NEODAAS: NERC EARTH OBSERVATION DATA ACQUISITION AND ANALYSIS SERVICE – NEW DEVELOPMENTS

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ABSTRACT:

The NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS a partnership between the Dundee Satellite Receiving Station and Plymouth Marine Laboratory) is funded by NERC to provide satellite data and products for the UK research community. Capabilities include the reception, archiving, processing and analysis of satellite data, along with support and research duties. NEODAAS products include geo-referenced chlorophyll concentration and other ocean colour properties from the MODIS, MERIS and SeaWiFS sensors, sea-surface temperature, land brightness temperature and vegetation index from AVHRR, and regular global coverage data from geostationary satellites including Meteosat and GOES. Atmospheric correction of freshwater and marine data acquired through the NERC Airborne Research and Survey Facility is also possible.

This paper will demonstrate the range of NEODAAS services, products, website tools, and recent developments including: processing of 500m MODIS chlorophyll-a and 250m water leaving radiance – which can be used to monitor suspended particulate matter; improved support for monitoring atmospheric dust by routinely processing L1b true colour (SeaWiFS and MODIS Aqua) images with areas of sun glint highlighted; access to Advanced Synthetic Aperture Radar products provided in near-real time through the ESA rolling archive; and closer integration between the Dundee and Plymouth services through the NEODAAS website. In-house research and development of inherent optical property models is also leading to the development of more robust ocean colour products. The ability to visualise our data in Google Earth has also been added to improve accessibility of satellite data.

1. INTRODUCTION

This paper gives a brief overview of the capabilities of NEODAAS (NERC Earth Observation Data Acquisition & Analysis Service) and to highlight new developments. This service was established in September 2006 linking the Satellite Receiving Station at Dundee and Remote Sensing Data Analysis Service based in Plymouth. These are now referred to as NEODAAS-Dundee and NEODAAS-Plymouth. The service provides the capability to receive, archive and process many satellite data in near-real-time, along with provision of support and analysis services to UK scientists using satellite data. In addition, staff undertake research to improve and extend the range of remote sensing products available to the UK research community.

Satellite data reception takes place at Dundee where a number of systems obtains data from a variety of satellites including NOAA, Aqua and Terra polar orbiting platforms and recently the new MetOp-A satellite. These provide multiple passes a day over the Dundee receiving range, from AVHRR (Advance Very High Resolution Radiometer) and MODIS (Moderate Resolution Imaging Spectroradiometer). Data are also received from geostationary platforms such as MSG (Meteosat Second Generation) at 15 minute intervals and GOES (Geostationary Operational Environmental Satellites), providing global coverage of the Earth, but lower spatial resolutions than the polar orbiting platforms. The service is currently authorised to allowed to distribute MSG data in its 6 hourly format.

The addition of data reception from the EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) new MetOp-A satellite was one of the major recent developments at NEODAAS-Dundee following the launch in October 2006. This will allow the service to continue its unique continuous archive of AVHRR data, started in 1978, from various satellite platforms. Despite having the same AVHRR instrument on board as existing NOAA satellites, the new data reception required much updating of hardware and software systems.

To provide global coverage the service also acquires data directly from NASA (National Aeronautics & Space Administration), NOAA (National Oceanic & Atmospheric Administration) and ESA (European Space Agency). This takes a little longer than the direct reception from Dundee. As well as providing global coverage this also allows the service to process data from more sensors including: SeaWiFS (Sea viewing Wide Field-of-view Sensor) and MERIS (Medium Resolution Imaging Spectrometer) and ASAR (Advance Synthetic Aperture Radar) data through ESA's 7-day rolling archive. The near-real-time availability of these data sets is vitally important to marine monitoring and research cruises that the service supports outside the Dundee range.

2. METHODS

2.1 Processing chain

The routine processing of satellite data at NEODAAS has a number of steps from data reception through to generation of mapped products and composites. Satellite data reception and archiving is done in-house at NEODAAS-Dundee. Quicklooks are generated for these products and provided to registered users via the web site. Customers who need access to the raw pass data can also gain this from the archives.

In cases where data are required for sensors or areas not available via NEODAAS-Dundee, the service downloads data from NASA, NOAA and ESA on a subscription basis and automatic systems retrieve new pass data from the remote servers when they become available.

Mapping and processing of data occurs once they have been transferred via internet to NEODAAS-Plymouth. The AVHRR, MODIS, MERIS, ASAR and SeaWiFS passes are all processed in by automated systems that extract and map specific products which include SST (sea surface temperature), chlorophyll-a, true colour (level 1b and level2) and water leaving radiance at various wavelengths. Once individual pass products have been mapped they are composited to create daily, weekly, monthly or arbitrary length level 3 data. Processed data are then mirrored to the NEODAAS website and can be searched and viewed through the NEODAAS data portal (www.neodaas.ac.uk/data_portal/).

The highly automated systems allow data from recent satellite overpasses to be processed, mapped and mirrored to the website in near real-time i.e. in the order of a few hours depending on data source. The service also deals with requests from the UK academic research community and re-processes products for specific sensors, areas of interest and date ranges. In these cases data are supplied to the user in a variety of formats from basic ASCII to geo-spatial formats such as GeoTIFF. Alternatively, data may be extracted from specific points, tracks or boxes in spreadsheets format with a range of statistical parameters.

2.2 Improvements to service resilience

One of the main objectives for NEODAAS is to be able to provide efficient and uninterrupted service to its many customers. Over the last year a new “grid-engine” computer cluster system has been installed and tested at the NEODAAS-Dundee site. This will act as a backup for the current processing at Plymouth and also speed up the processing of data received at Dundee – which will positively impact on near-real-time applications of data.

To improve the resilience of the website and ensure data are still available to customers, steps are being taken to investigate hosting the web-site off-site. Whilst content would still be under our control the hardware would be off site and run by a dedicated hosting service that can provide high levels of availability.

3. RESULTS: CASE STUDIES OF NEW NEODAAS DATA AND SERVICES

The field of remote sensing is ever changing and progressing. As a dynamic service, NEODAAS is continually striving to add new and improved data products and services. Some recent changes are outlined below to give an idea of how this service can be exploited by the UK research community.

3.1 New MODIS Products

3.1.1 Routine Processing of High Resolution MODIS Data: Due to an increased need to monitor coastal and estuarine environments it is desirable to produce ocean colour products at spatial resolutions higher than 1 km. Each MODIS sensor has one 250 m band and two 500 m bands in the visible part of the spectrum. Whilst the processing of these higher spatial resolution bands has been possible for land applications, their routine use in ocean colour has not been possible.

Recent work (Shutler *et al*, 2006) has provided the ability to generate chlorophyll-a products mapped to 500 m. Previously it was only possible to process chlorophyll-a from the 1 km MODIS bands using various algorithms such as OC3M. However this algorithm is not applicable to the high resolution visible bands as it uses bands with different centre wavelengths.

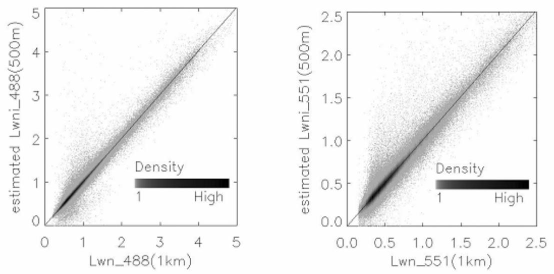

Figure 1. Match-up of 1km water leaving radiance (L_{wn}), at 488nm and 551nm, with the equivalent estimated 500m L_{wn}’s.

The chlorophyll-a algorithm of Carder *et al* (1999) uses two bands which are reasonably close to the centre wavelengths of the 500 m bands. Through spatial and spectral interpolation it is possible to determine the 500 m atmospheric correction parameters from their 1 km counterparts. A similar approach is then used to determine the simulated data at the wavelengths required for the Carder chlorophyll-a algorithm. Figure 1 shows the match-ups between the actual 1 km bands and the estimated 500 m bands for 12 passes in 2003. Figure 2 shows mapped 1 km and the novel 500 m products of water leaving radiance and chlorophyll-a respectively. These simulated bands are then used to generate a chlorophyll-a product from MODIS 500 m data. Following validation against in situ samples and existing 1 km MODIS chlorophyll-a data, this technique shows good promise.

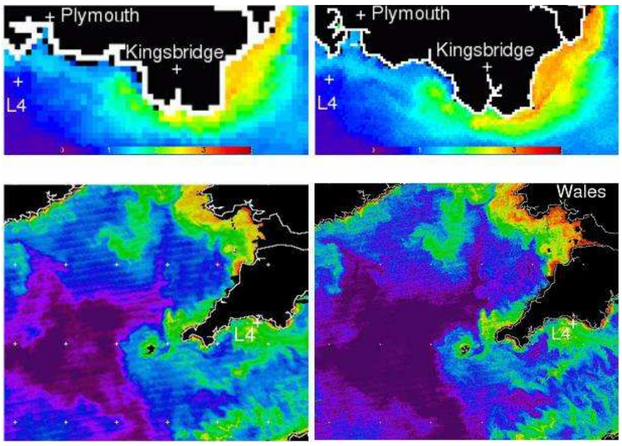

Figure 2. (top) Aqua MODIS L_{wn} images of the south Devon coast for 11 July 2005, 13:38 UTC at (left) 1 km resolution L_{wn} (551nm) and (right) 500 m resolution L_{wn} (555 nm); (bottom) Aqua MODIS chlorophyll-α images of South West UK waters: (left) 1 km resolution OC3M; and (right) 500 m novel chlorophyll-α algorithm.

In a similar manner a water leaving radiance product can be generated from the MODIS 250 m visible band. This band’s centre wavelength is well suited to provide a qualitative guide to suspended particulate matter.

3.1.2 Level 1b Top Of Atmosphere Products: Monitoring of sand and dust storms has become an important activity due to increased environmental risks and effects on regional climates (Qu *et al*, 2006). Studies such as the UK Surface Ocean / Lower Atmosphere Study (SOLAS) are looking into ocean-atmosphere interactions (and effects on the environment). In support of some of the SOLAS cruises, NEODAAS has developed a new MODIS level 1b processing chain which generates of top of atmosphere (TOA) images with global coverage. This product is useful in visualising areas of the data that would otherwise be masked out by atmospheric corrections used in level 2 products.

SOLAS cruises are making use of these data to monitor dust in near real time. Due to the low latitude of the studies, around the Cape Verde Islands, it is also necessary to highlight regions of sun-glint in the images. This prevents the sun-glint being miss-identified by the untrained eye as dust.

A sample of the L1b true colour data can be seen in Fig. 3 as used for support of SOLAS cruises in 2007. This shows a composite of all pass granules in the region of West Africa on 17^{th} June 2007. Areas of sun-glint have been annotated as previously described. Down the left hand edge of the image a zone of sun-glint has been highlighted, and forms a distinctive strip. Next to this it is also possible to see a region over the ocean showing atmospheric dust being transported from the land (Sahara) over the ocean.

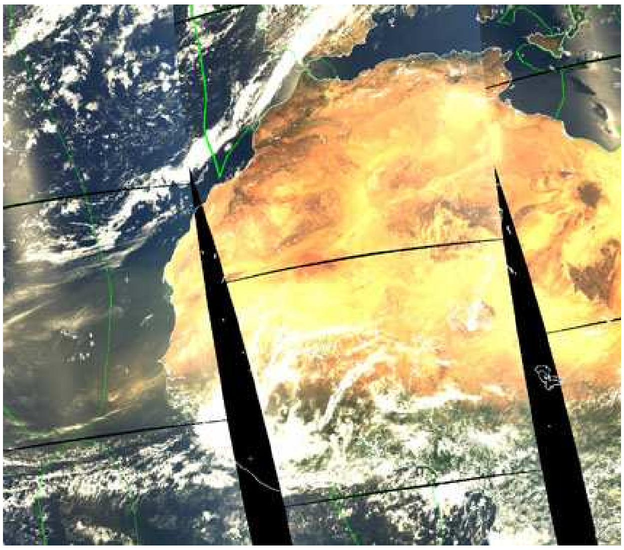

Figure 3. Level 1b (top-of atmosphere) true-colour image of 17th June 2007 showing West Africa. The image is a composite of all pass granules for that day. Sun-glint regions are automatically highlighted with a green outline.

3.1.3 Inherent Optical Properties products:
The extension of the MODIS processing systems to produce inherent optical properties (IOPs: Smyth *et al*, 2006) has been completed and these are now produced in near-real time for U.K. waters. The IOP model calculates spectral absorption (a) and backscatter (b_b) for the available wavebands. These parameters are further broken down to more specific products such as: absorption due phytoplankton (a_{ph}), absorption due to detrital and coloured dissolved organic matter (a_{dy}) and backscatter due to particles (b_{bp}) for given wavebands (see Fig. 4). Basic water clarity (horizontal and vertical) products are now routinely processed and provided to the Met Office to integrate into their models.

These products are also playing an important role in developing systems that can detect and differentiate various plankton blooms.

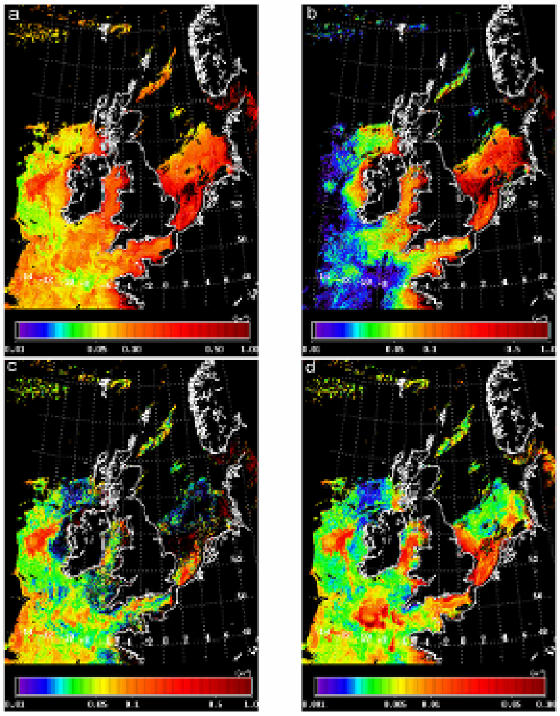

Figure 4. (a) Total absorption at 443nm, a(443): high values (0.2 – 0.5 m^{-1}) in coastal seas; (b) $a_{dy}(443)$: coastal seas dominated by CDOM; (c) $a_{ph}(443)$: phytoplankton bloom to the west of Ireland; (d) $b_{bp}(555)$: high scattering in the Celtic Sea caused by a *Emiliana huxleyi* bloom (confirmed from in situ samples).

3.2 New MERIS Products

The NEODAAS service aims to process land products such as top and bottom of atmosphere vegetation maps from MERIS data. Currently the service supplied ocean colour products but and terrestrial data will be a natural development. It will also be possible to obtain the 300 m data on a regular basis in the future facilitating the generation of high resolution land maps and indices, as well as ocean colour products.

3.3 Processing of ESA ASAR Data

Along with the ocean colour data that NEODAAS-Plymouth routinely downloads and processes from ESA's rolling archive, it has also been possible to gain access to ASAR (Advanced Synthetic Aperture Radar) data. Following a successful proposal to ESA, we have developed a processing methodology with the aim of providing ASAR data to the SOLAS cruises in near-real time.

The design of the ASAR instrument on ENVISAT means that it can operate in one of five, mutually exclusive, modes. Whilst this provides some flexibility it also means that the Wide Swath Mode (WSM) data, which provides global coverage, is not always available. To guarantee these are available for research cruise support it is necessary to request that the WSM mode be activated for the relevant.

3.4 Environmental Monitoring

To support wider outreach an environmental monitoring web page is being developed. This provides simple viewing of remote sensing products by the science community and the general public. Example products include level 1B TOA true colour, coccolithophore bloom maps, ASAR backscatter products, dust and vegetation indices, IOPs and primary productivity maps.

3.5 Visualising Data via GoogleEarth and Open Geospatial Consortium approaches

PML is at the forefront of developments for visualisation of satellite and in situ data as well as numerical models. With the increasing use of Google Earth, KML (Key-hole Markup Language) scripts have been generated to provide data visualisations for the AMT (Atlantic Meridional Transect) programme. This displayed a combination of the cruise tracks from the programme along with point CTD data that could be displayed through pop up windows, all overlaid on a MODIS Aqua monthly 4km global chlorophyll-a composite.

a

b

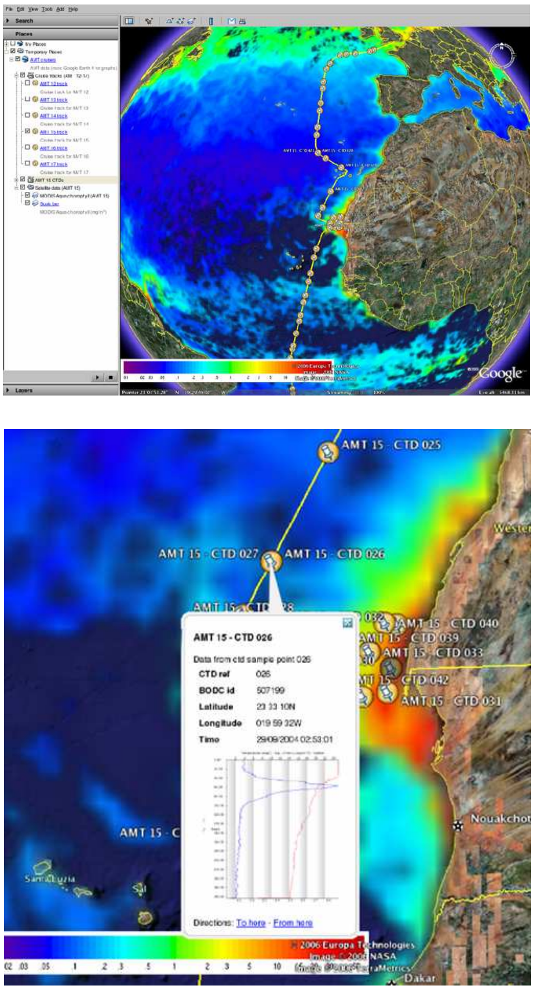

Figure 5. Example Google Earth data visualisations. a) MODIS chl-a for N Atlantic overlaid with AMT cruise tracks and station locations. b) Dynamic link from GE to database.

One of the aims for the service is to allow users to easily load data products from its website into Google Earth. To aid this process it is necessary to first change the map projection of data to be compatible with Google Earth. At present most of the mapped data are in Mercator projection whilst Google Earth requires data in Geographic format.

Figure 6. Screen shot from NEODAAS WMS/WFS. Bathymetry and coastlines are overlaid on a MERIS chl-a image from 7th June 2007 around the UK, along with an ASAR scene off the coast of Portugal. In the Tamar estuary a point is linked through a web feature server (WFS) to river flow data.

In parallel to developing 3D visualisations for our data, work is also underway to complete open standards approaches to data visualisation using the Open Geospatial Consortium specification such as a Web Map Server (WMS). These will allow users to easily compare data by loading complementary layers. For example, overlaying wind vectors on SST (sea surface temperature) images. An example screen shot from this WMS can be seen in Fig. 6. showing Western European waters with a variety of layers activated.

The demo WMS interface includes: satellite data from MODIS, MERIS and ASAR; overlays of coastlines and bathymetry at varying depths; and in-situ data from sources such as the PML meteorological observatory, UK water quality sample locations and river estuary samples.

3.6 Airborne Research and Survey Facility Data Processing:

PML has taken over responsibility for processing data from the NERC Airborne Research and Survey Facility (ARSF) and processing line has been established at PML. Processing of ARSF data requires geo-correction to correct for aircraft motion and attitude variations along track as well as radiometric calibration.

Current instruments include the Compact Airborne Spectrographic Imager (casi) and the Airborne Thematic Mapper (ATM), but from 2007 data will be operationally taken from the SPECIM Eagle/Hawk, a new dual instrument that provides continuous spectral coverage from 400 to 2400nm.

Fig. 7 shows an example false colour scene near Kielder. The degree of mapping due to aircraft attitude changes can be seen quite clearly by the uneven edge of the data. ARSF data users seeking advice on ARSF processing should contact arsf-processing @pml.ac.uk

Figure 7. Sample mapped output from aircraft processing of AMT data. Image shows part of a mapped false colour scene (bands 2, 3 and 5) in the area of Kielder.

4. CONCLUSIONS

This paper has presented the NEODAAS service and highlighted developments over the last year. From this it has been demonstrated that this service offers an impressive range of products and support duties to the UK scientific research community along with a unique ability to tailor data requests to individual customers needs. Work at NEODAAS will continue to develop new products and tools and improve existing ones, keeping the service relevant to the ever advancing field of remote sensing. Any enquiries about the service or requests for data, analysis or support can be sent by email to info@neodaas.ac.uk.

5. REFERENCES

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