Studies of sea level and ocean circulation variations and tides

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The Proudman Oceanographic Laboratory (POL) and the Department of Earth Sciences (DES) of Liverpool University (LU) intend to employ data from the Jason-1 mission in several areas of research. The work is a continuation of research with TOPEX/ POSEIDON (T/P) data, with some new directions. The areas overlap but common themes include the use of in-situ data (tide gauges, bottom pressure recorders, etc.) to validate and complement Jason-1 altimetry; the use of numerical models to compare or assimilate altimeter data; and a geographical concentration of interest in the Atlantic Ocean, although other regional and global studies (e.g. of the Antarctic Circumpolar Current, or of global ocean dynamics or of global tidal loading) are also included.

Exploitation of a sea level/bottom pressure network in the South Atlantic and southern oceans

Since 1983, POL has operated a network of seven tide gauges in the South Atlantic and Antarctica, and has deployed bottom pressure recorders (BPRs) at the Drake Passage and other sites, in a programme called ACCLAIM (Antarctic Circumpolar Current Levels by Altimetry and Island Measurements). It is our intention to maintain the tide gauge network of ACCLAIM for the foreseeable future as part of the Global Sea Level Observing System (GLOSS), which is one of the first components of the Global Ocean Observing System (GOOS). This extensive network has applications in a number of scientific areas: as UK contributions to GLOSS development; for the construction of indices of ACC flow at high southern latitudes inaccessible by altimetry; for ongoing regional validation of altimetry (GLOSS-ALT); in combination with altimetry for studies of meteorological influences on sea level variability; and, in the case of BP measurements, for the determination of additional tidal constants in the Southern Ocean where K1-Ssa ambiguity from T/P and Jason-1 altimetry alone is large.

Argentine Basin bottom pressure coherence experiment

The objective of this experiment is to compare bottom pressure measurements in the Argentine Basin to T/P and Jason altimetry as part of an ongoing programme to assess the scales of coherence of bottom pressure fluctuations and their dynamical significance.
This work will address the different information content of sea level and bottom pressure measurements in the deep ocean, using altimetry to put point measurements of bottom pressure into a broader spatial context, and using model output (for example, from the OCCAM OGCM) and theoretical development to understand the dynamics.
The experiment will build on previous work in the area using T/P data.

During the GRACE mission (scheduled for launch late-2001), analysis will be extended to include remotely-sensed bottom pressure for the study of signals of "barotropic hot spots" observed in the different data types (altimetry, bottom pressure, space gravity). Theory suggests that the combination of sea levels and bottom pressure satellite measurements will provide powerful constraints on deep ocean dynamics, as discussed at an important scientific meeting on space gravity and bottom pressures hosted by POL at the Royal Society in April 1999. Also on the subject of space gravity missions, we note here that POL has been actively involved in planning the European Space Agency's Gravity Field and Steady-State Ocean Circulation Explorer Mission (GOCE), which will also be of major benefit to ocean circulation studies by enabling us to determine the absolute circulation from large to small wavelengths.

Assessing changes in the open ocean circulation and heat content from altimetry and model studies

We shall use open ocean satellite altimetry to estimate the time-varying and steady circulation, as well as to understand the controlling dynamical processes. Of particular interest is reducing the uncertainty in estimating the volume transport and heat content associated with ocean gyres within basins. A novel combination of an ocean thermocline model and the dynamic height evaluated from T/P has already been used to estimate the ocean transport of volume over the subtropical gyre of the North Atlantic. This approach has identified the relative importance of surface and lateral boundary conditions in controlling the gyre transport. It is important now to assess how interannual variations in surface forcing are connected with interannual variability of the gyre circulation, as well as the impact on heat fluxes and tracer distributions. The role of mesoscale eddies in likewise transferring momentum, heat and tracers has been studied in idealized modeling experiments, which in particular reveal how eddies can advect properties (even up-gradient) as well as diffuse them. Previous studies

will be extended to address the interannual variability of ocean gyres through a combination of diagnostics of altimetric and hydrographic data, as well as conducting experiments with general circulation models to identify the controlling processes.

European shelf edge studies

This experiment has three objectives: (1) to estimate the scales of surface elevation transferred between ocean, shelf and coast, and the extent of on-shelf penetration; (2) to relate variable ocean-shelf differences in surface elevation to processes, especially along-slope flow, wind and possibly density-related ocean-shelf exchange; (3) to assess the value of ocean surface elevation as an input to models of shelf and slope seas. For (1) and (2), altimetry and coastal elevations from tide gauges will be used to estimate the amplitude and scales of sea-surface elevation variability, in the deep ocean, in shelf seas and at coasts (including islands). A trial off Namibia with earlier altimetry showed that there, variability over the shelf was less than over the ocean, and that variability correspondence between ocean and shelf edge was more apparent at scales of 200 kilometres than 400 kilometres; this may have been associated with Agulhas eddies; little oceanic variability penetrated the shelf. Winter 1982-3 "CONSLEX" data northwest of Scotland showed extensive along-shelf correlation of coastal and on-shelf bottom pressures, with propagation clockwise around Scotland. The largest-scale oceanic pressure signals reached the coast, especially at higher frequencies, but additional weather-related signals occurred on the shelf. These findings correspond more with general expectations from theory.

This study will focus on the shelf north of Scotland, which is nearly parallel to altimeter tracks and has adjacent permanent tide gauges for comparison data. Present measurements of currents on the slopes in Nordic WOCE and the EU project MAIA relating coastal sea levels to North Atlantic warm-water flows to the Nordic Seas are planned to continue. For objectives (2) and (3), an ocean model, with assimilation of surface elevation data and some (coarse) representation of the shelf, will be coupled with a model of the continental shelf and slope. The study should provide a methodology for assimilation of surface elevations from altimetry to an ocean model driving a shelf-sea model in turn; estimates of transfer scales in some contrasted contexts; and estimates of relations between elevations and North Sea in-out-flows.

Regional and global ocean tide modeling and tidal loading

Data from the T/P project have enabled major improvements in global ocean tide models. We expect that similar improvements will also eventually be achieved in regional and local modeling, as, for example, authors employ T/P and Jason-1 data for model boundary conditions. It is our intention to further develop local tide models in the future at POL, with the objective of aiding the development of truly global models applicable to both deep sea and coastal research. In our view, the "One Centimetre Challenge" for T/P and Jason-1 in deep ocean models has to be accompanied by: (i) a "Several-Centimetre Challenge" for tidal predictions in shallow seas, and (ii) a "Useful tidal current estimation Challenge" for tidal currents to provide useful corrections to oceanographic cruise ADCP information, for a large number of practical applications (e.g. rig deployment), and for several areas of geophysics. The work programme will also include extensive tidal loading studies.

Ongoing altimeter calibration

The objective is to provide a collaborative mechanism for ongoing altimeter calibration by use of either dedicated calibration sites and/or through the global tide gauge network. In collaboration with Newcastle University, POL has in the past undertaken both "absolute" and "relative" calibrations for T/P and ERS-1/2, and these exercises will be continued for Jason-1. The main component of the new research will be to use UK tide gauges equipped with permanent GPS receivers to provide estimates of geocentric sea surface height at nearby overpasses of the satellite, the small offsets in height due to the geoid being corrected by advanced, new models of the geoid now available for NW Europe (e.g. EGG97, EDIN2000). The construction of long-term, precise global data sets is clearly the main motivation for the Jason series of missions. With regard to sea level studies, the acquisition of calibrated altimeter data will provide truly global estimates of change for input to climate studies, extending POL's "Mean Sea Level" interests in this area.

More information?

A longer version of this report, containing more background information and details of other areas of work, is available from the corresponding author.

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