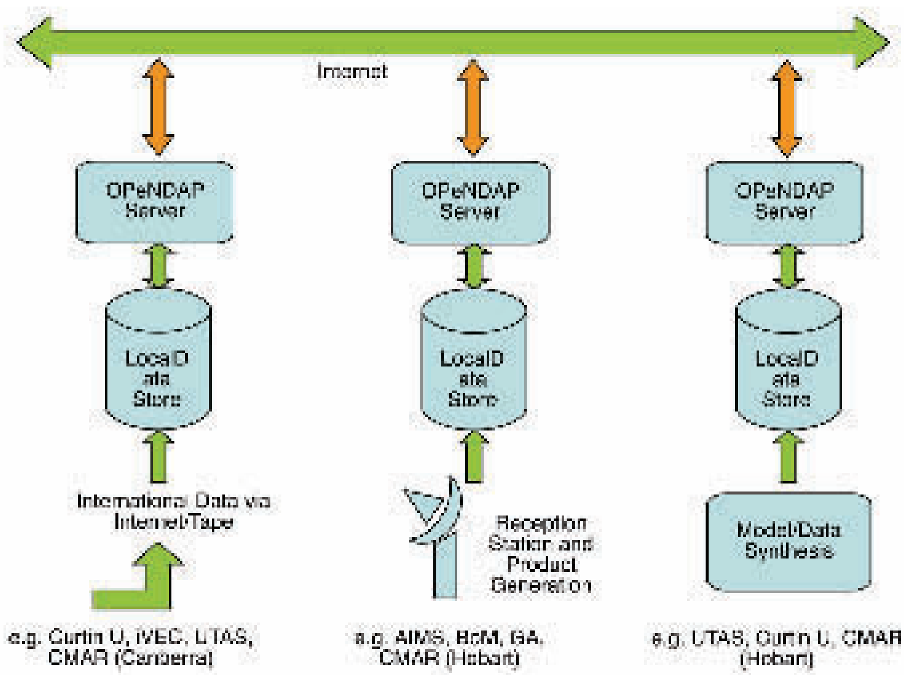


Figure 3. The OPeNDAP protocol is used as a backbone transport protocol to make different data sets interoperable.

Figure 4. The web interface to the prototype AO-DAAC aggregator service enables selection of data sets, as well as geographical and temporal bounds. All data matching the request specification is retrieved and written to an output file in HDF, netCDF or ASCII format that is then provided to the user.

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

OCEAN COLOUR – HYPERSPECTRAL AND MULTISPECTRAL SENSORS

Peter Fearns, Merv Lynch, Wojciech Klonowski, Mark Gray

For the last decade the operational multispectral sensors MODIS and SeaWIFS have provided the marine community with ocean colour data at ~ 1 km spatial resolution. MERIS, an ESA sensor with many more spectral bands in the visible, has delivered global 1 km data and, on request, 300 m resolution products, albeit for limited geographic regions. While presently there is no operational hyperspectral sensor on orbit, there have been sensors such as Hyperion which was launched as a proof of concept sensor. However, Hyperion lacked an ongoing calibration plan. We have a database of SeaWiFs, MODIS, MERIS and airborne HyMap and AISA hyperspectral data at 3 m spatial resolution for the Ningaloo Reef and Kimberley, as well as in situ hyperspectral data from a Curtin sensor (DALEC). We are investigating and comparing the retrieved products from these sensors given their differing spatial scales. Figure 5 shows remotely sensed chlorophyll products from Aqua MODIS (1 km resolution) and MERIS (300 m resolution).

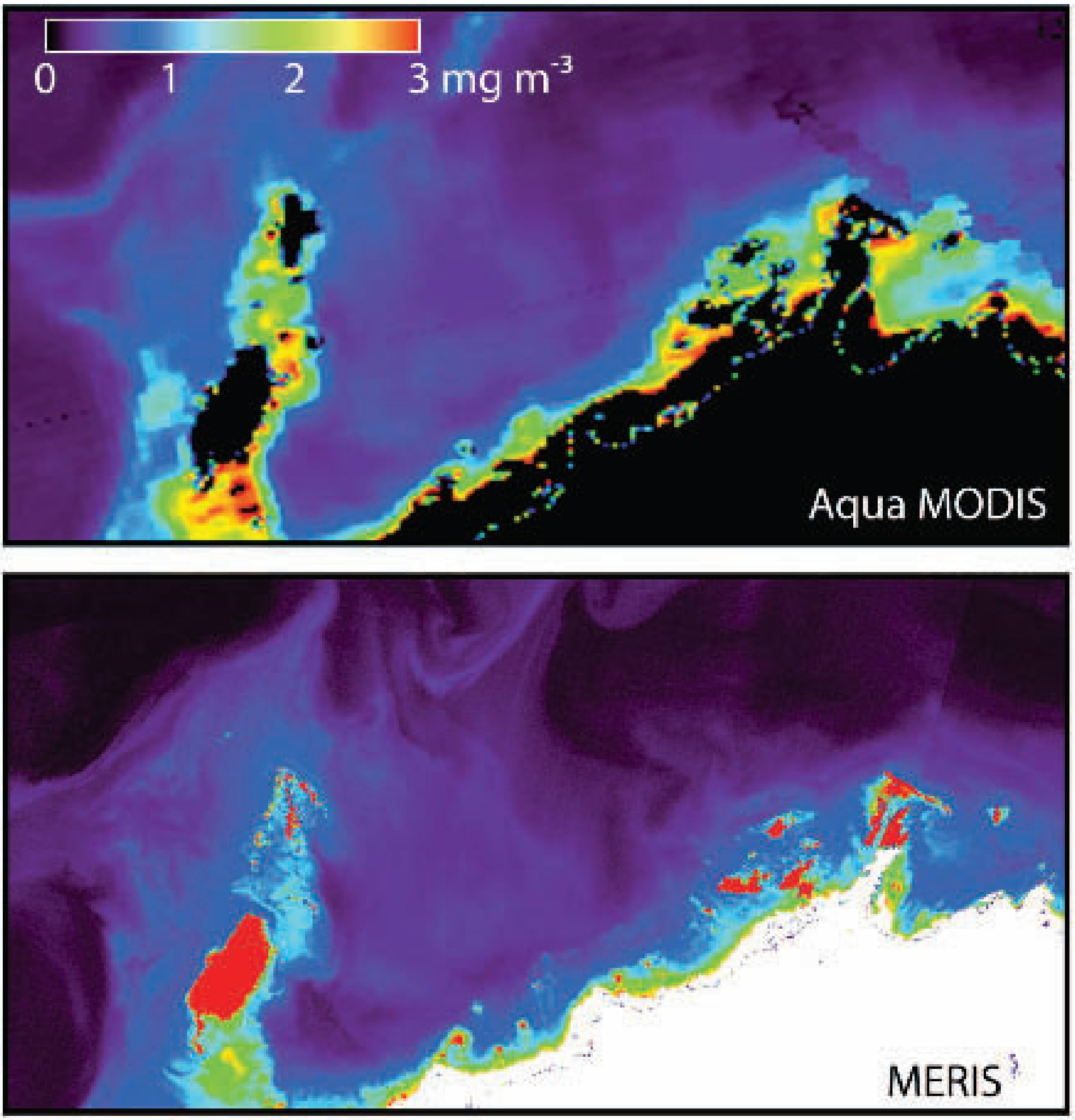


Figure 5. Remotely sensed chlorophyll concentration from Aqua MODIS (1 km resolution) and MERIS (300 m resolution). Red, black and white regions mask land or poor data.

PREPARATIONS FOR NCRIS TERRESTRIAL ECOSYSTEM NETWORK (TERN)

Merv Lynch, Peter Fearns

A collaboration between, Curtin, Landgate and iVEC forms the WA component of AusCover, a national effort under NCRIS TERN to produce a continental scale archive of satellite-derived products that relate to the ongoing health of the terrestrial ecosystem. NCRIS TERN is led by University of Queensland and the remote sensing and associated metadata task which comprises AusCover is led by CSIRO. TERN initial funding is for 3 years which formally commences mid-2009 and continues through mid-2012. Products for initial delivery have been defined. In WA, iVEC will be the data processing facility that supports the product generation.

HYPERSPECTRAL REMOTE SENSING

Wojciech Klonowski, Mark Gray, Peter Fearns, Merv Lynch

In April 2006 hyperspectral data were collected over the Ningaloo region using an aircraft-borne sensor, HyMap. This campaign was funded by the Ningaloo Collaboration Cluster within the project, "Reef use, biodiversity and socio economics for integrated management strategy evaluation of Ningaloo". The Ningaloo Collaboration Cluster sits within the CSIRO's National Research Flagships. The Ningaloo Collaboration Cluster is playing a part in addressing the challenge of integrating the knowledge of reef use, biodiversity and socioeconomics into a management strategy for the Ningaloo Marine Park of Western Australia.

The hyperspectral campaign provided data at approximately 3m resolution over an area of approximately 3,400 Km^2. These data were processed to produce bathymetry, water column optical properties and substrate cover maps for the complete Ningaloo coastline. Figure 6 shows a true colour image overlayed on a 3D representation of bathymetry derived from the HyMap campaign data.

In 2008 another aircraft campaign was undertaken to collect hyperspectral data over the Kimberley and Pilbara coastal regions using the AISA+ sensor. This project was a collaboration between the RSSRG, Flinders University, the University of Western Australia and the Western Australian Marine Science Institute (WAMSI), with research funding from MetOcean Engineers, Woodside and Apache.

Hyperspectral campaigns such as these are valuable research & development opportunities for developing an understanding of the processing algorithms to be applied to future on-orbit hyperspectral sensors. Figure 7 shows an application of the hyperspectral data processing methods to MERIS data. This figure shows bathymetry data for the same region as shown in Figure 6, Coral Bay.

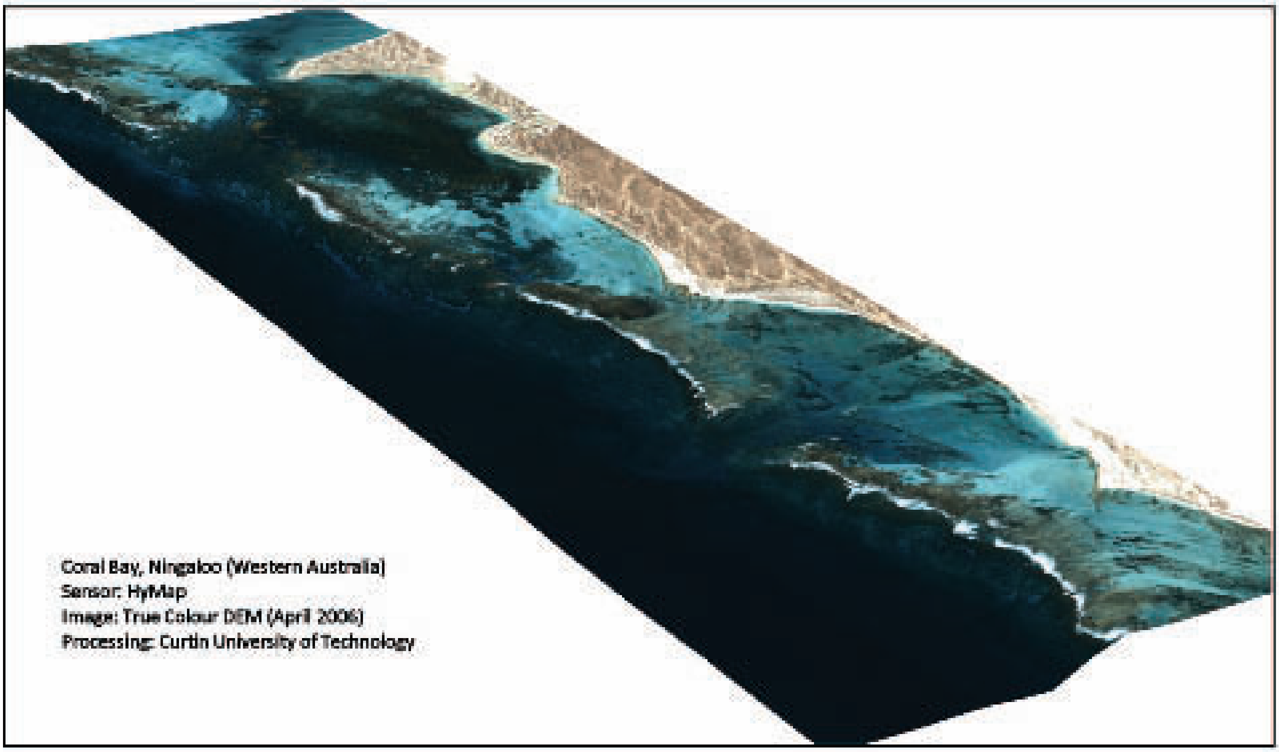


Figure 6. Coral Bay. Hymap Hyperspectral-derived true colour image overlayed in 3D on bathymetry data, also derived from the HyMap data.

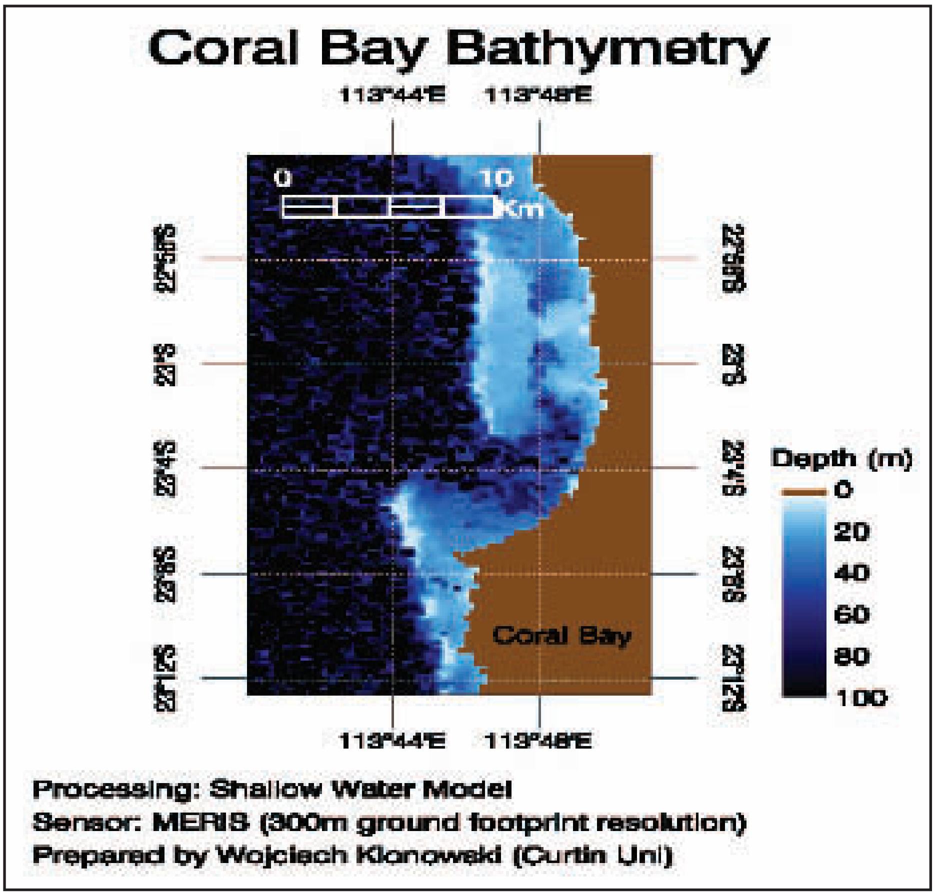


Figure 7. Coral Bay bathymetry derived from MERIS 300 m resolution data.

NCRIS IMOS SRS ACTIVITY

Peter Fearns, Merv Lynch, Mark Gray

$55.2 million has been committed through the National Collaborative Research Infrastructure Strategy (NCRIS) to establish an Integrated Marine Observing System (IMOS). In a true paradigm shift in Australian marine research, IMOS is creating an enhanced, nationally integrated capacity to collect marine data, draw it together and make it accessible to researchers and other users.

IMOS involves a large number of universities, research agencies and government agencies around Australia. International organisations, such as the USA's Scripps Institute of Oceanography, are also taking part. The Integrated Marine Observing System (IMOS) comprises a distributed set of equipment, co-operative agreements and data and information services. Collectively they will contribute to meeting the needs of marine research and other uses in Australia based on data in both open and coastal oceans. (http://ncris.innovation.gov.au/Capabilities/Pages/IMOS.aspx)

Remotely sensed ocean data provide invaluable daily ocean scale views of Australian waters to researchers in many scientific disciplines. There are a number of reception stations around Australia which acquire data from environmental satellites. These stations are operated by a variety of agencies. IMOS is developing a coordinated approach through the Satellite Remote Sensing (SRS) facility to integrate the data from all these reception stations and serve derived data products to the Australian research community. In Perth, the RSSRG and iVEC are utilising WASTAC data and making standard gridded ocean products available to the Australian Ocean Distributed Active Archive Centre (AO-DAAC). IMOS has provided support to increase data storage capacity at iVEC which will enable remotely sensed data to be accessed efficiently by the AO-DAAC data search and delivery system.

WASTAC SATELLITE DATA ARCHIVE ON iVec

Peter Fearns, Merv Lynch, Huw Lynch, Nick Bower

WASTAC has committed to make its data archive available to WASTAC members in an efficient and timely manner. To this end WASTAC has initiated a project to integrate WASTAC's satellite data archive with iVec's storage and computing facilities to solve accessibility challenges and make data in WASTAC's archive easily and readily available to those who need it.

The project will;

- catalogue scene metadata, to facilitate scene based search over the web
- routinely produce data products and make those available to entitled users
- spatially index product and scene data to allow search based on scene quality parameters

Figure 8 shows a "screen grab" of the WASTAC iVec Integration Portal. This portal will provide members with tools to search and access the WASTAC satellite data archive. To date work has been directed at loading a MODIS archive for the Australian region onto iVEC. The cover image of this report shows a composite true colour image of one complete day of coverage from MODIS AQUA.

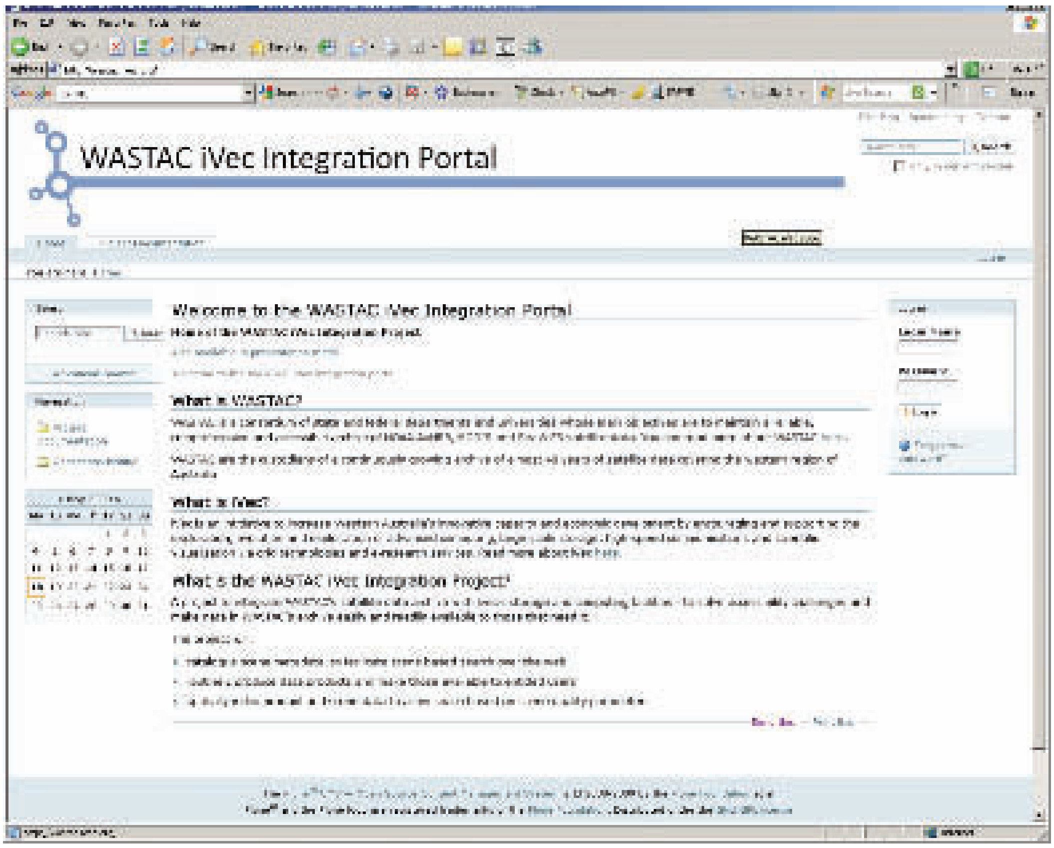


Figure 8. Screen grab of the WASTAC iVec Integration Portal.

LANDGATE

A DYNAMIC THRESHOLD ALGORITHM FOR CLOUD DETECTION BY USING MTSAT IMAGES

Mario Ferri

Accurate remote sensing of cloud parameters is essential for improving predictive model accuracies as well as for monitoring climate change. Several cloud detection techniques are available in literature, varying from complicated algorithms based on radiative transfer models, statistical analysis, threshold determination, etc, to the simplest method known as the Split Window Technique which makes use of a threshold on Brightness Temperature difference between split infrared channels 12μm and 11μm. The proposed algorithm is based on a tri-spectral approach by using the shortwave and longwave infrared channels IR1, IR2 and IR4 of MTSAT, corresponding to central wavelengths of about 11μm, 12μm and 3.7μm, respectively, all at spatial resolution of 4km. Instead of using a simple difference between split infrared channels the proposed algorithm makes use of two Normalized Brightness Temperature Difference Indices between split infrared channels:

$$NTDI_1 = \frac{(BT_{11} - BT_{3.7})}{(BT_{11} + BT_{3.7})} \qquad NTDI_2 = \frac{(BT_{12} - BT_{11})}{(BT_{12} + BT_{11})}$$

where BT_i is the Brightness Temperature converted from the radiance detected in channel with wavelength i.

The normalization has been considered to diminish the influence of diurnal and seasonal temperature changes on brightness temperatures at different wavelengths. Restricting the observations to Australian land, the above indices have been analyzed using a 2-years time-series of MTSAT images collected in 2007 and 2008. During the day $NTDI_1$ has shown, in general, large negative values in the presence of clouds and minimum absolute values in correspondence of clear regions. This contrast is due to the fact that, although the emissivity of clouds is lower than that of the land, reflected solar radiation at 3.7μm is larger, resulting in a higher brightness temperature. In fact, a typical histogram of NTD1 exhibits a shape of a double-gaussian distribution, referable to clear and cloudy regions. It may be fitted by two gaussians Γ_1 and Γ_2 and the intersection τ_1 between them will be considered as the dynamic threshold corresponding to the transition from a cloudy to a clear region (Figure 9).

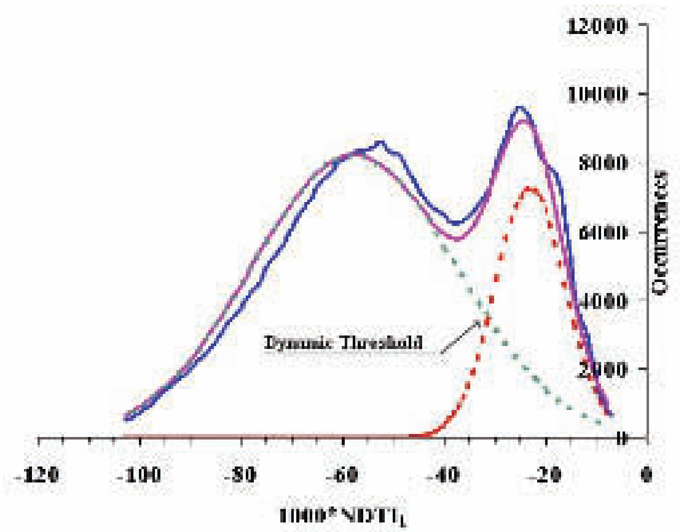


Figure 9. – Histogram of $NDTI_1$ (blue) calculated for MTSAT image acquired in Australia on 21 November 2008 09:30 WST fitted by a double Gaussian (magenta) considered as a sum of cloud (dotted green) and clear regions (dotted red).

At night time the solar radiation is absent. Consequently, only the emissive component is significant and then $NTDI_1$ will not show the large negative values observed during day time. Therefore, it is unusable. By contrast, $NTDI_2$ is based on the difference between the brightness temperatures measured at 11μm and 12μm, both in the longwave infrared, and is sensible to the differential water vapour absorption existing between clouds and land. As a result, the histogram of $NTDI_2$ can be interpreted with a double-gaussian from which it is possible to infer the dynamic threshold τ_2 separating clouds from clear regions (Figure 10).

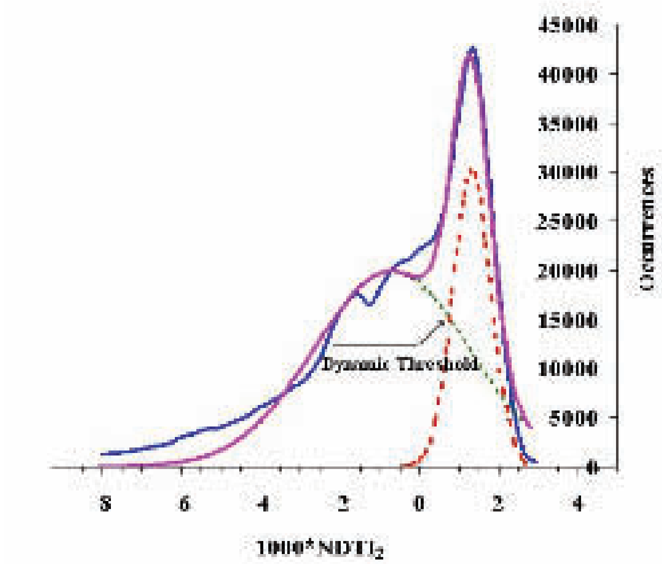


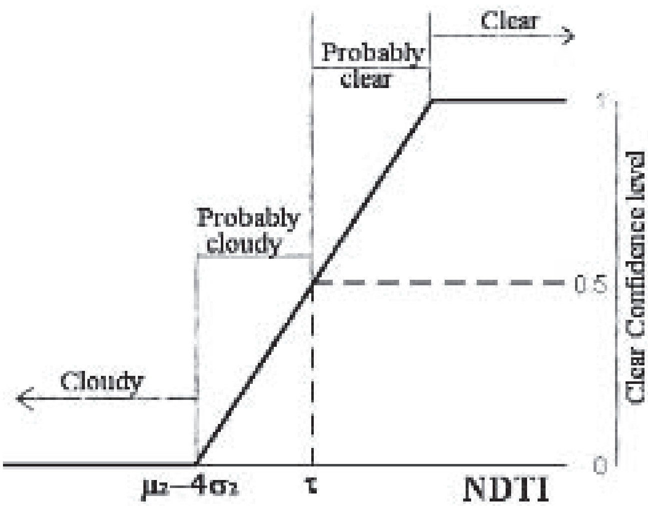
Figure 10. Histogram of $NDTI_2$ (blue) calculated for MTSAT image acquired in Australia on 12 January 2009 02:30 WST fitted by a double Gaussian (magenta) considered as a sum of cloud (dotted green) and clear regions (dotted red).

However thresholds are never universal. Therefore a confidence level for each pixel has been assigned on the basis of:

a) the dynamic threshold τ_1 (or τ_2) found in each image;

b) the concept that statistically speaking the probability for a pixel to have a value of $NTDI_1$ (or $NTDI_2$) less than $(\mu_2-4\sigma_2)$, μ_2 and σ_2 being the mean and standard deviation of the second gaussian (clear), is practically zero.

This confidence level has been used to classify all pixels into four main categories as shown in Figure 11.



When the cloudiness is very low, the histogram of NTDI shows a unimodal shape. In this case the threshold τ cannot be derived. Nevertheless, the value of $(\mu-4\sigma)$ can be considered as dynamic threshold of cloud region. Of course, a unimodal histogram is also expected when the cloudiness is very high. In this case the value of $(\mu+4\sigma)$ will be considered as dynamic threshold of clear region. A simple test applied on the mean value at 11μm brightness temperature will resolve the ambiguity. Moreover, in order to adjust pixels that might be incorrectly classified, a final adjustment will be done according to the following conditions:

BT_{11} > 290K _ Clear

BT_{11} < 250K _ Cloudy

Finally, Figure 12 shows examples of the subdivision of some MTSAT images – at different times of the day – into Clear (grey), Probably Clear (green), Probably Cloudy (yellow) and Cloudy (red) obtained applying the illustrated technique. Comparison with RGB false colour composite images - using VIS, IR1 and IR4 channels for day time and IR1, IR2 and IR4 for night time - demonstrates a clear correspondence.

This algorithm can be implemented in automatic near-real-time systems in the same context of the Soil Moisture Saturation Index available at the Landgate website. The almost continuous picture of the dynamic cloudiness so obtained can be used to supplement the flood mapping product provided in FloodMap. Other applications can be considered, for example cloud frequency over Australia, in order to assess seasonal variations and put them in correlation with rainfall data, or in global warming studies such as the influence of the change of cloud radiative effect on the amount of carbon dioxide gas in the atmosphere.

Figure 11. Confidence level used to divide an MTSAT image into four categories. The value of NTDI equal to μ_2-4σ_2 has been chosen as the value corresponding to the minimum confidence level (0) for clear. The slope of the straight line is determined by τ at which a confidence level of 0.5 has been assigned. The value of NTDI corresponding to the maximum confidence level (1) for clear will be consequently equal to 2τ- (μ_2-4σ_2).

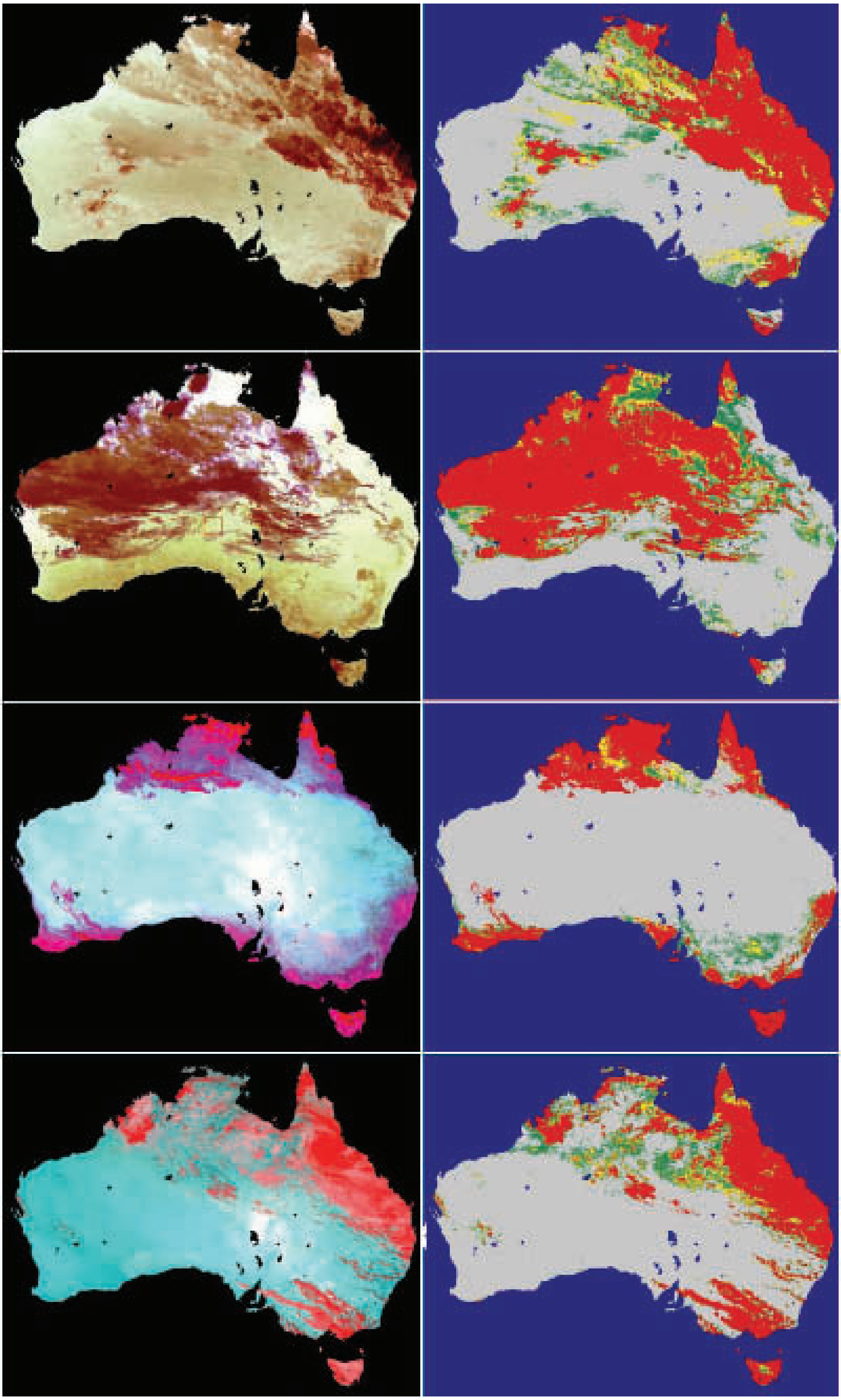


Figure 12. – Left: RGB false colour composite images. Right: corresponding classification in Clear (grey), Probably Clear (green), Probably Cloudy (yellow) and Cloudy (red) based on the described tri-spectral algorithm.

MURDOCH UNIVERSITY

USE OF SST IMAGERY IN POPULATION VIABILITY ANALYSIS OF LITTLE PENGUINS IN THE PERTH METROPOLITAN REGION

Belinda Cannell (Biological Sciences and Biotechnology, Murdoch University) and Mike Steber

During 2007 and 2008 satellite tracking tags were attached to Little Penguins from Penguin and Garden islands during their breeding season (Figure 13). This is part of a project to determine the Population Viability Analysis of Little Penguins. The aim of the satellite tagging project is to determine where the penguins travel and feed at different stages in their breeding cycle. The stage of the breeding affects the time the penguins spend at sea, and potentially the areas they use. For example, when penguins incubate eggs, one parent is at sea for approximately 3-5 days, whilst the other is on the eggs. The "at-sea" parent then returns in the evening, and they swap roles the next day. Once the eggs have hatched, one parent must remain with the chicks whilst the other is at sea feeding. In the evening, the parent returns to the nest, feeds the chicks, and the next day the other parent goes to sea. This is called the guard phase and the parents alternate between feeding at sea or remaining with the chicks usually on a daily basis. After the chicks are approximately two weeks old both parents spend the day at sea and return to feed the chicks in the evening. By knowing where the penguins go, the possible threats they are exposed to on both the short or long trips can be identified. To date the penguins from Garden Island travel and feed within Cockburn Sound, whilst those from Penguin Island generally travel and feed in Warnbro Sound and Comet Bay. However, during the incubation period, when the trips can be much longer, the penguins can travel much farther south.

The data obtained from the satellite tags will be overlaid on appropriate sea surface temperature (SST) images (Figure 14) from either the NOAA-AVHRR or MODIS sensors for the same time periods. This will be used to determine if SST influences the areas the penguins use for feeding and travelling.

Figure 13. A Little Penguin with a satellite tracking device attached.

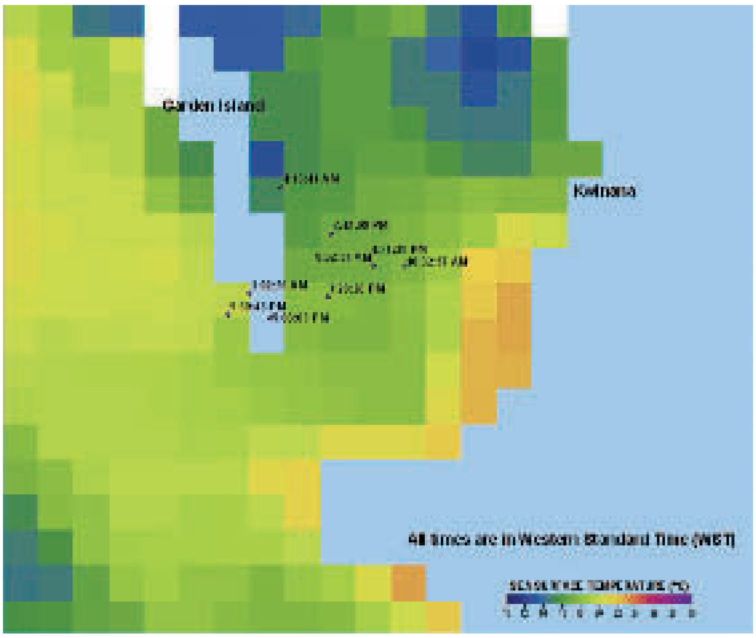


Figure 14. Movement of a Little Penguin around Garden Island on 24/05/2007 plotted onto MODIS derived sea surface temperature data.

Financial Statements

2008

CPA

Santo Casilli Accounting and Auditing Services is a CPA Practic

Liability limited by a scheme approved under Professional Standards Legislation

COVER OF EXCELLENCE

Santo Casilli
Accounting and Auditing Services

Certified Practising Accountant

52 Lockeport Approach Madeley WA 6065
Mobile: 0409 104 929 - **Fax:** (08) 9408 1782 - **Email:** scasilli@bbnet.com.au

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 2009

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

Dated this 20th day of April 2009.

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 APPLICATION CONSORTIUM

L Band Income Statement for the Year Ended 31 December 2008

	NOTE	2008	2007
		$	$
REVENUE			
Contributions received		40,000	40,000
Interest received		20,173	23,902
Total Revenue		**60,173**	**63,902**
EXPENDITURE			
Telephone rent & calls		1,776	5,312
Service & equipment charges		0	864
Mobile phone services & calls		851	0
Microwave licenses		2,171	1,013
Minor new works charges		9,606	0
External painting costs		7,778	5,638
Other computing expenses		30,000	0
Other equipment maintenance		4,091	4,686
Depreciation expense		10,842	3,092
Cost of other equipment sold		4,812	0
Total Expenditure		**71,928**	**20,605**
Net Operating result for the year		**(11,755)**	**43,297**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATION CONSORTIUM

L Band Balance Sheet as at 31 December 2008

	NOTE	2008	2007
		$	$
CURRENT ASSETS			
Cash At Bank		214,188	288,777
Prepayments		5,250	596
TOTAL CURRENT ASSETS		**219,438**	**289,373**
NON - CURRENT ASSETS			
Property, plant and equipment	2	87,138	28,958
TOTAL NON - CURRENT ASSETS		**87,138**	**28,958**
TOTAL ASSETS		**306,576**	**318,332**
CURRENT LIABILITIES		**0**	**0**
TOTAL CURRENT LIABILITIES		**0**	**0**
TOTAL LIABILITIES		**0**	**0**
NET ASSETS		**306,576**	**318,332**
EQUITY			
Retained funds	4	306,576	318,332
TOTAL EQUITY		**306,576**	**318,332**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATION CONSORTIUM

L Band Cash Flow Statement for the Year Ended 31 December 2008

	NOTE	2008	2007
		$	**$**
CASH FLOWS FROM OPERATING ACTIVITIES			
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		20,173	23,902
Total Receipts		**60,173**	**63,902**
Payments			
Payments to suppliers		(60,928)	(66,325)
Total Payments		**(60,928)**	**(66,325)**
Net cash provided by operating activities	**3**	**(755)**	**(2,423)**
CASH FLOWS FROM INVESTING ACTIVITIES			
Payments for property, plant and equipment		(73,835)	(23,802)
Net cash used in investing activities		**(73,835)**	**(23,802)**
Net increase/(decrease) in cash		**(74,589)**	**(26,225)**
Cash at the beginning of the year		288,777	315,002
Cash at the end of the year		**214,188**	**288,777**

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 Applications Consortium (WASTAC) L Band financial report is a special purpose financial report and 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 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

	2008 $	2007 $
Computer Equipment		
At cost	151,468	116,272
Accumulated depreciation	(118,291)	(116,272)
	33,177	**0**
Other Equipment		
At cost	233,861	210,892
Accumulated depreciation	(179,900)	(181,934)
	53,961	**28,958**
Total Property, Plant and equipment	**87,138**	**28,958**

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	0	28,958	28,958
Additions	35,196	38,638	73,834
Depreciation expense	(2,019)	(8,823)	(10,842)
Adjustment due to change in asset policy	0	(4,812)	(4,812)
Carrying amount at end of year	**33,177**	**53,961**	**87,138**

3. Notes to the Cash Flow Statement

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

	2008	2007
	$	**$**
Net operating result	(11,755)	43,297
Depreciation expense	10,842	3,092
Cost of other equipment sold	4,812	0
Movement in current liabilities	0	(48,216)
Movement in current assets	(4,654)	(596)
Net cash provided by operating activities	**(755)**	**(2,423)**

4. Retained Earnings

	2008	2007
	$	**$**
Balance at the beginning of the year	318,332	275,836
Adjustment due to change in asset policy	0	(802)
Operating surplus/(deficit) for the year	(11,756)	43,297
Balance at end of year	**306,576**	**318,332**

5. Changes in Accounting Policy

With retrospective 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 are expensed in the year of purchase.

The increase in threshold was introduced in order to simplify administration of the University's assets, enabling, in particular, more reliable and relevant information from fixed asset stock takes.

CPA

Santo Casilli Accounting and Auditing Services is a CPA Practic

Liability limited by a scheme approved under Professional Standards Legislation.

COVER OF EXCELLENCE

Santo Casilli
Accounting and Auditing Services

Certified Practising Accountant

52 Lockeport Approach Madeley WA 6065

Mobile: 0409 104 929 - **Fax:** (08) 9408 1782 - **Email:** scasilli@bbnet.com.au

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.

The accompanying special purpose financial report has been prepared by the "Consortium Agent" (Curtin University) on behalf of the Board to satisfy the reporting requirements as outlined in the existing "Joint Venture Agreement".

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 – X 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 2009

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

Dated this 24th day of April 2009.

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 INCOME:	**$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 APPLICATION CONSORTIUM

X Band Income Statement for the Year Ended 31 December 2008

	NOTE	2008	2007
		$	$
REVENUE			
Contributions received		80,000	80,000
Interest received		29,774	23,818
Total Revenue		**109,774**	**103,818**
EXPENDITURE			
Hospitality		164	445
Fringe Benefit Tax paid		264	0
Other computing expenses		57	0
Maintenance		1,933	0
Depreciation expense		94,172	94,080
Loss on disposal of Non - Current Asset		0	9,160
Total Expenditure		**96,590**	**103,685**
Net Operating result for the year		**13,184**	**133**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATION CONSORTIUM

X Band Balance Sheet as at 31 December 2008

	NOTE	2008	2007
		$	$
CURRENT ASSETS			
Cash At Bank		382,785	324,750
Prepayments		7,159	13,337
TOTAL CURRENT ASSETS		**389,944**	**338,087**
NON - CURRENT ASSETS			
Property, plant and equipment	2	152,213	190,886
TOTAL NON - CURRENT ASSETS		**152,213**	**190,886**
TOTAL ASSETS		**542,157**	**528,973**
CURRENT LIABILITIES		0	0
TOTAL CURRENT LIABILITIES		**0**	**0**
TOTAL LIABILITIES		**0**	**0**
NET ASSETS		**542,157**	**528,973**
EQUITY			
Retained funds	4	542,157	528,973
TOTAL EQUITY		**542,157**	**528,973**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATION CONSORTIUM

X Band Cash Flow Statement for the Year Ended 31 December 2008

	NOTE	2008	2007
		$	$
CASH FLOWS FROM OPERATING ACTIVITIES			
Receipts			
Contributions received:			
Department of Land Information		20,000	20,000
CSIRO		20,000	20,000
Bureau of Meteorology		20,000	20,000
Geoscience Australia		20,000	20,000
Interest received		29,774	23,818
Total Receipts		**109,774**	**103,818**
Payments			
Payments to suppliers		(9,577)	(13,783)
Total Payments		**(9,577)**	**(13,783)**
Net cash provided by operating activities	**3**	**100,197**	**90,035**
CASH FLOWS FROM INVESTING ACTIVITIES			
Payments for property, plant and equipment		(42,162)	0
Net cash used in investing activities		**(42,162)**	**0**
Net increase/(decrease) in cash		**58,035**	**90,035**
Cash at the beginning of the year		324,750	234,715
Cash at the end of the year		**382,785**	**324,750**

1. Summary of Significant Accounting Policies

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

Basis of Preparation

The Western Australian Satellite Technology and Application Consortium (WASTAC) X Band financial report is a special purpose financial report and has been prepared in accordance with 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 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

	2008	2007
	$	$
Computer Equipment		
At cost	14,408	14,408
Accumulated depreciation	(14,408)	(14,408)
	0	**0**
Other Equipment		
At cost	789,767	734,268
Accumulated depreciation	(637,554)	(543,382)
	152,213	**190,886**
Total Property, Plant and equipment	**152,213**	**190,886**

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	0	190,886	190,886
Additions/(disposals)	0	55,499	55,499
Depreciation expense	0	(94,172)	(94,172)
Carrying amount at end of year	**0**	**152,213**	**152,213**

3. Notes to the Cash Flow Statement

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

	2008	2007
	$	**$**
Net operating result	13,184	133
Depreciation expense	94,172	103,240
Cost of other equipment sold	0	0
Movement in current liabilities	0	0
Movement in current assets	(7,159)	(13,337)
Net cash provided by operating activities	**100,197**	**90,035**

4. Retained Earnings

	2008	2007
	$	**$**
Balance at the beginning of the year	528,973	528,840
Operating surplus/(deficit) for the year	13,184	133
Balance at end of the year	**542,157**	**528,973**

5. Changes in Accounting Policy

With retrospective 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 are expensed in the year of purchase.

The increase in threshold was introduced in order to simplify administration of the University's assets, enabling, in particular, more reliable and relevant information from fixed asset stock takes.

Notes