

**DEVELOPPEMENT OF A REAL TIME IN SITU OBSERVING SYSTEM
IN THE NORTH ATLANTIC OCEAN,
BY AN ARRAY OF LAGRANGIAN PROFILING FLOATS**

GYROSCOPE

Project N° EVK2 – CT - 2000 - 00087

Key Action 2 “Global Change, Climate and Biodiversity”

2.4. European component of the global observing systems

2.4.2. Development of new long-term observing capacity

First Progress Report

January 1st to June 30th , 2001

GyroScope : First progress report

1. Highlights of the first semester

In accordance with the work plan, the first semester has been devoted mainly to instrumental evaluation, field work preparation and planning, and setting up the data management structure (WP1 to 3). Progress on the other work packages, which is dependent on the availability of data, will start mostly in the second year of the project. Nonetheless, work is reported here on preliminary activities such as setting up models, preparing data bases, developing techniques and methodology, etc ... In all those areas, progress follows the work plan. However, some delays have incurred in carrying out the field work (which is not unusual in marine operations).

Field operations were to begin in June, on *FS Poseidon*, on a cruise from Lisbon to Reykjavik. Unfortunately a severe accident (fire in the engine room) occurred in April, which disabled the vessel. Alternate deployments opportunities are presently being considered.

Since the inception of the ARGO programme, float manufacturers have received large number of orders, so that delivery of the instruments is slow. It now appears that the deployment of the 80 GyroScope floats will not be completed until the summer 2002. This represents only a delay of a few months with respect to the Work Plan which anticipated full deployment of the array by month 18 (but the first seedings will be ramping up more slowly than anticipated).

2. Progress report

WP 1 : Design and deployment of a pilot array

Task 1.1 – Array and experiment design

The work with the $1/3^\circ$ MERCATOR model simulation is completed at CLS, and a publication on the results of the study was submitted to the Journal of Marine Systems. The objective was to assess the large scale temperature and salinity mapping capability of a profiling float array (as the one envisioned for Gyroscope). The results are sensitive to the a priori definition of the large scale and low-frequency reference fields. However, they show that a three-degree array with a ten-day cycle can retrieve most of the variance of the large scale and low-frequency signal. Comparison between Eulerian and Lagrangian arrays shows only a slight degradation in the results due to the dispersion of the floats. We are now working with a higher resolution model ($1/6^\circ$) to better analyze the effect of mesoscale variability and float dispersion. This work has been slightly delayed due to the unavailability of the $1/6^\circ$ CLIPPER model simulations. It will be completed within the next three months.

A complementary approach has been pursued at the IFM : simulations have been carried to study float dispersion properties in the subpolar North Atlantic, using all available “historical“ (existing) deep float trajectories from various European and US investigators. A large data base has been assembled, with sufficiently dense trajectories that at any point where a simulation was to be started, an existing trajectory could be found to be followed from there on, serving as a simulation for the path. If in different realizations different trajectories are chosen, a certain randomness can be obtained, serving as a set of ensembles over which the dispersion properties can be assessed.

The key experimental parameters have been discussed at the kickoff meeting and at the ARGO Science Team meeting in Sidney (Canada). It was agreed that the parking depth (i.e. the depth at which the floats drift) would be selected according to the water mass of interest in a given region; with a cycling period of 10 days and a profiling depth to 2000 m. The positions of float release will be dependent on ship availability (see Task 1.3).

Task 1.2 - Preparing the floats

The first order of business has been to review float characteristics proposed by the different manufacturers : only two of them (Webb Research Corporation, WRC in the USA) and Martec, in France) can provide floats for the GyroScope programme. The two types, called the APEX and the PROVOR, respectively, can be fitted with Seabird or Falmouth Scientific Instrument (FSI) sensors. The prices are comparable. The APEX float is a more proven technology, the PROVOR is a new product, still in the stages of validation. The manufacturing delays are of the order of 6 to 8 months (although WRC could provide a first lot of 10 instruments at shorter notice), thus precluding significant deployments in the 2001 summer.

These issues were reviewed at the kickoff meeting, and it was decided that IFM would order 40 APEX from WRC, and LPO, 40 PROVOR from Martec. Thus it will be possible, as planned, to evaluate different types of instruments and to assess their relative performances.

At this time, the first lot of 10 APEX has been delivered to IFM and are on board the *RV Meteor*. They will be prepared for launch during the cruise 50/4 departing in Reykjavik on 17 July 2001. They will be deployed en-route in the Iceland and western European Basins. Prior to the floats' delivery they were uploaded with mission software modules. The mandatory 10 day cycle, a maximal profiling depth at 2000 m, and a park depth of 1500 m were selected in accordance with the expected spreading of Labrador Sea Water in the NE Atlantic. Efforts to adopt the WMO unique tag system for Gyroscope are underway.

Task 1.3 - Field work

Planning for deployments has proceeded along several lines. Several discussions have taken place at the kickoff meeting in Brest and at the ARGO science team meeting in Sidney to adjust planning between the participating countries (Canada, EU, France, Germany, UK, and USA) in order to achieve as complete and uniform coverage as possible.

The first cruise for deployment was to be on the *FS Poseidon* on route between Lisbon and Reykjavik in June 2001. A significant problem occurred in May when the ship's central electrical power and control unit caught fire at sea west of the Cape Verde Islands. Fortunately nobody was severely injured. A careful inspection after the ship had been towed safely into port revealed the extent of the damage which will not be repaired before the end of 2001. With *FS Meteor* presently operating in the subpolar gyre off Labrador the cancellation of the *Poseidon* cruise for the Gyroscope seeding task can be partially compensated in regions south and east of Iceland. The Irminger Sea south-west of Iceland will be covered by cycling floats from national UK sources as was discussed during the Sidney meeting of the ARGO science team. It unexpectedly sets free Gyroscope resources for regions of the North Atlantic farther east and south of Iceland.

Other cruises presenting opportunities for deployment have been identified : on the *RV Pelagia* in October 2001 (north and north-east of the Azores) and on a research ship from the French navy (*BSHM*¹) in November (in the Madeira region). Further deployments will take place in the Spring and Summer 2002 : ship-time has been granted for several cruises (on *NO Thalassa* from Brest to South Greenland to Spain; on *Vizconde de Eiza* in the Canaries

¹ Bâtiment de Soutien de Haute Mer

Basin ; on *Meteor* and *Poseidon* in subpolar gyre) and a request is pending on a French *BSHM* in the Azores area. Those cruises will allow deployment of the array to be completed as planned during the summer of 2002.

WP 2 : Instrumental monitoring and evaluation

Task 2.1 - Monitoring float performance

This task will begin as soon as the first floats are deployed. In preparation, and in support of float purchases from Martec, LPO has reviewed in detail the performances of floats that were deployed in other programmes. There are presently 12 PROVOR of various types active in the North East Atlantic (most are temperature only ; three are identical to those ordered for GyroScope). Various indicators of performance and design have been scrutinized closely, and synthesis graphics developed. Recommendations have been made to the manufacturer for improvement of the software controlling the float movements and data acquisition. Those modifications will be implemented in the floats to be delivered in the future. One prototype, equipped with the latest software version will be deployed in July.

Visual tools are developed at IFM, that will be implemented for monitoring the array when it is operational. In addition, a web site for real-time graphic presentation of the data from IFM floats is being prepared in Kiel.

Task 2.2 - Sensor evaluation

The floats presently active indicate good performance of the sensors (FSI or seabird). Detailed and accurate evaluation of the long term stability and accuracy awaits deployment of the GyroScope floats. Techniques to assess stability with respect to climatology are presently considered at IFM and LPO.

WP 3 : Data management and information centre

Task 3.1 - Specification and design of data management structure

The Gyroscope float data will be managed by the Coriolis data center, which fulfills real-time and delayed-time functions. In real time the data are decoded, quality controlled and disseminated to users (on the GTS in particular). Various types of visualizations are available (profiles, maps, etc..). Updates of the software have been made to handle the APEX floats as well as the PROVOR.

A second version is in preparation, which should be operational at the end of this year. It offer improved presentation and a wider range of tools and presentations of the data.

The CORIOLIS data centre has been designated as one of the two ARGO data centres, so that all developments are made according to ARGO specifications.

Quality controlled data sets are available through the WMO/GTS network and on the Coriolis Web site :

www.coriolis.eu.org

Task 3.2 - Real time data management

Both types of floats from various programmes are presently successfully managed by the CORIOLIS center, which is now ready to receive data from the Gyroscope floats.

Task 3.3 - Assembly of integrated data set

This task to start towards the end of the project.

WP 4 - Information content of the float data

Until the float array begins operations, work on this package is preliminary.

Detection of climate change : At UKMO, a code has been written for sub-sampling climate simulations at ARGO resolution. The next step is to investigate the usefulness of simulated Argo data for detection of climate change.

Calculation of information content : At UKMO : various statistics of observation minus FOAM forecast model differences using 3 years worth of data from 1997-1999 have been calculated. The forecast model covers the North Atlantic at 1/3 degree resolution. The observational data used are (a) altimeter data (b) SST data and (c) thermal profile data. With altimeter data one can produce coherent estimates of the observation minus model variances on a 2 degree grid. The horizontal error co-variances have been calculated on a 10 degree grid. Fitting these co-variances with two functions whose length scales and amplitudes are varied to give the best fit to the data one finds that quite coherent ocean mesoscale and atmospheric synoptic scales are extracted. Similar information can be extracted from the SST data though the results are not as coherent as for the altimeter data. Further work proceeds on working on ways to group the thermal profile data to provide coherent and useful statistics. Data from January 2000 - June 2001 which includes more Argo data for further calculations will be generated over the next few months.

WP 5 - Develop and implement methods for real time field estimation

The implementation of an objective mapping procedure was the main activity scheduled in this work package at LPO for the first semester of 2001. For that purpose, the NADA software package has been adapted to the GyroScope area. Some difficulties specific to the interpolation of float profiles have been solved 1) a procedure to fill gaps in the float network by climatological estimates has been developed 2) because the float network does not fully resolve the dynamics of the ocean circulation, a procedure to smooth the float data according to the resolution of the network has been implemented. This procedure ensures that the climatological estimates used to fill in the gaps are not corrupted by this smoothing. The solutions to the various problems encountered during the implementation of the interpolation package are detailed in a report that will be made available to the GyroScope team.

WP 6 - Ocean processes

Ocean processes cannot be studied from the GyroScope array until it is in place. However some preliminary studies have been initiated :

UKMO has started work to make the Met Office surface fluxes for the North Atlantic area available for the work on the Gyroscope project planned by LPO.

LPO has started a study on the information given by PROVOR float profiles about the time evolution (from week to year) of the heat content in the upper layer of the North-Atlantic ocean (0-400 m). Heat content is computed using float temperature ascending profiles. On a float-by-float basis, the time evolution of this heat content is evaluated and compared to the sum of the other terms involved in the heat balance: surface atmospheric flux (data from CNRM, Toulouse), large scale heat advection (obtained from historical ocean data), etc... When the UKMO fluxes are available, the procedure will be extended to the whole North

Atlantic. In this way, one should be able to better understand heat transport in the ocean, one of the goals of WP6.

IEO has started a compilation of bibliography to review hydrological conditions and circulation in the southern part of the GyroScope area. Historical temperature and salinity data has been collected in order to map the geographical distribution on MW and AAIW in the Canary basin. These data will be also used to find out the range of variation in temperature and salinity of the Mediterranean water (MW) and Antarctic intermediate water (AAIW) in support of climatological studies, and to define the range of variability to be expected in the float data.

WP 7 - Management, assessment and reporting

The project started officially on January 1st. After contract negotiations, the budgets have been notified and various administrative matters were settled.

The first kick-off meeting, held in Brest, Feb. 1st and 2nd, was attended by all participants.

It gave an opportunity to all participants to present what they intend to do, and to recall the scope of the project. Some minor adjustments to the work plan were made to tune the different contributions, to encourage complementarity, and to foster collaboration. Various issues related to data sharing, availability of numerical models, forcing fields, and needed complementary data were reviewed. Special attention was given to the actions for the first year, particularly field work planning.

In March, several of the project participants² attended the *3rd Meeting of the International ARGO Science Team* held at the Institute of Ocean Sciences (Sidney, Canada). This was the occasion to review and co-ordinate plans for float deployments in the Atlantic with our partners in Canada, France, the UK and the USA. The EU contribution to ARGO activities was clearly recognized, and Y. Desaubies was designated as a member of the newly formed ARGO Executive Committee.

The project coordinator participated in two meetings in Brussels : a project coordination meeting (May 15), and the 3rd Operational Forecasting Workshop (June 18-20). On both occasions the GyroScope project was presented.

A. Lavin gave a presentation of Gyroscope at the ICES Oceanic Hydrography Working Group in March, and G. Parrilla gave it at the IEO Governing Board. A short article on Gyroscope has been published in "Hoja Informativa", no. 52. Junio, 2001.

A paper entitled *Design of an array of profiling floats in the North Atlantic from model simulations*, S. Guinehut, G. Larnicol, P.Y. Le Traon, has been submitted for publication to the Journal of Marine Systems.

A first version of the User Requirement Document has been written and sent to the Commission.

A preliminary test version of the GyroScope Web site has been set up for comments by the project participants. It is expected to go on line in September.

² Desaubies, King, Parrilla, and Send