Experience of Applications of Near Real Time JASON wave and wind data.

David Cotton, Ellis Ash and David Carter
Satellite Observing Systems, 15 Church Street, Godalming, Surrey GU7 1EL, UK
Phone +44 1483 421213, Fax +44 1483 428691,
d.cotton@satobsys.co.uk

Satellite Observing Systems

ABSTRACT
Perhaps the most usual application of Near Real Time (NRT) satellite altimeter wind and wave data is through assimilation into wave models. (NRT- delay from measurement to application of less than 3 hours). However, a number of users have a requirement to receive satellite wind and wave data at first hand. This enables the user to compare directly these data with other sources of information at their disposal, and so come to operational decisions informed by the best available information
Satellite Observing Systems (SOS) routinely receives and processes NRT JASON data through ftp (and, intermittently, though the GLOBECAST satellite link), and is now carrying out a number of trial applications of these data. In this presentation we provide an overview of these applications.

Sea State Alarm
In this demonstration application, near real time JASON significant wave heights are quality controlled, calibrated and then overlaid on the wave model forecast appropriate to the current time. The combined data are available in graphic or text format. Users can then assess the accuracy of the wave model forecast, judge how well severe events are represented in the forecast and then make appropriate operational decisions. Previous trials have involved vessels carrying out cable laying operations, and bulk LPG tankers. We also review a severe event experienced off the North West coast of Scotland in January 2003, and consider how availability of altimeter wave data could have contributed to the decision making process.

MISEC – Marine Information for Security.
MISEC is a UK project designed to extend existing technology by integrating near real time satellite observations and EO-based data into electronic charting services for potential users in the Marine Security field. The MISEC trials will integrate EO data from JASON and other satellites with foundation data sets such as charts, maps and background statistical information and investigate their potential value in support of Marine Security based operations and planning by the Ministry of Defence, the Royal Navy and UK Hydrographic Office.

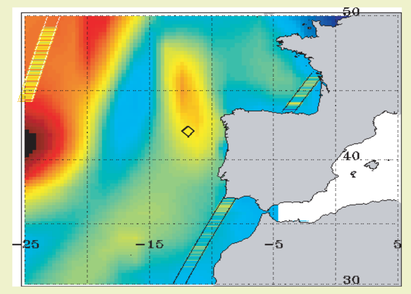
COASTWATCH
As part of the ESA GMES Services Elements COASTWATCH project, SOS is supplying near real-time wave information to CEFAS (Centre for Environment, Fisheries and Aquaculture Science), for evaluation and subsequent inclusion in their WaveNet monitoring system. The WaveNet system is a strategic initiative to provide real-time coastal wave data for Flood, Coastal Managers and other stakeholders in England and Wales. It consists of a network of buoys, and support from numerical models, but to date no satellite data have been included.

SEA STATE ALARM (1)

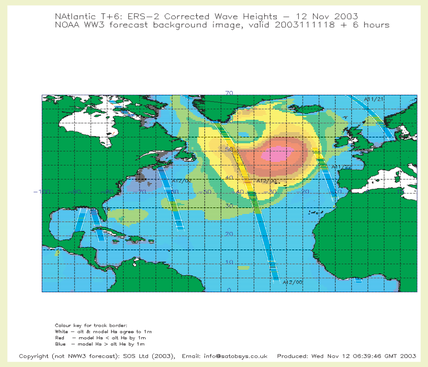
Very high waves are responsible for the largest environmental forces on ships and other offshore structures. Once the significant wave height rises above 7 metres most vessels need to reduce speed to limit damage to cargo or structure. Wave models often provide reliiable forecasts of moderate sea conditions, but when extreme events happen, they have more difficulty in accurately predicting the true situation - even if these models have assimilated satellite altimeter data.This deficiency has been recognised by offshore operators, particularly those who are carrying out operations sensitive to sea-state (e.g. cable laying, heavy lift operations, transport of unusual loads). The cost of unplanned abandonment of operations can be significant (>100s K€).

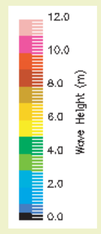
To address this issue, and investigate the potential value of delivering Near Real Time data direct to offshore operators, Satellite Observing Systems set up a "Sea State Alarm" demonstration . Altimeter wave height data are overlaid on the output of a wave model (in this example the NOAA WW3 model) and colour coded boundaries identify when the model and altimeter estimates of signficant wave height differ by more than 1m. Offshore operators have taken part in trials of earlier versions of Sea State Alarm (see panel below) and indicated that such a service could improve safety of operations, through helping real time decision making, but that a greater coverage than is available from a single satellite altimeter would be required for a genuinely useful and practical system.

Acknowledgement: The NOOA/NCEP WW3 web page is the source of the wave model output used on this page. We wish to emphasise that these data are, and have been used, for demonstration purposes only.



NRT JASON NRT OSDR, ERS FD and NOAA WW3 Model SWH. 12UTC 24 Feb 2003
The Diamond marks the location of the "Prestige".

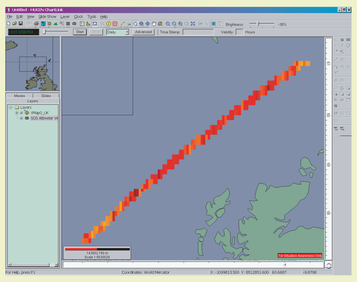




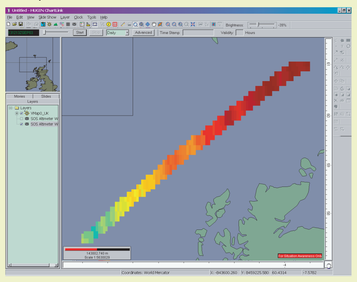
ERS-2 and NOAA WW3 model SWH for 00 UTC 12 Nov 2003
Blue borders indicate measured SWH lower than model by > 1m.

MISEC - Marine Information for SECurity

MISEC, for Marine Information for SECurity, is a project funded by the British National Space Centre. It began in June 2003 and runs until March 2004. The broad objective of MISEC is to investigate the integration of EO-based data and services into marine information products used for security purposes, specifically into the ChartLink product that is marketed by the lead partner, TENET Defence Systems. EO data are being provided by Satellite Observing Systems (wind and waves) and Plymouth Marine Laboratory (temperature and information derived from ocean colour).

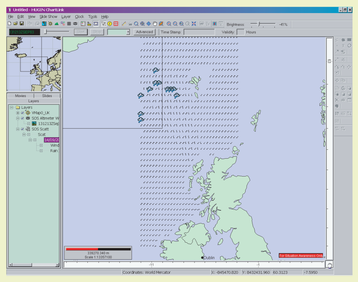


JASON OSDR 10m wind speed (knots) and significant wave height (m)
Date 13/09/2003 Time: 1213
Wave Height 4.8 to 6.6 m (blue = 0 m, red = 6.59 m)
Wind Speed 12 to 26 knots

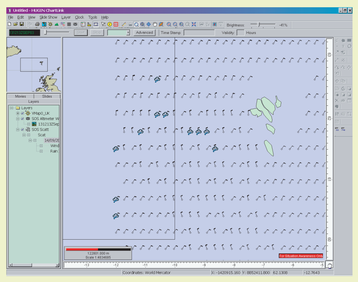


The main technical work was to develop the infrastructure required to deliver the EO-based data into the existing ChartLink system. This included the development of the appropriate processing capabilities to suit the data sources to be employed, and extensions to ChartLink to be able to read the data, which is provided in various formats, and visualise it in an appropriate manner. User feedback during the development period is a vital component of this work, supported by the plan to deploy the system during two maritime exercises (planned for early 2004).

In the four panels shown here we present screenshots taken from the modified Chartlink system. On the left sig. wave heights (top) and wind speeds (bottom) from JASON. On the right wind vectors from Quikscat.



Quikscat wind speed and direction
(cloud logos indicate rain flag is set)
Date 14/09/2003 Time: 0420
Wind Speed 5. to 47 knots



"MISEC" Screenshots courtesy of and copyright Tenet Defence Systems

SEA STATE ALARM (2) - A CASE STUDY carried out as part of the EC COMKISS project.

"Can satellite measurements of wave heights improve the decision-making process on a ship carrying out a mission sensitive to sea conditions?"

The case study reported here was carried out in the COMKISS European project. It consisted of provision of an experimental Sea State Alarm service to cable ship Dock Express 20 of Dockwise N.V. during the lay-out of a San-Francisco -- Guam telecommunications cable in spring 1999.

During the experiment, maps were sent as graphical files to the ship:
- General waveheight contour map of FNMOC WAM model
- Satellite measurements plotted as overlays, using the same colour scale
- Area covering Northern Pacific Ocean
- Planned route + last reported ship position
- File size around 44 KB, one or two updates per day

The transmission used internet and e-mails to the vessel were held in a mailbox and reached the ship only when the crew decided to (or were able to) remotely poll for mesages. In case of wave heights above the operational limit, a specific warning was sent.

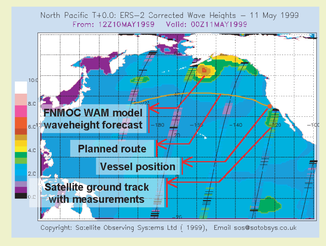
Analysis of the example (acros)
In the case of the single example presented, one can see that the FNMOC model underestimated high wave heights (12-6-99). On the other hand, although this is of less consequence, calm sea-states are overestimated.

The storm to the NE of the ship's location on 12.6.99 was ``behind" her, and the corresponding warning did not effect any decision on board. Had it reached the ship earlier, the warning of 14.6.99 would have fully demonstrated the benefit of the satellite data correction to the forecast. However, because of the time and span between satellite measurements, and of the procedure requiring the ship to poll its mailbox to retrieve the map, the crew were fully aware of the actual wave heights by the time they had retrieved the satellite corrections.

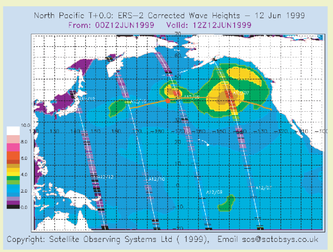
This experiment was thus a good demonstration of the validity of the principles used, and provided a strong encouragement to address the practical defects in subsequent follow-up trials.

Conclusions from the Captain of Dock Express 20:
- Data were considered correct, measurements close to vessel position were accurate.
- Graphical presentation is clear, it is best to cover a large area of interest.
- SSA warnings should be sent by FAX, vessel can then poll the data.
- Data were used to confirm other weather forecasts.
- SSA gave early warning to unpredicted adverse weather conditions.
- Size of data ~45 KB compared favourably to forecast provider's data (200 - 270 KB).

The Dock Express 20 trans-ocean cable laying Vessel



Example SSA image 10 May 1999.
ERS2 SWH and FNMOC model predictions.



SSA image of 12 June 1999.
ERS2 SWH and FNMOC model predictions.
Note the under-prediction by the model of the highest waves in the centre of the storm

COASTWATCH (An ESA GMES Service Element Project)

The European GMES programme (Global Monitoring for the Environment and Security) is a joint initiative of the European Space Agency (ESA) and European Commission looking to the future of Earth Observation (EO) technologies and applications.

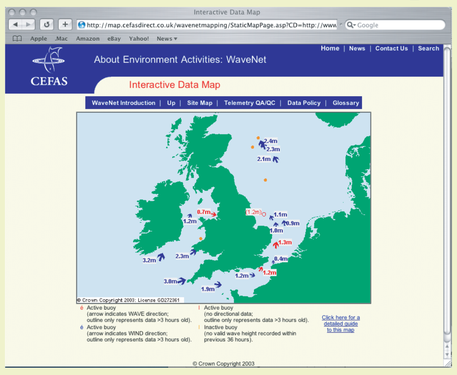
Coastwatch is one of 10 projects funded under ESA's GMES Service Element (GSE) programme that focuses upon the delivery of policy-relevant services to end-users, primarily (but not exclusively) from EO sources.

Coastwatch aims to respond to the growing need for cost-efficient monitoring data on the coastal environment triggered by European policy measures such as the Water Framework Directive, the European Strategy for Integrated Coastal Zone Management or the Bathing Water Directive. Coastwatch integrates a network of experienced service providers delivering EO based information products on the coastal and marine environment.

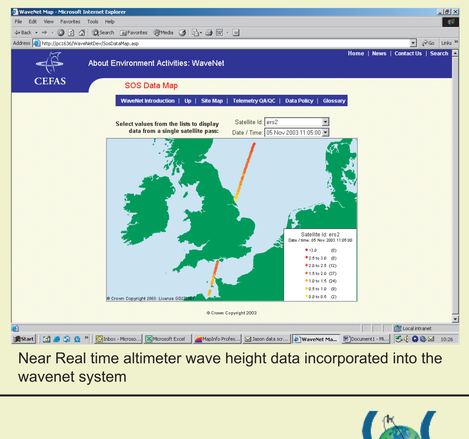
SOS is involved in Coastwatch as one of the 5 service providers with a role in providing statistics and near real-time information on sea state, based mainly on data from satellite altimeters and wind scatterometers.

Under COASTWATCH, SOS is providing Near Real Time JASON and ERS-2 altimeter wave data for evaluation and subsequent inclusion in the WAVENET Monitoring service. This strategic wave monitoring network for England and Wales aims to provide a single source of real time wave data from a network of wave buoys located close to coastal regions where flooding is a problem. Data from this network will be used to improve the management of flood and coastal erosion risk.

Acknowledgement: COASTWATCH Screenshots courtesy of Centre for Environment, Fisheries, and Aquaculture Science, UK



Real Time Wave Buoy data from the UK "WAVENET" System



Near Real time altimeter wave height data incorporated into the wavenet system

Case Study of 15 Jan 2003 Storm at Schiehallion off NW Scotland

At ~1500 UT on 15 January 2003 a severe storm hit the Schiehallion offshore installation to the N of Scotland. 48 hours previously, two MetOcean service providers had given widely differing predictions of the maximum significant wave height (Hs) to be expected - 17m and 9m (see table below). The higher estimate was dangerously close to the design Hs of the installation.

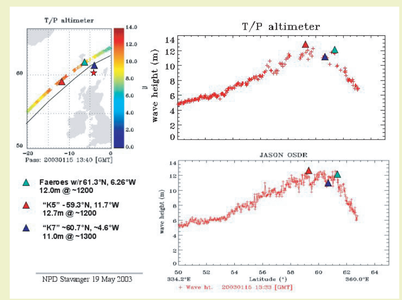
	H sig (1)	H sig (2)	H max (2)	10 m wind (1)	10 m wind (2)
72 hr		6 m	11.5 m		47 kn
48 hr	17 m	9 m	17 m	50 kn	50 kn
24 hr	16 m	12 m	21 m	50 kn	48 kn
12 hr		10 m	18 m		45 kn

Wind/Wave Forecasts for Schiehallion 15 Jan 2003

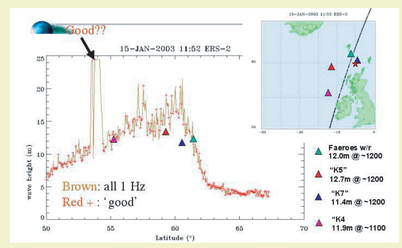
The platform operators had to decide whether to evacuate personnel from the platform, but had no objective basis to judge between the two forecasts. Post event analysis showed that TOPEX, JASON and ERS-2 passed close by in the hours preceding the highest waves. If real time satellite altimeter data had been available, they would have provided a robust basis for such a difficult decision. In the event, the lower forecast proved to be accurate, and the installation escaped severe damage. Nonetheless subsequent long period swell resulted in mooring damage.

Observations
During severe conditions, there is enhanced variability on small spatial and temporal scales - consequently models find these situations the most difficult to predict accurately, though it is precisely such conditions that represent the biggest risk to operations, personnel and the environment.

Recommendations
- A priority consideration is to improve model representation of small scale variability in the most energetic regions.
- Efforts should be made to reduce delay on NRT delivery of data (ideally to ~1 hour).
- Comparisons with nearby buoy data showed good agreement for significant wave heights of up to 12m.
- Co-location criteria for alt-buoy comparisons should be even more restrictive in severe (and so highly variable) conditions.



JASON and TOPEX IGDR Significant Wave Heights - 15/01/03
★ - Approximate location of Schiehallion



ERS-2 FD Significant Wave Height - 15/01/03

SATELLITE OBSERVING SYSTEMS

SOS is a private company, founded in 1988, which provides consultancy on marine remote sensing and wave data analyses based on satellite observations of the sea surface. The work of its expert group of consultants has evolved into 3 main activities:

• Promotion and Development of Marine Applications of EO data
Principal projects in recent years have included:
'COMKISS' - a study to evaluate the contribution of satellite wave information to the operations of high-speed ferries, transport of unconventional loads, and ship certification trials.
JASON - SOS is a PI for calibration and validation of wind and wave data.
ENVISAT Cross Calibration and Validation – Contracted to ESA to carry out a calibration and validation of ENVISAT RA2 wind and wave data.
'GAMBLE' – A Thematic Network to bring together European experts in ocean altimetry to optimise planning for, and data use from, future satellite altimeter missions.
'SEAROUTES' – A Framework V RTD project to provide Near Real Time satellite sea-state data and forecasts onto advice systems on board High-Speed Shipping.
Innovative Radar Altimeter Concepts Study (Prime Contractor ALCATEL), SOS carried out a user requirements survey to define required characteristics of altimeter derived geophysical data products.
ESA GMES Projects
ROSES - SOS is a member of a consortium developing a portfolio of water quality monitoring services to support environmental policies
COASTWATCH - This project is addressing the need for cost-efficient monitoring data on the coastal environment.

• Training and Education Programmes.
SOS staff have organised conferences and workshops for:
European Commission (EC), European Space Agency (ESA)
Intergovernmental Oceanographic Commission (IOC)
United Nations Development Programme (UNDP)

• Supply of Data and Statistics
on the mean and extreme values of wave height and wind speed from calibrated and validated satellite observations, and direct provision of near real time satellite data to offshore users. Customers include oil companies, shipping lines, accident investigation teams, navies (USA & UK), and insurance companies.

Conclusions

Satellite Observing Systems has been piloting a number of applications in which Near Real Time altimeter wind and wave data are sent directly to the user. The guiding principle is that even though the sampling is sparse, many operators prefer to have access to direct measurements, presented accessibly. At the very least such services help the user to assess the reliability of information from other sources (e.g. forecast models) at best they could make a significant contribution to reducing risk to the environment, personnel, and operations.
Many segments of the marine industry could strongly benefit from such services, including navies, oceanographic fleets, and, if extensions can be carried out to closed seas and coastal areas, short distance shipping and pleasure yachting.

Recommendations
Increase satellite sampling density.
Investigate options to reduce the delay on NRT data to ~ 1hr.
Provide a single consistent and reliable source of information.
Extend application from open sea to nearshore and to closed seas.
Include wave direction and period, and wind speed and direction.
Subdivide wave data into sea and swell if feasible.