Research & Operational Applications

Research and Operational Applications

CSIRO

Remote sensing of the Leeuwin Current

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CSIRO Marine Research

Sea levels and ocean temperatures off Western Australia reached record levels during 1999, closely linked with El Nino/Southern Oscillation (ENSO) events. The Southern Oscillation Index (SOI) is derived from the atmospheric pressure difference between Tahiti (in the South Pacific Ocean) and Darwin, and is a measure of the "see-sawing" of the atmospheric pressure between the Pacific and Indian Oceans. During ENSO events, the Pacific Ocean atmospheric pressure is lower than that in the Indian Ocean, leading to a negative SOI. The longest ENSO period of this century occurred between 1990 and 1994 (Figure 1), and in 1997/98 we experienced one of the most intense ENSO events ever. This was followed by an intense La Nina (the opposite phase of ENSO, with high atmospheric pressures in the Pacific Ocean and therefore positive SOIs) in late 1998 and 1999.

Monthly averaged coastal sealevels off Western Australia can be used as an approximate "index" of the strength of the Leeuwin Current, the dominant southward-flowing current off our state, with high sealevels reflecting a relatively strong current. Sealevels tend to be lower during ENSO periods (Figure 1), indicating a weakening of the flow during El Nino periods and generally cooler ocean waters offshore. One consequence of these ENSO events is poorer settlement of rock lobster larvae in the coastal reefs and hence greatly reduced lobster catches 3 to 4 years later, and there are implications for other commercial fisheries as well.

As is evident from Figure 1, sea-surface temperatures (SSTs) off Perth in the autumn of 1999 were the highest of this decade, and indeed the highest since the satellite data became available in 1982. The anomalies were almost 2˚C higher than average in April/May/June, and both commercial and recreational fishermen reported anomalously warm water at many places along the west coast during the early part of the year. Temperatures off the Abrolhos Islands were particularly high, reaching 27˚C in the warmest part of the Leeuwin Current just west of the Islands (Figure 2). A cross-shelf SST transect (Figure 3) showed that the temperature peaked at almost 28˚C, and there was a remarkable 4˚C temperature change across the outer boundary of the Current.

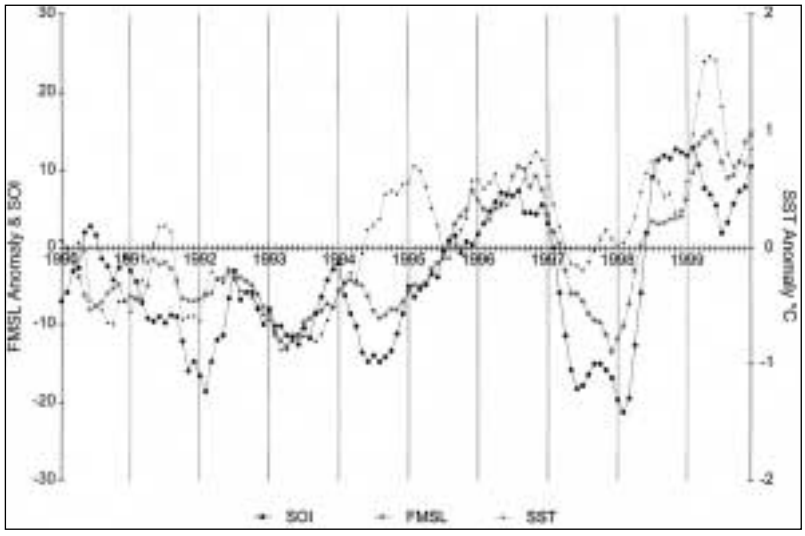

Figure 1: Monthly anomalies of sea-surface temperature (SST - small dots), Fremantle sealevel (FMSL - asterisks) and the Southern Oscillation Index (SOI - large dots) for the decade of the 1990s. The ocean temperatures are from the Reynolds satellite-derived dataset (supplemented with surface measurements), while the sealevel data are courtesy of The National Tidal Facility, Flinders University of South Australia, copyright reserved. The anomalies have been calculated by subtracting the mean annual cycle from the individual monthly sealevels and temperatures, and all the data have been smoothed by a 5-month moving average to better illustrate the trends.

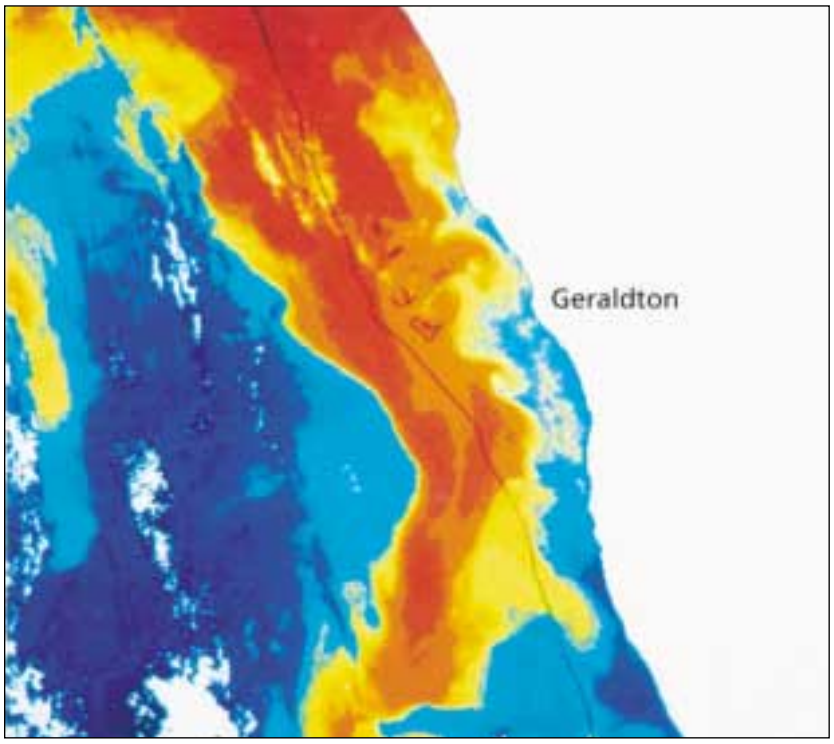

Figure 2: NOAA Advanced Very High Resolution Radiometer (AVHRR) satellite image of the Leeuwin Current (in red) off the Abrolhos Islands on 7th April 1999. The patchy white areas are clouds and the black line marks the approximate edge of the continental shelf.

Figure 3: Sea-surface temperature transects across the Leeuwin Current just south of the Abrolhos Islands on 7th April 1999 (see Figure 2). The larger dots are from the McMillin and Crosby SST algorithm, and the smaller dots from the Non-Linear SST.

NOAA imagery is also being used to assist in the oceanographic interpretation of taylor and herring larval distributions sampled during a cruise by the FRV Flinders off Rottnest by Fisheries WA in May 1999 (Figure 4). Tongues of warm Leeuwin Current water (red) are seen penetrating shorewards across the shelf and engulfing Rottnest Island; the cooler coastal water is shown in blue.

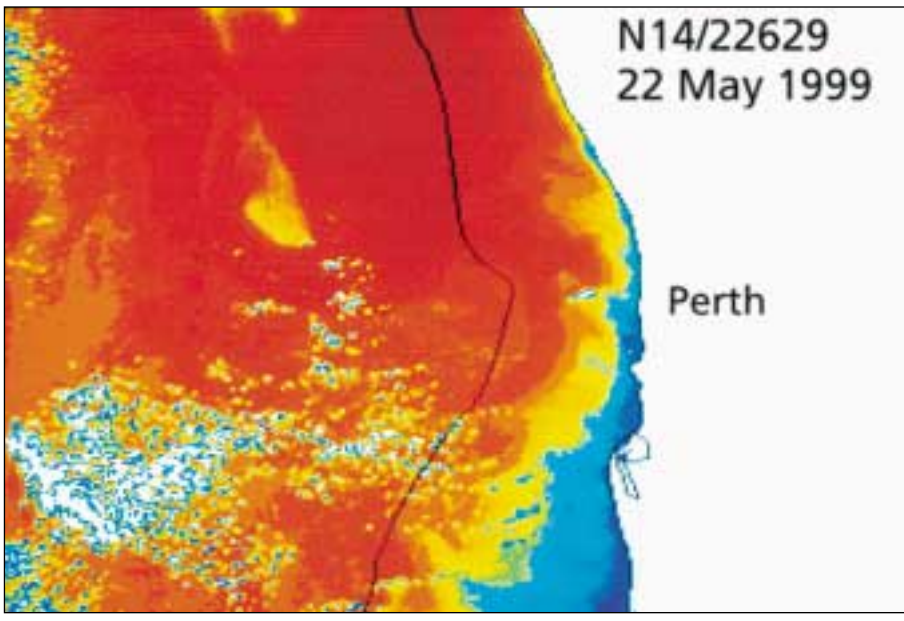

Figure 4: NOAA/AVHRR image of the Leeuwin Current off Rottnest Island on 22nd May 1999, during a Fisheries WA cruise sampling larval fish across the continental shelf. The small patchy blue/white areas are clouds and the black line marks the approximate edge of the continental shelf.

Validation of NOAA/AVHRR sea-surface temperatures (SSTs)

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The surface temperature measurements taken during the 2-year series of Hillarys Transects are being used in validation of SSTs derived from the NOAA-14 AVHRR. The measurements encompassed the full width of the continental shelf off Perth and in all seasons. Excluding the few obvious "outliers" (which were probably due to undetected cloud), the correlation coefficient between the two sets of measurements was 0.945 (Figure 5), with a satellite-bucket bias of 0.19˚C and an RMS difference of 0.58˚C, very comparable with some earlier measurements off Perth in the mid-1980s using the NOAA-7 and NOAA-9 satellites. About 65% of the differences were less than ±0.5˚C and 88% within ±1˚C.

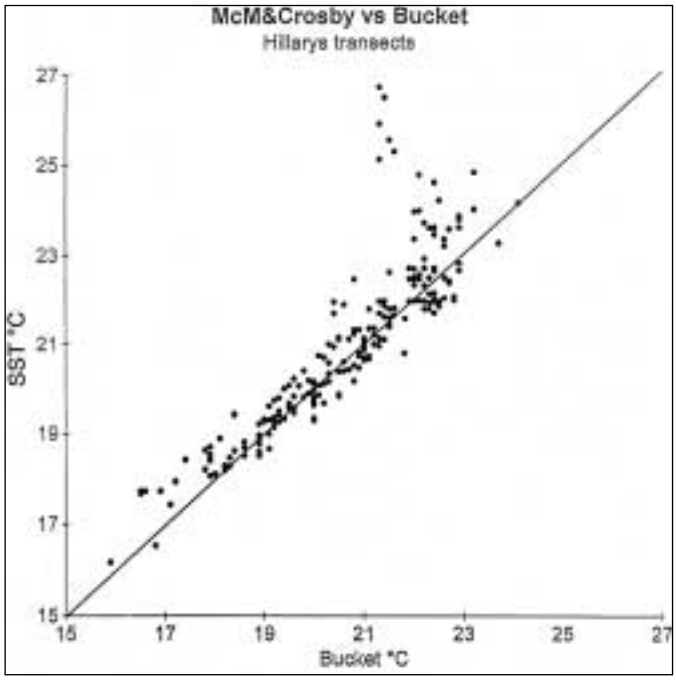

Figure 5: Comparison of SSTs derived from the NOAA-14 AVHRR against surface ("bucket") temperatures during the Hillarys transects 1996 to 1998, using the McMillin and Crosby algorithm.

CURTIN UNIVERSITY OF TECHNOLOGY

Compiled by M J Lynch
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SeaWiFS Monitoring of Perth Marine Parks: the Hillarys Cruise Validation Program*

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Data from the ocean colour satellite SeaWiFS is being applied to assessing its value in monitoring of the water quality of Perth's marine parks. This initiative, if successful, has the capacity to expand to monitor other WA marine reserves and also coastal zones designated as multiple use regions. The present three year program is monitoring the seasonal and interannual change in the marine parks primarily using the ocean colour data. Use is also being made of sea surface temperature data (SST) from the NOAA/AVHRR sensor series. The prime variable delivered by SeaWiFS is the chlorophyll a (Chl a) loading in the water column. This variable, if measured over time, may be used to assess the primary productivity of the marine park waters. Of particular interest to the study is the determination

from imagery of the relative importance of the inherent productivity of the marine parks and how this responds to changes in the larger scale environment. For example, the transport of productive waters both into and out of the park might be an important process. Specifically, the role of the Leeuwin Current, the nutrient and sediment load from the Swan River and the possible impact of the inshore northward flowing extension of the Capes Current are all factors that can impact the water quality in the marine parks and, accordingly, these will be investigated in the current study.

* This project is funded under a grant from the Coasts and Clean Seas Program of the Natural Heritage Trust and sponsored with in-kind support from the WA Department of Land Administration (DOLA) and the WA Department of Conservation and Land Management (CALM). The principal investigators acknowledge the contribution of numerous graduate students from Curtin University of Technology to data collection activities during the cruise program.

SeaWiFS Algorithm Development

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Normalised water-leaving spectral radiance is the quantity from which the concentrations of the optically active pigments in the water column are retrieved. There are several numerical procedures adopted to achieve this end. For example, regression of radiometric observations against measured in-water constituent concentrations has been used frequently to obtain a suitable algorithm. Neural networks are another approach. In this project a Monte Carlo model has been developed which relates the water-leaving radiance to the concentration of various in-water pigments. While computationally demanding, this approach has the advantage that it may be used diagnostically to gain insights into appropriate approaches to use in the retrieval process. It also directly indicated the sensitivity of the spectral radiances to various pigment concentrations. Further, it can assist in analysing the source of retrieval errors. A focus of the present effort is establishing the sensitivity of Chl a retrieval to 'yellow stuff' or coloured dissolved organic matter for the SeaWiFS spectral bands. An extension of the work will use the Monte Carlo model (i) to improve our understanding of the information content in hyperspectral ocean colour data and (ii) to investigate algorithms for discrimination of pigments, pigment concentration retrieval and quantitative assessment of suspended sediment load.

The Australian Ocean Colour Atlas

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An overview of the temporal and spatial variability of Chl a in Australian oceanic waters may be assessed using data from the SeaWiFS sensors. In particular, this project sets out to determine the seasonal variability in Chl a production for the year 1998. To this end 9 km resolution Level 3 archive ocean colour data were used. These weekly composites of Chl a were averaged for the the year 1998 to obtain a mean concentration. Next the weekly fields were differenced from the mean on a pixel-by-pixel basis to yield a variance and hence a standard deviation. The final product, again determined on a pixel-by-pixel basis, was the Chl a standard deviation normalised by the annual mean. These products were produced for the Australian EEZ and identified as an Australian Ocean Colour Atlas.

Ocean productivity in the South Western Pacific Ocean

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This project was initiated in an attempt to establish the spatial and temporal variability of waters in the South Western Pacific as part of classifying regions as high medium and low variance over the annual cycle. The interest in assessing this approach to classification arose in terms of using such information to identify regions for further investigation as possible marine reserves. An overview of the temporal and spatial variability of Chl a in the SW Pacific oceanic waters was assessed using data from the SeaWiFS sensors. In particular, this project sets out to assess the seasonal variability in Chl a production for the year 1998. To this end 9 km resolution Level 3 archive ocean colour data were used. These weekly composites of Chl a were averaged for the year 1998 to obtain a mean concentration. These weekly fields were subsequently differenced from the mean on a pixel-by-pixel basis to yield a variance and hence a standard deviation. The final product, again determined on a pixel-by-pixel basis, was the Chl a standard deviation normalised by the annual mean. These products are presently being assessed in terms of their value in the marine reserve identification.

The Productivity of the Abrolhos Archipelago

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The Abrolhos Islands are an important habitat for many marine species. This region is the centre of the Western Australian rock lobster industry and as such an improved understanding of the seasonal and interannual bioproductivity of the region are important. In particular, on the larger scale, coastal dynamics are complicated by what appears to be the change in direction of the mean flow along the coast between summer and winter. This project processed SeaWiFS imagery for the year 1998 for the majority of the cloud free days and then examined the time sequences of imagery to identify the temporal and spatial behaviour over the annual cycle. On the smaller scale, the Islands and the associated regional bathymetry appear to be important factors in controlling the flushing or throughflow of coastal waters. There is evidence of depleted and relatively low productivity waters essentially stagnating in the region between the Island and the coast. Also, we see evidence of the summertime northward flowing inshore current being turned south at the Abrolhos Islands. Despite these dynamical processes, the region appears to be relatively high in productivity and this clearly relates to its role as a coastal habitat.

A study of the productivity of the region continues. It is intended that several of the above hypotheses will be tested further by combining ocean colour data from SeaWiFS with ocean temperature data (sea surface temperature from NOAA AVHRR) and ocean current information (from Topex / Poseidon).

Water Quality and the WA Pearling Industry

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Ocean colour data from SeaWiFS has been applied to a study of several NW coastal regions adjacent to areas used by the pearling industry. In particular, the productivity over the annual cycle, as measured by chlorophyll a concentration derived from SeaWiFS, and the presence of sediments were of interest. High sediment loads are a significant source of mortality to pearl farming and to this end the sediment outflow from a number of river systems was also investigated with respect to the temporal nature of the flow and the destination of the sediments along the coastal system.

This study was supported by a Neville Stanley Studentship and co-sponsored by M G Kailis Pty Ltd.

Coral Spawning

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It is now well known that 1998/1999 was possibly the most severe ocean warming event on record. Not only did the event impact every ocean basin, but the magnitude of the warming and the depth to which the oceans warmed were unprecedented. The Maldives in the western Indian Ocean island states and the Great Barrier Reef were just two areas where recent research has revealed the extent impact. The long term destruction of corals, due to what is termed coral bleaching, finally resulting in death of the coral reefs has been extensively documented with bleaching frequently reaching in excess of 90% and extending down to 30 metre depth. In this research we endeavoured to study the spawning of the coral reefs located at Rowley Shoals off the NW shelf. Our hypothesis was that if coral reefs were severely damaged their ability to reproduce during subsequent spawning cycles would be severely impacted. The approach adopted was to use data from SeaWiFS to observe the activity in the waters surrounding the reefs before, during and subsequent to the spawning period. The coral in this region are known to be coloured an intense reddish-pink due to the reflectance of the plenulae during the spawning period. SeawiFS has a spectral band in the red spectral region at 670 nm and one might expect to see evidence of spawning as an enhanced signal in this band. Preliminary conclusions suggest that during March-April of 1998 spawning was not detected using the techniques we employed. Several explanations are possible. In particular, perhaps the corals did not spawn or their spawning was time delayed or diminished during this period because the impact of the warming event on coral bleaching was still in progress. Alternatively, the technique we applied was not sufficiently sensitive to detect the event, particularly if it was weaker than usual. It is unfortunate that direct on-site evidence of the dates and extent of the spawning at Rowley Shoals has not been available. Further research will examine 1999 and 2000 data to both refine the techniques employed and to attempt to establish if the coral recovery is in progress as evidenced by an increased vigour of the spawning events.

The Productivity of Indonesian Oceans

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The bioproductivity of Indonesian waters is characterised by a wide range of productivity regimes and water quality. Studying the bioproductivity from space sensors has significant advantage over ship access given the large extent and complexity and, in some regions, the difficulty of access with reasonable frequency. The initial effort on this project involved an overview of the annual productivity cycle using the level 3, 9 km resolution SeaWiFS chlorophyll product from the NASA DAAC. This enabled (i) regions to be characterised by their productivity and the phase of the productivity cycle, (ii) priority areas for more detailed study to be identified and (iii) cruise planning for in-situ sampling of the biological constituents to proceed. During the latter part of 1999 Umi Zakiyah undertook field campaigns comprising (i) a cruise program in the Makassar Straits on an Indonesian oceanographic research vessel Baruna Jaya VIII# and (ii) in Bali Strait in cooperation with staff of the Hang Tuah University (Surabaya) using ships of opportunity. In part the field program was intended to achieve a characterisation of water quality (type I and II) and also to provide in-situ validation for SeaWiFS measured chlorophyll and water attenuation coefficients. Presently, the analysis of these data sets is in progress. The products from the cruise will be compared with the same products derived from SeaWiFS 1 km archive data from both Perth (WASTAC) and the Singapore SeaWiFS ground stations.

+AusAID Scholar from University of Brawaijaya, Malang, Indonesia.
The Baruna Jaya VIII is operated by the R&D Centre of Oceanography, Jakarta and their coperation with this research project is acknowledged.

Atmospheric Aerosols Optical Depth and Correction to Ocean Colour

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The so-called atmospheric correction to satellite-detected radiances involved accounting for the effect of the scattering and absorption of the molecular aerosol constituents in the atmosphere. The molecular component is well handled because it is of analytical form. The aerosol component is more complex because it is dependent on the type of aerosol and its physical and chemical characteristics and the resulting optical scattering properties. This particular project determines the aerosol optical depth (AOD) as measured by SeaWiFS and compares it to the equivalent product measured by a solar photometer# located at Rottnest Island. The comparison essentially is a validation of the SeaWiFS aerosol product. As part of this research the SeaWiFS aerosol product is inverted to yield an aerosol size distribution. The solar photometer multi-wavelength AODs may be inverted to yield an aerosol size distribution and these two products compared.

*Postdoctoral Fellow at Curtin University supported by the Ministry of Education, Japan.
The solar photometer was acquired with the support of a grant from FRDC

Atmospheric Aerosols over the Oceans

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Ideally, the estimation of atmospheric aerosol optical thickness is best made using a solar photometer that uses the change with time of day of the air mass through which the instrument views the sun as it tracks the sun's position in the sky throughout the day. Over the oceans it is more difficult to utilise solar photometer since frequently suitable sites are not available - the eastern Indian Ocean and the Southern Ocean south of the Australian continent being prime examples. An alternative is to use data from visible sensing instruments on satellites. The AVHRR instrument on the NOAA series of satellites has been used for many years to monitor the aerosol optical thickness on a global scale. More recently, SeaWiFS has performed this role as part of correcting ocean colour imagery for the quite large atmospheric effects. With satellite measurements formulations need to be made to account for the effect of multiple scattering of photons by the earth's atmosphere. In the current project these corrections, which include both single and multiple scattering, have been applied to AVHRR data and are being validated using solar photometer data from the Cape Grim Baseline Air Pollution Station (Tasmania) and a solar photometer located at a

Rottnest Island field station operated by Curtin University of Technology. In year 2000 the Rottnest Station will become part of the NASA AERONET solar photometer global network and will use a Cimel solar photometer provided by NASA GSFC.

Broome, Alice Springs and Hay Satellite Validation Sites

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* CSIRO Atmospheric Research, Aspendale, Victoria

Curtin has benefitted greatly from a collaboration with CSIRO Atmospheric Research in establishing and utilising data from satellite data validation sites at three locations across the Australian continent. These sites are at Uardry Station, Hay (NSW), Amburla Station, Alice Springs (NT) and Thangoo Station, Broome (WA). The locations of these stations are characterised by quite different regimes both climatically and with respect to the soil and vegetative cover. A range of in-situ measurements are continuously monitored and archived at these sites. These typically include wind speed, wind direction, air temperature and humidity (at 2 metre) , in-situ land surface temperature, radiometric land surface temperature, sky brightness temperature, downwelling and upwelling longwave and shortwave radiation and aerosol optical thickness. Data from these sites have been and are currently being used to validate a number of different geophysical products from satellites that include NOAA/AVHRR, SeaWiFS, GMS, ATSR2 and in the near future MODIS and ASTER.

This project is supported by NASA JPL (Pasadena, CA, USA) and the CSIRO Earth Observation Centre, Canberra.

DEPARTMENT OF LAND ADMINISTRATION (DOLA)

Sea Surface Temperature (SST)

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Satellite Remote Sensing Services, Department of Land Administration

SRSS and CSIRO Marine Research continued their collaborative project producing Sea Surface Temperature images for the WA fishing industry. During the year 384 separate SST images were produced for clients. These clients included other government departments like Fisheries WA and also commercial fisherman from Perth, Fremantle, Albany, Dongara, Geraldton and Tasmania. Several images were also provided to an oil company.

Late in 1999 DOLA started developing an E-commerce web site on which SST images (under the guise of “Fishing Hotspots”) could be purchased (Figure 1). Clients will be able to purchase images 24 hours a day using a credit card at a much cheaper rate than is currently possible. As a community service SST images and a current interpretation were placed on the SRSS web site for the Naturaliste Game and Sports Fishing Club.

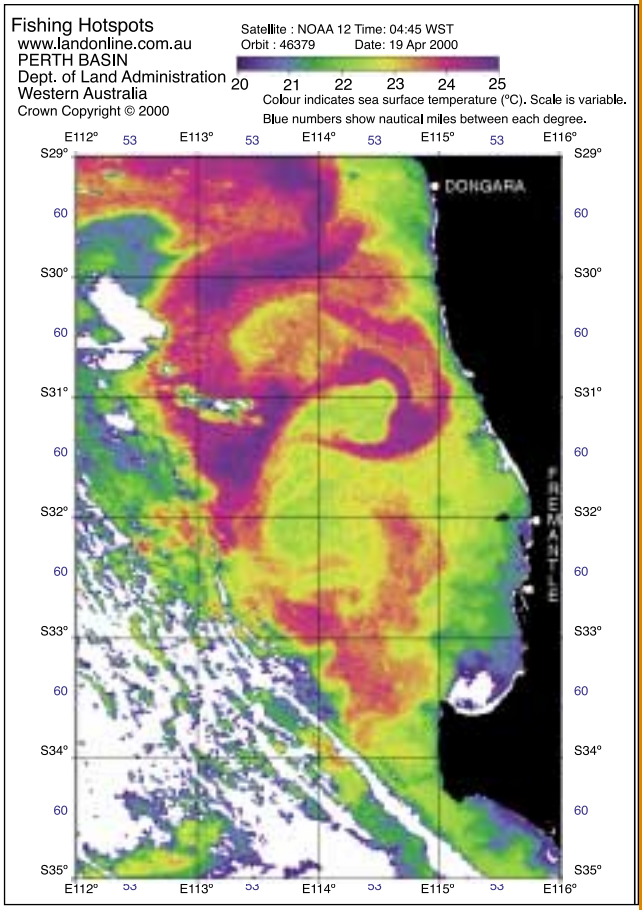

Figure 1. Sea Surface Temperature image derived from NOAA 12 46379 dated 19/04/2000.

Vegetation Watch

J Adams and R Shaw
Satellite Remote Sensing Services, Department of Land Administration

The vegetation watch project involves producing NDVI composite images of Western Australia during the first and second halves of each month. The best cloud free composite of each month is then distributed to the following state government agencies either by hard copy or on DOLA's web page:-

11 Agriculture WA metro and regional offices
9 Fire and Emergency Services Agency offices
5 Department of Conservation and Land Management metro and regional offices
1 Conservation Commission office in NT
1 Bureau of Meteorology office
2 Shire of Norseman offices

Each office receives hard copy sub scenes of their area of interest along with local government or pastoral boundaries embedded into their image. Over a period of time these images verify the vegetation changes that have occurred during the various seasons and past years, making them ideal for large scale land management monitoring. The state composite can be viewed on our web site at: http://www.rss.dola.wa.gov.au/ndvi_archive_new/index.html

Frost Images

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Satellite Remote Sensing Services, Department of Land Administration

In October, SRSS was asked by Agriculture WA to provide land surface temperature images on mornings when frosts occurred across the wheatbelt. The three days when the temperature was at its lowest were on the 16th and 17th of September and 2nd of October (Figure 2). The images showed that temperatures in many sections of the agricultural region were dropping below 0˚ Celsius.

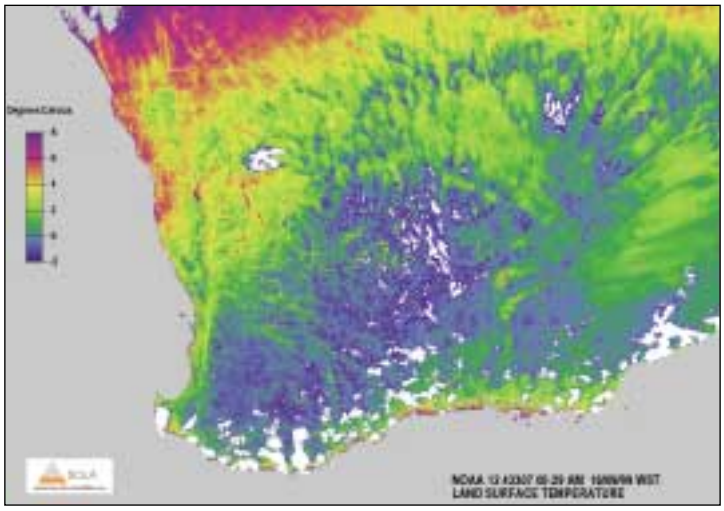


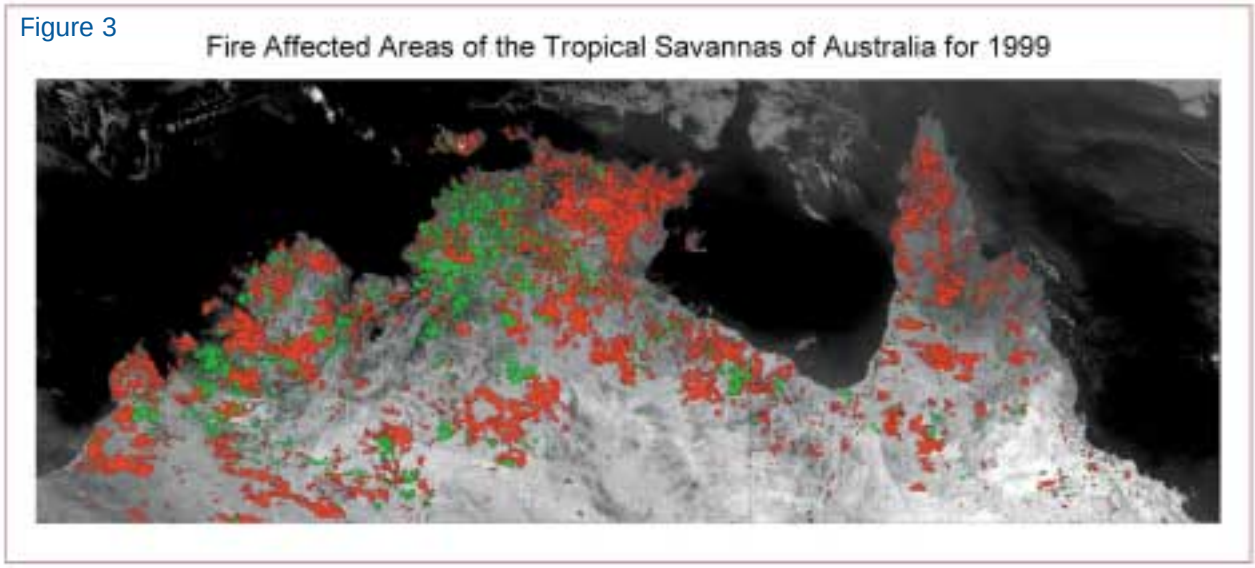
Figure 2. Land Surface Temperature image derived from NOAA 12 43307 dated 16/09/1999.

Continental Mapping of Fires across Australia

R Craig et al.
Satellite Remote Sensing Services, Department of Land Administration

The mapping of fire hotspots (Figure 4) and fire affected areas (Figure 3) across the continent has continued through 1999. The data sets are being created to satisfy the requirements of the national State of the Environment reporting. The collection of data has been extended a further twelve months to June 2000.

Figure 3

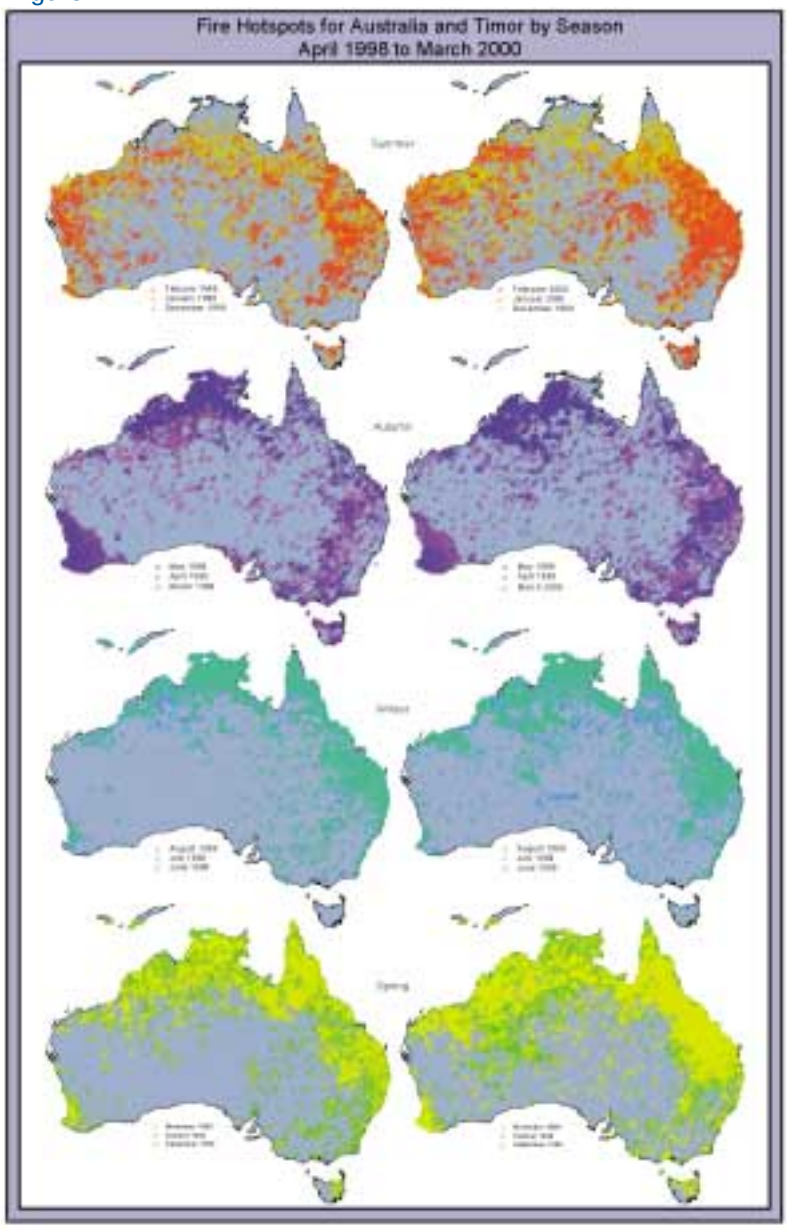


Fire hot spots are mapped from night-time NOAA 12 and 15 satellite passes on a daily basis. The presence of a hot spot is determined from observing the temperatures detected in channels 3 and 5 of the AVHRR instrument on board the NOAA satellites. The process to produce the hot spots is automatic and creates a web page plot and listing.

The fire affected areas are mapped manually every nine days from the daytime NOAA 14 satellite passes. As the AVHRR sensor has a ground resolution of about 1 kilometre, small or strip fires may be missed. The results of this mapping are also presented as vector files and images on DOLA's web pages.

The data from both of the above processes are ingested into an Arcview Geographic Information System (G.I.S.) for further analysis. The previously mapped fire affected areas for Western Australia have also been ingested. The results of various G.I.S. queries can be displayed and plotted out. Some examples include a multi-year fire burn history over requested areas and time since last burn, or fuel age. Further products will be generated including fire seasonality, from the density and time of fire hot spot occurrences.

Figure 4



NOAA-AVHRR night thermal data for groundwater detection in palaeodrainages

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Satellite Remote Sensing Services, Department of Land Administration

The north eastern goldfields district of Western Australia is host to a system of ancient rivers which may or may not be visible at the surface. In places the drainages contain water which is an important resource to the active mining industry in this arid region. These water bearing palaeodrainages may be amenable to detection by thermal sensors as they can be cooler at the surface relative to the surrounding terrain.

For the purpose of supplying water to mining operations in the region an area 100x150km centred on Mulgabbie (120°E,30'30"S) was selected for analysis by thermal sensing. NOAA-AVHRR night thermal (Band4) was complemented with Landsat7 (ETM) day thermal and visible/IR data to aid interpretation of vegetation, current drainage, topography and geology .

The results of the study are best explained by examining the accompanying images (Figures 5-7) for the presence/absence of thermal features suggesting evidence of water bearing palaeodrainages.

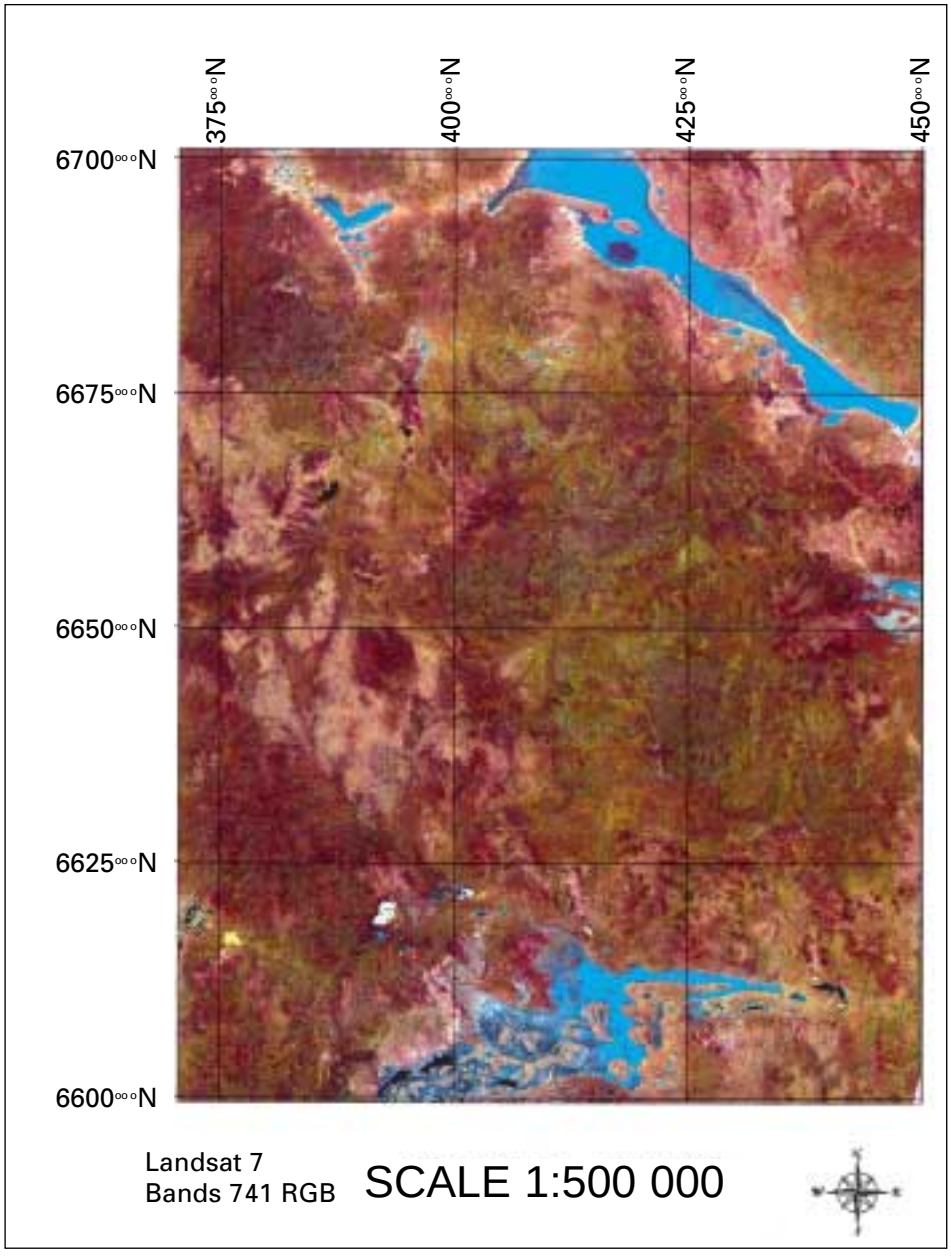

Figure 5: Landsat 7 (ETM) Bands 7,4,1 (RGB).
Image date : October 3, 1999. Major palaeodrainage axes display as blue, areas devoid of vegetation as shades of brown and red and vegetation as green. Current drainage patterns are clearly visible.

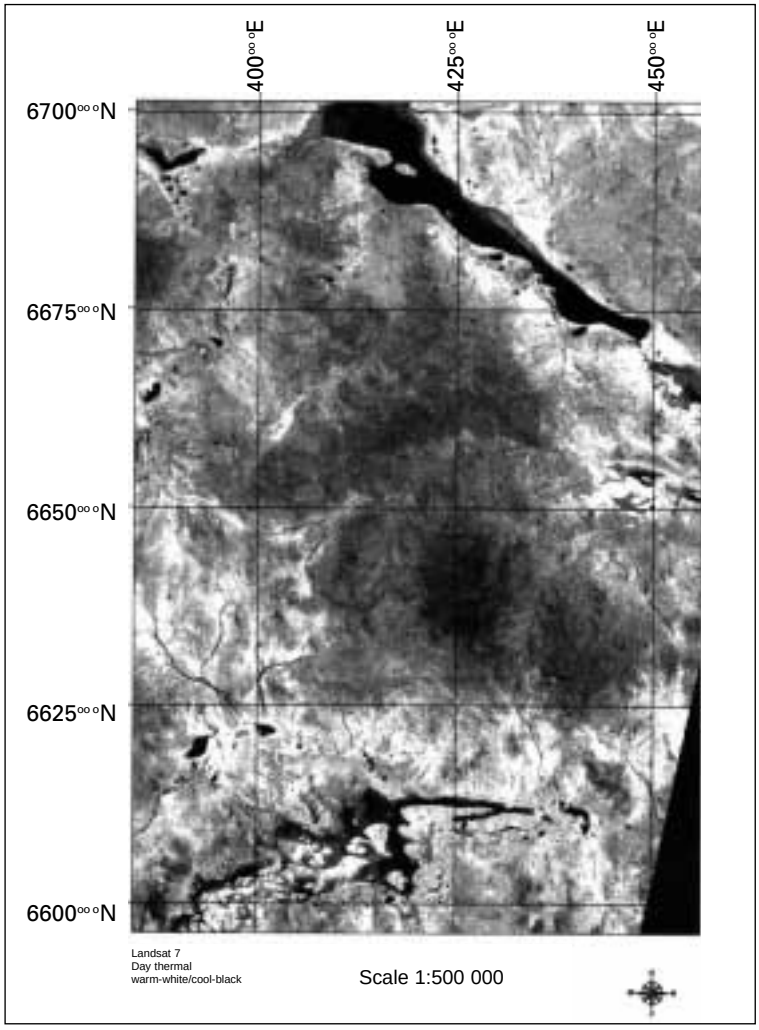

Figure 6: Landsat 7 (ETM) day thermal (Band 6 - 60m spatial resolution). Image date : October 3, 1999. The lighter the pixel tone the warmer the feature. This image is dominated by the effects of vegetation. Areas dominated by vegetation are cool while areas devoid of vegetation are warm. Major palaeodrainage axes are cool however concealed palaeodrainages are still not evident.

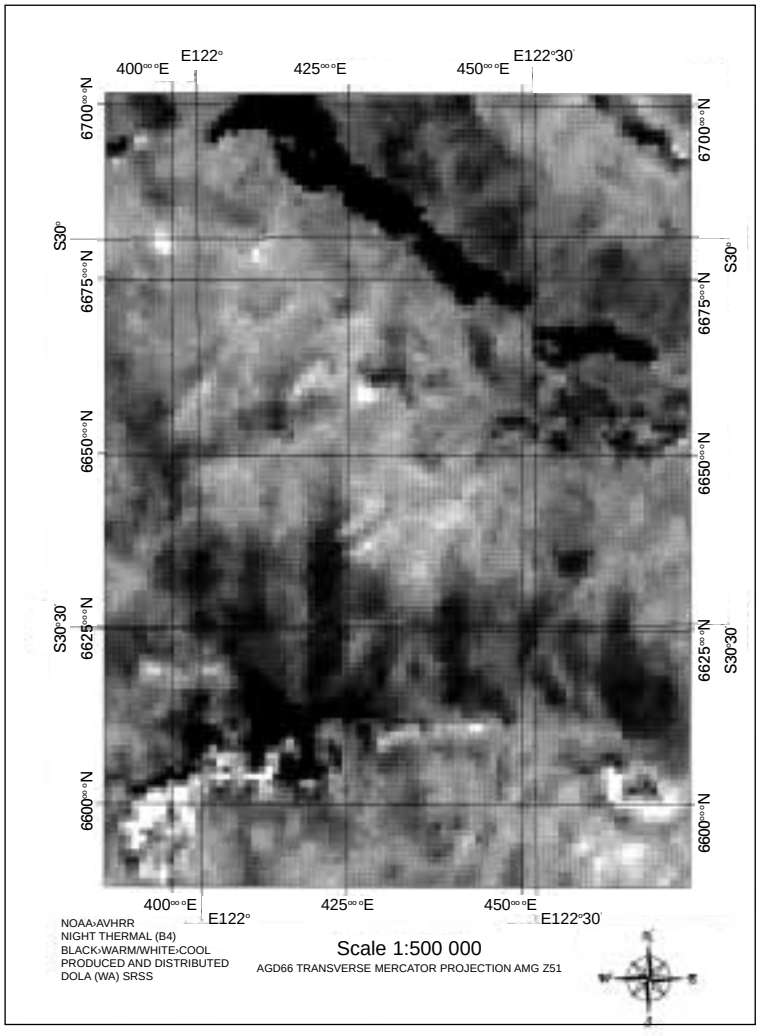

Figure 7: NOAA-AVHRR night thermal (Band 4). Image date : September 4, 1984. The darker the pixel tone the warmer the feature. This image appears to be dominated by thermal inertial properties of water. Concealed palaeodrainages at high angles to major palaeodrainage axes are clearly visible (425000mE, 6625000mN). These concealed drainages are targets for industrial water resources.

BUREAU OF METEOROLOGY

Compiled by M Willmott et al.
Bureau of Meteorology, Melbourne

Sea Surface Temperatures (derived from NOAA data)

The Bureau of Meteorology calculates satellite derived sea surface temperatures (SSTs) for the Australian region by combining data from WASTAC Perth station with similar NOAA AVHRR data from its Casey, Melbourne and Darwin stations. The AVHRR data is navigated, calibrated, cloud cleared in near real time and the processed orbit is available within an hour after the completion of the ingest. The resulting SSTs for a particular orbit are then sent to Melbourne for inclusion into the Bureau's national data set. The data is quality controlled against SST data collected from ships and drifting buoys prior to being mosaiced into a national map. These data are mainly used in support of internal and defence operations (e.g. assimilation into Bureau numerical weather prediction models) but are also available to external users as metadata and browse images of daily mosaics (from November 1998) via the world wide web at

http://www.bom.gov.au/sat/archive_new/sst/.

A subscription service is also available for real time SST data and regional products via the Bureau's 'Weather by Fax' service. The SST grid data are archived as part of Australia's National Climate Record.

The coverage from the four stations can be seen in Figure 1, which shows the contribution from the WASTAC station and the Bureau's stations at Melbourne, Darwin and Casey.

SSTs are calculated using the Local Area Coverage data received at Melbourne, Perth and Darwin for each orbit of NOAA-15, -14 and -12. The maximum resolution of the pixels in each orbit is 1.1 km^2. The SSTs for any individual orbit will have gaps where the pixels have been tested and rejected from the calculations due to suspected cloud contamination or where the satellite zenith angle is greater than 53°. Corrections are applied in the SST algorithms for intervening atmospheric absorption and to daytime algorithms for reflected solar radiation.

A running 15 day composite SST mosaic in Mercator projection is used to provide complete coverage of the Australian region. The Mercator mosaic has a resolution of 2 x 2 km at the equator increasing to 1.4 x 1.4 km at 45°S. The latest available data pixels are used. However, where pixels are rejected on the basis of cloud contamination over a sequence of orbits, the data from previous days orbits are used. Areas of

Figure 1. Map showing NOAA coverage from the Bureau's Casey, Melbourne, and Darwin reception stations and the Perth WASTAC reception station.

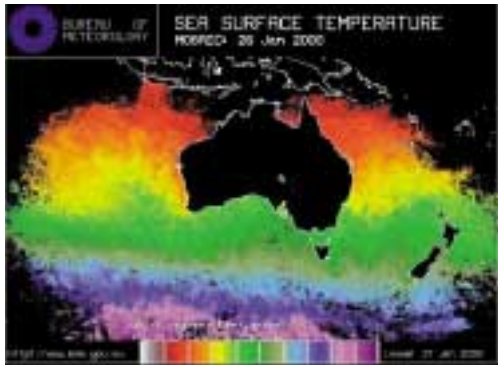

Figure 2. Map showing national coverage of Sea Surface Temperatures for 26 January 2000.

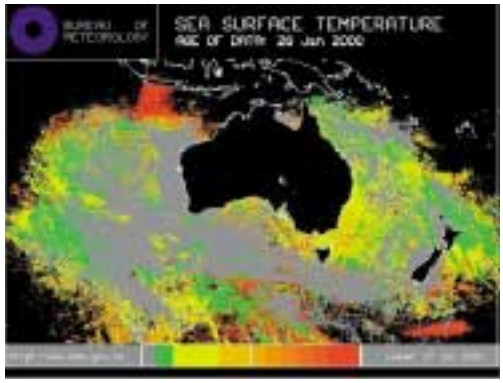

Figure 3. Map showing 'age of pixels' for 26 January 2000. The black pixels are either 'no data' or rejected pixels over 15 days old.

missing data in the composite mosaic indicate areas of cloud contamination persisting for more than 15 days. An associated age of data mosaic is also produced to complement interpretation of the SST mosaic. Figure 2 shows the mosaic for the Australian Region and Figure 3 the age of data used in the mosaic.

The Bureau has upgraded the resolution of the SST and in the next stage of this project will look at using the better temporal resolution of the geostationary satellites (hourly as compared to 6 hourly) to reduce the impact of diurnal cloud contamination which can be evident on some of the current SST mosaics.

Weather Modelling/Forecasting

The Bureau has produced locally derived Tiros Operational Vertical Sounder (TOVS) data for a number of years. This data provides valuable information on vertical profiles of atmospheric temperature and moisture. With the increased resolution of the numerical weather prediction (NWP) models, data analysis and assimilation has become increasingly important. The standard observational network (ground and balloon based) has been supplemented by the inclusion of TOVS data into the analysis and assimilation schemes. It has been shown (Le Marshall et al, 1998 - 3 references) that assimilation of TOVS data into the Limited Area Prediction System (LAPS) NWP model improves the overall skill scores of the prognosis for +6, +12, +24 and +36 hours. The data received from the WASTAC system greatly improves the coverage of the data to the west of the continent and hence improves the overall skill of the models. Figure 4 shows the coverage of TOVS data for 3 orbits from the Bureau system, whilst Figure 5 shows an example of output in the form of 300 hPa temperatures.

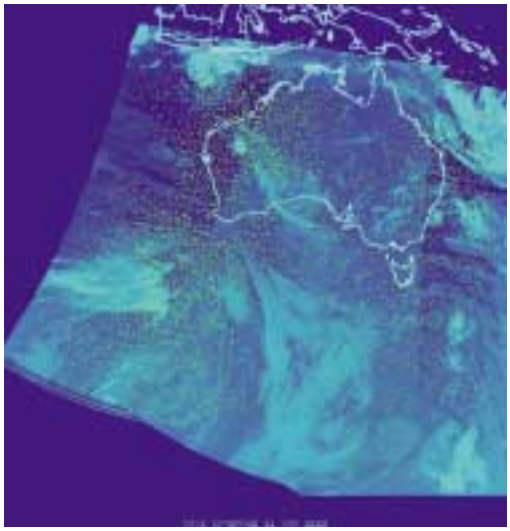

Figure 4. Coverage of TOVS data for three orbits over the Australian Region overlaid on corresponding AVHRR data

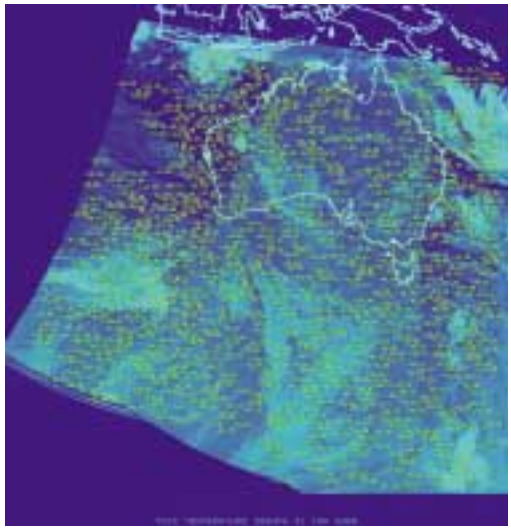

Figure 5. Example of TOVS coverage for three orbits showing 300 hPa Temperatures

Fire Hot Spots

The Bureau has developed algorithms for fire detection and although focussed on the southern States will, in the future, use WASTAC AVHRR data operationally in support of its statutory obligations to supply fire weather forecasting and warning services for Western Australia.

NDVI and Relative green-ness index

The Bureau currently produces NDVI products using AVHRR data and plans to complement this using WASTAC data to give more comprehensive coverage in support of Bureau services, climate studies and research. The data is mosaiced using a Maximum Value Composite approach and the WASTAC data is needed for a more complete coverage. The current product is available at http://www.bom.gov.au/sat/archive_new/ndvi/ (an example of output is given in Figure 6).

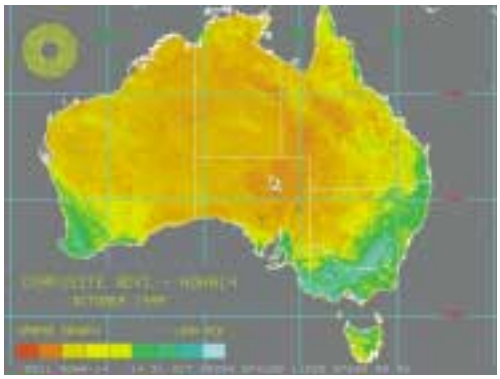

Figure 6. An example of the Bureau's Maximum Value Composite NDVI product.

Flood Monitoring

The Bureau is developing the use of AVHRR data for flood monitoring in an operational environment using various techniques. The systems, although under development, have produced many useful images for the Bureau's hydrological services. The Bureau currently produces ad hoc NDVI images to assist in the national monitoring of flooded areas as well as special enhancements using multi channel techniques.

Volcanic Ash

The Bureau uses AVHRR (and GMS-5) data to monitor volcanic ash plumes from active volcanoes which are extremely hazardous to aviation. The most active volcanic region in the world lies just to the north of Australia where international air traffic to and from Australia is concentrated. Even though the Volcanic Ash Advisory Centre is located in Darwin, the AVHRR data from Perth is reviewed for a full coverage of Darwin's area of responsibility. By way of example, in 1996/97 Darwin issued a total of 267 advices covering the area south of 10˚N between longitudes 100˚E to 160˚E.

Cyclone Monitoring

The Bureau's Western Australian Regional Forecasting Centre in Perth provides warnings of tropical cyclones whenever the need arises from their Tropical Cyclone Warning Centre (TCWC). The AVHRR data is used to assist in the monitoring of fine detail of tropical cyclones and supplements the positioning of these large systems by radar, GMS-5 imagery and NWP analysis. It is also a critical back-up to GMS-5 imagery. As an example, Figure 7 shows Tropical Cyclone John nearing the coast of Western Australia.

Data Collection Platforms (DCPs)

As part of an international commitment, the Bureau provides Tiros Information Processor (TIP) data to Argos (Collecte Localisation Satellites) for input into their tracking system. The TIP data stream has embedded data from the Argos instrument which is onboard the NOAA satellites. The instrument allows the collection of data from remote platforms or transmitters on board ships, yachts, ocean buoys, animals, birds, cargo, etc. The Perth data gives Argos enhanced capabilities of receiving and using the data real-time (within 15 minutes of the end of the orbit) rather than having to wait 1 to 3 hours for the recorded data. In addition, the Bureau extracts and processes DCP data from the WASTAC TIP data to provide observations of meteorological variables such as pressure and temperature over data sparse ocean areas.

AVHRR Access Service

The Bureau provides a realtime ftp subscription service to AVHRR data.

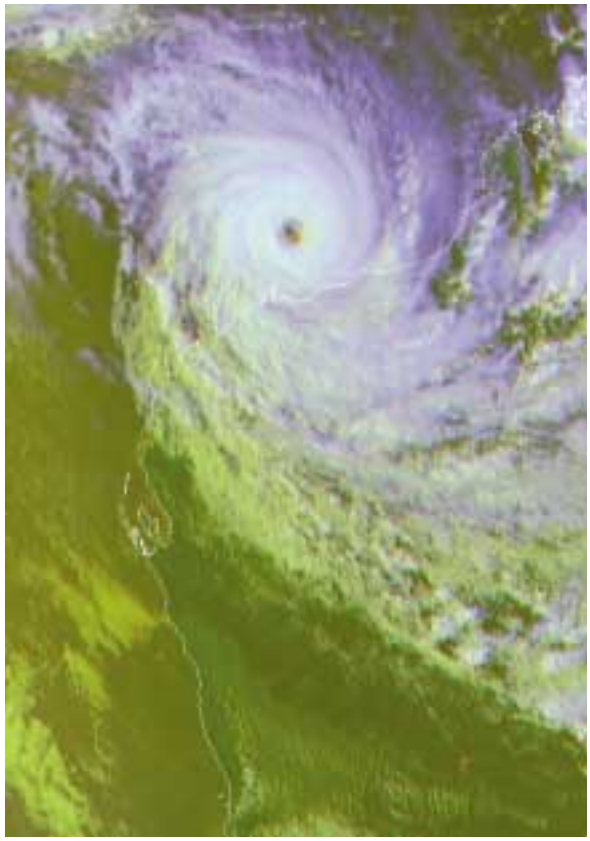

Figure 7. Tropical Cyclone John 200 kms off the coast of Western Australia bearing down on Whim Creek (NOAA-14, 07:51 UTC, 14 December 1999).