Western Australian Satellite Technology and Applications Consortium

2014

Annual Report

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Front Cover :
Landgate continues to provide the continental FireWatch service to fire management agencies across Australia. The image depicts fire frequency information which was derived from 1 kilometre resolution NOAA AVHRR satellite images from 1988 to 2014.

Editors: R. Stovold - Landgate
B. McAtee - Landgate
M. Steber - Landgate

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CONTENTS

CHAIRMANS REPORT

At a strategic level, the WASTAC Board agreed to commission a report looking at the medium and long term options for the reception facilities at Curtin University and Murdoch University in light of the Australian Space Utilisation Policy and the National Earth Observations from Space Infrastructure Plan. It is hoped this work will be commissioned sometime in 2015.

At an operational level the X-band receiver at Murdoch University required its first significant repairs in 13 years. The demodulator was found to be faulty and was replaced in June 2014. Unavoidable delays in completing procurement processes resulted in the total number of passes received dropping from 19,181 in 2013 to 14,010 in 2014. No new satellites were added to the capture list in 2014, but we expect to begin receiving FY-3C in 2015. It is hoped that software updates will allow for processing of FY3 data locally and FY3 may become a source for application development in 2015 and beyond. In addition, with the Bureau of Meteorology's move from East Perth to West Perth communications have been rerouted with all Curtin data being transmitted to the Bureau via Murdoch University.

As the Operational Applications reports show, data sourced from WASTAC is contributing to worldwide numerical weather forecasting, and tracking and monitoring cyclones in Australia, as well as tracking a changing climate (Willmott et al., BOM). Landgate continues to explore new uses for MODIS to support pasture utilisation in the rangelands of Australia and improve user experience in the intensive sheep production in south western Western Australia through Pastures from Space (Stovold et al., Landgate and Santich, Landgate). Landgate extended the range of fire information available to land and emergency managers through the introduction of 375m fire hotspots (and supporting imagery) from the VIIRS instrument on board the Suomi NPP satellite (Steber et al., Landgate). Perhaps an interesting statistic, the Northern Territory had the most proportion of fire hotspots detected (39.8%) across Australia in 2014 from WASTAC data (McMillan, Landgate).

Of special significance is Aurora, a development between the Department of Fire and Emergency Services, the University of Western Australia and Landgate with support from the Department of Communications, which utilises MODIS-derived fire hotspots to predict bushfire spread across all of Australia. Aurora won a 2014 Western Australia Premier's Award in the Revitalising the Regions Category and has now become an endorsed operational system supporting bushfire management in Western Australia.

On the research front, CSIRO's ASTER-derived mineral maps resulted in a new gold deposit discovery in the Northern Territory with commercial exploitation possible (Cudahy, CSIRO). The ASTER products are also being used to identify areas of potential desertification. Curtin University and the WA Department of Fisheries (DoF) have been collaborating to understand the potential impact of seasonal changes in sea surface temperature on marine life in Shark Bay (Pearce and Thomsett; Curtin and DoF and Broomhill et al., Curtin), have been exploring the use of MODIS data to measure and monitor total suspended solids from natural and dredging events in Western Australia's north west waters.

Further on the research front is the exploration of Sentinel-1, a European radar satellite, for mapping fire scars in cloudy or smoky conditions (Khokhar, Landgate), as well as a look at inferring fire hotspots not detected due to cloud in Indonesia using the Indofire system (Cahyono and Fearns, Curtin).

Lastly are two novel applications of WASTAC and other satellite data: correlation of the gross primary productivity with the occurrence of bird species in the Greater Western Woodlands of Western Australia (Andrew, Murdoch) and the impacts of natural and anthropogenic disturbance estimated from satellite imagery on bilby and bilby predator populations (Dawson, Murdoch).

WASTAC remains in a strong financial position with sufficient reserves to make modifications to existing systems as needed.

The WASTAC partners have contributed generously to the efficient running of WASTAC. Ron Craig, Mike Steber, Jackie Marsden, Joe Cudmore and Justin Pitsikas (Landgate), along with Russell Steicke (BOM), have kept the stations and processing systems running with a high degree of reliability. CSIRO maintains the high speed data link needed for near realtime processing at the Leeuwin Centre, as well as production of the NOAA Stitched Archive utilising WASTAC data at the NCI in Canberra. Our Secretary, Richard Stovold (Landgate), has kept the decision making on track. Curtin University continues to manage our accounts. Murdoch University maintains an excellent site for the X-band antenna. Geoscience Australia provides valuable national coordination and access to MODIS data from Alice Springs for WASTAC members. Lastly, I would like to welcome Dr. Brendon McAtee and Mr. Mike Steber, who have agreed to pick up the Annual Report editing role from Alan Pearce who was unable to edit the report this year.

As Chairman, I take pride in the major contributions WASTAC is making to advance our understanding of land, ocean and atmospheric processes within Australia.

Dr. Matthew Adams
Chairman, WASTAC 2014

WASTAC BOARD FOR 2014

Dr Matthew Adams - Chairman	Landgate
Mr Richard Stovold - Secretary	Landgate
Prof. Merv Lynch	Curtin University
Prof. David Antoine	Curtin University
Dr Kimberley Clayfield	CSIRO
Dr Edward King	CSIRO
Dr Anthony Rea	Bureau of Meteorology
Mr Mike Bergin	Bureau of Meteorology
Dr Adam Lewis	Geoscience Australia
Prof. Tom Lyons	Murdoch University
Dr Halina Kobryn	Murdoch University

WASTAC STANDING COMMITTEE AND PROXY TO THE BOARD

Dr Matthew Adams - Chairman	Landgate
Mr Richard Stovold - Secretary	Landgate
Prof. Merv Lynch	Curtin University
Dr Robert Corner	Curtin University
Mr Andrew Burton	Bureau of Meteorology
Mr Russell Steicke	Bureau of Meteorology
Prof. Tom Lyons	Murdoch University
Dr Halina Kobryn	Murdoch University
Dr Tom Cudahy	CSIRO
Dr Nick Hardman-Mountford	CSIRO
Dr Medhavy Thankappan	Geoscience Australia

WASTAC TECHNICAL COMMITTEE:

Mr Russell Steicke (Chairman)

Prof. Merv Lynch

Mr Ronald Craig

WASTAC STRATEGIC PLAN

VISION:

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

MISSION:

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

CURRENT STRATEGIES:

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

FUTURE SATELLITE RECEPTION OPPORTUNITIES:

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

OPERATIONS

WASTAC maintains an L-band reception facility at Curtin University and a dual X- and L-band facility at Murdoch University. The L-band facility has been operational since 1983, although satellite tracking at Curtin (then the WA Institute of Technology) began in the late 1970s. The X-band facility has been operating since 2001. WASTAC members make use of the satellite data for weather prediction, vegetation and fire monitoring, and research. WASTAC maintains an ongoing near real-time archive of L-band images beginning in 1983, and X-band images from 2001.

With the relocation of the Bureau of Meteorology (BoM) Regional Office to West Perth, work is underway to establish a dedicated fibre link to the Murdoch facility. This will allow for satellite data, from both the Murdoch antenna and Curtin antenna to be delivered to BoM Head Office, as Curtin is connected to Murdoch via a dedicated microwave link.

Curtin University – L-band

The L-band facility at Curtin University in Bentley consists of a 2.4m antenna and an antenna controller supplied by Environmental Systems and Services (ES&S) and dual ingestor computers running an AVHRR ingest and display system developed by the Bureau of Meteorology. This data is ingested into the central processing computers at the Bureau's Head Office.

The L-band facility receives 500 to 600 passes per month from a range of satellites – including NOAA-15, NOAA-18 and NOAA-19. Refer to the WASTAC Data archive for the full list of received passes.

The Curtin University satellite reception facility is maintained by BoM staff.

Murdoch University – L and X-band

The L and X band reception facility was supplied by SeaSpace Corporation in 2001. It consists of a 3.6m antenna in a fiberglass dome, and an antenna controller computer. This facility receives data from Aqua, Terra, MetOp, Suomi-NPP, FY3-B and FY3-C, as well as the L-band satellites. Having two reception facilities for L-band allows some satellite conflicts to be resolved.

The Murdoch University satellite reception facility is maintained by Landgate and Murdoch University staff.

Applications

TOVS (sounding) data 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 data, fire scar mapping and agricultural applications in real time.

Russell Steicke, Regional Computing Manager (WA), Bureau of Meteorology
Denis Margetic, Satellite Operations Manager, Bureau of Meteorology

WASTAC DATA ARCHIVE

The WASTAC archive of satellite passes continues to be managed and maintained by Landgate's Satellite Remote Sensing Services (SRSS) group 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.

The archive forms the basis for the development, processing and delivery of a range of products listed in the Operational and Research Applications sections of this report.

A total of 14,010 passes were archived at Curtin and Murdoch in 2014.

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 and VIIRS quick-look data is also held on the web. The archive of MODIS, NOAA, VIIRS and SeaWiFS data can be viewed at:

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

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

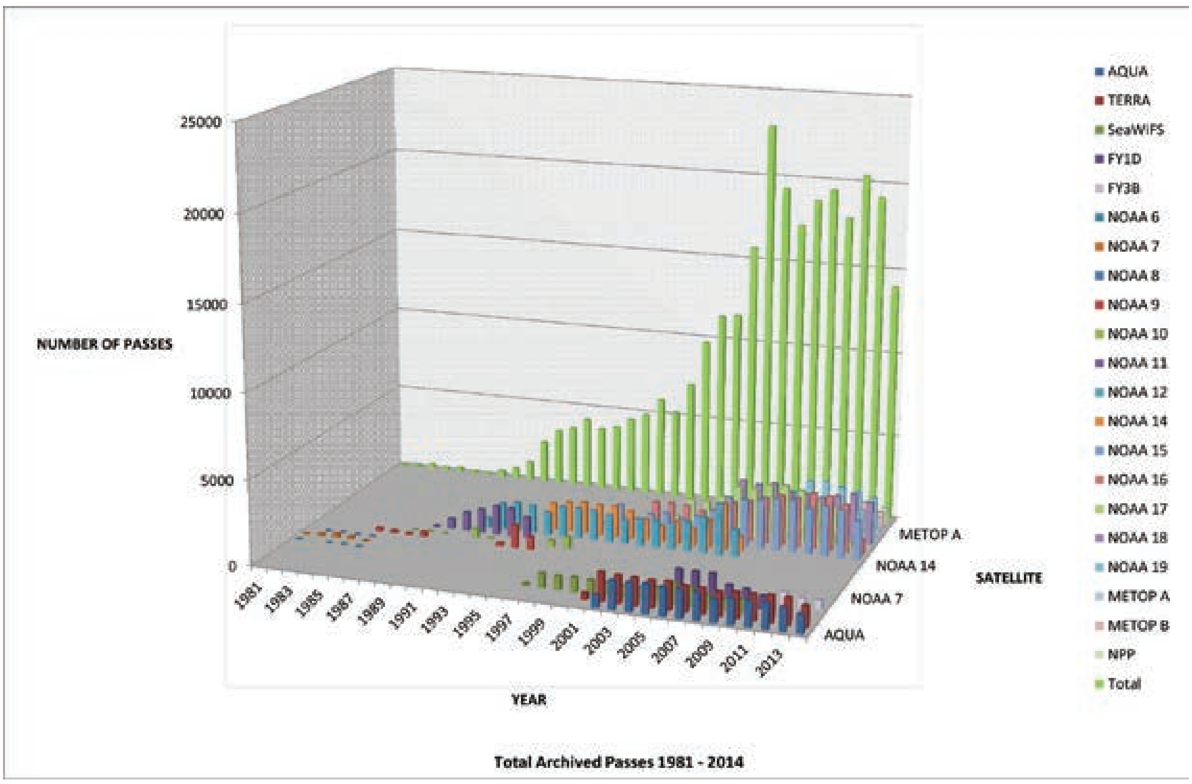
http://www.rss.dola.wa.gov.au/newsite/seawifsql/SeaWiFSql.html

http://www.rss.dola.wa.gov.au/newsite/viirsql/VIIRSql.html

Landgate currently holds the archive on 8mm Exabyte and DAT tapes. 20Gb DLT tapes were introduced as the archive medium in late 2000 for the L band data and since the commissioning of the facility in 2001, X band data has been archived on DLT 35Gb tapes and since last year on on-line mass storage devices, with backup on LTO5 tapes.

Duplicate copies of the raw data archive are produced for a national archive program that is coordinated by CSIRO in Canberra.

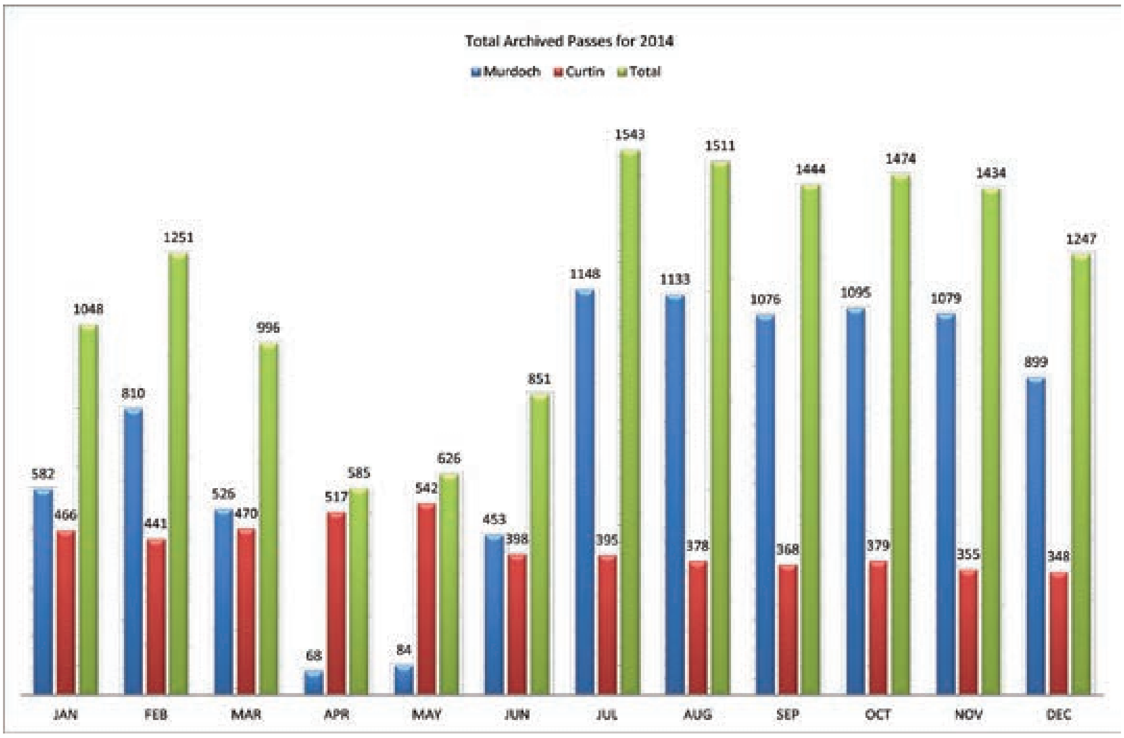
Total Archived Passes 1981-2014

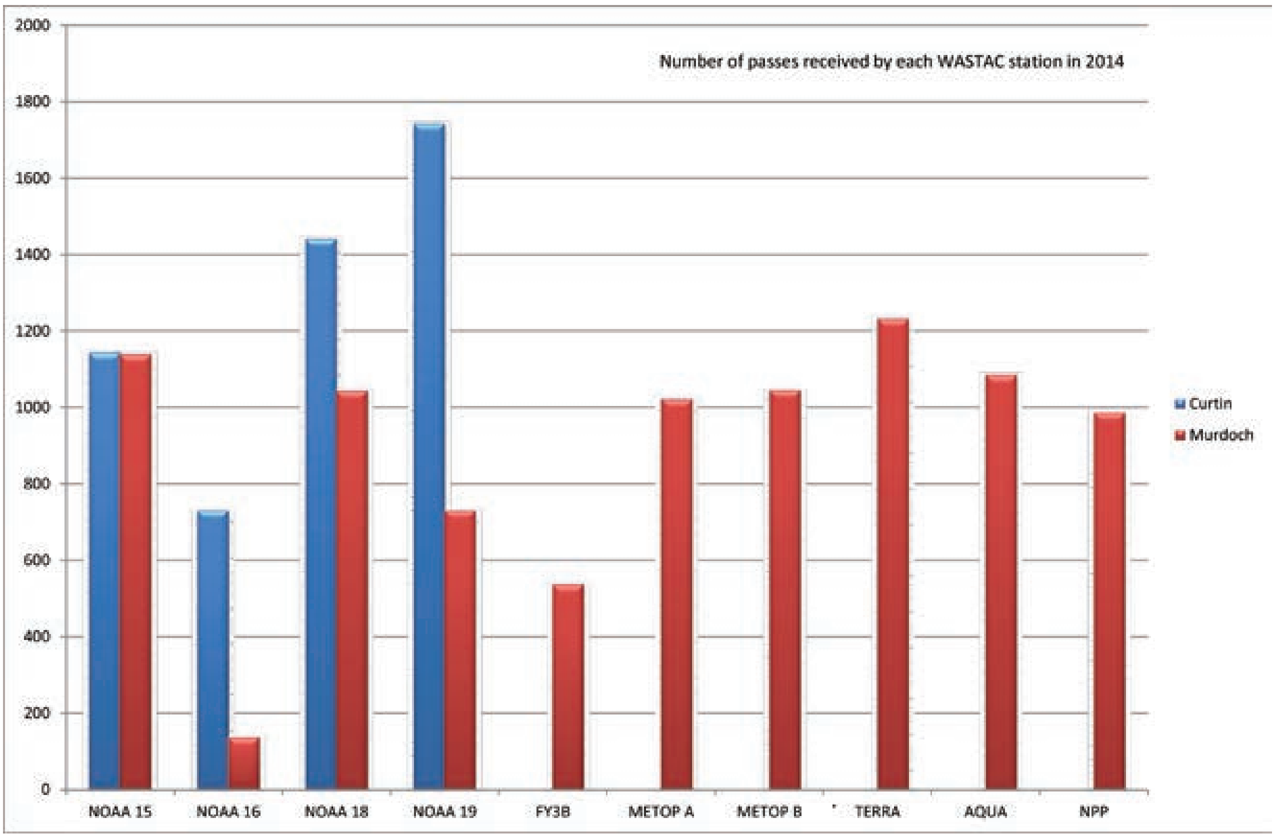


	AQUA	TERRA	FY3B	METOP A	METOP B	NPP	SeaWiFS	FY1D	NOAA 6	NOAA 7	NOAA 8	NOAA 9	NOAA 10	NOAA 11	NOAA 12	NOAA 14	NOAA 15	NOAA 16	NOAA 17	NOAA 18	NOAA 19	Total
1981									5	22												27
1982										115	1											116
1983									12	244	12											268
1984									7	179	4											190
1985									7	33	4	212										256
1986												151										151
1987												97	18									115
1988												280	25	53								358
1989													21	601								622
1990														1103								1103
1991													506	1399	575							2480
1992													47	1693	1571							3311
1993												183		1656	1720							3559
1994												1362		1227	1641							4230
1995												770			1326	1615						3711
1996													354		1780	1776						3910
1997							142						694		1797	1876						4509
1998							859								1763	1828	432					4882
1999							822								1589	1839	1663					5912
2000							843								1427	1681	905	341				5197
2001		390					811								1548	1271	1292	1733				7045
2002	734	1710					780								1579	976	1455	1789	709			9732
2003	1651	1645					696								1521	1351	1200	1728	1827			11388
2004	1665	1602					680								1727	1058	1481	1524	1797			11534
2005	1705	1577					863	553							2101	1706	1904	1743	2212	1339		15703
2006	1635	1639					1239	1683							3030	2761	2823	2240	2883	2989		22922
2007	1615	1512					1092	1678							1571	952	2777	2442	2869	2839		19347
2008	1553	1495					787	1673									2844	2711	3165	2985		17213
2009	1327	1411					687	1132									3055	2951	3254	2622	2306	18745
2010	1454	1516					793	1040									3061	2895	3054	2567	3058	19438
2011	1485	1537						751									2692	3282	2527	2453	3128	17855
2012	1465	1571	775	1118	316	924		255									2923	3223	2278	2677	2880	20405
2013	1349	1569	557	1383	1503	1243											2781	2845	316	2883	2752	19181
2014	1085	1232	536	1021	1044	987											2282	866		2484	2473	14010

Total Archived Passes for 2014

		NOAA 15	NOAA 16	NOAA 18	NOAA 19	FY3B	METOP A	METOP B	TERRA	AQUA	NPP	TOTAL
JAN	C	101	144	71	150							466
	M	38	30	40	16	67	39	39	127	102	84	582
												1048
FEB	C	98	137	71	135							441
	M	114	68	128	37	26	121	108	93	74	41	810
												1251
MAR	C	99	138	90	143							470
	M	69	38	70	32	22	69	54	72	61	39	526
												996
APR	C	100	146	128	143							517
	M	0	0	0	0	7	0	0	34	17	10	68
												585
MAY	C	98	143	150	151							542
	M	0	0	0	0	2	0	0	37	32	13	84
												626
JUN	C	87	22	140	149							398
	M	57	0	54	46	23	42	47	80	53	51	453
												851
JUL	C	98	0	148	149							395
	M	155	0	128	115	75	129	145	135	131	135	1148
												1543
AUG	C	88	0	147	143							378
	M	147	0	134	115	73	130	131	137	132	134	1133
												1511
SEP	C	91	0	140	137							368
	M	141	0	134	103	64	123	129	135	121	126	1076
												1444
OCT	C	85	0	145	149							379
	M	144	0	127	100	61	130	134	141	132	126	1095
												1474
NOV	C	92	0	119	144							355
	M	142	0	123	104	63	128	125	135	129	130	1079
												1434
DEC	C	106	0	92	150							348
	M	132	0	105	62	53	110	132	106	101	98	899
												1247
		2282	866	2484	2473	536	1021	1044	1232	1085	987	14010
	Curtin	1143	730	1441	1743							5057
	Murdoch	1139	136	1043	730	536	1021	1044	1232	1085	987	8953


Total Archived Passes for 2014
Murdoch
Curtin
Total
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
582
466
1048
810
441
1251
526
470
996
68
517
585
84
542
626
453
398
851
1148
395
1543
1133
378
1511
1076
368
1444
1095
379
1474
1079
355
1434
899
348
1247


Number of passes received by each WASTAC station in 2014
2000
1800
1600
1400
1200
1000
800
600
400
200
0
NOAA 15
NOAA 16
NOAA 18
NOAA 19
FY3B
METOP A
METOP B
TERRA
AQUA
NPP
Curtin
Murdoch

OPERATIONAL APPLICATIONS 2014

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

BUREAU OF METEOROLOGY, MELBOURNE

Mike Willmott and the Western Australian Regional Forecasting Centre

Tropical Cyclone Monitoring

The Bureau of Meteorology is responsible for Tropical Cyclone warnings to the Australian public. To assist in the effective mitigation against the loss of life and damage to property, the Bureau operates tropical Cyclone Warning Centres (TCWC) in Brisbane, Darwin and Perth. The Perth Tropical Cyclone Warning Centre operates out of the Perth Regional Forecasting Centre. Each TCWC has an area of responsibility for Tropical Cyclone Warning (Figure 1). In previous years it has been found that polar orbiting satellites have provided an abundance of data for assisting in the determination of intensity, movement and positioning of tropical cyclones. In the future, geostationary satellites will also provide valuable information, particularly with the launch of the new Himawari 8 satellite operated by the Japan Meteorological Agency.

The WASTAC L-Band and X-Band systems have provided higher resolution data to assist in the analysis of these destructive systems, but with the newer geostationary satellites having 10 minute data and less than 1km spatial resolution, these satellites are becoming comparable for tropical cyclone monitoring. The polar orbiting data will also continue to be an important input to the Bureau's Numerical Weather Prediction (NWP) system due to the timeliness afforded by local reception.

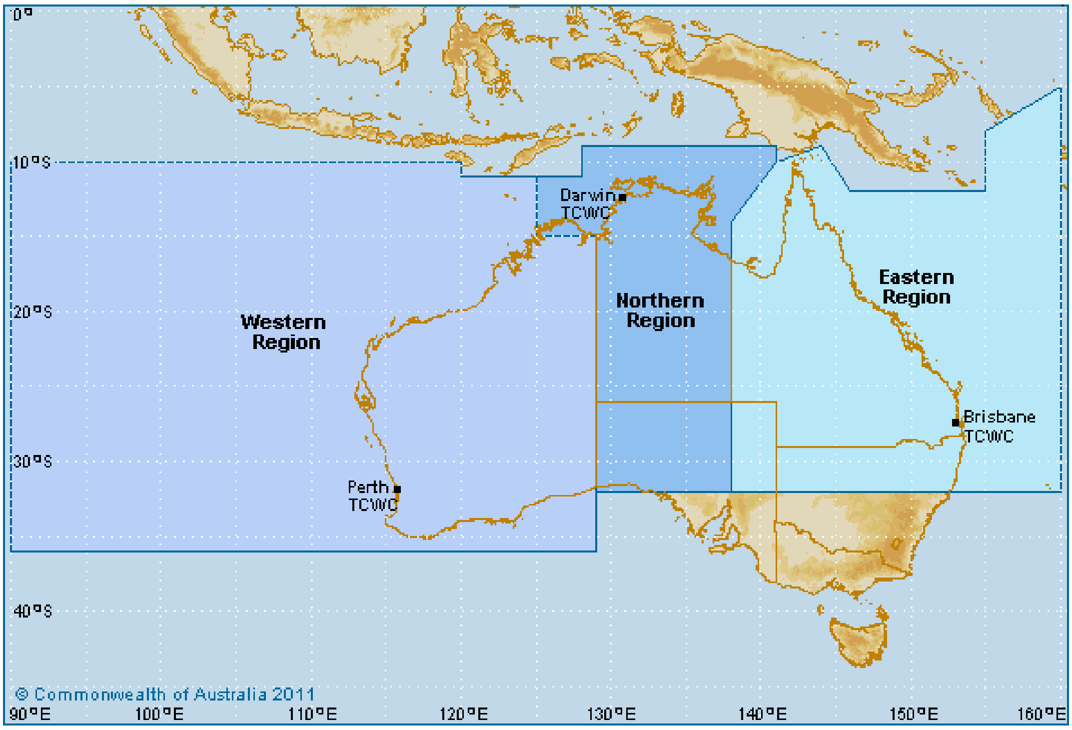


Figure 1: The three Tropical Cyclone Warning Centres and their areas of responsibility. To the west of the Western Region, the area of responsibility falls to La Reunion.

For the period between 1 January 2014 and 31 December 2014, there were four tropical cyclones that entered or formed within Perth TCWC's area of responsibility (Table 1 and Figure 2). Of these, the most severe tropical cyclone that threatened the Australian coastline was Severe Tropical Cyclone Christine. It is also interesting to note that for three of these cyclones (Gillian, Kate and Jack), the cyclones reached maximum intensity at the limit of the Perth reception. (This can be seen in the imagery following for each particular tropical cyclone).

Tropical Cyclone	Period (2014)	Max Intensity	Impact on Coast or Other Aus. Territory	Means of Detection
Christine*	25 Dec 2013 – 1 Jan 2014	4	Severe	Satellite
Gillian*	6 – 26 Mar 2014	5	Severe	Satellite
Jack*	15 – 22 Apr 2014	3	Nil	Satellite
Kate*	21 – 30 Dec 2014		Moderate	Satellite

* Classified as Severe Tropical Cyclone

Table 1: List of Tropical Cyclones within the Western Region for the Period: January 2014 to December 2014.

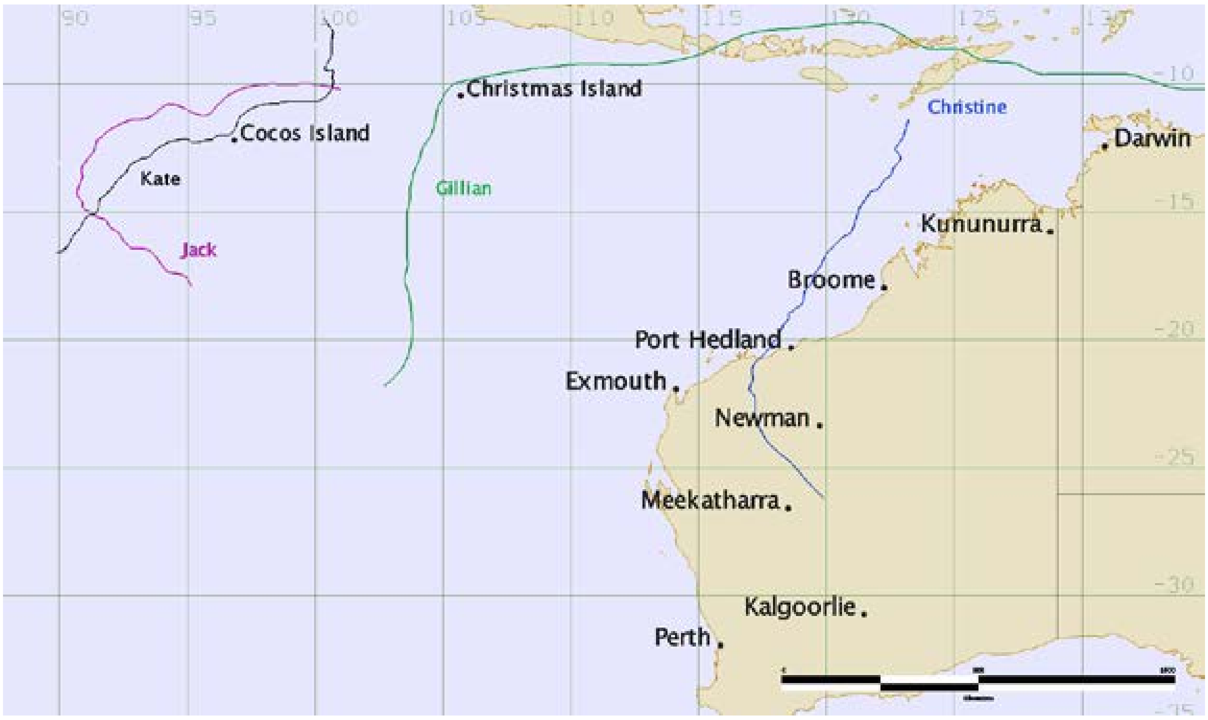


Figure 2: Tropical Cyclone Tracks within the Western Region of responsibility for the period 1 January 2014 to 31 December 2014.

Severe Tropical Cyclone CHRISTINE
(25 December 2013 to 1 January 2014, figure 3)

A very active monsoon trough to the north of Western Australia (WA) produced a number of transient low pressure systems during mid-December 2013. A discreet centre within this broad circulation formed late on 25 December and moved southwest. The low developed slowly and did not reach tropical cyclone strength until 06:00 UTC 28 December.

Christine steadily intensified while continuing on a south to southwest track, reaching category 3 intensity (Severe Tropical Cyclone) at 18:00 UTC 29 December. A feature of the system was its large size, with gale force winds and heavy rainfall well away from the centre. Severe Tropical Cyclone Christine crossed the Pilbara coast as a category 4 system with a peak intensity of 90 knots between Roebourne and Whim Creek around 15:00 UTC 30 December (near midnight local time). As Christine crossed the coast very destructive winds were experienced, with a gust of 93 knots (172km/h) recorded at Roebourne Airport. Other notable wind speeds were 72 knots (133km/h) at Karratha and 70 knots (130km/h) at Port Hedland.

Christine weakened once it crossed the coast and began to accelerate to the southeast. The system maintained its cyclonic structure further inland than most tropical cyclones and was finally downgraded to below cyclone strength at 12:00 UTC 31 December. After weakening below cyclone intensity, the system moved quickly across south eastern WA, producing damaging winds and moderate to heavy rainfall.

Heavy rainfall was recorded in the vicinity of the cyclone path, with the heaviest 24 hour fall being 168mm at Abydos North, a rain gauge to the southeast of Port Hedland. Other notable 24 hour falls were 134mm at Roebourne airport, 123mm at Port Hedland and 113mm at Karratha. There was minor to moderate flooding in Pilbara river catchments, particularly of the De Grey River and Pilbara Coastal Rivers.

When Christine made landfall, 10 minute mean winds of 165km/h (maximum wind gust of 230km/h) were recorded near the centre. Fortunately it is likely that the maximum winds occurred in unpopulated areas just east of the crossing point. Preliminary results suggest a storm surge (inundation level above event tide) of approx. 2.5 - 3m along this stretch of coast.

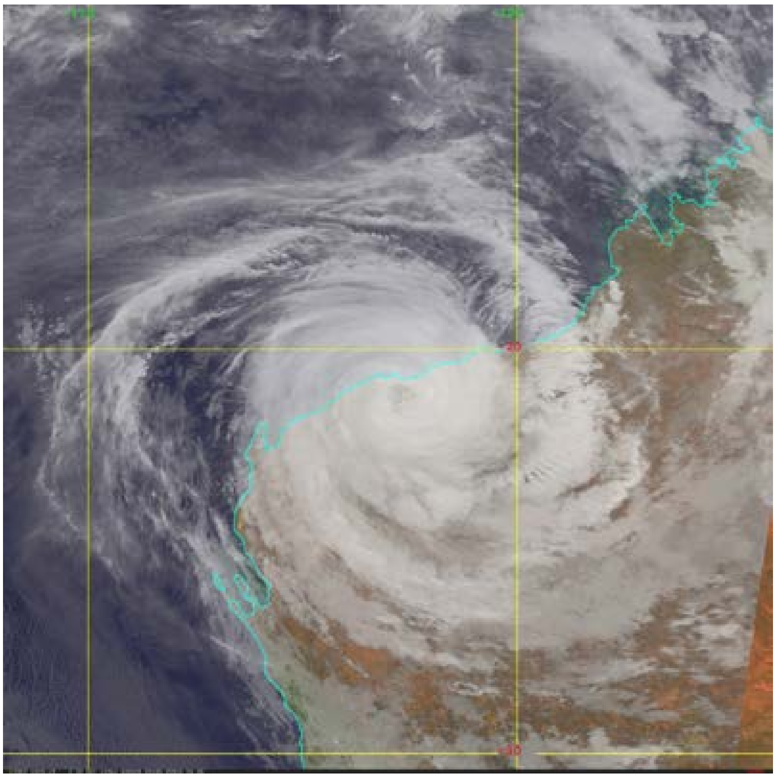


Figure 3: Severe Tropical Cyclone Christine some hours after making landfall. The system maintained its cyclonic structure further inland than most tropical cyclones. Image received by the Perth receiver at 18:00 UTC from NOAA-19 on 30 December 2013.

Severe Tropical Cyclone GILLIAN
(6 March 2014 to 26 March 2014, figure 4)

On 10 March 2014, Tropical Cyclone Gillian Category 1 was estimated to be 125km south southwest of Weipa and 40km north northwest of Cape Keerweer and moving south south-east at 8 km/h. This Tropical Cyclone had formed in the Eastern Region and was the responsibility of the Queensland TCWC. Gillian turned to the west and as it moved to the west over the next few days, it maintained its circulation and headed across the top end of Cape York and spent a few days within the Gulf of Carpentaria. It continued to move west towards the Indonesian islands and weakened whilst in the Darwin TCWC area of responsibility until it dropped below a Category 1.

During the 19 and 20 March, ex-TC Gillian maintained its westward track over the Indonesian islands, only slowly developing due to less than ideal atmospheric conditions. From 21 March, as the system moved south of the Indonesian archipelago, it encountered an environment more conducive to tropical cyclone development. By the evening of 21 March, the system had re-intensified to tropical cyclone strength. Further, gradual development continued until Tropical Cyclone Gillian commenced a more southerly track during 22 March and entered a significantly more favourable environment.

A cyclone watch was first issued for Christmas Island early on the morning of the 20 March, with a warning first issued during on 21 March. TC Gillian passed to the north of Christmas Island as a Category 1 tropical cyclone, generating a period of gales on the afternoon of the 22 March with a peak wind gust of 96km/h. Heavy rainfall also affected Christmas Island with 181mm falling in the 24 hour period to 9am on 22 March. There were reports of structural damage on the island with several buildings incurring roof damage, power lines downed and trees felled. Gillian was the first tropical cyclone to affect Christmas Island since Tropical Cyclone Rosie in April 2008.

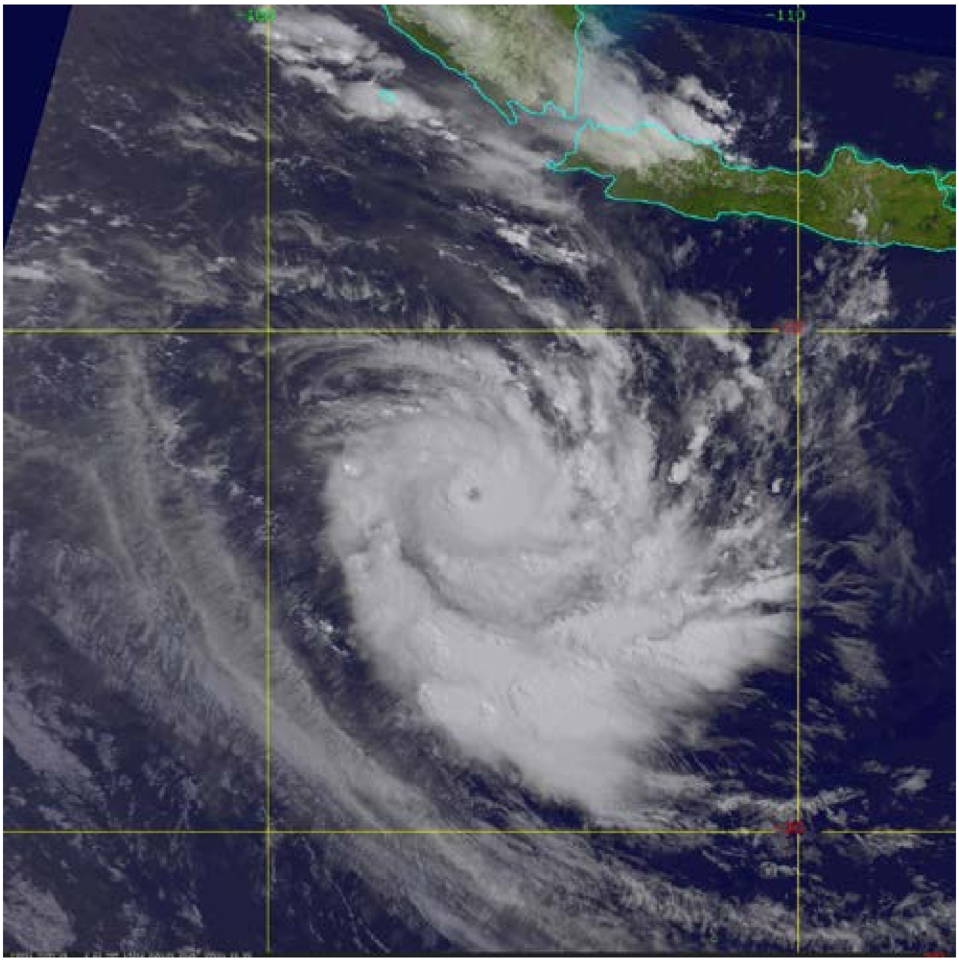


Figure 4: Severe Tropical Cyclone Gillian some 400km to the south west of Christmas Island. Image received by the Perth receiver at 02:01 UTC from NOAA-16 on 23 March 2014.

The system commenced a rapid intensification phase as it continued to move southwards, and was classified as a severe tropical cyclone (Category 3 and above) by the evening of 22 March. Tropical Cyclone Gillian continued to develop rapidly and was upgraded to a Category 5 system during the evening of 23 March. At its peak, Gillian was estimated to have maximum wind gusts of 285km/h.

Commencing on 24 March, atmospheric conditions became less favourable and Gillian began to weaken. The system continued to move south, weakening further. During the morning of 26 March, the system was downgraded to a low. Severe Tropical Cyclone Gillian was the first tropical cyclone to reach Category 5 status in the Western Region since Tropical Cyclone Laurence in December 2009. Gillian was also an exceptionally long-lived tropical low, existing as an organised, identifiable circulation for 20 days, affecting the waters of Queensland, Northern Territory and Western Australia.

Severe Tropical Cyclone JACK
(15 April 2014 to 22 April 2014, figure 5)

On 15 April, a tropical low developed in the central Indian Ocean near 10°S, 100°E. From 16 April the low tracked towards the west southwest and gradually developed. It passed about 160km to the northwest of Cocos Island early on 17 April. From late 18 April the environment became conducive for rapid development and as such the system developed into Tropical Cyclone Jack at 08:00 WST 19 April. Jack continued to rapidly develop and became a category 2 cyclone at 14:00 WST 19 April as it tracked towards the south southwest. Jack reached severe category 3 intensity at 23:00 WST 19 April and was at peak intensity during the morning of 20 April with mean winds of 150km/h and wind gusts to 205km/h near the centre. Early on 20 April, the system started to move towards the south southeast due to the approach of an upper-level trough and started to weaken. Jack continued to weaken on 21 April due to increasing wind shear and was below tropical cyclone intensity by 11:00 WST 22 April. There were no known impacts from severe tropical cyclone Jack.

Severe Tropical Cyclone KATE
(21 December 2014 to 30 December 2014, figure 6)

A tropical low developed to the southwest of Sumatra during 21 December. The low initially moved towards the south and then towards the west-southwest. The system reached cyclone strength at 09:30 UTC 24 December when it was 275km northeast of the Cocos Keeling Islands. Kate tracked towards the west-southwest and passed close to the Cocos Keeling Islands on 25 December. Gales were recorded on the islands with a maximum gust of 55 knots (102km/h) at 07:08 UTC 25 December. This was also accompanied by 107.6mm of rain in a 24 hour period to 9 am WST 25 December. Flooding was reported from Home and West Islands. A number of trees were damaged and there was some property damage.

As Severe Tropical Cyclone Kate continued to move in a southwest direction the system intensified further in favourable conditions. The system reached a peak intensity of around 150km/h at 00:00 UTC 27 December. Around 12:00 UTC on 27 December wind shear increased and the cyclone began to weaken. Wind shear decreased during 28 and 29 December which allowed Kate to re-intensify. Kate crossed 90°E at 00:00 UTC 30 December with an intensity of 150km/hr. The system continued to intensify in La Reunion's area of responsibility. The passage of Kate close to the Cocos Keeling Islands on 25 December produced strong winds and heavy rainfall.

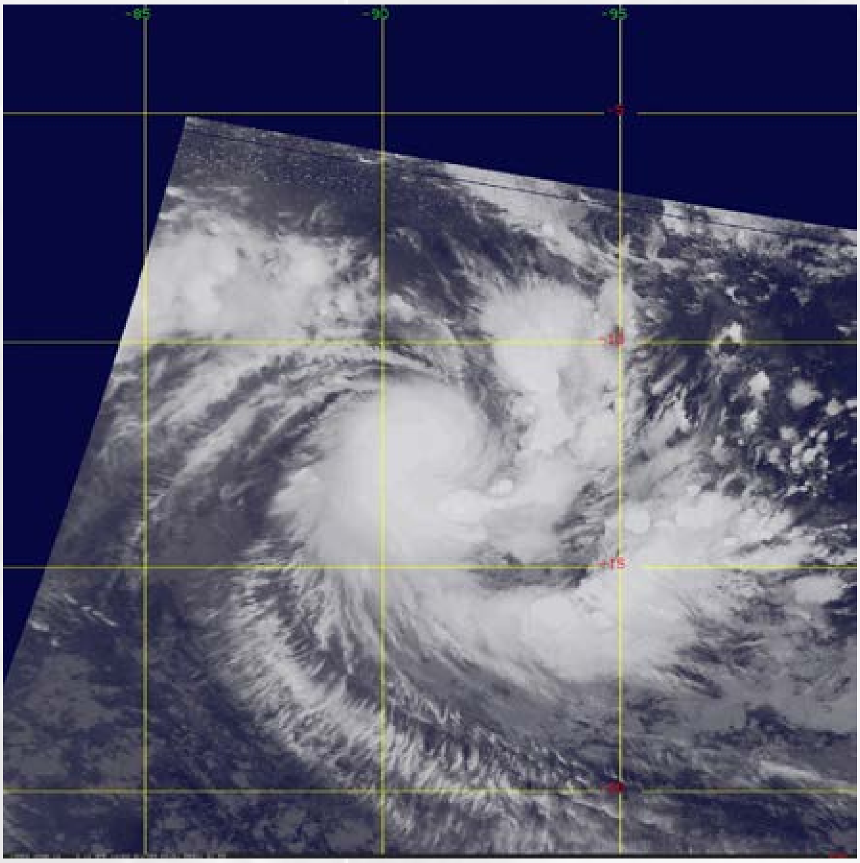


Figure 5: Severe Tropical Cyclone Jack. Note that this tropical cyclone has not yet reached maximum intensity and is almost on the limit of reception from the Perth antenna. Image received by the Perth receiver at 21:17 UTC from NOAA-18 on 18 April 2014.

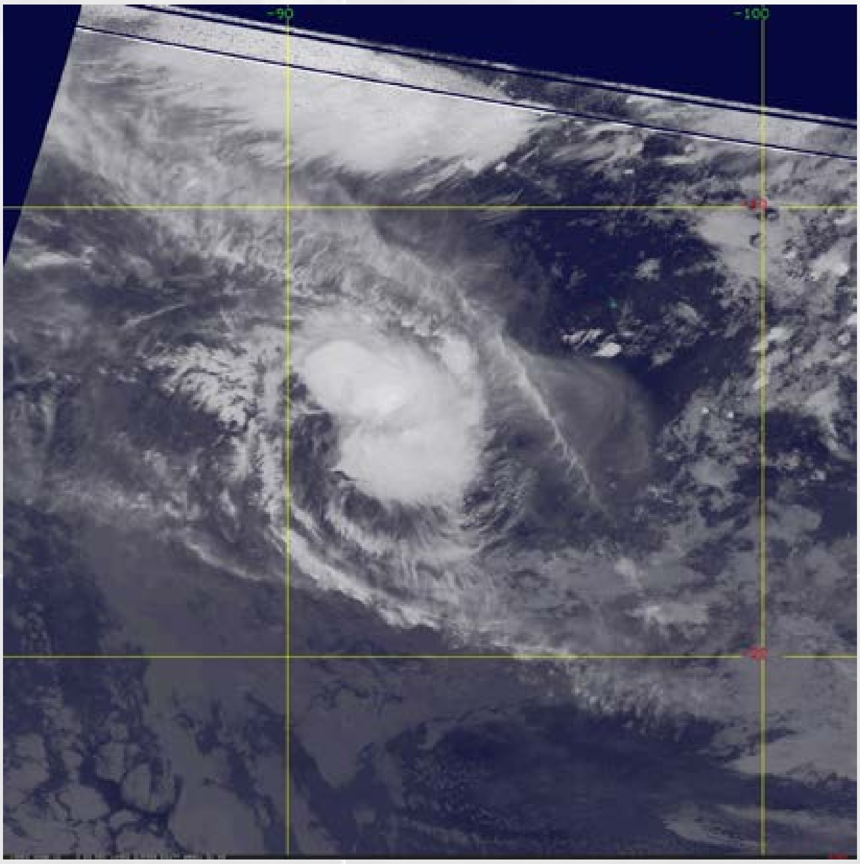


Figure 6: Severe Tropical Cyclone Kate. Note again that this Tropical Cyclone has not yet reached full potential and is on the limit of the Perth Reception area. Image received by the Perth receiver at 21:53 UTC from NOAA-18 on 28 December 2014.

LANDGATE, SATELLITE REMOTE SENSING SERVICES (SRSS), FLOREAT

RangeWatch - CRC-SI Biomass Business Project

Richard Stovold

RangeWatch was developed from a 3 year federally funded Cooperative Research Centre for Spatial Information (CRC-SI) project run at Liveringa Station in the Kimberley region of WA to develop improved use of the Moderate resolution Imaging Spectroradiometer (MODIS) data from the Terra and Aqua satellites to support pasture utilisation in the rangelands of Australia for pastoralists.

This Landgate R&D project, to model pasture growth in the pastoral rangelands, was undertaken in conjunction with project partners from the Precision Agriculture Research Group from the University of New England NSW, CSIRO Centre for Environment and Life Sciences, Curtin University and industry partner the Milne Agrigroup, who own Liveringa Station. The project was completed in June 2014.

The project aims were to:-

1. Utilise MODIS satellite imagery and climate data to derive a pasture biomass model to estimate available stock feed at critical times in the pasture growing season in northern Australia.
2. Provide a web enabled delivery tool for the pastoralist to view seasonal biomass and pasture growth rate estimates.

A simple web tool (Figure 7) was developed to allow pastoralists to access their weekly paddock pasture biomass and pasture growth measurements. The RangeWatch web tool and pasture growth model will assist producers to calculate the viable number of stock from the dry to wet season each year for sustainable land management. A stocking rate calculator and new higher resolution 30m Landsat 8 datasets were added to the tool.

The expected benefits to the agricultural industry are the establishment of more efficient, sustainable and profitable pastoral enterprises leading to improved supply of meat and livestock for local and overseas markets. It is envisaged that with further validation this model could be extended to the Kimberley and Pilbara regions of WA and other northern rangelands regions in other states of Australia.

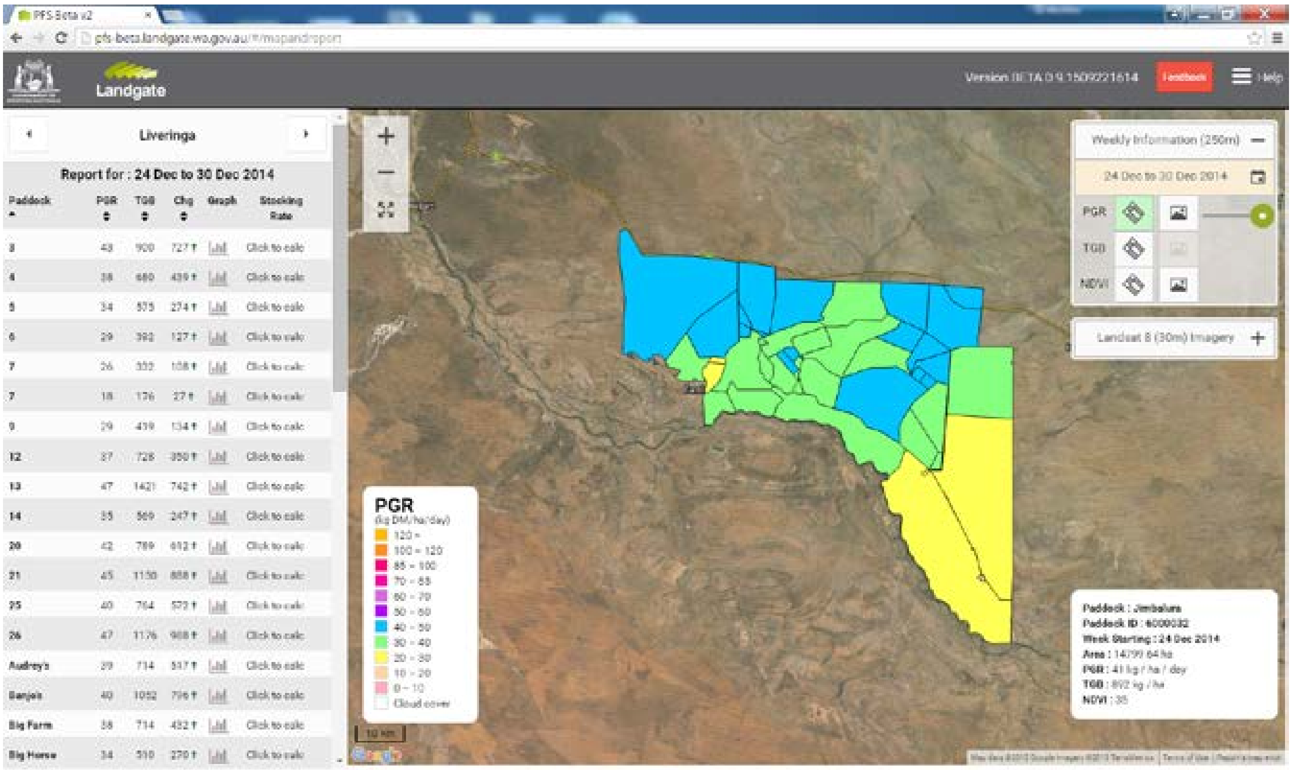


Figure 7: The web tool and derived pasture growth model RangeWatch shows weekly biomass and pasture growth measurements of pastures in every paddock. A stocking rate calculator and Landsat 8 data is included.

RangeWatch Model Calibration and Validation Project - De Grey Station Pilbara

Richard Stovold, Norm Santich and Graham Donald[1]

Purpose of the project:

To analyse, calibrate and validate the Kimberley RangeWatch pasture biomass and plant growth model from field sampled pasture data collected on De Grey station in the Pilbara region.

Progress to Date:

Pasture sampling for the first of two years has been completed.

The data analysis enabled the calibration/validation of the RangeWatch biomass and plant growth model. Analysis of estimated Pasture Growth Rate, Total Green Biomass and Total Biomass has indicated that the model is potentially viable in the Pilbara environment despite the abnormal growing season caused by the lack of seasonal cyclone activity. This seasonal abnormality has caused some uncertainty in the validation of the model this year.

Preliminary investigation using Landsat 8 higher resolution 30m data has also been undertaken. As further data is collected it will be more evident if the higher resolution data provides extra value for the assessment of pasture growth and biomass estimates. It is envisaged that this could be routinely provided as a secondary data set to the MODIS 250m pixel resolution information.

Future Planned Activities in 2015/16

a) Continue the calibration /validation analysis of the RangeWatch model on De Grey Station following field sampling over four more dates covering the 2015/16 growing season.

b) Provide a SPOT 5 satellite infrastructure map update covering De Grey Station.

c) Demonstrate the web mapping tools to De Grey Station personnel and seek their evaluation of the value of the data for station management and setting of stocking rates.

Preliminary conclusions

The project is due to be completed by the 31 May 2016. It's apparent from this initial analysis that more information is required before any final modification can be made to the models to suit the unique Pilbara environment. The on-going dry conditions have made progress difficult but overall the results are certainly encouraging. It is expected that a model to estimate the pasture growth patterns of the Pilbara environment can be derived.

[1]University of New England, Precision Agriculture Research Group

Improving Pastures from Space

Richard Stovold, Norm Santich, Bruce Hearder, Adrian Allen and Sarfraz Khokhar

A redevelopment of the Pastures from Space service has been completed by the agriculture and web teams within SRSS to better meet the changing needs of the agricultural industry. Trials to test and validate the service with key agricultural users are planned for 2015. Feedback from the testers will be collected and assessed for implementation by Landgate.

The redeveloped web service (Figure 8) provides weekly Pasture Growth Rate (PGR) and Feed On Offer (FOO) biomass values at 250m and 30m resolution as well as historical Feed On Offer growth trend graphs (Figure 9) at a paddock scale for farmers in the southern agricultural zone of eastern and western Australia.

A feed budgeting tool is also included to allow farmers to calculate optimum numbers of livestock to sustainably run on their properties. This information is provided via our new web delivery service. The service is available to invited participants at: pfs-beta.landgate.wa.gov.au. The key benefit to the agricultural industry is access to more reliable and regular information of the productive potential of the pasture lands which in turn can be converted to increased producer profits. It is proposed to collect feedback from users over a 3 month trial period to assist us to improve the product.

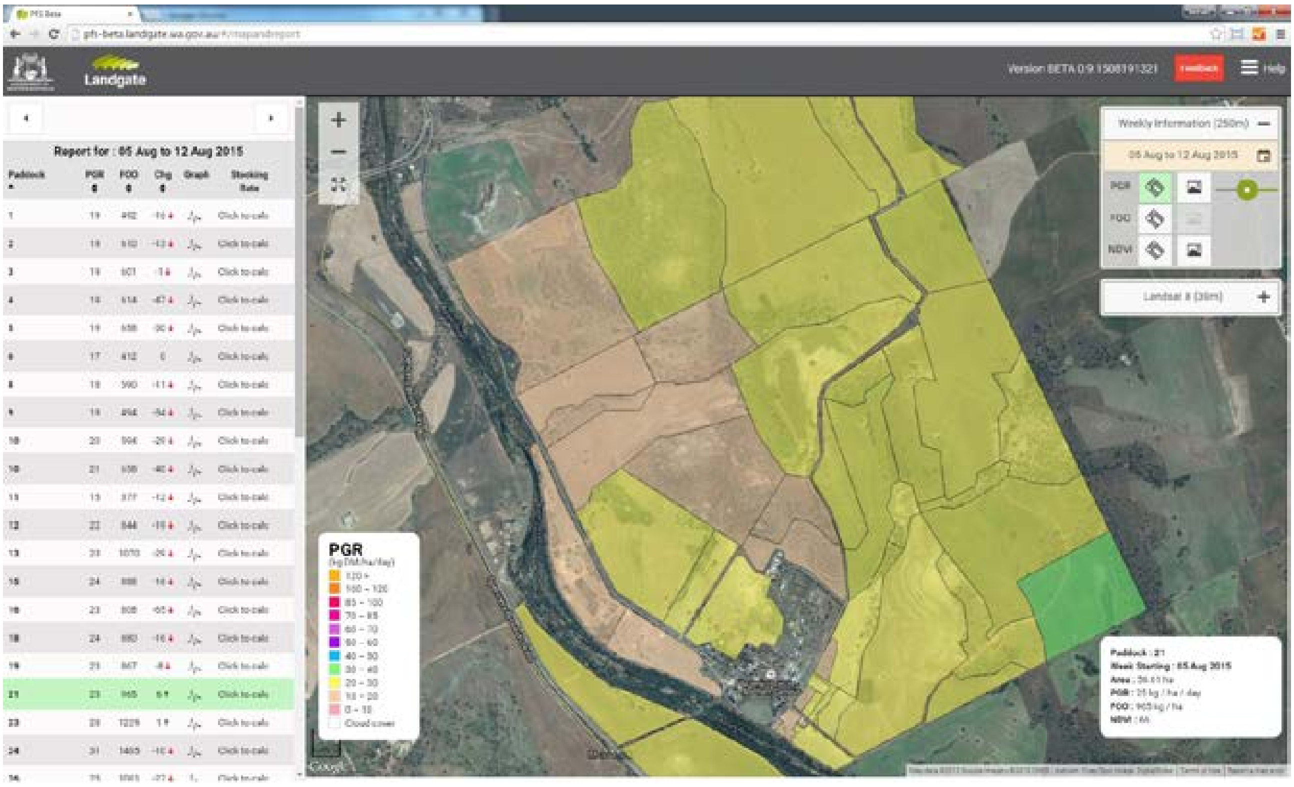


Figure 8: The redeveloped Pastures From Space service..

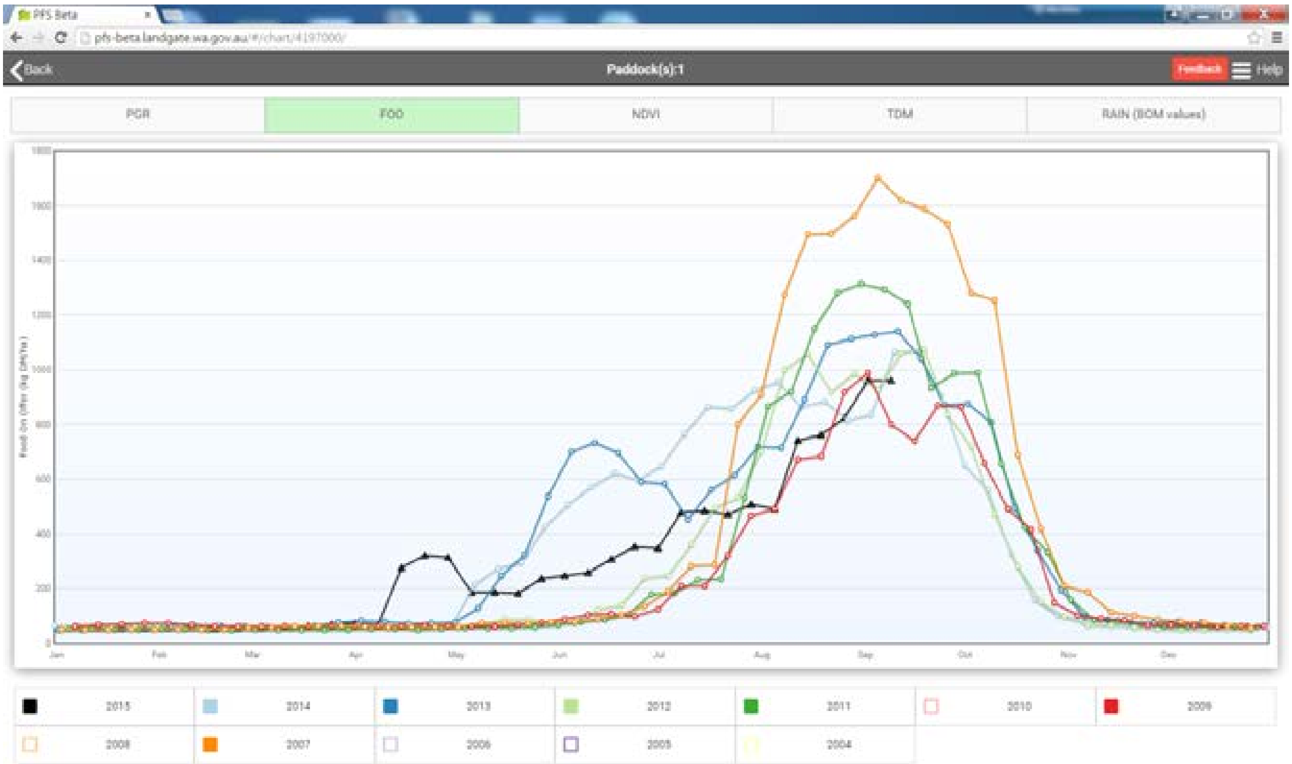


Figure 9: Historical graphs of available Feed On Offer (FOO) in kg/DM/ha for paddock 1.

Continental Agriculture Data Sets

Norm Santich

With new enhancements planned for Pastures From Space in 2015, it became necessary to rebuild several MODIS-derived data sets to have a continental extent and provide coverage for properties in the northern rangelands and eastern Australia, as well as the Western Australian wheat belt. This also presented an opportunity to improve efficiencies with the existing datasets and make them compatible with new online mapping technologies. Previously, imagery developed with the old software was limited to 3-band TIF or ECW formats without support for imagery transparencies. It wasn't possible to include image compression in TIF images and ECW is a lossy compression format.

The new continental images have been constructed as 1-band TIFs with a built in colour table, LZW compression and a NoData value to enable image transparencies. The NoData value negates the need for an opacity layer (alpha channel) which means the images are smaller and are quicker to process. Examples of the new continental images for Pasture Growth Rate (Figure 10), Normalised Difference Vegetation Index (NDVI) anomaly image (Figure 11) and the NDVI rank image (Figure 12).

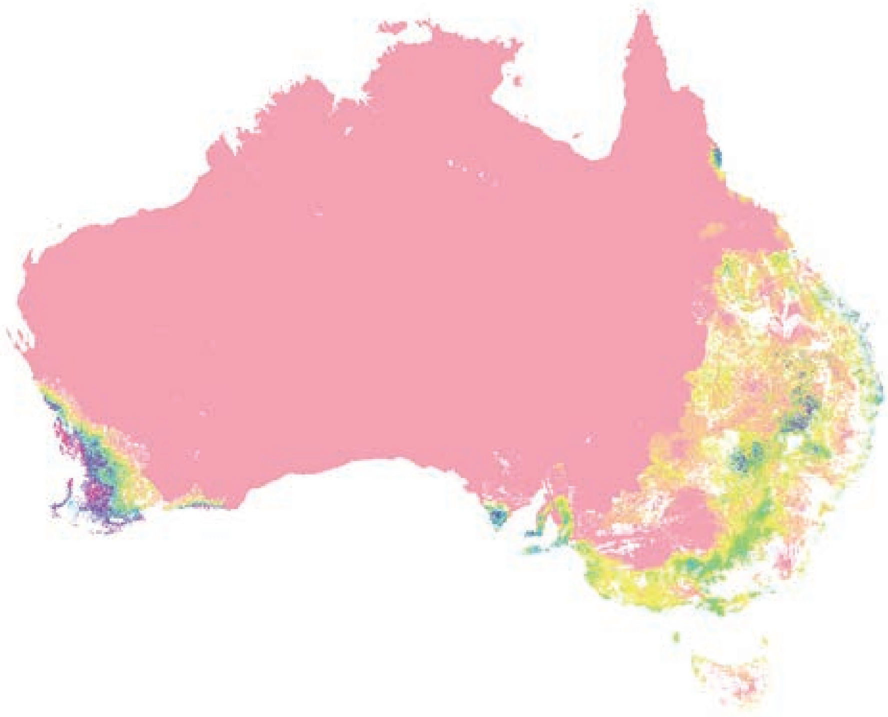


Figure 10. Pasture Growth Rate (PGR) image for the week starting 20/8/2014.

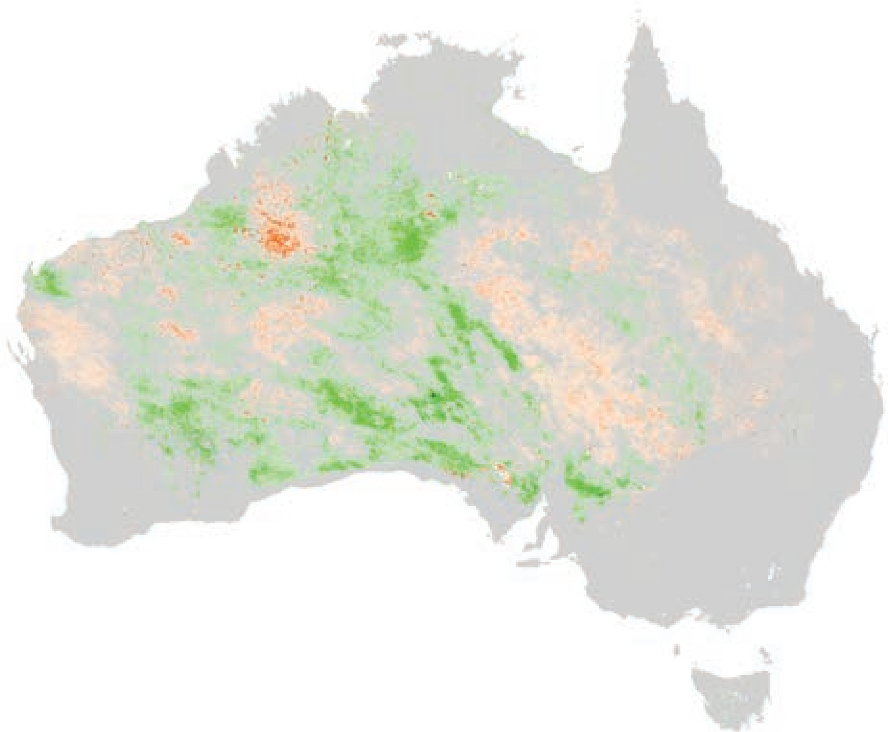


Figure 11. NDVI anomaly image for the week starting 20/8/2014. Grey regions are showing about average levels of greenness for that time of year compared with the years between 2004 – present. Green regions are showing higher levels of greenness than average for that time of year when compared with the years between 2004 – present. Brown regions are showing lower levels of greenness than average for that time of year when compared with the years between 2004 – present.

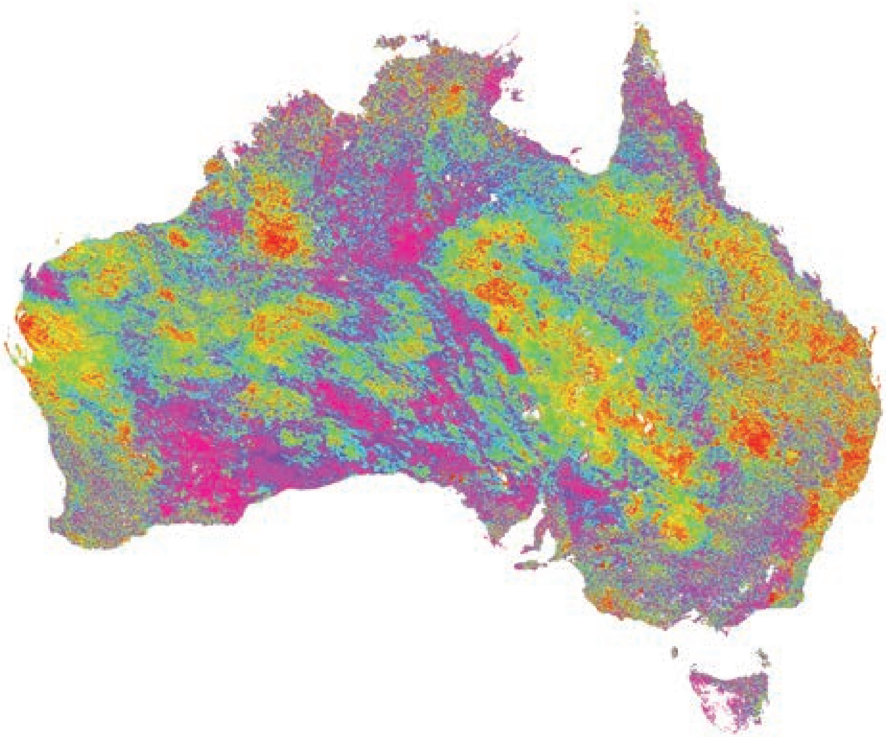


Figure 12. NDVI rank image for the week starting 20/8/2014. The rank image shows how many years (between 2004 – present) have been greener at that time of year. Red-orange years have had many other years greener at the same time of year as the week starting 20/8/2014, whereas pink-purple regions have been greener than most other years at the same time of year as the week starting 20/8/2014.

Detecting Fire Hot Spots from Suomi NPP

Mike Steber, Dave Foster and Jackie Marsden

In late 2011 the Suomi National Polar-orbiting Partnership (SNPP) satellite from the NOAA - Joint Polar Satellite System (JPSS) was launched. One of the instruments onboard the satellite, the Visible Infrared Imaging Radiometer Suite (VIIRS), is similar to the MODIS sensor. It has been designed as the follow on to MODIS in the event of MODIS coming to the end of its operational lifetime. Further JPSS satellites will follow Suomi NPP providing WASTAC members with ongoing access and redundancy for the provision of fire information to the community. Using the SNPP fire hot spot (FHS) information will reduce the risk associated with losing access and, thus FHS information, from the aging US fleet of polar orbiting satellites. SNPP passes over Australia between 3:30 UTC and 8:30 UTC during the day and between 14:45 UTC and 19:30 UTC during the night. Currently it conflicts with overpasses from Aqua.

During 2012 Landgate implemented the FHS detection algorithm developed by the National Aeronautics and Space Administration (NASA), which works reasonably well across the globe. But like previous NASA algorithms it does not meet Landgate's quality control standards for Australian conditions as there are errors of omission. To meet this standard Landgate setup a project to develop a FHS detection algorithm that worked well for the Australian continent. This project was completed in 2014 and the resulting data was made available online via Firewatch Classic (firewatch-classic.landgate.wa.gov.au). Initial comparisons show that the Landgate algorithm performs much better than the NASA algorithm as the NASA algorithm suffers from large errors of omission. After a short period of quality assurance testing the SNPP FHS information will be switched on within FireWatch Pro (firewatch-pro.landgate.wa.gov.au). With the 3.5µm channel of VIIRS having a nominal resolution of 375m this means that the number of FHS detected on a single pass has increased dramatically (Figures 13 and 14).

Figure 13: FHS detected using Landgate's SNPP FHS algorithm on SNPP VIIRS image dated 13:59 WST 31/12/2014

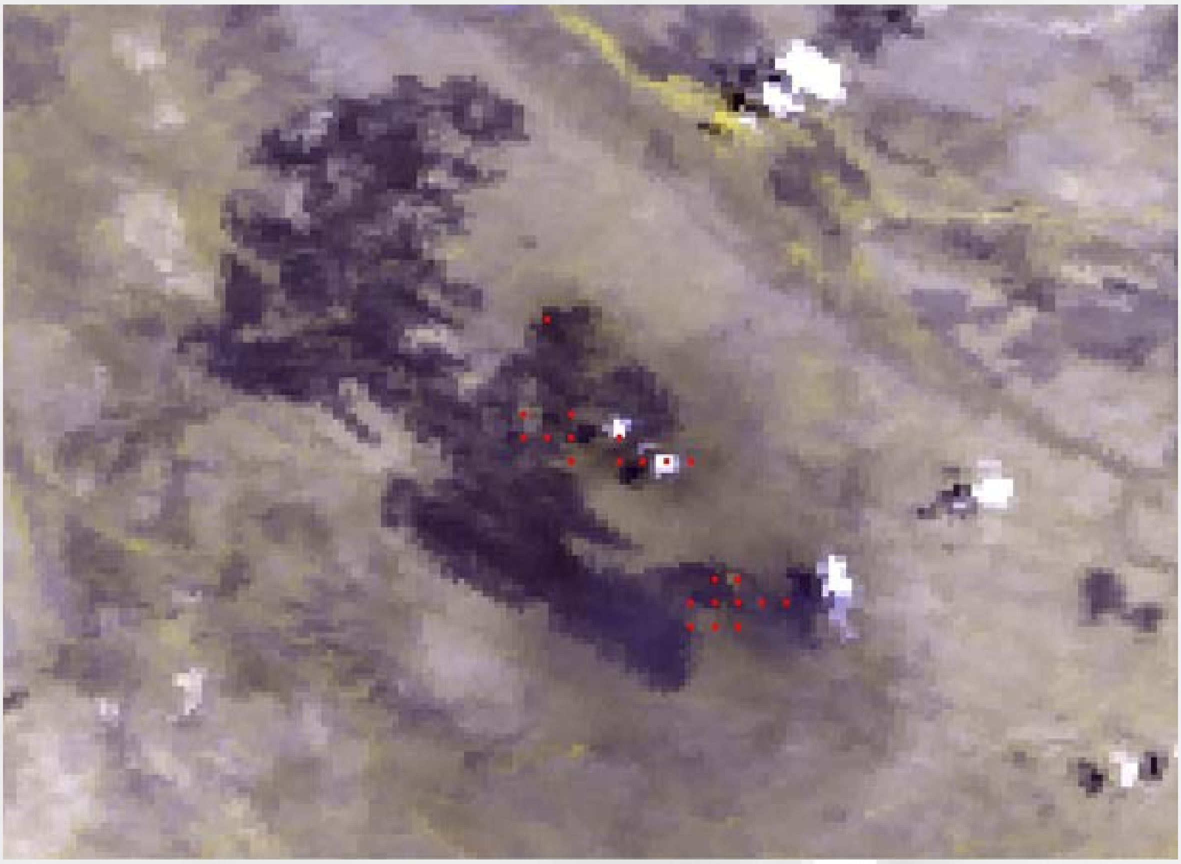


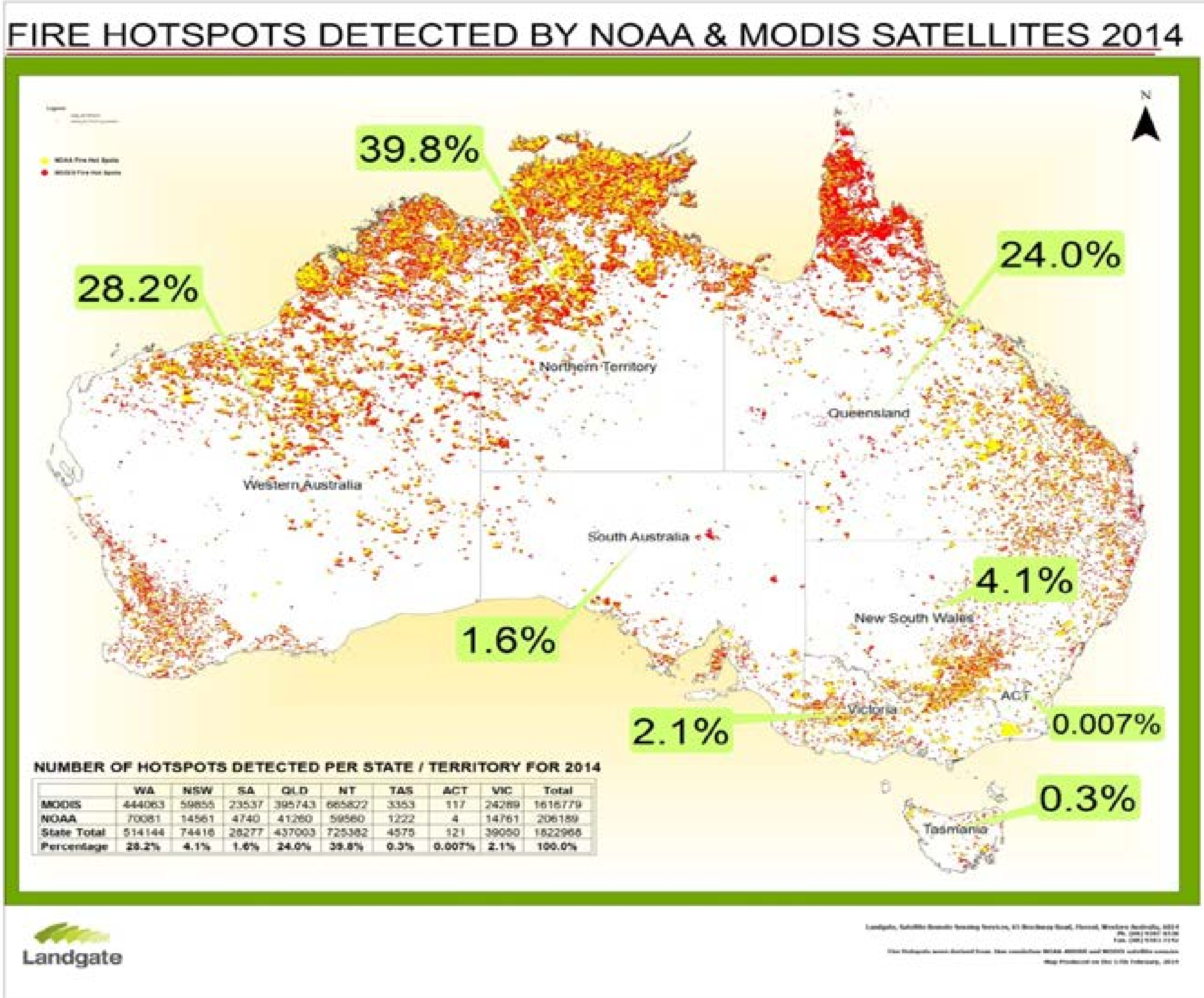
Figure 14: FHS detected using Landgate's MODIS FHS detection algorithm on Aqua MODIS image dated 14:27 WST 31/12/2014

Australian Fire Season 2014

Carolyn McMillan

Satellite Remote Sensing Services (SRSS), Landgate map the location of active fires Australia wide.

Satellite data from the WASTAC receiving stations at Perth and Murdoch plus data from other satellite receiving stations at Crib Point, Alice Springs, Darwin, Townsville, and Hobart are downloaded at SRSS and the thermal channels from the MODIS (Aqua and Terra) and NOAA (16,18 and 19) are processed to detect fire hotspots (FHS) using NASA algorithms and algorithms derived by SRSS for more local conditions. All of the FHS data, including the imagery used to map the FHS, will appear on the Firewatch website (firewatch.landgate.wa.gov.au) within one hour of the pass being received at SRSS. This information is collated in a GIS so the data can be analysed and interpreted along with other data such as fire burnt areas. The archive of FHS data extends from 2002 for MODIS and 1998 for NOAA. The FHS data is used by a variety of land managers, Department of Fire and Emergency Services, pastoralists and other government organisations such as Department of Parks and Wildlife to plan and assess controlled burning activities, active firefighting and fire prediction modelling. Analysis of the 2014 FHS data has found that 92% of detected FHS occur in Queensland, Northern Territory and Western Australia, with the remaining 8% in all other states combined (Figure 15).



	WA	NSW	SA	QLD	NT	TAS	ACT	VIC	Total
MODIS	444063	59855	23537	395743	665822	3353	117	24289	1616779
NOAA	70081	14561	4740	41260	59560	1222	4	14761	206189
State Total	514144	74416	28277	437003	725382	4575	121	39050	1822968
Percentage	28.2%	4.1%	1.6%	24.0%	39.8%	0.3%	0.007%	2.1%	100.0%

Figure 15: Australian FHS detected by the NOAA, Terra and Aqua satellites during 2014.

Fire Scar Mapping using Sentinel-1 Synthetic Aperture Radar (SAR) imagery

Ifra Khokhar

Fire scars can be very easily mapped using multispectral imagery. However, one of the limitations of multispectral sensors is that they can't see through clouds. On the other hand, imaging sensors based on Synthetic Aperture Radar (SAR) are able to provide all-weather, day-and-night imagery. The Sentinel-1 mission consists of two SAR satellites designed and developed by the European Space Agency (ESA) for the Global Monitoring for Environment and Security (GMES) programme. The first satellite, Sentinel-1A, (Figure 17) was launched on the 3rd April 2014 and is providing C-Band synthetic aperture radar data for operational applications to the GEOSS (Global Earth Observation System of Systems). The second satellite of the mission, Sentinel-1B, will be launched sometime in 2016**.** The Sentinel-1A orbits Earth in a 693km, near-polar Sun-synchronous orbit.

Sentinel-1A operates in two main modes: Interferometric Wide (IW) Swath and Wave. Interferometric Wide Swath mode is the default mode over land and has a swath width of 250km and a ground resolution of 5 x 20m. The Wave mode is useful to determine the direction, wavelength and heights of waves on the open oceans and has a ground resolution of 20km x 20km. The Sentinel-1 data is freely available for download from the Sentinal-1 Scientific Data Hub (https://scihub.esa.int/dhus). Due to limited mission capacity, data over Australia is not routinely acquired (it will improve over time and after the Sentinel-1B is launched and becomes operational). In exceptional cases, emergency observation requests may alter the pre-defined observation scenario.

There were two bushfire emergencies in south western WA in early February 2015; one near Northcliffe and the other near Boddington. The Boddington fire, about 120km south-east of Perth, has left a large fire scar. To estimate the extent of the fire scar, MODIS images were looked at. The extent of fire scar is clearly visible in the cloud free Terra MODIS image acquired on the 8 May 2015 at 10:09 WST (Figure 18). However, due to cloud the fire scar is obstructed in the Aqua MODIS image acquired on the 8 May 2015 at 14:16 WST (Figure 19). A Sentinel-1 (Level 1) image acquired on the 8th May 2015 at 14:45 WST was downloaded from the ESA's website to evaluate if it clearly shows the extent of fire scar. The image was acquired in dual IW mode. The single look resolution of IW mode image is 5m in range and 20m in azimuth and the swath is 250km.

Figure 17: Artist's impression of Sentinel-1A (ESA)

Figure 18: Terra MODIS image acquired on 8 May 2015 (Time of acquisition: 10:09 WST).

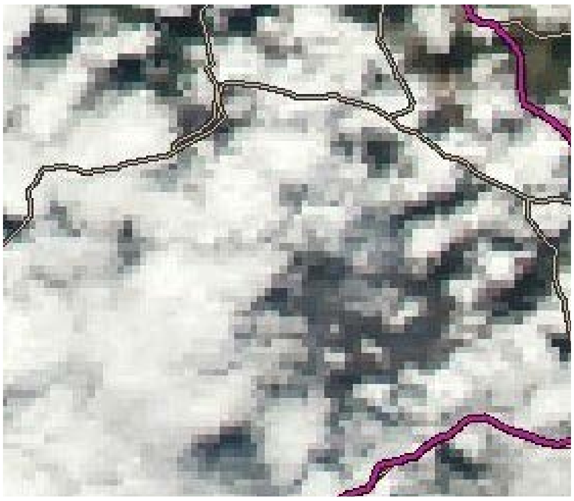


Figure 19: Aqua MODIS image acquired on 8 May 2015 (Time of acquisition: 14:16 WST).

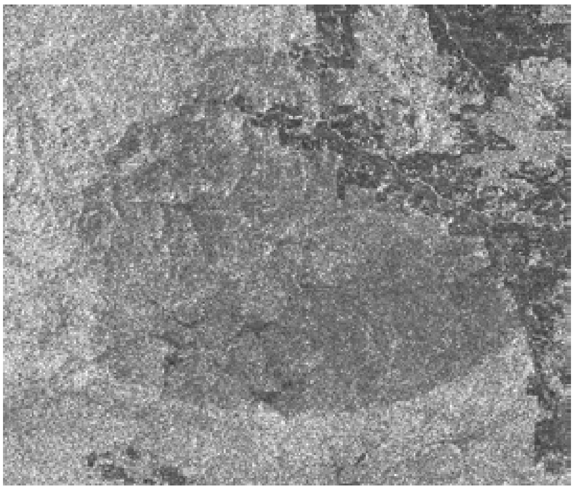


Figure 20: Sentinel-1 image acquired on 8 May 2015. Intensity product of VH Band in grayscale (Time of acquisition: 14:45 WST).

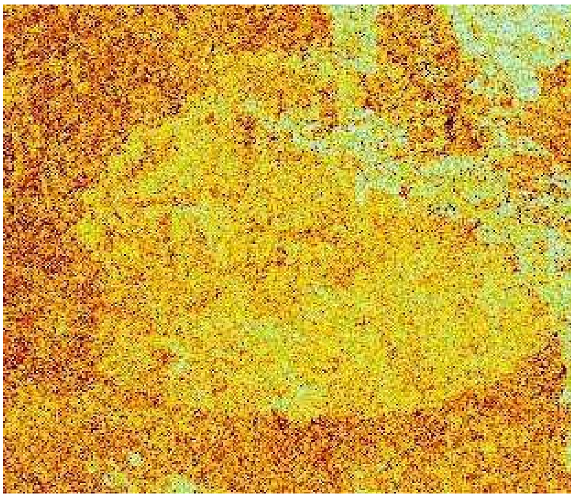


Figure 21: Sentinel-1 image acquired on 8 May 2015. Intensity product of VH Band in pseudo colour (Time of acquisition: 14:45 WST).

After processing to Level-1 four Sentinel-1 image products were compared:

1. Amplitude product for VV band
2. Intensity product for VV band
3. Amplitude product for VH band
4. Intensity product for VH band

The Amplitude and Intensity products of the VH band clearly showed the fire scar. The Intensity product of the VH band in greyscale (Figure 20) shows a fire scar unimpeded by the clouds. The same image in pseudo colour (Figure 21*)* shows the fire scar with a better contrast.

In conclusion, during cloudy periods SAR images, particularly from the Sentinel-1 mission with polarised bands acquired in the Interferometric Wide Swath mode can be used for fire scar mapping. Further research and testing would be needed to streamline the process to successfully use Sentinel-1 data for operational fire scar and flood mapping.

RESEARCH AND DEVELOPMENT 2014

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

CSIRO

ASTER Mapping of Mineralogy

Tom Cudahy

Minerals are fundamental to the formation of the Earth and its dynamic processes though Earth scientists have not had access to local- to continental-scale maps that target the diversity of the land surface's mineral composition. The only satellite sensor designed specifically for mapping the Earth's surface mineralogy and which has operated successfully acquiring global land surface coverage is ASTER (Advanced Spaceborne Thermal Emission and Reflection radiometer). Since its launch in 1999, the user community has had access to inexpensive ASTER Level 1 and 2 data, though there have been no standard higher-level mineral products available for users, which has limited the value and uptake of this unique global dataset. To help address this problem, a team of twenty organisations led by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), generated and publicly released a suite of seventeen geoscience products of the Australian continent (Caccetta *et al.*, 2013).

ASTER satellite sensor

The Japanese designed and built ASTER sensor was launched in December 1999 as part of a multi-sensor payload onboard the USA's Terra platform for servicing NASA's "Earth Science Enterprise". ASTER is a polar-orbiting (<83° latitude) imaging system with a 60 km swath and sensing 14 spectral bands at a pixel resolution between 15 and 90 m. These bands include six in the shortwave infrared (SWIR, 1-2.5 μm) wavelength region, where clay minerals have diagnostic absorption features, and five in the thermal infrared (TIR, 8-12 μm) wavelength region, where other silicate minerals like quartz have diagnostic features (Abrams *et al.*, 2015).

Geology and Mineral Exploration

The Version 1 Australian ASTER geoscience maps were designed to help mineral explorers map specific rock types and the effects of superimposed alteration (footprints to mineralisation) and regolith processes (weathering, erosion and deposition). Thousands of mineral maps have subsequently been downloaded over the web by users from over 40 countries or obtained via external drive (~1 TB for a complete set of products), which are available through the government geoscience agencies across Australia. This demonstrates how access to new geoscience mapping data can attract interest and investment into a country like Australia, which is reliant on the health of its resources sector.

The first gold discovery using the Australian ASTER minerals maps was announced by Kentor Gold Limited on the Australian Stock Exchange soon after the public release of the satellite products. Their discovery at Chukbo in the east Arunta of the Northern Territory (Figure 1) was based on recognition in the ASTER geoscience maps of coincident phyllic and propyllitic alteration. Similar new targets are also apparent.

The ASTER mineral maps are easily integrated with other geospatial data allowing for improved understanding of geological processes, including into the 3rd dimension (3D). For example, Figure 2 shows a 3D oblique view of the Australian crust with the ASTER clay composition measured from the surface and the base with the crust (MOHO) measured/modelled using geophysics (Kennet *et al.*, 2011). Thin crust (~20 km) is spatially associated with illite/montmorillonite (warmer colours) while kaolinite (cooler) is developed over thick (up to 40 km) crust. This pattern is interpreted to be related to long-lived depositional (e.g. Lake Eyre basin) versus erosional (e.g. Yilgarn and Gawler Blocks) environments (respectively) with seismic activity related by isostatic re-adjustments to ongoing erosion/deposition along zones of contrasting crustal thickness (Figure 2).

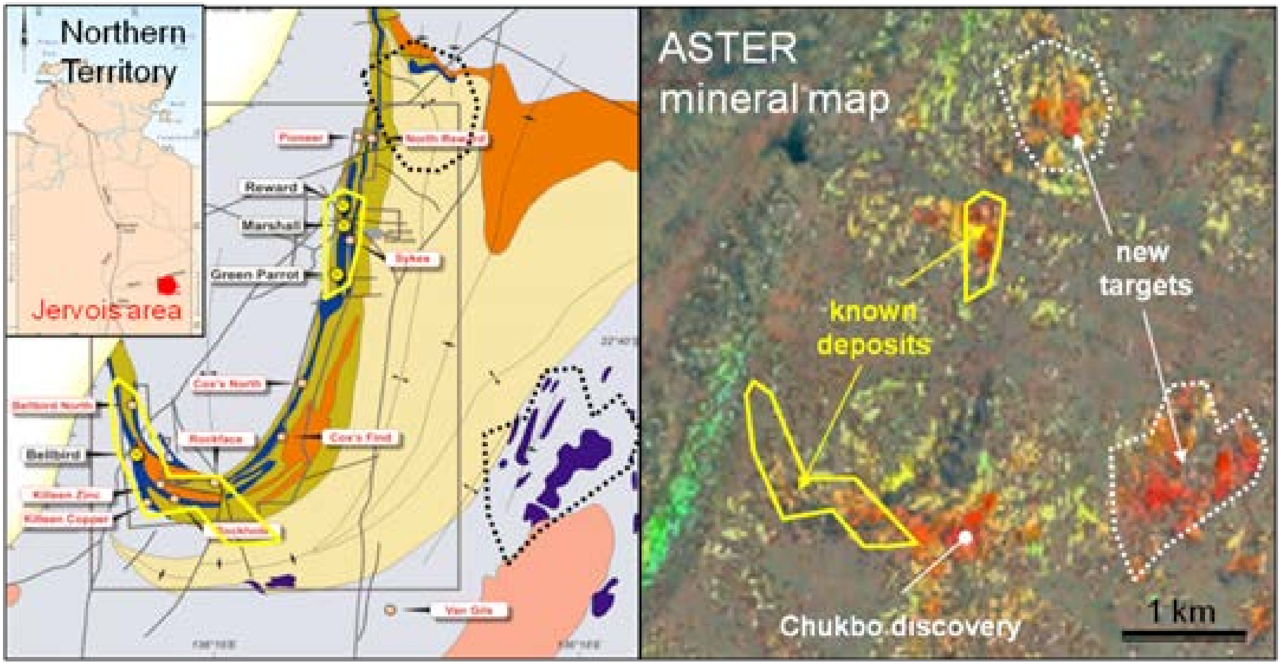


Figure 1: Published (from Kentor Gold) geology and mineral occurrences in the Jervois area, Northern Territory (left); and propyllitic alteration (warmer colours) evident in the ASTER "MgOH" product, which was critical in the discovery of Chukbo (right).

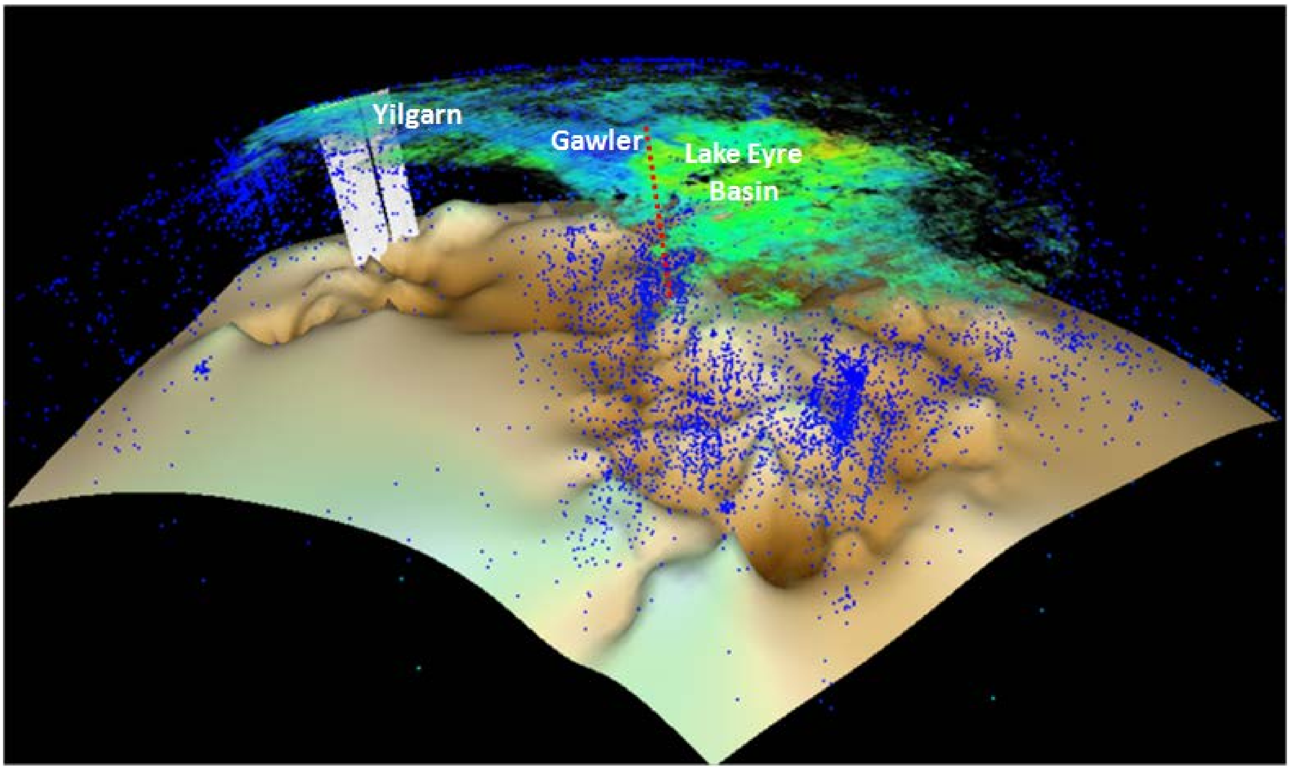


Figure 2: 3D oblique view of the Australian crust that combines the surface clay mineral composition from ASTER (warmer colours are illite-montmorillonite and cooler colours are kaolinite) with the base of crust (MOHO) and seismic activity (blue dots). www.ga.gov.au/data-pubs/interactive-3d-models/world-wind-3d-data-viewer

Environmental Monitoring

The ASTER data archive is currently being tested for environmental monitoring, namely, tracking surface clay loss (indicator for the process of desertification) by measuring the proportion of the sand versus clay size fractions. The results to date (Figure 3) show that ASTER provides superior measurement of this information compared with other standard datasets (e.g. Landsat TM's NDVI, airborne radiometric K, U, Th data) and that there appears to be sufficient resolution with ASTER to track annual changes with a study site in the Lake Eyre basin showing a yearly increase (size and content) of the sand fraction.

Future

The loss of ASTER's full functionality in 2008 means that any future monitoring of similar mineral information will require the launch of new satellites with sensors that have mineral-sensitive SWIR-TIR spectral bands (e.g. NASA's proposed HyspIRI). There also exists a global archive of ASTER imagery from 2000-2008 with approximately six complete coverages of the Earth's land surface that has yet to be processed into standard land surface composition products for which three time slices can be generated.

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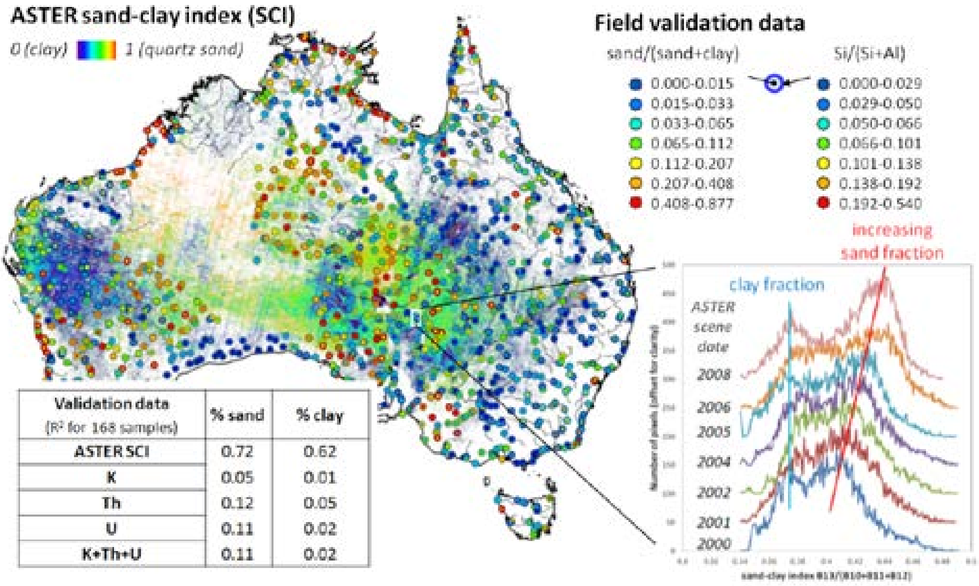
Acknowledgements

Key scientists and organisations involved in creating the Version 1 ASTER geoscience maps of Australia include: Tom Cudahy, Mike Caccetta, Simon Collings, Rob Hewson, Cindy Ong, Ian Lau, Carsten Laukamp, Robert Woodcock (CSIRO); Michael Abrams (NASA-JPL); Dave Meyer, Chris Doescher (USGS); Masatane Kato, Osamu Kashimura (Japan Space Systems); Yasushi Yamaguchi (Nagoya University); Yoshiki Ninomiya (AIST); Matilda Thomas, Michael de Hoog, Patrice de Caritate (Geoscience Australia). Current research on ASTER monitoring of clay loss is part of a collaborative project between CSIRO and the Chinese Academy of Sciences.



Validation data (R^2 for 168 samples)	% sand	% clay
ASTER SCI	0.72	0.62
K	0.05	0.01
Th	0.12	0.05
U	0.11	0.02
K+Th+U	0.11	0.02

Figure 3: ASTER map of the proportion of sand to clay size material (SCI) validated using field sample analyses of particle size and Si and Al geochemistry. The table (bottom left) provides regression statistics for field sample data. Yearly (2000-2008) histograms (bottom right) of the ASTER SCI for an area near Lake Eyre.

CURTIN UNIVERSITY OF TECHNOLOGY

Remote Sensing and Satellite Research Group (RSSRG)

Seasonal surface temperature profiles in Shark Bay

Alan Pearce[1,2] and Marnie Thomsett[1]

AVHRR sea surface temperature (SST) images of Shark Bay show a strong contrast between summer and winter conditions (Figure 4). In winter, the Leeuwin Current flows strongly down the coast along the outer continental shelf, and tongues of the warm tropical water intrude into the Bay where heat loss to the atmosphere leads to strong winter cooling. In summer, on the other hand, the shallow waters in Shark Bay gain heat from the atmosphere and so are warmer than the (now weaker) Leeuwin Current.

To quantify this seasonally reversing temperature gradient, digital SST transects were extracted from a selection of AVHRR SST images to represent monthly conditions across the continental shelf and into Shark Bay. Averaging over a 6 year period, the sharp seasonal rise and fall of the temperature in Shark Bay is evident (Figure 5). Offshore, the Leeuwin Current is warmest as it strengthens in autumn and coolest in spring as it is weakening, and in these two seasons the SST is approximately constant across the shelf and into Shark Bay. In summer, the shallow waters in the eastern part of the Bay warm strongly, while in winter they cool equally dramatically. There is also a phase shift in the timing of the seasonal extremes (Figure 6): offshore, the Leeuwin Current is warmest in April and coolest in September/October, while in the eastern reaches of the Bay the peak temperature occurs in February and the trough is in August.

In consequence, the monthly mean SST in the innermost segment of the Bay peaks at about 28°C in summer and drops to <18°C in winter (Figure 6), an annual range of ~10°C. In the deeper water outside the Bay flushed by the warm Leeuwin Current, the annual range is only 4°C. This is likely to have major implications for the development and survival of the marine life in the Bay.

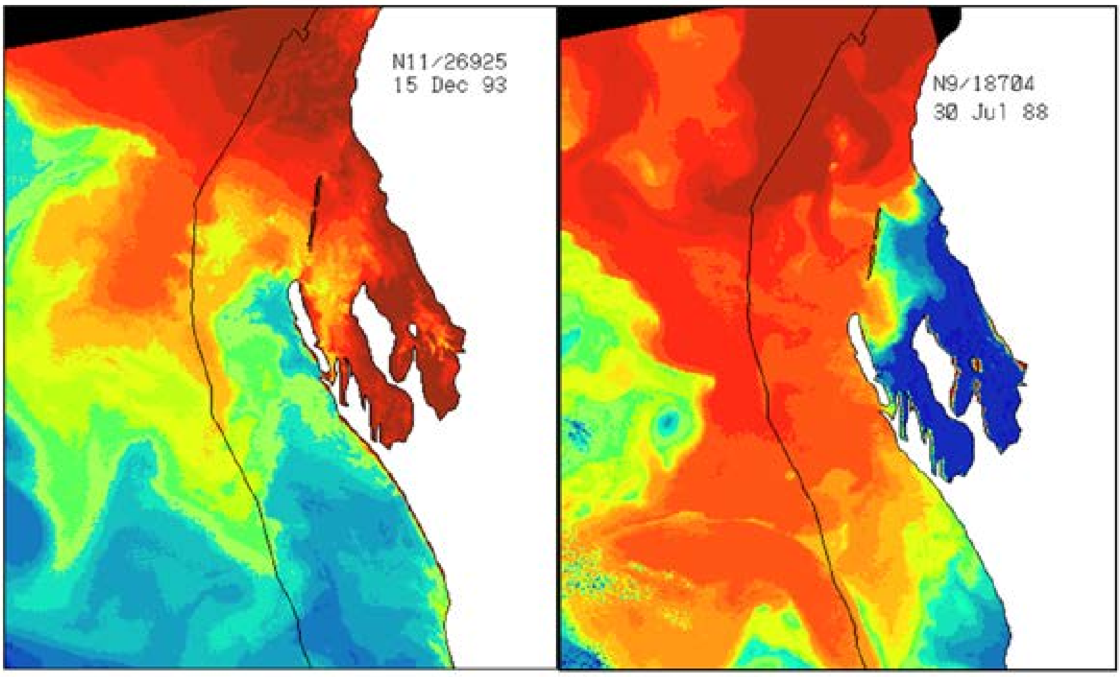


Figure 4: Summer (left) and winter (right) SST images of Shark Bay, showing the relatively cool water in the Bay in winter compared with the warm conditions in summer. The warmest water is shown in red, cooling through yellow and green to the coldest water in blue. The black line marks the edge of the continental shelf. Satellite data courtesy of WASTAC

[1] Curtin University [2] Department of Fisheries

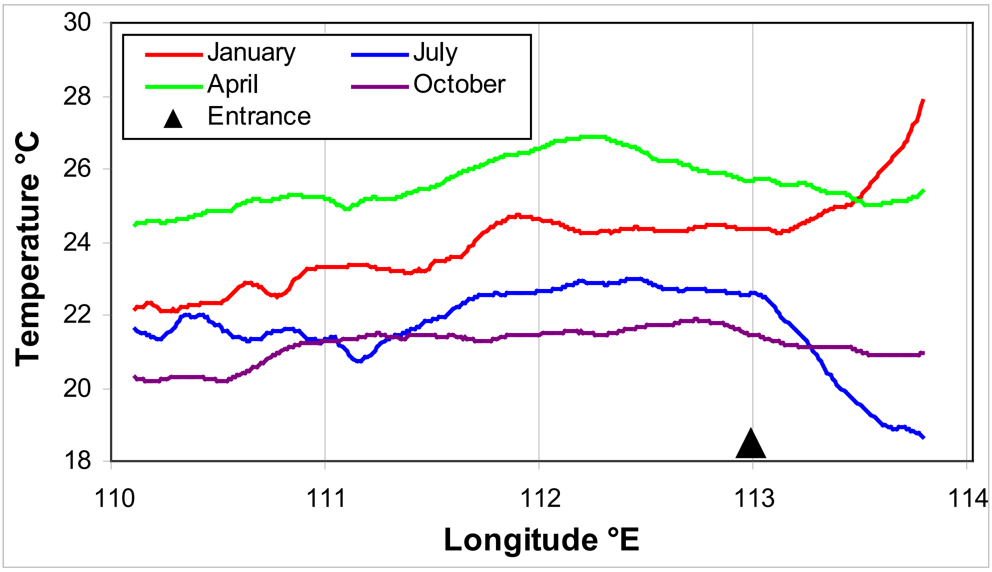


Figure 5: SST transects from offshore into Shark Bay along 25° 20'S for January (a, representing summer, red), April (b, autumn, green), July (c, winter, blue) and October (d, spring, mauve). The entrance to Shark Bay at 113°E is shown by the black triangle.

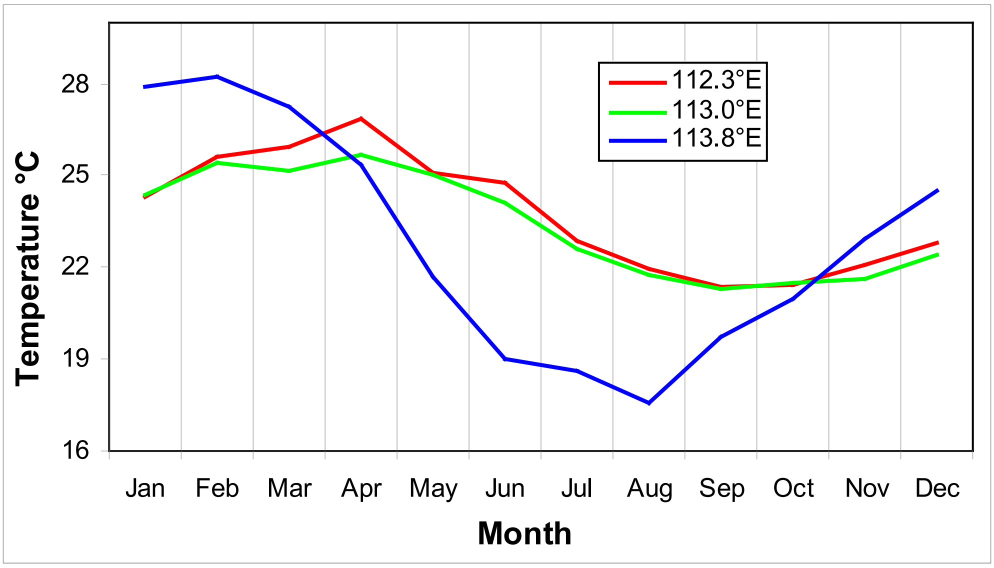


Figure 6: Seasonal SST cycle in the Leeuwin Current outside Shark Bay (red), at the entrance to the Bay (green), and in the shallow eastern part of the Bay (blue).

Acknowledgement: The satellite data were sourced from WASTAC.

MODIS Monitoring of Sediment Plumes

Mark Broomhall, Peter Fearns and Passang Dorji

RSSRG has, in conjunction with the Western Australian Marine Science Institution (WAMSI) dredge node, conducted field trips to the North West region of WA to measure both the concentration and optical properties of dredge plumes associated with dredging. When these *in situ* data are related to the characteristics of a satellite sensor, such as MODIS, the result is a geophysical model to relate the subsurface optical properties of coastal waters to the sediment load within the waters.

Figure 7 shows a set of red and green points, which are for samples taken in October 2013 and June 2014. Each point shows the measured Total Suspended Sediment (TSS) load for a measured remote sensing reflectance (Rrs), which has been altered to match the characteristics of MODIS. It also shows three plots that represent the estimate of TSS for a given Rrs for three models.

The Dorji model has been developed recently at RSSRG and is currently being tested and validated and shows superior performance to the other models being tested.

This model was applied to MODIS imagery captured in the wake of Cyclone Quang, which passed over the North West coast near Exmouth on the 1 May 2015. The result was very large amounts of sediment were either stirred up by the storm surge or deposited from river outflow.

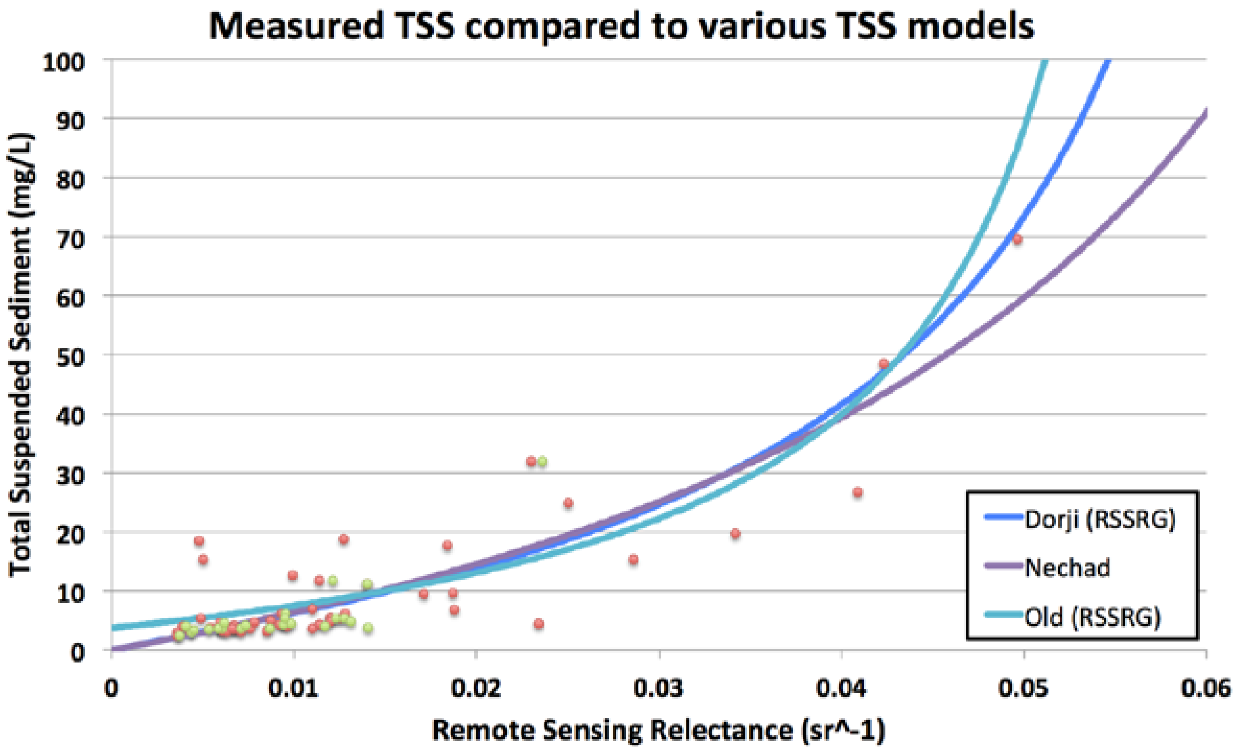
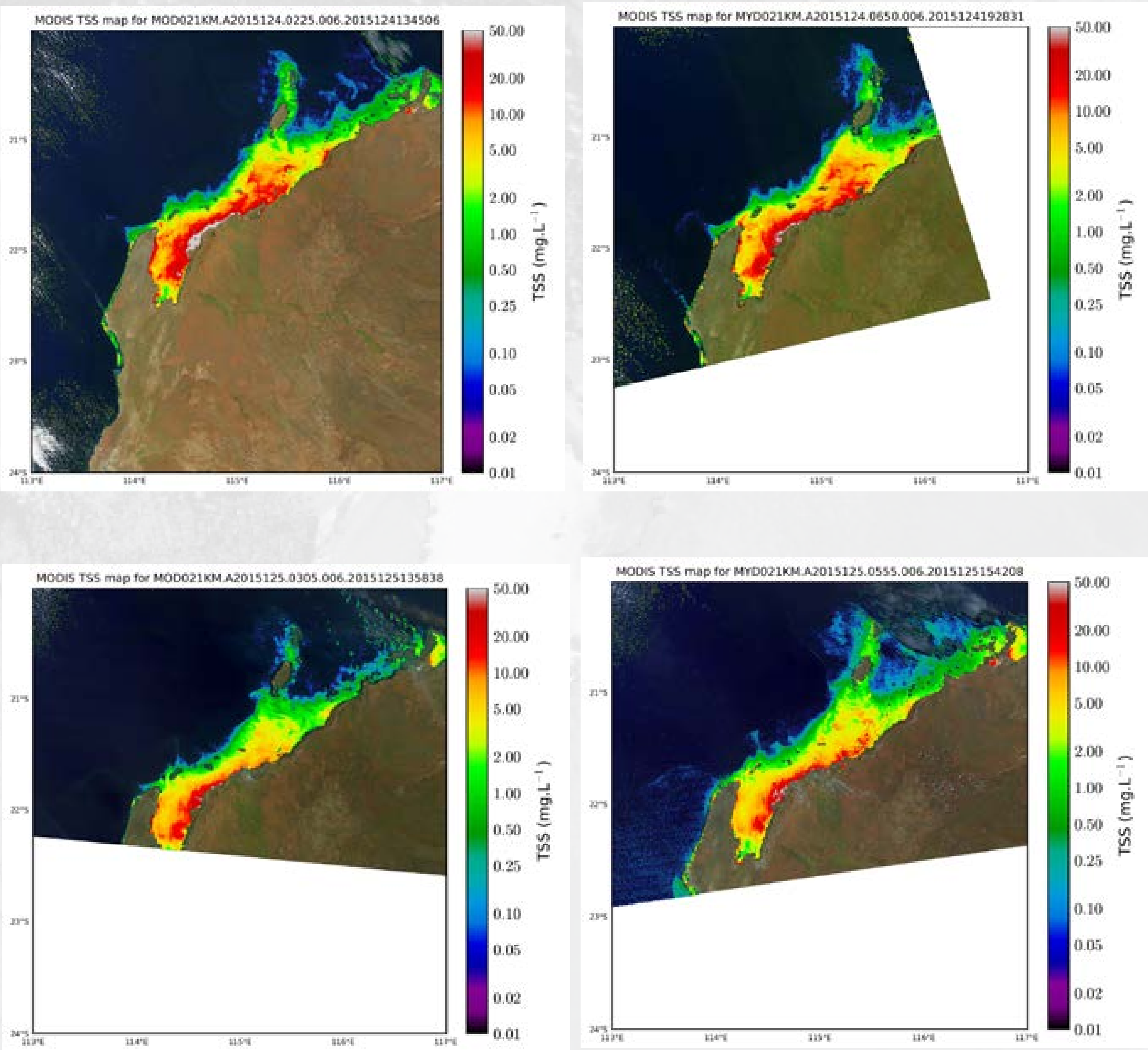
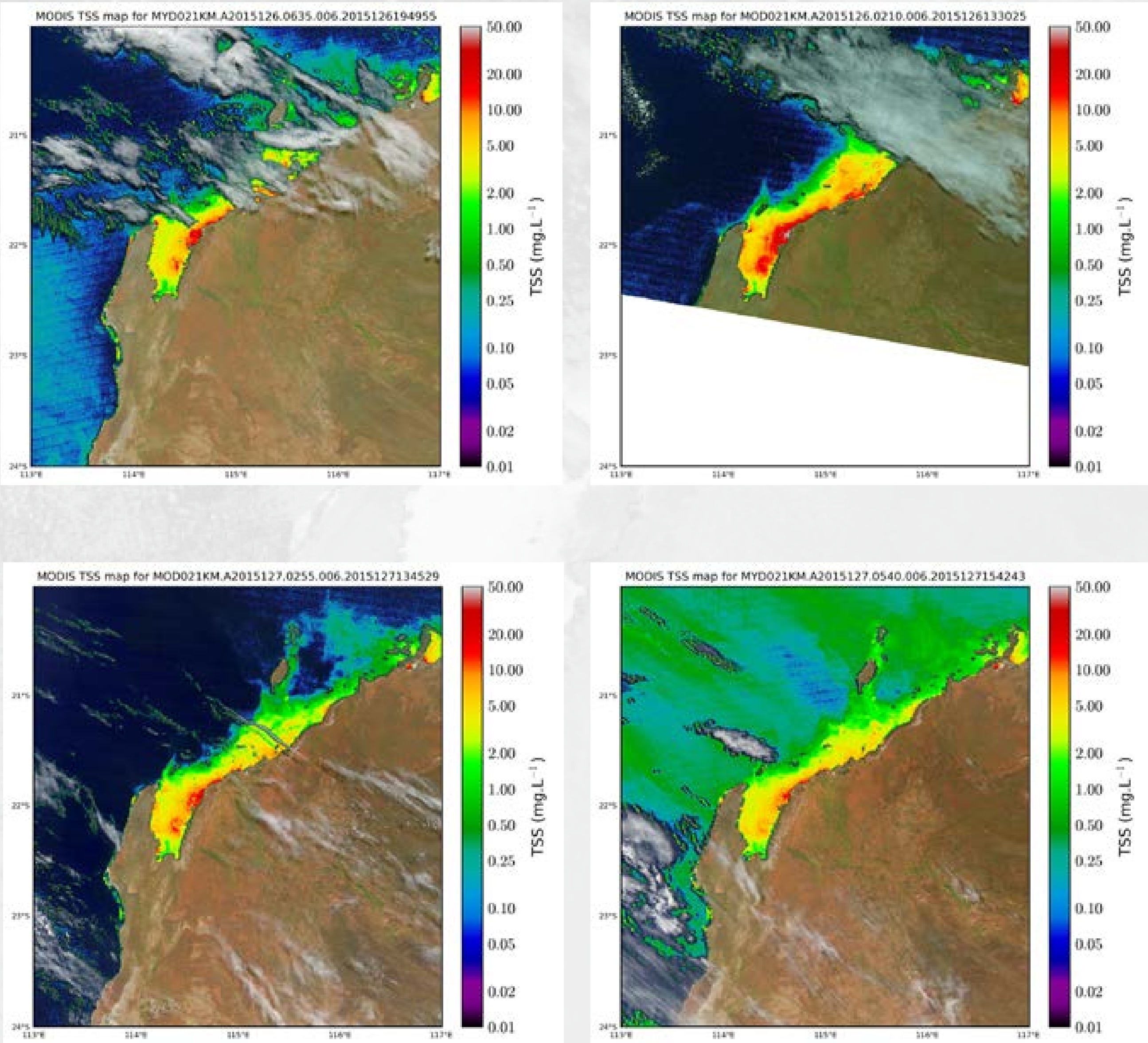


Figure 7: In situ samples compared to various models.

Figure 8 shows 8 TSS maps produced over the period of the 4 to 7 May 2015, one each day for both the Terra and Aqua MODIS instruments. These images show that the heavy coastal plume mostly settles out over the 4-day period. Examination of the satellite data record for other such events may show if the recent dredge program had an effect on the severity or duration of the storm related sediment plume.





Figures 8a-8h: MODIS TSS for both Terra and Aqua over the period of the 4 to 7 May 2015.
The thick coastal plume (grey and red) has settled out over the period.

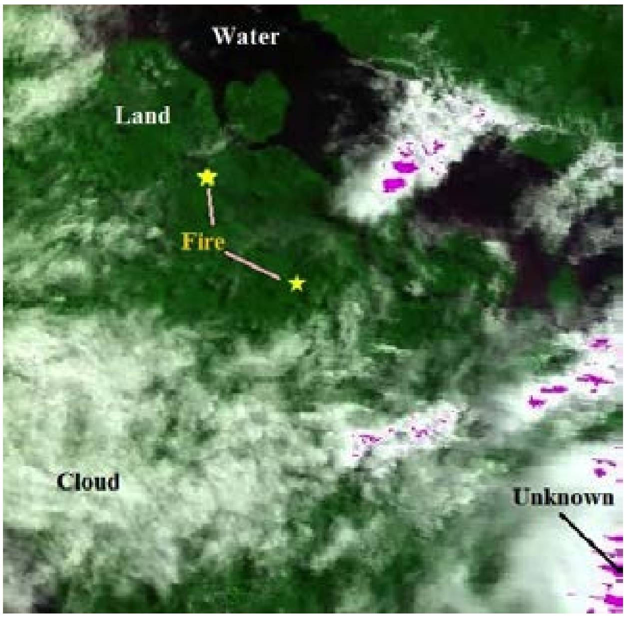
Monitoring fire over Indonesia using MODIS data

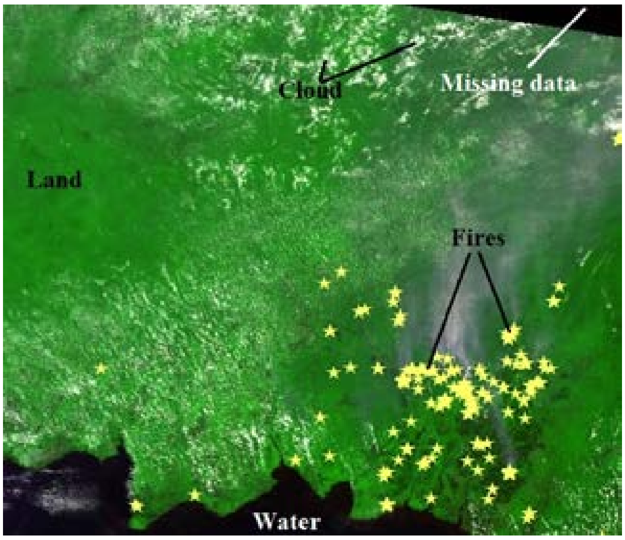
Bowo Eko Cahyono and Peter Fearns

Fire Watch Indonesia (FWI), otherwise known as the IndoFire system, was developed to fulfil the Indonesian government's need for a fire monitoring system as a base system for forest fire control and forest management. This fire monitoring system is used by three authorised agencies for fire monitoring in Indonesia: the Forestry Ministry, the Ministry of Environment, and LAPAN (National Institute of Aeronautics and Space). The IndoFire system was developed in 2007 as a collaborative project between the Indonesian government and the Australian Government, through AusAID and the Western Australian Land Information Authority, Landgate (IndoFire, 2007).

Data from the Indofire system provides early detection of fires, potentially leading to their suppression and minimising their spread. However, the fire detection algorithms are not able to detect fire under cloud cover. Figures 9a and 9b show examples of MODIS Fire Hot Spots (FHS) sub-scenes with FHS indicated. Also shown are image classifications cloud, land, water, missing data, and unknown (algorithm failures).

If one has an interest in seasonal or annual patterns of fire in a region, then correction for fires not observed due to cloud may provide a better representation of temporal patterns. Figure 10 shows the annual fractional cloud cover over Indonesia for the decade 2001 to 2010. Notwithstanding the fact that cloud cover may indicate fire suppressing conditions (rain), we have used the detected FHS numbers and the fractional coverage of cloud to extrapolate the FHS to a "cloud free" value. Figure 11 shows the Indofire FHS monthly data as a solid curve, and the extrapolated cloud free FHS number as a dotted curve.





Figures 9a and 9b: Typical MODIS scenes showing regions classified into fire, land, cloud, water, missing data and unknown (algorithm failure). The fractions of cloud to land cover may be used to extrapolate the number of FHS to a cloud free value.

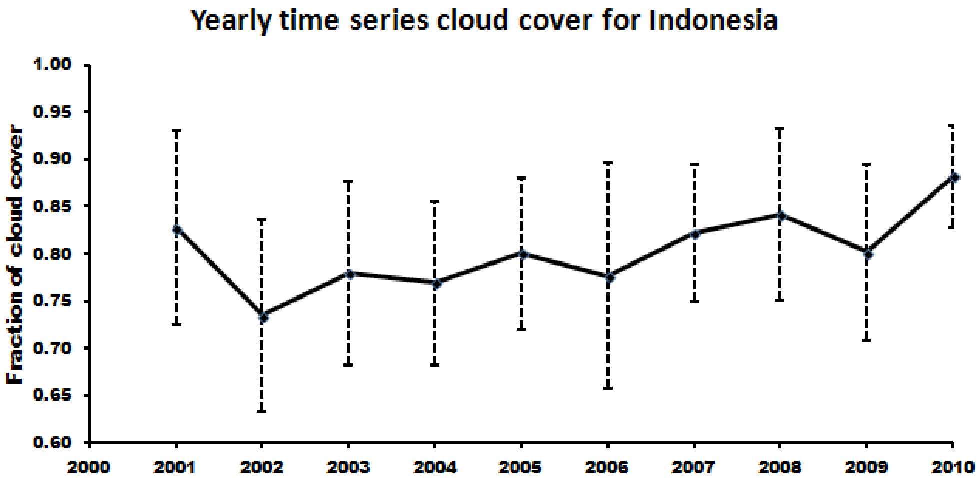


Figure 10: Yearly time series cloud cover for Indonesia (Latitude 6°N to 11°S and Longitude 95°E to 141°E) for the decade 2001-2010. Data are derived from the average monthly cloud cover data every year from Giovanni GES DISC (Goddard Earth Science Data and Information Services Center). Error bars represent the standard deviations of cloud cover for the region selected.

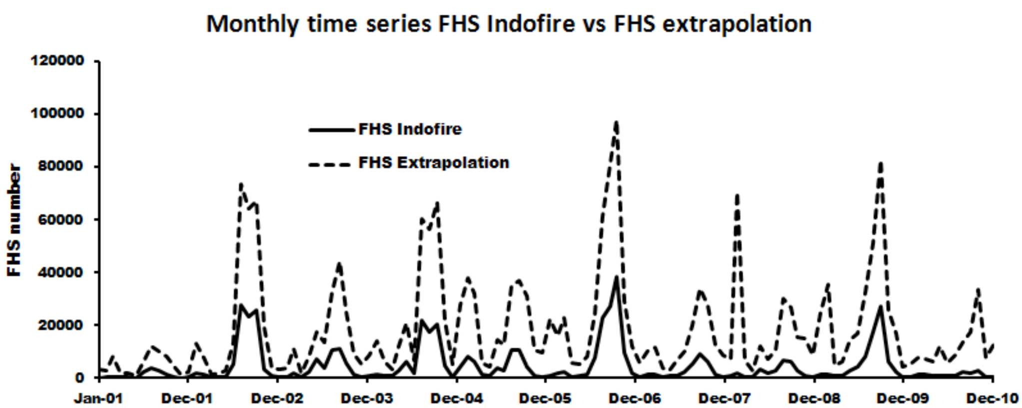


Figure 11: Monthly time series of FHS detected by IndoFire and the extrapolated number of actual fires based on monthly cloud cover data, over Indonesia during the decade 2001-2010.

References

IndoFire. 2007. IndoFire Map Service, Landgate, WA. indofire.landgate.wa.gov.au/indofire.asp. Accessed: 11-04-2011.

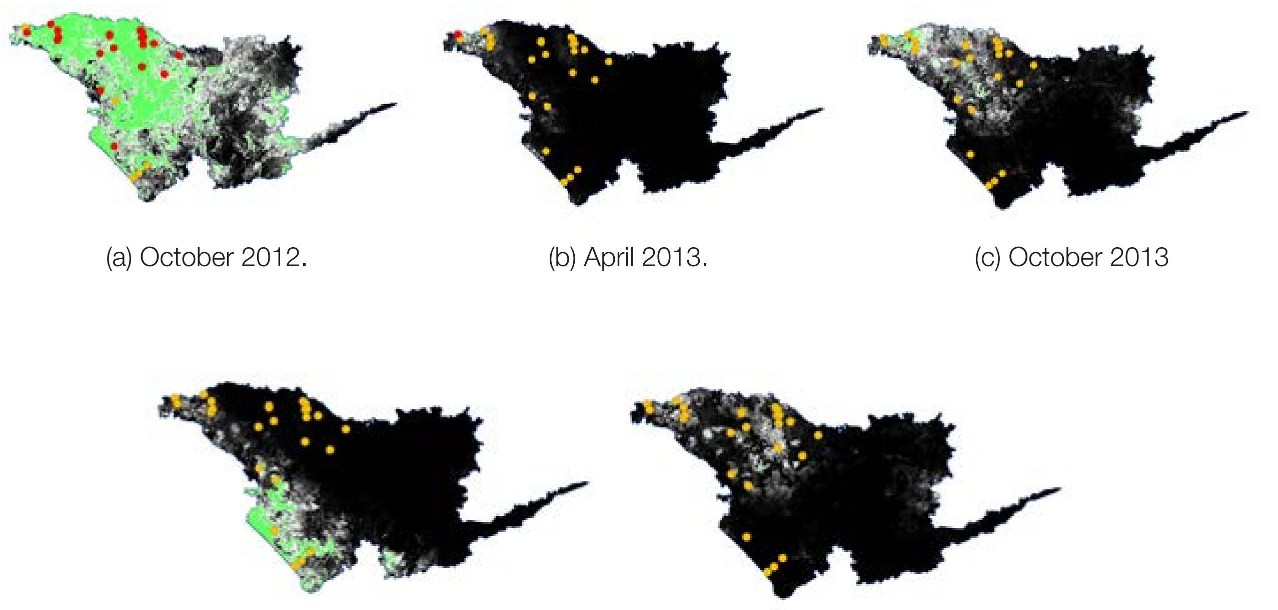
MURDOCH UNIVERSITY

Modelling species distributions in dynamic landscapes: the importance of the temporal dimension

Margaret E. Andrew

A potential source of error in many species distribution models is a temporal mismatch between the species occurrence records and the environmental predictor variables that are used to model habitat relationships. Mismatches arise when environmental variables are either single-time snapshots or temporal averages that poorly represent the conditions actually experienced by a species at the particular time it occurred at that location. Temporal mismatches may be especially problematic in dynamic systems, such as arid and semi-arid environments, where weather patterns and resulting resource pulses are unpredictable in space and time and where, consequently, vagile organisms are often relatively nomadic.

This project modelled the distributions of >30 bird species in the Great Western Woodlands (GWW) of Western Australia. The GWW are of considerable conservation importance regionally and globally: They are the largest remaining intact Mediterranean woodland worldwide and are part of the southwest Australia global biodiversity hotspot. The temporal dimension was added to distribution models with two types of environmental predictor variables: (1) time-specific estimates of gross primary productivity (GPP) and precipitation (aggregated over 1-, 3-, or 6-month periods prior to the survey date), and age of last fire; and (2) estimates of the temporal stability of GPP over the 14-year MODIS archive, providing an index of the degree to which sites might function as refugia from drought, fire, or other disturbances.



(a) October 2012. (b) April 2013. (c) October 2013

(d) April 2014. (e) October 2014.

Figures 12a-e: The inclusion of time-specific environmental variables allows temporal variation in species distributions to be explicitly modelled. (Green: predicted distribution of the black honeyeater; Red Species observations in the modelled season; Yellow: observations at other times)

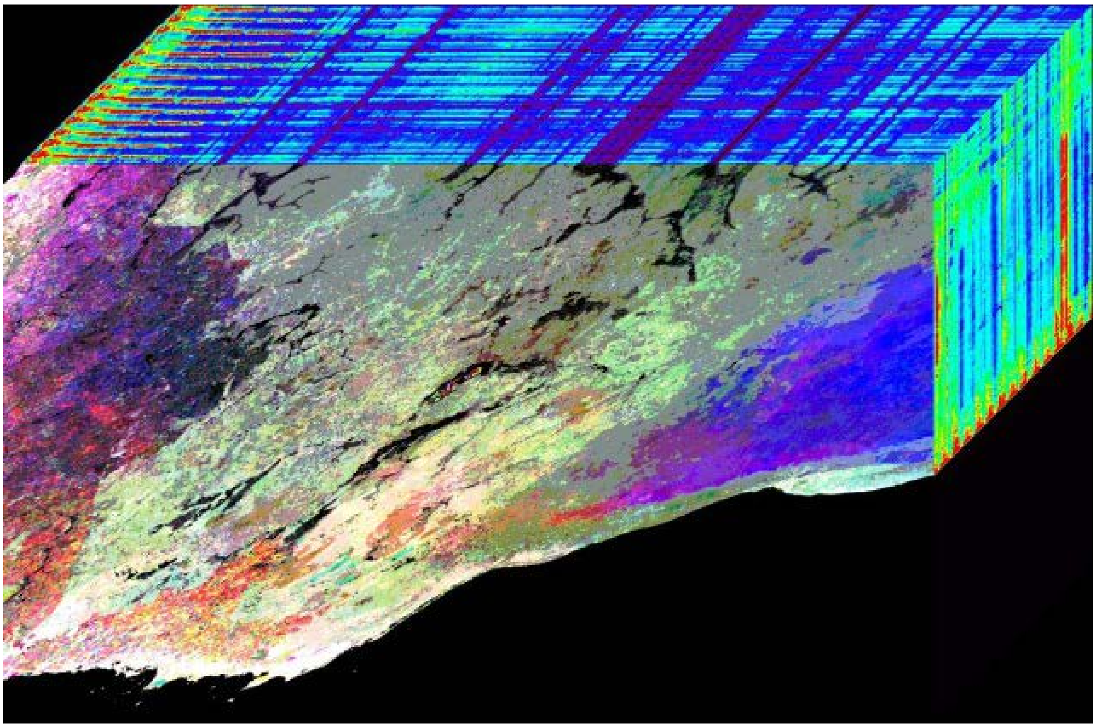


Figure 13: Image cube of monthly MODIS GPP estimates, 2000-2013. The false-colour composite image maps June GPP from 2013 (R), 2012 (G) and 2011 (B).

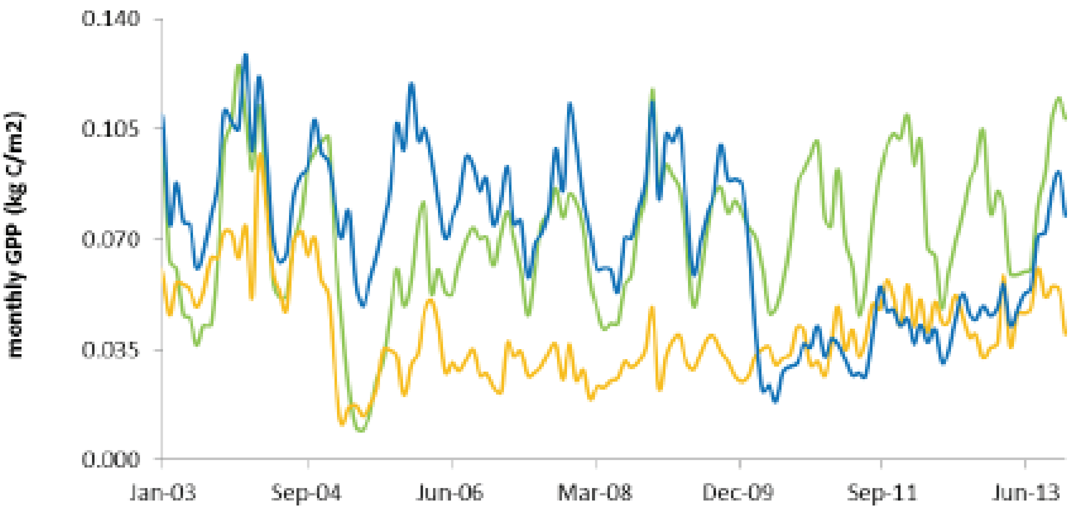


Figure 14: GPP time series from select pixels. Measures of long-term GPP variability, which may indicate habitat refuges, provided valuable information to models of species distributions.

Bilbies in the Basin

Stuart Dawson

Murdoch University, has been studying bilbies from across the Canning Basin, in partnership with Buru Energy Limited. The study is designed to examine the effects of disturbance, both natural, and anthropogenic on bilbies and potential bilby predators. Use has been made of ground surveys of bilby burrows, vegetation surveys, and diet surveys to examine the relationships between bilbies and their predators, in an environment where fire plays a key role as an ecosystem driver. Investigations will also be undertaken to use the access tracks used by bilbies, and possible consequences of non-intense modification of the environment bilbies exist in.

A survey was conducted in partnership with the Yawuru Native Title Holders during July 2014. This survey aimed to map the distribution of bilbies across the Yulleroo region near Broome, in the Kimberley. This joint survey provided a detailed dataset that has increased our understanding of bilby habitat use in the region. In the Yulleroo region, bilbies prefer areas with an open understory and dense overstorey of vegetation. Satellite remote sensing data are being used to extend this analysis, such as using fire scar mapping, Landsat imagery, and surface mineralogy from the ASTER sensor to further our understanding of bilbies preferred habitat.

A further component of the research is examining the effect of fire and other activity on the site occupancy of cats, foxes and dingoes. This study has been completed in an adjacent site to the bilby survey, and aims to understand the interactions of fire and track clearance, and the effects on bilby predators.

INDEPENDENT AUDITORS' REPORT

To The Members of the Board

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION

CONSORTIUM - L BAND

We 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 2014, income statement and cash flow statement for the period ended 31 December 2014 and notes comprising a summary of significant accounting policies and other explanatory information.

Officer's Responsibility for the Financial Report

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

Auditor's Responsibility

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

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

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

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

Auditor Independence

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

Electronic publication of the audited financial report

It is our understanding that the Western Australian Satellite Technology and Application Consortium intends to electronically present the audited financial report and auditor's report on its internet website. Responsibility for the electronic presentation of the financial report on the Western Australian Satellite Technology and Application Consortium website is that of those charged with governance of the Western Australian Satellite Technology and Application Consortium. The security and controls over information on the website should be addressed by the Western Australian Satellite Technology and Application Consortium to maintain the integrity of the data presented. The examination of the controls over the electronic presentation of audited financial report on the Western Australian Satellite Technology and Application Consortium website is beyond the scope of the audit of the financial report.

Opinion

In our opinion, the financial report presents fairly, in all material respects, the financial position of Western Australian Satellite Technology and Application Consortium – L Band as at 31 December 2014 and its financial performance for the period then ended.

Basis of Accounting

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

Santo Casilli CPA

Date: 10 AUGUST 2015

Perth

WASTAC L- Band BUDGET 2014

Estimated expenditure for the year
January 2014 – December 2014

		$ 2013	$ 2014
1.	Data Tapes	0	0
2.	System maintenance/repairs	5000	5000
3.	Telecommunications license of facility	5000	5000
4.	Consultants	5000	5000
5.	Sundry consumables	1500	1500
6.	Traveling – Airfares	3000	3000
7.	Provision for major equipment	12000	12000
8.	Annual Report	6000	6000
	TOTAL:	**$37,500**	**$37,500**

Estimated income/revenue for the year
January 2014– December 2014

1.	Contributions received ($10,000 each)	40000	40000
2.	Interest	10000	14000
	TOTAL INCOME:	**$50,000**	**$54,000**

WESTERN AUSTRALIAN SATELLITE
TECHNOLOGY and APPLICATION CONSORTIUM
L - BAND
INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2014

	2014 $	2013 $
REVENUE		
Contributions Received	40,000	40,000
Interest Received	19,632	14,259
Total Revenue	**59,632**	**54,259**
EXPENDITURE		
Outsourced work	4,250	-
Depreciation Expenses	7,805	7,805
Equipment maintenance	-	7,153
Hospitality	227	-
Microwave License	2,436	2,630
Other operating expenditure	3,737	4,191
Total Expenditure	**18,456**	**21,779**
Net Operating Result for the Year	**41,176**	**32,480**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY and APPLICATION CONSORTIUM
L - BAND
BALANCE SHEET AS AT 31 DECEMBER 2014

	NOTE	2014 $	2013 $
CURRENT ASSETS			
Cash at Bank		449,643	414,661
Prepayments		-	-
Accrued Revenue		-	-
TOTAL CURRENT ASSETS		449,643	414,661
NON - CURRENT ASSETS			
Property, plant and equipment	2	7,130	14,936
TOTAL NON - CURRENT ASSETS		7,130	14,936
TOTAL ASSETS		**456,773**	**429,596**
CURRENT LIABILITIES			
Income received in advance		-	10,000
Accrued Expenses		-	4,000
TOTAL CURRENT LIABILITIES		-	14,000
TOTAL LIABILITIES		**-**	**14,000**
NET ASSETS		**456,773**	**415,596**
EQUITY			
Retained Funds	4	456,773	415,596
TOTAL EQUITY		**456,773**	**415,596**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM
L - BAND
CASH FLOW STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2014

	Note	2014	2013
CASH FLOWS FROM OPERATING ACTIVITIES		**$**	**$**
Receipts			
Contributions Received:			
Department of Land Information		10,000	10,000
CSIRO		-	20,000
Bureau of Meteorology		10,000	10,000
Curtin University of Technology		10,000	20,000
Interest Received		19,632	14,259
Other Receipt			3,800
Total Receipts		49,632	78,059
Payments			
Payments to suppliers		(14,651)	(9,974)
Total Payments		(14,651)	(9,974)
Net cash provided by operating activities	3	**34,981**	**68,085**
CASH FLOWS FROM INVESTING ACTIVITIES			
Payments for property, plant and equipment		-	-
Net cash used in investing activities		**-**	**-**
Net increase/(decrease) in cash		**34,981**	**68,085**
Cash at the beginning of the year		414,661	346,576
Cash at the end of the year		**449,643**	**414,661**

NOTES:

1 Summary of Significant Accounting Policies

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

Basis of Preparation

The Western Australian Satellite Technology and Application Consortium (WASTAC) L Band financial report is a special purpose financial report has been prepared in accordance with Australian Accounting Standards including Australian Accounting Interpretations, other authoritative pronouncements of the Australian Accounting Standards Board and Urgent Issues Group Consensus Views.

Compliance with AIFRS

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, less subsequent depreciation and impairment losses. Cost includes expenditure that is directly attributable to the acquisition of the items. Subsequent costs are included in the asset carrying amount or recognised as a separate asset, as appropriate, only when it is probable that future economic benefits associated with the item will flow to the entity and the cost of the item can be measured reliably.

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

(b) Depreciation of non-current assets

All property, plant and equipment having a limited useful life are depreciated over their estimated useful lives, in a manner which reflects the consumption of their future economic benefits.

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

- Computing equipment 3 years
- Other equipment 8 years

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

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

(c) Impairment of property, plant and equipment

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

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

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

(d) Income Tax

The Board considers that its operations are exempt from income tax under the provisions of section

50-25 of the Income Tax Assessment Act (1997) as amended.

(e) Goods and Services Tax (GST)

Revenues, expenses and assets are recognised net of the amount of GST, except where the amount of

GST is not recoverable from the Australian Taxation Office. In these circumstances the GST is recognised

as part of the cost of acquisition of the asset or as part of an item of the expense.

(f) Income Recognition

The Board recognises income as it is received. All income is stated net of the amount of goods and services tax (GST).

Interest is recognised on the effective interest rate method.

2 Property, Plant and Equipment

	2014	2013
Computer Equipment		
At cost	35,196	35,196
Accumulated depreciation	(35,196)	(35,196)
	-	-
Other Equipment		
At cost	202,441	202,441
Accumulated depreciation	(195,310)	(187,505)
	7,130	14,936
Total Property, Plant and Equipment	**7,130**	**14,936**

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	-	14,936	14,936
Additions	-	-	-
Depreciation expense	-	(7,805)	(7,805)
Carrying amount at end of year	**-**	**7,130**	**7,130**

3 Notes to the Cash Flow Statement

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

	2014	2013
Net operating result	41,176	32,480
Depreciation expense	7,805	7,805
Movement in Current Assets & Liabilities	(14,000)	27,800
Net cash provided by operating activities	**34,981**	**68,085**

4 Retained Earnings

	2014	2013
Balance at beginning of the year	415,596	383,116
Operating surplus/(deficit) for the year	41,176	32,480
Balance at end of the year	**456,773**	**415,596**

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Santo Casilli Accounting and Auditing Services is a CPA Practice

INDEPENDENT AUDITORS' REPORT

To The Members of the Board

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM - X BAND

We 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 2014, income statement and cash flow statement for the period ended 31 December 2014 and notes comprising a summary of significant accounting policies and other explanatory information.

Officer's Responsibility for the Financial Report

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

Auditor's Responsibility

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

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

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

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

Auditor Independence

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

Electronic publication of the audited financial report

It is our understanding that the Western Australian Satellite Technology and Application Consortium intends to electronically present the audited financial report and auditor's report on its internet website. Responsibility for the electronic presentation of the financial report on the Western Australian Satellite Technology and Application Consortium website is that of those charged with governance of the Western Australian Satellite Technology and Application Consortium. The security and controls over information on the website should be addressed by the Western Australian Satellite Technology and Application Consortium to maintain the integrity of the data presented. The examination of the controls over the electronic presentation of audited financial report on the Western Australian Satellite Technology and Application Consortium website is beyond the scope of the audit of the financial report.

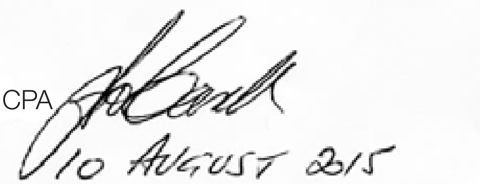
Opinion

In our opinion, the financial report presents fairly, in all material respects, the financial position of Western Australian Satellite Technology and Application Consortium – X Band as at 31 December 2014 and its financial performance for the period then ended.

Basis of Accounting

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

Santo Casilli CPA



Date:

Perth

WASTAC X- Band BUDGET 2014

Estimated expenditure for the year
January 2014 – December 2014

		$ 2013	$ 2014
1.	Data Tapes	2,000	2,000
2.	System maintenance	23,000	30,000
3.	System repairs	4,000	4,000
4.	Consultants, product development	120,000	120,000
5.	Sundry consumables	2,000	2,000
6.	Travelling – Airfares	4,000	4,000
7.	Provision for major equipment	25,000	25,000
	TOTAL:	**$180,000**	**$187,000**

Estimated income/revenue for the year
January 2014 – December 2014

1.	Annual Contributions $20,000 each	80,000	80,000
2.	Interest	25,000	25,000
	TOTAL INCOME:	**$105,000**	**$105,000**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM
X - BAND
INCOME STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2014

	2014 $	2013 $
REVENUE		
Contributions Received	80,000	80,000
Interest Received	29,676	21,529
TOTAL REVENUE	109,676	101,529
EXPENDITURE		
Freight Expenses	-	113
Equipment < $5000	-	-
Other Software & Licence <$5,000	2,406	9,707
Maintenance	-	-
Outsourced Work	8,295	
Depreciation	23,709	22,911
TOTAL EXPENDITURE	34,410	32,731
NET OPERATING RESULT FOR THE YEAR	**75,266**	**68,798**

**WESTERN AUSTRALIAN SATELLITE
TECHNOLOGY AND APPLICATION CONSORTIUM
X - BAND
BALANCE SHEET AS AT
31 DECEMBER 2014**

	NOTE	2014 $	2013 $
CURRENT ASSETS			
Cash at bank		638,730	632,524
TOTAL CURRENT ASSETS		638,730	632,524
NON-CURRENT ASSETS			
Property, plant and equipment	2	120,188	71,128
TOTAL NON-CURRENT ASSETS		120,188	71,128
TOTAL ASSETS		**758,918**	**703,652**
CURRENT LIABILITIES			
Income received in advance		-	20,000
TOTAL CURRENT LIABILITIES		-	20,000
TOTAL LIABILITIES		**-**	**20,000**
NET ASSETS		**758,918**	**683,652**
EQUITY			
Retained Funds	4	758,918	683,652
TOTAL EQUITY		**758,918**	**683,652**

WESTERN AUSTRALIAN SATELLITE TECHNOLOGY AND APPLICATION CONSORTIUM
X - BAND
CASH FLOW STATEMENT FOR THE YEAR ENDED 31 DECEMBER 2014

	NOTE	2014 $	2013 $
Receipts			
Contributions Received:			
Landgate		20,000	20,000
CSIRO		-	40,000
Bureau of Meteorology		20,000	20,000
Geoscience Australia		20,000	20,000
Interest Received		29,676	21,529
Total Receipts		89,676	121,529
Payments			
Payments to suppliers		(10,701)	(9,820)
Total Payments		(10,701)	(9,820)
Net cash provided/(Used) by operating activities	3	**78,975**	**111,709**
CASH FLOWS FROM INVESTING ACTIVITIES			
Payments for property, plant and equipment		(72,769)	-
Net cash used in investing activities		**(72,769)**	**-**
Net increase/(decrease) in cash		**6,206**	**111,709**
Cash at the beginning of the year		632,524	520,815
Cash at the end of the year		**638,730**	**632,524**

NOTES:

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

Basis of Preparation
The Western Australian Satellite Technology and Application Consortium (WASTAC) X Band financial report is a special purpose financial report has been prepared in accordance with Australian Accounting Standards including Australian Accounting Interpretations, other authoritative pronouncements of the Australian Accounting Standards Board and Urgent Issues Group Consensus Views.

Compliance with AIFRS
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, less subsequent depreciation and impairment losses. Cost includes expenditure that is directly attributable to the acquisition of the items. Subsequent costs are included in the asset carrying amount or recognised as a separate asset, as appropriate, only when it is probable that future economic benefits associated with the item will flow to the entity and the cost of the item can be measured reliably.
Any gains and losses on disposals are determined by comparing the disposal proceeds with the carrying amount and are included in the Income Statement.

(b) **Depreciation of non-current assets**
All property, plant and equipment having a limited useful life are depreciated over their estimated useful lives, in a
manner which reflects the consumption of their future economic benefits.

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

- Computing equipment 3 years
- Other equipment 8 years

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

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

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

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

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

(d) Income Tax

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

(e) Goods and Services Tax (GST)

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

(f) Income Recognition

The Board recognises income as it is received. All income is stated net of the amount of goods and services tax (GST). Interest is recognised on the effective interest rate method.

2 Property, Plant and Equipment

	2014	2013
Computer Equipment		
At cost	26,224	26,224
Accumulated depreciation	(26,224)	(24,852)
	-	1,372
Other Equipment		
Equipment		
At cost	852,918	866,833
Accumulated depreciation	(732,730)	(797,076)
	120,188	69,757
Total Property, Plant and Equipment	**120,188**	**71,128**

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	1,372	69,757	71,129
Additions/(Disposals)	-	72,768	72,768
Depreciation expense	(1,372)	(22,337)	(23,709)
Carrying amount at end of year	**-**	**120,188**	**120,188**

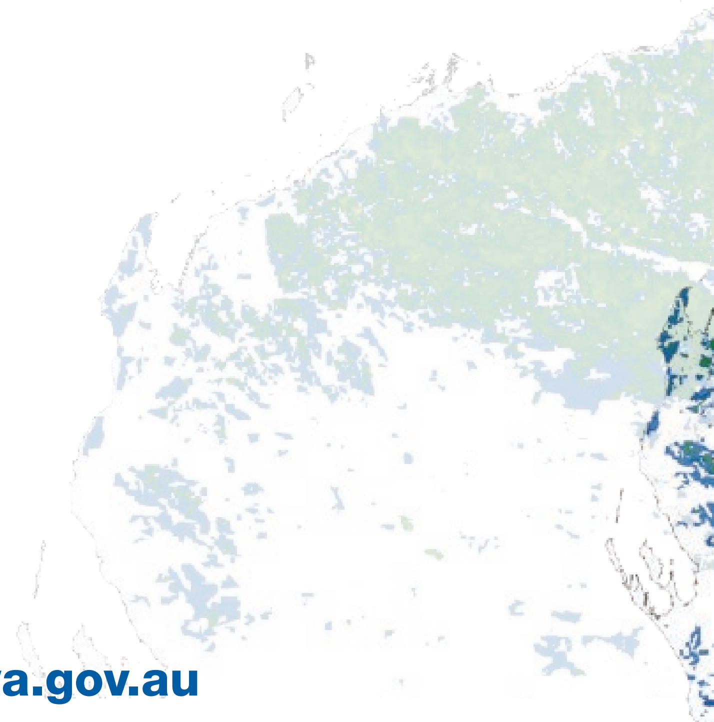
3 Notes to the Cash Flow Statement

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

	2014	2013
Net operating result	75,266	68,798
Depreciation expense	23,709	22,911
Movement in Current Assets & Liability	(20,000)	20,000
Net cash provided/(used) by operating activities	**78,975**	**111,709**

4 Retained Earnings

Balance at beginning of the year	683,652	614,854
Operating surplus/(deficit) for the year	75,266	68,798
Balance at end of the year	**758,918**	**683,652**



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