Climate Initiative – BNP Paribas Foundation
Call for projects 2013

# SOCLIM

## SOUTHERN OCEAN AND CLIMATE

### FIELD STUDIES WITH INNOVATIVE TOOLS

A proposal led by:

**Stéphane Blain (coordinator)**

Laboratoire d'Océanographie Microbienne

(Université Pierre et Marie Curie-CNRS)

**Hervé Claustre**

Laboratoire d'Océanographie de Villefranche

((Université Pierre et Marie Curie-CNRS)

**Sabrina Speich**

(Laboratoire de Météorologie Dynamique)

(ENS, CNRS, Université Pierre et Marie Curie)

## *1 ) PRESENTATION OF THE SCIENTIFIC RESEARCH (max 8 pages)*

### 1.1 Current knowledge, and general scientific objectives

The Southern Ocean (SO) is the most remote and the least understood of the world's oceans, although it plays a crucial role in past and present climate state and changes. It is unique in being the only zonally unbounded ocean. For this reason, it is the major link by which water properties are exchanged among the other oceans. It is a region of large exchanges of heat, fresh-water, momentum and carbon between the ocean and the atmosphere. The large rate at which energy is locally imparted to the ocean by the strong westerly winds forces the Antarctic Circumpolar Current (ACC; Wunsh, 1998), which is the longest and strongest oceanic current on Earth (Figure 1).

The strong eastward-flowing ACC tends to isolate the warm subtropical waters from the cold polar waters, acting primarily as a barrier to the inter-basin exchange of heat and other properties between the SO and the remainder of the global ocean.

Nonetheless, the intense air-sea ice-ocean exchanges across the SO, Ekman pumping due to the powerful and persistent wind regime together with the highly turbulent nature of the ACC give rise to two major meridional overturning circulation (MOC) cells, namely upper and lower (cf. Speer et al. 2000). The upper cell corresponds to the upwelling of deep waters and the equatorward return flow of lighter modal and intermediate waters. The lower cell combines the densest part of the deep waters with newly formed northward-flowing bottom waters originating along the Antarctic continental shelf. As a consequence, the deep circumpolar water is efficiently upwelled along the Antarctic divergence and it has been suggested that 65% of this water comes for the first time in contact with the atmosphere in the SO (De vries and Primeau 2011).

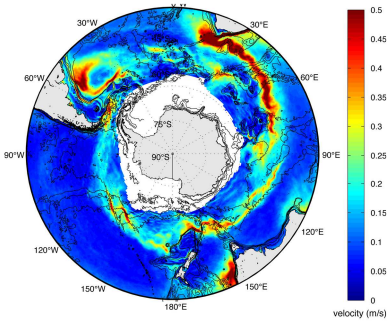



**Figure 1** : *geostrophic velocity intensity 26 december 2012*

Given the above, embedded in the global thermohaline circulation, SO contributes to the central role played by the SO in regulating the Earth's climate, through the formation, transformation and redistribution of water masses throughout the other three major oceans.

Accurately describing the circulation of the SO is difficult because of the prominent role of very intense fine-scale dynamics that characterizes the flows in this region all-along their paths, including the ACC, (Gille and Kelly 1996). It has been suggested that this dynamics, which is characterized by small eddies, jets and filaments, has a strong impact on the ocean circulation, biogeochemical properties and ecosystems in setting the density structure and transport properties of the current and in ruling vertical transfers as well as the structure of the upper branch of the MOC (Rintoul et al. 2001).

For example, the SO is a major source of natural $CO_2$ due to the upwelling of $CO_2$-rich deep waters, but a major sink of anthropogenic $CO_2$ due to the formation of intermediate and bottom waters (Takahashi et al. 2012). Moreover, the SO largely contributes to supply nutrients from the deep ocean to upper water layer everywhere in the world ocean (Sarmiento et al., 2004).

For all these reasons, the SO plays a critical role in the control of the Earth's climate. (Sigman et al. 2010, Kohfeld et al. 2005). In turn it is very sensitive to climate variability (Figure 2). Given the critical role of the SO in the Earth's climate system, changes in that ocean have global ramifications. In fact, such changes are already under way.

The SO is warming more rapidly and to greater depth than the global ocean average (Böning et al., 2008; Gille, 2008), and freshening has been detected at all depths (Durack and Wijffels, 2010), The SO $CO_2$ sink has decreased (Lequéré et al. 2007). Anthropogenic $CO_2$ concentrations have increased, changing the ocean chemistry (Orr et al. 2005) with impacts on marine organisms (Moy et al, 2009); ocean warming is contributing to enhanced melt of floating ice shelves, with implications for ice sheet mass balance and sea-level rise (Shepherd et al., 2004; Rignot, 2008); and changes in oxygen concentrations have been detected (Helm et al., 2010).

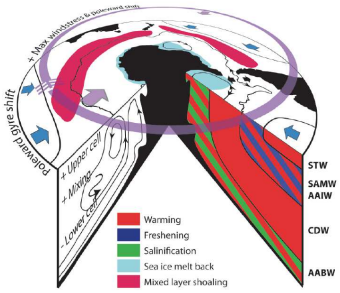



**Figure 2 :** *possible future changes in the SO (Meijer 2013)*

The SO is the largest High Nutrient Low Chlorophyll region in the World Ocean, where the potential for carbon storage by the biological pump is not fully realized. This is mainly due to iron limitation but other factors (light-mixing regime, silicate) also also important roles (Boyd 2002, Blain 2007, 2013). Future changes in atmospheric and oceanic dynamics may alter these factors, and therefore modify the efficiency of the biological carbon pump in a way that is presently very difficult to predict.

For a long time, the overturning circulation, the ventilation of the SO and other properties (e.g. nutrient distributions) have been described in terms of zonal means. However, recent studies have shown that within-zone spatial and temporal differences require detailed regional studies (Sallé et al. 2010).

### 1.2 General concept of SOCLIM and specific objectives

The SO extends over a vast area of the Earth's surface and it is located far away from the other continents and most of the research facilities. Extreme weather conditions and significant sea-ice coverage prevail there most of the year. At present, the SO remains very under-explored, and the scarcity of oceanographic data limits our ability to understand key climatic-relevant processes and document ongoing changes.

The present proposal (SOCLIM) intends to implement a cutting-edge approach that will qualitatively and quantitatively improve the observation of the SO *via* pioneering *in situ* data acquisition. We propose a coordinated and collaborative deployment of a network consisting of different innovative instrumented platforms. Such a network has not been conceived before, or deployed in the SO. The network (Fig. 3) will be based on newly developed instrumented profiling floats, moorings, and drifting platforms, which, in combination with existing systems will allow unprecedented data acquisition.

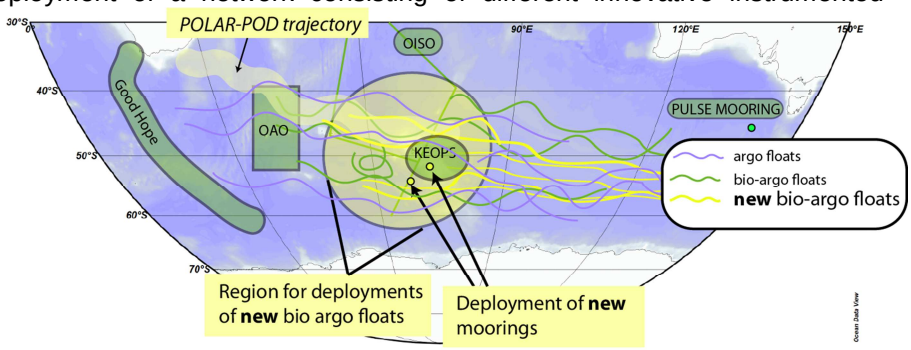



***Figure 3 :*** *The general concept of SOCLIM with the existing systems (in green and blue)*

We will explore a region of the SO encompassing the longitudes of South Africa and of Tasmania, and the latitudes from 40 °South to the Antarctic continent. This zone represents one third of this vast ocean. Our study will embrace the major types of systems that are relevant to climatic studies. From the circulation viewpoint, it will include regions representing fronts, the large Antarctic upwelling, and the formation of intermediate and modal waters. From the biogeochemical viewpoint, the study will investigate the whole range of productivity regimes, from the typically low productivity encountered in High nutrient Low Chlorophyll regions to large-scale naturally fertilized regions, e.g. Kerguelen, where the productivity is the highest measured in the SO.

A key deliverable of the present SOCLIM proposal would be an unprecedently consistent and high-quality data set covering a sizeable part of the SO (i.e. from South Africa to Australia and from 40°S to the Antarctic continent). This data set would be used to achieve the following four specific objectives.

#### 1.2.1 Improve the quantification of important climate relevant parameters such as air-sea fluxes of heat, fresh-water and carbon

A common element to high-latitude climate changes is their dependence on surface fluxes, and the ocean and atmosphere reactions to and interactions with these fluxes. Air–sea fluxes are exchanges of energy and materials between the ocean and the lower atmosphere. They include the net fluxes of momentum from wind, energy, and mass. Mass fluxes encompass a broad range of variables that include moisture and gases (e.g.,$CO_2$) as well as atmospheric aerosols. Surface fluxes at high latitudes affect processes that occur within the ocean (e.g., deep ocean convection; heat, fresh water and carbon budgets; changes in biogeochemistry and ecosystems) and the atmosphere (changes in energy and cloud cover). However, the magnitude and variations of these processes are poorly known, contributing to the present large uncertainty in climate change estimates (Bourassa et al. 2013). Hence improving our quantitative understanding of these processes is a key challenge for improving our ability to understand and predict climate changes, and develop adequate adaptation strategies.

During SOCLIM, we propose to simultaneously use different platforms, in order to significantly enhance the presently very limited number of estimates of air-sea fluxes of heat, fresh-water and $CO_2$, and thus allow a "quantum jump" in our knowledge of these processes. We will carry out both synoptical observations and quasi-Lagrangian high-frequency measurements. This way, we will obtain quantitative understanding of the spatio-temporal distribution, phenomenology and variability of these processes, and their functional links with oceanographic dynamical features and the large-scale atmospheric circulation.

### 1.2.2 Describe and quantify the physical and biogeochemical processes driving the sequestration of carbon

From the dynamics of blooms …

In the SO, iron is the proximate factor that controls phytoplankton production, but the highly dynamic light-mixing regime may also influence phytoplankton production over a broad range of timescales. In addition to the seasonal cycle associated with a shoaling of the mixed layer in summer, episodic deepening of the mixed layer causes changes in the light-mixing regime that may promote algal growth by alleviating nutrient limitation. Deepening of the mixed layer may also lower phytoplankton photosynthesis by reducing the average light intensity in the upper water column. Such short-term events may lead to interannual variations in the properties of seasonal blooms (i.e., onset, magnitude, and decline), and possibly cause "secondary" blooms. Simultaneously, the phytoplankton biomass interacts with the light field through attenuation of irradiance, which modifies the amount of light available for photosynthesis (i.e. the so-called "self-shading"; reported in the Southern Ocean by de Baar et al., 2005; Blain et al., 2013).

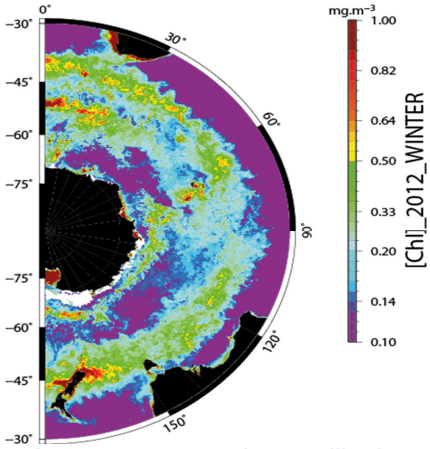



***Figure 4 :*** *Composite satellite image of summer phytoplankton chlophyll a (Dec-Feb).*

The vertical distribution of the phytoplankton biomass results from complex interactions between physical and biological factors. Deep or subsurface chlorophyll maxima (DCM) are recurrent features in the Southern Ocean (Uitz et al., 2009). Nevertheless, the processes responsible for their development, formation, and decay vary with seasons and regions and are often poorly characterized. Although DCMs are typically attributed to photoacclimation of phytoplankton to low light intensity in oligotrophic conditions (Cullen, 1982), complex mechanisms associated with the sedimentation and accumulation of particles from the upper mixed layer (Quéguiner et al., 1997) or the development of active algal cells supported by a deep nutricline (Holm-Hansen et al., 2004) have been observed in the SO. Further characterizing these processes is crucial to improve our understanding of the dynamics of DCMs and quantifying their contribution to primary production and associated carbon fluxes.

The important process of bloom triggering has long been attributed to the seasonal vertical displacement of the mixed layer depth relative to the critical depth, as explained by Sverdrup's theory (1953). Owing to recent technological developments and new observational approaches, this classical theory is becoming strongly challenged (Behrenfeld, 2010; Taylor and Ferrari, 2011).

Achieving a comprehensive understanding of the effects of light-mixing conditions on phytoplankton dynamics requires concurrent in situ observations of both physical forcing and biological variables in the ocean interior (i.e. not just in the surface layer "seen" by satellite-borne sensors) over a broad range of timescales. For SOCLIM, we propose to use extensively the recently developed Bio-Argo floats together with surface instrumented moorings, which would provide the high-quality time-resolved data over the large spatio-temporal scales needed to really understand bloom dynamics and the underpinning factors. Intensive investigations will be conducted in contrasted biogeochemical regions of the SO.

…. To carbon sequestration in the deep-sea

The attenuation of the downward flux of particulate organic carbon is a key process to be quantified as it is an important factor of control for exchanges of $CO_2$ between the ocean and the atmosphere (Kwon et al. 2009). Estimation of downward particulate fluxes mostly relies on deployment of sediment traps or thorium deficit measurements (Buesseler, 2009) with unavoidable large uncertainties because of the difficulties in acquiring coherent and interoperable datasets. More accurate estimations of the attenuation flux exponent (b), and a better understanding of its spatio-temporal variability represent one of the "hot topic" in marine biogeochemistry (Kwon et al., 2009). Better estimations of b may significantly reduce the uncertainties in quantifying and modeling the strength of $CO_2$ sink/source in the SO. Such determination are highly needed because there is recent evidence suggesting that the SO has a lower carbon export potential than what is predicted by models (M[illegible] et al., 2013). Some real hopes now come from the use of Bio-Argo floats that drift most of the time (90%) in the mesopelagic zone and record optical proxies of POC. Recent refinements, (Briggs et al., 2011, Est[illegible] et al., 2013) open the extremely attractive perspective to get highly resolved estimation of b. The combination of data from floats and moorings hosts a great potential for major scientific advances on this issue.

### 1.2.3 The bio-optical anomaly of Southern Ocean surface waters

Given the remoteness of the SO and the associated difficulties to acquire data, remote sensing has been, to date, the most efficient way to determine surface Chlorophyll (Chla) concentration at large spatial and temporal scales. However, a growing body of in situ evidence now shows that standard algorithms underestimate *in situ* Chla in the SO, actually by more than 50% (Johnson et al., 2013). These austral "anomalies" might be due to the composition (structure) of the phytoplankton community and its photo-adaptation status. Hence there is a pressing need to acquire *in situ* biogeochemical and bio-optical data to (1) better address and understand the reasons for these anomalies, and (2) refine algorithms for the SO waters allowing more accurate retrieval of Chla from space. SOCLIM, by deploying two types of platforms, i.e., Bio-Argo and Pro-Val floats (see 1.3.1), will contribute to address both issues.

### 1.2.4 The role of mesoscale and submesoscale dynamics in driving physical, biogeochemical and biological processes

The role of meso-scale eddies and, more recently, that of submeso-scale features like jets, filaments and small-scale eddies, in the lateral and vertical transfer of properties in the ocean and the atmosphere is widely regarded as potentially important for time-mean budgets of key variables in both fluids (Marshall and Radko 2003, Lambaerts et al. 2013). The potential energy created in the ACC is converted into vigorous nonlinear dynamical structures such as eddies, jets and filaments (Nikurashin et al. 2012). This turbulent energy can power strong air-sea transfers, water-mass formation, transformation, and water properties transport and mixing (Lambaerts et al. 2013).

However, because the observation of such small-scale oceanic structures is very difficult, the exact nature of these processes and their impact are poorly understood, and quantified. This assessment is essential to evaluate, for example, the ocean uptake of climate-relevant tracers such as heat and carbon. Indeed, these oceanic processes drive tracers transport into the ocean (Resplandy et al. 2014). They are also functionally linked to the vertical transfers (*i.e.*, subduction) of water masses and related properties, and they are the rate-limiting step in estimating the ocean sequestration of anthropogenic $CO_2$. The understanding of these processes is therefore capital to accurately estimate the meridional fluxes of mass, heat, fresh-water and biogeochemical tracers.

The project will make it possible (1) to focus on the meso and submeso-scale dynamics, and enhance our understanding and estimates of their role in mixing, and (2) to recover the three-dimensional transport (i.e., lateral, and vertical) of water properties generated by this scale dynamics in this Indian sector of the SO which is characterized by the highest turbulence of the world's ocean.

Because of their very high variability in space and time, the observations of such processes are challenging, as they cannot be achieved through the classical observational *in situ* strategy. Within SOCLIM we propose an innovative approach that consists in using the quasi-lagrangian nature of the proposed observing platforms such as profiling floats (Argo and Bio-Argo) and the PolarPod. The deployment of profiling floats will be carried out in selected fine-scale features that will be defined judiciously beforehand by analyses of real-time satellite data. The Lagrangian observations will be associated with measurements provided by others innovative instruments (Seasoar, UCTD, gliders, wave gliders) deployed in collaboration with our foreign partners. These field data, in combination with satellite products, will give us the ability to observe for relatively long spans of time the selected ocean fine-scale structures, and the evolution of their dynamical context as well as that of their properties. These innovative observations will enable us to understand the role of the small–scale ocean dynamics in mixing and 3D transfers of properties in the upper 2000 m of the ocean.

## 1.3 Implementation

### 1.3.1 Description of the different platforms and instruments

**Profiling floats** : As part of projects funded by agencies in France (ANR, CNES, EQUIPEX) and Europe (ERC), the Laboratoire d'océanographie de Villefranche (LOV) has developed high-tech versions of bio-optical and biogeochemical profiling floats (Bio-Argo floats). These technological developments have been achieved through solid (and lengthy) interactions with companies involved in sensor development (e.g. Wetlabs, Satlantic) and platform conception (NKE). Preliminary studies based on the first versions of these floats were conducted in various regions of the World Ocean (see http://www.newoao.obs-vlfr.fr/ ), showing that the scientific benefits of single Bio-Argo floats was potentially very high (e.g. Xing et al., 2011, 2012). As part of the ERC remOcean and the Equipex NAOS projects, the technological developments initiated under the ERC funding were further continued (e.g. Leymarie et al., 2013), and the new generation of Bio-Argo floats is now fully operational. These floats have reached a degree of maturity that allow cutting-edge

observations to be undertaken in a variety of environments, including the harshest and most remote ones (including the eye of a tropical cyclone; Doxaran et al. 2013). The SOCLIM project will thus benefit from the experience and feedbacks gained over several years of successful developments. In particular we propose to deploy two types of floats described below, i.e. PROVBIO-2 and PROVAL.

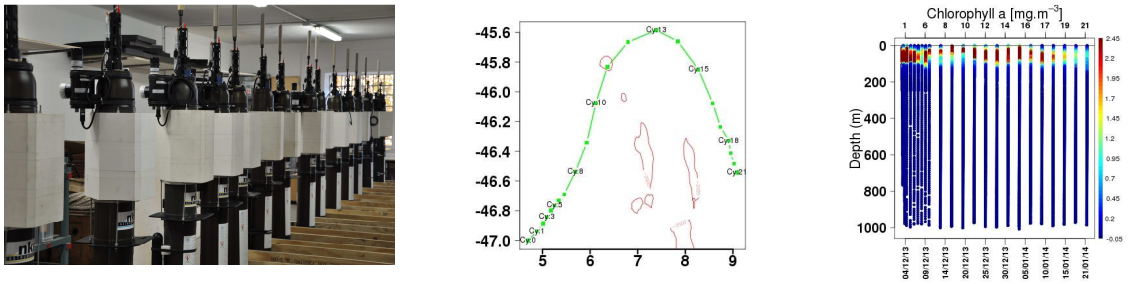



***Figure 5** : Left panel : Bio-Argo floats ready for deployments. Center panel: trajectory of the Bio-Argofloat lovbio055 deployed in January 2014. Right panel: chlorophyll profiles from Bio-Argo float lovbio055.*

The PROVBIO-2 float is dedicated to biogeochemical studies (Fig. 5). This float is a Lagrangian Argo-type (PROVOR CTD) float on which Iridium two-way communication (instead of Argos) has been implemented together with a variety of optical and biogeochemical sensors. The ProvBio-2 mission can be easily modified (almost in real time) by the operator thanks to Iridium telemetry. Basically two main modes of operation are used: the standard Argo mode, and the quadri-profile mode in which the diel cycle of optical (especially Chla and $c_p$) and chemical ($O_2$) properties is characterized. These diel characteristics are essential to quantify key biogeochemical fluxes, and such important processes as net community production and respiration. Eight PROVBIO-2 such floats will be deployed (see details below).

The PROVAL float is mainly dedicated to the bio-optical characterization of water masses, especially in the context of the calibration/validation activities of ocean colour satellites. Two PROVAL floats will be deployed (see details below).

**Moorings.** As part of SOCLIM, we plan to deploy two different kinds of moorings (SURFMOOR and DEEPMOOR) to monitor key parameters in the functioning of the biological carbon pump. SURFMOOR will be dedicated to autonomous measurements (e.g. $CO_2$; Fig. 6 b,c), and collection of samples in the surface mixed layer (~30 m), whereas DEEPMOOR will sample the sinking material, and make autonomous measurements of relevant environmental variables.

SURFMOOR. The deployment of an instrumented package in the surface mixed layer of the Southern Ocean is very challenging because of the extreme weather and sea state conditions there. The mooring will be designed not only to survive these strong conditions, but also to maintain the instrument package at a constant depth in the mixed layer. One partner of SOCLIM (Prof. Thomas Trull, University of Tasmania) has succeeded in constructing and deploying such a mooring south of Tasmania, as part of the Southern Ocean Time Series (SOTS) project. SURFMOOR will be largely inspired by the design of Prof. Trull's Pulse Mooring illustrated in Fig. 6a.

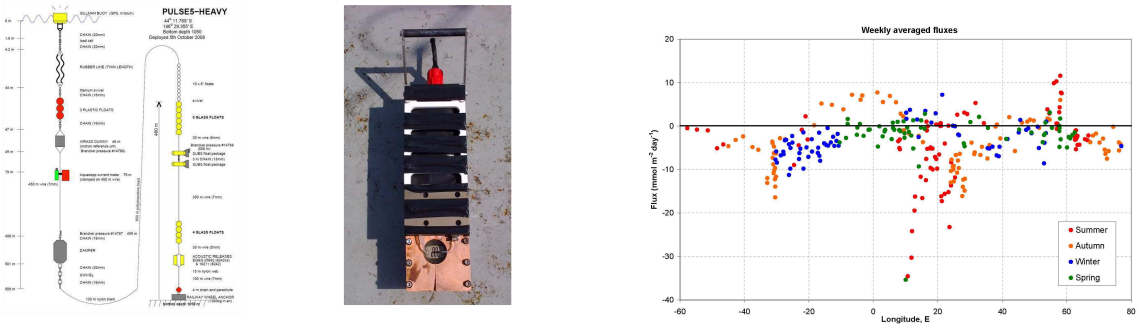



***Figure 6** (a) Pulse Mooring deployed by Prof Tom Trull south of Tasmania*

*(b) CARIOCA $pCO_2$ sensor deployed on the BOUSSOLE buoy, NW Mediterranean.*

*(c) Weekly averaged air-sea $CO_2$ fluxes estimated from 8 drifting CARIOCA buoys deployed in the Southern Ocean (Boutin et al. EU FP6 Carboocean project, data published in Resplandy et al. 2014.)*

**The POLAR.ROD** pl[illegible] a 100-m-long spar buoy shaped and strengthened to face the hugest waves on Earth. [illegible] combines the FLIP experience and offshore spar technology (http://jeanlouisetienne.com/polar-rod/). It can host 5 people on board, 2 sailors, 2 oceanographic engineers or technicians and 1 researcher for a period up to 6 months. The POLAR.ROD is designed to cause low

disturbance on the surrounding waters and air flows. This will create optimal conditions for monitoring air–sea processes and flux observations, and will allow to work in higher winds and sea state conditions than presently possible with a conventional research ship. The POLAR.POD is expected to reach a drifting speed of 1 knot. With these specifications, the estimated time for the POLAR.POD to circle around the Antarctic Continent in the ACC is one year.

The construction of the POLAR.POD platform has been delayed, but it should be launched in the Southern Ocean in 2016. In the context of SOCLIM (mid 2014-mid 2017), we only plan to deploy a few sensors on the POLARPOD, to test a concept that may prove useful in future work. If additional delays occured, and the platform was not available for SOCLIM, this would in no way impair the scientific objectives or program of SOCLIM.

Instruments to deployed on the different platforms (DM: DEEPMOOR; F: bioargo float; P: polar pod; SM: SURFMOOR):

| Instrument | Measured parameters | Platform |
|---|---|---|
| Fluorescence sensor | Chlorophyll | F,SM,P |
| Fluorescence sensor | CDOM | F,SM,P |
| Backscattering meter | Particulate organic carbon | F,SM,P |
| Radiometric sensor 380, 412, 490 nm | Chlorophyll, CDOM | F,P |
| PAR sensor | Photosynthetic Available radiation | F,SM,P |
| CTD | Salinity temperature | F, SM, DM, P |
| ISIS | Nitrate | F,SM,P |
| OPTODE | $O_2$ | F, SM, P |
| CARIOCA sensor | $CO_2$ | SM |
| GTD | $N_2$, gas tension | SM,P |
| Autosampler | (DIC, TAC, nutrients) | SM |
| Sediment trap | Particulate matter composition | DM |

### 1.3.2 Deployment strategy

Two sub-groups of 4 PROVBIO-2 floats (2 “flux” and 2 “chemistry”; total: 8 floats) will be deployed close to the Eastern and Western Kerguelen moorings, respectively. This strategy will allow a redundancy in measurements during the initial, short period of float deployment, which will be especially useful for the inter-comparison of sensors. For each location, one “flux” and one “chemistry” float will be set to one profile every 10 days, while the other two floats will be set to the quadri-profile mode with adaptative sampling strategy when required (e.g. bloom initiation, and collapse).

The two PROVAL floats will be deployed on each side of the Kerguelen plateau to explore the bio-optical anomalies of the SO (Johnson et al., 2013) over a range of Chla concentrations that is representative of what is typically encountered in SO waters. Note that, as part of a collaboration with Australian colleagues, David Antoine (who recently left the LOV for a 3-year position at the Curtin University in Perth) intends to perform similar PROVAL observations in the Tasmanian-Australian sector of the Southern Ocean (a proposal is pending).

### 1.4 Data processing and management

The data collected during SOCLIM will be made available via a portal on the SOCLIM web site(http://www.obs-banyuls.fr/SOCLIM/). The quality control, data storage, and data access will rely on standard international protocols and will be managed as describe in the data flow scheme in Fig. 7.

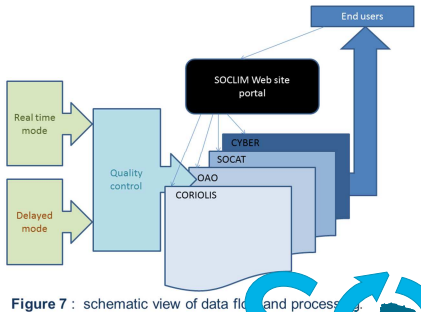
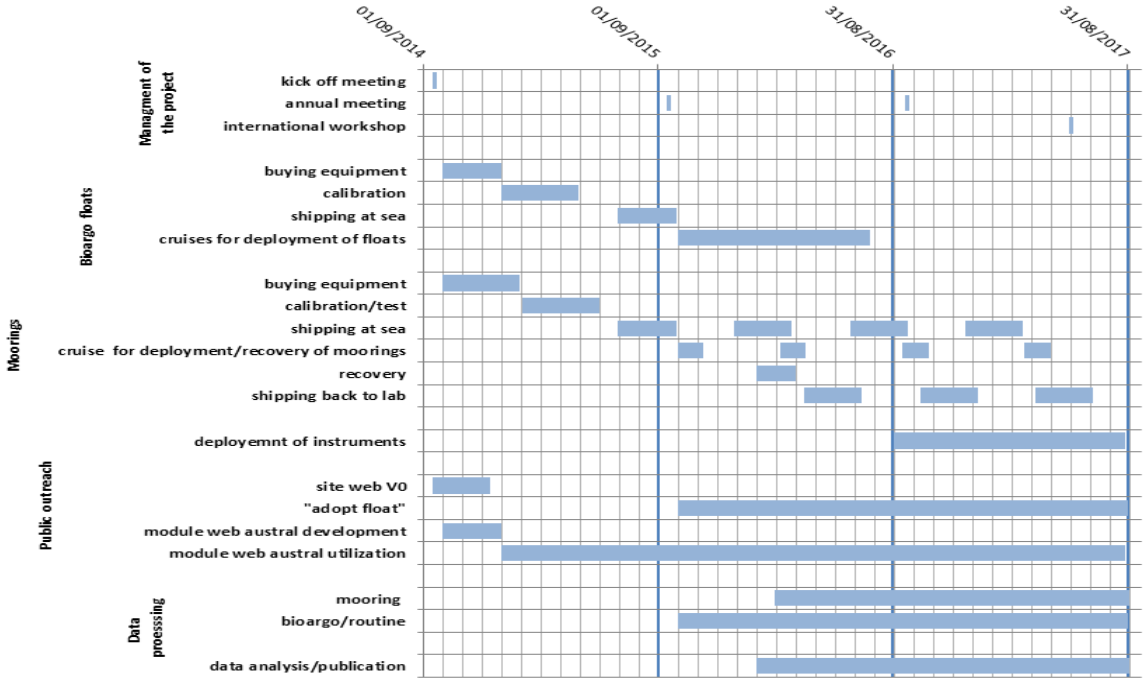


**Figure 7** : schematic view of data flow and processing

All components of the data processing are already implemented:
The LOV group is developing a data management system for Bio-Argo that will be analogous to the Argo’s one. Within the international Argo program, H. Claustre is chairing the international Bio-Argo data management team, where data management and quality control procedures are being developed. The management of large amounts of data is rather new for the biogeochemical oceanographic community, and there is a major effort going on to engage this community to adopt the new procedures of data management and accessibility that will be the rule in a very near future. SOCLIM will benefit from the latest developments of the data quality control procedures. SOCLIM’s data will be made available (real-time and delayed mode) through the OAO site (reference), and mirrored at the Coriolis data center (Ifremer, Brest, France), which is one of the two data center managing the global Argo data (the other is in Monterey, USA).

### 1.5 Major milestones of the project during the 3 years of funding (mid 2014-mid 2017)




### 1.6 International dimension of the research and outreach activities

#### 1.6.1 International dimension: (see also letters of support in annex)

Profiling floats and moorings are two pillars of modern pelagic ocean observation systems. These platforms and the programs relying on their implementation (Argo, OceanSite) are key components of the progressively developing Southern Ocean Observing System (SOOS, http://www.soos.aq/). Most of autonomous observations presently developed within SOOS are related to physical oceanography. SOCLIM will add a biogeochemistry component to these robotic observations (until now, biogeochemical observations have been made on board ships). SOCLIM thus prefigures the likely evolution of the SO observation system in the near future, with the progressive maturation of new sensors and improvements of platforms, which will allow the automatic sampling of increasingly diverse key essential biogeochemical variables. The Bio-Argo part of SOCLIM, which is centered on the Indian Ocean (deployment of the floats near Kerguelen Island), is largely complementary of that developed as part of a large U.S. proposal funded by the NSF (SOCOM, PI J. Sarmiento). In particular, SOCLIM and SOCOM will share their expertise and effort to develop a unified data stream and quality-control (see letter of support) in the context of the emerging Bio-Argo international program.

**Australia and South Africa are the two major partners of SOCLIM**. The long-lasting collaboration of SOCLIM's project leaders with researchers of these two countries is attested by numerous joint publications. Thanks to their own observing system, the two partners will provide essential complementary data at the eastern and western boundaries, respectively, of the investigated region. In addition, the Australian partner will share with us its "know how" to design part of the moorings (SURFMOOR). Moreover, the Bio-optical part of SOCLIM is also complementary to projects developed for the SO by David Antoine, a LOV's scientist now at the Curtin University (Perth, Australia). Our partners will also provide shiptime for the deployments of some of the SOCLIM's equipment. Researchers from both countries will also actively collaborate to the interpretation of the data and the resulting scientific publications. Researchers from India and USA will also contribute to SOCLIM.

#### 1.6.2 Outreach activities

The general public does not generally know the critical role of the SO, which is located far away from Eurasia and North America. However, the SO hosts features that fascinate the general public even if little information is available compared to other oceans (e.g. Arctic). SOCLIM will develop the public's interest, to make the still mysterious SO more accessible to the general public. Especially, SOCLIM will explain why and

how the SO plays a key role in climate. To reach this goal, we build on on our experience of public outreach and our development of the educational web site http://www.monoceanetmoi.com/, which is part of the project MEDITES

The project "**mon océan & moi**" project has been developed to disseminate ocean sciences. Besides the objective to outreach via a specific web site (www.monoceanetmoi.com) to the "wider public", special attention is given to school children (age 10 to 16). In order to favour integration of ocean sciences in school curricula and/or as additionally proposed school activities, the participating researchers work in close collaboration with school teachers and school authorities.

As part of the "**mon océan & moi**" project, the initiative "**adopt a float**" offers to school classes to possibility of "adopting" an undersea robot (Bio-Argo float), and follow it during its scientific voyage (Fig. 8). Together with their teachers (and if needed with the support of researchers and science facilitators), the students can explore many ocean topics, and communicate via a dedicated Internet platform. With an integrated community builder, this platform facilitates exchanges and also facilitates access to real-time data from the float via an interactive map.

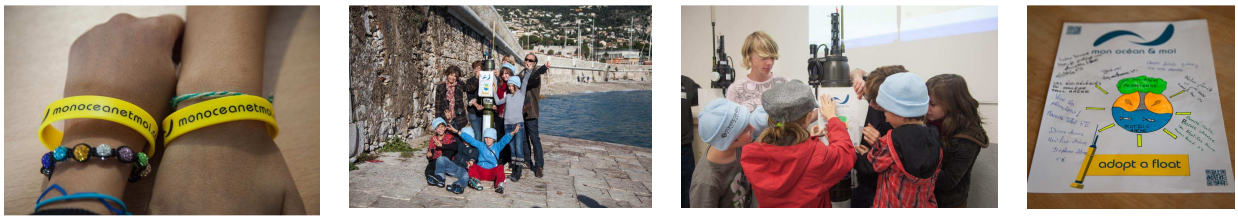



***Figure 8 :*** *A school class adopted a profiling Bio-Argo float before its departure from the laboratory in Villefranche-sur-mer, France. The students attached to the float a sticker they had drawn and on which they had added some personal notes. After deployment of the float, they will follow its voyage through the ocean, and have access to its data via an interactive map.*

After the development and one-year testing of a prototype with two schools, the web-based part of the project is now operational. Its content is regularly improved, and as prerequisite for a possible co-adoption of floats by classes of different countries, French-English versions of the texts are progressively implemented.

We propose to outreach specific components of the SOCLIM science using the facility "**mon océan & moi**". We will develop a relevant science-based content around several key questions (following the "template" provided by mon "**mon océan & moi**" web site Together with specific illustrations and other visual tools developed for school purposes (e.g. animations like the one that illustrates the functioning of a float, quizzes, and games), the proposed SOCLIM component will address two major topics:

1/ The SO as a key area to study climatic and environmental changes.

2/ The island mass effect through the comparison of the sides of the Kerguelen plateau, and a possible comparison with other islands located in sub-equatorial environments (i.e. Marquesas, Galapagos).

**References :**

De Baar, H. J. W. et al. (2005) J Geophys Res, 110//Behrenfeld, M. J. (2010), Ecology, 91(4), 977–98 //Blain, S. et al. (2007), Nature, 446(7139), 1070–1075 //Blain, S., et al. (2013), Geophys. Res. Lett., 40, 1-5//Boyd, P. W. (2002), J. Phycol., 38, 844–861//DeVries, T. & F. Primeau (2011), J. Phys. Oceanogr., 41(12), 2381–2401.,//Doxaran, D. et al. (2013), Remote Sensing of Env., doi.org/10.1016/j.rse.2013.06.020//Estapa, M. L et al. (2013) Biogeosciences, 10(8), 5517–5531//Helm, K. P., et al. (2011) Geophys. Res. Lett., 38(23).//Holm-Hansen, O. et al. (2004), Deep Sea Res. Part II Top. Stud. Oceanogr., 51(12-13), 1323//Johnson, R., P. et al. (2013) J. Geophys. Res. Oceans, 118(7), 3694–3703//Kohfeld, K. E., et al. (2005), Science, 308, 74–78//Kwon, E. Y., et al. (2009), Nat. Geosci., 2(9), 630–635,.//Lambaerts, et al. (2013), J. Geophys. Res. Atmospheres, 118(17), 9611–9621//Leymarie et al. (2013), Coriolis Quarterly Newsletter - Special Issue #48-June 2013.//Maiti, K., et al. (2013) //Geophys. Res. Lett., 40(8), 1557–1561//Moy, A. D., et al. (2009), Nat. Geosci., 2(4), 276–280.//Nikurashin, M., et al. (2012), Nat. Geosci., 6(1), 48–51.//Orr, J. C. et al. (2005), Nature, 437(7059), 681–686//Quéguiner, B., et al. (1997), Deep Sea Res. Part II, 44(1-2), 69//Le Quéré, C. et al. (2007), Science, doi:10.1126/science.1136188.//Resplandy, L. et al. (2014) Biogeosciences, 11, 75-90//Rintoul, S. R., et al. (2001) in Ocean Circulation and Climate, G. Siedler, et a., Eds., Acad. Press, 271–302.//Sallée, J. B., et al. (2010), , Nat. Geosci., 3(4), 273–279//Sarmiento, J. L., et al. (2004), Nature, 427//Shepherd, A. et al. (2012), Science, 338(6111), 1183–1189//Sigman, D. M., et al. (2010), Nature, 466(7302), 47–55.//Speer, K.G. et al. J. (2000) Phys. Oceano. 30, 3212-3222//Sverdrup, H.U. (1953), J. Cons. Int. Por. Explor. Mer, 287–295//Takahashi, T., et al. (2012), Oceanography, 25(3), 26–37//Taylor, J. R. & R. Ferrari (2011), Limnol. Oceanogr., 56(6), 2293–2307//Uitz, J., et al. (2009), Deep-Sea Res. I, 56, 541–560//Wu, sci. C., 998), J. Phys. Oceanogr., 28, 2331–2339.//Xing, X., et al. (2011), J. Geophys. Res., Vol. 116, No. C4, C06020//Xing, X., et al. (2012), J. Geophys. Res. Vol. 117, No. C4, C04022.

## 2) PRESENTATION OF THE PROPONENTS (max 6 pages)

### 2.1) Organization of the team and responsibilities of the partners

SOCLIM is organized has schematically represented on the figure XXX **The work package (WP)1** (management of the project, responsible LOMIC) is dedicated to the coordination of all the different work packages and tasks, the organization the different internal meetings, the organization of the final open international colloquium, the external relationships with BNP-Paris Bas Fondation, with University of Paris 6, and with IPEV. **WP2** (public outreach) is dedicated to the implementa34580tion of all the actions for the dissemination of SOCLIM's sciences and activities to a wide public, with a focus on the young people. The action "mon océan et moi" will be coordinated by LOV, and all the actions involving the Marion Dufresne and sea operations will be coordinated by IPEV (service communication). **WP3** (floats, responsible LOV)**, WP4** (moorings, responsible LOMIC) **and WP5** (polar pod responsible LMD) are dedicated to the operational parts of SOCLIM. They will be based on the 7 tasks listed in Figure XXX. There will be a lot of interactions and synergy between the 3 WP, both during the preparation and deployment of the platforms (T1-T4) and during the data management (T5), analysis (T6) and publication (T7).

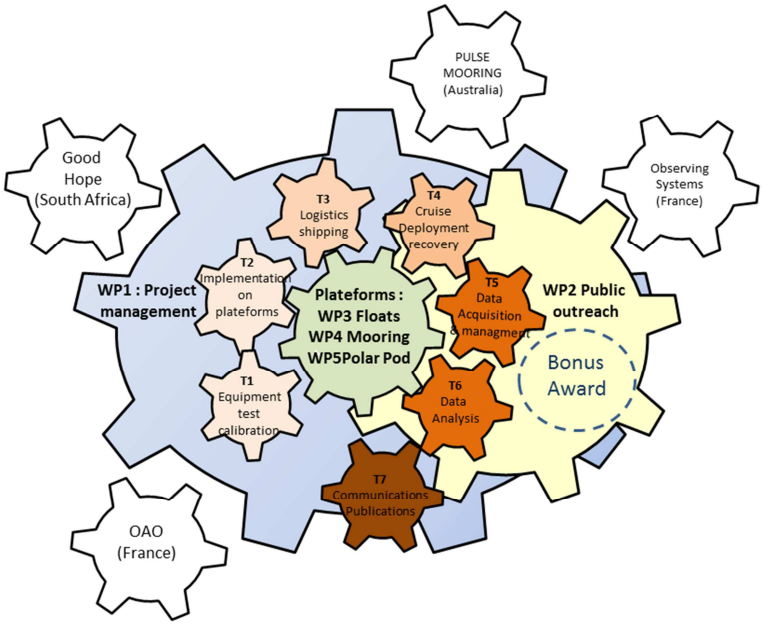



***Figure 9***
*Schematic presentations of the different work packages (WP) and tasks(T). in Color are the activities of SOCLIM planned in this proposal. In white the actions in close collaboration with SOCLIM and that provide, data, shiptime, expertise, scientific collaboration and exchanges.*

The table below summarizes the different laboratories/institutions involved in SOCLIM and their responsibilities and main field of expertise.

| Partners | institution | WP responsabilities | Main expertise |
|---|---|---|---|
| LOMIC[(1)] | UPMC, CNRS | Coordination projet(WP1)<br>Moorings (WP4) | Carbon flux and instruments on moorings |
| LOV[(2)] | UPMC, CNRS, | Floats (WP3)<br>Public outreach (WP2) | Biooptics and instruments on bioargo-floats |
| LMD[(3)] | UPMC, CNRS, ENS | Polar pod WP5 | Physics |
| LOCEAN[(4)] | UPMC, CNRS, IRD | | $CO_2$ fluxes and sensor |
| DT- INSU[(5)] | CNRS | | Realization of operation at sea, calibration of $CO_2$ sensors |
| IPEV[(6)] | | Bonus award | Logistics, cruise, public outreach |

[(1)]Laboratoire d'Océanographie Microbienne, [(2)]Laboratoire d'Océanographie de Villefranche, [(3)]Laboratoire de météorologie dynamique, [(4)]Laboratoire d'océanographie et du climat, observations et approches numériques, [(5)]Division technique de l'institut des sciences de l'univers, [(6)]Institut polaire français, Paul Emile Victor.See previous section 1.6.1 for the international partners and collaborators.

## 2.2) Presentation of the principal investigators (CV of PI and Co pI 2 pages max each)

**Stéphane Blain** received his Ph.D. in chemical oceanography from the University of Brest in 1992. In 1993, he served as a post doc at the Moss Landing Marine Laboratories during the preparation of IRONEX1. He is actually professor of chemical oceanography at the University Pierre et Marie Curie (Paris). He is working at the Marine station of Banyuls sur Mer, where he has founded and directed the Microbial Oceanography Laboratory (2010-2013), a research unit in partnership with the UPMC and the CNRS. His research interests are the functioning of the biological pump of $CO_2$ in the ocean with focus on iron biogeochemistry and the Southern Ocean. He is also involved in the development of new analytical tools and methods for in-situ chemical oceanography.
He has initiated the project KEOPS (KEOPS: Kerguelen Ocean and Plateau compared study) ten years ago. The main objective of KEOPS is to study the impact of natural iron fertilization of the Southern Ocean. KEOPS is international project that gathered researchers from 10 French laboratories and foreign colleagues from different nations (Australia, Belgium, Chili, The Netherlands, South Korea, USA, UK). The first phase of this project was conducted in 2004-2009 and has produced more than 50 publications. The second phase (2011-2014) is currently underway with the publications of the papers related to the KEOPS2 cruise. As principal investigator of KEOPS, I have co-organized two special sessions with colleagues of the National Oceanographic Center of Southampton (OSM, Hawaii 2006) and with colleagues of the Alfred Wegener Institute (ASLO meeting, Orlando 2013). I was involved in the SCOR WG and invited to international workshops and conferences.
During the past 20 years he has been very interested in observing systems. In 1997, I have organized an international symposium on marine analytical chemistry for the monitoring of oceanographic research. I have participated to the first development of nutrient *in situ* chemical analyzers and to the deployments of biogeochemical sensors on buoys. Recently, I have used fluorescence sensors mounted on elephant seals of Kerguelen to produce the first two dimensional climatology of chlorophyll in a region of the Southern Ocean.

**PROFESSIONAL positions**
1986-1992 Research assistant URA CNRS 322, Université de Bretagne occidentale
1993 Post-doctoral position Moss Landing Marine Laboratory CA USA
1993-1996 Research assistant, Université de Bretagne Occidentale.
1996-2003 Associate professor, Université de Bretagne Occidentale.
2003-2007 : Professor Université de Marseille II
2008- : Professor Université Pierre et Marie Curie. PARIS

### Selected committees and professional memberships

Member of the organizing committee for the international (SO-JGOFS) symposium on the “Circulation and biogeochemistry of water masses in the Southern Ocean”, Brest, France, 1990
Member of the organizing committee for the international (SO-JGOFS) symposium on “Hydrodynamic processes in the Southern Ocean”, Brest, France, 1995.
Chairman of the scientific committee of the international symposium on “Marine analytical chemistry for monitoring and oceanographic research”, Brest, France, 1997
Member of the SCOR Working Group 109 on “Iron biogeochemistry”, 1999
PI of the French-Australian science technology program (FAST) 2005-2007.
Member of SCOR and SOLAS Working Group on « A synthesis of mesoscale iron enrichments 2005”.
Co-convener of a special session at the Ocean Science Meeting, 2006.
PI of “Programme international de coopération scientifique » of the CNRS with Australia (2007-2009).
Co-convener of a special session at the ASLO-AGU-TOS Meeting, 2013.

**Selected publications relevant to this proposal**

Stéphane Blain has published 50 papers, which have been cited times. His h-index is 23.


- **Blain S.**, Sophie R., Xiaogang X., Claustre H. and Guinet C. (2013) *Seasonality in Chlorophyll and light-mixing regime in the iron fertilized Southern Ocean*. Geophysical Research Letter, vol. 40, 1–5.
- Bozec,Y., Merlivat,L., Baudoux,A. C., Beaumont,L., **Blain,S.**, Bucciarelli,E., Danguy,T., Grossteffan,E., Guillot,A., Guillou,J., Répecaud,M., Treguer,P. (2011). *Diurnal to inter-annual dynamics of $pCO_2$ recorded by a CARIOCA sensor in a temperate coastal ecosystem (2003-2009)*. *Marine Chemistry*, 126, 13-26
- **Blain, S.**, B. Quéguiner, L. Armand, S. Belviso, B. Bombled, L. Bopp, A. Bowie, C. Brunet, K. Brussaard, F. Carlotti, U. Christaki, A. Corbière, I. Durand, F. Ebersbach, J.L. Fuda, N. Garcia, L.J.A. Gerringa, F.B. Griffiths, C. Guigue, C. Guillerm, S. Jacquet, C. Jeandel, P. Laan, D. Lefèvre, C. Lo Monaco, A. Malits, J.

Mosseri, I. Obernosterer, Y.H. Park, M. Picheral, P. Pondaven, T. Remenyi, V. Sandroni, G. Sarthou, N. Savoye, L. Scouarnec, M. Souhault, D. Thuillers, K.R. Timmermans, T. Trull, J. Uitz, P. Van-Beek, M.J.W. Veldhuis, D. Vincent, E. Viollier, L. Vong, and T. Wagener, *Effect of natural iron fertilisation on carbon sequestration in the Southern Ocean.* Nature, 2007, 1070-1074.

- Jouandet M. P., Trull T. W., Guidi L., Picheral M., Ebersbach F., Stemmann L., **Blain S.** (2011). *Optical imaging of mesopelagic particles indicates deep carbon flux beneath a natural iron-fertilized bloom in the Southern Ocean*. *Limnology and Oceanography*, 56, 3, 1130-1140.
- Boyd, P.W., T. Jickells, C. Law, **S. Blain**, E.A. Boyle, K.O. Buesseler, K.H. Coale, J.J. Cullen, H.J.W. De Baar, M. Follows, M. Harvey, C. Lancelot, M. Levasseur, D.A. Pollard, R.B. Rivkin, J.L. Sarmiento, V. Schoemann, V. Smetacek, S. Takeda, A. Tsuda, D.R. Turner, and A. Watson, (2007) *A synthesis of mesoscale iron-enrichment experiments 1993-2005: key findings and implications for ocean biogeochemistry.* Science, 2007, 315, 612-617.

**Cruise in the Southern Ocean :**

October-November 1995 : R/V Marion Dufresne, ANTARES 3, Southern Ocean.
January-February 1999 : R/V Marion Dufresne, campagne ANTARES 4 , Southern Ocean.
January-February 2005: R/V Marion Dufresne KEOPS Southern Ocean (P.I.)
January-February 2007 : R/V Marion Dufresne KEOPS Southern Ocean. (P.I.)
October-November 2011 :R/V Marion Dufresne KEOPS2 Southern Ocean. (P.I.)

**Funding records**

| | | |
|---|---|---|
| 2003-2007 | 1,205 k€ | **KEOPS** (PI): CNRS (205 k€), IPEV (ship-time: ~ 1 M€) |
| 2008-2011 | 380 k€ | **BACCIO** (PI): National Research Agency (ANR) |
| 2011-2014 | 2,720 € | **KEOPS2** (PI): CNRS (220k€) National Research Agency (ANR) (1.2 M€), IPEV (ship-time1,3 M€) |

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**Hervé Claustr**e got his PhD in 1987 and, after a post-doc at Plymouth Marine Laboratory, became CNRS Research Associate (1990) and then CNRS Senior Scientist (2001) at LOV. His research activities can be summarized as follows: *To develop interdisciplinary approaches at the frontiers of marine biology, chemistry and optics for the study and understanding of biogeochemical processes ranging from the small to the global scale to address the variability of stocks and fluxes of matter in the upper ocean in the context of global change*. Within this broad topic, his scientific contributions can be classified in three main groups. (1) the development of a research field based on HPLC techniques for measuring phytoplankton pigments and their application through chemotaxinomic investigations (pigments used as bio-markers of phytoplankton communities) (2) the development of new observational approaches at the interface of marine optics (theoretical and experimental, *in situ* and remote sensing) and biogeochemistry. (3) Since 2003, and as a natural extension of his work, Hervé Claustre is pursuing investigation of biogeochemical processes at presently unresolved scales or in poorly observed oceanic areas. For that purpose, he dedicates a large part of his effort to develop new observational techniques based on gliders and profiling floats. (http://www.OAO/obs-vlfr.fr/).

**Selected publications relevant to this proposal**

*Hervé Claustre has published more than 100 papers, which have been cited more than 5000 times. His h-index is 39.*

- Claustre, H., Antoine, D., Boehme, L., Boss, E., D'Ortenzio, F., Fanton D'Andon, O., Guinet, C., Gruber, N., Handegard, N.O., Hood, M., Johnson, K., Lampitt, R., LeTraon, P.-Y., Lequéré, C., Lewis, M., Perry, M.-J., Platt, T., Roemmich, D., Testor, P., Sathyendranath, S., Send, U., & Yoder, J. (2010). "Guidelines Towards an Integrated Ocean Observation System for Ecosystems and Biogeochemical Cycles" in Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 1), Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306, doi:10.5270/OceanObs09.pp.14 (Get PDF reprint)
- Xing, X., Morel, A., Claustre, H., Antoine, D., D'Ortenzio, F., Poteau, A., Mignot, A. (2011). Combined processing and mutual interpretation of radiometry and fluorimetry from autonomous profiling Bio-Argo Floats. The retrieval of Chlorophyll a, Journal of Geophysical Research, 116, C06020, doi:10.1029/2010JC006899. (Get PDF Reprint)
- Guinet, C., X. Xing, E. Walker, P. Monestiez, S. Marchand, B. Picard, T. Jaud, M. Authier, C. Cotté, A. C. Dragon, E. Diamond, P. Antoine, P. Lovell, S. Blain, F. D'Ortenzio, and H. Claustre (2013). Calibration procedures and first data set of Southern Ocean chlorophyll-a profiles collected by elephant seal equipped with a newly developed CTD-fluorescence tags. Earth System Science Data, 5, 15–29, 2013 www.earth-syst-sci-data.net/5/15/2013/ doi:10.5194/essd-5-15-2013 (Get PDF Reprint)

- Johnson, K.S., Berelson, W.M., Boss, E.S., Chase, Z., Claustre, H., Emerson, S.R., Gruber, N., Körtzinger, A., Perry, M.J. and S.C. Riser (2009). Observing biogeochemical cycles at global scales with profiling floats and gliders: prospects for a global array. Oceanography, 22(3), 216-225.


**Summary of Selected activities / animation / awards**

- 2000-2003: Associated editor for Journal of Geophysical Research-Ocean
- 2008: Editor of the Biogeosciences special issue (30 papers published) for the Biogeochemistry and Optics South Pacific Experiment (BIOSOPE).
- 1999-2005: Co-Organizer of three international HPLC intercomparison exercises (NASA funds)
- 2008 AGU-ASLO-TOS meeting, Orlando, FL. Organizing Committee.
- 2009 US OCB Floats and Gliders Workshop, Moss Landing, CA. Steering committee.
- Supervision 13 students and 4 post-docs
- PI of the PROSOPE (32 days, 28 scientists) and BIOSOPE (55 days, 35 scientists) cruises
- CNRS Silver Medal (2005)
- ERC advanced grant (2010-2014).

**Funding records**

| | | |
|---|---|---|
| 1999-2003 | 875,000 € | **PROSOPE** (PI): CNRS (205,000 €), NASA (30,000 €), IFREMER (ship-time: ~ 640,000 €) |
| 2003-2008 | 1,994,000 € | **BIOSOPE** (PI): CNRS (255,000 €), CNES (148,000 €), NASA (75,000€), ESA (86,000 €), IFREMER (ship-time: ~1,430,000€) |
| 2006-2009 | 530,000 € | **PABO** (PI): National Research Agency (ANR) |
| 2005-2009 | 170,000 € | **PROGLO** (PI): CNES |
| 2007-2010 | 381,589 € | **SEAEXPLORER** (Co-PI): French Department of Defence. Project led by a private company (total cost of the project: 3,839,000 €) |
| 2008 | 50,000 € | **Mediterranean glider** (PI): “Alpes Maritimes” County |
| 2008 | 83,000 € | **Mediterranean glider** (PI): “Provence Alpes Côte d’Azur” county |
| 2009-2013 | 402,000 € | **VASQUE (**co-PI) : French department of Industrie. Project led by a private company (total cost of the project: 3,839,000 €) |
| 2011-present | 42,000 € | “Mon Océan et Moi” (Co-Pi) |
| 2010-2016 | 3,332200 € | **remOcean** (PI) : ERC advanced grant |

**Synergistic Activities**

- Between 2001 and 2010, Hervé Claustre was Chair of the French Scientific Committee for the Oceanic Biogeochemistry Program ands thus responsible of coordinating the yearly call topics as well as the subsequent evaluation of submitted projects.
- One of his strongest wishes is to help with the progressive implementation of an international Bio-Argo program, following the model of the (exemplary) Argo program. In this context, he has served or serves in several committees. He was (2008-2010) the Chair of the “Bio-Argo” Working Group of the International Ocean Color Coordinating Group (IOCCG). Presently he is member of the scientific and technical advisory group of the Euro-Argo consortium, member of the Argo Science Team, member of the SCOR Unesco Working group “Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders” and member of the international committee of the SOCOM (Southern Ocean Climate Observation and Modeling) program. He has led several sessions at international meetings (e.g. AGU/ASLO/TOS) on “new science applications” based on floats and gliders.
- In 2004, Hervé Claustre was the PI of the international BIOSOPE cruise [Biogeochemistry and Optics South Pacific experiment, supported by French, European and US (NASA) agencies]. This 2-month cruise with 35 scientists onboard realized a 8000 km transect from the Marquesas Islands to Chile, crossing the unknown (desert) waters associated with the South Pacific Gyre. The BIOSOPE project focused on Ocean Optics (satellite validation), biogeochemistry and molecular biology. To date, more than 85 papers using the BIOSOPE data have been published among which a special issue in Biogeosciences (35 papers)
- Within the Laboratoire d’Océanographie of Villefranche, Hervé Claustre is leading the Ocean Autonomous Observation (OAO:http://www.newoao.obs-vlfr.fr/), whose topics range from scientific analysis and valorization of data acquired by autonomous platforms to technological developments of new sensors (e.g. a Jelly fish camera) or platforming (e.g. the group is involved in the development of the SeaExplorer robot).
- Hervé Claustre is highly concerned by outreach and science dissemination to a wider audience. In this context he is co-PI of the educational projects « Mon Océan & Moi » and « Adopt a float » which aims at

increasing ocean literacy of large public and especially the youth (see: www.monoceanetmoi.com ). These projects are presently involving more and more scientists, engineers and students from the LOV in these outreach activities. Internationalization of “adopt a float” (by different classes of different countries) is presently one of the future targets of this project. This project has been endorsed by the International Oceanographic Committee of UNESCO.

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**Sabrina Speich** is Professor of Geosciences at the *Ecole Normale Supérieure* in Paris, France. She studied Physics in Italy at the University of Trieste (Italy), at the CERN in Geneva (Switzerland), and at the University of Paris 6. She received a PhD in Physical Oceanography from the University of Paris 6 (France) in 1992, then was postdoctoral researcher at the Department of Atmospheric Sciences at University of California, Los Angeles (UCLA, USA) from 1992 to 1994. She was researcher at the CNRS (Paris, France) in 1995, then became Professor at University of Brest (France) until 2013. She was invited Professor at the University of Cape Town (South Africa) in 2001.

Prof. Speich' research interests concern the uncovering and understanding ocean dynamics and its role on climate variability and change. She is a world-recognized expert in ocean modelling as well as in organizing wide programs of in situ observations. She is recently focusing her research on scale-interactions in ocean dynamics and how they affect the global ocean circulation, air-sea interactions and ecosystems. She initiated and led many field experiments to study ocean processes as well as ocean variability and changes. She pioneered the use of Argo floats to observe the ocean.

Prof. Speich has co-authored 60 publications in top-tier peer-reviewed journals (h-index=21 and 1230 citations as of December 2013), has given over 30 invited lectures and seminars, and contributed to more than 150 presentations at national and international meetings. He has supervised 15 graduate students and post-graduate fellows and teaches Physical Oceanography and Climate Sciences at the undergraduate and graduate level. Prof. Speich is currently co-chairing and has chaired or co-chaired some international programs within the CLIVAR program, The International Polar Year initiative and the European Research Projects framework and ANR. She has been serving on a number of national and international committees and review panels. She has been convener, organizer, or program committee member for many international scientific meetings.

**Selected publications relevant to this proposal**


Meinen, C. S., S. Speich, R. C. Perez, S. Dong, A. R. Piola, S. L. Garzoli, M. O. Baringer, S. Gladyshev, and E. J. D. Campos, Temporal variability of the Meridional Overturning Circulation at 34.5°S: Results from two pilot boundary arrays in the South Atlantic, J. Geophys. Res., 118 (12), 6461-6478, doi:10.1002/2013JC009228, 2013.

Rusciano, E., S. Speich and M. Ollitrault, 2012 : Antarctic Intermediate Water dynamics, budget and fluxes. Interocean exchanges South of Africa. J. Geophys. Res. doi:10.1029/2012JC008266, in press.

Swart, S., S. Speich, 2010: A satellite altimetry based Gravest Empirical Mode South of Africa. Part II: 1992-2008 Heat, Salt andMass Transport variability and changes. J. Geophys. Res., 115, C03003, doi:10.1029/2009JC005300.

Speich, S., B. Blanke, et G. Madec, 2001 : Warm and cold water paths of a GCM thermohaline conveyor belt. Geophys. Res. Lett., 28, 311-314.

Speich, S., B. Blanke, and W. Cai, 2007: Atlantic Meridional Overturning and the Southern Hemisphere Supergyre. Geophys. Res.Lett., VOL. 34, L23614, doi:10.1029/2007GL031583.

Speich, S., H. Dijkstra, M. Ghil, 1995 : Successive bifurcations in a shallow-water modelapplied to the wind-driven ocean circulation.Nonlinear Processes in Geophysics, Vol. 2, pp 241-268.


**Summary of Selected activities / animation / awards**

- Since Jan. 2014: CLIVAR Atlantic Panel member
- Since 2012: SCAR Panel member
- 2005-2012: Southern Ocean CLIVAR/CliC/SCAR Panel member
- 2013: Guest Editor of Journal of Marine Science special issue for Tracers of physical and biogeochemical processes, past changes and ongoing anthropogenic impacts: 43rd International Liege Colloquium on Ocean Dynamics.
- 2010-2012: Guest Editor for OceanSciences special issue for the BONUS-GoodHope International Polar Year Project
- 2007-2014: Co-organizer of seven international meetings on the South Atlantic and Southern Ocean research
- 2008-2014 Co-convener of various conferences sessions for the AGU, SCAR sessions.
- Since 2004, PI of [illegible]50 Argo floats deployment, validation and calibration of profiles data.
- Supervision 21 students and post-docs
- PI of the Clivar GoodHope Project (since 2003) and BONUS-GoodHope (50 days, 72 scientists) cruises
- Co-PI of the Clivar SAMOC program (since 2007)

**Funding records**

| | | |
|---|---|---|
| 1996-2000 | 800 000 € | **TRACMASS FP3 EUC project** (Co-PI). |
| 2003-2007 | 750 000 € | **MOTIF FP4 EUC project** (Co-PI). |
| 2003-present | 4 000 000 € | CLIVAR **GoodHope** project (PI): INSU ( 2 250 000 €, essentially Argo floats), IFREMER (500 000 €), UBO (100 000 €), Departement of Environmental Affairs, South Africa (ship-time: ~ 150 000 €), Shirshov Institute of Technology, Russia (ship-time: ~ 1 000 000€) |
| 2009-2012 | 200 000 € | **MEECE FP7 EUC project** |
| 2009-2012 | 3 960 000 € | **BONUS-GoodHope IPY Project** (PI): ANR (700 000 €), IFREMER (1 000 000 €), IPEV (2 000 000 €), INSU (500 000 €), UBO (100 000 €), IRD (100 000 €) |
| 2009-present | 1 410 000 € | CLIVAR **SAMOC programme** (Co-PI): ANR (700 000 €), IFREMER (500 000 €), LEFE (50 000 €), MENR (160 000 €). |

**Synergistic Activities**

- Since the early 2000s, Sabrina Speich started to coordinate the scientific observing efforts in the Southern Ocean. In 2001, she spent one year at the University of Cape Town, South Africa as invited professor. This visit led to the construction of the CLIVAR GoodHope project strategy and objectives. The project started officially in 2003. Prof. Speich was then invited to be part of the Southern Ocean CLIVAR/CliC/SCAR scientific panel to help coordinate the observing activity in the Southern Ocean. This led to a very organized and coordinated observing effort within the International Polar Year (2008-2009), during which Prof. Speich led one of the most complete observing project of the Southern Ocean, BONUS-GoodHope. This project federated 27 international research units and institutes. Il gathered more than one hundred scientists from different scientific fields of Oceanography, Atmospheric Sciences and Geophysics.
- In 2007 Prof. Speich initiated together with Drs S. Garzoli (NOAA, USA) and AL. Piola (SNHA, Argentina) a new international initiative dedicated to build an integrated observing system for the South Atlantic sector of the Southern Ocean, SAMOC. This initiative evolved successfully and today is almost completed in terms of deep mooring arrays and repeated observations. SAMOC has been approved by CLIVAR and the Southern Ocean Observing System (SOOS). This initiative gather many institutions from many countries (France, South Africa, Argentina, Brazil, Uruguay, USA, Russia, Spain, Germany, United Kingdom).
- This year Prof. Speich has integrated the Atlantic CLIVAR Panel.
- Within the *Laboratoire de Physique de l'Océan* (LPO) in Brest, Prof. Speich was leading one of the three teams of the laboratory.
- Prof. Speich is highly concerned by outreach and science dissemination to a wider audience. In addition to her teaching activity within the Brest University and the *Ecole Normale*, she gave many talks for the large public; participated to the making of a documentary on the ocean's currents (*Voyage au centre de la mer*; Directed by M. Jampolski. Produced by MC4, Arte and Radio Canada), and she wrote or collaborated in the writing of numerous outreach articles.

## 2.2) Presentation of the partners (be synthetic, internet link to researchers presentation pages (more exhaustives CV in the appendix).

**Jacqueline Boutin** received the Ph.D. degree in physical methods in remote sensing from the University Paris VII, Paris, France, in 1990. She is currently research director at CNRS/Laboratoire d'Océanographie et du Climat-Expérimentations et Approches Numériques, Paris. She widely study the air-sea exchange of $CO_2$, using autonomous instruments (CARIOCA sensors) and satellite measurements (wind speed, SST, ocean color, now SSS from the Soil Moisture and Ocean Salinity (SMOS) satellite mission). She was responsible for a large program of CARIOCA drifters deployment in the Southern Ocean (EU FP6 CarboOcean and FP7 Carbochange projects) and she participated to the KEOPS2 experiment, focussing on the physical and biogeochemical processes responsible for huge variability of $CO_2$ partial pressure observed in the Southern Ocean. Publications: 70 refereed papers; 4 chapter books

**Lionel Guidi** got a PhD in 2008 both at the Université Pierre et Marie Curie (France) and at Texas A%M University. He moved to the University of Hawaii between 2008 and 2012 for a first postdoctoral fellowship with David M. Karl and Matthew Church at CMORE and HOT. He did a second post-doc in 2013 at the Laboratoire d'Oceanographie de Villefranche before to get a permanent research position at the CNRS. During his PhD and Postdoctoral experience he focused his studies on the biological pump using imaging technologies to work on particles dynamic across all spatial and temporal scales.

**Louis Legendre** : Professor emeritus at the Pierre and Marie Curie Paris 06 University, France, and Laval University, Canada. Fellow of the Royal Society of Canada, Academy of Science. Chair, Scientific Council, Oceanographic Institute, France and Monaco. Director of the Villefranche Oceanography Laboratory, France, from 2001 to 2010. Fields and topics of research: biological oceanography, marine biogeochemistry, numerical ecology, and philosophy of science. Prizes and honours include: Order of Saint Charles (Principality of Monaco), International Ecology Institute Prize, G. Evelyn Hutchinson Award (American

Society of Limnology and Oceanography), Highly Cited Researcher (Institute for Scientific Information), Honorary Doctorate from the University of Liege (Belgium), Quebec Prize in Pure and Applied Sciences. Publications: 234 refereed papers, 9 full books, and 10 book chapters. H-index: 42.

**Ingrid Obernosterer** received her PhD in Biological Oceanography at the University of Groningen (The Netherlands) in 2000. She was awarded the Schroedinger Fellowship (Austrian Science Foundation) and a Marie Curie Fellowhsip by the European Community to support her Post Doctoral research at the University of South Carolina (USA) and the Laboratoire d'Oceanographie Biologique (Banyuls, France). She is presently a CNRS Research Scientist at the Laboratoire d'Océanographie Microbienne (Banyuls, France). I. Obernosterer has expertise in marine biogeochemistry, aquatic microbial ecology and marine organic matter cycling. Her research is centered on key issues on the bioavailability and transformation of different sources of dissolved organic carbon by the microbial community, and the metabolic balance of the ocean. Due to her participation to the international project KEOPS, she has experience with the particularities of the Southern Ocean system.

**Carolyn Scheurle**. Carolyn has a multi-disciplinary background centered on geosciences (PhD). She had been working as a marine expert in national and international organizations focusing on the Mediterranean. Since three years, Carolyn Scheurle is in charge of outreach, scientific communication and the development of educational activities for the Observatoire Océanologique de Villefranche. In particular, she has been at the origin of the « mon océan & moi » initiative including the « adopt a float » concept. Within this context, Carolyn works at present on the elaboration and integration of new science-based contents for "mon ocean & moi." She is also networking with the national and international community (e.g. South Africa) to bridge classes from different countries around the international "adopt a float" initiative.

**Julia Uitz** received a PhD degree in biogeochemical oceanography from the Aix-Marseille University (France) in 2006. She then spent 5 years (2007-2011) at Scripps Institution of Oceanography (UCSD, USA) where she was a postdoctoral fellow with the Ocean Optics Lab. Since 2012 she is a CNRS research scientist at LOV. Julia Uitz has interest in the spatio-temporal dynamics of phytoplankton communities and associated carbon fluxes at global and regional scales. Using large extensive phytoplankton pigments and bio-optical datasets, she has developed a novel approach for estimating phytoplankton group-specific biomass and primary production rates in the world's oceans on the basis of satellite ocean color observations. As part of the KEOPS project, she has studied the interplay of light and nutrient on phytoplankton distribution in the iron-enriched region of Kerguelen. As she has joined LOV she is pursuing her research and developing innovative coupled in situ-satellite approaches for gaining further insights into phytoplankton community composition and productivity. Julia Uitz has been deeply involved from the early stages in the children's outreach initiative "mon ocean & moi" and its twin project "adopt a float" on which the team has built for developing the outreach component of this project.

## 3) BUDGET (max 4 pages )

SOCLIM results from discussions between 3 groups who each initially intended to submit "individual" proposals in response to the Climate initiative call. We have decided to merge our initial projects into an integrated proposal, hence offering synergetic perspectives. The implementation of such a large proposal requires resources that are certainly more important than those required for a "standard" proposal. We nevertheless believe that merging our efforts is the right and after all a cost-effective way to develop novel approaches for acquiring unique *in situ* observations and conducting top-level research in the harsh and remote environment as the SO.

Compared to our first estimate (1,424 k€) provided during the stage 2 of the call, we have now reduced the budget by 15 % . Thus the budget (1220 k€) requested to the foundation should be considered as the appropriate funding to be able to conduct the research described in this proposal.

BNP's contribution will be dedicated mainly to buy equipment and to contribute to their deployment and processing of data. Collecting funds by more conventional ways (multiple institutional calls) would require several years and th[illegible] considerably slow down or even impair the implementation of SOCLIM. The BNP's will lead to a rapid and effi[illegible] implementation of a project that will give us an international leadership on this topic. Additionally SOCLIM is beside the type of projects usually funded by institutional agencies. Therefore the financial leverage of BNPS contribution is high.

| Use of funds | | Sources of funds | |
|---|---|---|---|
| **Human resources** | | **Funders** | |
| Permanent staff | 650 k€ | **University** | |
| Other staff | 185 k€ | Human ressource | 277 k€ |
| **Material** | | Public outreach | 117 k€ |
| Equipment | 1424 k€ | **CNRS** | |
| **Others** | | Human ressource | 373 k€ |
| Shiptime | 600 k€ | Equipment | 80 k€ |
| Logistics | 28 k€ | **IPEV** | |
| Public outreach | 147 k€ | Shiptime | 600 k€ |
| Analysis of sample | 40 k€ | **CORIOLIS** | |
| Travel expense | 36 k€ | Equipment | 534 € |
| Overheads | 91 k€ | | |
| | | **Requested funding** | **1220 k€** |
| | | …… | |
| ***TOTAL*** | ***3201 k€*** | ***TOTAL*** | **3201 *k€*** |

| | expenses | | | resources | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Other Resources | | | Requested to BNP | | |
| | Year1 | Year2 | Year3 | Year1 | Year2 | Year3 | Year1 | Year2 | Year3 |
| Perm.staff | 220* | 220 | 210 | 220 | 220 | 210 | 0 | 0 | 0 |
| other staff | 85 | 50 | 50 | 0 | 0 | 0 | 85 | 50 | 50 |
| Equipment | 1130 | 164 | 130 | 314 | 170 | 130 | 770 | 40 | 0 |
| logistics | 7 | 314 | 307 | 0 | 300 | 300 | 7 | 14 | 7 |
| Travel | 6 | 15 | 15 | 0 | 0 | 0 | 6 | 15 | 15 |
| Consumables | 5 | 10 | 25 | 0 | 0 | 0 | 5 | 10 | 25 |
| Public outreach | 52 | 52 | 25 | 40 | 40 | 37 | 12 | 12 | 6 |
| **TOTAL** | **1505** | **825** | **780** | **574** | **730** | **677** | **885** | **141** | **103** |
| Overheads | 71 | 11 | 9 | | | | 71 | 11 | 9 |
| TOTAL | 1576 | 836 | 789 | 574 | 730 | 677 | 956 | 152 | 112 |
| TOTAL | 3201 | | | 1981 | | | **1220** | | |

* all cost in k€

**Salaries**

- *Post-doctoral fellow*: 2 x 1 year of salary support are requested for 2 post-doctoral fellows with the following profiles : post-doc #1 she/he will work in close collaboration with S. Blain, I. Obernosterer and J. Boutin on the processing and the interpretation of data provided by the moored instrument, with a focus on the carbon fluxes at the air-sea interface and at depth.
  Post-doc#2 : She/he will work in collaboration with H. Claustre and J. Uitz in the tasks relevant to the study of the biogeochemical processes driving the sequestration of carbon. She/he will contribute to the

quality control, analysis, and interpretation of the Bio-Argo profiling float data with the purpose of characterizing the phytoplankton bloom dynamics in the Kerguelen region.

- *SOCLIM outreach activities*: 1 year of salary support is requested for its coordinator (4 months per year). In close interaction with the SOCLIM PIs and IPEV, the person will be in charge of the three main activities relevant to the project. This includes (1) the elaboration of the specification of the Web site and the supervision of its editorial during the project life-time; (2) the development of educational resources specific and relevant to SOCLIM (the SO as a key area to study climatic and environmental changes; the island mass effect) that will be linked to "Mon Océan & Moi" web platform. (3) the coordination of the "adopt a float" initiative, including its internationalisation and favouring exchanges between classes (e.g. South Africa and Australian classes exchanging with French ones)
- *Engineer*: 1 year of salary support is required for 1 engineer who will be in charge of the preparation of the moorings and the integration of the instruments. She/he will be supervised S.Blain and will work in close collaboration with DT-INSU.

**Equipment**

- *PROVBIO 2 biogeochemical float (8 units)*: the standard Argo floats (13 k€ each) can be obtained through a request to the national park (the condition for obtaining this float for "free" is that the PI makes the appropriate data quality controlled and make the data publically available in the Argo data system). These floats have to be upgraded into Bio-Argo floats (iridium transmission replacing Argos, additional lithium batteries) for a cost of 7k€. Then after, the bio-optical and biogeochemical sensor package (38 k€ each, estimation from the remOcean project) has to be integrated on the float.
- *PROVAL "cal-val' float (2 units)*: the standard Argo floats cannot be available (it is not considered as a standard Argo float). The full cost of a Bio-Argo float (20 k€) on top of which the dedicated optical package (35 k€, estimation from our PROVAL CNES-funded project).
- *Surface mooring (2 units)*: the cost per unit includes the equipment for the mooring 40k€ (weight, release floats…) half of it will be borrow at the national facilities for oceanographic equipment. and the instruments (bioopticial package identical to biofloats (38k€), $CO_2$ carioca (25 k€), $O_2/N_2$ sensors (25k€), remote auto-sampler McLane (50 k€). 1 of the 2 units of these instruments will eventually be installed on polar pod during the last year of the project.
- *Deep mooring (1 unit)* : the cost per unit includes the equipment for the mooring 40k€ (weight, release floats…) half of it will be borrow at the national facilities for oceanographic equipment.
  The cost for the sediment traps (Technicap) and for the sensors (CTD, inclinometer, current meter).

**Consumables**

- *Float iridium communication*. The cost per float (3k€) corresponds to an estimation of communication cost estimated from the return of experience of our on-going programmes (ERC remOcean).
- *Outreach* (10 k€). Dissemination material (e.g. flyers, posters); Educational material for school classes (e.g. ocean experimental kits); outreach small material for science facilitators (e.g. touchpad).
- *Consumables for moorings (40 k*€) : for calibration and preparation of the instruments. Chemicals and costs for laboratory analysis of the samples collected by the auto-sampler and the sediment traps (estimates based on previous projects e.g. KEOPS).

**Logistics, missions and ship time**

*Shipping of equipment* (21 k€ based on 3 shipping of one 20 feet container from france to la Reunion, and 7 k€ for other shipping (samples)). *The ship time* is estimate on the base of 50 k€/day. it will be requested via the annual call for access to the French fleet of RV. No problems are anticipated to obtain this ship time because SOCLIM will request a limited number of days (3-6 of operations per voyage) that will be pooled with other demands to organise a campaign. For *the missions*, the estimate is based on 36 travels with a mean cost of 2k€ (flight tickets+per diem). The travels are for participation to the cruises, the internal meetings or the participations to international conferences.

**Sub-contracting (outreach)**

- *SOCLIM web site (7 k€)*: Web-design and web-mastering activities including the integration of statistic analysis for evaluation, maintenance.
- *Mon Océan & Moi Web platform (7 k€)*: development and integration of SOCLIM relevant topic web pages, including games, quizzes
- Visual development (6k€) : illustrations/ animations (e.g. see here or here) for the SOCLIM and "Mon Ocean & moi" websites, [illegible] identity for SOCLIM.

**Overheads :** The management charges for the projet applied by Université Pierre et Marie Curie are 8 % of the total requested (9[illegible] K€)

## 4) BONUS AWARD (max 1 page)

As exposed in section 1.6.2 “public outreach”, our efforts regarding outreach are actually focused on young peoples. The Bonus award would allow us to widen the communication about this project and to focus on press communication.

The bonus award activities would be managed by the head of communication Department of the French polar institute (IPEV) that possesses the know-how for communication project management. The development of the communication actions will be done by communication services of the partners involved, in closed relation with Aude Sonneville. Biologist, she has worked few years as scientific journalist in different type of media in Europe and South America. Returned to France, she starts in communication at the *Institut de recherche pour le développement* where she had the responsibilities as press officer. After 4 years as head of communication for AMMA, international interdisciplinary program dealing with the West African Monsoon, she has been recruited by the IPEV to be in charge of the communication department.

The IPEV is largely involved in educational programmes, first by the partnership that the institute and the rectorat de Bretagne have signed two years ago. Every year and during all the year, we work closely with classes to integrate to their pedagogical program our tools, to organise meetings and create exchanges and interactions with our polar stations staff. We also work to organize regularly large public event as exhibitions, conferences….

It is essential to integrate and transmit the scientific collected knowledge through the pedagogic activities. It is also important to enlarge this transmission to a larger public. The press is a good way to do that. That is why we want to propose a pedagogic work that Medias can disseminate. We would invite a few selected journalists to follow “day-day” the educational work performed amongst selected classes (S. Blain is currently working with Lycée Arago of Perpignan and the scientists of LOV are working with Collège Les Vallergues d’Antibes and College Paul Arene de Peymainade in the context of “adopt a float”).

The mile stones of this work are:

1. Make aware a journalist of the scientific topics. This journalist will work first for a scientific newspaper for young people. Second, he will propose different work around the project (paper, pictures, interviews, portraits…) to other media supports.
2. This journalist meets the classes and their teachers to follow the pedagogical work and help inserting the scientific topics into the pedagogical activity of the class. He will also prepare the field campaigns and the work around with students.
3. This reporter accompanied by a teacher, a group of students will join the SOCLIM cruise on board the oceanographic vessel Marion Dufresne. They will write a blog that is published on the journal(s) website. The journalist helps the students/ teacher with the writing of articles for the journal.
4. To enlarge the press diffusion, a press trip would be organized. A few other media will be invited, especially a scientific journalist and a TV team that makes a documentary on the project with the possibility of an highlight on the educational work carried out by classes.

Around these activities, it will be necessary to organize press conferences (at the beginning, when the results will be publishing …), to realize press releases, to create pedagogic tools… In addition, the presentation of results and prospects may be considered after three years.

The main expenses for the bonus award would be: Communication officer: 15 k€, Press trip: 15 k€
Documents and tools for press and pedagogic actions: 7 k€, Related actions: 7 k€, Overheads : 6 k€

## 5) APPENDIX (max 6 pages)

Letters of :

Dr. Thomas Trull , ACE CRC Carbon Program Leader, Australia.

Pr. Jorge Sarmiento (University of Princeton) and Dr K. Johnson (Monterey Bay Aquarium Research Institut). P.I. of SOCOM, (Southern Ocean Carbon and climate Observation and Modeling) USA.

Dr. Michael Roberts Program Leader: Observational & Operational Oceanography, Department of Environment Affairs, Oceans and Coasts, South Africa.

ANTARCTIC CLIMATE & ECOSYSTEMS CRC

Antarctic Climate & Ecosystems Cooperative Research Centre
**Location** Centenary Building, University of Tasmania
Grosvenor Crescent Sandy Bay Tasmania 7005
**Postal** Private Bag 80, Hobart Tasmania 7001, Australia

www.acecrc.org.au

**Date:** 24 Jan 2014
**Memo to:**
Drs. Stephane Blain, Herve Claustre, and Sabina Speich
Principal Proponents of the SOCLIM initiative
**Memo from:**
Dr. Tom Trull, ACE CRC Carbon Program Leader
**Regarding:** Australian support for SOCLIM

We are extremely pleased to see the initiation of the proposed SOCLIM project to advance the use of innovative methods for climate and carbon cycle observations of the Southern Ocean. This region, as the dominant site of the deep overturning circulation, is the key to understanding climate change on timescales ranging from the great ice ages to the coming century. The problem is urgent as it governs the rate of rise of surface temperatures driven by anthropogenic $CO_2$ emissions. The region is logistically difficult to access and the seas are amongst the most severe in the global ocean. Only the implementation of in-situ autonomous observations can address the problems of assessing the uptake of heat and $CO_2$ – satellite observations are insufficient as they cannot observe the interior. Great progress on heat observations has been made via the Argo autonomous profiling float program, although it has not yet been able to observe the chemical properties required to quantify carbon uptake or the biological properties required to understand biological responses to both climate change and the ocean acidification that accompanies $CO_2$ uptake.. The proposed SOCLIM project offers an excellent path forward to contribute to these needs for expanded Southern Ocean observations – needs which have been clearly articulated and underlined as top priorities by the Intergovernmental Panel on Climate Change Assessment Report 5 (www.ipcc.ch/report/ar5/wg1/ ) and by the Global Ocean Observing System in its Southern Ocean Observing System plan (www.soos.aq).

Australia is strongly committed to ongoing observations of Antarctic and Southern Ocean processes involved in the climate system, and the centre for this activity is Hobart, Tasmania, where the Antarctic Cooperative Research Centre established in 1991 has recently been awarded ongoing funds to 2019, to bring together research scientists from its core partnes: the Australian Antarctic Division, the Commonwealth Scientific and Industrial Research Organisation, the Australian Bureau of Meteorology and the University of Tasmania (augmented by many international collaborations; www. acecrc.org.au). The ACE CRC has implemented a novel suite of three moorings that compose the Southern Ocean Time Series (SOTS) to observe physical, chemical, and biological processes that control heat and carbon uptake in the Subantarctic Zone – where they enter the upper limb of the overturning circulation and are transported into the ocean interior. These moorings have proved to be

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The ACE CRC is a unique collaboration between partners the Australian Antarctic Division, CSIRO, the University of Tasmania, the Australian Government's Department of Climate Change & Energy Efficiency, the Alfred Wegener Institute for Polar and Marine Research (Germany) and the National Institute of Water and Atmospheric Research Ltd (New Zealand) and a consortium of supporting partners. It is funded by the Australian Government's Cooperative Research Centres Program.

CRC AUSTRALIA

ANTARCTIC CLIMATE & ECOSYSTEMS CRC

Antarctic Climate & Ecosystems Cooperative Research Centre
Location Centenary Building, University of Tasmania
Grosvenor Crescent Sandy Bay Tasmania 7005
Postal Private Bag 80, Hobart Tasmania 7001, Australia

www.acecrc.org.au

durable and deliver new information on atmosphere-ocean coupling and carbon cycling (Trull et al. 2001; Trull et al., 2010; Pender et al., 2010; Schulz et al., 2011, 2012; Weeding and Trull, 2013).

As part of the SOTS program we have also deployed several Argo floats with added bio-optical and dissolved oxygen sensors, and our efforts in this area are expanding in other regions as well, including Bio-Argo float deployments in January 2014 as part of the French Mycto project near Kerguelen Island, and others as part of an Australia-India collaboration for a pilot project in the Indian Ocean.

We look forward to providing our expertise in mooring systems and autonomous float deployments to the SOCLIM project team, and conversely to benefitting from their parallel experiences and expertise. We are also able to offer float and mooring deployment opportunities in the context of ship visits to the SOTS site as well as a voyage to the Kerguelen-Heard plateau region in austral summer 2014-15.

We believe the SOCLIM initiative is timely, powerful, and of great merit and will assist in all ways that we can to make it a success.

Trull, T.W., Bray, S.G., Manganini, S.J., Honjo, S. & François, R. (2001) Moored sediment trap measurements of carbon export in the Subantarctic and Polar Frontal Zones of the Southern Ocean, south of Australia. *Journal of Geophysical Research*, **106**, 31489-31510.

Trull, T.W., Schulz, E., Bray, S.G., Pender, L., McLaughlan, D., Tilbrook, B., Rosenberg, M. & Lynch, T. (2010) The Australian Integrated Marine Observing System Southern Ocean Time Series facility. *OCEANS 2010 IEEE - Sydney*, 7 pp.-7 pp.

Pender, L., Trull, T., McLaughlin, D. & Lynch, T. (2010) Pulse-a mooring for mixed layer measurements in the open ocean and extreme weather. *OCEANS 2010 IEEE - Sydney*, 6 pp.-6 pp.

Schulz, E.W., Grosenbaugh, M.A., Pender, L., Greenslade, D.J.M. & Trull, T.W. (2011) Mooring Design Using Wave-State Estimate from the Southern Ocean. *Journal of Atmospheric and Oceanic Technology*, **28**, 1351-1360.

Schulz, E.W., Josey, S.A. & Verein, R. (2012) First air-sea flux mooring measurements in the Southern Ocean. *Geophysical Research Letters*, **39**, doi:10.1029/2012GL052290.

Weeding, B. & Trull, T.W. (2013) Hourly oxygen and total gas tension measurements at the Southern Ocean Time Series site reveal winter ventilation and spring net community production. *Journal of Geophysical Research - Oceans*, **118**, 1–11, doi:10.1002/2013JC009302

Thomas W. Trull. 20 February 2014, Hobart

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The ACE CRC is a unique collaboration between partners the Australian Antarctic Division, CSIRO, the University of Tasmania, the Australian Government's Department of Climate Change & Energy Efficiency, the Alfred Wegener Institute for Polar and Marine Research (Germany) and the National Institute of Water and Atmospheric Research Ltd (New Zealand) and a consortium of supporting partners. It is funded by the Australian Government's Cooperative Research Centres Program.

**PRINCETON**
UNIVERSITY

**Program in Atmospheric and Oceanic Sciences**
300 Forrestal Road, Sayre Hall
Princeton, New Jersey 08540-6654
*Jorge Sarmiento*
*Phone: (609) 258-6677*
*Fax: (609) 258-2850*

January 24, 2014

Drs. Stéphane Blain, Hervé Claustre, and Sabina Speich
Principal Proponents of the SOCLIM initiative

Dear Stéphane, Hervé, and Sabina

We are very pleased to hear of your plans for the SOCLIM initiative in the Southern Ocean. As you know we are working very hard within the US science community to promote the development of the Bio-Argo network in the Southern Ocean. There is an urgent need to acquire biogeochemical data in this environment and Bio-Argo floats and their associated sensors have now reached a degree of maturity that allows the effective implementation of an operational network. A network of Bio-Argo floats would provide an unprecedented view of carbon and nitrogen cycles and the physical and biological processes that drive them.

We have received support from the US National Science Foundation to deploy 13 floats with pH, nitrate, oxygen and biooptical sensors in March 2014. We have just submitted a $21 million proposal to follow this pilot project with a much larger scale effort. This 6-year project, known as SOCOM (Southern Ocean Carbon and climate Observation and Modeling), will enable us to deploy some 185 Bio-Argo floats (about 30/year). SOCOM will have a closely linked modeling and analysis component that utilizes the data produced by the floats. While SOCOM is still in review at NSF, we have high confidence for its success.

The effort to observe the Southern Ocean is directly dependent on strong international collaborations. No single nation will be able to sustain a network in the Southern Ocean and international collaboration will build a comprehensive observing system in a much shorter time. To facilitate international collaborations, we have implemented a Foreign Advisory Committee (S. Rintoul, Australia is Chair, H. Claustre is a member). One charge of the Committee is to ensure that there is significant synergy across the various national efforts, including the sharing of technology such as our newly developed pH sensor. The Committee will also ensure transparent data access and comparability.

Obviously, we strongly support your effort to acquire and deploy floats in the Southern Ocean. In particular, the addition of optical package to the standard biogeochemical sensors is a clear added value to address key issues of bio-optical anomalies in the Southern Ocean and subsequently to improve remote sensing algorithms for chlorophyll *a* retrieval in this unique environment.

Should the SOCLIM project be funded, we are sure that this would represent an invaluable complement to SOCOM and to the other projects that are planned in the international community (e.g. Australia, India, South Africa, Brazil and Argentina). There is no question that synergies could be easily developed between our groups.

We hope the best for the final outcome of your submission.

Best regards,

Jorge Sarmiento, Professor

Kenneth Johnson, senior scientist

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environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Branch: Oceans and Coasts · PO Box 52126· Victoria and Alfred Waterfront · CAPE TOWN · 8002
No.2 East Pier Shed · East Pier Road · Victoria and Alfred Waterfront · CAPE TOWN · 8000
Tel (+ 2721) 402 3318 · Fax (+ 2721) 425 6976

Attention: *Sabrina Speich,* Professor

École Normale Supérieure
Department of Geosciences,
Laboratoire de Météorologie Dynamique (LMD)
24 rue Lhomond, 75231 Paris cedex 05, France

30 January 2014

**RE: Letter of support for proposed SOCLIM project**

Dear Sabrina,

Thank you for contacting me regarding the above proposed novel project. As you know, South Africa has very strong interests in the Southern Ocean, in particular in the African sector. Not only do we have a good track record of research and annually operate cruises in this region, but we also have an ambitious plan into the future. Both DEA and the Department of Science and Technology (DST) are currently finalizing this plan in terms of a national strategy. As indicated in your draft proposal, there are several other South African institutions who perform research in the Southern Ocean, who may also be interested. Certainly from a DEA perspective, I can confirm our willingness to be part of the SOCLIM project. Details can be worked out in future drafts of the project proposal.

Yours sincerely

Prof Michael J. Roberts
Program Leader: Observational & Operational Oceanography
Department of Environment Affairs, Oceans and Coasts,
South Africa

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