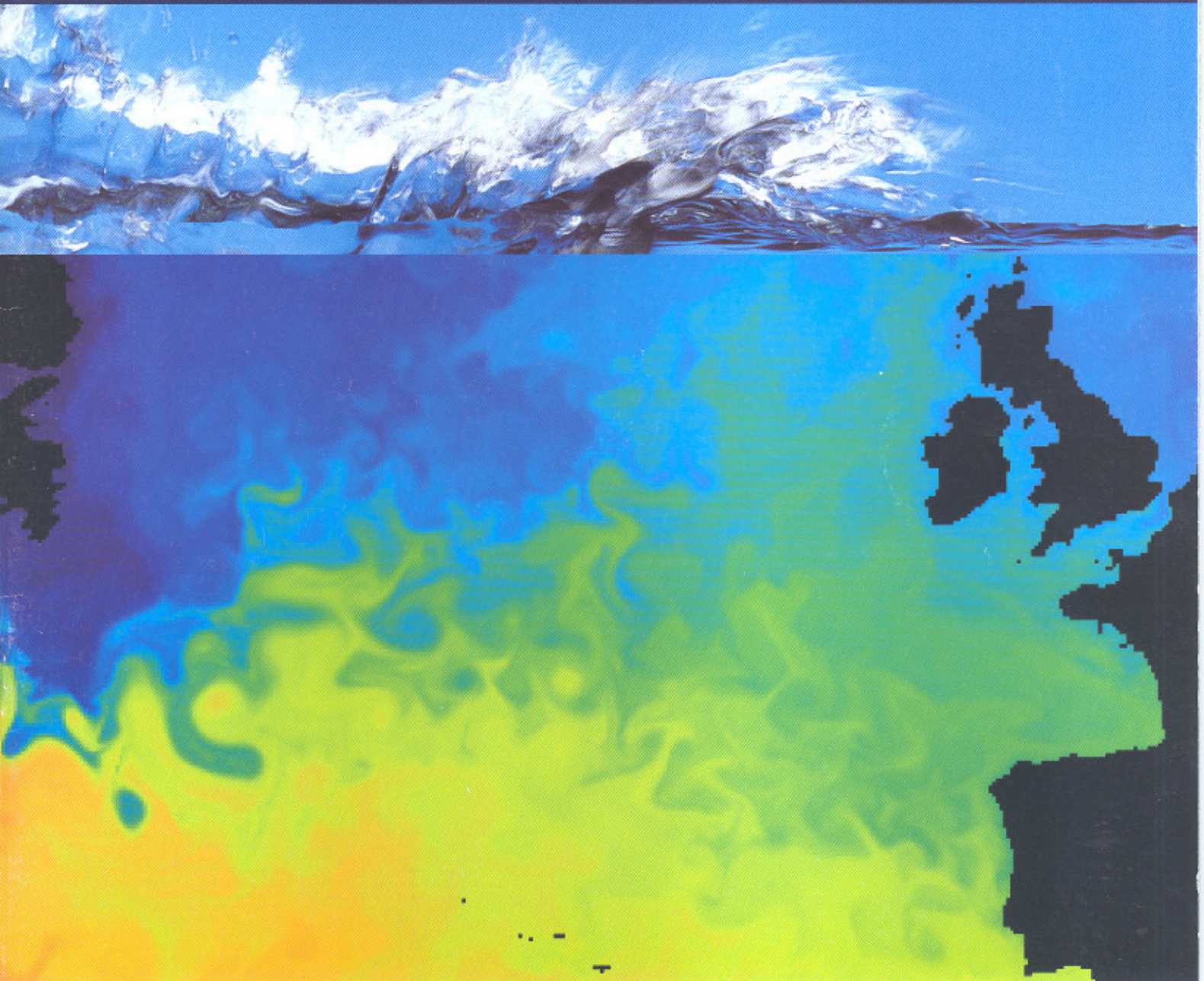


# NCOF

The National Centre  
for Ocean Forecasting



IN PARTNERSHIP TO PROVIDE WORLD-CLASS OCEAN FORECASTING AND RESEARCH

**NCOF** is a strategic partnership between the Met Office and the Proudman Oceanographic Laboratory, Plymouth Marine Laboratory, National Oceanography Centre, Southampton and the Environmental Systems Science Centre at Reading.

**Our mission is to establish ocean forecasting as part of the national infrastructure, based on world-class research and development.**



## Why we need ocean forecasts

The oceans affect us all. They cover about 70% of the Earth's surface and around 60% of the world's population lives within 200 km of the coast. For those who work at sea or live near the coast, forecasts of ocean conditions can be just as important as forecasts of the weather. Rough seas and strong currents can make many marine activities difficult or dangerous.

High waves or storm surges can lead to coastal flooding. Ocean currents transport and disperse oil slicks and other marine pollution. Changes in ocean temperature can affect the marine ecosystem, from plankton through to fisheries.

NCOF builds on existing collaborations which bring together the operational

forecasting capabilities of the Met Office with the world-class underpinning research carried out by a number of the UK's leading marine and oceanographic research centres, much of which is funded through the Natural Environment Research Council (NERC).

## Working with others

Ocean information is required by many different organisations for various purposes; for disaster mitigation, ensuring safety at sea, marine and offshore operations, sustainable development and exploitation of the marine environment. Ocean forecasts are also used by the Royal Navy on a daily basis for a variety of locations across the globe. Government agencies such as the Department for Environment, Food and Rural Affairs (Defra), Environment Agency (EA), Maritime and Coastguard Agency (MCA), and Fisheries Laboratories, have increasing requirements for ocean information to protect and manage the marine environment in line with EC regulations, especially in coastal waters. Making ocean forecast information readily available to them is vital to ensure their needs are met. Through this partnership, NCOF will deliver ocean forecasts based on the

latest research to users across Government, commerce and research.

NCOF will also provide a focused UK contribution to European plans to develop an operational oceanography capability under the EC Global Modelling for Environment and Security (GMES) initiative to better understand and manage the ocean environment. Through the GMES Marine Environment and Security for the European Area (MERSEA) project, we are working closely with the French Mercator consortium to advance the goal of operational ocean forecasting in Europe.

With our global ocean modelling capability, NCOF products and services will be a major contribution to the Global Ocean Observing System (GOOS), as well as its European component EuroGOOS.





## The forecasts we make already

### Wave forecasting

We run wave models to provide predictions of wave conditions, globally and around the UK. Work carried out under the EC MAXWAVE project has led to the development of improved diagnostics of occurrence of extreme or damaging waves at sea. At low frequencies, swell can cause enhanced vessel motion. Using ray-tracing models, site-specific forecasts of near-shore wave conditions can be made.

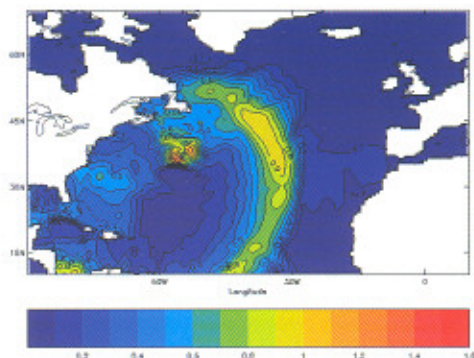
### Ocean forecasting

With the Forecasting Ocean Assimilation Model (FOAM) and Proudman Oceanographic Laboratory Coastal Ocean Modelling System (POLCOMS), we are able to make predictions of the 3-dimensional properties (temperature, salinity, currents) of the oceans and of sea ice. The predictions range from the global oceans (at 1 degree horizontal resolution) to coastal models around the UK, or elsewhere (at 1 nautical mile resolution). At higher resolutions, the models are able to resolve ocean eddies. All resolutions of POLCOMS also include tidal flow around the coastline.

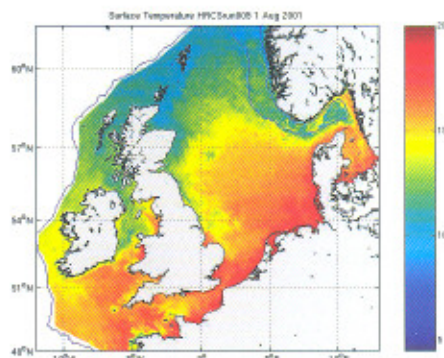
### Storm surge forecasting

The North Sea storm surge of 1953 caused disastrous flooding which led to pioneering developments in numerical modelling. Nowadays, tide-surge models are routinely used to forecast storm surges up to two days ahead along the UK coastline.

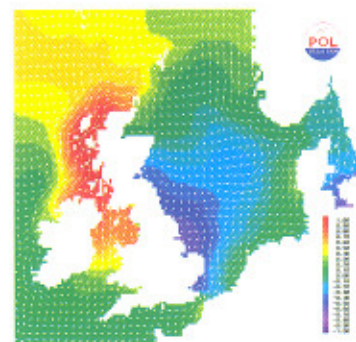
This surge prediction system is a prime example of successful collaboration between the Met Office and Proudman Oceanographic Laboratory (POL), where research has led to a national forecasting service. Forecasts are made four times per day and results are used to provide early warnings of coastal flooding and to indicate when it is necessary to close the Thames Barrier.



WAVE FORECAST showing long period swell generated during Hurricane Gert propagating across the North Atlantic. The arrival of swell is often related to strong wave conditions in exposed western coastal regions



OCEAN FORECAST showing a prediction of sea-surface temperature (SST) for UK and surrounding waters



STORM SURGE FORECAST showing high surge levels (red) along the west coast of Scotland and reduced surge levels (blue) along the North Sea coast

### Validation

Validation of model results is essential for understanding how the models should best be used and identifying areas for improvement. Physical predictions from our models are routinely validated against Argo data, hydrographic section data, and data from buoys and moorings. Ecosystem predictions have been validated against data from the L4 station in the Western Channel run by Plymouth Marine Laboratory (PML) and SmartBuoy data from the Centre for Environment Fisheries and Agriculture Science (CEFAS).

### Product dissemination

The NCOF website (<http://www.ncof.gov.uk>) provides a portal to various systems making forecast data and products available. These include the NERC Environmental Systems Science Centre (ESSC) GODIVA web-server, the Met Office Data and Products Distribution System (DPDS) and the Liverpool Bay and Western Channel Coastal Observatories.

*www.ncof.gov.uk provides a portal to various systems making forecast data and products available*



## How we make ocean forecasts

For forecasting the state of the oceans out to 5-days ahead on global to regional scales, we use the FOAM system. This is a nested modelling system providing high-resolution, regional ocean predictions of temperature, salinity, currents and sea ice.

To provide forecasts of the north-west European shelf-seas and UK coastal waters, we run the POLCOMS, which in turn takes boundary forcing from North Atlantic FOAM. Forecasts are forced by surface fluxes from the Met Office's operational numerical weather prediction (NWP) system.

Ecosystem forecasts are made using the coupled POLCOMS-ERSEM (European Regional Seas Ecosystem Model) developed by PML. Models are also routinely run for storm-surge and wave prediction.

### Ocean observations

We receive in situ ocean data from floats, moorings and ships, and remotely sensed data from satellite. Typically, around 20,000 in situ surface observations and 300 sub-surface observations are received each day.



Sea-surface height data come from satellite altimeters such as Jason-1, sea-surface temperature data from AVHRR and ENVISAT



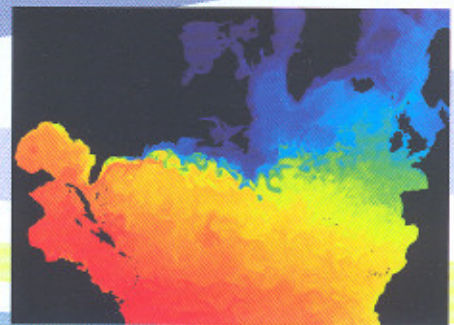
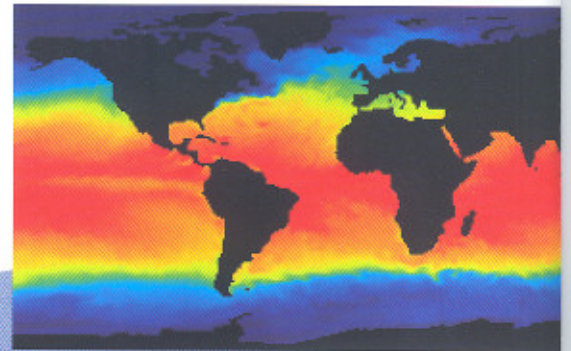
Sea-surface temperature data come from buoys, moorings (middle picture) and ships



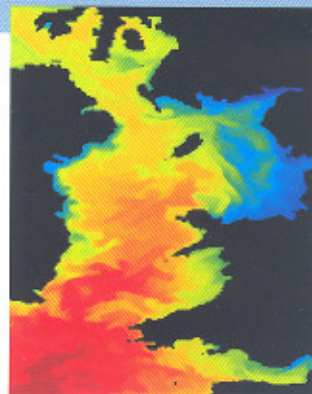
Sub-surface temperature and salinity data come from Argo floats, expendable bathythermographs and moorings

### Ocean forecasting

FOAM assimilates in situ ocean data and remotely sensed data. Data assimilation provides the optimal combination of model and observational data to define the present state of the ocean.



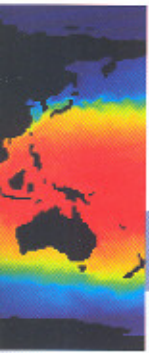
Sea-surface temperature from North Atlantic FOAM at  $1/9$  degree resolution (middle figure) showing details of the mesoscale structure



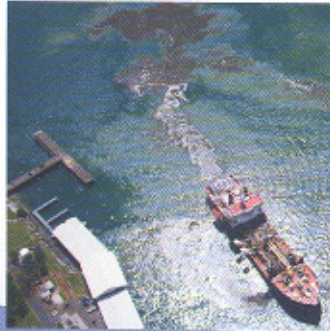
Predicted sea-surface temperature from the Irish sea configuration of POLCOMS

### Products and services

Dissemination of ocean forecast information to users across Government, commerce and research to support policy and decision making.



Predicted sea-surface temperature from global FOAM at 1 degree resolution



Forecasting oil slick movements



Forecasting waves and currents for offshore oil and gas production (middle picture)



Forecasting for Search and Rescue

### Verification and validation

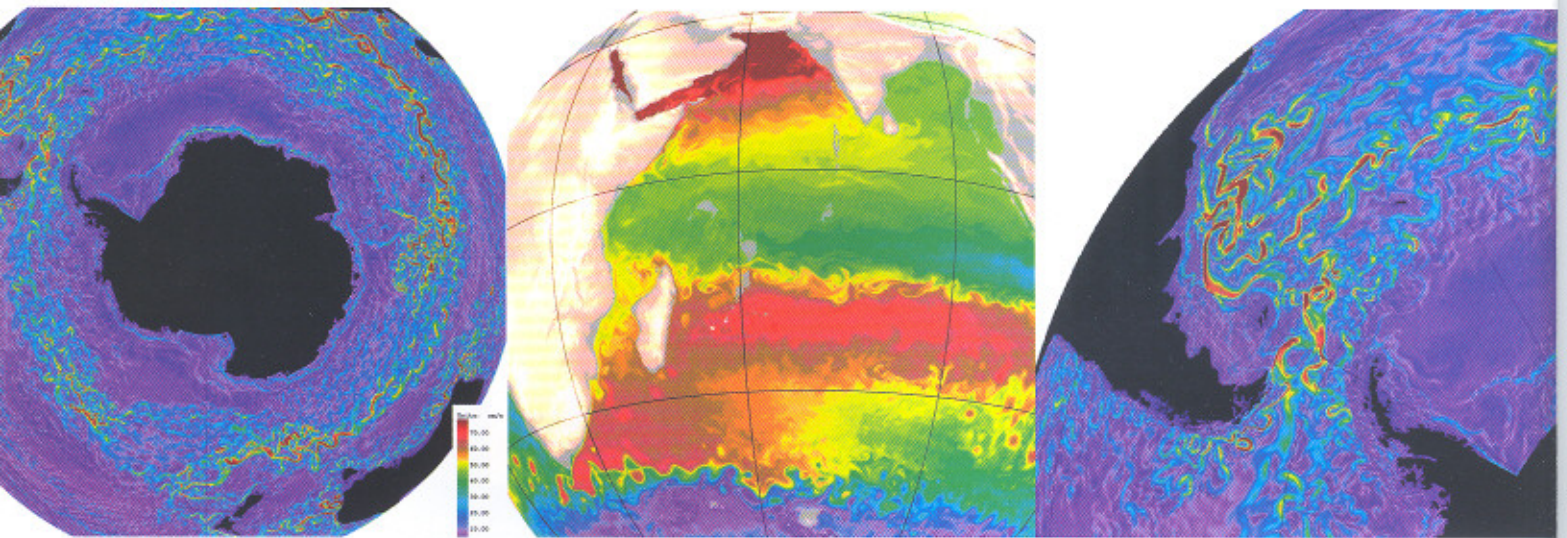
A key activity is verification and validation of the model forecasts so we can quantify their accuracy and usefulness to users, and target research at improving deficiencies.

## Underpinning scientific research

Our capabilities are based on world-class research and development carried out by the partner institutes within NCOF. Much of the work undertaken by POL, PML, NOCS (National Oceanography Centre,

Southampton) and ESSC is funded through the Research Councils, in particular NERC, while the MoD funds and guides a large part of the Met Office's ocean modelling research and development.

Through the NCOF partnership this research is integrated into a coordinated programme and targeted to meet existing and emerging user needs.



High resolution ( $1/12$  degree) simulation of currents (left and right) and salinity (centre) from the NOCS OCCAM global ocean model

This includes work on:

### Ocean modelling

The development of advanced numerical models for the oceans, ranging from the global oceans to the local scale. Our future modelling systems will be based on the Nucleus for European Modelling of the Oceans (NEMO) code — a new ocean model code being developed in collaboration with a range of European ocean modelling institutes.

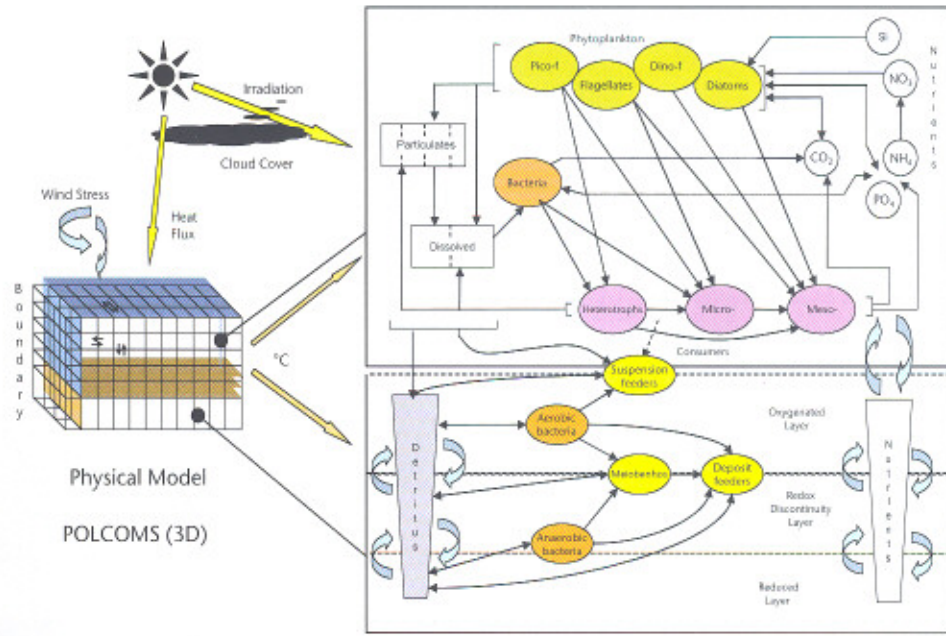
### Ocean observations

Within NCOF we have expertise in in situ observations from global networks such as Argo, Voluntary Observing Ships/Ships of Opportunity through to local systems such as 'Ferrybox', moorings and buoys, as well as on remotely sensed data from satellites (SST, ocean colour) and HF radar. Our work focuses on the assimilation of these data into models, and the generation of integrated data products.

### Data assimilation

Development of improved techniques for assimilation of in situ information (e.g. salinity from Argo floats) and remotely-sensed data (e.g. altimeter data from Jason-1 and satellite sea ice) underpins all operational ocean forecasting. NCOF has world leading expertise in this area.





Schematic of the POLCOMS-ERSEM coupled physical-ecosystem model

### Ecosystem modelling

We are applying carbon-cycle and biogeochemical models for both the open ocean and UK waters. Through inclusion of the Hadley Centre Ocean Carbon Cycle (HadOCC) model in FOAM, we are able to make predictions of biological parameters for the global oceans. Work is ongoing to develop techniques for assimilation of satellite ocean-colour data to improve initialisation of chlorophyll in the model.

For UK and surrounding waters we are working on the coupled POLCOMS-ERSEM system and developing new products in support of the ecosystem-based approach to managing the marine environment, which is being advocated by European governments. ERSEM is a generic model which includes all those processes which significantly influence ecosystem dynamics. It is being run in near-real-time mode with a

view to implementation operationally in forecast mode, and provides biogeochemical information for monitoring water quality and ecosystem behaviour. The model is also being used to provide derived outputs such as indicators of eutrophication, aligned to OSPAR (Oslo-Paris) convention requirements, and predictors of harmful algal bloom occurrence.

*NCOF has world-leading expertise in the area of data assimilation*



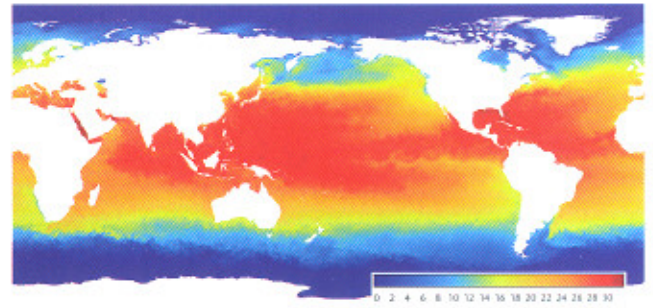
*We are developing new global and regional sea-surface temperature products with enhanced accuracy*



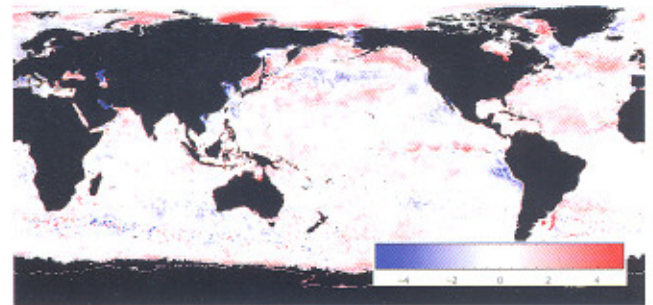
### Sea-surface temperature

Daily, global coverage sea-surface temperature (SST) and sea-ice (SI) analyses are fundamental to NWP, ocean forecasting, seasonal prediction, and climate activities within NCOF partner activities. A new global coverage operational high-resolution combined SST and sea-ice analysis system called the Operational SST and sea Ice Analysis (OSTIA) has been developed, and is now maintained and is operated within NCOF. OSTIA makes full use of the latest generation of infrared and microwave satellite

SST observations from the GODAE High Resolution Sea Surface Temperature Pilot Project (GHRSSST-PP, see <http://www.ghrsst-pp.org>). The primary output is a daily global coverage 1/20° (~5 km) combined SST and sea-ice concentration product. This product specification is designed to meet the current high-resolution space-time scales of global NWP and NCOF ocean forecasting models and to prepare for future generation of high-resolution mesoscale forecast systems.



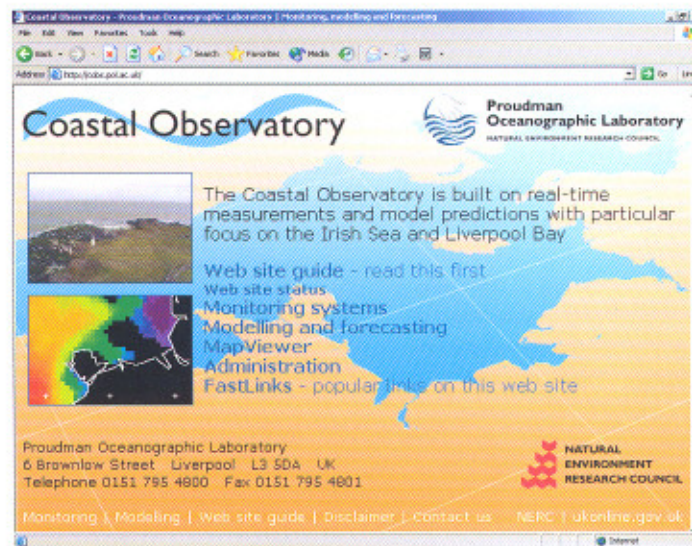
Global sea-surface temperature map generated by the OSTIA system for 18th August 2005. (Scale is degrees centigrade)



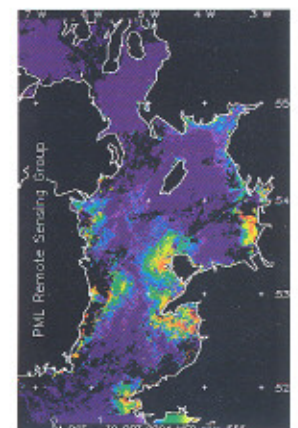
SST anomaly field relative to Pathfinder v5.0 AVHRR climatology (1985-2001). (Scale is degrees centigrade)

### Coastal modelling and observation

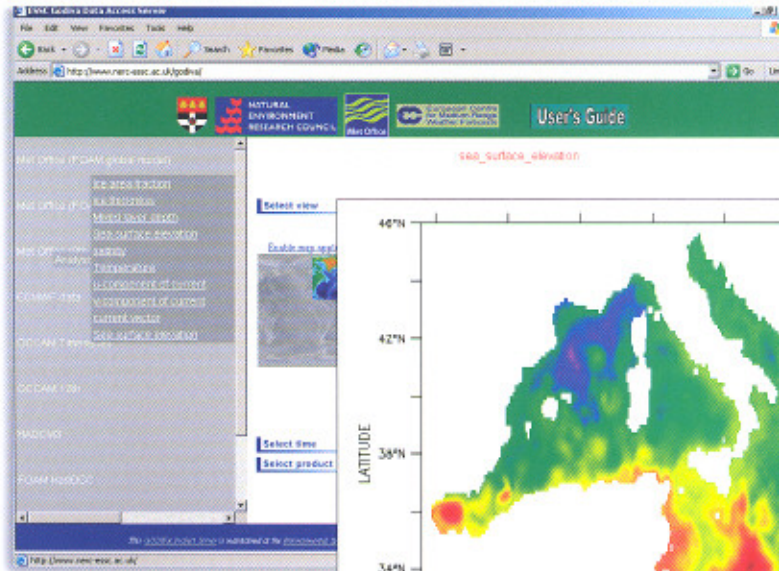
Detailed coastal information is vital for many local applications, including shipping, recreation, fishing, coastal flooding, pollutant discharge and water quality. The POL Coastal Observatory is built on real-time measurements and model predictions with particular focus on the Irish Sea and Liverpool Bay. The aim of the Observatory is to understand and predict the response of a coastal sea to both natural forcing and the consequences of human activity. It integrates (near) real-time measurements with coupled models into a pre-operational coastal prediction system whose results are available on the internet.



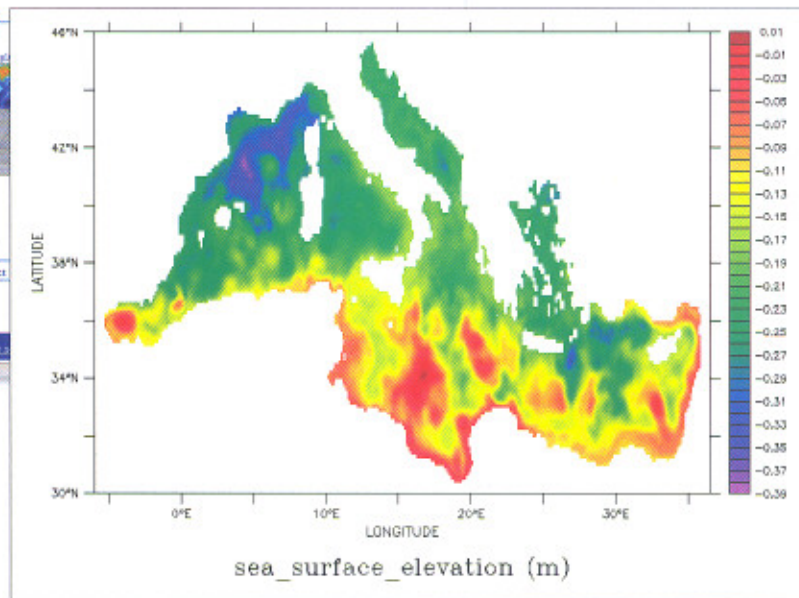
For products and services from the Coastal Observatory, visit [cobs.pol.ac.uk](http://cobs.pol.ac.uk)



Satellite image of suspended sediment



To access products from GODIVA, visit [www.nerc-essc.ac.uk/godiva](http://www.nerc-essc.ac.uk/godiva)



A sea surface elevation (height above the mean reference surface) map from the FOAM system over the Mediterranean sea on 17 February 2005

### E-science

Through the Environmental Systems Science Centre at Reading, we are making model analysis and forecast data available for non-commercial use via Web Services developed by the NERC e-Science GODIVA project. The GODIVA web portal provides access to FOAM and POLCOMS data in real-

time, as well as other data from NERC models such as OCCAM. Clients can generate graphical displays – including time-series and movies on-the-fly – as well as selecting subsets of data for download in a variety of client-selected formats. NCOF is thus in the vanguard of developing new Web Service data delivery mechanisms for all potential users.

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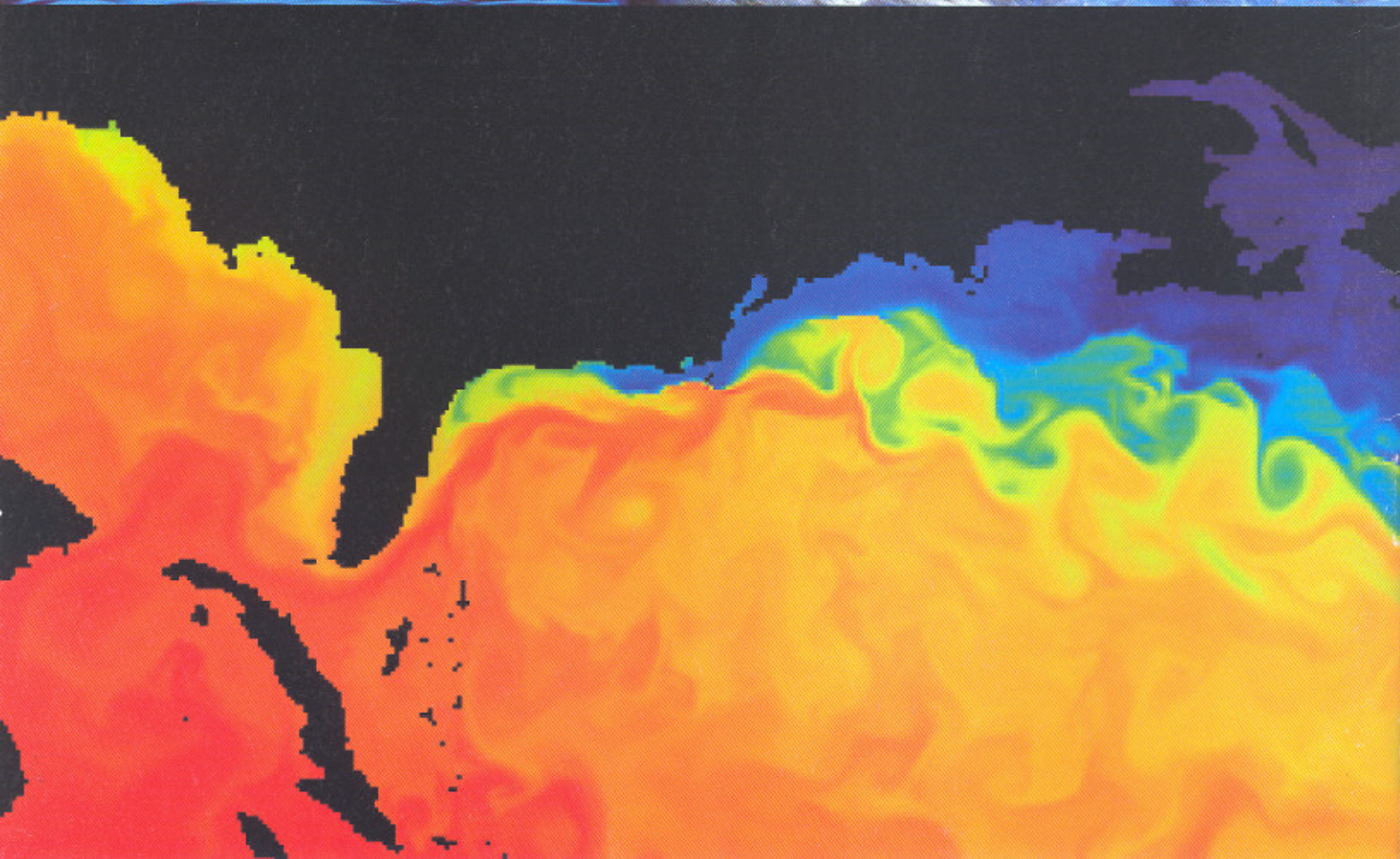
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