Delivering NCOF operational marine data through the Internet

K Haines, BACantab, PhD, J Blower, Chunlei Liu, Adit Santokhee, ESSC, University of Reading, UK

The National Centre for Ocean Forecasting (NCOF) partnership is now promoting the delivery of operational marine forecasting data over the internet, with the aim of pioneering new relationships with interested clients in government and commercial companies, and with marine and climate research organisations. This paper reviews some of the objectives of this work, particularly regarding standard protocols and service capabilities that are needed to make the products more useful.

AUTHORS' BIOGRAPHIES

Keith Haines is BMT Professor of Marine Informatics and Director of the Reading e-Science Centre at Reading University. He formerly worked at Edinburgh University, MIT and Imperial College London, from where he holds a PhD in Dynamical Meteorology. He is a Fellow of the Royal Meteorological Society.

Dr Jon Blower holds a PhD in Volcanology and is Technical Director of the Reading e-Science Centre. He formerly worked for the software company Tessella.

Both Dr Chunlei Liu and Mr Adit Santokhee work on Marine Research and Marine data management projects using operational NCOF data at Reading University.

INTRODUCTION

The National Centre for Ocean Forecasting (NCOF) was formed in March 2005 to raise the profile of marine forecasting in the UK by coordinating the expertise of the Met Office and the Natural Environment Research Council (NERC) marine institutes (www.ncof.co.uk[1]). Currently the NERC institutes involved in NCOF include the National Oceanography Centre, Southampton, the Proudman Oceanographic Laboratory, the Plymouth Marine Laboratory and the Environmental Systems Science Centre at the University of Reading.

One area of rapid development that is being promoted by the NCOF is the ability to develop new methods for delivering marine forecast products in a timely manner via the internet. This work is going on in the presence of strong international efforts to develop standards for interoperable geospatial data exchange, in particular those of the Open Geospatial Consortium (OGC[2]). The NCOF sees these standards as a means to enable the building of partnerships to promote new internet-enabled applications and services using its products. More research and development is required in order to apply these standards successfully and the NCOF aims to be at the forefront of these developments.

Web portals are a convenient way of investigating operational products. The 'GODIVA' and Godiva2 web portals developed in Reading through the national e-Science programme, give access to gridded operational NCOF products, and allow user selection of datasets and areas for interactive browsing of images and movies. The Coastal Observatory portal at Proudman Laboratory gives a more regional focus and includes recent satellite and *in-situ* data, along with model analyses and forecast fields for the area of Liverpool Bay and the Irish Sea.

The NCOF data archive at Reading is also enabled with Web Services which allow clients to link their own applications and services directly to the data over the internet, without human intervention through a portal. A demonstration of this using a Search and Rescue client developed by BMTCordah is presented. It is possible to Web Service-

enable other marine services that require access to the most up-to-date operational forecast data and potential clients for such services are encouraged to contact the NCOF.

The DEWS (Delivering Environmental) project was sponsored by the then Department for Trade and Industry (DTI) and helped to harden the Web Service delivery mechanisms for Met Office data, with a particular focus on maritime and health sector applications. The demonstrators delivered in this project should eventually enable the Met Office to move towards delivering all of its operational products through Web Services. The NCOF aims to keep maritime data at the forefront of these developments.

CURRENT NCOF OPERATIONAL DATA SERVICES

The current (June 08) NCOF suite of physical models of the marine environment run on a daily basis, include:

- Global ocean at 1°x1° resolution with 20 levels
- Atlantic and Arctic (including ice) at 1/3°x 1/3° resolution with 20 vertical levels
- North Atlantic at 1/9°x1/9° resolution with 20 levels (provided as EU MERSEA product)
- Mediterranean at 1/9° resolution with 20 levels
- Indian Ocean model at 1/3° resolution with 20 levels
- Antarctic circumpolar model at $\frac{1}{4}$° resolution with 20 levels
- All above UM models to be replaced Sept 08 with NEMO $\frac{1}{4}$° Global or 1/12° regional, 50 levels
- European Atlantic margin model at 12km resolution with 30 sigma levels: POLCOMS
- European shelf-only at 6km resolution, 30 sigma levels POLCOMS (EU MERSEA product)
- Irish Sea at 1 nautical mile resolution, 30 sigma levels: POLCOMS
- Global, European and UK shelf, wave models at 60, 35 and 12km resolutions respectively.

All the ocean models are forced with surface meteorological conditions from the Met Office atmospheric forecast suite and typically run out to 5 or 7 days ahead. In addition the first four models use Data Assimilation code to incorporate available ocean observations from satellites and Argo floats to set the ocean model initial conditions. Ongoing developments include improved nesting of the shelf models into larger scale models; application of assimilation methods to shelf models, and development of biogeochemical models embedded within the shelf models. All of these are challenging scientifically but when implemented they should raise the value of the NCOF products for marine protection and planning.

Web portals

Many of the operational products above are now available for browse on a number of web portals. These portals are tailored for different communities and uses, but are built on top of a common infrastructure.

The GODIVA web portal (www.nerc-essc.ac.uk/godiva, operational since 2004 and developed under the e-Science research project of the same name at the University of Reading) makes NCOF data available for visualisation and download. Example output from this portal is shown in Fig 1a. Operational analysis and forecast data are received from the Met Office daily; metadata are automatically generated and the data then appear under the portal, from which users can explore data and choose to download subsets of data in the file format of their choice (NetCDF, HDF or GRIB). Data access feeds are password-protected. Users can also access data directly without using the portal interface, by using the GADS Web Service[3]; the GODIVA portal is essentially a graphical user interface for this web service. [See below for more examples of use of NCOF Web Services]. The portal provides access to an ever-growing store of around 3 terabytes of data and averages around 20 hits per day from users all over the world.

The Godiva2 web portal (www.reading.ac.uk/godiva2[4]) provides a new dynamic, interactive portal for visualising NCOF data. Users browse through NCOF data using a

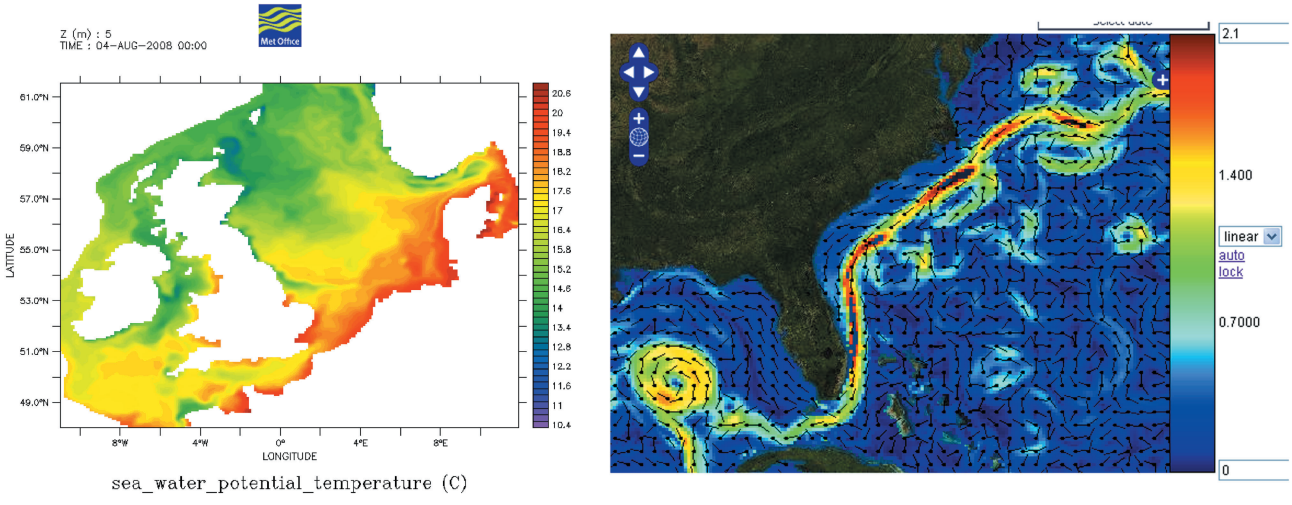

Fig 1: (a) Output from the GODIVA web portal, Temperature at 5m at 12km res. from POLCOMS MRCS model Aug 4th 2008; (b) Screenshot of the interactive Godiva2 web portal, sea surface currents from FOAM 1/9° Aug 4th 2008

draggable, zoomable map and can create animations and timeseries plots, change colour palettes and click on the map to discover the precise data value at any point. A screenshot from Godiva2 is shown in Fig 1b. Data can be visualised in a wide range of coordinate systems with transformations being performed on the server. This allows clients to view NCOF data in the context of their own data, without the need to understand the particular numerical grid employed by the ocean model in question. Data can be transferred from the portal to Google Earth, which is becoming increasingly popular as a means to visualise and overlay different types of environmental data.[5]

In the Godiva2 portal the emphasis is on easy-to-use, fast visualisation, rather than data download. Godiva2 is in regular use by research scientists and is also being used to interest potential clients of the data, to allow them to more fully explore the data variability and quality before the data are used in more specialised applications and services. The Godiva2 system is based upon the OGC Web Map Service standard, which allows interoperability with third-party visualisation systems, which can also access images of NCOF data directly through Godiva2's web services. The Web Map Service standard for geospatial data visualisation is mandated by the European INSPIRE directive and so the Godiva2 system has been adopted by a number of European programmes including MERSEA, ECOOP and the ESA lead GENESI programme. The Godiva2 portal also won the OGC website of the month award in January 2008.

The web portals described above are suited to certain types of gridded datasets such as model forecasts, with a focus on the ability to steer and select small subsets of these data for display. This is an ideal tool for presenting the main NCOF products, which are in the form of model output. The aim is eventually to provide all NCOF model forecasting products through such a portal. Therefore an alternative, more regionally-focussed presentation of NCOF, and other data, is being developed at the Proudman Oceanographic Laboratory for the Liverpool Bay and Irish Sea area. These products are put together online as a 'Coastal Observatory' which can be found at http://coastobs.pol.ac.uk.

The Coastal Observatory contains real-time satellite and *in-situ* observational data, schematic displays, as well as output from the above operational forecast models wherever they overlap the local region. The provisions of regionally-focussed portals, especially for the shelf seas and near coastal regions, is a complementary strategy to encourage the development of further applications of NCOF forecasting products, and also as a means to display the complementarity of these products with other information, such as satellite data. Examples of the Coastal Observatory *in-situ* data sites from which live data are available are shown in Fig 2.

Web Services: A search and rescue decision support tool

For a client seeking to develop a decision support service, it would not be sensible to require access to operational products via the web portals described above. Therefore, the capability is being developed for clients to directly link their own software to NCOF Web Services. In order to demonstrate this capability, a Search and Rescue application (SARIS), developed by BMTCordah Ltd and currently used by the UK Maritime and Coastguard Agency, was modified to read live NCOF-supplied marine winds and currents from Web Services. Fig 3 shows the situation forecast generated by the front end to this SARIS application. The user need not know anything about web portals or the file structure of any of the data they are using. The most recent NCOF data is delivered behind the scenes directly to the application. All that is needed is for the client's laptop to be connected to the internet. Other decision support applications, such as oil spill dispersion prediction systems, could also be made to access live data in this way.

The SARIS application is an example of how user communities can develop their own specialist client software that consume NCOF data. Such clients can be sophisticated desktop applications (such as SARIS) or web applications and services. There is an increasing trend towards the delivery of capability and software through web applications (so-called Rich Internet Applications) as the capabilities of web browsers increase. The use of Web Services for data delivery allows for different user communities to present NCOF data in a manner most suitable for them and their clients.

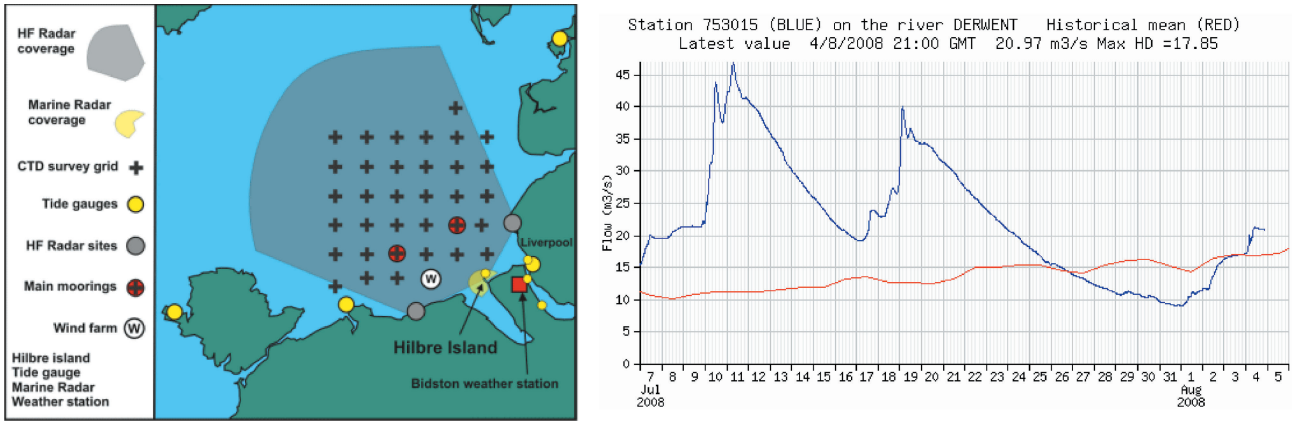

Fig 2: (a) Mooring and coastal stations and, (b) River flow on the Derwent. Live data on the Coastal Observatory Web Site

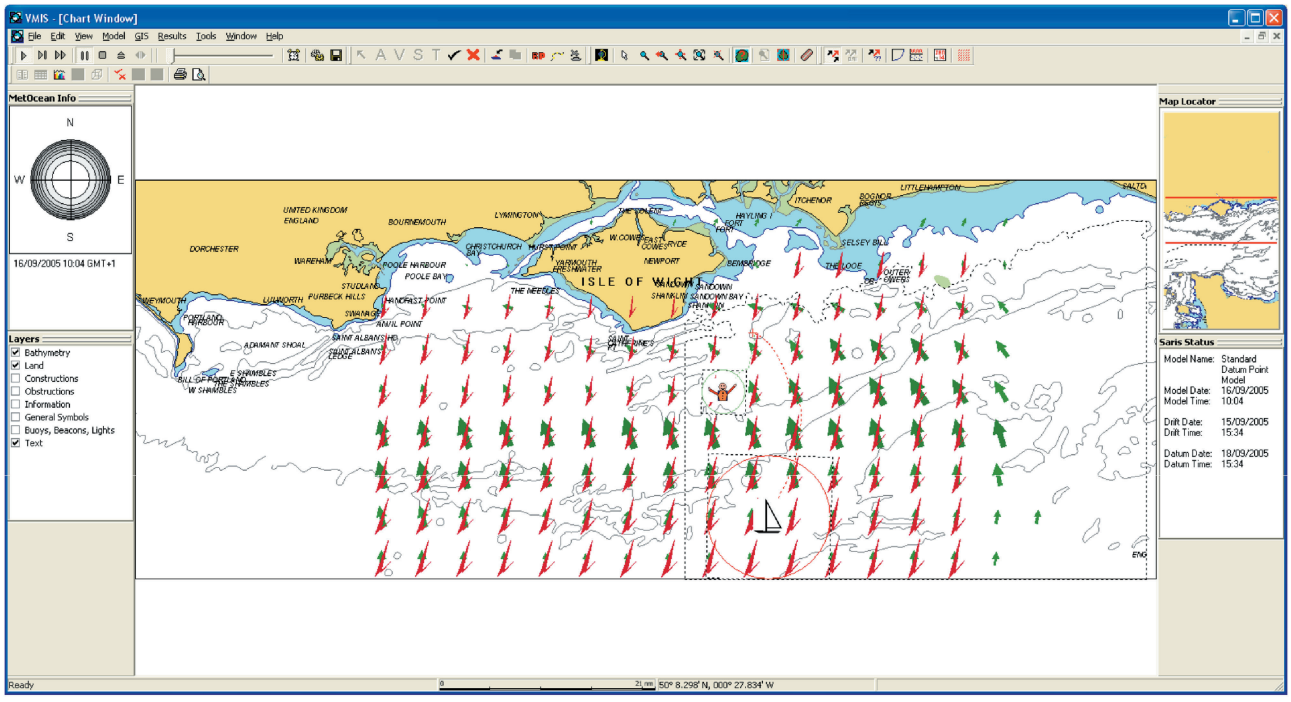

Fig 3: Search and Rescue Decision Support screen shot. Winds and currents are shown with drift positions and error circles

The DEWS project (Delivering Environmental)

DEWS was a multi-partner two-year £2.2M project, 50% funded by the UK DTI, and aimed to pioneer the operational application of Web Services in the Met Office, with demonstrators in the maritime and health service sectors. The aim of DEWS was to take previous data delivery solutions such as GADS[3] and make them more suitable for an operational environment in the context of wider spatial data infrastructure programmes, such as INSPIRE. Key advances were made in the areas of increased security for Web Service data transfers (using the security mechanism of the NERC Data Grid,[6]) and ensuring that the Web Services are compatible with OGC standards. Adherence to such standards is extremely important to ensure that data delivery systems satisfy a wide range of clients. The capabilities developed mean that the marine sector is now well in advance of other sectors of Met Office data delivery.

FUTURE OF NCOF DATA SERVICES

As the archive of operational data products build up and the resolution of operational modelling continues to increase, the volume of data that must be sifted for useful knowledge increases alarmingly. The solution is to develop more sophisticated automated means of analysing these data. Two application examples are being used to motivate research. The first is the automatic warning of extreme conditions in forecast products, eg, extreme winds, currents, sea levels, temperatures or biogeochemical conditions. The second, related, application is in planning and legislating for the probability of such future extremes, by quickly sifting the archive of past conditions to assess locations and frequencies of any given set of conditions occurring.

Both applications involve the setting of thresholds and the ability to automatically query the data for these thresholds. This goes beyond the geospatial management of the data into the realms of data mining. In other fields, database technology is typically used for such tasks, but the large, four-dimensional nature of meteorological and ocean data poses strong challenges to most database systems. The NCOF is actively researching this area, working with database developers, and testing current data management systems with these applications in mind.[7]

CONCLUSIONS

The aim of this paper is to set out the NCOF plans and perspectives on the delivery of operational maritime data services. It is hoped that this will encourage new partnerships for the development and application of new operational maritime products, especially by taking advantage of real-time data availability using the internet. The NCOF is now actively seeking partnerships with other government agencies and with companies in order to grow the operational maritime services sector.

ACKNOWLEDGEMENTS

Funding from the UK Research Council EPSRC and NERC e-Science programs, and from the DTI supporting the DEWS project, are gratefully acknowledged.

REFERENCES

1. Bell MJ, Haines K, Hill E, Owens NJP, Proctor R. The National Centre for Ocean Forecasting.

2. Open Geospatial Consortium, Inc. online http://www.opengeospatial.org/

3. Woolf A., Haines K, Liu C. 2003. *A Web Service model for climate data access on the grid.* Int. J. HPC Applic. 17, 281-295.

4. Blower J, Haines K, Santokhee A, Liu C. 2008. *Godiva2: Interactive visualisation of environmental data on the web.* Accepted for publication in Phil. Trans. Roy. Soc. A.

5. Blower J, Gemmell A, Haines K, Kirsch P, Cunningham N, Fleming A, Lowry R. 2007. *Sharing and visualising environmental data using Virtual Globes*. Proceedings of the UK e-Science All Hands Meeting, 10-13 Sept 2007, pp102-109, ISBN 978-0-9553988-3-4.

6. Lawrence B, Kershaw P, Blower J. 2007. *Practical access control using NDG security.* Proceedings of the UK e-Science All Hands Meeting 10-13 Sept 2007, pp262-269, ISBN 978-0-9553988-3-4.

7. Santokhee A, Liu CL, Blower JD, Haines K, Barrodale I, Davies E. 2005. *Managing and serving large volumes of gridded spatial environmental data.* Proceedings of the 11th EC GI & GIS Workshop, ESDI: Setting the framework 29 June-1 July 2005.