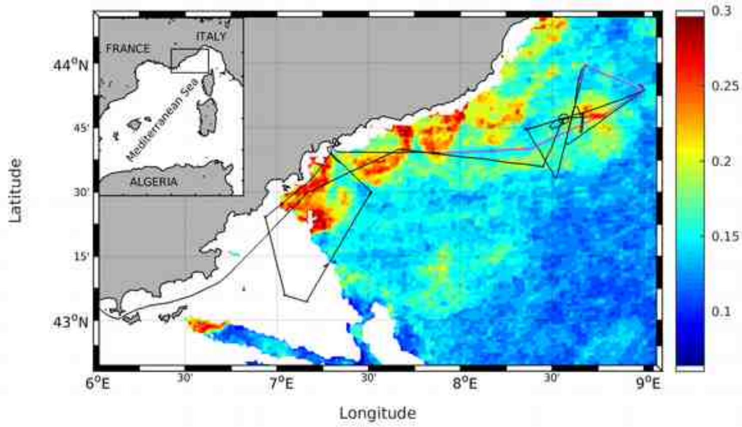
OSCAHR

Observing Submesoscale Coupling At High Resolution



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List of Contents

1. Cruise details……………………………………………………………………………. 5

2. Participants……………………………………………………………………………… 6

3. Scientific background and goals…………………………………………………………... 7

4. Strategy and planning …………………………………………………………………... 8

4.1 Satellite data 8

4.2 Coastal radar 10

4.3 Numerical models (Symphonie, MARS3D-ECO3M, WRF) 11

5. Cruise Narrative…………………………………………………………………………… 13

6. In situ measurements and collected data…………………………………………………... 17

6.1 S-ADCP 17

6.2 TSG and associated measurements 18

6.3 MVP-Moving Vessel Profiler 24

6.4 Vertical water pumping PASTIS_HVR and associated measurements 25

6.5 SCAMP 27

6.6 CTD-rosette and associated measurements (EcoVSF3, deepLISST, deepLOPC) 27

6.7 Drifters 29

6.8 BioArgo 29

6.9 Glider 30

7. Bibliography…………………………………………………………………………….. 32

Appendix A……………………………………………………………………………… 33

1. Cruise details

Dates (Harbor) : 29/10/2015 (La Seyne-sur-Mer) - 06/11/2015 (La Seyne-sur-Mer)

Sea/Ocean : Mediterranean Sea, Western Basin

Limits : North : 44.0 South : 43.0 East : 9.0 West : 5.5

Scientific Authority : INSTITUT MEDITERANNEEN D'OCEANOLOGIE - LUMINY (MIO)
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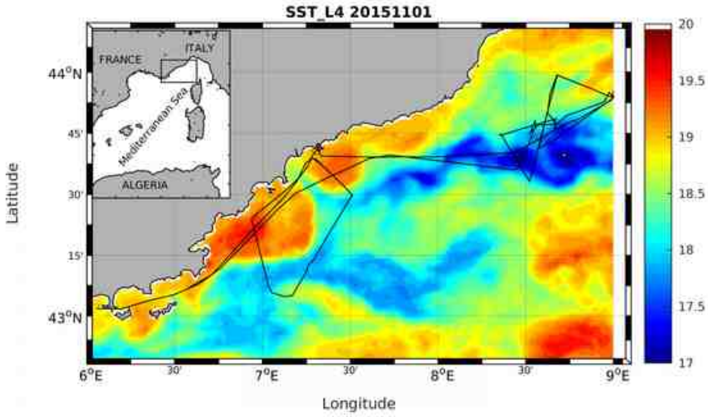
Ship owner : CNRS

Discipline(s) : PHYSICAL OCEANOGRAPHY
MARINE BIOLOGY
OCEAN COMPOSITION

Location map :



OSCAHR cruise route (black line) superposed to the Sea Surface Temperature [degree Celsius] of 1rst November 2015 (data provided by CMEMS- Copernicus Marine Environment Monitoring Service).

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2. Participants

Onboard

Bhairy Nagib	Research Engineer, CNRS	CTD, glider
Doglioli Andrea	Assistant Professor, Université d'Aix-Marseille	Chef de Mission
Fenouil Julien	Research Engineer, Genavir	MVP
Gregori Gérald	Researcher, CNRS	Biogeochemical measurements
Marrec Pierre	Post-doc, Université d'Aix-Marseille	Biogeochemical measurements
Rougier Gilles	Research Engineer, CNRS	MVP, drifters
Ross Oliver	Post-doc, Université d'Aix-Marseille	SCAMP
Thyssen Melilotus	Researcher, CNRS	Biogeochemical measurements
Wagener Thibaut	Assistant Professor, Université d'Aix-Marseille	Biogeochemical measurements

Onshore

André Jean-Michel	Researcher, CNRS	SPASSO, strategy
Cyr Frédéric	Post-doc, Université d'Aix-Marseille	glider
de Verneil Alain	Post-doc, Université d'Aix-Marseille	ADCP, strategy
d'Ovidio Francesco	Researcher, CNRS	SPASSO
Duforet Lucille	Assistant Professor, ULCO	VSF
Duhaut Thomas	Research Engineer, CNRS	SYMPHONIE model
Goutx Madeleine	Researcher, CNRS	glider
Meriaux Xavier	Research Engineer, CNRS	VSF
Nencioli Francesco	Researcher, PML	SPASSO
Petrenko Anne	Associate Professor, Université d'Aix-Marseille	ADCP, strategy
Pinazo Christel	Associate Professor, Université d'Aix-Marseille	MARS3D-ECO3M model
Quentin Céline	Research Engineer, CNRS	radar
Rousselet Louise	PhD Student, Université d'Aix-Marseille	SPASSO, strategy
Yohia Christophe	Research Engineer, CNRS	WRF, MARS3D-ECO3M models
Zakardjan Bruno	Professor, Université de Toulon	radar

3. Scientific background and goals

The word 'submesoscale' is used for those ocean processes and dynamics characterized by horizontal scales less than the first baroclinic deformation radius, i.e. of order of 1-10 km. High-resolution satellite images (surface temperature, ocean color) show that submesoscale activity in the upper ocean is quite energetic and almost ubiquitous. Recent research, mainly based on numerical modeling (e.g. Capet et al. 08), suggests that the origins of the submesoscale is strongly linked with the stirring induced by mesoscale and frontogenesis. The associated steep density gradients create strong three-dimensional ageostrophic circulations characterized by i) intense vertical velocities (e.g. Klein and Lapeyre, 2009) ; ii) instabilities attempting to restore the stratification in the upper mixed layer (e.g. FoxKemper et al., 2008) ; iii) local micro-structure turbulence (forward energy cascade, e.g. Molemaker et al., 2010).
Consequently, submesoscale dynamics is considered a key factor in regulating biogeochemical and ecological processes. For example : i) vertical velocity generates strong nutrient injections (Lévy et al., 2012) ; ii) stabilization after the winter period of maximal mixing and grazing relaxation can allow phytoplankton to bloom (Chiswell 2011, Taylor and Ferrari 2011 vs Behrenfeld 2010).
These processes can have significant large-scale impact on primary production and, thus, contribute to the global biogeochemical cycles. Moreover, the ecological response can rapidly propagate to the higher trophic levels (Cotté et al., 2011). Their impact on community competition and ecosystem distribution is considered a key aspect for the ecological conservation and management of marine resources (Cury et al., 2008).

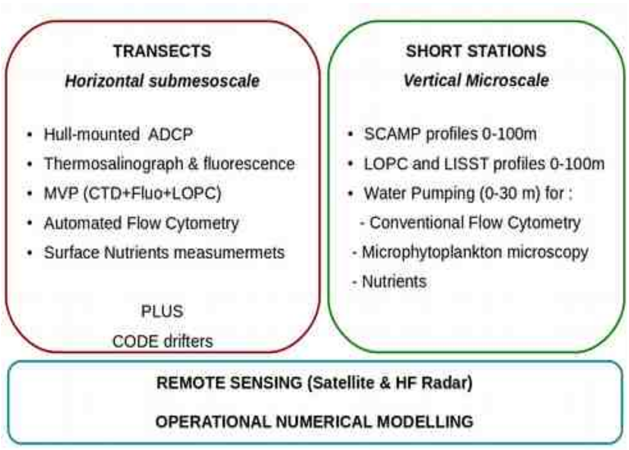
In the last decade, submesoscale dynamics has been predominately investigated through the analysis of numerical models and modelers generally highlight the need of in situ measurements at submesoscale. However, this represents a big challenge due to the ephemeral nature of these structures. Moreover, in order to study physical-biological coupling at the submesoscale it is crucial to perform biological measurements with automated methodologies capable of high frequency sampling (up to several times per hour).

The scientific objectives of the OSCAHR (Observing Submesoscale Coupling At High Resolution) project are to characterize a submesoscale dynamical structure and to study its influence on the distribution of biogenic elements and on the structure and dynamics of the first trophic levels associated with it.
Our methodology includes the use of novel platforms of observation for sampling the ocean surface layer at a high spatial and temporal frequency. In particular, a MVP (Moving Vessel Profiler) is deployed with CTD, Fluorescence and LOPC (Laser Optical Particle Counter) sensors. Furthermore, a new version of the automated flow cytometer is installed for real-time, high-throughput sampling of phytoplankton functional groups, from micro-phytoplankton down to cyanobacteria (including Prochlorococcus). Two sources of seawater have been used in OSCAHR: along with the onboard surface water intake, a new pumping system is developed and tested in order to sample the upper water column at one meter resolution. Hereinafter, we indicate with “TSG+” the array of automated instruments and sensors connected to the surface water intake downstream of the TSG (ThermoSalinoGraph) and combined with discrete manual sampling (see details in section 6.2); whereas, the acronym PASTIS_HVR (Pumping Advanced System To Investigate Seawater with High Vertical Resolution) is used for the new pumping system presented in section 6.4.

The cruise strategy utilizes an adaptive approach based on the near-real time analysis of both satellite and numerical modeling data to identify the dynamical features of interest and track their evolution. In return, the OSCAHR dataset allows the validation of remote sensing measurements (altimetry, ocean color, reconstitution of planktonic assemblages) and numerical modeling output.

4. Strategy and planning

The OSCAHR sampling design has been based on a combination of transects for horizontal sampling of the sea surface and short-duration (about 1 hour) stations to perform vertical sampling in the surface layer.
The ocean area of the study has been targeted on the basis of information from remote sensing (satellite and HF coastal radar measurements) and numerical modeling.



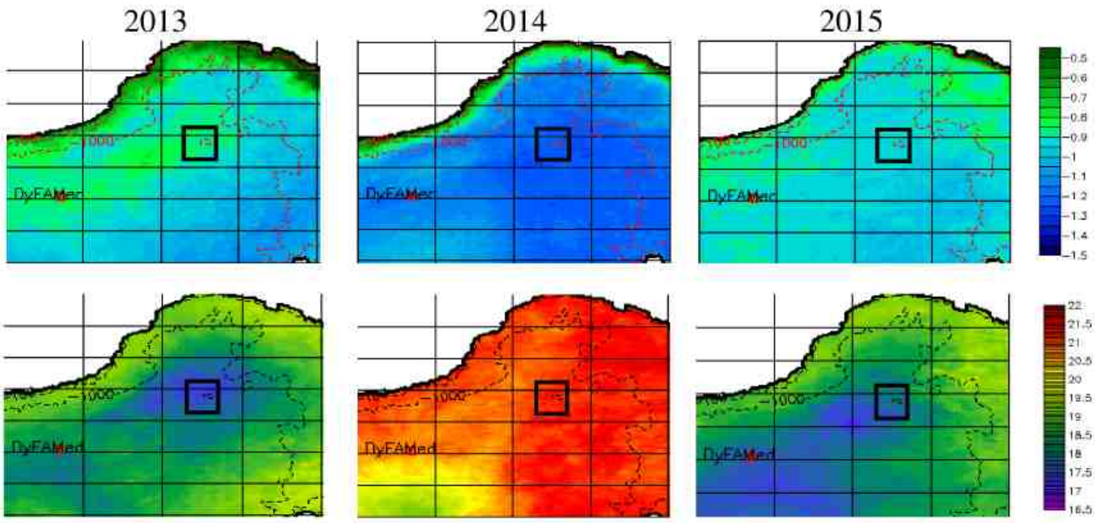
The variability of the horizontal mesoscale and submesoscale circulation strongly affects biogeochemical budgets and represents a real challenge during in situ measurements. Indeed, samplings which are only few tens of kms or few weeks apart may be representative of very different situations. For this reason, d'Ovidio et al. (2009), Nencioli et al. (2011) developed several diagnostics based on the analysis of combined near-real time altimetry data and ocean color maps, to identify physical structures of biogeochemical interest (fronts, eddies, filaments). Adaptive strategies based on these diagnostics has been successfully applied during several ocean campaigns such as LATEX (2010), KEOPS2 (2011), STRASSE (2012) and very recently OUTPACE (2015).
The software, collected in the package SPASSO (**S**oftware **P**ackage for an **A**daptive **S**atellite-based **S**ampling for **O**cean campaigns http://www.mio.univ-amu.fr/~doglioli/spasso.htm), has been implemented, developed and run operationally for the OSCAHR cruise at the OSU Institut Pyhteas (Marseille and Toulon).
The web directory http://mio.pytheas.univ-amu.fr/OSCAHR/OSCAHR_Figures/ contains the plots created each 3 hours by SPASSO treating and analyzing the near-real time data from satellite altimetry, sea surface temperature and ocean color, coastal radar and numerical modeling.
The data has been treated on land and then transmitted on board together with a daily bulletin containing the analysis of information and the suggestions for the station positioning. An example of daily bulletin is attached to the present document (see Appendix A), while the complete series of bulletins is available on the OSCAHR website.

4.1 Satellite data

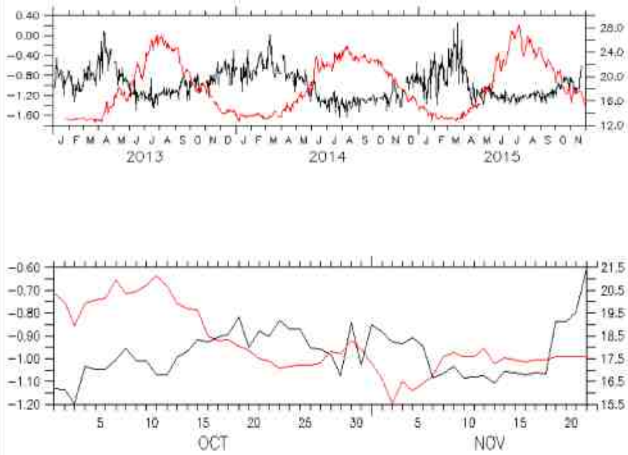
The altimetry data are the AVISO Mediterranean regional product (http://www.aviso.altimetry.fr/index.php?id=1275). The derived currents are processed by SPASSO to derive Eulerian and Lagrangian diagnostics of ocean circulation: Okubo-Weiss parameter, particle retention time and advection, Lagrangian Coherent Structures.
Sea surface temperature (level 3 and 4, 1 km resolution) and chlorophyll concentration (level 3, 1 km resolution, MODIS-Aqua and NPP-VIIRS sensors) have been provided by CMEMS-Copernicus Marine Environment Monitoring Service (http://marine.copernicus.eu).
Moreover, Météofrance provided AVHRR (Advanced Very High Resolution Radiometer) channel 4 imagery (also called "brightness temperature") for a better detection of the thermal fronts (OSIS archive http://www.ifremer.fr/osis_2014/index.php).

MyOcean-L3/daily-NRT-1x1km data for the study area from 2013 to 2015 were analyzed.

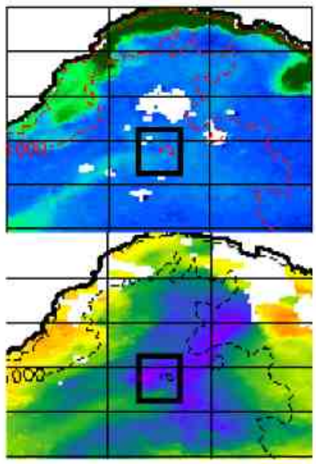
SST and CHL average maps for October-November show that the autumnal winds create sufficient vertical mixing to support phytoplankton blooms. In 2013 and 2015 a local SST minimum associated with a chlorophyll maximum is observed. In contrast, in 2014 the entire gulf of Genoa was characterized by high temperatures and low chlorophyll concentrations at this time of the year. The temporal series in the cruise area (the black square) show a strong seasonality and significant inter-annual variations in both the amplitude and the timing of the seasonal cycle. High-frequency (~day-1) variations are of the same order of magnitude as the annual cycle. At low frequency SST an CHL are most of the time strongly anti-correlated. Singularly, the two parameters evolve in parallel during three weeks encompassing the cruise. Filament submesoscale features were also present in the cruise area in autumn 2013.



October-November averages of surface chlorophyll (top) and temperature (bottom). The black squares show the area studied during the second leg (Data provided by CMEMS- Copernicus Marine Environment Monitoring Service).



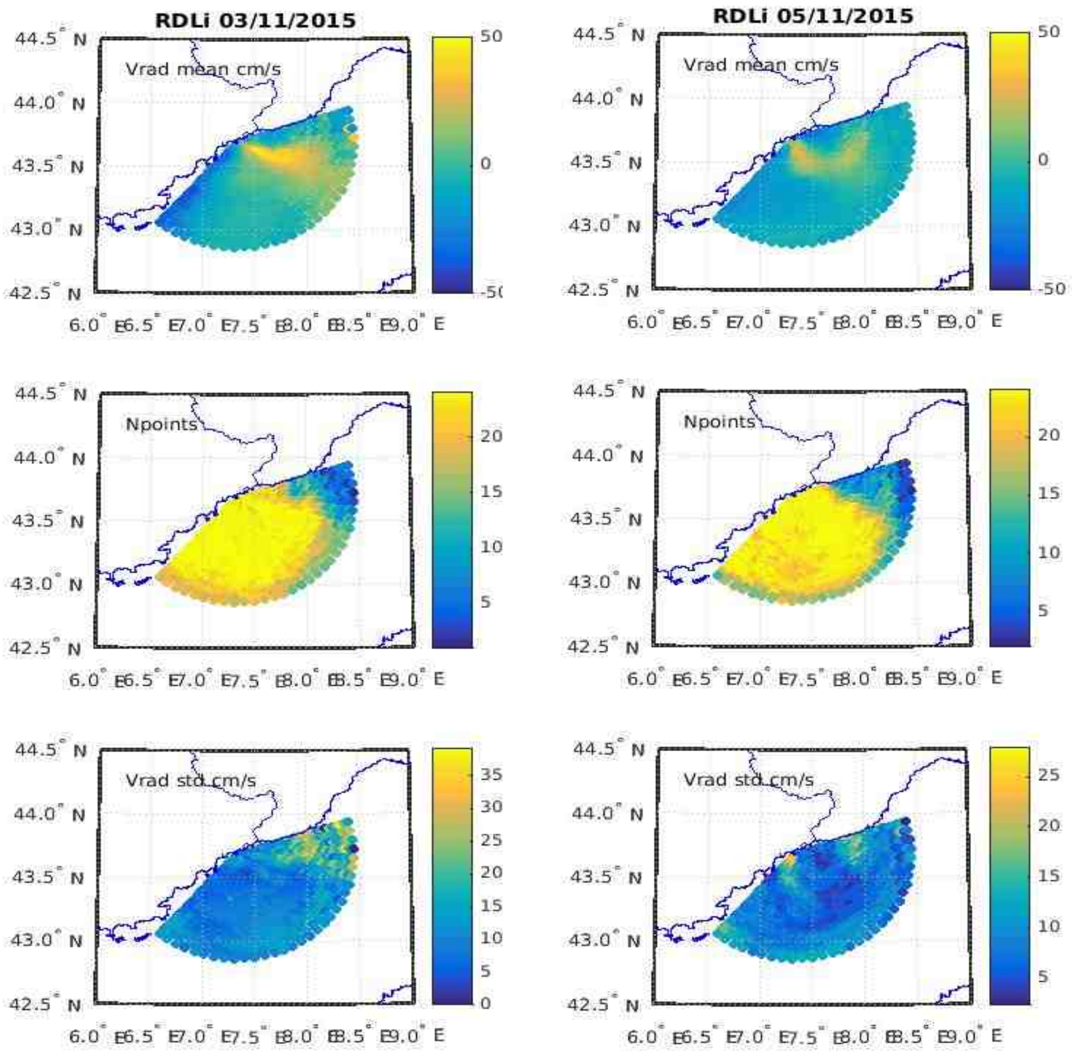
Times series of the surface chlorophyll (black) and temperature (red) averaged on the area indicated by the black square showed in the figure above. The bottom plot is focused in on the cruise period.
(Data provided by CMEMS).



Surface chlorophyll (top) and temperature (bottom) of the 6 November 2016.
(Data provided by CMEMS).

4.2 Coastal radar

The OSCAHR area is covered by one HF radar system that operates from the Cap Ferrat as part of the French Mediterranean observatory system (MOOSE : http://www.moose-network.fr/ and http://hfradar.univ-tln.fr). The instrument is a CODAR Seasonde CODAR operated at 13.5 MHz, allowing a 80-100 km spatial coverage with hourly estimation of surface radial velocities. The Figure below illustrate examples of raw data where high radial velocities (~ 40-50 cm/s) plausibly show the surface velocity of the Northern current. The twin system installed to the west at Cap Benat that would have allowed the estimation of total velocities was not in function during the cruise. Nevertheless, HF radar data from 28/10/2015 to 30/11/2015 will be treated in conjunction with other current measurement (ADCP, buoys-derived Lagrangian current) during the OSCARH cruise to assess the system and to help model validation.



Daily mean radial velocities, time coverage (nb of measurement over 24 hours) and daily stnadard deviation from the Cap Ferrat CODAR Seasond on 3 and 5 November 2015.

4.3 Numerical models

The atmospheric numerical model WRF provided meteorological forecast as well as forcing fileds for the physical-biogeochemical coupled model MARS3D-ECO3M used for the forecast of surface physical and biogeochemical tracers. The ocean circulation model Symphonie also provided ocean forecast. A short description of the implementation of these models is reported below.

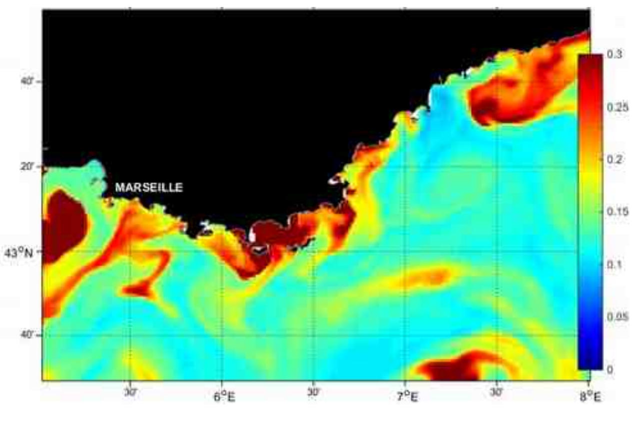
WRF

The WRF (Weather Research & Forecasting, Skamarock et al. 2008) system contains two dynamical solvers, referred to as the ARW (Advanced Research WRF) core and the NMM (Nonhydrostatic Mesoscale Model) core. WRF has been implemented at the OSU Institut Pytheas (Marseille) as an operational model. The NMM core configuration uses 2 nested Arakawa-E grids for a horizontal resolution varying from 10~km to 2~km and 38 vertical $\sigma - P$ levels. The ARW core configuration uses a Arakawa-C grid with a 2-km resolution and 28 vertical σ levels.
The open boundary conditions are obtained from the output of the GFS (Global Forecast System) by NCAR/NCEP (National Center Atmospheric Research/National Centers Environmental Prediction).
Both cores have had three runs per day starting at 5:00, 17:00 and 22:00 ; the output of the 05:00 WRF-ARW run provided the meteorological forcing for the oceanographic model MARS3D-ECO3M.

MARS3D-ECO3M

This system coupled the free-surface, three-dimensional circulation MARS3D model (3D hydrodynamic Model for Applications at Regional Scale, IFREMER) with the biogeochemical mechanistic model ECO3M-Massilia (Lazure et Dumas, 2008; Nicolle et al., 2009; Pinazo et al, 2012).

The high resolution MARS3D-glxl configuration, part of MENOR-MEditerranné NORd occidentale configuration, was used to the forecast of the oceanic circulation of the Gulfs of Lions and Genoa, with a horizontal resolution of 1.200 km with 322x195 grid cells and 30 sigma vertical levels. The time step was fixed at 50 s. The initial and boundary forecast conditions provided by PREVIMER (http://www.previmer.org) are imposed using a downscaling method of grid nesting (Andre et al., 2005).



Chlorophyll-a concentration (microg.l^{-1}) October 30th 2015 12:00:10 at sigma vertical level =30

The North Western Mediterranean Sea circulation model MENOR forecast was forced by the MFS (Mediterranean Forecasting System) 1/16° regional model (Pinardi et al., 2003) daily outputs of temperature, salinity, current and sea surface elevation spatially and temporally interpolated into the MENOR grid. The MENOR modeling was validated for the years 2005–2006 in the Gulf of Lions by comparing the main characteristics of the simulated shelf-slope circulation with in situ (Andre et al., 2009) and satellite observations (Andre et al., 2005), and for the years 2001–2008 with satellite observations and drifter trajectories in the GoL by Nicolle et al. (2009).

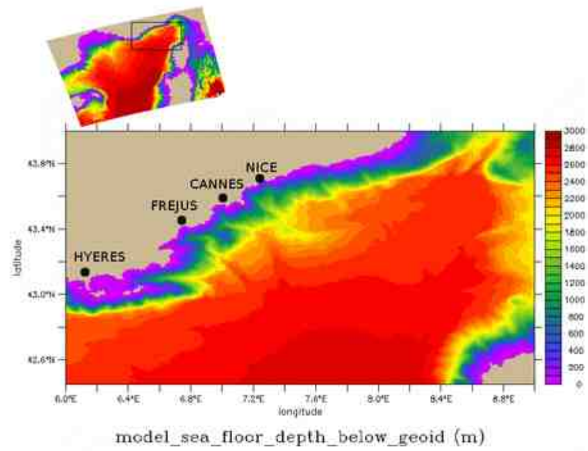
The ECO3M biogeochemical platform (Baklouti et al., 2006a&b) in the Massilia configuration (Fraysse et al, 2013; 2014; Ross et al., 2016) has 17 state variables and implements mechanistic formulations to describe the carbon, nitrogen and phosphorus cycles in five compartments : (i) phytoplankton, (ii) bacteria, (iii) detrital particulate organic matter, (iv) labile dissolved organic matter and (v) dissolved inorganic matter including ammonium, nitrate, and oxygen. Chlorophyll-a is a diagnostic variable related to the variable phytoplankton ratios. A more detailed description of the model can be found in Fraysse et al. (2013).

Every day, the coupled-system was used to produce a 24-hour forecast for currents, SSH, Temperature, salinity and biogechemistry (chlorophyll, nitrate, phosphate) with output every 3 hours at sea surface, 10m and 50m depth.

SYMPHONIE

The SYMPHONIE model (Marsaleix et al., 2008, 2009, 2012) has been used to forecast the velocity, temperature and salinity fields during the OSCHAR campaign. A 1/111° horizontal grid (about 1km, 764x556 nodes) has been implemented on the north western Mediterranean sea in order to cover the OSCHAR site at a regional scale.

The vertical grid consists of 50 generalized sigma levels with increased resolution near the surface. The initial state and the lateral open boundary conditions are provided by the daily PSY2V4R4 MERCATOR-OCEAN fields. The MERCATOR fields are delivered once a week (every Wednesday). They cover a period of 4 weeks consisting of a 2 weeks hindcast simulation (preceding the delivering day) followed by a 2 weeks forecast simulation. The regional simulation is thus synchronously restarted once a week, 14 days before the delivering day, using the 14 days PSY2V4R4 hindcast fields.

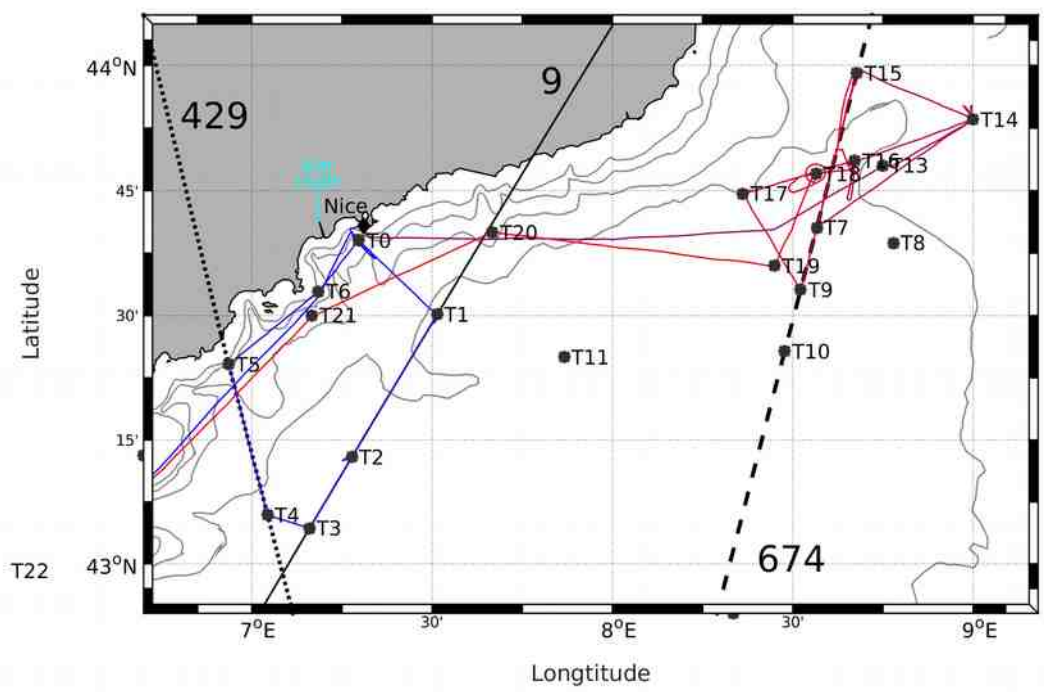


Bathymetry of the model. Top: the entire domain. Bottom: the domain of interest for the cruise.

The regional simulation takes advantage of the data assimilation process performed in the PSY2V4R4 hindcast fields using a spectral nudging procedure preserving the small scale structures permitted by the 1km resolution grid. As far as meteorological fields are concerned, a 5 days meteorological forecast is delivered every day by ECMWF at a horizontal resolution of 1/8° and with a time sampling of 3h. A 5 days regional ocean forecast is thus performed every days. River inputs of the Rhône, Hérault, Orb and Aude rivers are provided by "Banque Hydro" (http://www.hydro.eaufrance.fr/). The regional simulation was started on 1st January 2015, providing a 10 month spin-up before the beginning the OSCHAR campaign. During the operational stage, daily maps of SST, SSS, surface, 10m and 30m current, focused on the area of interest (5°E-8°E, 42°N-44°N, see Figure 2) have been deposited on the OSCAHR website.

5. Cruise narrative

The beginning of the field experiment initially planned on 1 November 2015 was anticipated of 2 days for meteorological reasons.



Cruise route with waypoints (black dots). The line color code represents the time (from blue to red). Note that the waypoints T8, T10, T11, T12 (42°30'N, 8°9'E; out of figure) were planned, but not visited. The black diamond near Nice shows the position of the SOMLIT station. The black lines represent the following satellite tracks: Jason2 #9 (continuous line), Saral/AltiKa #429 (dotted line) and Saral/AltiKa #674 (dashed line). In order to zoom on the cruise area, the La Seyne port (43°06'N, 5°53'E) is not shown in the map.

Waypoint T…	Lat [degrées minutes]		Lon [degrées minutes]		Lat [degrées]	Lon [degrées]
0	43	39.0450	7	17.7910	43.65080	7.296500
1	43	30.1324	7	30.8620	43.50221	7.514366
2	43	12.9284	7	16.6576	43.21547	7.277627
3	43	4.3124	7	9.6111	43.07187	7.160185
4	43	5.9080	7	2.6294	43.09847	7.043824
5	43	24.1221	6	56.1610	43.40204	6.936016
6	43	32.9060	7	11.0650	43.54840	7.184400
7	43	40.5331	8	33.9714	43.67555	8.566190
8	43	38.7453	8	46.7143	43.64576	8.778571
9	43	33.1221	8	31.3087	43.55204	8.521812
10	43	25.7103	8	28.6547	43.42851	8.477579
11	43	25.0000	7	52.0000	43.41670	7.866667
12	42	30.0961	8	9.0196	42.50160	8.150327
13	43	48.0000	8	45.0000	43.80000	8.750000
14	43	53.5260	9	0.0000	43.89210	9.000000
15	43	59.0569	8	40.6665	43.98428	8.677775
16	43	48.5660	8	40.2950	43.80940	8.671600
17	43	44.6475	8	21.7095	43.74412	8.361826
18	43	47.0060	8	33.8890	43.78340	8.564800
19	43	36.0000	8	27.0000	43.60000	8.450000
20	43	40.0000	7	40.0000	43.66670	7.666700
21	43	30.0000	7	10.0000	43.50000	7.166670

Table containing geographical coordinates of all waypoints.

Thursday 29 October 2015

The material was loaded on board in the early afternoon. The R/V Téthys II sailed from La Seyne port at 19:00 (all times hereafter will be referenced to UTC - Universal Time Coordinated) toward the Nice port. During the first night of cruise some tests on the connections of the automated instruments to the onboard surface water intake were performed.

Friday 30 October

The MVP technician J.Fenouil embarked at Nice harbor at 7:00. Afterwards, the Téthys II sailed toward the first waypoint T0 offshore Nice. Tests on the MVP setup and the first transect T0-T1 with sampling by the MVP and the array of automated instruments connected to the onboard surface water intake (hereinafter TSG+) were performed. The first station S1 was performed at T1 between 12:05 and 14:30. The first deployment of the vertical pumping system was performed successfully. Then, the second transect T1-T2 along the Jason2 track #9 was performed with MVP and TSG+ sampling. The second station S2 at T2 was performed between 19:30 and 21h01. Due to the sea conditions, the SCAMP was not deployed at S2. After the S2 station, the Téthys II returned to the Jason track #9 until the waypoint T3, reached at 23:30. Due to military restrictions, the Jason track was not followed until the crossing point with the SARAL/AltiKa track #429.

Saturday 31 October

The SARAL/AltiKa track #429 was reached at 1:30 (waypoint T4). Then, Téthys II returned toward the coast along the satellite track toward the waypoint T5, performing MVP and TSG+ sampling. The waypoint T5 was reached at 6:20. An along coast route was followed toward the waypoint T6. Along the transect, MVP and TSG+ sampling was continued and offshore the Var river mouth a big patch of suspended matter and floating debris was observed. At 9:45 the waypoint T6 was reached and the MVP and TSG+ sampling was continued along a transect toward T0, where a station was planned. T0 was reached at 11:00 at but the sea state precluded performing the planned station. The Téthys II took shelter in the entry of Villefranche harbor and finally docked in the Nice port at 13:30, where it remained anchored until the next day.

Sunday 1 November

The sea conditions did not permit to work offshore. Therefore, at 7:50 the Téthys II sailed from Nice port toward the Villefranche harbor in order to collect a set of measurements for future instrument inter-calibration at the position of the local observation station SOMLIT (43°41'N, 7°19'E).

The station S3 was performed between 8:20 and 10:45 with vertical profiles of (in chronological order) SCAMP, vertical water pumping, SCAMP (second attempt), CTD-rosette, MVP (3 profiles in automatic station mode and 3 profiles in manual-control mode), plankton net. Unfortunately, during this station the SCAMP showed serious malfunctioning problems.

Téthys II remained anchored in the inner part of the Villefranche harbor for lunch.

The station S4 was performed between 13:20 and 16:40 with vertical profiles of (in chronological order) SCAMP, vertical water pumping, CTD-rosette, SCAMP (second atempt), MVP (3 profiles in in manual-control mode and 4 profiles automatic station mode and 1 test of the security mode).

The Téthys II returned to the Nice port, where it docked at 16:50.

Monday 2 November

The sea conditions still did not permit to work offshore. The Téthys II remained docked in the Nice port and the entire day was spent trying to repair the SCAMP and set up the pCO2 sensor which was just delivered before the beginning of the cruise.

In the evening, it was decided to stop the SCAMP measurements for the remainder of the cruise.

Oliver Ross was replaced on board by Gérald Grégori. The pCO2 sensor was eventually set up with a new power supply.

Tuesday 3 November

Since the weather forecast announced better sea conditions in the evening and the following days, the Téthys II sailed from Nice port at 6:55 toward waypoint T7. As the sea conditions did not allowed us to use the MVP, only TSG+ sampling was performed. The PCO2 sensor provided abnormal measurements, evidencing a malfunction. It did not work for the rest of the cruise (afterwards the maintenance by the provider has identified a default electronic board which was replaced). At 13:13 the route direction was changed toward T13 on the basis of the most recent satellite information. A first CODE buoy (sn:568520; anchor depth: 1 m; name:“Farfalle”) was activated at 10:53, then released at 14:57 at 43°47.446'N, 8°43.742'E. Then, the station S5 was performed at T13 between 15:17 and 15:52 with only vertical water pumping. Indeed, the sea conditions did not permitt to perform a CTD-rosette cast. A SVP-like drifter (anchor depth: 15 m, name: “Spaghetti”) was released at the end of the station S5 at 15:55 at 43°47.587'N, 8°44.286'E to ideally mark the center of the water mass. A second CODE buoy (sn:568510; anchor depth: 1 m; name:“Coquilette”) was released 1 mile away of the SVP drifter at 16:06 (the vessel position at the release was not recorded, the position emailed at 16:07 was 43°46.714'N,8°47.038'E). After MVP tuning, the Téthys II started the transect T13-T14 at 16:20 with MVP and TSG+ sampling. The waypoint T14 was reached at 18:13. Here the station S6 was performed between 19:48 and 20:24 with, again, only vertical water pumping.
The transect T14-T15 was performed between 20:32 and 23:00. The transect T15-T7 with MVP and TSG+ sampling along the SARAL/AltiKa satellite track #647 was performed during the night until 2:52.

Wednesday 4 November

During the night the wind weakened and the sea conditions significantly improved.
The transect T7-T14 with MVP and TSG+ sampling was performed during the night between 2:52 and 6:30.
At 6:43 the station S7 was performed at T14 with vertical profiles of (in chronological order) vertical water pumping, CTD-rosette, plankton net.
Since satellite images were not available because the strong cloud coverage of the previous day, the waypoint T16, ideally representing the actual center of the patch, was positioned at the position of the SVP buoy at 7:14.
The transect T14-T16 with MVP and TSG+ sampling was performed between 8:52 and 11:20. At the end of the transect, the check on the MVP fish showed a little rip on the cable near the fish attachment.
The station S8 was performed at T16 between 13:00 and 15:30 with vertical profiles of (in chronological order) vertical water pumping, CTD-rosette with Niskin bottles sampling, plankton net, a second CTD-rosette (since the VSF did not worked during the first profile due to a battery problem).
During the station S8 many debris were observed at the sea surface. Moreover, the MVP fish ligature was re-built in order to cut off the damaged part of the cable.
Between 15:30 and 16:45 the transect T16-T17 was performed with only TSG+ samplig. During the transect some traction tests of the new MVP fish ligature was successfully performed. At T17 the MVP fish ligature was successfully tested at sea between 16:45 and 17:10.
The station S9 at T17 was then performed between 17:42 and 19:02 with vertical profiles of (in chronological order) vertical water pumping and CTD-rosette (0-300 m).
The transect T17-T9 was conducted between 20:07 and 23:22 with MVP and TSG+ sampling.

Thursday 5 November

During the next transect T9-T15, started at 23:22 along the SARAL/AltiKa #647 track, the MVP sampling was stopped for 1 minute at 3:07 since the SVP buoy drifted across the vessel route. For this reason, the Téthys II deviated from its route along the satellite track between 3:07 and 3:30. Then, the MVP sampling continued until 6:20. The TSG+ sampling was performed all along the transect.

The station S10 was performed at T15 between 6:26 and 7:40 with vertical profiles of (in chronological order) vertical water pumping and CTD-rosette (0-300 m).

The waypoint T18, ideally representing the actual center of the patch, was positioned at the location of the SVP buoy at 7:29. Along the transect T15-T18 only the TSG+ sampling was performed and the two CODE drifters "Coquillette"(sn:568510) and "Farfalle"(sn:568520) were recovered on board at 9:44 and 10:17.

The station S11 was performed at T18 between 13:21 and 16:30 with vertical profiles of (in chronological order) vertical water pumping, plantkon net, CTD-rosette (0-300 m), CTD-rosette without the VSF (0-2200 m). Before the first CTD-rosette profile the SVP drifter "Spaghetti" was recovered at 13:49.

At the end of the station, the BioArgo (sn: WMO-6902700; name: "Côtes de Provence") has been deployed at 16:45.

Along the transect T18-T19 between 17:26 and 19:34 only TSG+ sampling was performed.

The station S12 was performed at T19 between 19:34 and 20:01 with a CTD-rosette vertical profile (0-300 m).

The Téthys II started the transect T19-T20 at 20:30 with TSG+ sampling.

Friday 6 November

The waypoint T20 was reached at 1:46 and here the CODE drifter "Coquillette"(sn:568510) was released again at sea in order to sample the DYFAMED radar field.

The Téthys II continued the TSG+ sampling and reached the waypoint T21 at 4:45. Here the the CODE drifter "Farfalle"(sn:568520) was released within the DYFAMED radar field.

From T21 the Téthys II followed an along-shore route toward the La Seyne port, performing the TSG+ sampling until 12:55:35 (5,92892 E, 43,08816N).

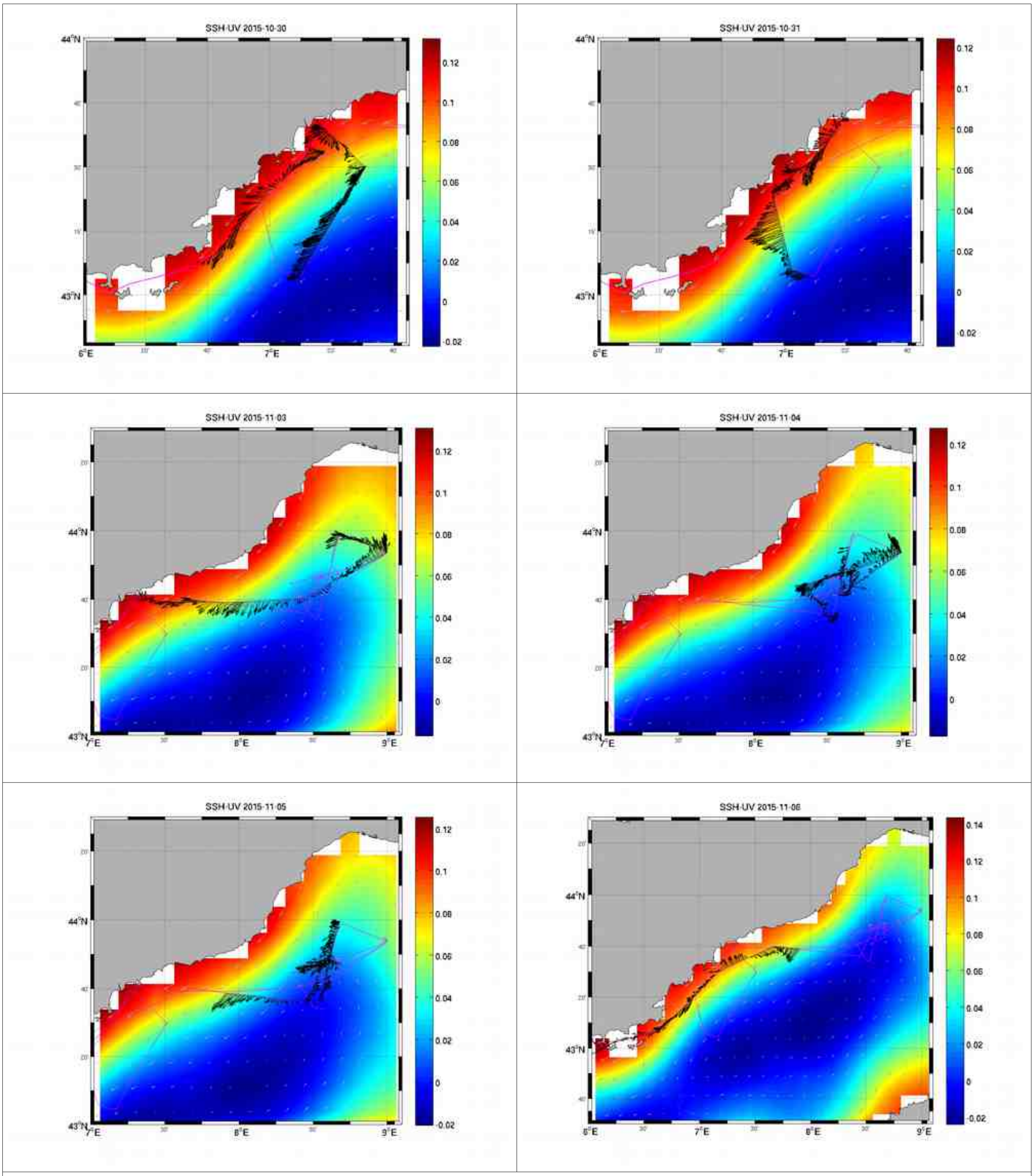
At 14:00 the scientific crew participated to a debriefing meeting.

The Téthys II docked at 14:30.

6. In situ measurements and collected data

6.1 S-ADCP

The ADCP is an RDI Ocean Sentinel 75 kHz. The configuration used during the whole cruise is : 60 cells, 8 m depth bins, an ensemble average of 1', and bottom tracking when possible (although most of the cruise took place out of reach of the bottom). The depth range extends from 18.5 m to 562.5 m.



Current vectors (black) measured by the hull-mounted S-ADCP vectors (second bin data, corresponding 26.5-m depth) to superposed to the corresponding daily map of AVISO SSH and associated geostrophic currents (grey vectors).

ADCP data analysis was done using Matlab software developed by LPO in coordination with IFREMER to process vessel-mounted ADCP data (Cascade V.7, http://wwz.ifremer.fr/lpo_eng/content/view/full/25928, Le Bot et al., 2011). No time or distance averaging has been done on the ADCP data beyond the 1' ensembles.

The angle of misalignment *phi* and vector amplitude *A*, were calculated with Cascade using a concatenation of all the ADCP files (individual ADPC files were too short). With these values, *phi* = -0.91 and *A* = 1.004. The pitch was then estimated all along the cruise in order to minimize the estimated vertical velocity ($w < 0.01$ m s^{-1}, see table below).

File Number	Pitch	Average w (cms^{-1})
352	1.5	0.769
353	2.5	0.420
359	1.5	0.882
360	2.5	-0.177

6.2 TSG and associated measurements

The sampling referred above as "TSG+" consists in an array of automated instrument able to sample at high frequency the sea surface water that was connected to the onboard surface-water intake system. Moreover, discrete sampling was performed to collect samples for quantifying parameters which are not measurable by automatics sensors, as well as for calibration and validation.

The Téthys II surface-water intake system samples seawater at 2 m depth with a flow rate of 60 L min^{-1} in the TSG, down to 2 L min^{-1} at the end of the seawater circuit with the various sensors. We installed in series a Pocket FerryBox, a pCO2 sensor, an automated flow cytometer and an O2 optode in the wet lab.

Picture of the Téthys II wet lab during the cruise with the sensors for the TSG+ sampling: Automated flow cytometer (left); pCO2 (center); Pocket Ferry Box (right).

In the Table below are summarized the characteristics of the instruments used during the campaign.

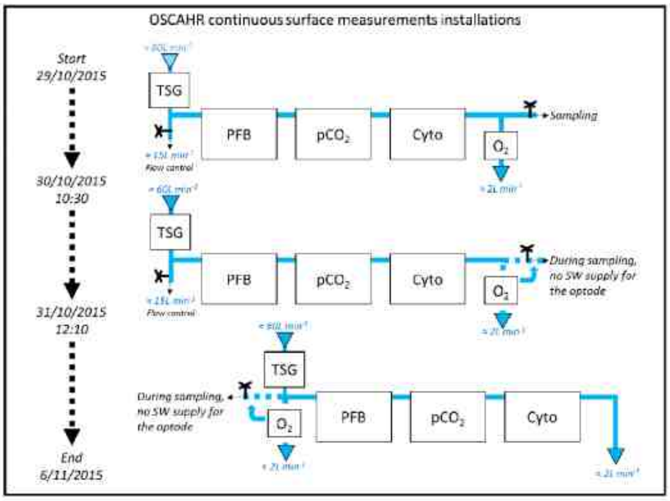
Instrument	Parameters	Model	Frequency
TSG	Temperature	*SBE21*	15s
	Conductivity	*SBE21*	
	Fluorescence	*Turner Designs 10-AU-005-CE*	
PFB	Temperature	*Aanderaa 4040 + Optode*	1min
	Conductivity	*Aanderaa 4040*	
	Fluorescence spectrale	*Algal Online Analyser*	
	Dissolved O_2	*Aanderaa Optode 3830*	
Cyto	Flow cytometer	*Cytosense - CytoBuoy*	20min
O_2	Dissolved O_2	*Aanderaa Optode 4330*	30s
pCO_2	Partial pressure of CO_2	*SubCtech MK2*	HS

The Table below resumes the details of the discrete samples.

Parameter	Volume collected	Frequency	Number of samples collected
Nutrients	15 mL	20 min	218
Ammonium	40 mL	40 min	109
Dissolved Barium	15 mL	20 min	216
Chlorophylle-A	250 mL	Aprox . 4 hours	30
Oxygen « Winkler »	100 mL	Aprox . 0.5 day	14
A_T / C_T	500 mL	Aprox . 0.5 day	10
Diversity	250 mL	Aprox . 1 day	3

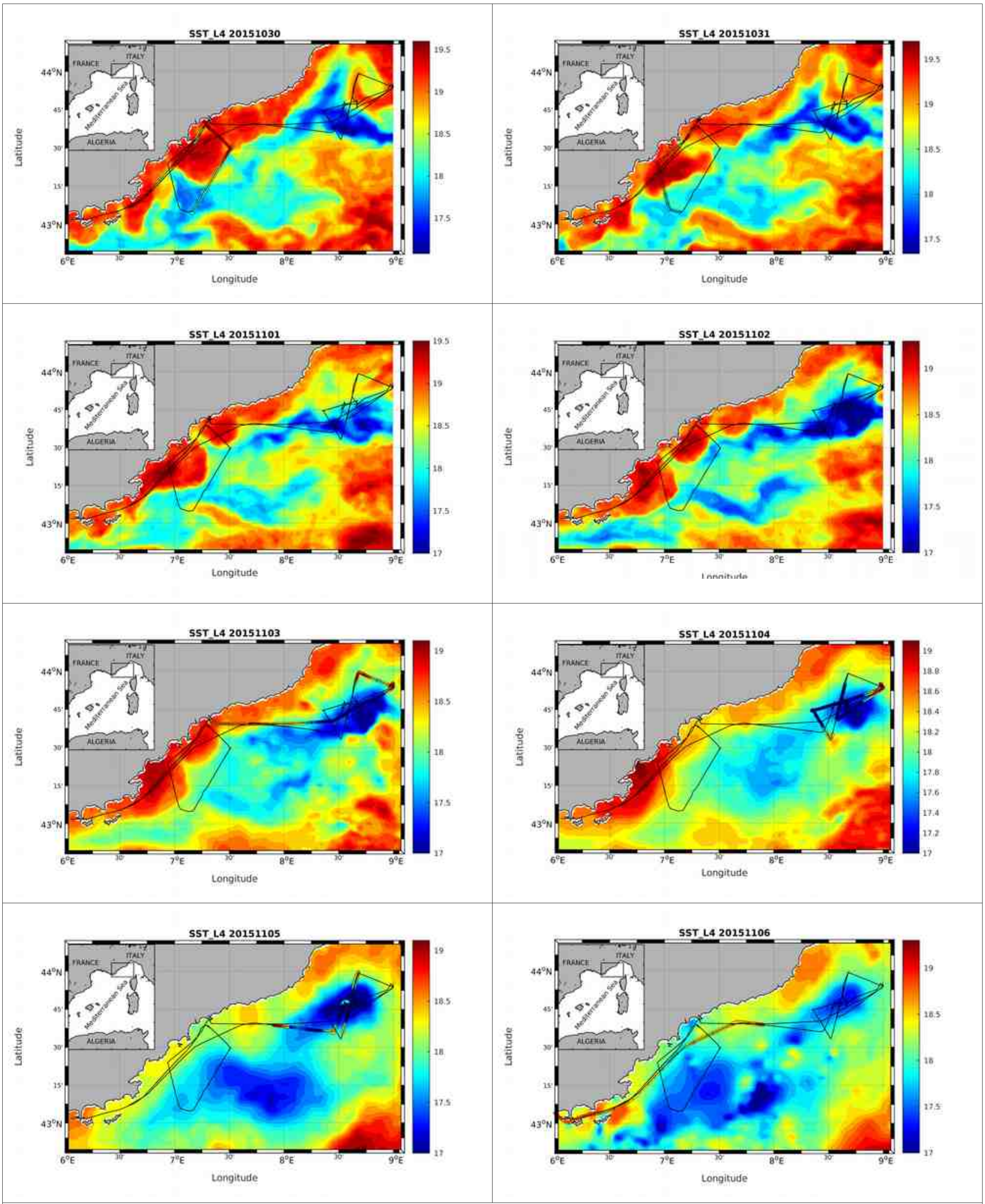
The discrete samples were collected using 2 different surface seawater circuit configurations. During the first days of the cruise (from the 29th to the 31st of October), samples were collected at the end of the seawater circuit, after seawater has flushed all the instruments connected to the TSG circuit.

From the 1st of November, the outlet for the discrete samples was moved at the beginning of the circuit, in order to avoid water flushing of all the instruments before sampling.

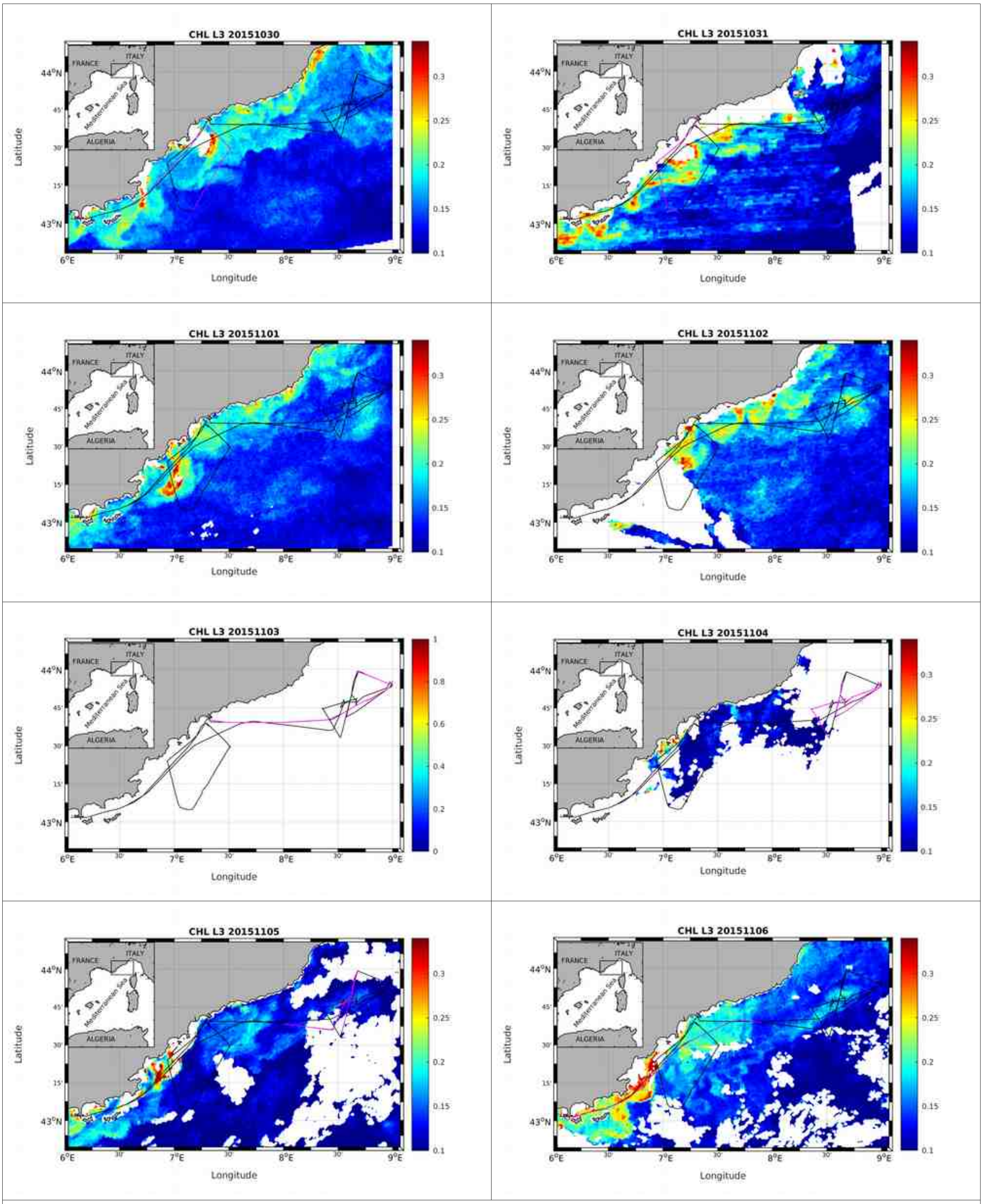


Overview of the different continuous surface seawater (SW) measurements configurations used during OSCAHR. TSG represents the SBE21 thermosalinograph, PFB the pocket FerryBox, pCO_2 the pCO_2 sensor, Cyto the flow cytometer and O_2 the O_2 optode.

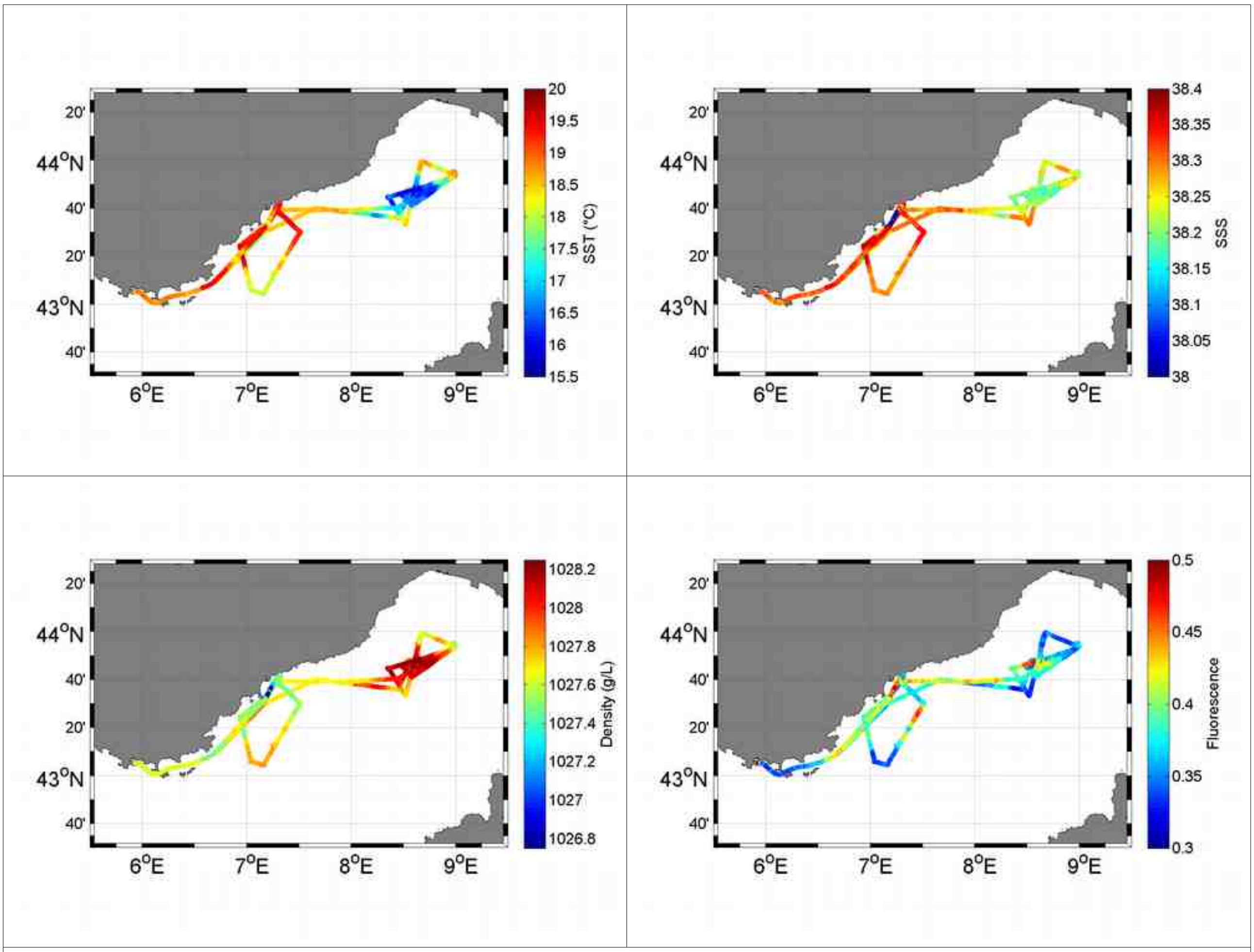
The TSG acquired sea surface temperature (SST), salinity (SSS) and fluorescence (FLUO) data during the whole cruise. The 1st of November, the start of TSG was delayed and few minutes of data between the harbor of Nice and the bay of Villefranche were lost.
Following the DT-INSU procedure one discrete salinity measurement has been performed by the Tethys II crew during the cruise the 31 October 2016. The sample, together with the daily samples performed before and after the cruise will be analyzed at the SHOM laboratory for post-cruise calibration of the TSG conductivity sensor.
The calibration of the Tethys II fluorimeter (data are provided in relative fluorescence units, rfu) will be done to convert the rfu intensities into discrete Chl-a concentrations (µg L^{-1}) obtained after sea water filtrations and Chl-a dosage in the laboratory. Chl-a analysis was initiated right after the cruise at the MIO and ended end of December 2015. We performed 30 filtrations on the TSG+ water supply with concentrations ranging from 0.06 to 0.25 µg/L. The inherent error on the filtered volume is estimated to +/- 20mL. In order to take into account quenching, 15 filtration has been performed during daytime and 15 during nighttime. 33 other Chl-a analysis (filtrations) were also performed during the campaign on the water column (vertical profiles) with values ranging from 0.08 to 0.49µg L^{-1}. These data will be used to calibrate the FLUO form the CTDs.



Vessel route (black line) with SST values measured by the on-board TSG (colored dots) superposed to the satellite SST map of the corresponding day (L4 product, data provided by CMEMS).



Vessel route (black line, in magenta the daily portion of the route) superposed to the daily maps of surface Chl-a concentration (satellite L3 product, data provided by CMEMS).



Raw sea surface temperature (SST), salinity (SSS), density and fluorescence recorded by the Tethys II TSG

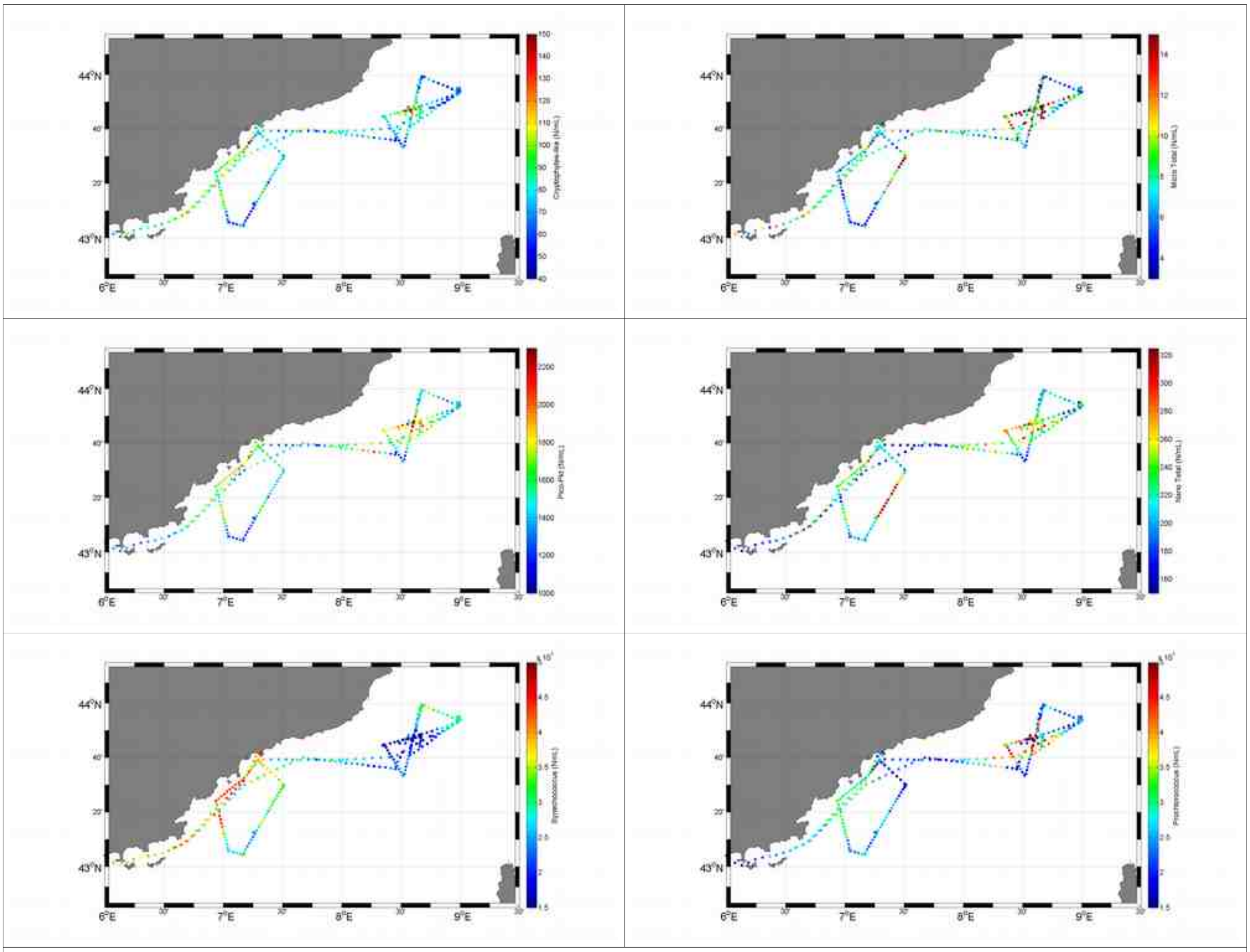
The O_2 optode 4330 acquired dissolved O_2 concentration data during the entire cruise together with seawater temperature. The different configurations of the optpode positioning along the cruise are reported in the scheme above. Calibration of the sensor will take into account the different configurations and also if the seawater supply to the sensor was cut or not for the discrete samples.
The optode 4330 is the field experiment reference optode for measuring dissolved O_2, since this sensor was calibrated just before and after the cruise. Moreover, as reported in the table above, 7 discrete samplings of dissolved O_2 were done during the cruise and successively analyzed by Winkler titrations. Finally, the O_2 data from the optode 4330 will be compared with the ones of the optode 3830 installed on the Pocket FerryBox.
The calibrated O_2 data will be used as a reference for the calibration of the dissolved O_2 sensor installed on the CTD rosette (SBE43).

The Pocket FerryBox allowed us to follow in real time the variations of the recorded parameters (SST, SSS, O2 and FLUO) thanks to a friendly interface. It provided also a second GPS position of the ship. Moreover, the PFB allowed us to have access to spare signal in case of reference sensors failure. No data was recorded from the departure from Nice the 3/11 in the morning to 17:00 because of a leaks in the water circuit due to the breakdown of the Aanderaa 4040 sensor. After this incident until the end of the cruise, we had access only to temperature data from the PFB optode.

Unfortunately, the pCO_2 sensor did not work during the whole campaign due to technical issues. The sensor was sent to the manufacturer immediately after the campaign.

The autonomous flow cytometer system was deployed during all the cruise with data acquisition every 20 min, with 2 different settings, hereinafter named FLR5 and FLR30 configurations. The FLR5 configuration (trigger level set on 5mV for the red fluorescence) allowed us to observe distinctly 2 cyanobacteria populations of prochlorococcus and synechoccocus for the first time with this embarked cytometer system. The FLR30 configuration (trigger level at 30mV for red fluorescence), was used to identify phytoplankton functional groups from micro-phytoplankton down to synechococcus (Prochlorococcus could not be observed).

Nutrients and ammonium analysis are in progress and results are expected for May 2016.
Barium analysis should start in February.



Preliminary abundances of cryptophyte like, micro-phytoplankton, pico-phytoplankton, nano-phytoplankton, synechococcus and prochlorococcus functional groups processed from the autonomous flow cytometer CytoSense every 20 minutes along the ship track.
The spatial distribution of nutrients and dissolved barium will be addressed at the same sample frequency as well.

6.3 MVP-Moving Vessel Profiler

We used a MVP200 equipped with a MSFFF I (Multi-Sensor Free Fall Fish type I) containing a microCTD, a fluorimeter and a LOPC (Laser Optical Plankton Counter, Herman & Harvey, 2006; particle size range: 100µm-1920µm).

A total of 448 casts has been performed along 366 km of route (55.7 hours of effective work).

MVP200 installation on the Téthys II deck.

The table below summarizes the MVP casts.

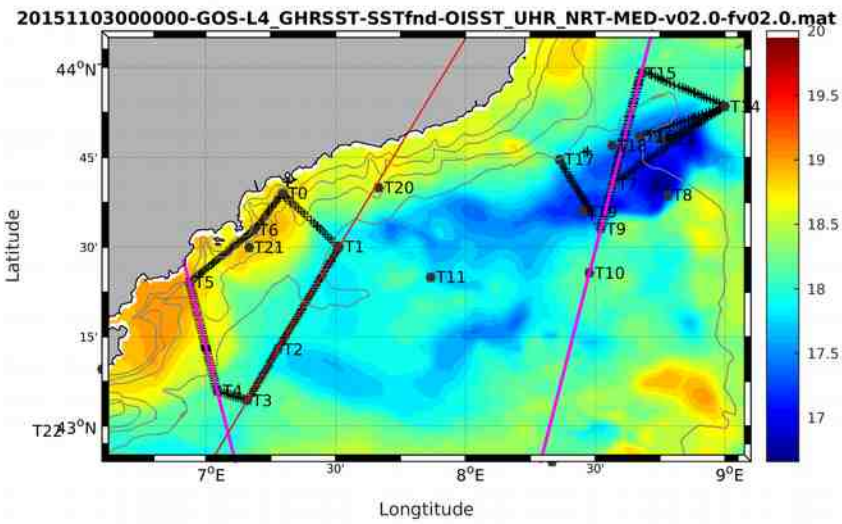
Plongée	*Date heure début de plongée (UTC)*	*Date heure fin de plongée (UTC)*	*Type de Poisson*	*Durée*	*Immersion*	*Vitesse navire*	*Nombre de cycles*	*Compteur horaire*	*Taux de réussite technique*	*Taux de réussite scientifique*	*Observations*
01/27/50	30/01/15 08:53	30/10/15 12:07	MSFFF	3:10	275 m	6 nds	22	555,3	100%	100%	Enveloppe du câble usée par frottement
02/28/51	30/10/15 14:17	30/10/15 19:30	MSFFF	5:13	343 m	4 nds	34	560,4	100%	100%	RAS
03/29/52	30/10/15 21:00	31/11/15 06:10	MSFFF	9:10	335 m	4 nds	80	569,5	100%	100%	RAS
04/30/53	31/10/15 06:20	31/10/15 11:50	MSFFF	5:30	328 m	4 nds	48	574,8	100%	100%	RAS
05/31/54	01/11/15 09:48	01/11/15 10:24	MSFFF	00:36	90 m	0 nd	6	575,1	100%	100%	RAS
06/32/55	01/11/15 15:15	01/11/15 16:05	MSFFF	00:40	90 m	0 nd	6	575,5	100%	100%	RAS
07/33/56	03/11/15 16 :00	03/1/15 18 :20	MSFFF	2 :20	275 m	6 nds	17	577,3	100%	100%	RAS
08/34/57	03/11/15 20 :15	04/11/15 06 :40	MSFFF	10 :25	288 m	6 nds	87	587,5	100%	100%	RAS
09/35/58	04/11/15 08 :49	04/11/15 11 :20	MSFFF	2 :31	325 m	6 nds	24	589,8	100%	100%	RAS
10/36/59	04/11/15 16 :30	04/11/15 17 :07	MSFFF	0 :37	335 m	4 nds	2	590,1	100%	0%	Test pièce d'attache
11/37/60	04/11/15 20 :04	05/11/2015 06 :20	MSFFF	10 :16	333	4 nds	74	600,2	100%	100%	RAS
12/38/61	07/11/2015 08 :54	07/11/2015 14 :12	MSFFF	05 :18	329	4 vers 9 nds	27	605,3		0%	Test Kgs/noeuds bateau

Table summarizing the MVP casts.

The majority of the MVP transects followed the satellites tracks of SARAL/AltiKa and Jason2 satellites, as detailed in the following table.

trace	satellite passage		beginning waypoint	MVP start		ending waypoint	MVP end		mean diff
jason2 #9	31/10	16:56	T1	30/10	15:30	T3	30/10	23:30	-21h
altika #429	30/10	05:02	T4	31/10	01:30	T5	01/11	06:30	+35h
altika #647	07/11	18:02	T15	03/11	23:00	T7	04/11	03:00	-89h
altika #647	07/11	18:02	T9	04/11	23:30	T15	05/11	06:00	-63h

Satellite-MVP synchronization



Position of all MVP casts superposed to the satellite tracks Altika (magenta) and Jason (red)

More details can be found in the MVP specific report by J.Fenouil available on the OSCAHR webpage.

6.4 Vertical water pumping (PASTIS_HVR - Pumping Advanced System To Investigate Seawater with High Vertical Resolution) and associated measurements

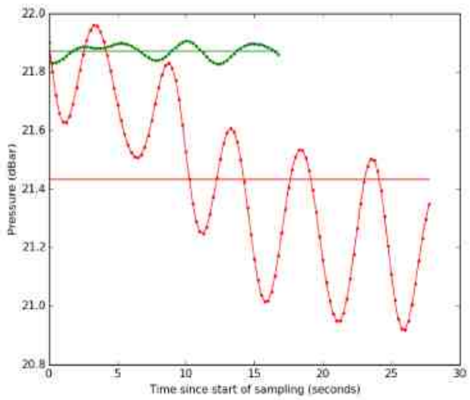
A system for seawater sampling down to 30 m with a vertical resolution of 0.1 to 1 m (depending on the sea state) was developed, tested and used.

Seawater was collected by a *Teflon* pump (*AstiPure™ II High Purity Bellows Pumps* – Flow rate = 30 L.min^{-1}) connected to a polyethylene (PE) tube (diameter =19 mm, length = 50 m, volume= 19 Liters) (Figure XX, picture down rigth). The entry of the PE tube was fixed to a frame with a *Seabird SBE19+ CTD* (Figure XX, picture top left), a *WetLab WETstar WS3S* fluorimeter and a *Sea Point* turbiditymeter. All sensors were used with real time acquisition at 4 Hz.

PASTIS_HVR system. From the top: the PE tube fixed on the CTD frame, the PE tube and the CTD cable attached togheter during a samplign operation, zoom in on the connection of the PE tube to the pump

The CTD frame was deployed at starboard with the winch normally used for the hydrological sampling. The PE tube and the electrical cable of the CTD were deployed manually along the steel wire.

At each sampling depth, seawater was pumped during 1' in order to flush at least twice the entire volume of the tube. Seawater was then collected through a split on the main seawater circulation with a flow rate of 2 L min^{-1}. Time at the begin and at the end of the sampling was recorded. Seawater temperature, salinity and depth for the collected sample was estimated from the average values of the parameters recorded by the SBE19+ CTD during the time of sampling. The vertical resolution of the sampling can be estimated from the difference between the highest and lower pressure recorded during sampling.



Example of the pressure records during the water sampling at different sea conditions: calm sea (green, station STA10–BTL5) and rough sea (red, STA06-BTL2).

The system was used during 11 stations in order to collect samples for nutrients, dissolved barium, conventional flow cytometry back to the laboratory and diversity measurements.
In order to complete the analyses performed at the surface with the TSG+ circuit, discrete samples have been collected on the 11 stations every 2 meters down to about 30 m (depending on the sea conditions). Structure of the microbial planktonic community will be investigated with conventional flow cytometry. Analyses will be run on a FACSCalibur flow cytometer equiped with a blue laser beam (488nm), providing the same wavelength excitation than the one on the Cytosense automated flow cytometer. Orange and red fluorescences will be collected, with two light scatter signals. These data are consistent with the ones collected by the automated flow cytometer. It makes possible to collect the same kind of information, providing the same flow cytometry clusters than the Cytosense used on the sea surface continuum (TSG+). The optical resolution of picoeukaryotes, nanoeukaryotes, Synechococcus, Prochlorococcus, and Cryptophycea will allow us to complement the data obtained at the surface during the cruise and expand the characterization of the phytoplankton down to about 30 m.
In addition, thanks to the analysis in the laboratory, it is possible to use fluorescent stains in order to put in evidence heterotrophs with flow cytometry. Heterotrophic bacteria will thus also be addressed for the 11 stations, along the 30 m of the investigated water column. That wastechnically not possible with the TSG+ flow cytometry installed on board during the cruise.
As flow cytometry remains a blind method, it is important to observe at least some samples by microscopy. This is why samples have also been collected and fixed in lugol, in the dark, at ambient temperature, to perform some diversity analysis back to the lab. After flow cytometry analyses are performed, and the most relevant samples identified, biodiversity analyses will be run for these very samples first. That will help us to better characterize the phytoplankton community in the various conditions met during the cruise. Flow cytometry and biodiversity analyses have been initiated. We expect to run most of the biodiversity analyses (80 samples) within the next 6 months.

Main information on these deployments is resumed in the Table below.

Station	Associated CTD File	Number of levels	Maximum depth (dB)
S1	"20151030_CTDpompe_oscahr_station1.asc"	11	31.38
S2	"20151030_CTDpompe_oscahr_station2.asc"	15	32.177
S3	"20151101_CTDpompe_oscahr_station3.asc"	11	31.525
S4	"20151101_CTDpompe_oscahr_station4.asc"	15	32.734
S5	"20151103_oscahr_ctd5261_station5_cnv_flt_algn_asc.asc"	12	24.452
S6	"20151103_oscahr_ctd5261_station6_cnv_flt_algn_asc.asc"	11	23.162
S7	"20151104_oscahr_ctd5261_station7_cnv_flt_algn_asc.asc"	15	29.407
S8	"20151104_oscahr_ctd5261_station8_cnv_flt_algn_asc.asc"	14	26.88
S9	"20151104_oscahr_ctd5261_station9_cnv_flt_algn_asc.asc"	10	29.359
S10	"20151105_oscahr_ctd5261_station10_cnv_flt_algn_asc.asc"	15	32.527
S11	"20151105_oscahr_ctd5261_station11_cnv_flt_algn_asc.asc"	6	31.033

6.5 SCAMP

Originally it was planned to deploy the SCAMP at fixed station profiles down to depths of 100m for the entire duration of the cruise. However, due to technical problems, only a total of 4 profiles were acquired.
Already on the first day, the conductivities measured by both the FAST and ACCURATE sensor were too low in comparison to the values measured by the CTD and MVP. On the second day, an additional problem appeared: the FAST T0 GRADIENT did not exhibit the typical scatter plot behavior but showed a clear asymptotic curve with rather large amplitudes, akin to the charge curve of a capacitor. In contrast to the CTD profiles, all three SCAMP profiles measured on the 2nd day showed unstable water columns and yielded unusable turbulence parameters. On the 3rd day we carried out several tests and eventually a decision was reached that it was not worth to carry out further samplings with the SCAMP.

More details on the SCAMP specific report by O.Ross are available on the OSCAHR webpage.

6.6 CTD-rosette and associated measurements

The CTD-rosette instrument used for vertical profiles at stations was constituted of a full-size, 12- *niskin* bottle (12L) *SBE 32 Carousel Water Sampler* with 3 extensions stands.
The first extension stand (fixed directly below the carousel) carried a *CTD SBE 911 Plus* for conductivity-temperature and pressure measurements, a *SBE 43* dissolved oxygen sensor, a *Chelsea Aquatracka III* fluorimeter for in situ detection of Chlorophyle-A, a *Wetlabs Cstar* transmissometer for underwater measurements of beam transmittance and a *Tritech PA500* altimeter.
The second extension stand (fixed under the first extension stand) carried two instruments for in-situ measurements of particle size distribution: a LISST (Laser In situ Scatterometer and Transmissiometer) Deep type B (particle size range: 1.25-250µm) and a LOPC (Laser Optical Plankton Counter, Herman & Harvey, 2006; particle size range: 100µm-1920µm). In order to calibrate the automated measurements, four nets hauls were done with a WP2 net with 200µm mesh. The net samples were preserved in formalin for further analysis with Zooscan and taxonomic determination.

The third extension stand (fixed on the side of the carousel) carried a ECOVSF3 (WET Labs). The angular distribution of scattered radiation in the backward hemisphere is important in the interpretation of remote sensing measurements, investigations of particle shape, and models of visibility in seawater. The ECOVSF3 measures the optical scattering at three distinct angles: 100, 125, and 150 degrees, at three wavelengths, thus providing the shape of the Volume Scattering Function (VSF) throughout its angular domain. Motivated by the need to better understand the relationship of water leaving radiance with the backscattering into the same direction, the three-angle measurement allows the determination of specific angles of backscattering through interpolation. Conversely, it can also provide the total backscattering coefficient by integration and extrapolation from 90 to 180 degrees.

Finally, a QCP-2350 (Cosinus collector) PAR sensor was directly fixed on the top of the carousel.

Picture of the CTD-rosette and its three extentions.

The CTD-rosette was deployed once or twice during 10 of the 12 visited stations. During two stations the CTD rosette could not be deployed due to bad weather conditions. The CTD-rosette was deployed with a dedicated winch. For a few casts, the bottles of the carousel were triggered for collection of seawater samples. The main objective of these collected samples was to retrieve terms of comparison for the parameters collected with the pumping system described in the section 6.4 (Nutrients, dissolved Barium, cytometry, diversity).
At S11, the CTD-rosette (Without ECOVSF3) was deployed along the entire water column (2250 m). Samples were collected from surface to 1000 m (Nutrients, Dissolved Oxygen winkler) in order to calibrate the sensors of the BioArgo.

The main informations on the CTD rosette cast are resumed in the the two tables below.

Station	Cast	CTD file	Bottles triggered	Depth (m)
S1	1	20151030_ctd0268_oscahr_station1.asc	NO	300m
S2	1	20151030_ctd0268_oscahr_station2.asc	NO	300m
S3	1	20151101_ctd0268_oscahr_station3.asc	NO	80m
S4	1	20151101_ctd0268_oscahr_station4.asc	YES	80m
S7	1	20151104_ctd0268_oscahr_station7.asc	NO	300m
S8	1	20151104_ctd0268_oscahr_station8.asc	YES	300m
S8	2	20151104_ctd0268_oscahr_station8bis.asc	NO	300m
S9	1	20151104_ctd0268_oscahr_station9.asc	NO	300m
S10	1	20151105_ctd0268_oscahr_station10.asc	YES	300m
S11	1	20151105_ctd0268_oscahr_station11.asc	NO	300m
S11	2	20151105_ctd0268_oscahr_station11_PI.asc	YES	2241m
S12	1	20151105_ctd0268_oscahr_station12.asc	NO	300m

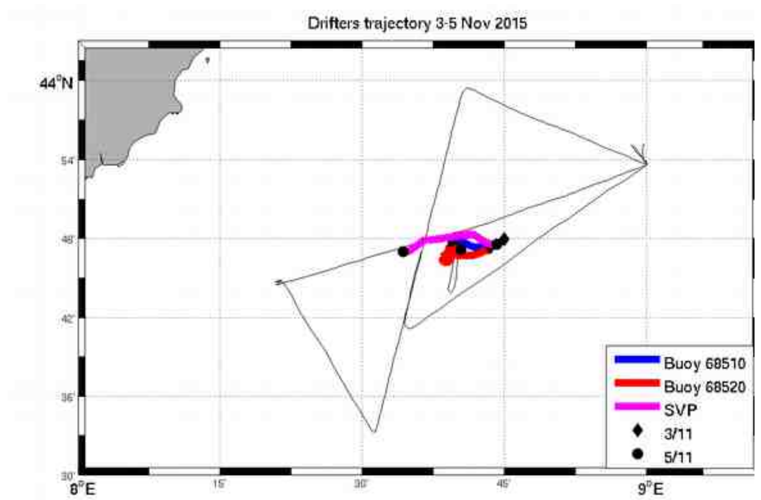
TIME (GMT)	Station	CTD-Pompé	CTD	LAT (N)	LONG (E)	Depth	LISST-Deep	LOPC-Deep	Filet
Fri 30 Oct 13:30	001	X	X	43 30.01 N	007 30.81 E	300m	L3031351	data0398 à data0399	
Fri 30 Oct 20:00	002	X	X	43 12.60 N	007 15.43 E	300m	L3032028	data0400 à data0402	
Sun 01 Nov 08:00	003	X	X	43 40.97 N	007 18.96 E	80m	L3050928	data0403	80m
Sun 01 Nov 13:00	004	X	X	43 40.90 N	007 19.04 E	80m	L3051440	data0404 à data0405	
Tue 03 Nov 15:30	005	X	none				none	none	
Tue 03 Nov 20:00	006	X	none				none	none	
Wed 04 Nov 07:00	007	X	X	43 54.54 N	008 59.04 E	300m	L3080747	data0406 à data0407	200m
Wed 04 Nov 14:00	008	X	X	43 48.50 N	008 40.10 E	300m	L3081355	data0408 à data0410	200m
Wed 04 Nov 15:00	008		Bis	43 48.50 N	008 40.10 E	300m	L3081506	data0411 à data0412	
Wed 04 Nov 18:00	009	X	X	43 44.54 N	008 21.19 E	300m	L3081820	data0413 à data0415	
Thu 05 Nov 06:30	010	X	X	43 59.35 N	008 40.66 E	300m	L3090715	data0416 à data0418	
Thu 05 Nov 14:00	011	X	X	43 47.14 N	008 33.33 E	300m	L3091408	data0419 à data0422	200m
Thu 05 Nov 15:00	011		PI	43 47.14 N	008 33.33 E	2241m	L3091459	data0423 à data0432	
Thu 05 Nov 19:30	012		X	43 35.96 N	008 27.05 E	300m	L3091948	data0433 à data0435	

6.7 Drifters

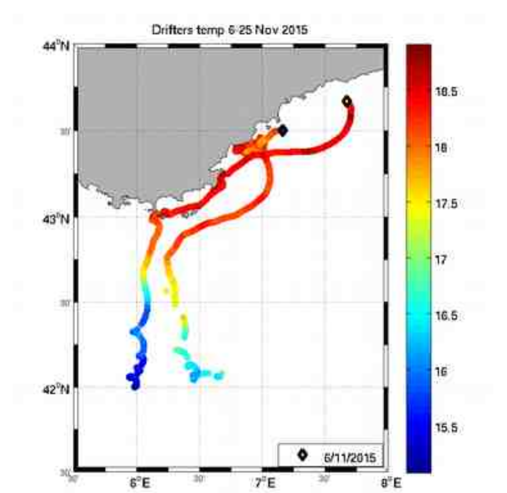
Two different types of floats were deployed during the cruise : 1 SVP-like drifter anchored at 15-m depth and 2 CODE drifters anchored at 1-m depth and equipped with a temperature sensor. All three buoys were equipped with an Iridium transmission system.

A first release was performed during the second leg in order to mark the water mass studied from 3 to 5 November 2015 (see figure below, left panel). Afterwards all the buoys were recovered on board.

The two CODE buoys were released again on 6 November 2015 during the return route in the Dyfamed radar field. They transmitted until 25 November 2015, showing a trajectory initially along the coast, then southward (see figure below, right panel). The latter trajectory corresponds to a Mistral wind episode associated with a coastal upwelling.



Trajectory of the drifters during the second-leg Lagrangian study.



Trajectories of the 2 CODE drifters after the second release.

6.8 BioArgo

A BioArgo automatized profiling platform was deployed at the end of the cruise. The BioArgo (sn: WMO-6902700; name: “Côtes de Provence”) was deployed at the location 43,7831 N and 8,558 E on the 5th November at 16:45.

The float was equipped with bio-optical sensors (fluorimeters, PAR sensors, backscatter and irradiance radiometers) together with a CTD, a nitrate sensor (SUNA) and an oxygen optode. Three hours before the deployment, in-air oxygen optode measurements with the float were collected for 20 minutes in order to correct the potential offset of the optode. Unfortunately, the oxygen sensor did not work correctly since the first profile.

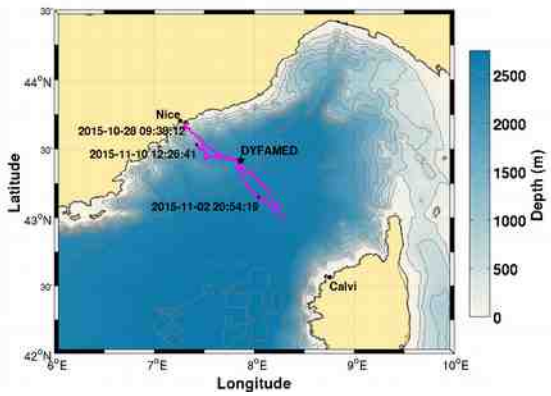
The float pumping system was checked before the release.

The float was equipped with an Iridium antenna allowing a double way communication used for quasi real time data transmission and for modifying the sampling strategy during the mission. First, a temporal daily resolution was fixed with a maximal depth at 1000m depth. This strategy was changed to a 3 Days sampling on the 25th of November. The last profile was performed on the 16th of January. The float was unable to dive anymore and it had to be picked up it in emergency.
The data available are potential temperature, salinity, Irradiance (Ed at 380, 410 and 410 nm), PAR and backscatter (at 700 nm) ; CDOM & Chla Fluorimetry ; .
The "Côtes de Provence" float not calibrated data are available at www.oao.obs-vlfr.fr/bioargo/PHP/lovbio016d/lovbio016d.html. Netcdf data files with Quality Control (Schmechtig et al, 2014; Wong et al, 2014; Lavigne et al, 2012; Johnson et al, 2013; Pasqueron de Fommervault et al, 2015) downloaded from Coriolis are available in the OSCAHR Dataset. More reliable data with QC for chlorophyll-a (Lavigne et al, 2012) and for nitrate (Johnson et al, 2013; Pasqueron de Fommervault et al, 2015) will be available in July 2016.

6.9 Glider

In parallel to ship-based measurements, the glider SeaExplorer SEA007 was deployed along the Nice-Calvi transect. This transect is regularly monitored with gliders as part of the MOOSE observation program. The glider was deployed on 26 November 2015 in Villefranche harbor near Nice. The glider first headed towards the DYFAMED monitoring station (43°25.00'N, 7°52.00'E) before continuing towards the 300-m isobath near Corsica (42°48.00'N, 8°28.00'E). The glider did not reach this target since it was set back to DYFAMED on 4 November 2015 at 14:30, when the southernmost point of the campaign was reached (42°59.796'N, 8°17.022'E). Shortly after reaching DYFAMED a second time on the return, its deployment was stopped due to software problems on 10 November 2015, 12:25.

The glider was fitted with conventional sensors (seabird GPCTD/O_2, wetlabs triplet puck Chl*a*/BB_{700}/CDOM), and an original FDOM bi-optical pathways sensor "the MiniFluo-UV" detecting TRY-like (λEx/λEm : 280/340 nm) and Phenanthrene-like (λEx/λEm : 255/360 nm) fluorophores (Tedetti et al. 2013), markers of microbiological activity and oil-related compounds respectively.

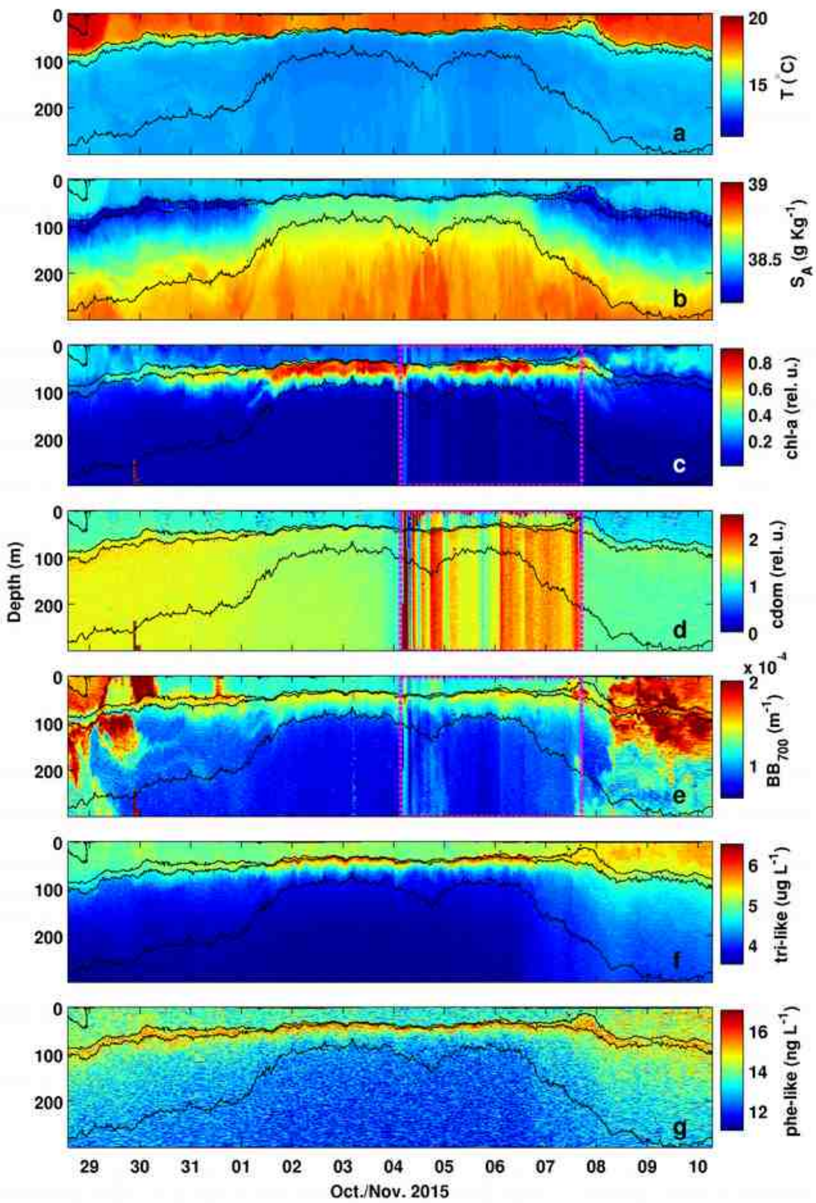


Details of the glider trajectory along the Nice-Calvi transect and passing by DYFAMED monitoring station (black star) in the NW Mediterranean Sea. Isobaths are drawn here in 250m intervals.

SeaExplorer gliders SEA003 and SEA004. One specific aspect of their design is the absence of side wings which make their deployment easier from smaller boat. This glider is also the only one manufactured in Europe (photo credit: Alseamar).

Time-depth series of glider measurements along the Nice-Calvi transect (two-ways).
(a) Conservative temperature (*T*);
(b) Absolute salinity (*SA*);
(c) Chlorophyll-*a* (Chl-*a*, in relative units);
(d) Colored dissolved organic matter (CDOM, relative units);
(e) Backscatter/turbidity measurements (BB);
(f) Tryptophan-like concentration measurements;
(g) Phenantrenes-like concentration measurements.

Measurements from the SeaBird conductivity-temperature-depth cell were converted to *T*, *SA* and density anomaly referenced to surface (σ_0) using McGougall and Barker (2011) and plot here in 0.5 kg/m3 increment as solid lines in all panels. Note that salinity measurements have not yet been compensated for thermal lag error caused by the vertical motions of the glider. Chl-*a,* CDOM and BB measurements were obtained using the Wetlabs ECO-puck. Note that the puck had electronic problems between 4-8 November 2016 (dashed-rectangles in panels *c,d* and *e*). TRY-like and PHE-like measurements were obtained using the MiniFluo-UV (Tedetti et al., 2013).



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APPENDIX A : Exemple of SPASSO daily bulletin

OSCAHR cruise

SPASSO Images Analysis

November 3, 2015

Author(s): L.Rousselet A.Doglioli, Petrenko, A., A.De-Verneil, Frederic Cyr

Executive Summary

Military Sampling restrictions are still in effect.

On November 2nd Oliver Ross disembarked with the SCAMP and Gerald Gregori got on board. The R/V Tethys left Nice harbor on November 3rd 7:00 AM.It is currently on its way to W4 (violet curve) (Fig. 1). Team Bulletin has received the proposed ship track from the incoming team taking into account Isabelle and Jean-Michel suggestions. This track will hereafter be referred to as 'Plan A'. In addition, Team Bulletin furthermore provides one possible alternative track, referred to as 'Plan B' (Fig. 2).

The waves are forecast to become more favorable for sampling throughout the afternoon, especially in the north-eastern region of the Gulf of Genoa and progressively towards the south-east.

1 Maps interpretation

1.1 AVISO, MOOSE radar and FSLE

Both proposed shiptracks cross the FSLE feature between W5 and W6. Bulletin Team recommend deployment of the buoys there.

1.2 MyOCEAN CHL

Both proposed shiptracks aim at doing the first station of the day in the core of the high Chlorophyll maximum. Plan B is proposed in order to return to that station after crossing the FSLE feature. Team Bulletin's suggestions are based on November 2nd's image (due to cloud cover on the 3rd)

1.3 MyOCEAN SST

Due to the variability of the SST data and cloud coverage for Nov 3rd, no sampling plans based on SST data have been formulated.

1.4 AVHRR pseudo-SST

Same as previous section (MyOcean SST).

1.5 SYMPHONIE model

Observed features in the model output are relatively stable, and are similar to those mentioned in previous bulletins.

SYMPHONIE data show a nearshore current traveling west throughout the focused study region.

1.6 Mars3D-ECO3M model

There is no new information from the model.

1.7 WRF model

Please refer to the link: http://mio.pytheas.univ-amu.fr/OSCAHR/Figures_web/Bulletin/

2 Strategy

2.1 Glider

No new instruction was given to the glider, and it continues its journey towards waypoint (42° 48.00'N, 8° 26.00'E, see magenta star on (Fig. 1).

Since it will not be possible for the glider to travel north-east and sample the maxChl region near W4, Team Bulletin suggests that the glider continues its current trajectory until noon, Nov 4th, and then return along the same path (heading back toward Dyfamed station 43°N25', 7°E52'

2.2 Plan A

Table 1: Tethys waypoints for plan A

#	Lat	Min	Sec	Lon	Min	Sec	D[km]	D[nm]	T[hr]	Cum.D.	C.D[nm]	Cum.T
4	43	49	0	8	45	0	0.000	0.000	0.000	0.000	0.000	0.000
5	43	56	0	9	0	0	24.957	13.476	1.684	24.957	13.476	1.684
6	44	0	0	8	41	0	26.393	14.251	1.781	51.350	27.727	3.466
7	43	41	0	8	35	0	36.487	19.701	2.463	87.837	47.428	5.929

2.3 Plan B

Table 2: Tethys waypoints for plan B

#	Lat	Min	Sec	Lon	Min	Sec	D[km]	D[nm]	T[hr]	Cum.D.	C.D[nm]	Cum.T
4	43	49	0	8	45	0	0.000	0.000	0.000	0.000	0.000	0.000
5	43	56	0	9	0	0	24.957	13.476	1.684	24.957	13.476	1.684
6	44	0	0	8	41	0	26.393	14.251	1.781	51.350	27.727	3.466
7	43	48	0	8	45	0	23.168	12.509	1.564	74.518	40.236	5.030

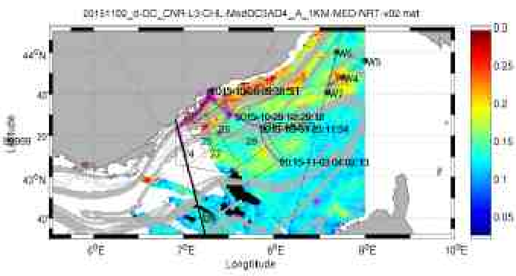

Figure 1: Plan A - Chl from MODIS

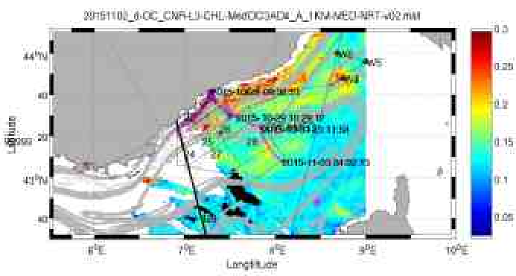

Figure 2: Plan B - Chl from MODIS

OSCAHR project webpages

http://mio.pytheas.univ-amu.fr/OSCAHR