



The marine environment requires sustained observations to obtain meaningful information on environmental changes and their causes. To this end, the National Oceanography Centre, Southampton, supports a number of marine time-series and monitoring studies in the Atlantic and Southern Oceans. The primary aims are to provide data and knowledge on a wide range of oceanic processes, from ocean circulation to biodiversity. They have been developed not only to provide long-term data sets but also to capture extreme or episodic events and to play a key role in the initialisation and validation of models.

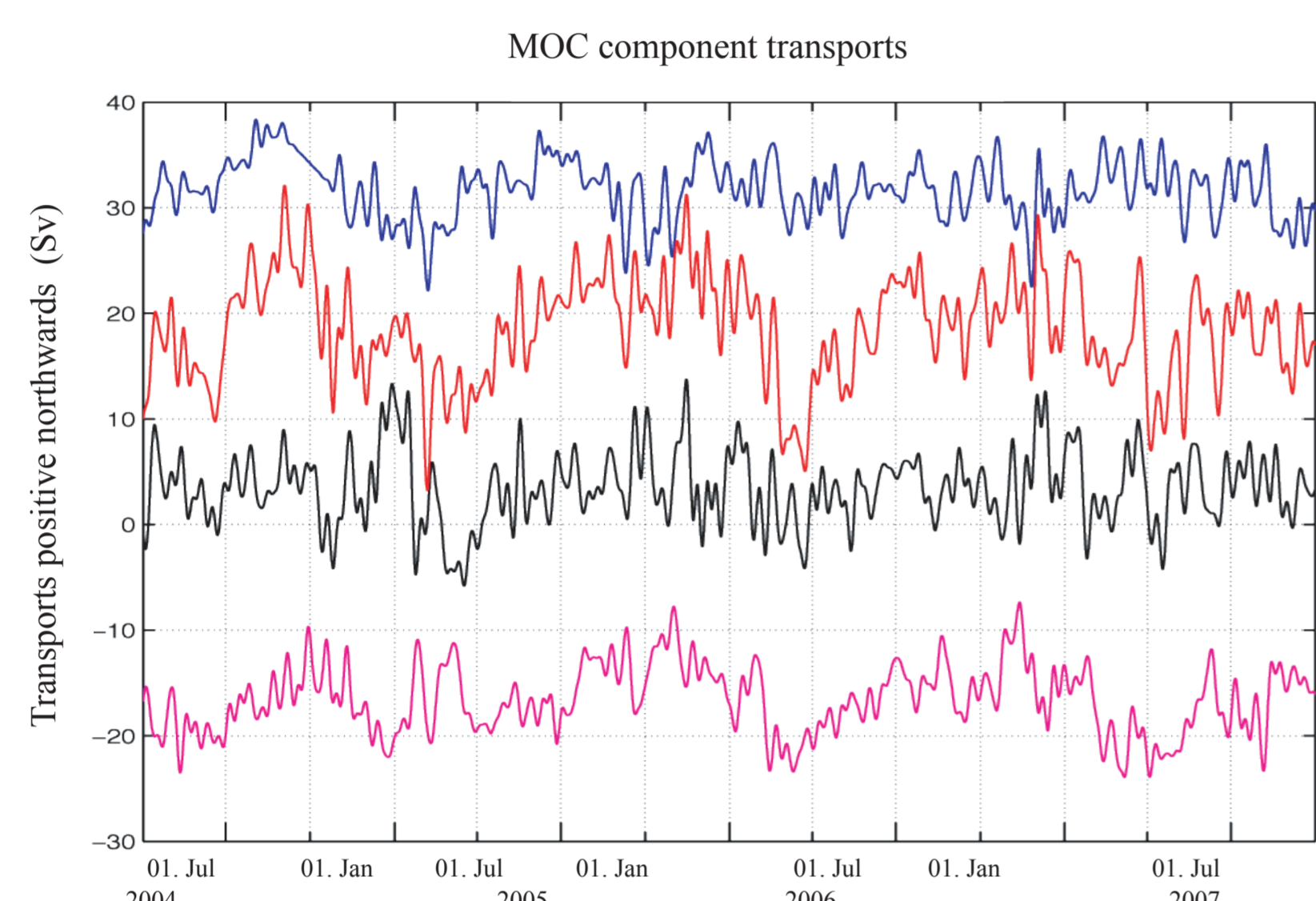
The Atlantic Meridional Overturning Circulation (AMOC) East-West mooring array

The aim of the project is to observe on a daily basis the strength and structure of the AMOC and deliver a decade-long time series of calibrated and quality controlled measurements.

The AMOC at 26.5°N, carries a northward heat flux of 1.3 PW and as it moves north much of this heat is transferred to the atmosphere and subsequently is responsible for maintaining the UK climate about 5°C warmer than the zonal average at this latitude. However, due to sparse data, it is unclear whether the AMOC is slowing in response to global warming as suggested by recent model results.

The data from the arrays and elsewhere will be used to determine and interpret recent changes in the Atlantic MOC, assess the risk of rapid climate change, and investigate the potential for predictions of the MOC and its impacts on climate.

So far results* demonstrate that the AMOC, has dramatic and unexpected variability with a mean strength in the first year of 18.7±5.6 Sv.



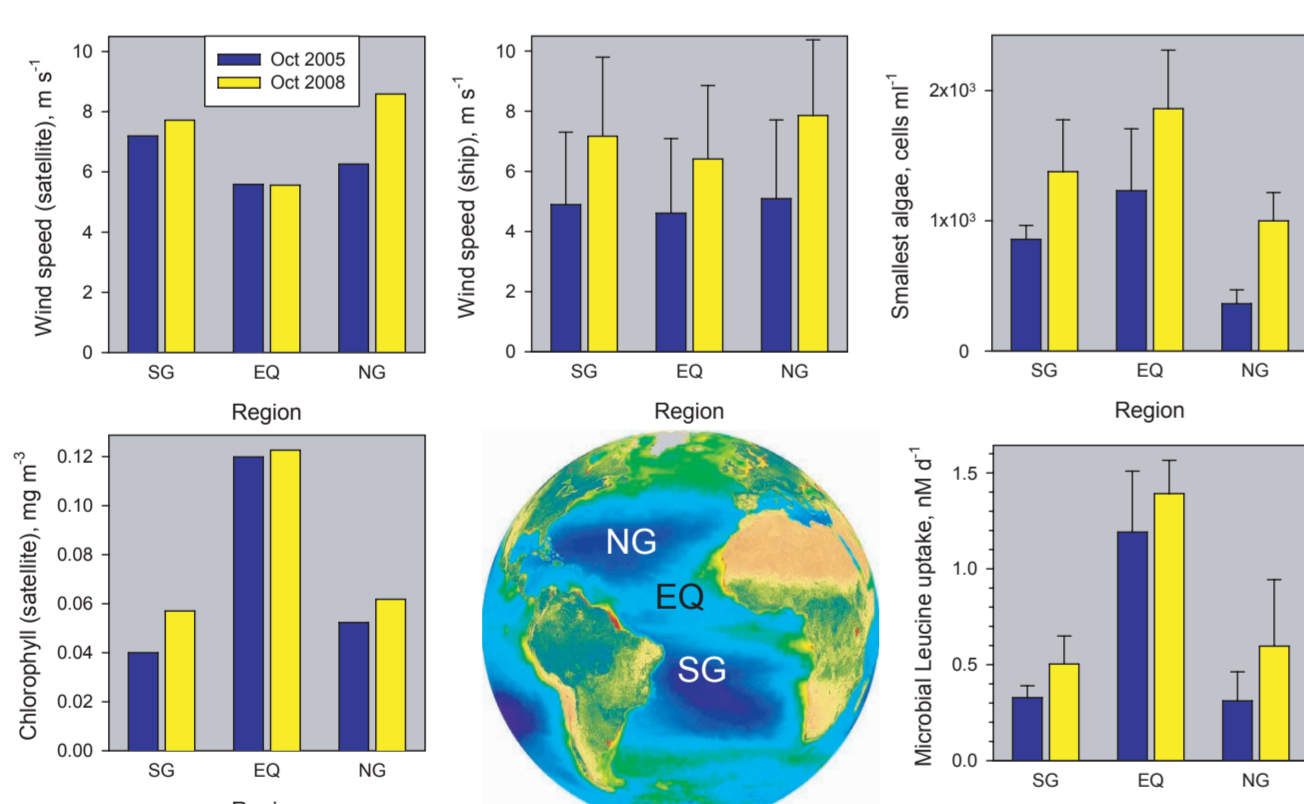
Twice daily time series of Florida Straits transport (blue), Ekman transport (black), upper mid-ocean transport (magenta) and reconstructed MOC transport (red).

*Cunningham, S. A., et al. (2007), Temporal variability of the Atlantic Meridional Overturning Circulation at 26.5°N, Science, 317, 935-938.

Atlantic Meridional Transect

The Atlantic Meridional Transect Programme, which began in 1995, is an open ocean in-situ observing system that utilises the passage of the RRS James Clarke Ross between the UK and the Falkland Islands southwards in September and northwards in April each year. The aim of the programme is to understand ocean plankton communities and improve our ability to predict the role of the open ocean in the global carbon cycle.

Recent results show that the abundance of the smallest algae, which are responsible for a major part of CO₂ fixation, were about twice as high across the Atlantic Ocean from 30°N to 30°S in autumn 2008 compared to autumn 2005. The observed differences are more likely related to large-scale changes of wind forcing rather than to seasonality, taking into account a corresponding ~50% increase in the mean wind speed in autumn 2008 compared to autumn 2005. This suggests that climate-change induced increase in wind stirring could elevate phytoplankton growth & sequestration of CO₂ in the open ocean.



Inter-annual differences in wind speed, chlorophyll, algal numbers & microbial activity in the three major regions of the Atlantic Ocean

Drake Passage

The UK maintains an annual full-depth repeat hydrographic section in the eastern Drake Passage. The first occupation was in 1993, and only two years have been missed since then. The measurements are mainly physical: CTD and shipboard ADCP, with Lowered ADCP added in 1996, at a maximum station spacing of 35 km.

This coast-to-coast transect across the Antarctic Circumpolar Current enables the baroclinic transport of the current to be measured, and this is found to have an average of 137 x 10⁶ m³/s, with an interannual variability of about 6%. The variability means that 20 years of measurements would be needed to be sure of detecting a change of 10%, and an even longer time series would be needed to detect smaller changes.

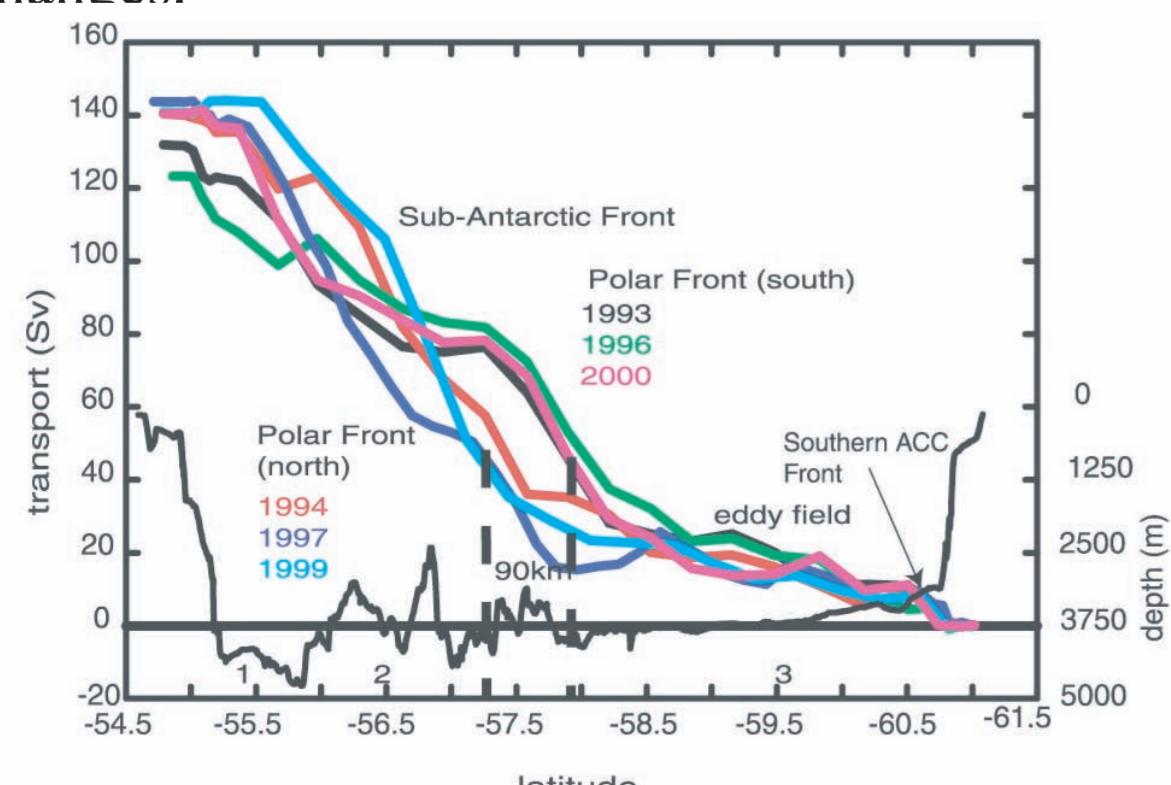


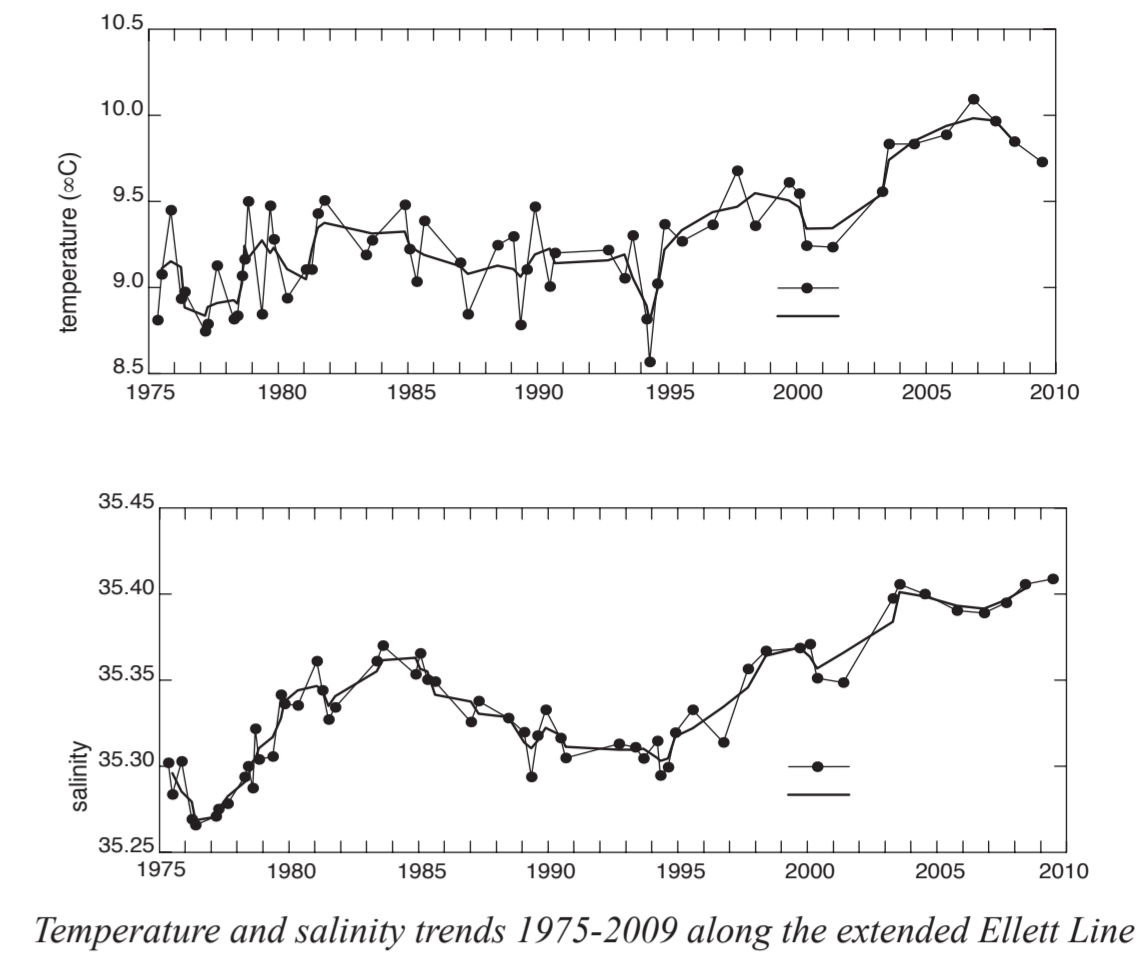
Illustration of the variation in transport across Drake Passage for six years of data. The main current jet, the Polar Front tends to be found in one of two locations. The volume transport is accumulated from south to north each year

The extended Ellett Line

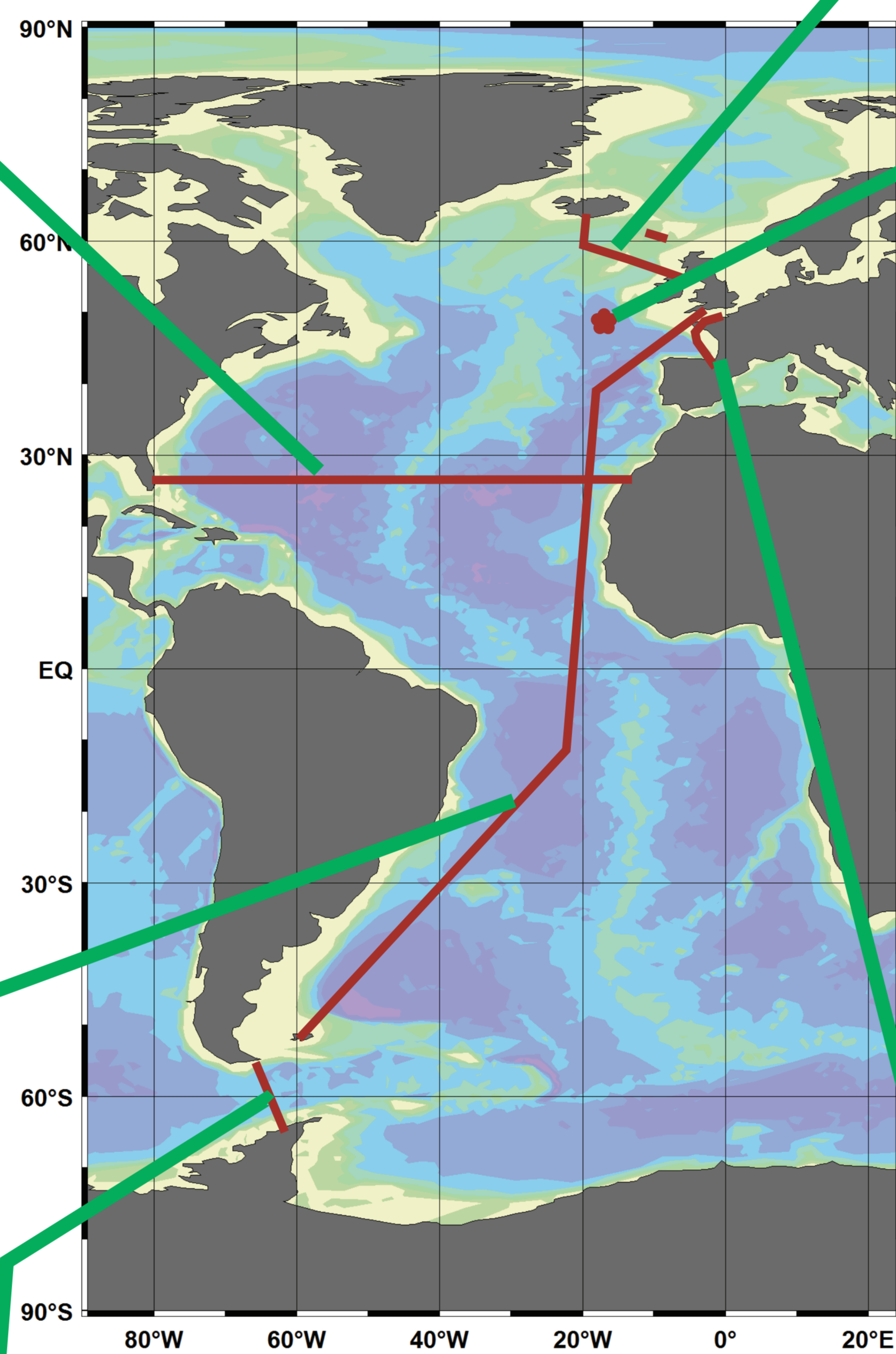
This annually occupied, full depth hydrographic section between Scotland, Rockall, 60°N 20°W and Iceland is designed to capture the warm saline inflow into the subpolar gyre and the Nordic Seas, and the path of the deep returning flow in the lower branch of the meridional overturning circulation. The aim is to create a time series that can be used as measure of climate change in the Northeast Atlantic and against which numerical models can be assessed. In addition there is an ADCP mooring monitoring the Wyville-Thomson Ridge overflow.

The line from Scotland to Rockall has been occupied since 1975 and the extension to Iceland since 1996. Results show a steady increase in both temperature and salinity in the upper ocean over the last 30 years with variability of up to 1.5°C and 0.1 in salinity. Both temperature and salinity have remained at an all series high over the last 5 years.

More details are available at <http://www.noc.soton.ac.uk/obe/PROJECTS/EEL.index.php>



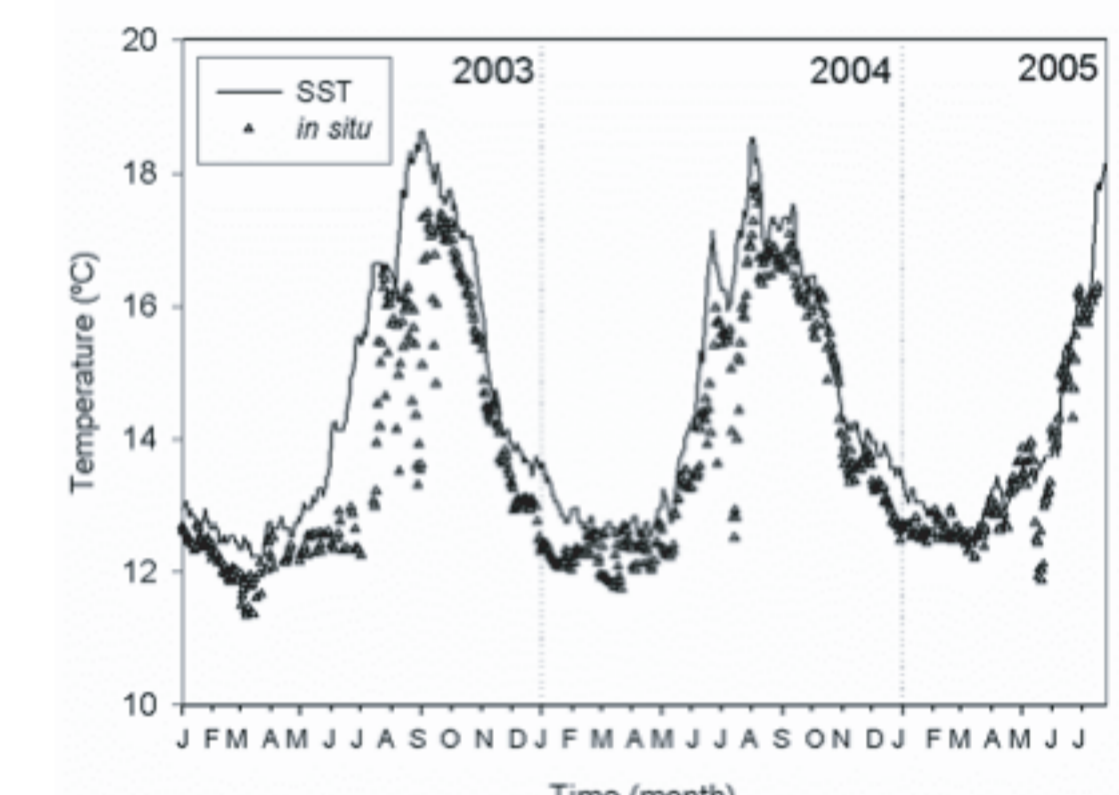
Temperature and salinity trends 1975-2009 along the extended Ellett Line



The Porcupine Abyssal Plain (PAP) fixed-point observatory

The observatory sited at 49°N, 16.5°W in the Northeast Atlantic is the longest running deep ocean time-series observatory in Europe. The aim is to collect high resolution in-situ multidisciplinary time-series data of climatically and environmentally relevant parameters from the euphotic zone to the benthic boundary layer. These include sub-surface measurements of temperature, salinity, chlorophyll-a fluorescence, nitrate, pCO₂ and deep ocean particle flux. Data are sent in near real-time from the upper 1000m through Iridium telemetry to shore stations.

Trends from 2003 to 2005 indicate a higher temperature and salinity signal in surface waters from 2003 to 2005 with increased stratification, decreased nitrate concentration and consequent decline in productivity and delay in the spring bloom. In addition, there is evidence that the levels of pCO₂ being absorbed in this persistently undersaturated region are reducing which has future implications for the global carbon cycle and importance of the oceans as a



Variation in temperature at the PAP observatory site from 2003 to 2005. Triangles = in situ subsurface mooring based measurements (from 20m to 225m; black line = Sea Surface Temperature (SST) data from the National Center for Environmental

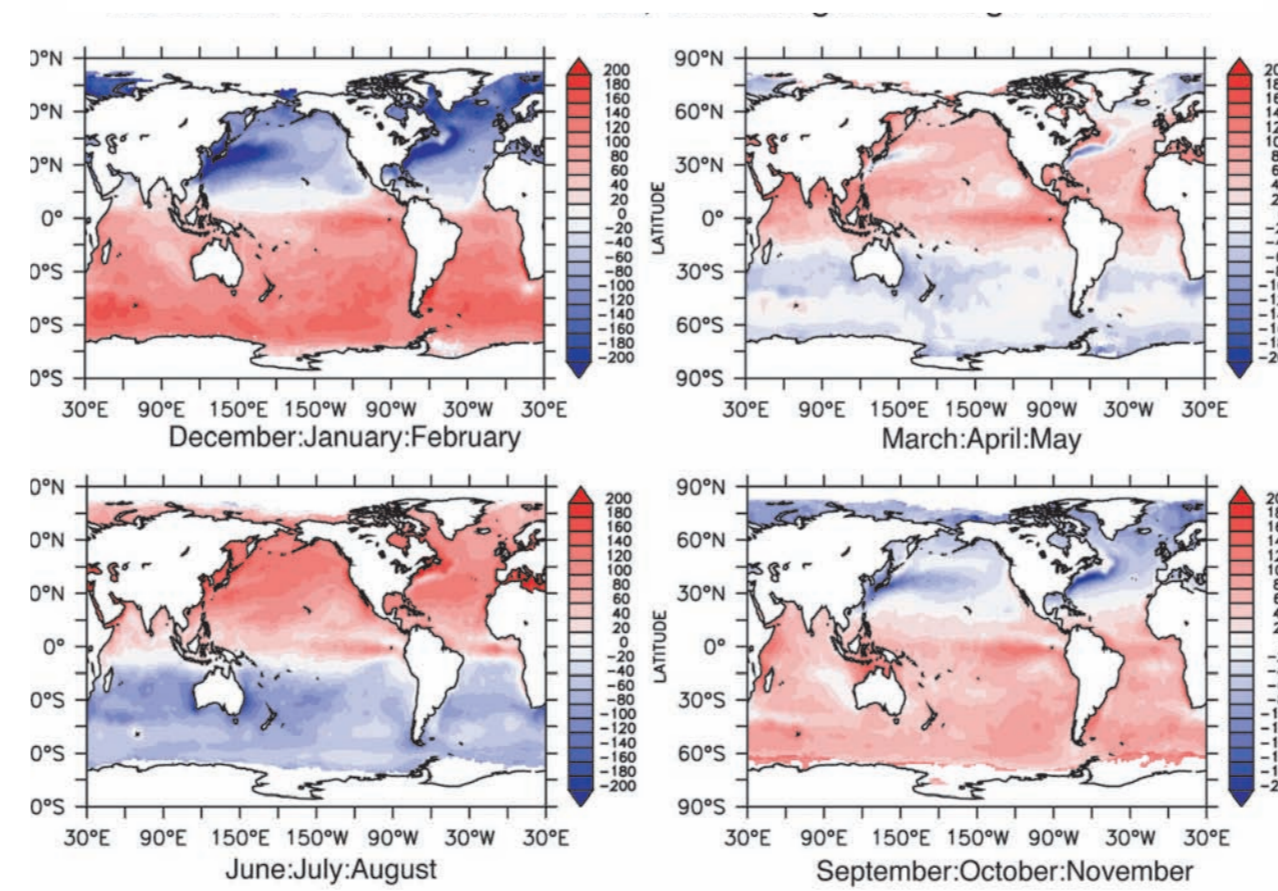
*Hartman, S. E., et al., Seasonal and inter-annual biogeochemical variations at PAP (49°N, 16.5°W) 2003-2005 associated with winter mixing and surface circulation. Deep Sea Research, accepted.

Climate quality surface marine observations and products

The aim of this programme is to take historical and operational data collected by international meteorological programmes and satellite agencies and develop data sets and data products that can be used in ocean circulation and climate research.

In situ marine meteorological data sets contain well-known variations in sampling density with good data coverage in the main shipping lanes and in Northern mid-latitudes, but are sparse in other areas of the world; there are also issues of quality control. Using state of the art flux parameterisations, improved bias corrections, data homogenization and uncertainty estimates, a 36-year (1973-2008) global monthly mean surface meteorological and flux dataset has been produced*. The dataset includes global marine monthly fields of air temperature, SST, humidity, wind speed, pressure, sensible and latent heat fluxes and shortwave and longwave radiation. The next steps for the flux dataset are to extend the record back to the late 1950s and to include selected satellite parameters.

Improved satellite datasets are also being constructed: a global wave height and period dataset from satellite altimeters is under development and research is working toward new methods to derive wind and wave parameters from GPS satellite "signals of opportunity" **

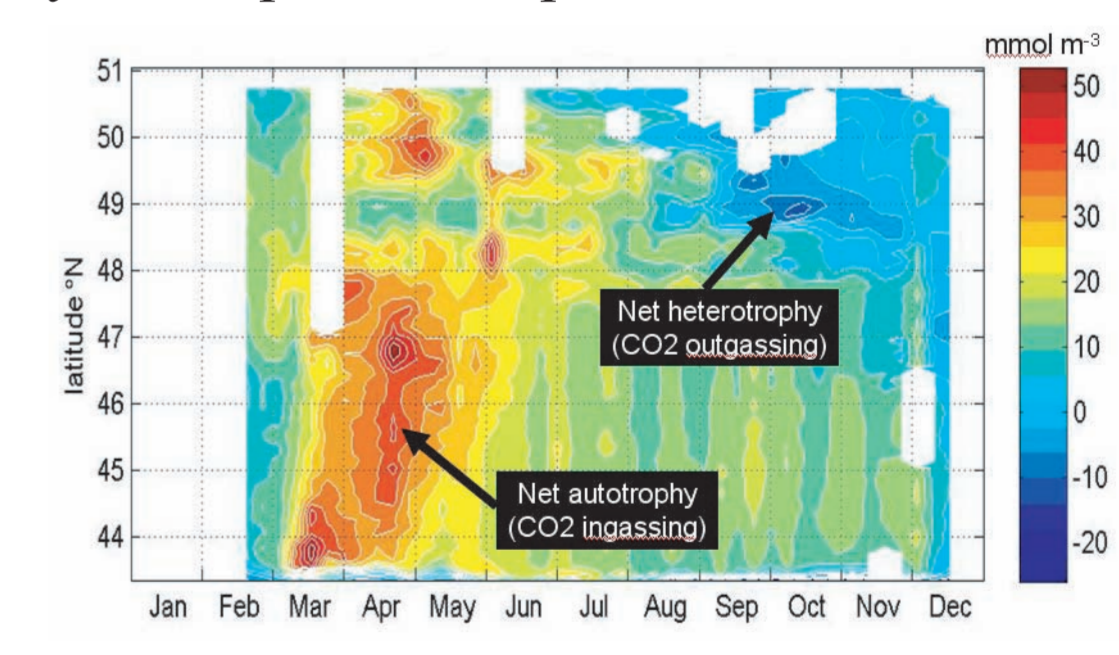


The NOCS v2.0 Net Surface Flux, Climatological Average 1973-2002

*Berry D. I. and E. C. Kent, 2009: A New Air-Sea Interaction Gridded Dataset from ICOADS with Uncertainty Estimates. Bull. Amer. Meteor. Soc.: 90, 645-656.
**Clarizia, M. P., C. P. Gommenginger, S. T. Gleason, M. A. Srokosz, C. Galdi and M. Di Bisceglie, 2009: Analysis of GNSS-R Delay-Doppler Maps from the UK-DMC satellite over the ocean. Geophysical Research Letters, 36, L02608. doi:10.1029/2008GL036292

The Portsmouth-Bilbao transect

This route is traversed twice weekly throughout the year by the commercially operated P&O ferry MV Pride of Bilbao. The ship is fitted with a dedicated seawater intake for scientific work and has been instrumented by NOCS with a standard 'Ferrybox' system which logs temperature, salinity, oxygen, fluorescence and occasionally carbon dioxide. There is also a radiometer above the bridge for sea surface temperature measurements. Data is received at NOCS via satellite link (EU Ferrybox project) and the novelty of the project is the long time series of integrated simultaneous measurements that began in 2001. Since the ferry crosses a number of oceanic and biological provenances, it provides data over a variety of temporal and spatial conditions.



Ecosystem trophic state as revealed by the oxygen anomaly along the MV Pride of Bilbao route: Mean 2005-2007

Argo

The UK has been a strong supporter of Argo since the program began, and is fully committed to the Argo goal of maintaining a global array. It has deployed nearly 300 floats since the start of the program in 2000, in the North and South Atlantic, Indian and Southern Oceans, and has been pleased to collaborate with other countries including Ireland and Mauritius on deployments and data handling.

Within the UK, the main customers for float data are the data assimilation activities at the Met Office, either for short-term ocean forecasting or seasonal combined ocean-atmosphere forecasts, and nearly 50 individual projects or researchers in Universities and Government Laboratories.



Deploying an Argo float in the South Atlantic. RRS James Cook Cruise 032 in March 2009