

Le dossier doit être impérativement approuvé par le Directeur du laboratoire proposant. Chaque dossier de proposition doit comporter 3 fichiers portant le même nom : un formulaire MS-word, un formulaire MS-excel et la fiche résumé du formulaire MS-excel signée par le Directeur du laboratoire et scannée au format .pdf.

1. RENSEIGNEMENTS GENERAUX

1.1. INTITULÉ DE LA PROPOSITION

Utiliser le même intitulé dans le fichier MS-word et dans le fichier MS-excel

CNES-OUTPACE (Oligotrophy from Ultra-oligoTrophy PACific Experiment)

1.2. SCIENTIFIQUE PROPOSANT

Nom : **Doglioli**
Prénom : Andrea
Téléphone : 33491829109
e-mail : andrea.doglioli@univ-amu.fr
Nom du Laboratoire : [Institut Méditerranéen d'Océanologie \(MIO\)](#)
Adresse : Campus de Luminy - Case 901
13288 MARSEILLE cedex 9
France
Organisme de tutelle : Université d'Aix-Marseille (AMU)
Organisme gestionnaire : Université d'Aix-Marseille (AMU)

1.3. CO-PROPOSANTS

Ajouter des lignes si nécessaire

Nom : **Petrenko**
Prénom : Anne
Téléphone : 33491829061
e-mail : anne.petrenko@univ-amu.fr
Nom du Laboratoire : [Institut Méditerranéen d'Océanologie \(MIO\)](#)
Adresse : Campus de Luminy - Case 901
13288 MARSEILLE cedex 9
France
Organisme de tutelle : Université d'Aix-Marseille (AMU)
Organisme gestionnaire : Université d'Aix-Marseille (AMU)

Nom : **Moutin**
Prénom : Thierry
Téléphone : 33491829560
e-mail : thierry.moutin@univ-amu.fr
Nom du Laboratoire : [Institut Méditerranéen d'Océanologie \(MIO\)](#)
Adresse : Campus de Luminy - Case 901
13288 MARSEILLE cedex 9
France
Organisme de tutelle : Université d'Aix-Marseille (AMU)
Organisme gestionnaire : Université d'Aix-Marseille (AMU)

Nom : **Bonnet**
Prénom : Sophie
Téléphone : 00 687 26 07 46
e-mail : sophie.bonnet@univ-amu.fr
Nom du Laboratoire : **Institut Méditerranéen d'Océanologie (MIO)**
Adresse : IRD Noumea 101 Promenade R. Laroque, BP A5
98 848 Nouméa Cedex
Nouvelle Calédonie
Organisme de tutelle : Institut de Recherche pour le Développement (IRD)
Organisme gestionnaire : Université d'Aix-Marseille (AMU)

2. PROPOSITIONS NOUVELLES

2.1. OBJECTIFS SCIENTIFIQUES

En une page maximum, indiquer le contexte scientifique au plan national et international. Détailler les objectifs à atteindre sur l'ensemble du projet et les résultats attendus.

The functioning and productivity of oligotrophic systems, and the balance between production and mineralization in these oceanic areas, is still the subject of much debate. Once thought to be biological deserts, these systems could **largely contribute to the global ocean organic carbon export** (Karl et al., 2012). The question of whether the plankton communities in low nutrient regions of the ocean, comprising 80% of the global ocean surface area, are **net producers or consumers of oxygen and fixed carbon is a key uncertainty in the global carbon cycle** (Riser and Johnson, 2008).

The OUTPACE project (PIs: T.Moutin and S.Bonnet) aims at studying this question. The overall objectives of the project are **to provide a zonal description of the biogeochemical functioning and biological diversity of the South West Pacific** along a gradient of macro- and micro-nutrients availability. Therefore, the project will produce **a detailed study of the biological production and its subsequent fate in 3 contrasting sites**, with a specific emphasis on the production sustained by nitrogen fixation. We will determine whether organic matter production, re-mineralization and export processes are different at these sites, and if so, determine how such differences are related with the diversity/function of nitrogen-fixing organisms in the planktonic community. Comparing different sites, along a zonal gradient of differing nutrient availability, will provide a **new insight for identifying and understanding the fundamental interactions between ocean dynamics, marine biogeochemistry and ecosystems**.

At the international level, the OUTPACE project fits into the scientific priorities of the large international programmes from IGBP and SCOR (IMBER, SOLAS, GLOBEC) as it aims at acquiring knowledge to understand, quantify and model/forecast interactions between biogeochemical cycles and marines ecosystems. The OUTPACE project received the support of the international IMBER (Integrated Marine Biogeochemistry and Ecosystems Research) programme. At the national level, it fits with the scientific priorities of the national LEFE programme described in the INSU Prospective 2011-2016. In particular, it fits with Topic 1 of the LEFE/CYBER action "Study of the marine production at different scales".

The OUTPACE cruise planned in 2015 will perform a **transect at 19°S** along a W-E gradient from the North of New Caledonia, an area exhibiting high N₂ fixation rates, to the western part of the South Pacific gyre, which has been identified as the most oligotrophic oceanic area of the world ocean (Claustre et al., 2008), and characterized by low N₂ fixation rates (e.g. Moutin et al., 2008). The oceanographic cruise will consist in 18 short duration (8 hours) stations (**SD stations**) and 3 long duration (7 days) stations (**LD stations**) distributed as shown in Fig.1. The campaign will last 45-days onboard the R/V Atalante (time ship accepted by the national Fleet Commission).

The OUTPACE project will **consider a variety of scales, from single-cell processes to the whole SW Pacific ocean**. In order to examine the biogeochemical role of diazotrophs, OUTPACE will describe the functioning of each distinct ecosystem from a **multidisciplinary point of view**, adopting an innovative approach combining remote sensing data, Lagrangian drifters, ship-based experiments and numerical modeling.

The present proposal aims at supporting the remote sensing/lagrangian strategy of the project. The specific objectives are:

- i) to guide the adaptative, Lagrangian sampling strategy for in situ process study on carbon export;
- ii) to provide insights of the spatial and temporal variability of the physical and biogeochemical characteristics of the surrounding waters of the OUTPACE cruise.

This implies an intense use of remote sensing products, that will in addition provide in situ data for satellite cal/val in a chronically under-sampled area.

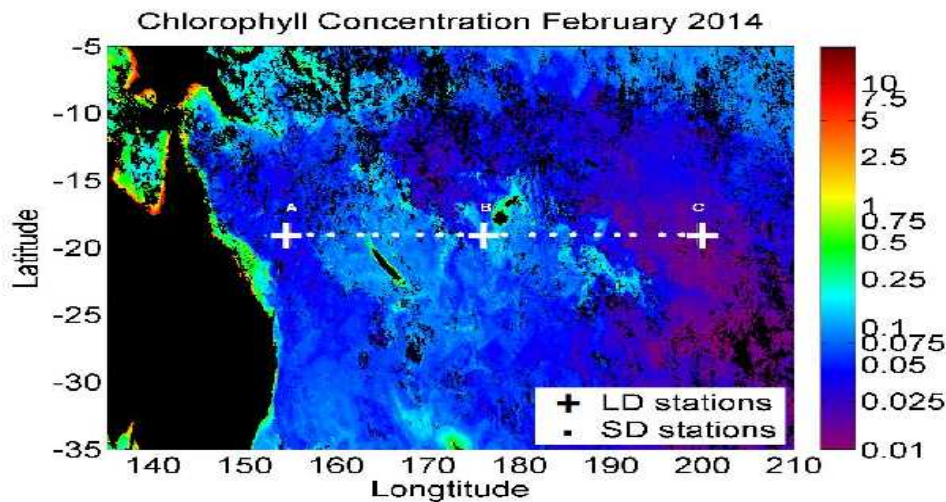


Fig.1 Transect of the OUTPACE cruise superimposed on Surface chlorophyll concentrations (MODIS, composite February 2014). The cruise is organized in a series of short duration stations (crosses) and three long duration stations (A,B,C)

2.2. SITUATION ACTUELLE DU THÈME DE RECHERCHE

Décrire la situation actuelle du thème de recherche et le projet, notamment le **cadre de réalisation**. Préciser le **statut de l'expérience**, notamment si elle est présentée dans un cadre de coopération internationale : expérience déjà sélectionnée, en cours d'examen ou encore à proposer.

Scientific Framework

In order to apply the OUTPACE methodology, it is necessary to know in detail the coupled physical-biogeochemical ocean dynamics at both the submeso- and the regional scale. Satellite data will provide a fundamental contribution to accomplish this complex task.

Regarding the submesoscale processes, it is known that they directly influence the characteristics of the marine food web and the efficiency of the biological pump and the carbon export. Indeed, the ecological response to submesoscale dynamics can rapidly propagate to the higher trophic levels (Tew Kai et al., 2009; Cotté et al., 2011). Sea surface temperature (SST) and ocean color, have for long time provided surface observations at the $O(1 - 10)$ km scale, indicating the ubiquitous presence of submesoscale fronts and filaments in the oceans. However, measurements of sea surface elevation, from which surface currents are derived, are still characterized by a much lower resolution. Therefore, although global maps of altimetry-derived currents have provided a fundamental contribution in the last twenty years for understanding the role and importance of mesoscale dynamics (Le Traon, 2013), they could not be used for the direct investigation of submesoscale dynamics. Information on submesoscale dynamics can be retrieved only indirectly through the analysis of the mesoscale-induced stirring, most commonly by computing Finite Size/Time Lyapunov Exponents (FSLE/FTLE, d'Ovidio et al., 2004). Such information has been often combined with products derived from ocean color observations to investigate the impact of submesoscale dynamics on biogeochemical (e.g. chlorophyll standing stocks, Rossi et al., 2008) and ecological processes (e.g. spatial distribution of the ecological communities, d'Ovidio et al., 2010). The results of such approach are however affected by two big restrictions: i) all the effects induced by the small-scale dynamics not directly resolved by satellite altimetry is neglected; ii) the analysis is markedly two-dimensional, as no information on the three-dimensional dynamics can be retrieved.

Although the in situ observation at the submesoscale represents a major challenge, many recent studies have shown that observations made by ship-towed profilers, such as the Moving Vessel Profiler (MVP), are extremely effective for collecting repeated synoptic sections of submesoscale structures, enabling an exhaustive investigation of the rapidly-evolving frontal dynamics (D'Asaro et al., 2011; Nagai et al., 2012; Hosegood et al., 2013).

The OUTPACE cruise transect is located in an area of intense mesoscale activity. Based on sea surface height (SSH) measurements from satellite altimeters, Qiu et al. (2009) have described a zonal band between 20°S and 30°S in the western half of the South Pacific subtropical gyre, characterized by strong mesoscale processes. Such band is associated with the South Pacific Subtropical Countercurrent (STCC). Two bands of relatively high eddy variability are also identified along 16°S in the Coral Sea and along 18°S in North Fiji Basin between Fiji and Vanuatu. Indeed, the islands of Fiji, Vanuatu and New Caledonia represent a series of meridionally aligned obstacles for the westward-flowing South Equatorial Current (SEC). As the SEC encounters these islands, it bifurcates and forms zonal jets. From a numerical simulation, Webb (2000) identified four main jets: i) north and ii) south of the Fiji Islands, iii) north of the archipelago of Vanuatu and iv) north of the barrier reef of New Caledonia. Many studies have successively confirmed and refined the description of these jets from both numerical simulations and in situ observations. The signature of these jets is also identifiable in recent climatologies such as CARS2009.

Project status

OUTPACE is a multidisciplinary project involving 50 scientists from 15 international institutions (7 French research units and 8 universities in 5 foreign countries: USA, Germany, Israel, Sweden, Fidji); it is based on an original combination of the most up to date techniques in oceanography, from genes to satellites. The proposed team will benefit from the rare presence of the French Research/Vessel “L’Atalante” in the South Pacific in early 2015. The project is founded by the French National Program LEFE-CYBER (51 k€) and by the “Action Sud IRD” program of the MIO-Mediterranean Institute of Oceanography (17 k€). A pre-proposal for ANR has been accepted. OUTPACE is supported by the international program IMBER.

A specific Argo-OUTPACE request is actually under consideration by the GMMC (Groupe Mission Mercator/Coriolis, PI: C. Maes, IRD LEGOS) in order to obtain between 8 and 12 Argo profilers and 3 PROVBIO (specific Argo profilers equipped with new biogeochemical sensors).

The OUTPACE cruise received priority for the use of the oceanographic vessel Atalante in 2015 by the French National Fleet Commission.

2.3. DESCRIPTION DETAILLEE DE LA PROPOSITION

Décrire la **méthodologie envisagée et les travaux** à réaliser. Décrire le cas échéant le dispositif expérimental et préciser s'il s'agit d'une campagne ballon ou aéroportée.

In sake of simplicity, in the following we separate the planned work in two main work packages (WP) on the basis of the scale of the studied processes: “WP1 - Submesoscale” and “WP2 - Regional scale”.

WP1 - Submesoscale studies

We plan to use an adaptive Lagrangian sampling strategy for the in situ estimates of carbon production and export. The intensive use of satellite data will provide a key contribution for the identification of the location of the three contrasting oligotrophic environments for the process studies at the LD stations. The high number of innovative measurements that we plan to perform at these sites will provide precious information for sub-grid parameterizations of global products.

As shown in Fig.1, we expect to locate the first LD station (A) in the north of New Caledonia in the Coral Sea, an area frequently dominated by the photo-heterotrophic diazotrophs UCYN-A present at very high abundances (105-106 nifH copies.L-1) (Moisander et al., 2010). We expect to locate the second LD station (B) close to the Fiji Islands in an area dominated by the autotrophic diazotrophs *Trichodesmium spp.* (Dupouy et al., 2011) and/or UCYN-B, which often appear spatially associated in the SW Pacific (Moisander et al., 2010). The third LD station (C) will be located in the western part of the extreme oligotrophic South Pacific Gyre, a low N₂ fixation region (Moutin et al., 2008).

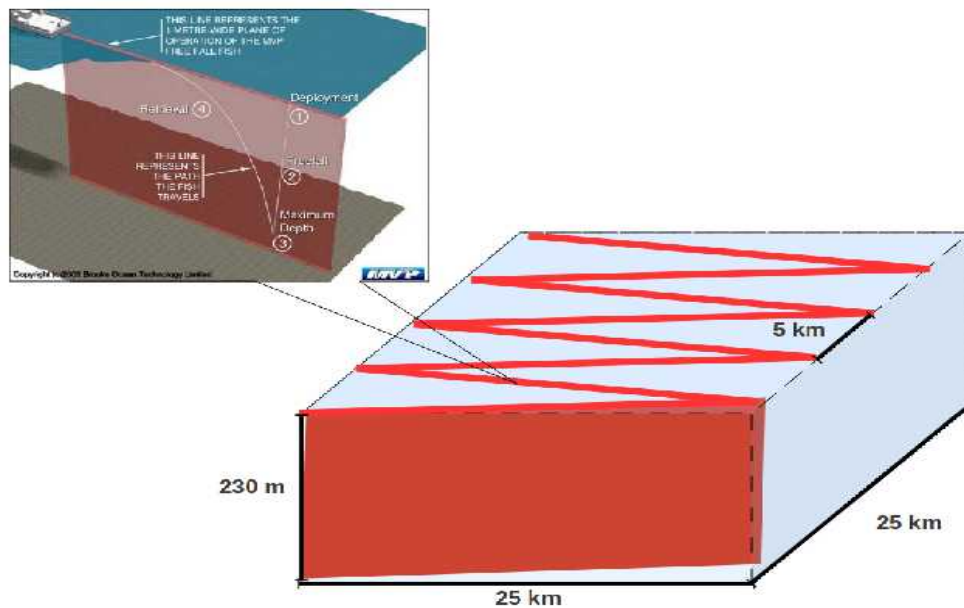


Fig.2 Sketch of the MVP zig-zag mapping, with a zoom on the events for a typical cast are: Deployment, Free-fall, Maximum depth, and Retrieval. Credit: ©Brooke Ocean Technology, Ltd.

During the field campaign, a very detailed knowledge of the local physics and biogeochemistry need. The positioning of the LD stations will be performed using the state-of-the-art methodologies, as follows.

The regions along the vessel route will be first characterized at large scale through the analysis of satellite (SST, Altimetry, Ocean color) and operational model data. These will be automatically retrieved and processed to derive Eulerian and Lagrangian diagnostics of ocean circulation and biogeochemistry: Okubo-Weiss parameter maps, Lagrangian Coherent Structures, Chlorophyll maps, Phytoplankton group maps (PHYSAT, Alvain et al. 2008). Moreover, the previously developed algorithm TRICHOSAT (Dupouy et al., 2011) and a new version of the algorithm PHYSAT will help to locate *Trichodesmium spp.* blooms from space. This information will be transmitted onboard by a dedicated server on land.

The data will be analyzed in near realtime both on board and on land in order to optimize the sampling strategy according to the local physical and ecological characteristics. This approach has already been successfully implemented by our team and employed during several previous cruises: LATEX (Nencioli et al. 2011), KEOPS2 (d'Ovidio et al., 2012) and STRASSE.

Then, the selected area will be sampled by performing a cross of multisensor MVP transects of about 40 km at a speed of 10 knots (maximum depth of the MVP 200 around 230 m). The MVP data (CTD, Fluorescence and LOPC) will be immediately processed onboard to identify a second smaller area (around 25×25 km²) where a high resolution mapping will be performed. Moreover, the phytoplanktonic assemblages will also be assessed onboard by using surface continuous flow cytometry (Cytosub) and discrete flow cytometry for bacteria, pico-, nano- and micro-phytoplankton.

In the smaller area local meso and submesoscale dynamics (eddy, filaments and frontal processes and their impact on regulating vertical fluxes and structuring the ecological community) will be characterized at very high resolution through MVP 200 zig-zag mapping at the beginning and at the end of each LD station survey (Fig.2). This will allow the accurate identification of the homogeneous and coherent water masses which will be the focus of each LD station. For this purpose the MVP 200 will represent an extremely useful instrument to sample a large zone in a short time to preserve synopticity.

This strategy will allow the investigation of the impact of high-frequency small-scale physical phenomena on biomasses and biogeochemical fluxes and the identification of the initial position of the Lagrangian reference frame for the Lagrangian navigation.

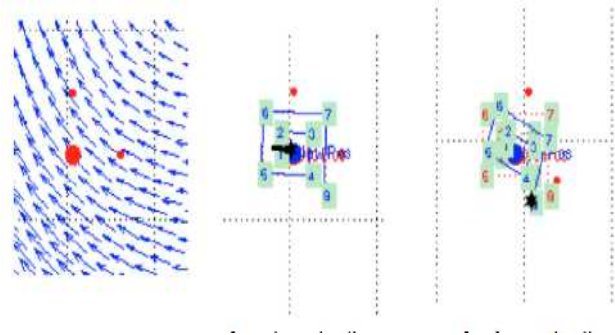


Fig.3 Example of Lagrangian navigation in a reference frame defined on the basis of the positions of three buoys (red dots). The square spiral route performed by the vessel (black star) is translated, rotated and deformed (red to blue lines) to follow the studied water mass.

Once the Lagrangian reference frame is defined, 3 drifters (1 central and 2 annex for each site) will be immediately dropped. A recently improved version of the Lagrangian navigation software developed during the LATEX project (Doglioli et al., 2013; Fig.3) will be adopted in order to take into account the translation of the studied water masses, as well as their rotation and deformation all along the 6-day process study.

Then, CTD and micro-structure profiles, water samplings and deployments of a drifting mooring line (equipped with a primary production line, O_2 productivity autosampler and sediment traps) will all be performed close to the central drifter all along the in-situ process study.

WP2 - Regional scale studies

We plan to use the satellite remote sensing to obtain a synoptic view in space and time of the physical and biological environment along and during the OUTPACE cruise. Most of the satellite observations are available over time periods longer than 10 years. When possible, the time evolution of these data set will be investigated over the last 10 years. This will allow the characterization of the seasonal and interannual (i.e., ENSO) cycles of physical and biological conditions along the OUTPACE transect, which will help interpreting the measurements and observations performed during the cruise in a broader spatio-temporal context. These satellite observations will also help characterizing the oceanic environment along the east-west gradient investigated by the field campaign.

We will use physical and radiometric observations (Table 1). Ocean color derived from radiometric remote sensing will allow the identification of the east-west gradient of phytoplankton biomass. The Photosynthetically Active Radiation (PAR) will give insight about the available light for phytoplankton growth. Primary production integrated over the oceanic upper layer and associated with phytoplankton communities based on surface chlorophyll determination (Uitz et al., 2006) will be compared with OUTPACE in situ measurements. Comparisons will also be undertaken to calibrate PHYSAT, which allows the determination of large organism's classes from space (Alvain et al. 2008), in order to a better representation of N_2 fixing organisms.

SSH will provide information about the thermocline depth which can be used as a proxy for the nutricline (Wilson and Coles, 2005) and, thus the food availability for phytoplankton growth. Satellite derived surface currents will provide insights about horizontal advection of the surrounding waters along the cruise transect. Winds will allow the characterization of the position of the STCZ (South Tropical Convergence Zone) and, coupled with SST and sea surface salinity (SSS), they will help identifying different water masses along the OUTPACE transect. Satellite derived SST and SSH along the transect will help identifying oceanic eddies off the northern boundary of the STCC. In the core of cyclonic eddies, the vertical transport of nutrient-rich waters can be associated with enhanced biological processes (e.g. Heywood et al., 1996; Aristegui et al., 1997). Identifying these structures will be a key goal for interpreting the gradient of collected in situ observations collected along the OUTPACE transect.

Variable	Data set	Resolution and time period	Data source
Chl, PAR, SST	Modis	4km, daily/weekly, 2001–	http://oceandata.sci.gsfc.nasa.gov/
SSH	Ssalto/Duacs merged product	1/3°x1/3°, 5-days, 1993–	http://www.aviso.oceanobs.com/
SSS	SMOS	50km, 3-days, 2009–	https://earth.esa.int
Winds	ASCAT	0.25°x0.25°, daily, 2009–	http://www.osi-saf.org/
Surface Current	OSCAR unfiltered	1/3°x1/3°, 5-days, 1993–	http://www.oscar.noaa.gov/

Table 1: Data sets used along with their sources.

Finally, **to obtain information linking the two scales**, we plan to release at each LD station between 3 and 4 Argo profilers and 1 PROVIO (specific Argo profilers equipped with new biogeochemical sensors). These instruments will be used to obtain long-time observations (up to several years) after the cruise. In particular, the PROVIO will allow to estimate organic matter export from fluorescence and backscattering sensors (Briggs et al., 2011) that will permit to extend the measurements after the occupation of the station to eventually catch the ends of the blooms.

2.4. CALENDRIER PREVISIONNEL DE LA PROPOSITION

Décrire en une page maximum le calendrier de réalisation en donnant les **étapes-clés** du déroulement du projet. Ce calendrier doit être compatible avec l'échéancier financier.

June 2014: Pre-cruise meeting with all participants (Marseille, France)

September 2014: Pre-cruise meeting with the organizing committee (Marseille, France)

October 2014-February 2015: Cruise preparation, shipping of equipment to R/V Atalante and Noumea

January-May 2015: M2 student internship on analysis and treatment of remote sensing data, help in implementation of the software for the adaptive strategy, onshore assistance in identification of sites for LD stations, analysis of regional circulation and biogeochemistry during the cruise.

February-March 2015: Cruise in the SW Pacific

December 2015: Post-cruise meeting with all participants (Marseille, France)

February/March 2016: Workshop focused on physics (~10 people)

May-June 2016: Workshop focused on biogeochemistry (~10 people)

October/November 2016: Workshop focused on remote sensing (~10 people)

2016: Request for a special session at the Ocean Sciences Meeting 2016, New Orleans, Louisiana

2016-2017: Publication of scientific results (Special issue, Journal to be determined)

The funding from the CNES are requested for the following activities:

in 2015 : i) the purchase of the 9 Lagrangian drifters necessary for the adaptive strategy (3 buoys release at each of the three LD stations), ii) travels and accommodations for the participation to the post-cruise meeting of several experts (see list below), iii) the studentship for a M2 student with a special background in mathematics, statistics and data processing;

in 2016 : the organization of the Remote Sensing Workshop in Marseille (travels and accommodations for participants, catering) ;

in 2017 : i) conference participations (fees, travels, accommodations) and ii) publication fees for several papers.

The experts are S. Alvain (LOG, Wimeraux), J. Bouffard (ESRIN, Rome, Italy), H. Claustre (LOV, Villefranche), F. d'Ovidio (LOCEAN, Paris), C. Dupouy (MIO, Nouméa, New Caledonia), E. Martinez (EIO, Papeete, French Polynesia), J. Uitz (LOV, Villefranche).

2.5. PUBLICATIONS

Les indicateurs que doit préparer le CNES pour ses tutelles ne prenant en compte que les publications mentionnant le nom de la ou des missions spatiales ou instruments, dans le titre ou le résumé, toute publication devra obligatoirement **mentionner dans le titre ou dans le résumé le nom** de la ou des missions ou instruments spatiaux dont des données ont été utilisées.

- Karl, D.M., M.J. Church, J.E. Dore, R.M. Letelier and C. Mahaffey. (2012). Predictable and efficient carbon sequestration in the North Pacific Ocean supported by symbiotic nitrogen fixation. *Proceedings of the National Academy of Sciences*, 109: 1842-1849.
- Riser, S., and K. Johnson (2008) Net production of oxygen in the subtropical ocean. *Nature*, 451, 323-325.
- E. Tew Kai, V. Rossi, J. Sudre, H. Weimerskirch, C. Lopez, E. Hernandez Garcia, F. Marsac, and V. Garçon. Top marine predators track Lagrangian coherent structures. *Proc. Natl. Acad. Sci. U. S. A.*, 106(20):8245#8250, 2009. doi: 10.1073/pnas.0811034106.
- C. Cotté, F. d'Ovidio, A. Chaigneau, M. Lévy, I. Taupier Letage, B. Mate, and C. Guinet. Scale-dependent interactions of Mediterranean whales with marine dynamics. *Limnol. Oceanogr.*, 106(20):219#232, 2011. doi: 10.4319/lo.2011.56.1.0219
- d'Ovidio, F., V. Fernández, E. Hernández García, and C. López. Mixing structures in the Mediterranean Sea from finite-size Lyapunov exponents. *Geophys. Res. Lett.*, 31:L17203, 2004. doi: 10.1029/2004GL020328. Rossi, V., C. López, J. Sudre, E. Hernández-García, and V. Garçon. Comparative study of mixing and biological activity of the Benguela and Canary upwelling systems. *Geophysical Research Letters*, 35:L11602, 2008. doi: 10.1029/2008GL033610
- d'Ovidio, F., S. De Monte, S. Alvain, Y. Dandonneau, and M. Lévy. Fluid dynamical niches of phytoplankton types. *Proc. Natl. Acad. Sci. U. S. A.*, 107(43):18366-18370, 2010. doi: 10.1073/pnas.1004620107.
- D'Asaro, E., C. Lee, L. Rainville, R. Harcourt, and L. Thomas. Enhanced Turbulence and Energy Dissipation at Ocean Fronts. *Science*, 332(6027):318-322, 2011. doi: 10.1126/science.1201515.
- Nagai, T., A. Tandon, H. Yamazaki, M. J. Doubell, and S. Gallagher. Direct observations of microscale turbulence and thermohaline structure in the Kuroshio Front. *J. Geophys. Res.*, 117(C8):C08013, 2012. doi: 10.1029/2011JC007228.
- Hosegood, P.J., M. C. Gregg, and M. H. Alford. Wind-driven submesoscale subduction at the north Pacific subtropical front. *Journal of Geophysical Research: Oceans*, 118:5333#5352, 2013. doi: 10.1002/jgrc.20385.
- Qiu, B., S. Chen, W.S. Kessler, 2009: Source of the 70-day mesoscale eddy variability in the coral sea and the north Fiji basin*. *J. Phys. Oceanogr.*, 39, 404-420. doi: <http://dx.doi.org/10.1175/2008JPO3988.1>
- Webb, D., Evidence for the shallow zonal jets in the South Equatorial Current region of the southwest Pacific. *J. Phys. Oceanogr.* 30, 706-720, 2000.
- Moisander, P. H., Beinart, R. A., Hewson, I., White, A. E., Johnson, K. S., Carlson, C. A., ... & Zehr, J. P. (2010). Unicellular cyanobacterial distributions broaden the oceanic N₂ fixation domain. *Science*, 327(5972), 1512-1514.
- Dupouy, C., Benielli-Gary, D., Neveux, J., Dandonneau, Y., T. Westberry, 2011. A new algorithm for detecting *Trichodesmium* surface blooms in the South Western Tropical Pacific, *Biogeosciences*, 8, 1-17, doi:10.5194/bg-8-1-2011.
- Alvain, S., Moulin, C., Dandonneau, Y., & Loisel, H. (2008). Seasonal distribution and succession of dominant phytoplankton groups in the global ocean: A satellite view. *Global Biogeochemical Cycles*, 22(3).
- Moutin, T., Karl, D. M., Duhamel, S., Rimmelin, P., Raimbault, P., Van Mooy, B. A. S., and H. Claustre. 2008. Phosphate availability and the ultimate control of new nitrogen input by nitrogen fixation in the tropical Pacific Ocean, *Biogeosciences*, 5, 95-109.
- Nencioli F., F. d'Ovidio, A.M. Doglioli and A.A. Petrenko, 2011. "Surface coastal circulation patterns by in-situ detection of Lagrangian Coherent Structures". *Geophysical Research Letters*, Vol 38, L17604. doi: 10.1029/2011GL048815
- d'Ovidio, F., Zhou, M., Park, Y.H., Nencioli, F., Resplandy, L., Doglioli, A., Petrenko, A., Queguiner, B., Blain, S., Guiding biogeochemical campaigns with high resolution altimetry: waiting for the SWOT mission. "20 years of progress in radar altimetry" Symposium, Venice, Italy.
- Doglioli, A.M., Nencioli, F., Petrenko, A.A., Fuda, J.-L., Rougier, G., Grima, N. (2013). A software package and hardware tools for in situ experiments in a Lagrangian reference frame. *J. Atmos. Ocean. Tech.*, Vol.30, pp.1945-1950, doi: 10.1175/JTECH-D-12-00183.1
- Uitz, J., Claustre, H., Morel, A., & Hooker, S. B. (2006). Vertical distribution of phytoplankton communities in open ocean: An assessment based on surface chlorophyll. *Journal of Geophysical Research: Oceans* (1978–2012), 111(C8)
- Heywood, K.J., D.P. Stevens, G.R. Bigg, Eddy formation behind the tropical island of Aldabra, *Deep Sea Research Part I: Oceanographic Research Papers*, Volume 43, Issue 4, April 1996, Pages 555-578, ISSN 0967-0637.
- Arístegui, J., P. Tett, A. Hernández-Guerra, G. Basterretxea, M.F. Montero, K. Wild, P. Sangrá, S. Hernández-Leon, M. Canton, J.A. García-Braun, M. Pacheco, E.D. Barton, The influence of island-generated eddies on chlorophyll distribution: a study of mesoscale variation around Gran Canaria, *Deep Sea Research Part I: Oceanographic Research Papers*, Volume 44, Issue 1, January 1997, Pages 71-96, ISSN 0967-0637.
- Wilson, C., and V.J. Coles (2005). Global climatological relationships between satellite biological and physical observations and upper ocean properties. *J. Geophys. Res.*, 110 (C10).
- Briggs, N., Perry, M.J., Cetinic, I., Lee, C., D'Asaro, E., Gray, A.M., Rehm, E., 2011. High-resolution observations of aggregate flux during a sub-polar North Atlantic spring bloom. *Deep-Sea Research Part I-Oceanographic Research Papers* 58 (10), 1031-1039.