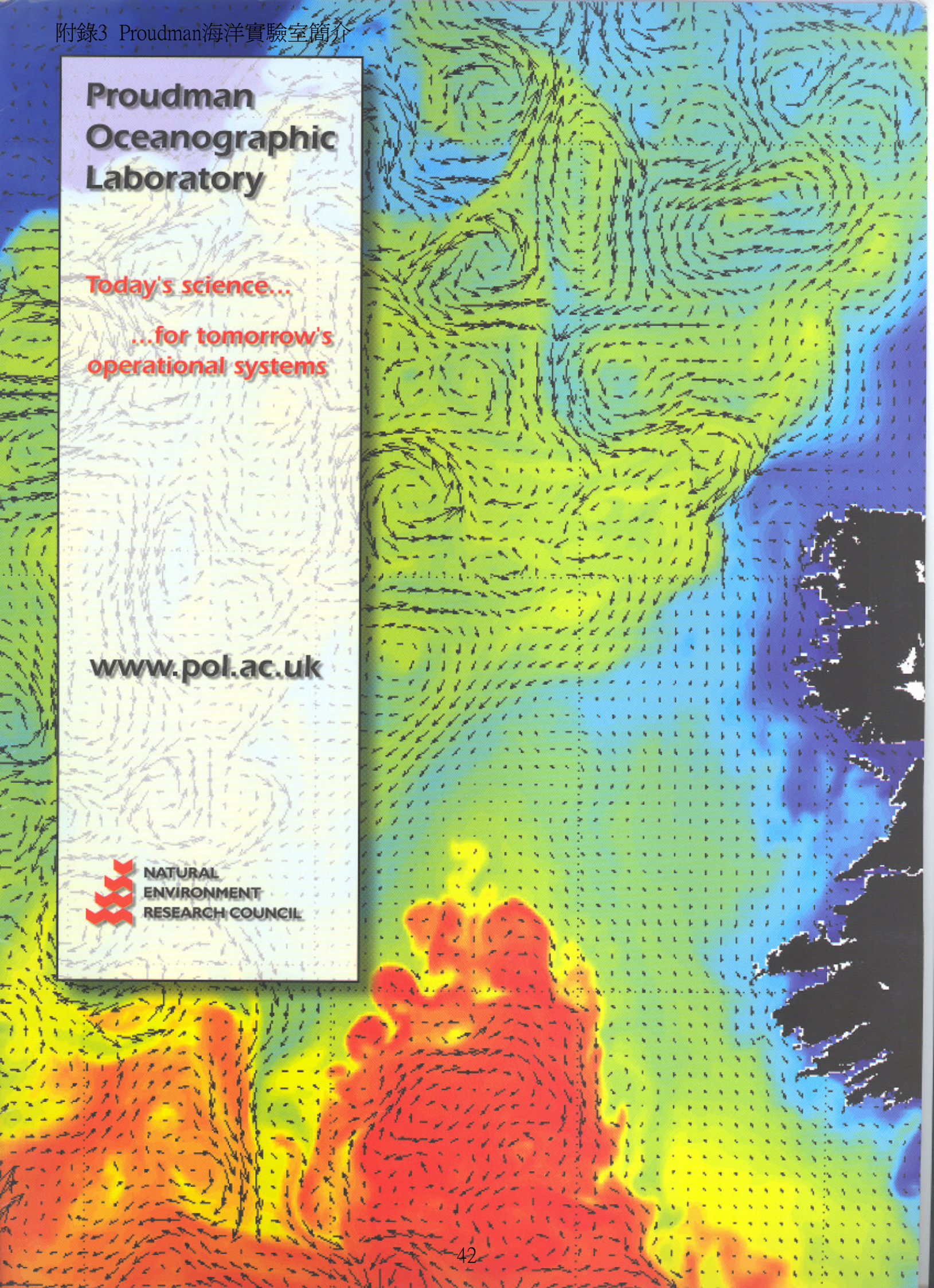

Proudman
Oceanographic
Laboratory
Today's science...
...for tomorrow's
operational systems
www.pol.ac.uk
NATURAL
ENVIRONMENT
RESEARCH COUNCIL

Proudman Oceanographic Laboratory

Advancing today's science in support of tomorrow's operational systems

The Proudman Oceanographic Laboratory (POL) is a Research Centre wholly owned and managed by the Natural Environment Research Council (NERC).

We provide services that underpin national operational functions (e.g. coastal flood forecasting) and undertake a NERC-funded Strategic Research Programme in ocean physics and geodesy.

As part of NERC's mission, to undertake long-term monitoring, curation and supply of data we host the following services and support functions.

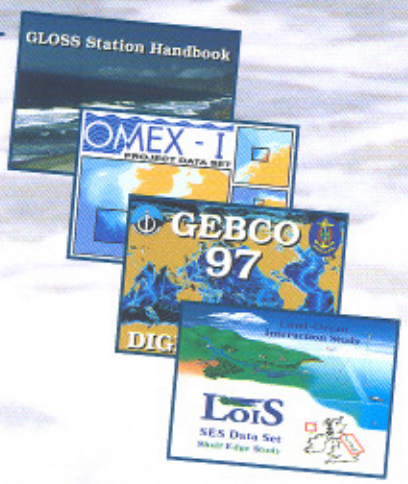
British Oceanographic Data Centre (BODC)

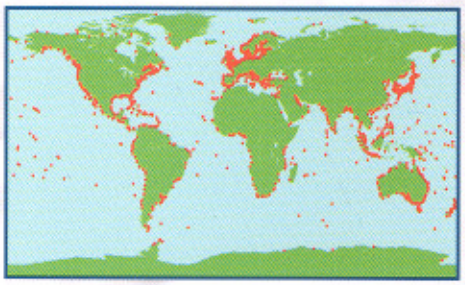
A world class Data Centre responsible for:

- Maintaining the UK's oceanographic data base
- Data management support for UK marine science
- Collaborating in international exchange and management of oceanographic data
- Making high quality data available to users in universities, government and industry
- Developing innovative marine data products.

BODC is one of NERCs seven designated data centres and part of the international network of oceanographic data centres.

www.bodc.ac.uk





Permanent Service for Mean Sea-level (PSMSL)

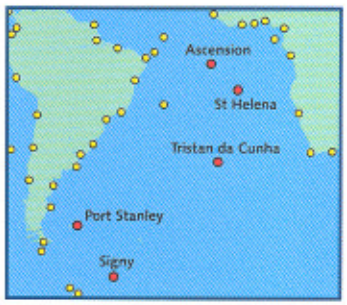
PSMSL

The global data bank for long term sea level change based on the global network of tide gauges. PSMSL is supported jointly by NERC and the International Council for Science through the Federation of Astronomical and Geophysical Data Analysis Services (FAGS).

www.pol.ac.uk/psmsl

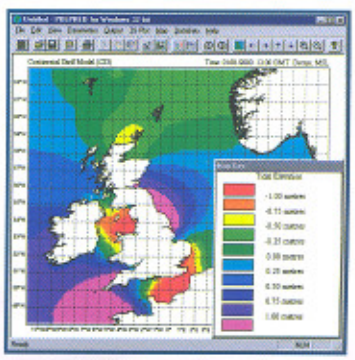
GLOSS South Atlantic Tide Gauge Network

Running the South Atlantic component of the Global Sea Level Observing System (GLOSS) global tide gauge network based on South Atlantic Island sites and Antarctica. Yellow dots are GLOSS sites of other countries.



UK Tide Gauge Inspectorate

Maintaining the UK's Class-A network of 44 coastal tide gauges – the front-line monitoring system for coastal flood warning. As part of the service we also maintain and quality control the UK's storm surge forecast model that runs operationally at the Met Office.



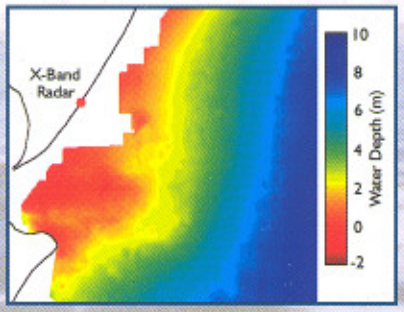
Proudman Applications

Creating added-value data products and services and supplying tidal predictions, offshore data, marine software, extreme levels and advice to help coastal/offshore businesses.

www.pol.ac.uk/appl

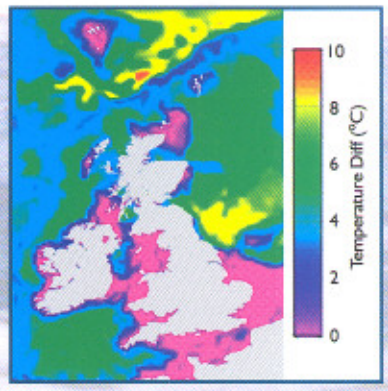
Front cover:

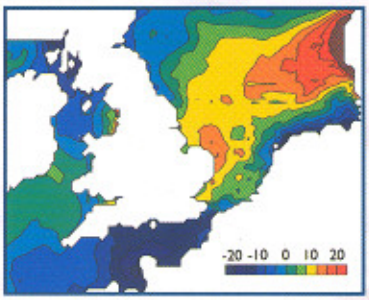
Improving predictive capability: measurements and models



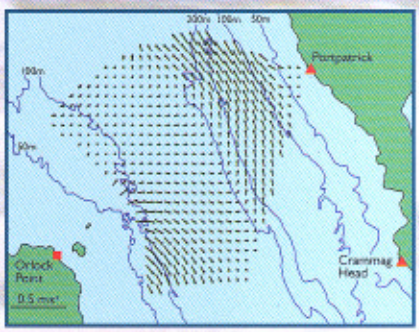
A revolutionary approach to remotely mapping water depths in coastal areas using X-band (standard ship's) radar.

Summer stratification (surface to bottom temperature difference) of the European Continental Shelf: a key control on phytoplankton production in coastal areas.

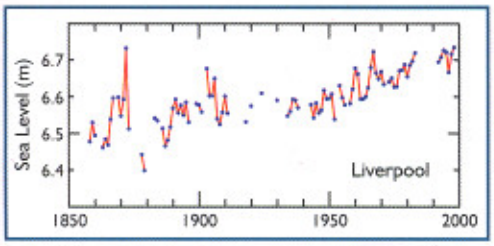




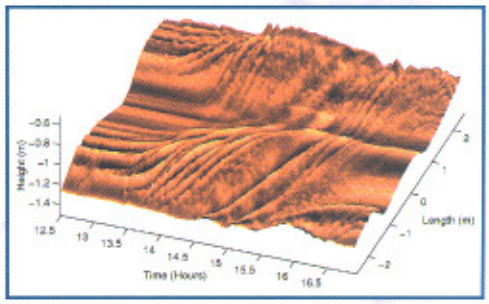
Using POL storm surge models to test scenarios. Computed change (cm) in 50-year return period surge elevation due to a 0.5m rise in mean sea level.



Mean surface flow through the North Channel measured over a year by shore based HF radar system. The outflow close to the Scottish coast, would be sufficient to empty the Irish Sea in a year.



Over one hundred and fifty years of sea level records show the change of sea level at Liverpool.



A line of sand ripples moving with a strong tidal current, measured with a high resolution scanning sonar system. These results will be used to improve parameterisation of sediment transport in models of bathymetric evolution.

Proudman Oceanographic Laboratory
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Dr A E Hill (New Director of NOC, Southampton)
Laboratory Director

Proudman Oceanographic Laboratory Science Programme

Our research programme is tied to existing, emerging and anticipated operational forecasting requirements, its foci being sea-level change and development of advanced modelling and observation systems for shallow coastal seas and ocean margins. We work in collaboration with Universities and Research Institutes world-wide and also with key operational agencies such as the Met Office. We have particular expertise in coordinating large projects involving many partners. Our science programme for the period 2001-2006 consists of three major themes:

Sea level, bottom pressure and space geodesy

For better prediction of the impacts of sea-level change.

We are working on:

- Changes in global and regional sea/land levels
- Sea level variability and extremes, particularly storm surges and waves
- Continuous ocean monitoring (in the Arctic and Antarctic) using sea-level and bottom pressure - linked to the calibration of satellite altimeter and satellite gravity missions.

Shallow coastal seas: function and impacts of change

To provide the scientific basis for sustainable management strategies for coastal seas through better predictive capability

We are working on:

- The function of shallow sea systems (at whole continental-shelf scale) using multi-year model runs for scenario and sensitivity tests
- Process experiments at small-scale (particularly sediment-water interactions and turbulence) for better representation/parameterisation of these processes in simulation models.

Modelling and observation systems for continental-shelf seas

To develop the next generation of tools for operational forecast systems

We are working on:

- POLCOMS – an advanced re-locatable numerical modelling system (spanning ocean to estuary and coupled to advanced ecosystem models)
- A pilot real-time Coastal Observatory as a development test-bed and for model validation.

The new Joseph Proudman Building on the University of Liverpool precinct.

The Proudman Oceanographic Laboratory has 100 staff and an annual turnover of £4.5 million. We have recently relocated to new purpose built accommodation on the campus of the University of Liverpool.
We remain a NERC owned and managed facility and now also enjoy the benefits of the dynamic environment of one of the UK's leading research Universities.

Pictures, from top:
Recovery of Inverted Echo Sounder from the Denmark Strait; deployment of Acoustic Doppler Current Profiler in the North Sea; installation of pressure

Proudman Oceanographic Laboratory
NATURAL ENVIRONMENT RESEARCH COUNCIL

BODC British Oceanographic Data Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

The National Tidal and Sea Level Facility

The Proudman Oceanographic Laboratory (POL), British Oceanographic Data Centre (BODC) and collaborating groups including the University of Nottingham are working towards the formation of a National Tidal and Sea Level Facility (NTSLF) constructed around the National Tide Gauge Network and geodetic networks for monitoring vertical land movement. The aim is to provide sea and land-level data and derived products, and to make scientific and technical expertise available to the wider community. The intention is for other relevant UK groups to become associated to the NTSLF, to provide a better service to the UK user.

OTT

POL activities:

- Operating the National Tide Network of 44 tide gauge stations.
- Operating the UK South Atlantic Network of 7 stations (the UK component of GLOSS).
- Hosting the Permanent Service for Mean Sea Level (PSMSL) of the International Council for Science. The PSMSL is the international data bank for long term global sea level change information and provides data to the scientific asessments of the Intergovernmental Panel on Climate Change (IPCC).
- Helping to coordinate the Global Sea Level Observing System (GLOSS) of the Intergovernmental Oceanographic Commission (IOC) - a major component of the Global Ocean Observing System (GOOS). The NTSLF organises and contributes to GLOSS training worldwide.
- Providing UK components of the European Sea-Level Service.
- Researching Vertical Land Movements in the UK and worldwide by Global Positioning System (GPS) and Absolute Gravity techniques.
- Researching complementary methods for sea level data acquisition by in situ methods (e.g. bottom pressure recorders) and from space (altimetry and space gravity).
- Developing advanced operational Tide-Surge Models and Techniques for flood warning at the Met Office.
- Researching using observational data and numerical models into trends, variability and extremes of sea level in the UK, Europe and worldwide, with particular emphasis on climate change.
- Collaborating with UK and international groups concerned with the science and impacts of sea level changes.

BODC activities:

- Aquisition and quality control of data from the National Tide Gauge Network, hosting the National Archive.

University of Nottingham activities:

- Operating the UK GPS Network and its data banks.

POL Applications Group activities:

- Providing a range of sea level-related products for the general public.

defra
Department for Environment Food and Rural Affairs

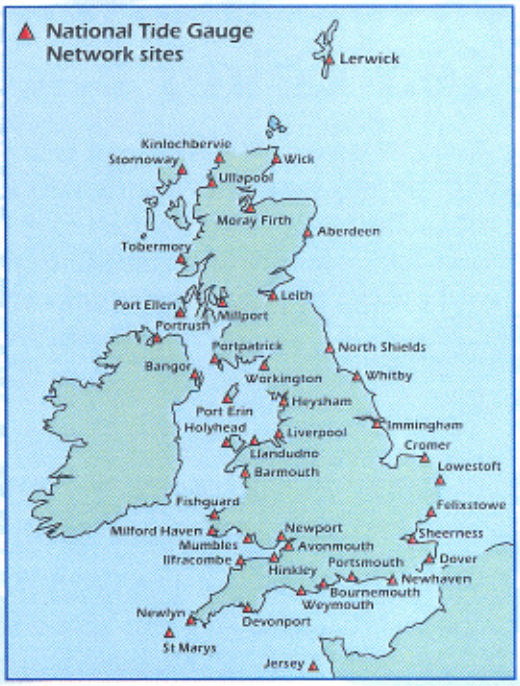
The National Tide Gauge and related land level networks are supported by Defra, with associated scientific research funded by both Defra and NERC.

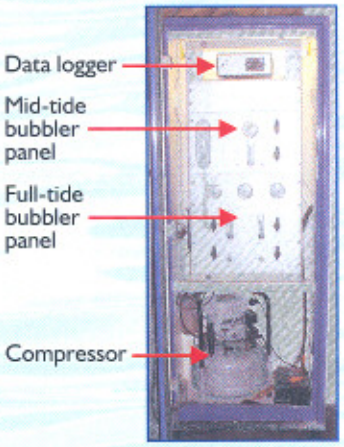
NATURAL ENVIRONMENT RESEARCH COUNCIL

Monitoring Sea and Land Levels

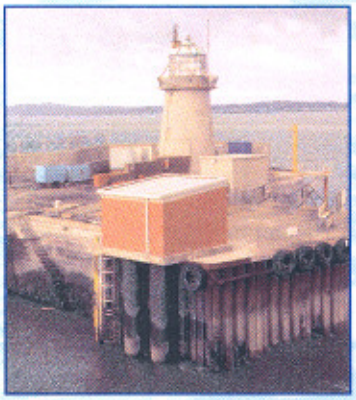
The National Tide Gauge Network

Lerwick, the National Tide Gauge Network's most northerly site.





The bubbler tide gauge system is housed in a cabinet, the parts of the system are identified.



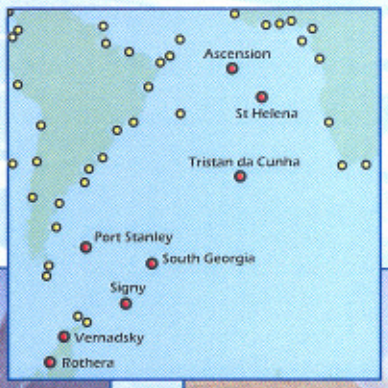
The Holyhead installation showing tide gauge building and the two stilling wells. POL uses this station as an experimental test site.

The Newlyn tide gauge site. Newlyn was used to determine UK mean sea level. It is the benchmark for the whole of the United Kingdom, that is, all heights are referenced to this point.

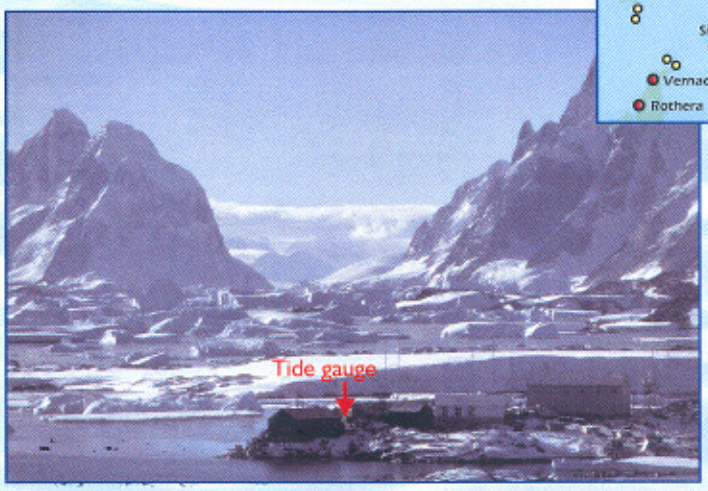
The tide gauge site at Dover.

The South Atlantic Tide Gauge Network

South Atlantic tide gauges operated by POL (red dots). Gauges at Gibraltar and South Georgia will be added in the near future. Yellow dots are GLOSS sites of other countries.



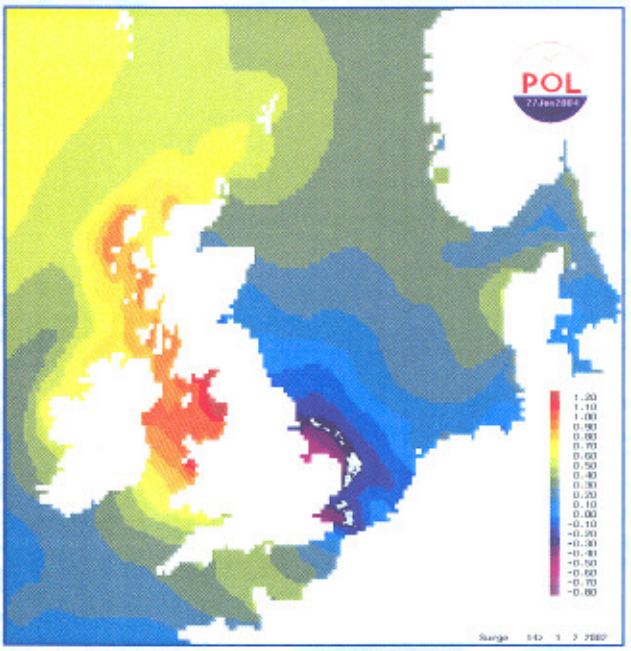
Vernadsky, showing the site of the tide gauge installation which has provided the longest record in the Antarctic.



RMS St Helena approaching Jamestown, St Helena. The tide gauge installation is shown on the left of the photograph.

Operational Forecasts

- POL surge forecast models have been run in real-time at the Met Office since 1978.
- Present system:
  - 12km shelf model (right), with refinements to 1km in the Bristol Channel & Severn Estuary.
  - Forced by met data from the Met Office's "mesoscale" weather forecast model.
  - Run four times a day producing forecasts up to 48hrs ahead.
- Results are used by the Environment Agency for coastal flood warning, and by other Government Agencies.
- Forecast accuracy is routinely monitored at POL; typical RMS errors are about 10cm.
- Developments:
  - System has been ported to the Met Office's new NEC supercomputer.
  - Additional 1km model for the South Coast.
  - Update of the system being planned.

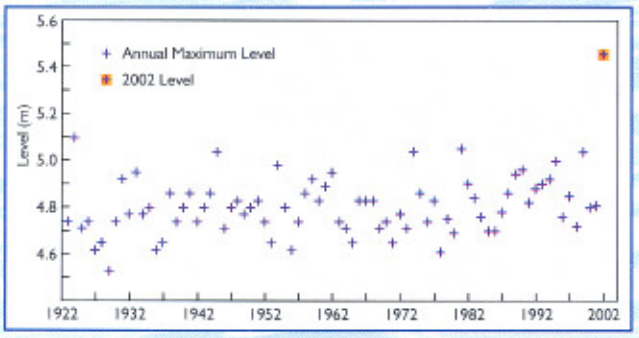


Surge elevations at 1400GMT 1/2/2002.

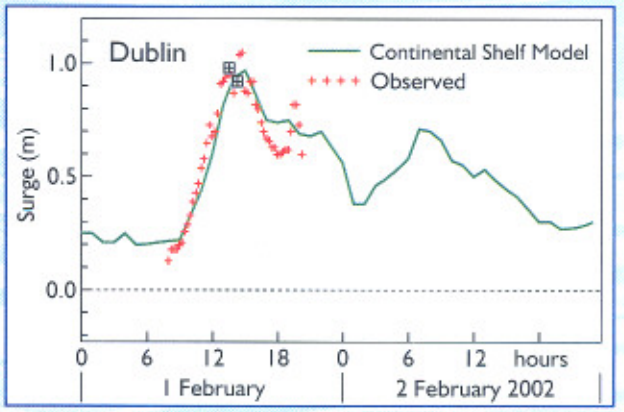
Forecasting the Irish Sea Floods on 1 February 2002

Douglas Promenade on 1 February 2002. Floods were "the worst in living memory".

- Flood events and forecast problems are investigated. An example is given here…
- Extreme sea levels and flooding occurred in the Irish Sea on the afternoon of 1 February 2002. The Isle of Man (see left) and Dublin were seriously affected.
- The high water at Dublin was the highest recorded, exceeding the previous maximum level in 1924 by more than 30cm (below left).
- The surge at HW was about 1.0m, and was well predicted by the operational model (below), but unfortunately not transmitted to the Authorities there.



Annual maximum sea levels recorded at Dublin.

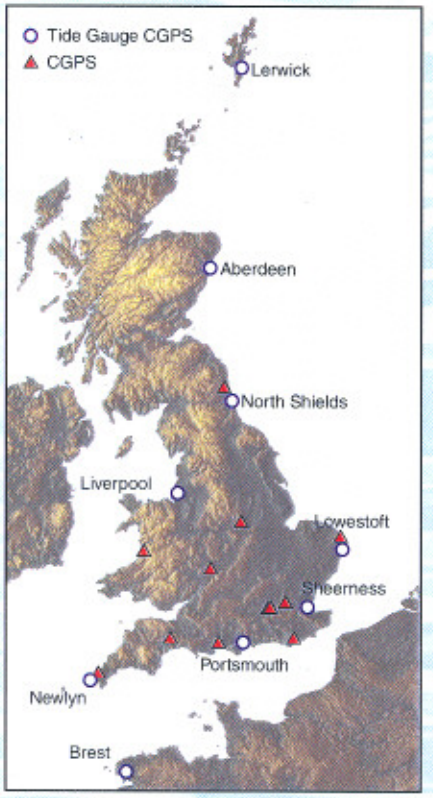


Observed and model surges at Dublin, ⊞ shows observed surge at time of high water.

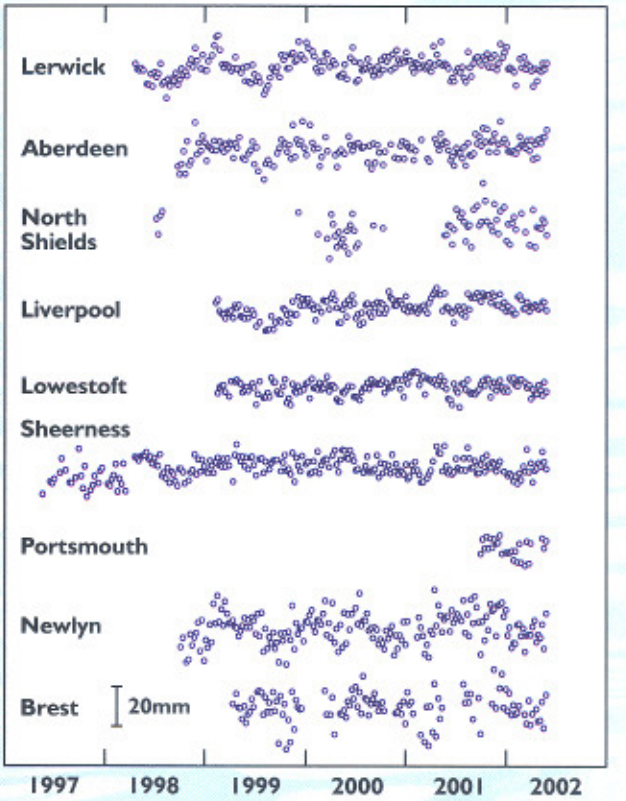
GPS and Absolute Gravity

Measurements of vertical land movements at tide gauges are required in order to separate the vertical land movement component from the climate related component of changes in mean sea levels.

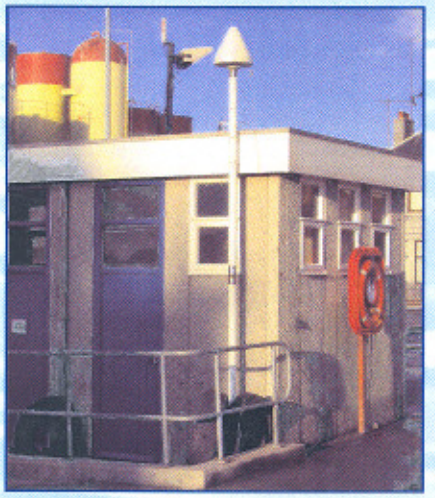
POL and the Institute of Engineering Surveying and Space Geodesy (IESSG), University of Nottingham, are using continuously operating GPS (CGPS) and absolute gravity to measure the vertical land movements at UK tide gauges.



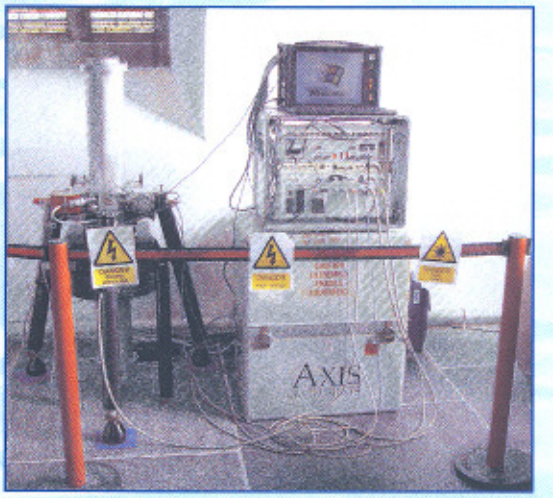
IESSG/POL network of continuously operating GPS (CGPS) stations.



Time series of weekly heights from the continuously operating GPS (CGPS) receivers at each tide gauge. The vertical land movements are of the order of 1-2mm/year, but longer time series are required in order to determine the land movements to the required accuracy.

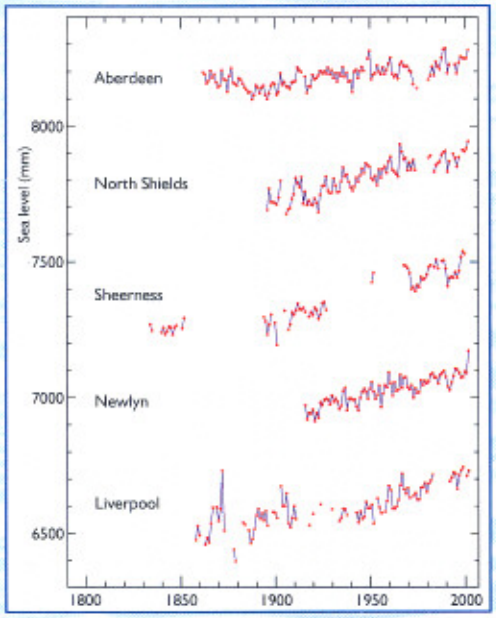


The continuously operating GPS (CGPS) at the Aberdeen tide gauge.

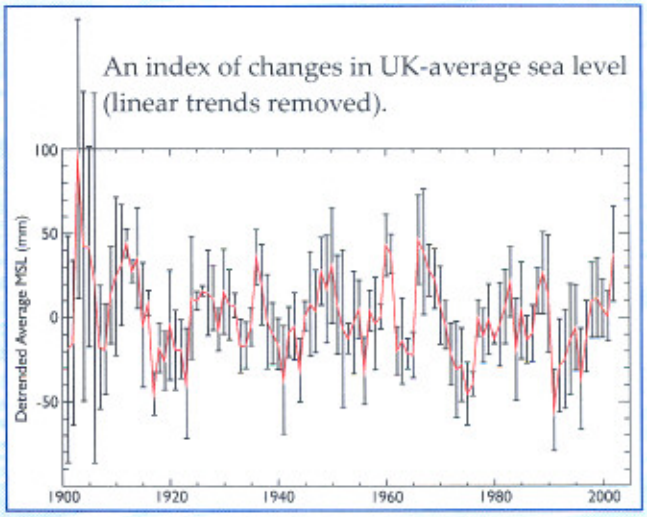


The POL absolute gravimeter installed at Newlyn.

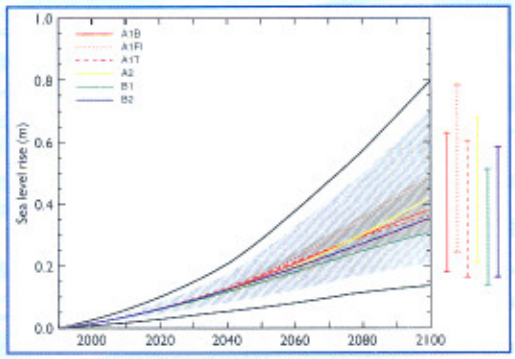
Long Term UK Sea Level Changes



Long term changes in sea level at UK sites with long records.



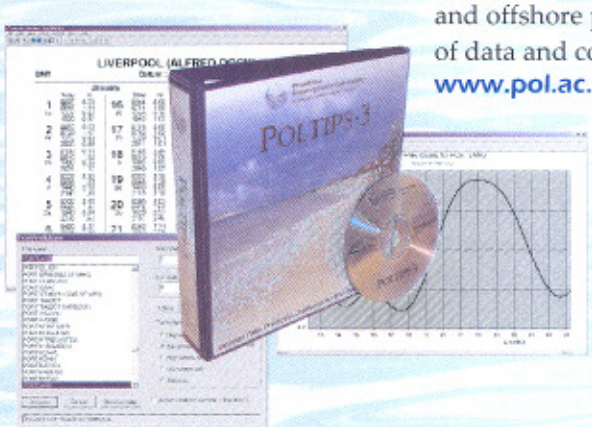
Intergovernmental Panel on Climate Change (IPCC) and UK Climate Impacts Programme (UKCIP) suggest a sea level rise of order 50cm in the next 100 years with uncertainties dependent on the 'climate scenarios' used.



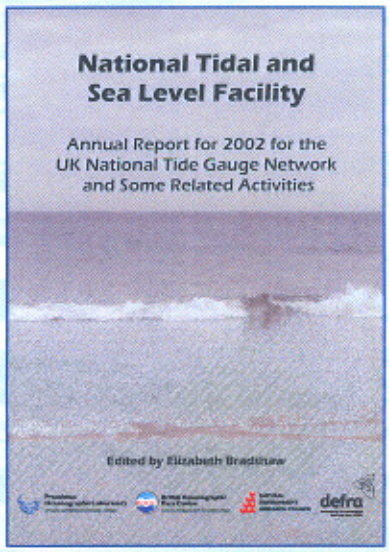
Data and Products

All National Tide Gauge Network data are freely available via the web.
www.pol.ac.uk/ntslf

POL Applications group provides a range of higher level products based upon tidal data. This includes customised tide tables, coastal and offshore prediction software, plus a range of data and consultation services.
www.pol.ac.uk/appl

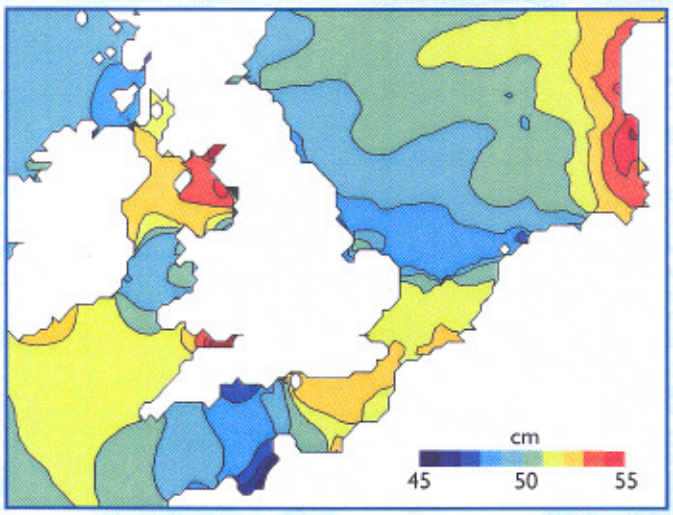


NTSLF web pages provide real-time displays of UK sea levels and free tidal predictions for the near future.
www.pol.ac.uk/ntslf

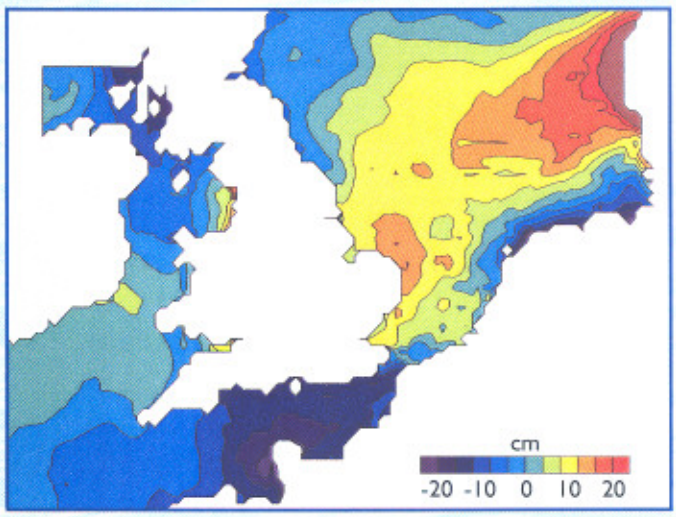


The first NTSLF Annual Report.

Examples of Possible Future Extreme Sea Level Change



Computed change in mean high water due to a 50cm rise in MSL.



Computed change in 50-year return period surge elevation from a POL 12km grid model using estimates of MSL, tide and extreme surge changes between 1990 and 2075.

Technical Developments

David Smith and colleagues have completed a successful one year test of a new type of tide gauge based on the use of radar. The instrument was installed at Liverpool and the data have been compared with data from the network gauge. The results to date are excellent. Such technology may be of great use to the UK networks in the future. The TGI is establishing a radar gauge in the commercial part of the Port of Gibraltar (North Mole). The stored data will be available for local use and will be telemetered to the NTSLF for quality checks and banking.

The radar tide gauge at Liverpool, similar to that planned for Gibraltar.

For further information please contact:
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The NTSLF is located at the new Joseph Proudman Building.

Proudman Oceanographic Laboratory
NATURAL ENVIRONMENT RESEARCH COUNCIL

PSMSL

The Permanent Service for Mean Sea Level

PSMSL
www.pol.ac.uk/psmsl

What is PSMSL?

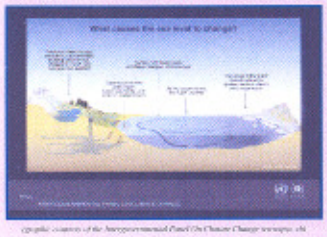
A little history....

Since 1933, the Permanent Service for Mean Sea Level (PSMSL) has been responsible for the collection, publication, analysis and interpretation of sea level data from a global network of tide gauges. It is based at the Proudman Oceanographic Laboratory (POL), Bidston Observatory which is a component of the UK Natural Environment Research Council (NERC). The PSMSL is supported by the Federation of Astronomical and Geophysical Data Analysis Services (FAGS), the Intergovernmental Oceanographic Commission (IOC) and NERC.

What Causes Sea Level Rise?

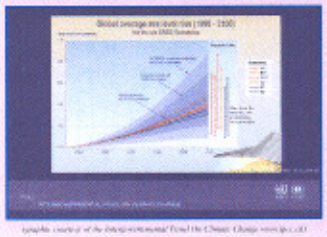
On the time-scale of decades to centuries, sea level rise is caused by:

- Thermal expansion
- Ice melt
- Ground water changes
- Changes in ocean circulation



Future sea level rise

The IPCC Third Assessment Report includes projected scenarios for sea level rise over the coming century. The central value of the scenarios projects a global average sea level rise of 0.48m between 1990 and 2100.



The PSMSL is a member of theFederation of Astronomical and Geophysical Data Analysis Services (FAGS) which was formed by the International Council of Scientific Unions (ICSU) in 1956.

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Svetlana Jevrejeva
Philip Woodworth
psmsl@pol.ac.uk

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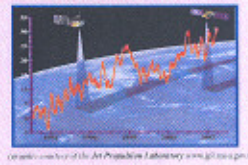
Liverpool L3 5DA, UK

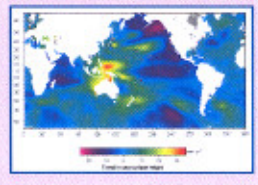
Measuring Sea Level

The data provided to the PSMSL comes from a global array of tide gauges, like the one in Venice shown to the right.

Increasingly sea level is also measured from space by satellites like Topex/Poseidon and Jason-1.

Tide gauges are used to calibrate and check trends measured by the altimeters. The tide gauges provide "ground-truth".





The circles shown here on the left are trends over the last 10 years from high quality tide gauge records in comparison with satellite derived values.

The IOC GLOSS Programme

- The Global Sea Level Observing System became known as GLOSS as it provides data for deriving the 'Global Level of the Sea Surface'
- It aims at the establishment of high quality global and regional sea level networks for application to climate, oceanographic and coastal sea level research.

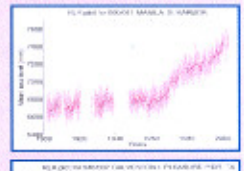
GLOSS will help to expand to the PSMSL database:

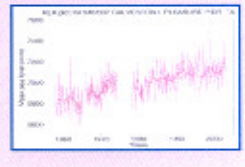
- The main component of GLOSS is the 'Global Core Network' of 290 sea level stations around the world for long term climate change and oceanographic sea level monitoring.

Global Core Network

Vertical Land Movements (VLM)

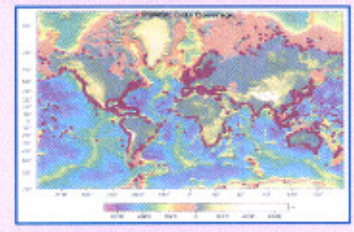
Vertical land movements can arise from earthquakes, Glacial Isostatic Adjustment (GIA) following the melting of ice sheets from the last Ice Age, or changes in water storage.Terrestrial water storage can be changed by extraction of ground water, building reservoirs and altering surface run-off. In places such asManila, Philippines, or Galveston, USA, ground water extraction has been causing the land to sink, further increasingthe effects of sea level rise.



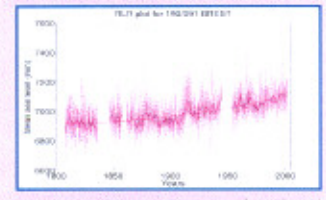


Data Coverage

At the last update, the PSMSL database contained over 52,000 station years of data from 1,952 stations around the world.



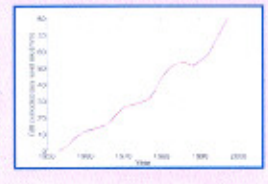
The longest record in the database is from Brest and began in 1807. The oldest British record is from Liverpool beginning in 1858 though we have a record of high waters since 1768.



The longest sea level record in the world is from Stockholm which began in 1774. However, the oldest record is from Amsterdam and began in 1700 but ended in 1925 following construction works. Both these records are available from the PSMSL but are not officially included in the database as their quality is variable.

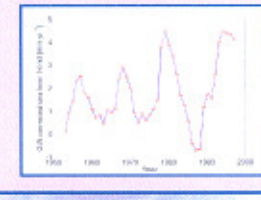
Current Research

The PSMSL actively exploits the sea level dataset to gain further insight into sea level changes.



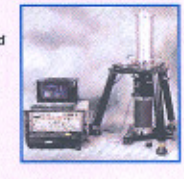
Current research is exploring trends in global sea level to look for evidence of an acceleration in sea level rise.

Global sea level rose at almost its fastest rate in 50 years during the past decade but it remains to be seen whether the rate will continue to increase over the coming years.



Measuring VLM

Vertical land movement can be measured using Absolute Gravity instruments, like the one owned by POL shown here. These are very expensive and only a few exist.



At tide gauge sites, Global Positioning Satellite (GPS) equipment is usually used (shown here at Newlyn). Other systems for measuring VLM include the French DORIS system which is very precise but lacks global coverage.

Proudman Oceanographic Laboratory
NATURAL ENVIRONMENT RESEARCH COUNCIL

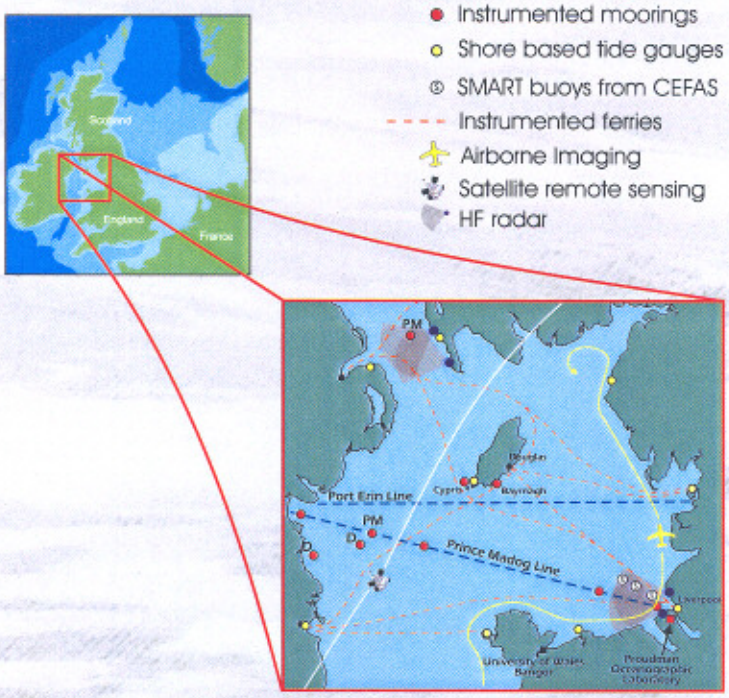
Met Office

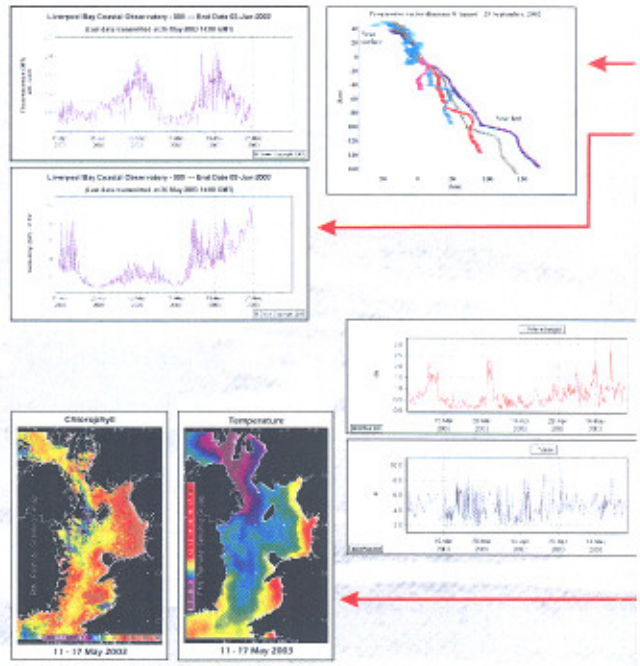
The Pol Coa

towards a real-ti

Objective

To understand a coastal sea's response both to natural forcing and to the consequences of human activity.





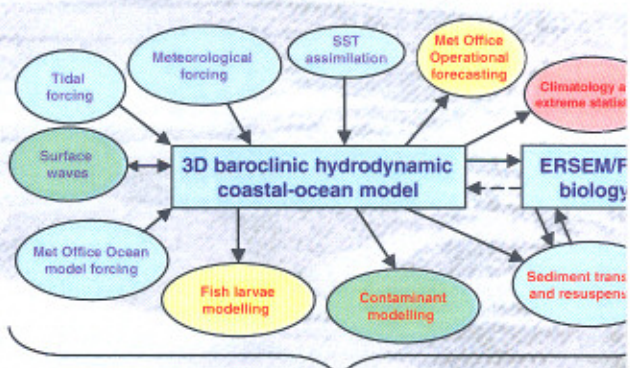
Introduction

The Observatory will integrate (near) real-time measurements with coupled models into a pre-operational coastal prediction system whose results will be displayed on the Web.

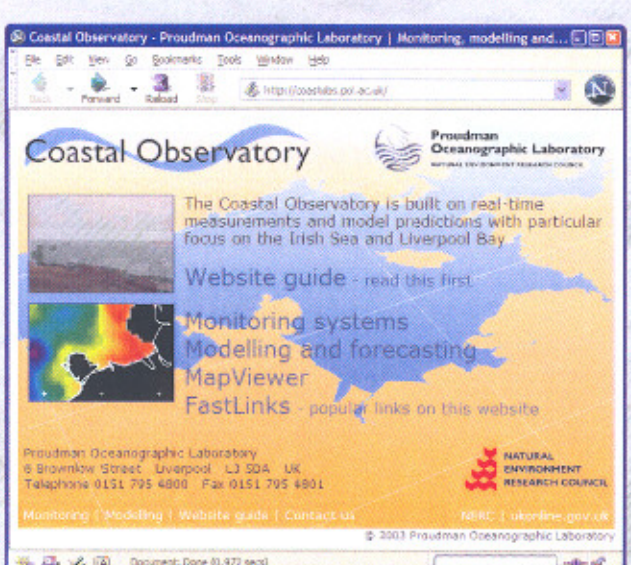
The concept is founded on obtaining data in (near) real-time, using telemetry, from underwater to the sea surface to land to POL to a web site (armchair oceanography). This, the aspiration of every oceanographer, is now feasible.

It will grow and evolve as resources and technology allow, all the while building up long time series. The foci are the impacts of storms, variations in river discharge (especially the Mersey), seasonality, and blooms in Liverpool Bay.

The Coastal Observatory will use POLCOMS (Proudman Oceanographic Laboratory Coastal Ocean Modelling Syst
www.pol.ac.uk/home/research/polcoms

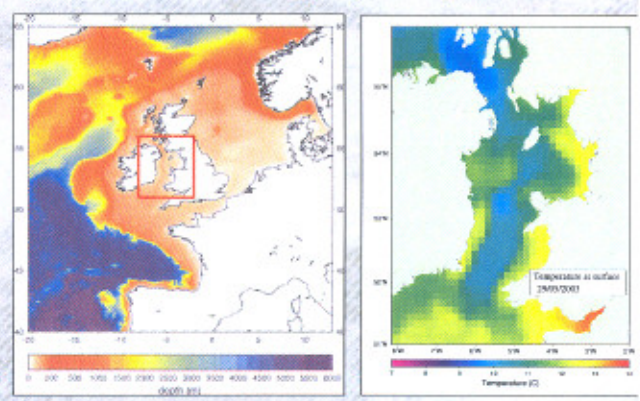


Visualisation, data banking (community products) & high performance computing



Real-time Mo

Atlantic Margin (12km) Model



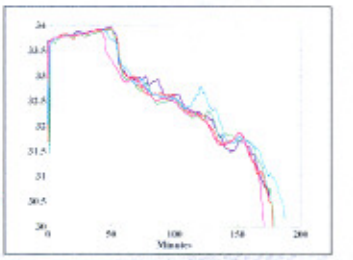
stal Observatory

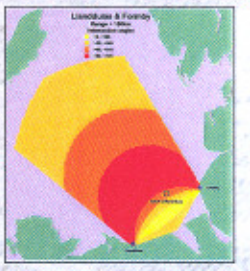
me coastal prediction system

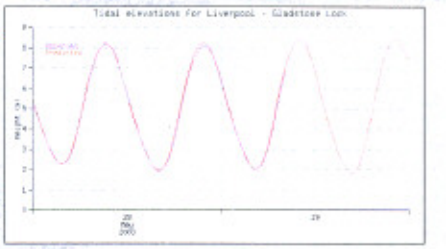
Contact : Roger Proctor, rp@pol.ac.uk
John Howarth, mjh@pol.ac.uk
url: cobs.pol.ac.uk

Measurements

- In situ time series of current, temperature and salinity profiles and of waves and weather
- The CEFAS SMART buoy for surface properties (N, P, Si, T, sal, turbidity, fluoresence) www.cefas.co.uk/Products/smartbuoy.htm
- RV Prince Madog to service moorings and for spatial surveys. www.vtplc.com/madog/
- Instrumented ferries for near surface T, S, turbidity, chl and later N
- Drifters, measuring surface currents and properties such as temperature and salinity
- Wave buoys and tide gauges
- Met data from Bidston Observatory
- Shore-based HF radar measuring waves and surface currents out to a range of 50km
- Satellite data - infra-red (for sea surface temperature) and visible (for chl and spm)



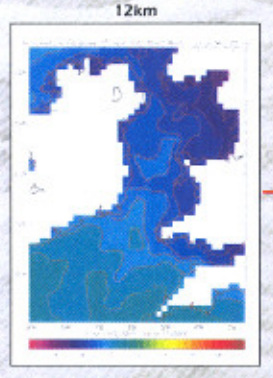




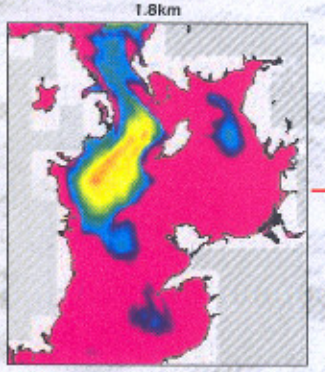
Modelling

At the Met Office POLCOMS on an ocean/shelf domain, forced by Numerical Weather Prediction mesoscale meteorology and ocean forcing from FOAM (Forecast Ocean Assimilation Model), provides the boundary conditions for the Irish Sea model, which in turn provides boundary conditions for the Liverpool Bay model. Local river discharges will be included through a link-up to the Environment Agency river-flow network.

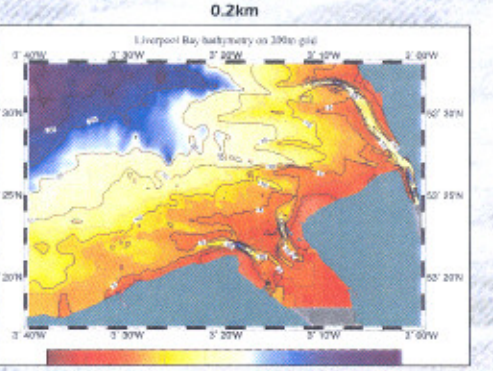
12km



1.8km

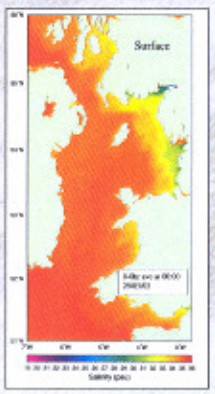


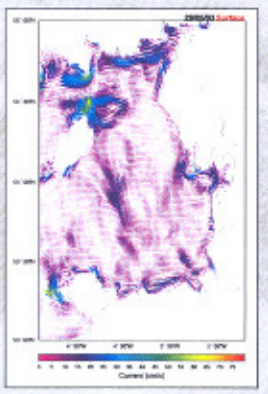
0.2km



del Results

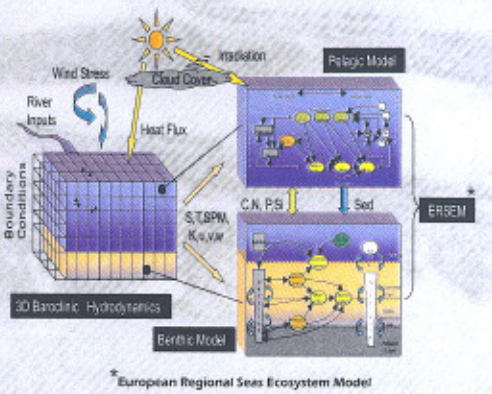
Irish Sea (1.8km) Model





Planned, mid 2003

Biological Forecasting



*European Regional Seas Ecosystem Model

Indicators

Typical indicators produced by model based marine monitoring system include

- plankton concentration
- total, new or primary production
- peak production of algal groups
- bottom oxygen concentrations
- zoobenthos
- oxygen consumption
- nutrient concentration and ratios
- nutrient transports to target areas