BCLME Project EV/PROVARE/06/01

Development of Satellite Remote Sensing Products for Operational Application

Report 2

August 2006

Remote Sensing Server Workshop Report

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Executive Summary

This report details the Remote Sensing Server Workshop, held at the University of Cape Town on the 7th of July 2006, and attended by forty-seven people representing a wide variety of interest groups. The workshop had the following aims:

- Introduce the trial remote sensing server to the southern African marine science community and other interest groups to encourage the widest possible use of the new facility. The server is located at http://www.rsmarinesa.org.za
- Briefly teach attendees how to use the trial server and associated visualization and analysis tools.
- Begin the formation of a server user group, to allow continued feedback on server usage and user requirements
- Give users an idea of broader project aims and future evolvement of the server to assess potential regional use and provide momentum to product development.

The workshop consisted of eight presentations by project members, interspersed with discussions aimed to provide the project with community feedback. This report summarises these presentations, provides a synopsis of the key points of the community discussions, and provides some initial recommendations arising from the meeting.

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1. Introduction

The workshop was intended to notify stakeholders of the availability of the remote sensing server, demonstrate server usage, and identify core server users. It was advertised through Sancor and remote sensing mailing lists, while specific invitations were issued, and travel funding made available, to Nande Nickanor from NatMIRC, Namibia, and Filipe Vianda from INIP, Angola. The workshop was organized by the regional Marine Remote Sensing Unit and held at the University of Cape Town on 7 July 2006. Forty-seven participants from various institutes attended, as listed in **Appendix 1**.

The programme for the day was structured as follows:

09:00-09:15	Project introduction	*Stewart Bernard*
09:15-10:00	Introducing the RS Server and Tutorial Part 1	*Bertrand Saulquin*
10:00-10:30	Tea	
10:30-11:15	RS Server Tutorial Part 2	*Bertrand Saulquin*
11:15-11:40	Satellites, Sensors and Validation	*Tarron Lamont*
11:40-12:10	Other Remote Sensing Sites	*Christo Whittle*
12:10-12:30	Feedback and Discussion – Use of the RS Server	
12:30-14:00	Lunch	
14:00-14:20	Alternative MODIS products	*Bertrand Saulquin*
14:20-14:40	New and Experimental Satellite Products	*Stewart Bernard*
14:40-15:00	Indices and Analysis of Remote Sensing Data	*Ray Barlow*
15:00-16:00	Feedback and Discussion – Identifying Community Needs	

2. Presentations

2.1 <u>Project introduction *Stewart Bernard*</u>

Dr Bernard welcomed the participants to the workshop and introduced the day's proceedings by briefly outlining the history of remote sensing (RS) in southern Africa. RS in the region has been somewhat fragmented with several independent initiatives that include:

- The Marine Remote Sensing Unit at UCT
- Marine & Coastal Management RS operations and
- An East Coast server project under the auspices of ACEP/BCRE.

With the aim of establishing a more coherent and integrated approach, a workshop (initiated by BENEFIT) was held in August 2005 at the SAC, Hartebeesthoek, South Africa – "Picture to Pixel: Charting the way forward for Marine Remote Sensing in Southern Africa".

The outcome of SAC workshop was a resolve to form a single permanent Marine Remote Sensing Unit (MRSU) providing data for all stakeholders. An intermediate step in securing and integrating resources for the MRSU was successfully sought through the BCLME programme with the inception of project BCLME EV/Provare/06/01 "**Development of Satellite Remote Sensing Products for Operational Application"**.

Some of the main objectives of the project are:

- Develop ocean colour and sea surface temperature products for operational use in the southern African region.
- Provide remote sensing and integrated products for the marine scientific community and resource managers.
- Develop capacity in the region though student projects and training initiatives.
- Provide remote sensing products for the BCLME Environmental Early Warning System (EEWS) and State of the Environment Information System (SEIS) projects that are currently underway.

Three key areas that will be focused on include:

- Provision of remote sensing products to the community
- Development of remote sensing products for regional use
- Validation of satellite data and remote sensing products

In conclusion, Dr Bernard emphasized that the purpose of the BCLME project and the workshop was to:

- Present the trial remote sensing server to the community
- Start encouraging RS users to be more involved in the development of products and to provide feedback.
- Give users an idea of future evolvement to assess potential regional use and provide momentum to product development.

2.2. Introducing the RS Server and Tutorial Part 1 *Bertrand Saulquin*

Mr Saulquin introduced his presentation by mentioning that the Server Project was initially a collaboration between the French IRD and Marine & Coastal Management, and was then developed further with funds from ACEP and BCRE. He thanked the BCLME Programme for its current support for the ongoing development of the server. He emphasized that it is important for users to provide feedback so that the server can be developed to meet user requirements. Mr Saulquin then outlined what the server website provides.

The site provides both satellite images and associated binary data for:

- MODIS products (historical and real-time SST and Chlorophyll *a*)
- SeaWiFS products (historical Chlorophyll *a)*
- AVHRR products (historical SST)

In addition, a visualization tool, named “SeaSat” has been added to the website, enabling users to manipulate the binary data for various applications, for example time-series studies. Relevant documentation for the various operations has been included on the site. The architecture of the software used on the server is shown in Fig. 1, and the channels for processing the daily MODIS data is shown in Fig. 2.

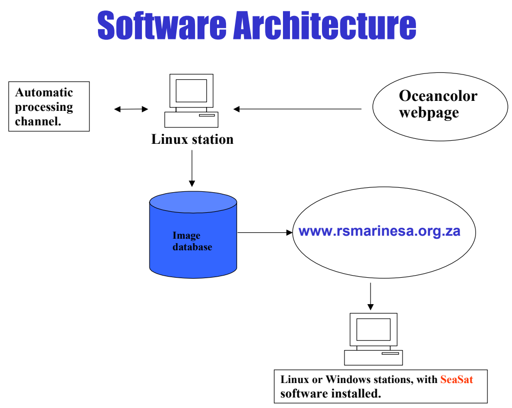


Fig. 1. RS server software architecture

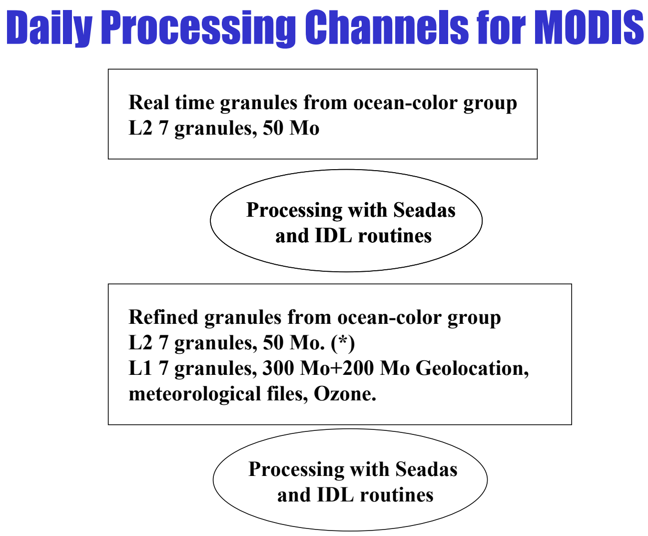


Fig. 2. Processing channels for MODIS data

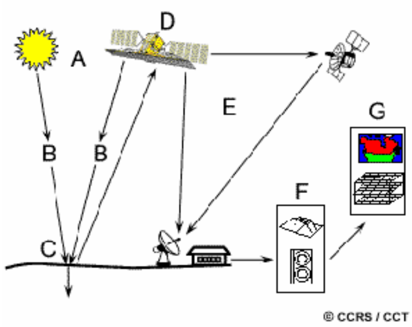
Mr Saulquin guided the participants through a tutorial on the RS Server. The server homepage is located at http://www.rsmarinesa.org.za. A set of instructions to assist users in accessing and viewing images was prepared and handed out to all participants. A copy of this tutorial is appended in Appendix 2. The tutorial introduced users to the latest products for various regions including Angola, Namibia, West Coast, South Coast, East Coast, Delagoa Bight and Madagascar, where daily, pentad and monthly images may be viewed. The quality of the standard MODIS products was discussed and some of the problems were mentioned. Some of the channels used in the NASA OC3 algorithm for estimating chlorophyll *a* are very sensitive to the effects of atmospheric correction, and to the influence of any suspended sediment. Thus, there can be an over-estimation of the chlorophyll *a* concentration, especially in inshore, high biomass waters where the atmospheric correction is overestimated by the model used for standard MODIS ocean colour products. The standard MODIS SST products are of good quality, but are very conservative and can suppress good pixels at times in southern African waters. This problem requires some tuning of the masks used in the generation of SST products. In future development work, it is intended to (1) implement some Kriging methods for the MODIS 1 Km data; (2) generate appropriate upwelling and phytoplankton biomass indices; (3) add other products such as 4 Km Pathfinder SST (1980-2005), TMI SST (1998-2006), weekly ERS wind at 1^{o} resolution (1991-2001), QuickSCAT wind at 0.5^{o} resolution (1999-2006), and add a link to AVISO altimetry.

2.3. RS Server Tutorial Part 2 *Bertrand Saulquin*

In this tutorial, Mr Saulquin discussed the visualization tool, “SeaSat”, and guided the participants through the website and the use of the tools. The first step allows a user to select and download multiple binary data files, process the data, and then archive the data. Other tools enable the user to view and manipulate images and illustrate images with grids, contours, coast lines, bathymetry, colour pallets etc. Other options include a zoom facility and an option to extract actual values of parameters. Bitmaps of modified images can also be created, and export of images and text files are other options offered. Details of the tutorial on the use of the “SeaSat” tools is presented in Appendix 2.

2.4. Satellites, Sensors and Validation *Tarron Lamont*

The main aim of Ms Lamont’s presentation was to provide an overview of observing the oceans from space (Satellite Oceanography). Remote sensing essentially deals with the detection and measurement of phenomena with devices sensitive to electromagnetic energy, such as light, heat, radio and microwaves. Ms Lamont discussed the differences between near-polar orbiting and geostationary satellites, and described the processes involved in satellite remote sensing (Fig.3).



A - Energy or radiation source: the sun or a satellite
B – Interaction with the atmosphere
C – Interaction with the target (sea surface or particles in water)
D – Recording of energy by the sensor
E – Transmission, reception and archiving (Satellite to receiving station)
F – Processing, interpretation and analysis
G - Application

Fig. 3. Processes in satellite remote sensing

She also illustrated the above-water apparent optical properties of reflectance, downwelling irradiance and water-leaving radiance in relation to the in-water inherent optical properties of absorption, scattering, backscattering and fluorescence. These optical properties are important in the development of models for improving the quality and quantity of products from the ocean color satellites. Ms Lamont then presented some details of the characteristics and specifications of the various satellite sensors, including AVHRR, CZCS, SeaWIFS, MERIS, MODIS-Terra and MODIS-Aqua.

The importance of validating satellite data was emphasized, particularly for radiometric and geophysical products. Radiometric validation is an assessment of the accuracy and precision of satellite measurements of the water leaving radiance and is achieved with in situ bio-optical moorings (Fig. 4) and dedicated field campaigns. Geophysical validation is an assessment of the accuracy and precision of satellite derived geophysical products such as chlorophyll concentrations and size descriptors from in situ measurements.

Fig. 4. In situ bio-optical mooring located at Lamberts Bay for satellite validation.

Ms Lamont presented examples of the validation for MERIS and MODIS-Aqua water-leaving radiances and reflectances, and an example is shown in Fig. 5.

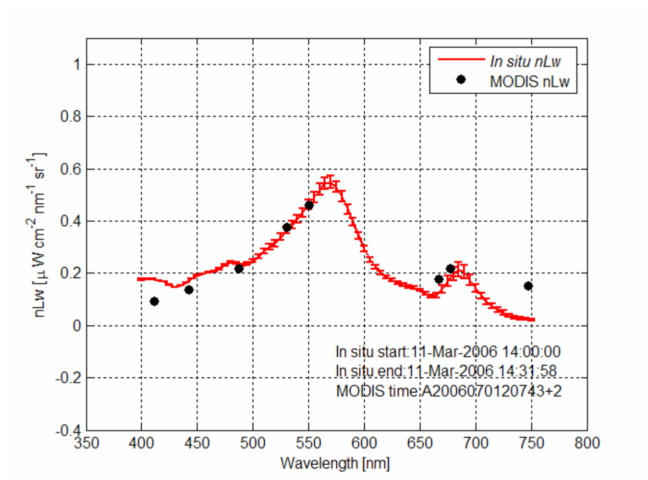


Fig. 5. Comparison of in situ and MODIS-Aqua water-leaving radiance spectra.

2.5. Other Remote Sensing Sites *Christo Whittle*

Mr Whittle presented an overview of other web-based satellite resources for marine applications. User data requirements are likely to vary and in selecting a site the following criteria need to be considered:

- Data needs vary according to end-user activities.
- Option of high-resolution versus low-resolution data.
- Quick information required to facilitate immediate decision making.
- Time series datasets for trend analysis.

- Different marine focus regions dictate the type of applicable data.

The various products that are available include Sea Surface Temperature (TRMM/TMI, MODIS, AVHRR), Chlorophyll *a* concentration (SeaWiFS, MODIS), Sea Surface Winds (SeaWinds), Sea Surface Height (Topex/Poseidon, ERS-2, GFO) and Sea Surface Geostrophic velocities (Topex/Poseidon, ERS-2). Mr Whittle discussed each of these websites in detail, illustrating the products that are available and how to download data from each site.

Satellite data for these different parameters is available on various websites such as:

NODC - National Oceanographic Data Centre
- http://www.nodc.noaa.gov

PODAAC – Physical Oceanography Distributed Active Data Archive Centre
- http://podaac-www.jpl.nasa.gov

CCAR – Colorado Centre for Astrodynamic Research
- http://argo.colorado.edu/~realtime/welcome

Quikscat – Marine Observing Systems Team
- http://manati.orbit.nesdis.noaa.gov/quikscat

Ocean Colour Website – NASA Ocean Colour Group
- http://seadas.gsfc.nasa.gov

Rapidfire – MODIS Rapid Response System
- http://rapidfire.sci.gsfc.nasa.gov

HAB – UCT Harmful Algal Bloom Group
- http://www.hab.org.za

SEIS – BCLME State of the Environment Information System
- http://www.under-construction

Some selected examples of websites are illustrated below in Figs 6-9.

Fig. 6. The NOAA Oceanographic Data Centre website

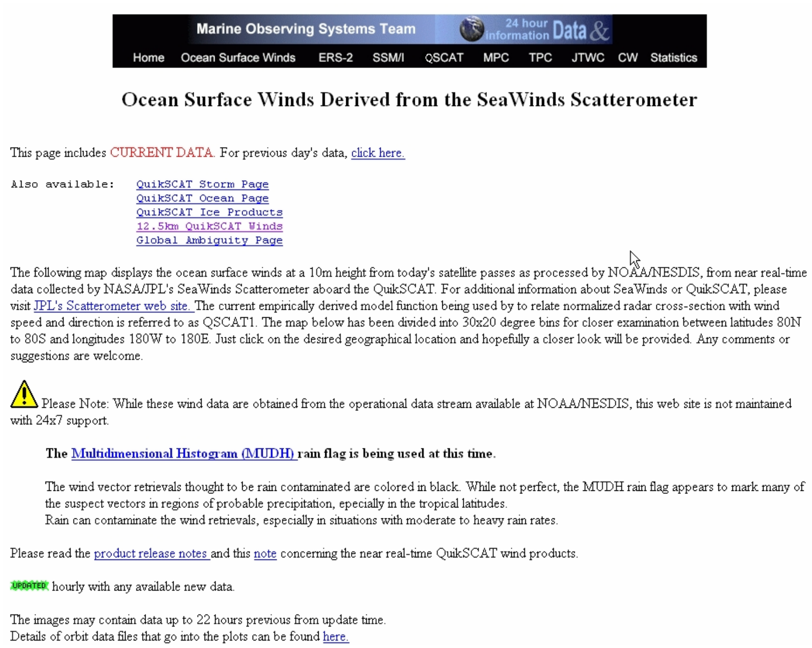


Fig. 7. Website for obtaining satellite wind data.

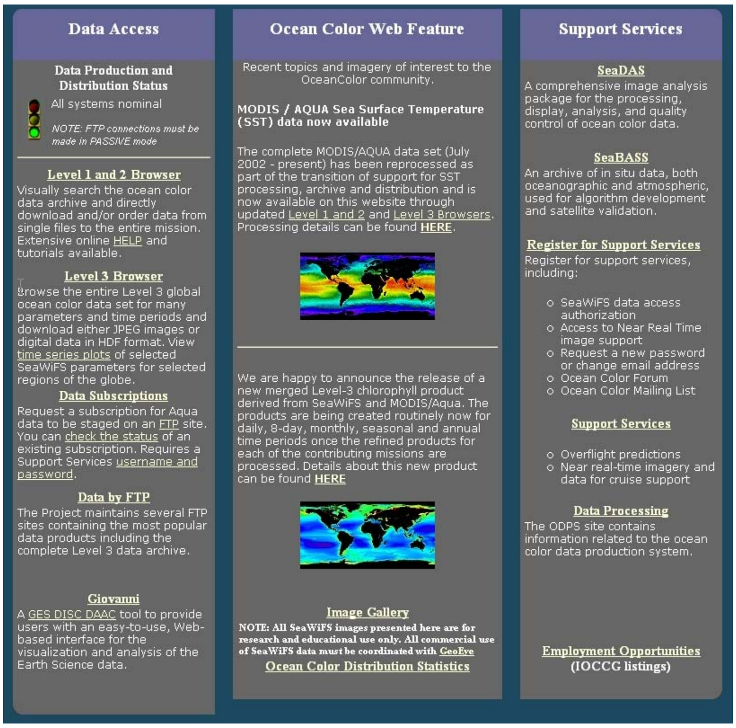


Fig. 8. The NASA Ocean Colour website

Fig. 9. The Harmful Algal Bloom website

2.6. Alternative MODIS products *Bertrand Saulquin*

Considering the problems with atmospheric correction and suspended sediment on the RS estimation of chlorophyll *a* concentration in coastal environments, Mr Saulquin is working on the development and modification of relevant empirical algorithms to improve the estimation of chlorophyll. IFREMER (France) have implemented such an empirical and regional algorithm for the English Channel and the continental shelf of the Bay of Biscay using standard Seawifs L2 products. Mr Saulquin is collaborating with IFREMER scientists to update the MODIS chlorophyll product for suitable application in the southern African region. The process involves modelling the effect of poor atmospheric correction (MODIS channel 412 nm) and suspended sediment (MODIS channel 555 nm) on the NASA OC4 ratio algorithm using comparisons with in situ chlorophyll *a* data. Comparisons between the new IFREMER empirical algorithms and in situ chlorophyll for the English Channel and the Bay of Biscay (Fig. 10) indicate improved estimates of satellite chlorophyll *a*, which is promising for application in the BCLME region.

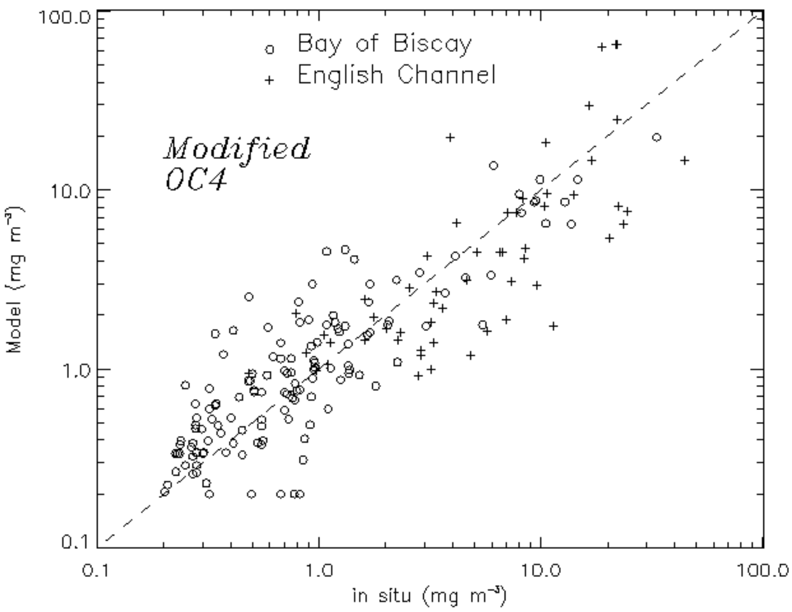


Fig. 10. Comparison between modelled and in situ chlorophyll concentrations for the Bay of Biscay and the English Channel.

2.7. New and Experimental Satellite Products *Stewart Bernard*

Dr Bernard presented various new RS ocean colour products that will be useful to users for various applications. Three locally produced algorithms include:(1) A simple and fast red wavelength empirical algorithm giving more accurate chlorophyll *a* estimates in high biomass waters; (2) an analytical reflectance algorithm giving more accurate chlorophyll *a* estimates, an algal size descriptor and constituent optical properties; and (3) fluorescence algorithms giving fluorescence quantum yield as a physiological proxy, and perhaps potential for instantaneous production estimates (see Fig. 11 for examples). Analytical algorithms offer an additional advantage of multi-sensor application i.e. production of similarly derived geophysical parameters from a variety of space-borne and in-water colour sensors.

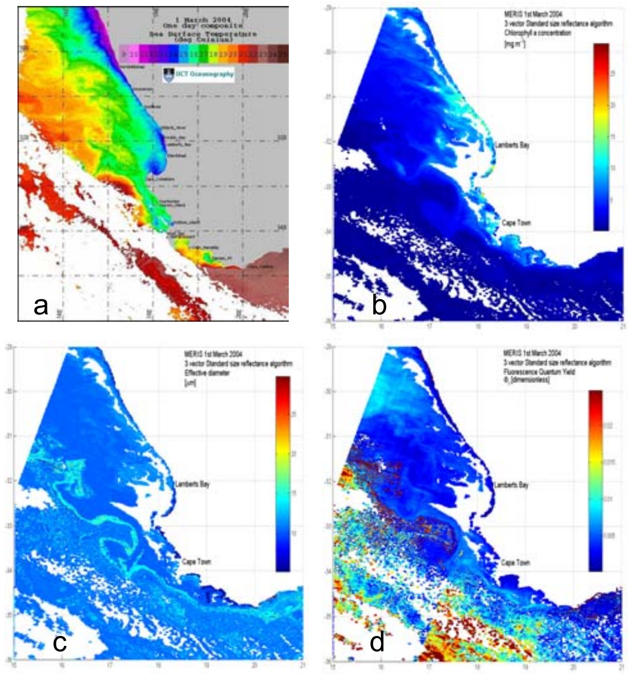


Fig. 11. RS products for (a) SST, (b) chlorophyll a concentration, (c) effective diameter, (d) fluorescence quantum yield.

Another product is a simple backscattering-based reflectance algorithm for high biomass application. Traditional blue/green empirical algorithms use a signal inversely related to algal biomass, and this signal becomes vanishingly small at high chlorophyll concentrations due to high algal absorption removing most available light. But at high biomass, phytoplankton backscattering has a considerable effect on reflectance at red wavelengths, and backscattering related algorithms thus have the advantage of using a strong, directly proportional signal in high biomass waters. Currently, this backscattering algorithm is only applicable for MERIS data at the 709 nm band (Fig. 12).

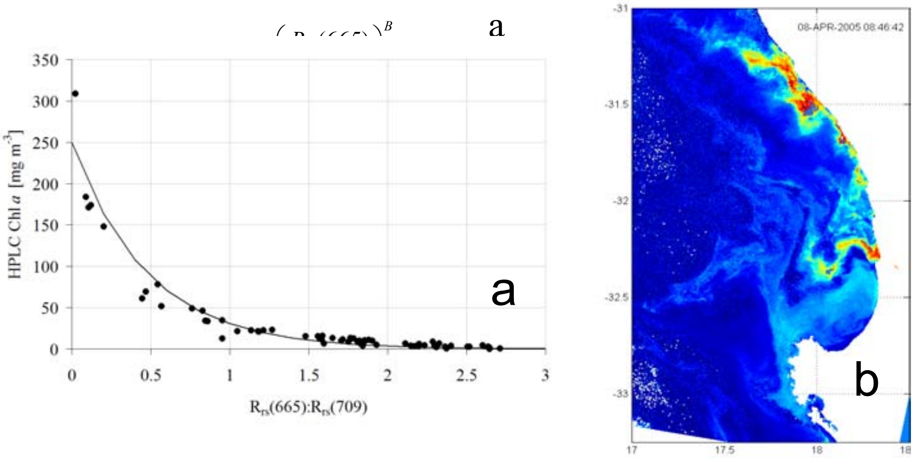


Fig. 12. A two waveband algorithm (a) and application to a high biomass HAB bloom (b).

An analytical reflectance algorithm was developed by modelling the optical properties of algal cells using size distributions of layered spheres. This allows algal absorption and backscattering to be manipulated with regard to average assemblage size, cellular chlorophyll concentration and accessory pigment complement.
Solar stimulated fluorescence has the potential to provide insight into phytoplankton physiology and rate processes such as primary production. Sun-induced fluorescence of phytoplankton can be quantified by retrieval of the fluorescence signal from near-surface radiance data, using a variety of algorithms. Typical products are fluorescence line height (Fig. 13) and fluorescence quantum yield. Fluorescence parameters can be calculated from both the MERIS and MODIS sensors, but accurate derivation of the fluorescence signal in high biomass waters can be problematic.

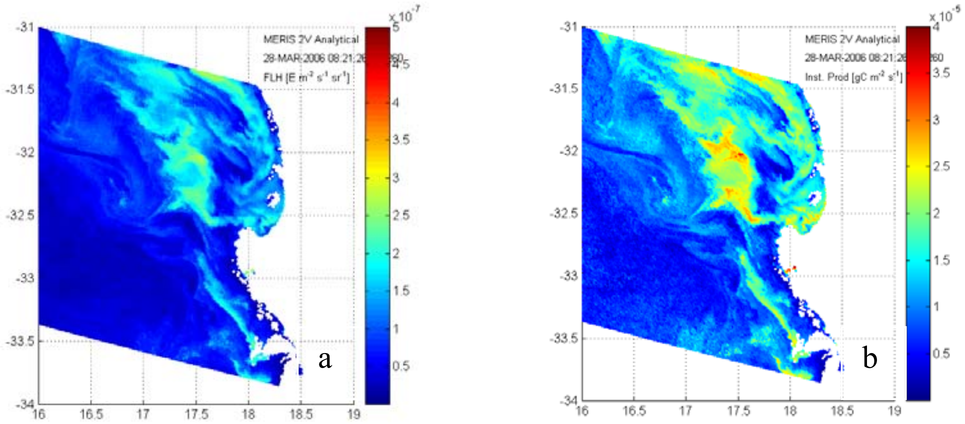


Fig. 13. Application of sun-induced fluorescence for fluorescence line height (a) and primary production (b).

MeteoSat Second Generation (MSG) is a geostationary satellite offering sea surface temperature and a single visible band at 3 km and 1 km spatial resolution at 15 minute sampling intervals, thus offering the potential of obtaining high frequency data. A study is currently underway examining the viability of using MSG SST and High Resolution Visible (HRV) data for: (1) Analysing high frequency shelf dynamics using the half-hour sampling period of MSG-1, with a particular focus on the development of the Columbine jet current, and (2) Assessing MSG data for feature tracking use, for example following potentially HAB related warm or dark parcels moving south and impacting the shoreline.

2.8. Indices and Analysis of Remote Sensing Data *Ray Barlow*

Dr Barlow presented aspects of collaborative work in the BENEFIT programme on applications of remote sensing in the Benguela ecosystem using AVHRR SST and SeaWiFS chlororophyll data. Dr Herve Demarcq (IRD) investigated the temporal variability in low resolution SST and chlorophyll from 12-34^{o}S (west coast) and from 18-29^{o}E (south coast), showing the general seasonal variation of cool winter waters and warm summer waters. A chlorophyll index, generated as an integration from the coast to the 1 mg m^{-3} offshore concentration, revealed six sub-provinces on the west coast and two on the south coast. Consistent low indices were observed in the Lüderitz upwelling sub-province 3 (25.5-28^{o}S), while sub-provinces 2, 4, 5 had high indices in the zones 17-25.5^{o}S and 28-33^{o}S (Fig. 14).

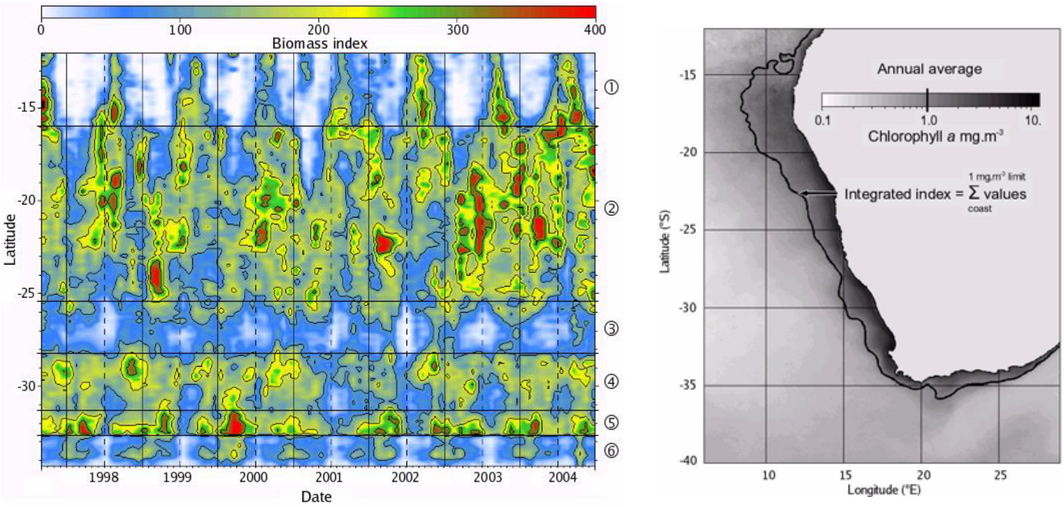


Fig. 14. Application of an integrated chlorophyll index on the west coast.

Dr Claude Roy's (IRD) study of upwelling variability using statistical analysis of temperature anomalies indicated various warm and cold events in the Benguela, such as the prominent Benguela Nino in 1995 where warm Angolan water penetrated to 24^{o}S. The data revealed that the northern and southern Benguela can be out of phase during major events, with the development of a dipole structure in 1995 and 1997 (Fig. 15). The effects of upwelling intensity on anchovy recruitment showed that moderate intensity favoured elevated recruitment in the Hondeklip Bay area, whereas high and low upwelling intensity resulted in lower recruitment.

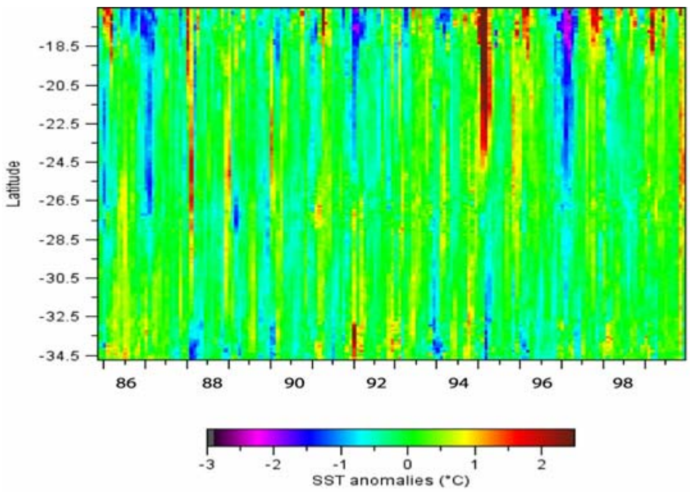


Fig. 15. Temperature anomalies in the BCLME showing cold and warm events.

Dr Scarla Weeks focused her investigations on the southern Benguela (29-35^{o}S) using high resolution SST and chlorophyll data. Hovmuller SST plots showed that upwelling was more prominent on the inner continental shelf (0-100m) at the Cape Peninsula, Columbine and Namaqua upwelling cells. Hovmuller chlorophyll plots indicated elevated phytoplankton biomass in the zones between upwelling cells, with particularly high chlorophyll levels in the zone 30.5-32.7^{o}S between the Columbine and Namaqua upwelling cells (Fig. 16).

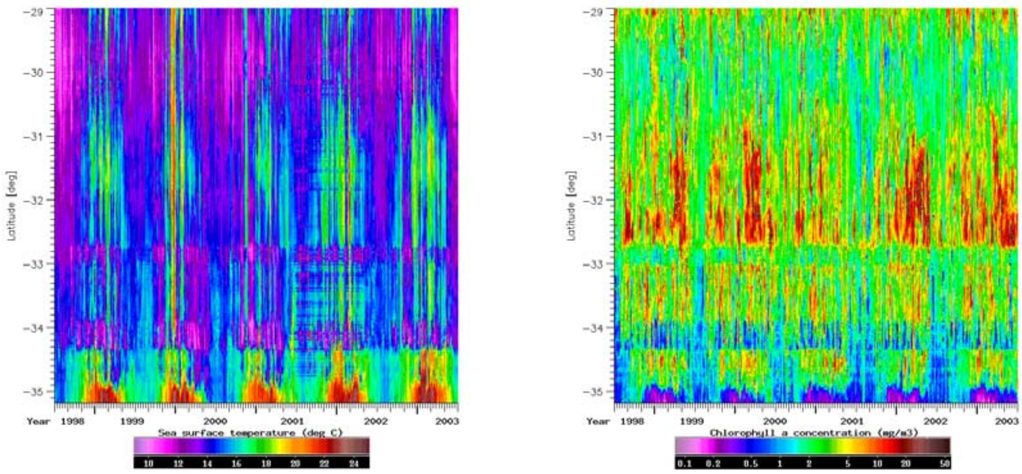


Fig. 16. Hovmuller plots of SST and chlorophyll variation in the southern Benguela for the inner continental shelf (1-100 m).

A site was selected in St Helena Bay near Cape Columbine for a temporal study and an upwelling index was estimated as a differential SST (difference in SST inshore and SST at 300 km offshore). The index was high in summer and low in winter, while a temporal plot of chlorophyll concentration indicated that chlorophyll tended to be more elevated in the summer months as the upwelling index increased (Fig. 17).

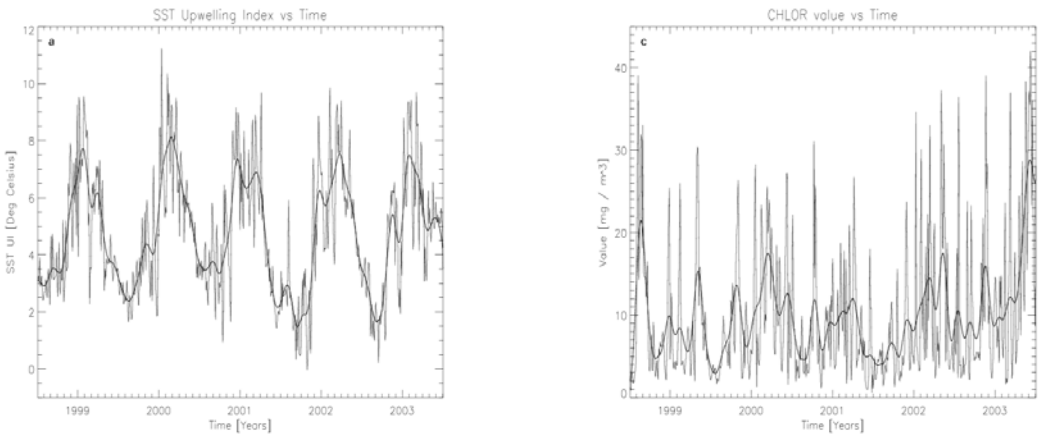


Fig. 17. Variation of an upwelling index and chlorophyll *a* concentration at 18.05^{o}E in St Helena Bay.

3. Discussions

The workshop provided for much involved discussion of the server, associated tools, and marine remote sensing and data provision in general. Key points and the potential responses to these are detailed below.

3.1 Public Use

Policy for public use and acknowledgements: The decision was made during the first month of project operation that future interests of both users and developers were better served by making the server completely open access i.e. the site is not password protected and is accessible by anyone. An offshoot of this is that the data on the server is understood to be in the public domain and therefore can be freely utilised and published for all purposes, whether research or commercial. It was suggested that proper acknowledgement of server usage in any public document in which server data is used should be considered the minimum appropriate acknowledgment. Obviously, such a policy cannot be policed and is an honour system of a kind. Given the short term current funding for the project, and the considerable importance of achieving sustainable funding, public acknowledgement of server use is extremely important in highlighting the value of the server as a public facility, and thus potentially attracting longer term funding.

Identification of user feedback to better understand stakeholder interests: User feedback is strongly sought by the project, and it was made clear on several occasions that users providing feedback must identify their affiliations and potential applications. It was also made clear that requests from scientific and management oriented-users, particularly regarding the development of new products, would receive considerably higher priority than those from commercial users. A user feedback template accessible from the server front end is under consideration as potentially the most effective means of generating appropriately structured feedback.

3.2 Links & coherence with other sites

Requests were made at several stages for a set of well structured links to other sites providing regional and international marine data, similar in ethos to the presentation made by Mr. Whittle. Such links are likely to be rated in two tiers: those associated with closely linked regional sites (typically BCLME funded) that may eventually be more closely integrated e.g. the EEWS, SEIS and hab.org.za sites; and international sites of a more general nature.

3.3 Server and Tools Product Development

This topic formed a major part of the discussions, and it became clear that there will be many suggestions for the development of new products or ways of analysing satellite data over the course of the project. Such suggestions will have to be considered on a case-by-case basis, most likely in the form of ongoing project reviews. It is also clear that the remit of the project is to develop and provide remotely sensed data in a form that is useable by a wide variety of concerned stakeholders, and not to undertake oceanographic research *per se*. At this early stages of the project, the line between development/provision and applied research is not as not clear as might be expected, and this will have to evolve over the course of the project. In addition, product development will need to be prioritised to be consistent with the project's aims, work plan and deliverables. Suggestions for product development and refinement included the following:

- The availability of indices, both online and with the SeaSat analysis tools. Popular requests included upwelling and enrichment. A simple means of allowing index calculation with the SeaSat tools was suggested as an area calculation between user determined threshold values e.g. calculating the area of a sea surface temperature image between 10°Cand 12°C.
- Making available the processing details of available data e.g. the chlorophyll product algorithm version.
- An analysis of ocean colour product performance in high sediment areas e.g. the South African south and east coasts and in the vicinity of the Congo river.
- Making available composited, mean and multi-sensor monthly data over wide areas. Whilst some of these data are already available through other sites (see section 2.5), specialised local composited products will be made available through the course of the project.
- Various cosmetic changes to image look-up tables, labeling, cloud identification etc.

- The ability to provide more sophisticated analyses with the SeaSat tools e.g. Hövmuller plots, gradient images and transect plots.

3.4 Educational Content

There were several requests to provide easily understood guides to both sea surface temperature and ocean products on the server site, ideally as downloadable Adobe Acrobat files. There is no doubt that these would be highly desirable, but for such guides to be useful, considerable time would need to be spent on them. Guides already available in the public domain may be made available in the short term, whilst an assessment is made of the project's ability to design specific local guides.

4. Recommendations

The potential migration of the remote sensing server to the SAEON server was suggested by the SAEON representative, as a means of promoting long term sustainability. This is an important consideration given the relatively short current time scale of project funding. There may be some political considerations given the commitment of South African national stakeholders to a national Marine Remote Sensing Centre, although the current very slow rate of realisation with regard to the establishment of this centre indicates that there should be little conflict by mid-2007.

The currently poor rate of delivery for the MERIS sensor is a major source of concern, and leaves the project almost entirely dependent on MODIS data for near real-time applications. This is an undesirable state of affairs: reliance on a single ocean colour sensor is sub-optimal with regard to best coverage and best practice, the MERIS sensor delivers possibly the highest quality atmospherically corrected ocean colour data currently available, and the MODIS sensor is still subject to sub-optimal atmospheric correction. The project currently has three ESA approved means of accessing real-time MERIS data: the Coastwatch programme, access to the seven day rolling archive as an approved Category-1 investigator, and provision of data through the Brockmann FTP server as a "semi-official" validation partner. All of these avenues to MERIS data suffer from a two-three week delay in reception, rendering the data useless for near-real time application. There would appear only one further route open to more effective data delivery from the ESA - becoming an official validation partner. It is recommended that the project makes significant investment in processing the back-log of validation data available to it (from two years of operation of the Namaqua shelf bio-optical mooring) and prepares a technical report for presentation to the ESA. The presentation of a high quality validation study from the highly productive waters of the southern Benguela should gain considerable leverage with the ESA, and thus facilitate better access to near-real time data.

Analogous reasoning can be applied to data from the MODIS sensor, currently suffering from poor atmospheric correction in the coastal zone i.e. the majority of data the project is concerned with. Presentation of a high quality validation study using data from the complex high biomass waters of the southern Benguela should at the very least highlight the problem to NASA.

A preliminary study of the MeteoSat Second Generation (MSG) sensor indicates that the data are potentially extremely valuable, offering high quality sea surface temperature data at the unique sampling resolution of 30 minutes. In addition, there is potential to process the data and have it publicly available within an hour of acquisition, of great potential value in operational applications. If licensing and IT issues can be overcome, it is suggested that an attempt should be made to construct an automated processing chain for MSG data and make it publicly available.

Appendix I - List of Attendees (Total of 47)

Attendee	Affiliation
Ray Barlow	M&CM
Christo Whittle	UCT
Tarron Lamont	UCT
Bertrand Saulquin	IRD
Selwyn Bergman	UCT
Stewart Bernard	UCT
Nande Nickanor	NatMirc
Filipe Vianda	INIP
Candice Hall	UCT
Christophe Lett	IRD
Marna vd Merwe	CSIR
Johann Lujeharms	UCT
Robert Williamson	UCT
Melanie Smith	UCT
Juliet Hermes	UCT
Howard Waldron	UCT
Andre du Randt	M&CM
Marten Grundlingh	CSIR
Sanette Gildenhuys	IMT
Philip de Bruyn	M&CM
Kim Prochazka	IOI
Frank Colberg	UCT
Tammy Morris	BCRE
Rick Harding	BCRE
Neil Engelbracht	BCRE
Marcel van den Berg	BCRE
Lisa Hancke	BCRE
Fiona Duncan	BCRE
Lisl Robertson	SASA
Gilbert Siko	DST Science Platform Unit
Humbulani Mudau	DST Science Platform Unit
Alberto Mavume	UCT/Mozambique
Derek du Preez	Botany, NMMU
Jenny Veitch	UCT
Ross Blamey	UCT
Frances Le Clus	M&CM
Karen Shine	UCT
Viit Mishra	CPUT, UCT
Vere Shannon	UCT/BCLME
Issufo Halo	UCT
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Appendix II - Workshop Tutorial

Remote Sensing Workshop

Introduction to the Southern African Remote Sensing Server

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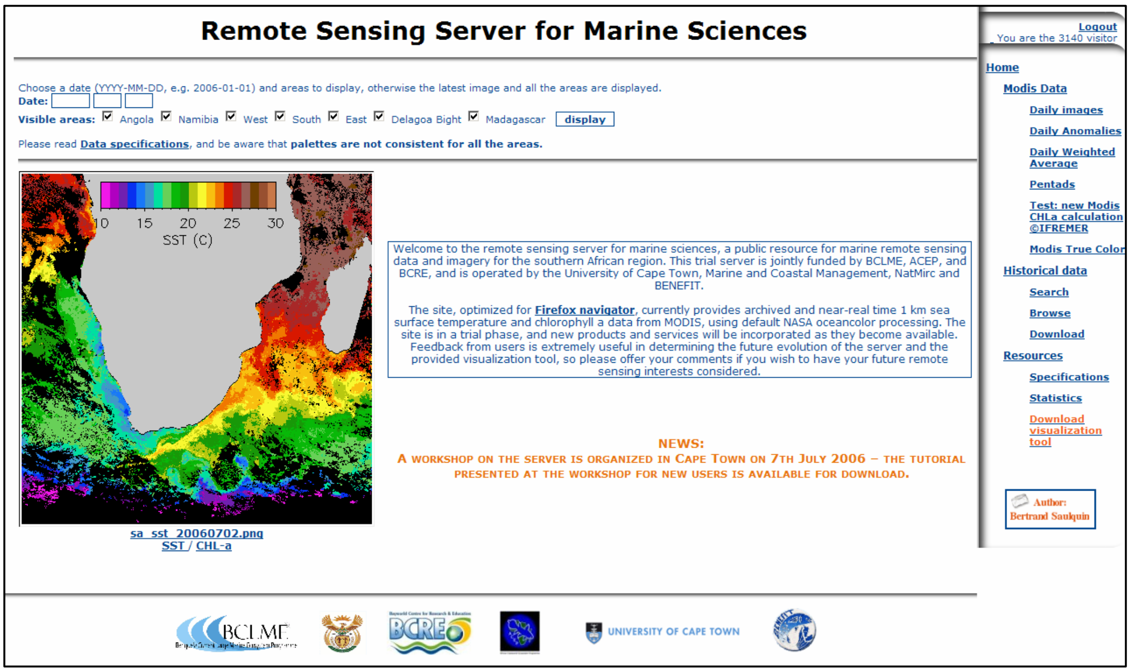
Introduction to the Remote Sensing Server

This tutorial introduces new users to the Remote Sensing Server for Marine Science, a trial facility to access marine remote sensing data in the southern African region. The server, developed with funding from the African Coelacanth Ecosystem Programme and the Bayworld Centre for Research and Education, is provided as a free public resource by the Benguela Current Large Marine Ecosystem Programme.

The server currently provides 1 km spatial resolution default sea surface temperature and chlorophyll *a* data from the Moderate Resolution Imaging Spectrometer (MODIS) sensor, and historical data from the Sea Viewing Wide-Field of View (SeaWiFS) sensor. New regionally optimized standard and experimental products will be added to the server as they evolve and mature. User feedback is therefore essential to server evolvement, and users are encouraged to give critical commentary on all aspects of the server to rsserver@ocean.uct.ac.za.

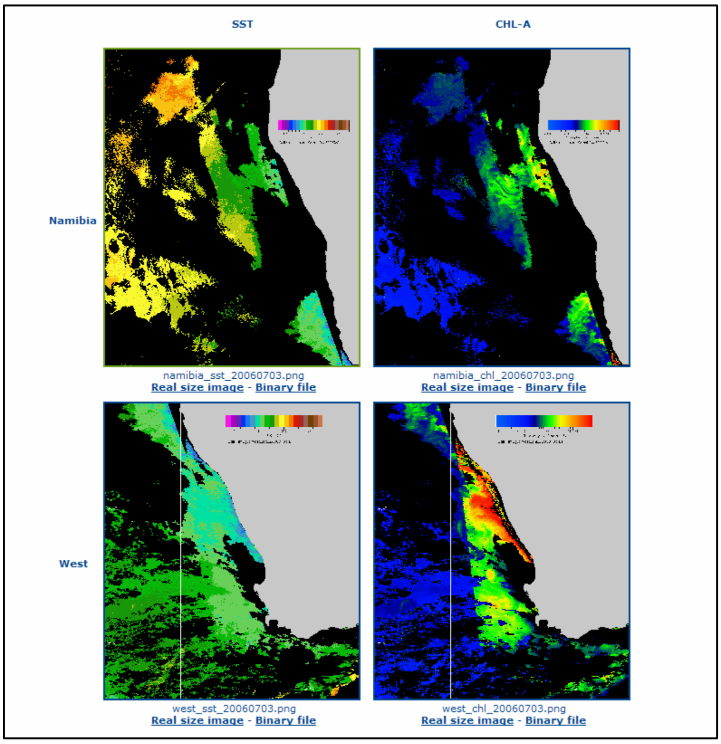
A series of simple exercises are used to introduce new users to the server, and the available visualization tools. Users are encouraged to experiment as they proceed through the tutorial to further familiarize themselves with the available server options. These exercises make use of the ***SeaSat*** visualization tool, which can be installed from the CD accompanying this tutorial, or downloaded from the server site.

The server homepage, located at at http://www.rsmarinesa.org.za, can be seen below. There are two primary navigation bars: the top toolbar determines the regions visible (up to seven of them), and the date of the SST and Chl *a* preview images displayed; whilst the side menu determines the type of products displayed.



1. Viewing the latest products for your region of interest

The most recent daily images for all selected regions are displayed as default, so all you have to do is check or uncheck the boxes for the region(s) you wish to view, using the top toolbar. Click on the **Namibia** and **West** region in the top toolbar, and then click on **display** and you will see the latest preview SST and Chl a images for these two regions.



Try checking the boxes for one or several other regions, using the top toolbar, and scrolling down the preview screens to see what the regional previews look like. The latitudes and longitudes of all the display regions available are shown below.

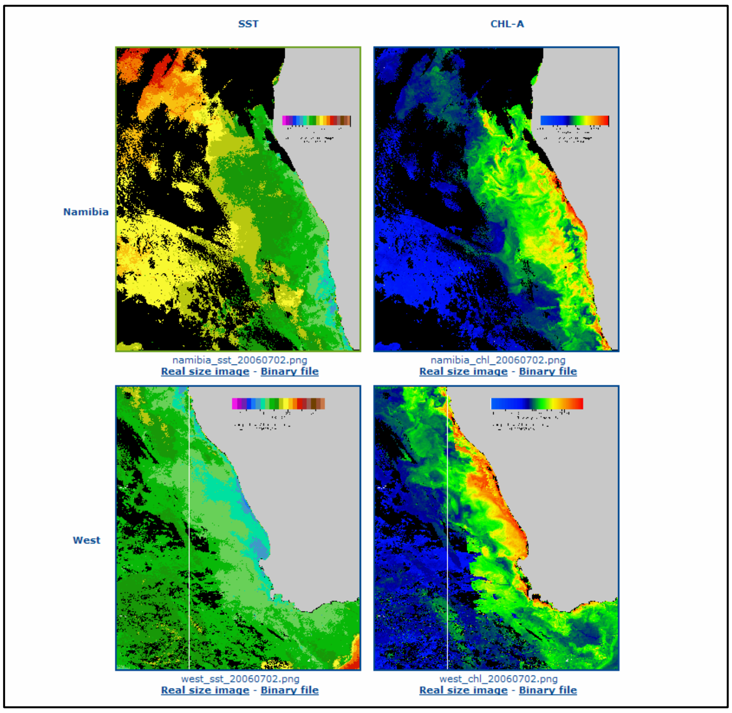
Display Regions:				
Angola:	4°S	4°E to	15°S	16°E
Namibia:	14°S	4°E to	28°S	16°E
West:	26°S	12°E to	37°S	22°E
South:	31°S	18°E to	41°S	28°E
East:	27°S	27°E to	37°S	40°E
Delagoa Bight:	18°S	32°E to	28°S	45°E
Madagascar:	10°S	37°E to	20°S	49°E

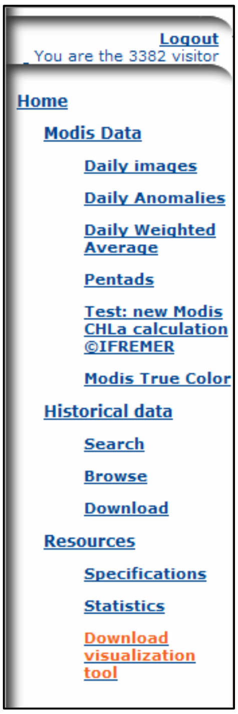
1. Viewing the latest products for your region of interest

Whilst the top toolbar allows selection of display region and date, the menu on the right can be used to display different product type. A brief summary of the product types available is shown below.

default NASA Ocean Color Group processed daily SST and Chl *a* daily products	Daily Images
calculated from 9km 5 day Pathfinder climatology data for SST, and 9 km monthly SeaWiFS climatology for Chl *a*.	Daily Anomalies
three day mean – used to display relatively cloud free images at the expense of temporal definition	Daily Weighted Average
five day mean – used to display relatively cloud free images representative of longer time scales	Pentads
Chl a images calculated using a new algorithm that accounts for the sometimes poor MODIS atmospheric correction	Test: new Modis CHLa calculation ©IFREMER

Try choosing different product types from the right hand menu e.g. the **Daily Weighted Average** or **Pentad** products, rather than the **Daily Image**. You should see a decrease in image clouding – note that this is at the expense of temporal definition, something which should be borne in mind if you are looking at a highly dynamic system such as the Benguela.





Once you have found the region and product of your choice, click on the preview image you wish to examine more closely to switch view to a high resolution bitmap of this image. You may have to rescale the full resolution image when it appears in your browser window. You can copy and save either the preview or full size image by right clicking to copy and paste.

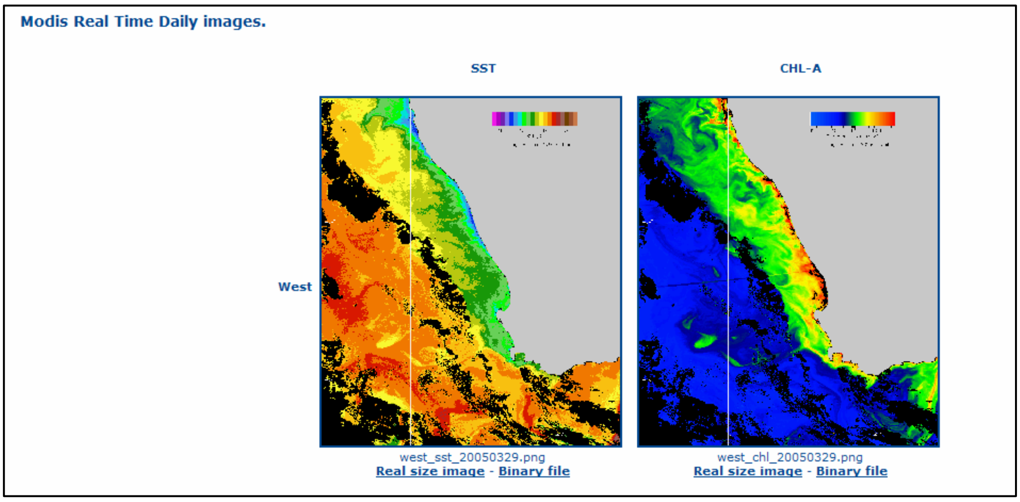
2. Viewing products for your region of interest from specific dates

It is also possible to view archived imagery for all the regions. The simplest way to view single images is to use the date boxes in the top toolbar. Simply enter the date you wish to preview in the boxes supplied – make sure to use the specified format and enter all leading zeros for month and day.

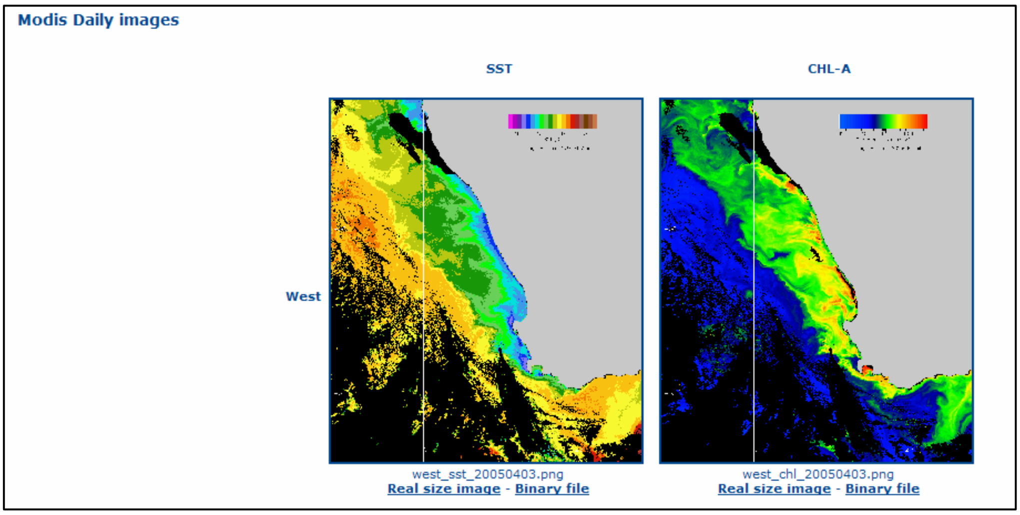
Choose a date (YYYY-MM-DD, e.g. 2006-01-01) and areas to display, otherwise the latest image and all the areas are displayed.
Date: 2005 03 29
Visible areas: ☐ Angola ☐ Namibia ☑ West ☐ South ☐ East ☐ Delagoa Bight ☐ Madagascar **display**

Please read **Data specifications**, and be aware that **palettes are not consistent for all the areas.**

The sample image shown is from the 29th of March 2005 on the South African west coast; depicting warm surface waters and intense dinoflagellate blooms in the St Helena Bay region.

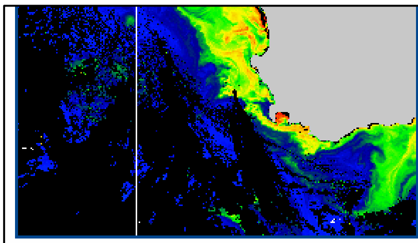


Try choosing a second image on 2005-04-03 (the 3rd of April 2005) which shows greatly elevated upwelling in Columbine region six days after the first image, and some dispersal of the high biomass blooms in the St Helena Bay region.



3. Downloading and analyzing data files for use with the *SeaSat* tools

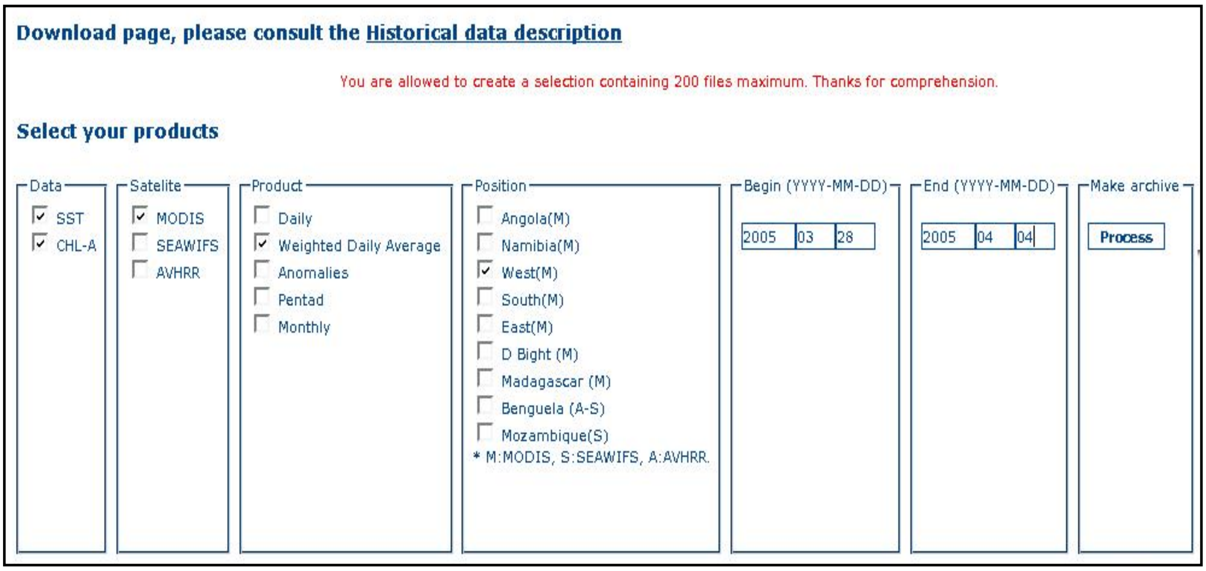
Users wishing to use the remotely sensed data in addition to the imagery can do so with the ***SeaSat*** tools, available with the CD accompanying this tutorial or as a download from the server site. Before demonstrating ***SeaSat*** use, ways of downloading single and multiple data files from the server are shown. The simplest way to download a single data file is to click on the **Binary file** link under each preview image, and save the file.



west_chl_20050403.png
Real size image - Binary file

Downloading multiple data files

Access the download area by clicking on the Download link on the right menu, under Historical data. Choose the products you would like, and enter a start and a stop date, then click Process. You can consult the Historical data description link to find out more about the datasets that are available. Your selection will be provided as a Zip file, and this file will contain both the binary compressed files (.bil.gz) and their associated images (.png).



Focusing on the same sample data set as the previous section, try downloading a dataset of SST and Chl *a* data for the South African west coast from 28th March 2005 to 4th April 2005. Set up a download selection as above, and press Process. The system will then tell you the number of files in the archives, and ask for confirmation - press Make archive. After a moment, you will be told that your file is downloadable here. Download the Zip archive file and decompress it. Be aware that these files can be large – the example data set above is contained in a 10 Mb file.

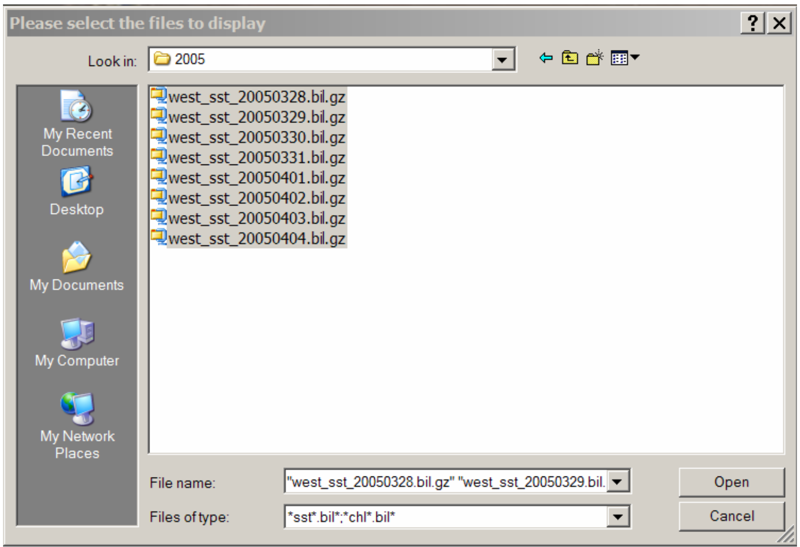
4. Using the ***SeaSat*** visualization tools to view and extract data

Download and install the ***SeaSat*** visualization tools

You can access the visualization tool download page by clicking on the Download Visualization Tool link on the right hand side menu. Alternatively, the installation files are on the CD accompanying this tutorial. To install the tool, you will need both the IDL Virtual Machine, and either Seasat for Windows or Seasat for Linux depending on your operating system. The Windows files are self extracting Zip files, so just download them (from the site) or copy them (from the CD), double click and follow instructions. When installing the IDL Virtual Machine, ensure you select the option to install the Virtual Machine rather the Whole Development Environment. Please be aware that the IDL Virtual Machine is a large file of ~ 115 Mb.

Starting ***SeaSat*** and choosing a data set

SeaSat **has been designed to allow non-specialists to manipulate the binary satellite data that can be downloaded from the server site. After installation double click on the** *SeaSat* **icon which has appeared on your desktop to launch the application. Following our tutorial example, try opening the data files you downloaded previously in Section 3.. First, unzip the archive file that was downloaded from the server – it will look something like 1152009018.zip. Then launch** *SeaSat* **, if you have not already, and browse into the directory you unzipped your archive file to. Then select one or multiple files using multiple selection windows keys – either by holding down the *Ctrl* key whilst selecting files, or by drawing a box with the mouse around the files you wish to select.** *SeaSat* **will automatically decompress the zipped data files, so you can select either the compressed data files (.bil.gz), or uncompress the files first and then select the binary data files (.bil). You should see something like the dialog box below, where the sample SST data files from the west coast from 28th March 2005 to 4th April 2005 are being selected. Note that some versions of Windows will only handle the uncompressed files (*.bil), so please try using these if** *SeaSat* **gives errors**



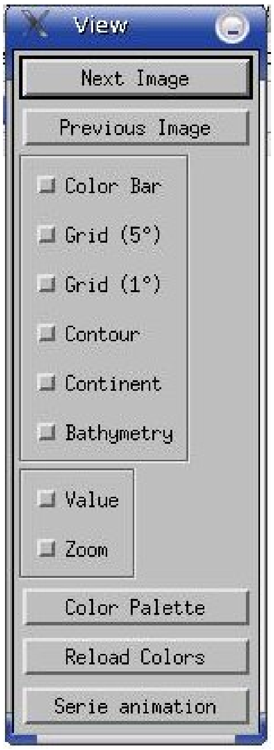
opening the compressed files (*.bil.gz).

4. Using the ***SeaSat*** visualization tools to view and extract data

SeaSat has two main components, a navigation bar that allows you to customize your view and navigate through the time series you've chosen, and a main window for displaying and extracting data. The purpose of this document is not to describe all the functions available in _SeaSat_ – the software has extensive help documentation and experimentation is encouraged as the best way to discover how to use _SeaSat_ for your purposes. Please keep in mind that _SeaSat_ is still under development, and should be regarded as a trial product - your feedback as a remote sensing user are very important in further developing this tool and you are strongly encouraged to comment on any aspect of the tool.

The SeaSat navigation bar

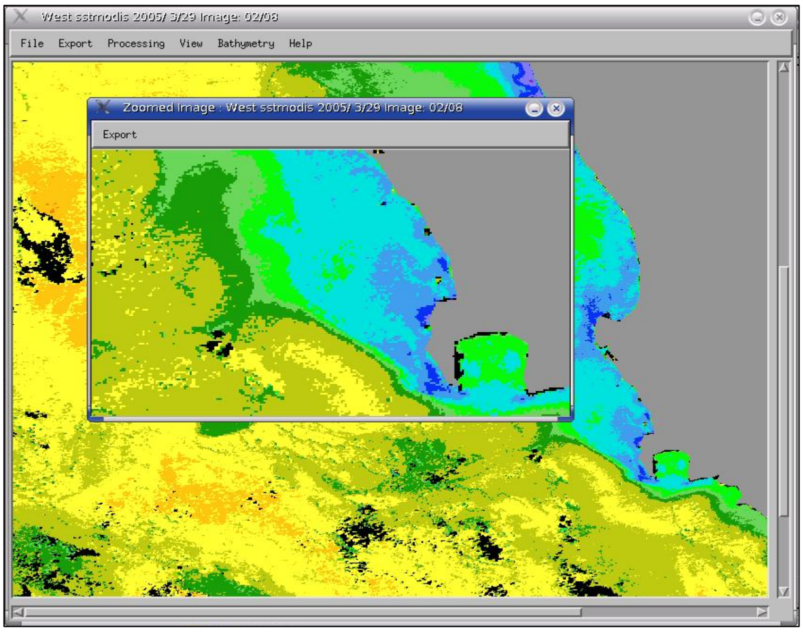
The main functions available through the navigation bar are described below.



Next image: display next image.
Previous image: display previous image
Color Bar: display color bar corresponding to the physical parameter.
Grid 5: draw a grid of 5° latitude and longitude in the main and zoom window.
Grid 1: draw a grid of 1° latitude and longitude in the main and zoom window.
Contour: display the contour dialog box in the main and zoom window.
Continent: draw the coast line.
Bathymetry: Show bathymetry.
Value: Enable values to be displayed by clicking in the main or zoom window.
Zoom: Displays the zoom dialog box. Click in the main window and drag keeping the left mouse button down. The Zoombox of this new area will be drawn**.**
Color Palette: display the color adjustment color tool.
Reload color: reload initial color values.
Serie animation: run through the time series of loaded images.

The main SeaSat display window

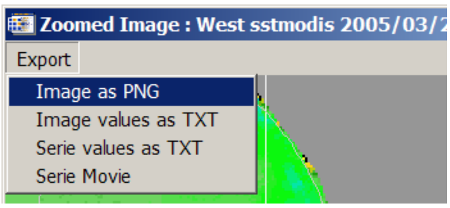
The main display window will show the first of the images you have selected at full resolution. Try selecting the zoom tool in the navigation bar and draw a rectangle in the main window around the southern Cape region. Try experimenting with the various other options available on the navigation bar to see the results e.g. extracting single values, adding bathymetry, or adding a grid.

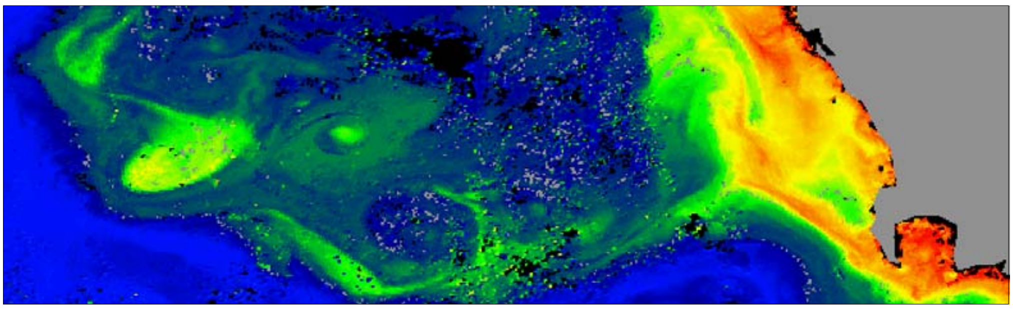


The menu bar within the main or zoom window also allows you to perform other tasks, such as exporting the image you have modified as a bitmap file, or extracting quantities of data. Some of the more common tasks you might wish to perform are described below.

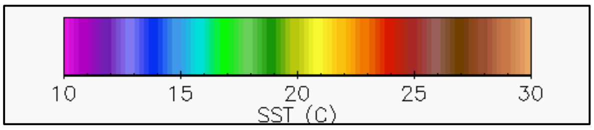
Creating a bitmap of the modified image

Export\Png: **create an PNG image of what you see in the either the main or the zoom window. The file will be written to \output\png\ in the main SeaSat directory path e.g. C:\Program Files\Seasat\output\ png. An example of the image output you can produce is shown below.**

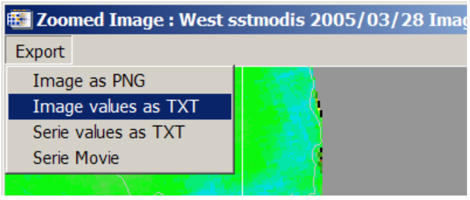




You may also wish to export the image legend to complement the image – simply choose export/as PNG in the legend window, and you will produce the following.



Creating a text file of the image data

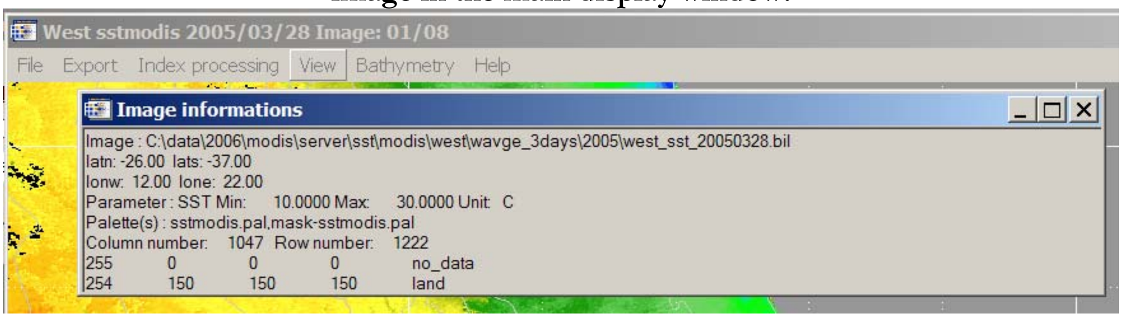


Export\ txt: creates a text file of the zoom window which contains latitude, longitude, and geophysical values from each pixel. The file will be written to \output\txt\ in the main SeaSat directory path e.g. C:\Program Files\Seasat\output\txt. Be aware that this can create very large files if your zoom area is too big e.g. a 3° x 3° zoom area will produce a file with ~100,000 lines. An example of the text output you can produce is shown below.

```
Current parameter : SST   Unit: C
Area LonW:        17.1767
Area LatS:       -34.3175
Area LonE:        18.5043
Area LatN:       -33.4804
Lon: 17.18 Lat:-34.32 value:no_data
Lon: 17.19 Lat:-34.32 value: 20.20
Lon: 17.20 Lat:-34.32 value: 20.00
Lon: 17.21 Lat:-34.32 value:no_data
Lon: 17.21 Lat:-34.32 value:no_data
Lon: 17.22 Lat:-34.32 value: 20.00
Lon: 17.23 Lat:-34.32 value: 16.80
Lon: 17.24 Lat:-34.32 value: 18.20
```

Viewing a summary of the image data

Menu View\Image information: **See the summarized characteristics of the current image in the main display window.**



Appendices: Data Specifications

You can find also product specifications on the web site, in the top toolbar, under the Data specifications link.

[redacted]

All the binary files are coded using bytes, and the png images are created using personal palettes.

Daily products **are generated from Modis L2 data, downloaded from the NASA OceanColor group web portal, using SeaDas Software and personal developments.**

SST Daily anomalies **are calculated using 9 km resolution 5 day Pathfinder climatology.**

CHL-A concentration anomalies **are calculated using 9 km resolution monthly SeaWiFS climatology.**

The Modis daily weighted average **product is a weighted average of day-1 (weight=1), day (weight=3), and day+1 (w=1).**

Pentads products **are an average of day to day-5 (naming convention: area_parameter_year1month1day1@year2month2day2)**

[redacted]

SST encoding procedure:

To get physical value from the byte value, apply the formula: y = (0.2 * PixValue)

Unit: Degree Celsius (°C)
Accuracy: 0.2 degree
No data Value: 255
Land value: 254

CHL-a concentration encoding procedure:

Unit: mg.m^{-3}
No data Value: 255
Land value: 254
To get physical value from the byte value, apply the formula: y = 10^(PixValue*0.015-2)

SST and CHL-A anomalies encoding procedure:

To get physical value from the byte value, apply the formula: y = 55 - 0.5*PixValue

Unit: Degree Celsius (°C)
Accuracy: 0.2 degree
No data Value: 255
Land value: 254

[redacted]

Angola area **(called Angola)** **limits=[15S,4E,4S,16E]** **xsize=1315** **ysize=1222**	South area **(called South)** **limits=[41S,18E,31S,28E]** **xsize=899** **ysize=1111**
Namibia area **(called Namibia)** **limits=[28S,4E,14S,16E]** **xsize=1245** **ysize=1555**	East area **(called East)** **limits=[37S,27E,27S,40E]** **xsize=1225** **ysize=1111**
West area **(called West)** **limits=[37S,12E,26S,22E]** **xsize=1047** **ysize=1222**	Delagoa bight **area (Called Dbight)** **limits=[28S,32E,18S,45E]** **xsize=1324** **ysize=1111**
Madagascar area **(called Mada)** **limits=[20S,37E,10S,49E]** **xsize=1288** **ysize=1111**	

[redacted]

SeaWiFS data are generated using L2 product from OceanColor group, SeaDas Software and personal developments. CHL-a concentration anomalies are calculated using 4 km resolution 5 day SeaWiFS climatology. The CHL-a concentration encoding procedure is the same as the Modis CHL-A product.

[redacted]

Benguela area (Called Ben2) **limits=[-40,5,-5,40]** **xsize=825** **ysize=825**	**Mozambique area (Called Moz)** **limits=[-30,30,0,54]** **xsize=576** **ysize=720**

[redacted]

Server & web site design: Bertrand Saulquin
Tutorial: Stewart Bernard, Bertrand Saulquin