7th EURO-ARGO SCIENCE MEETING

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BOOK OF ABSTRACTS

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TALKS

SESSION 1: MESO-TO-LARGE SCALE OCEAN STRUCTURE AND VARIABILITY

1/ INTERIOR WATER-MASS VARIABILITY IN THE SOUTHERN-HEMISPHERE OCEANS DURING THE LAST DECADE

Esther Portela [1], Nicolas Kolodziejczyk [1], Christophe Maes [2] and Virginie Thierry [3]

1 LOPS/CNRS, Plouzané, France

2 LOPS/IRD, Plouzané, France

3 LOPS/Ifremer, Plouzané, France

portelaro(at)univ-brest.fr

Using an Argo dataset, a volume budget was performed to address the main mechanisms implied in the volume change of the interior water masses in the southern-hemisphere oceans between 2006-2015. The subduction rates, and the isopycnal and diapycnal water-mass transformation were estimated in a density-spiciness framework. Spiciness, defined as thermohaline variations along isopycnals, was added to the potential density coordinates to discriminate between water-masses spreading along isopycnals. The main positive volume trends were found to be associated with the SubAntarctic Mode Waters (SAMW) in the south Pacific and Indian basins revealing a lightening of the upper waters in the Southern Hemisphere. The SAMW exhibits a two-layer density structure in which the upper layers gained volume as a result of local subduction while the volume of the lower layer reduced as a result of isopycnal and diapycnal transformation. The Antarctic Intermediate Waters (AAIW), defined between the 27.2 and 27.5 kg m-3 isopycnals, showed the strongest negative volume trends. This volume loss can be explained by negative isopycnal transformation southward from the ACC into the fresher and colder Antarctic Winter Waters (AAWW) and northward into spicier tropical/subtropical Intermediate Waters. The AAWW is destroyed by obduction back into the mixed layer so the net volume change remains nearly zero. The proposed mechanisms to explain the transformation within the Intermediate Waters are discussed in the context of Southern Ocean dynamics. It is shown that the σ-τ decomposition provides new insight on the spatial and temporal waters-mass variability and driving mechanisms over the last decade.

2/ HIGH RESOLUTION ARGO PROFILING IN A WESTERN BOUNDARY CURRENT

Tamaryn Morris [1,2], Tarron Lamont [3,2], Romain Cancouët [4]

1 Marine Unit, South African Weather Service, Cape Town, South Africa

2 Oceanography Department, University of Cape Town, South Africa

3 Oceans and Coasts, Department of Environmental Affairs, Cape Town, South Africa

4 Euro-Argo European Research Infrastructure Consortium, Brest, France

tamaryn.morris(at)weathersa.co.za

Six MOCCA Argo floats were deployed in a perpendicular transect off Port Edward, South Africa, on 10 August 2017. The floats were deployed from inshore of the Agulhas Current, through the core, and considered quasi-synoptic of the Agulhas Current. The floats propagated at an average speed of 0.62 m s-1 , with the most inshore float at less than 0.5 m s-1 ; the 'core' floats never exceeding 1 m s-1 . Given the floats were parked at 1000 db, we assume these currents to be representative of subsurface dynamics. Two floats became entrapped within a cyclonic eddy found semi-permanently in satellite imagery in a bight east of the Agulhas Bank, but not often surveyed by means of in situ instrumentation. Four of the six floats move in to the Subtropical Front of the Antarctic Circumpolar Current (i.e. south of 40° S), with one float moving in to the South Atlantic and the remaining float propagating eastwards with the Agulhas Return Current. This result challenges the long held vision of the Agulhas Current System, where rings are shed westwards in to the South Atlantic, and the remaining waters retroflect eastwards into the Indian Ocean. These six floats, coupled with a further ten high-resolution Argo floats from three previous experiments, further challenge the perception of the Agulhas Current System with 37.5 % of the floats propagating eastwards with the Agulhas Return Current, 37.5 % moving southwards beyond 40° S, and 25 % propagating westwards into the South Atlantic Ocean. Critically, we have shown the most efficient way to study the Agulhas Current is by means of high-resolution profiling Argo floats. We have captured lesser-sampled features and look to progressing these results with further analysis in terms of mixing and the fate of waters transported down the east coast of South Africa from the subtropics.

3/ INTERANNUAL IMPACT OF EXTREME WINTERTIME WEATHER ON THE NORTH ATLANTIC SUBTROPICAL STRATIFICATION

Kenneth E. Lee [1], Guillaume Maze [1], Herlé Mercier [2]

1 LOPS/Ifremer, Plouzané, France

2 LOPS/CNRS, Plouzané, France

kenneth.e.lee(at)ifremer.fr

Serving as the largest heat reservoir on earth, the North Atlantic subtropical gyre was shown to have experienced warming since 1970. But this trend sits on top of a large interannual variability driven by mechanisms that are yet to be clarified, especially with regard to extreme winter events. In this research, we developed an observation-based ocean heat budget of the upper 800 m in the western subtropical North Atlantic, a region where heat is mostly stored in the Eighteen Degree Mode water (EDW). On interannual time scale, the variability of geostrophic advection, mostly driven by the Gulf stream, is the most dominant factor to that of the ocean heat content (OHC) variability, 2.5 times as large as that of Ekman advection and almost four times as large as that of surface heat loss (which dominates at the seasonal cycle only). However, the annually ventilated EDW exhibits extreme values in 2008, 2013, and 2015 that correspond to opposite OHC anomalies. We will show that Ekman advection is the best indicator and driving mechanism explaining these extreme occurrences. We will further show that such extreme extreme Ekman advection patterns can be linked to large scale atmospheric weather storms and that both storm intensity and duration have an impact on the extremity of EDW ventilation and North Atlantic heat content.

4/ SCOTIA SEA PATHWAYS AS DEDUCED FROM ARGO FLOATS

Anna Olivé Abelló [1] and Josep L. Pelegrí [1]

1 Institut de Ciències del Mar (CSIC), Barcelona, Spain

aolive(at)icm.csic.es

We use the Argo floats database to quantify the water transports of the Antarctic Circumpolar Current (ACC) through the Scotia Sea in the upper 2000 m of the water column. The reference velocities are calculated from the speed of the floats at the 1000-m parking depth and the relative geostrophic velocities are calculated from the float profiles nearby the selected sections. After removal of all floats deployed too close to the Drake Passage, the number of floats crossing each passage correlates well with the transports, and the individual trajectories allow identifying the preferred pathways. Considering the entire database till October 2018, we identify a total of 253 floats drifting through the Drake Passage with 214 of them following through the North Scotia Ridge passages. This allows reconstructing the vertical hydrographic structure at 25-km resolution from the sea surface to 2000 m. Our results indicate a geostrophic transport of 174.0 Sv in the Drake Passage, with a barotropic component of 114.1 Sv and a baroclinic component of 59.9 Sv, while in the North Scotia Ridge passages the total transport is 192.8 Sv, with a barotropic component of 107.9 Sv and a baroclinic component of 84.9 Sv. Most transport through the Drake and North Scotia Ridge Passages comes from jets associated with the Subantarctic and Polar Fronts, and to a lesser degree the Southern ACC Front. The amount of data is enough to explore the inter-annual variations (through a 5-yr running filter), which illustrates the existence of substantial changes, up to 45.5 Sv through the Drake Passage.

5/ A DEEP COHERENT EDDY IN THE NORTHERN NORWEGIAN SEA OBSERVED WITH ARGO FLOATS.

Henrik Søiland [1], Kjell Arne Mork [1]

1 Institute of Marine Research, Bergen, Norway

henrik(at)hi.no

In recent years several studies have identified an area of intense anticyclonic activity in the central part of the Lofoten Basin in the Norwegian Sea. This is now recognized as the coherent Lofoten Basin Eddy (LBE). Recent ADCP and CTD surveys, subsurface float records, altimetry from the last 20 years and historical hydrography indicate that the LBE is a permanent feature.

In the PROVOLO project [http://www.uib.no/en/rg/fysos/97330/provolo], a range of instrumentation, including CTD, VM-ADCP, LADCP and ocean microstructure profilers, was used at cruises in June 2016 and March 2017. The surveys confirmed that the LBE typically has maximum swirl velocities at 17-20 km radius, with peak velocities between 600 and 900 m depth. In PROVOLO
24 neutrally buoyant acoustically tracked subsurface floats (RAFOS) were deployed in the LBE in 2016 and 2017. RAFOS floats deployed between 550 and 850 meter depth inside the radius of velocity maximum remained in the eddy for the duration of the deployment (5-14 months).
In May 2019, 3 Argo floats were deployed close to the center of the LBE. These floats are different types of Argo floats. One of the floats deployed with a park depth at 1000 m is a deep Argo floats that profiles from the surface to close to the bottom. The other with the same park depth is a BCG Argo that profiles from surface to 2000 m. The Argo float with a park depth at 800 m is a Bio Argo that profiles from surface to 2000 m. We are interested to study how park and profile depth affect the ability of the floats to remain in the LBE and thus investigate if we may be able to do long term monitoring of the LBE with Argo floats. Preliminary results will be presented.

6/ SALINITY - OXYGEN INDICES FOR CLIMATE VARIABILITY IN THE SOUTH ATLANTIC

Cristian Florindo Lopez [1], Elaine McDonagh [1], Brian King [1], Louis Clement [1], Gerard McCarthy [2], Maria Paz Chidichimo [3], Sabrina Speich [4], Johannes Karstensen [5]

1 National Oceanography Centre, Southampton, United Kingdom

2 National University of Ireland Maynooth, Maynooth, Ireland

3 Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)/Servicio de Hidrografía Naval, Buenos Aires, Argentina

4 Ecole Nationale Supérieure de Paris, Paris, France

5 GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

criflor(at)noc.ac.uk

The strength of the Atlantic Meridional Overturning Circulation (AMOC) is key in determining the global budget and inventories of anthropogenic carbon and heat. The high salinity in the Atlantic (relative to the Pacific and Indian Oceans) results in deep water mass formation and deep overturning associated with the AMOC. The South Atlantic preconditions the salinity of the Atlantic Ocean. Here we investigate the multi-decadal salinity variability of Intermediate water masses (1000 m) in the South Atlantic and relate this salinity variability to changes in circulation, specifically the relative contribution of (low salinity) Atlantic and Drake Passage water and (high salinity) Indian ocean water that enters via the Agulhas Current system. We use NAVIS/Oxygen floats to study the seasonality and spatial variability.

By examining the repeat hydrographic GO-SHIP sections in the South Atlantic occupied at 24S in 1958, 1983, 2009 and 2018, we find an increasing influence of Indian Ocean water in the South Atlantic at Intermediate levels over time. This is evident from the changing properties at the salinity minimum associated with Antarctic Intermediate Water (AAIW). We also examine the Apparent Oxygen Utilisation (AOU; saturation oxygen minus observed oxygen) properties and interpret this as an age tracer. We interpret those salinity changes that are correlated with changes in AOU as reflecting changes in the circulation as follows. Higher salinity and higher AOU indicates increased Indian Ocean Influence. Lower salinity, lower AOU indicates decreased Indian Ocean influence.

Using data from oxygen-enabled profiling floats that were deployed on hydrographic cruises at 35S and 24S we are able to extend the analysis to inform the meridional and seasonal to interannual variability of the salinity-oxygen indices. Preliminary analysis shows meridional dependence on the salinity-AOU relationship, the strength of which results from the timescale of the circulation and mixing of AAIW along the meridional pathway.

SESSION 2: MARGINAL SEAS WITH A FOCUS ON THE MEDITERRANEAN & BLACK SEAS

7/ A STUDY OF THE TYRRHENIAN INTERMEDIATE WATER (TIW) USING ARGO FLOATS, XBT AND MODEL DATA

Ernesto Napolitano [1], Roberto Iacono [1], Tiziana Ciuffardi [2], Franco Reseghetti [2], Pierre-Marie Poulain [3], Giulio Notarstefano [3]

1 ENEA–CR Casaccia, Roma, Italy,

2 ENEA–CR Santa Teresa, La Spezia, Italy

3 OGS, Trieste, Italy

ernesto.napolitano(at)enea.it

The Tyrrhenian Intermediate Water (TIW) is a water mass present in the Tyrrhenian Sea, which approximately lies between 100 m and 200 m of depth and is characterized by a local minimum of temperature. We have performed, for the first time, a thorough investigation of this water mass, using long time series of observations (XBT, Argo float, dissolved oxygen data) and modeling results. We find that the TIW is present in a large part of the Tyrrhenian basin, and is a persistent feature of the basin hydrology. The TIW is formed by winter convection, with some differences between the southern part of the basin and the northern part, where strong winter cooling produces deeper convection and mixing. Our analysis has excluded remote contributions from intermediate waters produced in the western portion of the Western Mediterranean basin. On the other hand, we present evidence that the TIW not only impacts the Tyrrhenian Sea hydrology, but also that of the adjacent Liguro-Provençal basin, because this water mass outflows from the Corsica Strait, and is transported as far as the Gulf of Lion, in the core of the region where deep waters are formed. Recent changes in the properties of this intermediate water mass are also highlighted, which result from the warming of the neighboring water layers.

8/ LOCAL RE-ANALYSIS OF THE CYPRUS BASIN: ASSIMILATING GLIDERS AND PROFILING FLOATS TO REPRODUCE SURFACE drifter tracks

Anastasios Matsikaris [1], Daniel R. Hayes [2]

1 University of Cyprus, Nicosia, Cyprus

2 Cyprus Subsea Consulting and Services C.S.C.S., Lakatamia, Cyprus

hayesdan(at)cyprus-subsea.com

We use an operational data assimilation system to produce a local re-analysis of the Cyprus Basin, Eastern Mediterranean. A numerical experiment is designed for a 3-month period (January-March 2017), comprising two almost identical hydrodynamic model runs; an assimilative run and a control run. In the first case, in situ temperature and salinity profiles from ocean gliders and Argo floats are assimilated daily into a high-resolution ocean model. The control run uses the same initial and boundary conditions as the assimilative one to produce the forecast but does not assimilate any data. The two short-term regional forecasts are evaluated to check whether the assimilation of glider and float data improve the forecast, both near and far from the region of assimilation. The region of the anticyclonic Cyprus eddy is of particular interest. A network of surface drifter tracks in the same basin are used to evaluate the agreement of the two runs with the drifter patterns.

9/ ARGO FLOATS - AN IMPORTANT ELEMENT OF OCEANOGRAPHIC OBSERVATIONS IN THE SOUTHERN BALTIC SEA.

Waldemar Walczowski [1], Małgorzata Merchel [1], Piotr Wieczorek [1], Daniel Rak [1]

1 Institute of Oceanology PAN, Sopot, Poland

walczows(at)iopan.pl

The Baltic Sea is a small, shallow shelf sea with low salinity of the surface layer and relatively high salinity of the bottom layer. Due to this specificity, the use of measurement methods and devices used in the oceans is often difficult or impossible in the Baltic Sea. The Argo float is such a device designed to work in the deep ocean. Therefore, the Baltic Sea was not intended for the operational use of Argo floats. However, the European program Euro-Argo decided to place the Baltic Sea among the priority research directions.

Experiences of oceanographers from Finland and Poland indicate that these floats can work well in the Baltic conditions. The first floats launched by Poland in the Southern Baltic Sea in November 2016 and March 2017 could not break through picknocline. Only the use of floats with a large buoyant bladder provided by the MOCCA-EU program and the use of special settings allowed for the elimination of this problem. There were no major problems related to the proximity of the shore or the presence of ships. After 3 years of using Argo floats in the Southern Baltic, it can be stated that they are a useful tool in monitoring the basin, especially the Baltic depths. They constitute an important element of the observation system monitoring the inflows from the North Sea and the hydrographic conditions of the Southern Baltic.

10/ ARGO FLOATS AS A PART OF THE BALTIC SEA MONITORING

Laura Tuomi [1], Petra Roiha [1], Simo Siiriä [1], Pekka Alenius [1], Noora Haavisto [2], Tero Purokoski [1]

1 Finnish Meteorological Institute, FMI, Helsinki, Finland

2 University of Helsinki, Tvärminne Zoological Station, Helsinki, Finland

laura.tuomi(at)fmi.fi

The Argo floats have been used in the Baltic Sea since 2012. The first deployment took place in the Bothnian Sea and since then FMI has had Argo floats in the Bothnian Sea, The Gotland Deep and, the Bothnian Bay. In the Gotland Deep and Bothnian Sea also Argo floats equipped with bio-optical sensors are used. From the Bothnian Bay, there are so far only TS-profiles available.

Although the FMI Argo missions concentrate on the deep basins, thus covering only part of the northern Baltic Sea, the increased number of TS profiles and increased temporal coverage have improved the monitoring capabilities in the Baltic Sea in addition to the traditional observational network, that consists of monitoring cruises, moorings and intensive monitoring stations.

The Baltic Sea floats measure profiles c. once a week. The two-way communication with floats enables changing the profiling frequency. This has been done e.g. during intensive algal blooms in areas where floats with O2 and fluorometer are available and also to observe autumn mixing and cooling in detail.

Using Argo floats, has for the first time, enabled observing the seasonal cycle of the water column in the open sea areas of the Bothnian Sea on a weekly scale. Furthermore, the timing of spring and autumn overturning and the development and decay of the thermocline are captured in more detail. When compared to the traditional ship-borne monitoring in the Bothnian Sea, the Argo floats seem to work well as an independent monitoring system for temperature dynamics. For salinity, the Argo floats still provide a more limited view than the monitoring data. Salinity is a more conservative and location-dependent variable in the Baltic Sea. However, the short-scale phenomena are well captured by the Argo floats. Our studies have also shown that Argo floats can also be used to study currents in the deeper layers of the Baltic Sea.

11/ EVALUATION OF THE FIRST BAROCLINIC ROSSBY RADIUS IN THE BLACK SEA USING REANALYSIS DATA AND IN-SITU ARGO PROFILES

Greta Georgieva [1] and Elisaveta Peneva [1]

1 Sofia University "St.Kliment Ohridski", Sofia, Bulgaria

gretageorgieva7(at)abv.bg

The first baroclinic Rossby radius of deformation R1 is a horizontal scale at which the Earth rotation's effects become as significant as stratification effects and thus characterizes the scale of mesoscale currents in oceans and seas. Radius R1 is important for estimating how correctly numerical models resolve mesoscale motions – it is necessary that the model grid resolution is smaller than characteristic R1 for that basin. Therefore it is useful to know the distribution of R1 in the basin as well as its seasonal and interannual variations. In general, the radius R1 depends on density stratification, depth and latitude. Worldwide it varies from several kilometers at high latitudes to several hundred kilometers at low extratropical latitudes. The Black Sea is a small zonally elongated basin, thus the variation of R1 is mainly due to density profile and depth. The objective of this study is to estimate the temporal and spatial variations of the R1 in the Black sea. We used the daily reanalysis of the Black Sea provided by Copernicus Marine Environment Monitoring Service (http://marine.copernicus.eu), based on numerical hydrodynamic model implemented over the whole Black Sea basin. Further we use the selected Argo profiles in different locations and seasons in order to validate our results and check the credibility of the obtained maps.

12/ INVESTIGATING THE IMPACTS OF A STRONG MEDICANE ON THE UPPER LAYERS OF THE EASTERN MEDITERRANEAN SEA

Dimitris Kassis [1] and George Varlas [1]

1 Hellenic Center for Marine Research, HCMR, Anavyssos, Greece

dkassis(at)hcmr.gr

The Mediterranean Sea is a semi-enclosed marginal sea particularly sensitive to climatic variability, which can cause extreme atmospheric events and complex hydrological changes. Air-sea interaction mechanisms that feed deep barometric lows have significant feedback effects on wave generation and the thermohaline properties of the upper ocean layers. Such an example is the severe meteorological conditions recorded over the Eastern Mediterranean area during the autumn of 2018 when, a strong tropical-like Mediterranean cyclone, known as a “Medicane”, was formed. In this work, the impacts of the Medicane are investigated, along its track in the Ionian and Aegean seas, using all the available Argo profiles in the area. The analysis of the temperature and salinity data indicated significant variabilities in the water physical properties, changes in the heat and salt content of the upper layers, and alternations of the water budget both during, and after the presence of the cyclonic system. The results depict significant heat and salt deficits within the first meters of the water column, and highlight the dynamic oceanographic processes triggered by air-sea interactions. Furthermore it is shown that the study of such hydrological transitions at different time scales also relies on the Argo expansion in marginal seas.

13/ LEVANTINE INTERMEDIATE AND LEVANTINE DEEP WATER FORMATION: AN ARGO FLOAT STUDY FROM 2001 TO 2017

Elisabeth Kubin[1], Pierre-Marie Poulain[1,2], Elena Mauri[1], Milena Menna[1], Giulio Notarstefano[1]

1 National Institute of Oceanography and Experimental Geophysics, OGS, Sgonico (TS), Italy

2 Centre of Marine Research and Experimentation, CMRE, La Spezia, Italy

ekubin(at)inogs.it

Levantine Intermediate Water (LIW) is formed in the Levantine Sea and spreads throughout the Mediterranean, following the general circulation. Together with the Cretan Intermediate Water it is the saltiest intermediate Mediterranean water mass and exhibits relatively high temperatures.

Argo float data from 2001-2017 were analysed to investigate the formation of LIW with a special focus on winter periods and on the Northwestern Levantine Sea, the larger area around Rhodes Gyre (lat:34-37°N, lon:27-32°E).

The data from free-drifting Argo floats was used in the analysis. The study shows where, when and to which intensity LIW and also Levantine Deep Water (LDW) formation occurred. The results were then compared to integrated heat fluxes from ERA-Interim reanalyses and to satellite data from Sea Surface Height (SSH) and Sea Surface Temperature (SST).

The study revealed that typical LIW formation (formation of intermediate water with typical LIW characteristics) occurred mainly along the coastline. LIW and also LDW formation occurred during convection events within temporarily and strongly doomed eddies within Rhodes Gyre.

The LIW and LDW formation processes depend on atmospheric forcings quantified by heat losses, i.e. the preconditioning phase including heat losses in December, on the intensity of the winter and on the values of surface salinity which not only depend on atmospheric forcings but also on internal processes (i.e. EMT-preconditioning, EMT-decay).

14/ HYDROGRAPHIC CHANGES AND ARGO ACTIVITIES IN THE NORDIC SEAS AND ARCTIC

Kjell Arne Mork [1], Øystein Skagseth [1], and Henrik Søiland [1]

1 Institute of Marine Research, Bergen, Norway

kjell.arne.mork(at)hi.no

Deployment of Argo floats in the Nordic Seas started in 2001. The last year there has been several Argo float deployments in the Barents Sea and Polar Ocean. This presentation will give an overview of the Argo floats and the recent hydrographic changes in the Nordic Seas. These changes include the recent warming and freshening of the Norwegian Sea that may further modify the overflow water that exits the Nordic Seas. The first deployments of biogeochemical and deep Argo floats in the Nordic Seas happened this year as part of the new Norwegian Argo project, NorArgo2, that started in 2018. Some preliminary results from these Argo floats will be presented together with future plans of new Argo floats deployment within NorArgo2.

SESSION 3: EXTENSION OF ARGO TO BIOGEOCHEMISTRY

15/ ATMOSPHERIC AND IN-WATER RADIATIVE TRANSFER MODEL VALIDATION WITH BGC-ARGO FLOAT DATA IN THE MEDITERRANEAN SEA

Elena Terzić [1], P. Lazzari [1], G. Cossarini [1], S. Salon [1], C. Solidoro [1], F. D'Ortenzio [2], V. Vellucci [2], E. Organelli [2]

1 National Institute of Oceanography and Experimental Geophysics, OGS, Sgonico (TS), Italy

2 Sorbonne Université, CNRS, Laboratoire d'Océanographie de Villefranche, LOV, Villefranche-sur-mer, France

eterzic(at)inogs.it

In order to improve our current knowledge on marine biogeochemical processes (e.g. primary productivity, chlorophyll concentration, plankton biomass and water turbidity), it is necessary to follow up with the pace of the multi- and hyperspectral approaches in remote sensing and in-situ platforms also within the modelling community. Most ecological models, despite their increasing spatial resolutions, shorter computational times and improved biological complexity, still employ an oversimplified methodology for optical calculations, usually to predict photosynthetically available light without considering the spectral dependency. A link between radiometric quantities and biogeochemical variables can be therefore established with an enhanced description of in-water optical properties through their absorption and scattering fingerprints.

With that in mind, an ocean-atmosphere spectral irradiance model was adopted with the final aim of upgrading the existing light parametrization for the CMEMS Mediterranean Sea biogeochemistry component.

We hereby demonstrate the first findings of a 1-dimensional multi-spectral bio-optical model comparison with the BGC-Argo data set in the Mediterranean Sea (comprised of 31 profiles between 2012 and 2016) in two different ways. Firstly, in the form of a match-up of surface downwelling irradiance data from BGC-Argo floats (at three wavelengths, i.e. 380, 412 and 490 nm) versus in-water irradiance obtained with the use of the atmospheric component of the OASIM spectral irradiance model. Secondly, through an in-water three-stream radiative transfer model validation with BGC-Argo radiometric profiles. More specifically, we test different parametrizations of inherent optical properties (IOPs) of the major water constituents, i.e. pure water, non-algal particles (NAP), phytoplankton pigments and colored dissolved organic matter (CDOM), and subsequently show the configuration that gives a highest skill when comparing modelled and measured radiometric profiles.

16/ HOW MULTIVARIATE BGC-ARGO DATA ASSIMILATION CAN IMPROVE THE BIOGEOCHEMICAL COMPONENT OF THE CMEMS MEDITERRANEAN OPERATIONAL FORECAST SYSTEM

Gianpiero Cossarini [1], Anna Teruzzi [1], Stefano Salon [1], Laura Feudale [1], Giorgio Bolzon [1]

1 National Institute of Oceanography and Experimental Geophysics, OGS, Sgonico (TS), Italy

gcossarini(at)inogs.it

The increased availability of near-real time data from BGC-Argo floats, besides satellite surface chlorophyll, may improve the forecast skill of marine biogeochemical forecasting systems. In the framework of the European Copernicus Marine Environment Monitoring Services (CMEMS), the MedBFM operational system provides the short-term forecasts of Mediterranean Sea biogeochemistry and already includes the assimilation of ocean color satellite observations. The 3D variational assimilation scheme accounts for horizontal and vertical error covariances along with biogeochemical multivariate error covariances. An upgrade of the error covariance operators has been designed for the assimilation of nitrate and chlorophyll vertical profiles of BGC-Argo floats. Further, different combinations of assimilated and updated variables and different assimilation strategies (i.e., frequency of the assimilation) have been tested and evaluated against novel skill performance metrics.

Results show that daily frequency assimilation provides enough time persistence of the increments and the best assimilation performances despite the decrease of the specific impact per assimilation cycle and the increase of computational burden. Indeed, the BGC-Argo floats data assimilation has local but very positive impacts on the vertical dynamics of phytoplankton and nutrients (e.g., deep chlorophyll maximum and nutricline) and allows to improve our knowledge of the biogeochemical heterogeneity of the Mediterranean Sea.

Tuning of error covariances, a crucial aspect of the variational scheme, has been solved by using variable in time and space multivariate profiles to account for the different processes driving biogeochemical dynamics.

Finally, when float and satellite chlorophyll data are simultaneously assimilated, skill and persistency metrics appear to be affected by some inconsistency between satellite and float data. Thus, for the operational forecast system implementation, we propose a separate hierarchy of the assimilated datasets providing for the physical-biogeochemical model to act as a smoother of the state variables evolution.

17/ DYNAMICS OF DEEP PHYTOPLANKTON BIOMASS MAXIMA IN THE GLOBAL OCEAN: A BIOGEOCHEMICAL ARGO FLOATS APPROACH

Marin Cornec [1], Alexandre Mignot [2], Léo Lacour [3], Lionel Guidi [1], **Fabrizio D'Ortenzio [1]**, Antoine Poteau [1], Catherine Schmechtig [1] & Hervé Claustre [1]

1 Sorbonne Université, CNRS, Laboratoire d'Océanographie de Villefranche, LOV, Villefranche-sur-mer, France

2 Mercator Ocean International, Ramonville-Saint-Agne, France

3 Takuvik Joint International Laboratory, CNRS and Université Laval, Québec City, Québec, Canada

dortenzio(at)obs-vlfr.fr

Permanently or seasonally stratified systems are characterized by the presence of a deep chlorophyll maximum (DCM) not detected by satellites. DCMs generally develop between an upper layer where phytoplankton are nutrient-limited and a layer below where nutrients are abundant, but phytoplankton are light-limited. A DCM does not necessarily implies a deep phytoplankton (carbon) biomass maximum (DBM) because physiological responses to low irradiance result in higher chlorophyll a per phytoplankton carbon. The presence of a DBM likely reflects a combination of ample nutrient concentrations and a favorable light environment enabling phytoplankton to thrive at those depths, and an effective accumulation of organic carbon. In order to investigate the spatial and temporal variability in DBMs and DCMs in open ocean, we use a global dataset of 420 Biogeochemical (BGC)-Argo floats, located in 28 different oceanic regions, thus representing a wide range of open ocean biogeochemical conditions. We first develop a method to identify DCMs and DBMs based on the comparative vertical distribution of both chlorophyll a concentration and particulate backscattering coefficient, and then investigate the environmental parameters involved in the appearance and maintenance of those features. We show that the depths of the DCM and DBM are primarily driven by the attenuation of light in the upper layer. We further highlight that the seasonal dynamics of DBMs and DCMs are clearly region-dependent, with high latitude environments (Subpolar Gyres and the Southern Ocean) being characterized by low occurrence of intense DBMs, while in oligotrophic regions (e.g. Subtropical Gyres), permanent DCMs essentially result from photo-acclimation with DBMs occurring preferentially in summer. The most permanent DBMs are observed in Subequatorial waters, where the DCM/DBM layer develops in both favorable light and nutrient conditions. We hypothesize here that cyclonic circulation patterns (e.g as in the Guinea Dome) are responsible for the favorable environmental conditions that stimulate phytoplankton growth, in a similar way to what is observed in the North western Mediterranean Sea around the summer solstice.

SESSION 4: NEW DATASETS, ANALYSIS METHODS AND SERVICES TO USERS

18/ THE NEED FOR OCEAN DATA IN NEAR REAL TIME IN OCEAN AND COSTAL MANAGEMENT

Stig Falk-Petersen[1], Lionel Camus[1], Geir Pedersen[2], Sünnje Basedow[3], Kjell Arne Mork[4] and Salve Dahle[1].

1 Akvaplan-niva, Tromsø, Norway,
2 NORCE, Bergen, Norway,
3 UIT The Arctic University of Norway, Tromsø, Norway,
4 Institute of Marine Research, Bergen, Norway

sfp(at)akvaplan.niva.no

In Norwegian waters there are large and increasing activities including traditional fishing and whaling, new fishery based on Calanus zooplankton as well as aquaculture farms in fjords and inshore waters, and new offshore farms. The coastal waters are further exploited by increasing tourism using small local vessels and large tourist ships. Offshore, along the shelf break there is a maritime corridor with large international traffic of oil tankers, dry cargo ships and bulk carriers, we see an increased military activity including missile testing and large navy maneuvers. In addition, the coastal waters are widely used for traditional recreation and fishing by the local communities. In order to optimize the long-term yield of the marine biological resources, as well as reducing the conflict between the different user groups, and take action in case of accidents, both management and business need up to date information on the coastal environment. And there is a need for real time data transfer to stakeholders and decision makers.

Here we discuss how we can use real time remotely collected data from satellites (https://www.nature.com/articles/s41598-018-37129-x), coastal liners (https://www.niva.no/miljodata-pa-nett/ferrybox-ships-of-opportunity/hurtigruteskipet-ms-trollfjord-bergen-kirkenes), Argo buoys (https://norargo.hi.no/) and data from autonomous platforms (Gliders). The Glider fleet consists of 3 autonomous and mobile platforms; a Sea glider (Kongsberg), a Sailbuoy (Offshore Sensing) and a Wave Glider (Maritime Robotics) fitted with a suite of sensors collecting chemical, physical and biological data of the ocean space. The Glider surveys provide new data, that together with satellite and Argo data, significantly will increase our our understanding of the dynamic and timing of biological events over spatial and temporal scales. Further, data are being analysed to study how the large meso scale eddies off the Northern coast of Norway structure the zooplankton (Calanus finmarchicus), fish larvae, and fish distribution and how these can be related to the migration of marine mammals and mesopelagic fish layers.

19/ DELAYED MODE QUALITY CONTROL OF ARGO FLOATS IN THE NORDIC SEAS

Ingrid M. Angel-Benavides[1] and Birgit Klein[1]

[1] Bundesamt für Seeschifffahrt und Hydrographie, BSH, Hamburg, Germany

ingrid.angel(at)bsh.de

Data collected by Argo floats undergo a strict Delayed Mode Quality Control (DMQC) procedure to ensure its scientific quality. The correction of salinity errors due to drifts in the conductivity sensors is based on the method described in Owens and Wong (2009). It requires historical hydrographic data to estimate a climatological reference salinity for the profile's position and time using objective mapping. Therefore, an appropriate correction requires a CTD Reference Database (CTD-RD) with a temporal and spatial coverage that allows a realistic estimate of such reference. For this end, the DMQC operators use a common CTD-RD covering the entire globe, centrally-maintained by the Coriolis/Ifremer team.

The Nordic Seas, where warming and salinification trends have been observed in the 2000 m (Latarius and Quadfasel, 2010; Lauvset et al., 2018), are underrepresented in the latest CTD-RD version (2018 v02). Only a few profiles (~50) collected in this decade are found, potentially compromising the DMQC efficiency. An in-house built CTD-RD for the region, based on quality controlled data from the Unified Database for Arctic and Subarctic Hydrography (UDASH, Behrendt et al, 2018) developed at AWI (Alfred Wegener Institute) and the International Council for the Exploration of the Sea (ICES) Oceanographic database, is used to assess the effects of an improved CTD-RD in the DMQC procedure.

20/ THE BGC-ARGO FLOATS: A NEW TOOL TO VALIDATE OCEAN BIOGEOCHEMICAL MODELS

Alexandre Mignot [1], Hervé Claustre [2], Gianpiero Cossarini [3], Fabrizio D'Ortenzio [2], Elodie Gutknecht [1], Julien Lamouroux [1], Paolo Lazzari [3], Coralie Perruche [1], Stefano Salon [3], Raphaëlle Sauzède [2], Vincent Taillandier [2], Anna Teruzzi [3]

1 Mercator Ocean International, Ramonville-Saint-Agne, France

2 Sorbonne Université, CNRS, Laboratoire d'Océanographie de Villefranche, LOV, Villefranche-sur-mer, France

3 National Institute of Oceanography and Experimental Geophysics, OGS, Sgonico (TS), Italy

mignot(at)mercator-ocean.fr

Numerical models of ocean biogeochemistry are becoming a major tool for a wide range of applications, from environmental monitoring and short-term forecasts to multi-decadal studies. The validation of such models is strongly limited by the availability of data as it relies principally on comparison with climatologies, few permanent fixed oceanic stations and surface observations from satellite. Therefore, with these datasets, it is not possible to evaluate how models represent many climate-relevant biogeochemical processes. These limitations have now been overcome with the availability of a large number of vertical profiles of light, pH, oxygen, nitrate and chlorophyll-a concentrations acquired by the Biogeochemical-Argo (BGC-Argo) floats network. Additionally, other key biogeochemical variables such as nutrients, dissolved inorganic carbon and alkalinity, not measured by the floats, can be predicted by neural network methods from the floats temperature, salinity and oxygen concentration. In this presentation, we show an overview of the new validation capabilities that are now possible thanks to BGC-Argo floats observations. We focus on model systems used in operational programs, at regional and global scales.

21/ MULTI-SCALE PRODUCTS FROM ARGO FLOAT DEPLOYMENTS DURING REGIONAL CRUISES

Ignasi Vallès-Casanova [1], Dorleta Orue-Echevarria [1], Joaquín Salvador [1], Josep L. Pelegrí [1]

1 Institut de Ciències del Mar, CSIC, Barcelona, Spain

valles(at)icm.csic.es

Here we show temperature and salinity maps obtained from Argo floats and different devices used in an oceanographic cruise carried out in the Brazil Malvines Confluence in April 2017. The floats deployed from the vessel were set up to have a high-frequency cycling of once per day during the 20-days period of the cruise before their 10-day cycle configuration. Other Argo floats that were already in the area were also included. This strategy increments substantially the study area and number of sampling locations allowing us to compute 3D grids of temperature and salinity data with different spatial and temporal resolution. The results allows a better understanding the frontal system of Brazil-Malvines Confluence in different scales. It is also a good example of multi-platform strategy that improves the efficiency of an oceanographic campaign as a result of a highly beneficial synergistic effort of Euro-Argo and a research team.

SESSION 5: TECHNOLOGICAL INNOVATIONS: PRESENT & FUTURE

22/ ASSESSMENT OF LONG-TERM SALINITY STABILITY OF THE RBRARGO CTD

Nikolay Nezlin [1], **Mark Halverson 1**, Jean-Michel Leconte [1], Greg Johnson [1]

1 RBR Ltd., Ottawa, Canada

mark.halverson(at)rbr-global.com

High salinity drift rates in Argo data are a problem widely recognized by scientific community. In this study, we assess the long-term salinity stability of profiling floats equipped with RBRargo CTDs. RBRargo CTDs are freely flushing, unpumped conductivity cells. As inductive cells, they require very little power, have no exposed metal parts, and can sample up to the sea surface.

Detecting salinity bias and long-term drift in Argo floats is difficult because there are rarely, if ever, simultaneous measurements to serve as a reference. Natural water mass variability further complicates the analysis. In this study, we combine several methods to assess the stability of RBRargo conductivity sensors. The preliminary analysis was based on a comparison of float salinities to World Ocean Atlas subthermocline climatology. Comparison of the 1/4° WOD18 climatology (2005 - 2017) indicates that the RBRargo CTD conductivity exhibits virtually no drift. For example, float #5904925, a Teledyne Webb Research APEX equipped with an RBRargo CTD, drifted at an average rate of -0.002 PSU per year relative to climatological values in the four years since it was deployed.

Next, a more rigorous assessment was made with the Owens and Wong (2009) approach, which includes objective mapping of reference data and piecewise linear fitting to the errors to detect variable drift rates. This method ideally requires a large number of high quality reference profiles near the test floats (e.g., delayed-mode Argo profiles). Three of the floats were deployed in early 2018. Unfortunately, concurrent delayed-mode profiles and WOD CTD data were not yet available at the time of writing. What is clear at this stage of the analysis, however, is that the salinity drift rates appear to be very low for these newer floats when compared to WOA values.

23/ SATELLITE SERVICES FOR OCEAN OBSERVATION PROGRAMS

Brice ROBERT [1] and **Solène ROUTABOUL [1]**

1 Collecte Localisation Satellites, CLS, Ramonville, France

sroutaboul(at)groupcls.com

CLS has been a key partner of all major Ocean Observing systems for over 30 years including ARGO, DBCP, Ocean Gliders, and many others. CLS, subsidiary of CNES, is the operator of the ARGOS system and unique provider of both ARGOS & IRIDIUM satellite telemetry services. For over 30 years, CLS has provided satellite services to ocean sciences community, working closely with most oceanographic & meteorological institutes globally, in order to implement satellite telemetry solutions for remote observations, and to facilitate & optimize the transmission, processing and delivery of critical data from ocean observing systems that underpin ocean, atmosphere and climate research. In the frame of ARGO, CLS provides a range of satellite telemetry services, as well as a dedicated data hosting platform service, a unique solution tailored to the needs of the community developed and maintained in collaboration with all major float manufacturers. In addition, CLS is a world leader in Altimetry data processing, and collaborates with ocean observing systems (including ARGO), in order to validate & calibrate in-situ measurements. Last, CLS is also leading projects at the edge of innovation for ocean observations, combining satellite telemetry expertise, in-situ measurements, and cross calibration/validation with satellite measurements. CLS offers to present an overview of the main innovative satellite services for ocean and meteorological data collection, with a focus on their application in the context of the ARGO international network. The main points that will be presented are: - The recent & critical evolutions of the ARGOS & Iridium satellite telemetry systems, and how these will enhance the data collection for autonomous platforms - CLS value-added services for met/ocean users (data web-display, decoding, GTS feeding, data hosting, etc.), and the recent evolution of CLS data hosting service for ARGO floats. - CLS will also introduce a new portfolio of data services that can be very useful to ARGO users: o high-quality state-of-the-art ocean data sets for scientists o A new generation of data vizualisation & platforms fleet management tool, that can be used by ARGO membersto monitor data, metadata as well as vital paramaters from their floats.

24/ PAST AND NEW TECHNOLOGICAL DEVELOPMENTS AT LOV FOR CORE AND NEW BGC APPLICATIONS

Edouard Leymarie [1], Antoine Poteau [1], Christophe Penkerc'h [1], Nour Alem [1], Alice Pierret [1], Vincent Taillandier [1], Fabrizio d'Ortenzio [1] et Hervé Claustre [1]

1 Sorbonne Université, CNRS, Laboratoire d'Océanographie de Villefranche, LOV, Villefranche-sur-mer, France

leymarie(at)obs-vlfr.fr

For more than 10 years, the Laboratoire d'Océanographie de Villefranche (LOV) has been working with sensor and float manufacturers to improve the capabilities of BGC-Argo floats. This work has enabled the recent deployment of the first float equipped with all 6 recommended BGC core variables together with greater mission flexibility and a higher acquisition depth resolution. This technical work on the core BGC-Argo mission has also been complemented by some prospective studies towards new applications on floats, including advanced radiometry (ProVal project), passive acoustics, under-ice capabilities (NAOS deployments in Baffin Bay) and measurement of particle size distribution (UVP: Underwater Video Profiler). These developments have been made possible in part thanks to the use of a dedicated electronic board allowing new applications to be integrated on the float directly by the research team.

The aim of this presentation is to show the achievements of past developments as well as on-going and future technical projects for both the core BGC-Argo and new applications including a new nitrate sensor and hyperspectral radiometry in the framework of the EA-RISE project, as well as ever improving passive acoustics and measurement of particle size distribution. Energy consumption, on-board processing and data transmission will be addressed, as well as the simultaneous use of these different sensors on the same float.

25/ NKE RECENT FLOAT EVOLUTIONS

Jérôme SAGOT [1]

1 NKE Instrumentation, Hennebont, France

jsagot(at)nke.fr

All type of NKE float (ARVOR, DEEP ARVOR, PROVOR BGC) have received in 2019, new evolutions to :

- improve reliability (software improvement for grounding behaviour after detection, Hydraulic design changes on DEEP-ARVOR, ...),
- add new function requested by community (Pressure automatic mission start for deployment by opportunity ship, new sampling zone after grounding for DEEP-ARVOR, ...)
- improve BGC floats with new electronic and software architecture to embbed new sensors easily and increase sampling capability.

26/ OBSERVING THE OCEAN WITH DEEP APEX FLOATS

Brian KING [1]

1 National Oceanography Centre, Southampton, United Kingdom

bak(at)noc.ac.uk

The UK deployed 12 Deep APEX floats between December 2015 and November 2018. Some have been a success, others have had problems, with a mixture of both early and later failures. The deepest profiles have been to 5600 dbar in the western basin of the North Atlantic on the 26N line. The presentation will review the problems and the actions taken by the manufacturer to fix them, and present results from the floats that have worked best. The longest-lived float has completed 187 cycles in Drake Passage and is still active in June 2019. The UK has 6 Deep APEX due to be delivered in 2019 for deployment in 2020.

POSTERS

SESSION 1: MESO-TO-LARGE SCALE OCEAN STRUCTURE AND VARIABILITY

1/ TEMPORAL VARIABILITY OF THE NORDIC SEAS INTERMEDIATE AND DEEP WATER PROPERTIES BASED ON ARGO FLOATS DATA IN 2008-2017 PERIOD.

Małgorzata Merchel [1], Waldemar Walczowski [1]

1 Institute of Oceanology Polish Academy of Sciences, Sopot, Poland

merchel(at)iopan.gda.pl

The Nordic Seas play an important role in global climate change. Compared with other areas, this region has the largest ocean surface and air positive temperature anomalies in the world. It is particularly important for the water masses formation and modification and for interactions between the ocean and atmosphere. This region is also the main route for freshwater and heat exchange between the North Atlantic and the Arctic Ocean.

Every summer the Institute of Oceanology, Polish Academy of Sciences conducts measurements along more than 10 hydrographic sections, including about 200 stations and covering the area between northern Norway and Fram Strait. This time series allowed us to analyze how the parameters of the intermediate and deep water have changed over the last decade.

However, because the ship-borne measurements are performed usually during the spring to the autumn season, there is no data to analyze seasonal changes in the intermediate and deep water. The Argo floats, operating throughout the whole year, allow observation of seasonal changes that occur in particular regions. This is especially important in the Nordic Seas, where conditions of the oceanographic observations are very difficult even during the summer.

In this study we compare the summer hydrographic data collected by IO PAN with the data from Argo floats in the Nordic Seas region in 2008-2017. Based on the data, both the temporal and spatial variability of the basic physical parameters of the intermediate and deep water were analyzed. It allowed determining how the parameters of these waters changed both seasonally and spatially.

The study was funded by the Ministry of Science and Higher Education, Poland under grant agreement No. DIR/WK/2016/12 for the research infrastructure EURO-ARGO ERIC and the National Science Centre, Poland within the DWINS Project (2016/21/N/ST10/02920).

2/ REKINDLING THE DEBATE ON THE FAR REACHING EUROPEAN CONTINENTAL SLOPE CURRENT AND ITS INFLUENCE ON SUBPOLAR NORTHEAST NORTH ATLANTIC DYNAMICS – ARGO AND MODEL OUTPUT DATA PERSPECTIVES

Angelina Smilenova[1,2], Kieran Lyons[2], Yves Reecht[3], Loïc Houpert[4], Jonathan Gula[5], Mathieu Le Corre[5], Nicolas Kolodziejczyk[5] , Penny Holliday[4]

1 Earth and Ocean Sciences, School of Natural Sciences, National University of Ireland, Galway (NUIG), University Road, Galway, Ireland, H91 TK33
2 Oceanographic Services, Ocean Sciences and Information Services (OSIS), Rinville, Co. Galway, Marine Institute, Ireland, H91 R673
3 Institute for Marine Research (IMR), Bergen, Norway
4 National Oceanography Centre (NOC), European Way, Marine Physics and Ocean Climate Division (MPOCD), Southampton, England, UK, SO14 3ZH
5 Laboratoire d'Océanographie Physique et Spatiale (LOPS), Institut Universitaire Européen de la Mer (IUEM), Rue Dumont d'Urville, 29280, Plouzané, France

Angelina.Smilenova(at)Marine.ie

The Rockall Trough (RT) is a deep channel in the northeast North Atlantic (NA). It falls in close proximity to the eastern boundary of the NA subpolar gyre, which is an area of relatively high mesoscale activity. Both anticyclonic and cyclonic eddies are persistent regional features, providing kinetic energy (65-100 cm2 s-2) for both vertical and lateral mixing, as well as isopycnal displacement.
The region's mesoscale activity, as noted in literature, is strongly influenced by interactions between north-eastward flowing North Atlantic Current (NAC) sub-branches and bottom topography at approximately 20° W. The region's mesoscale settings are further strongly influenced by bottom topography - continental slope current (SC) interactions, which, in the southern section of the trough, have not been thoroughly investigated previously.
We performed an in-depth analysis of a recurrent, non-stationary anticyclone, at times centred between the 15°-16° W and 53°-54° N longitudinal and latitudinal bands using ship-board in-situ data sets, model output using the Coastal and Regional Ocean COmmunity model (CROCO) and AVISO altimetry absolute dynamic topography. Our analysis showed that the anticyclone is the results of the merging of smaller anticyclones, due to bottom topography - SC interactions along the southeast banks of the trough. High ship-board in-situ-derived salinity and temperature anomalies within the Mediterranean Overflow Water (MOW) regional depth (750-1100 m) and density (27.41 – 27.60 kg m-3) ranges, found within the anticyclone's deep core, support model-based deductions on the locality of the eddy generation mechanism, where interactions between MOW-rich, poleward flowing SC and bottom topography lead to anticyclonic (and cyclonic) vortices pinch off. Our findings thus brought new insights on the generation and water masses origin of the central RT anticyclone, formerly suggested and noted in the literature as a spin-off from instabilities of a NAC sub-branch, flowing into the trough.
Here, we further check and extend our previous analysis to regional and larger scale northeast Atlantic. We employ the following freely available data sets and tools: delayed mode processed Argo in-situ data set, ISAS-15, Global Reanalysis (GLORYS) PHY-001-025, eddy-permitting (1/4°) model output data set, and Ariane (offline Fortran-based Lagrangian particle tracking tool, computing three-dimensional streamlines from velocity fields). ISAS-15 Argo data set aids us to extend temporal and spatial analysis of the water column structure with respect to water masses, present in the region, thus allowing for the detection of the central RT anticyclone signal and interpretations of its vertical structure. GLORYS output data, in conjunction with Ariane allow for investigations into the pathways and thus origin of water masses, encapsulated in the anticyclone's core. Our Argo, ISAS-15-based water masses analysis and Ariane particle tracking within the MOW upper and lower veins depth ranges, based on GLORYS model output u,v (m s^{-1}) velocity components, complement our initial findings of the anticyclone's generation and core water masses origins. Our preliminary particle tracking analysis shows that the MOW reaches the RT and penetrates deep into the trough, also spreading westward of the trough's southern approach, into the northeast NA subpolar gyre, encapsulated in (sub)mesoscale eddies.
Findings presented here carry significance, as the locally generated (sub)mesoscale features in the southern section of the RT, and their northward and westward propagations, and dissipations, could potentially have direct/indirect impact on the large-scale subpolar northeast NA dynamics, mode and deep waters formation in particular, as they introduce additional salt and heat into the northeast NA subpolar gyre.

3/ INTERANNUAL VARIABILITY OF UPPER OCEAN WATER MASSES AS INFERRED FROM ARGO ARRAY

Nicolas Koldoziejczyk [1], William Llovel [2], Esther Portela[1]
1 LOPS / UBO, Université de Bretagne Occidentale, Brest, France
2 LEGOS, Toulouse, France

nicolas.kolodziejczyk(at)univ-brest.fr

Interannual variability of Ocean Heat Content (OHC) is intimately linked to ocean water mass changes. Water mass characteristics are imprinted at the ocean surface and are modulated by climate variability on interannual to decadal time scales. In this study, we investigate the water mass change and their variability using an isopycnal decomposition of the OHC. For that purpose, we address the thickness and temperature changes of these water masses using both individual temperature-salinity profiles and optimal interpolated products from Argo data. Isopycnal decomposition allows us to characterize the water masses interannual variability and decadal trends of volume and OHC. During the last decade (2006–2015), much of interannual and decadal warming is associated with Southern Hemisphere Subtropical Mode Water (STMW) and Subantarctic Mode Water (SAMW), particularly in the South Pacific Eastern Subtropical Mode Water (SPESTMW), the Southeastern Indian Subantarctic Mode Water (SEISAMW) and the Southern Pacific SAMW (SPSAMW). In contrast, Antarctic Intermediate Water (AAIW) in the Southern Hemisphere and North Atlantic STMW (NASTMW) in the Northern Hemisphere have cooled. This OHC interannual variability is mainly explained by volume (or mass) changes of water masses related to the isopycnal heaving. The forcing mechanisms and interior dynamics of water masses are discussed in the context of the wind stress change and ocean adjustment occurring at interannual time scale. 23

4/ NORTH-ATLANTIC OCEAN SUBTROPICAL GYRE: NEW OBSERVATIONS AND MECHANISMS OF LOW-FREQUENCY VARIABILITY

MAZE Guillaume [1], BALEM Kevin [1] and PENDUFF Thierry [2]
1 Ifremer/LOPS, Plouzané, France
2 Institut des Géosciences de l'Environnement, Grenoble, France

gmaze(at)ifremer.fr

Using Argo based recent ocean analysis and historical datasets going back to the 1960s, we diagnosed the low-frequency variability of the North-Atlantic Ocean Subtropical Gyre stratification key components: the Eighteen Degree Water, the permanent pycnocline and the Gulf Stream Extension. We have found a 2005-2015 quasi-decadal trend of reduced EDW heat content due to a combined reduction of its volume and temperature. These changes are explained by modified EDW formation region properties and wind-driven reduced overturning circulation. We will put these recent changes into a more historical context of multi-decadal trends of the North-Atlantic Western Boundary system determined using a new statistical approach based on un-supervised classification of profiles. The robustness of the signal will be discussed using an ensemble approach. This work is part of the CNRS/LEFE SOMOVAR and OST/ST PIRATE projects.

SESSION 2: MARGINAL SEAS WITH A FOCUS ON THE MEDITERRANEAN & BLACK SEAS

5/ CLIMATE CHANGE AND REGIONAL OCEAN WATER MASS DISAPPEARANCE IN THE BLACK SEA

Emil Stanev [1], Elisaveta Peneva [2], **Boriana Chtirkova [2]**

1 Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

2 Sofia University "St. Kliment Ohridski", Sofia, Bulgaria

bchtirkova(at)gmail.com

Data from autonomous profilers Argo for the period 2005-2018 reveal that climate change in the Black Sea could lead to the disappearance of the cold intermediate layer (CIL). The trend of the CIL temperature of ~0.05°C/yr was more than double of the trend in previous decades, and its temperature approached that of the waters in the deeper layers (~9°C). This evolution was due to the warmer winters over the last fourteen years. Intermittent major cold water formation events (only three during this period) could not sufficiently refill the CIL.

A dynamic T-S analysis, represented by the position of a current T-S pair in respect to time and depth, is made to assemble the relationship between the thermohaline states of the Black Sea. The variability in the T-S relationships at given σt levels in the CIL revealed trends dominated by diapycnic mixing with deeper layers (the high-salinity pool acts as a source of salt for the upper ocean).

After 2010, salinity anomalies started to occur rhythmically with increasing amplitudes at the depths of the CIL. In the absence of a pronounced CIL in recent years, the relative role of salinity variability in the thermohaline state of the upper layers increased.

6/ A NEURAL NETWORK APPROACH TO ESTIMATE WATER-COLUMN NUTRIENT CONCENTRATIONS AND CARBONATE SYSTEM PARAMETERS IN THE MEDITERRANEAN SEA: CANYON-MED

Marine Fourrier [1], Laurent Coppola [1], Fabrizio D'Ortenzio [1], Hervé Claustre [1]

1 Sorbonne Université, CNRS, Laboratoire d'Océanographie de Villefranche, LOV, Villefranche-sur-mer, France

fourrier(at)obs-vlfr.fr

The semi-enclosed nature of the Mediterranean Sea, together with its small inertia due to the relatively short residence time of its water masses, make it highly reactive to external forcings and anthropogenic pressure. In this context, several rapid changes have been observed in physical and biogeochemical processes in recent decades, partly masked by episodic events and high regional variability. To better understand the underlying processes driving the Mediterranean evolution and to anticipate changes, the measurement and integration of many climatic and biogeochemical variables are mandatory.

In the context of a critically undersampled ocean, the development and intensive use of instrumented in situ autonomous platforms will allow to densify the measurements of some biogeochemical variables. However, the measurements carried out by in situ autonomous platforms are not exhaustive.

The CANYON-MED (for Carbonate system and Nutrients concentration from hYdrological properties and Oxygen using a Neural-network in the MEDiterranean Sea) neural network-based method provides estimations of nutrients (i.e. nitrates, phosphates and silicates) and carbonate system parameters (i.e. total alkalinity, dissolved inorganic carbon, pHT) from systematically measured oceanographic variables such as in situ measurements of pressure, temperature, salinity, and oxygen together with geolocation and date of sampling.

This method allows for the prediction of nutrients with satisfactory results: accuracies of 0.83, 0.052, and 0.85 µmol.kg-1 for nitrates, phosphates and silicates concentrations respectively, and 0.017, 12 µmol.kg-1 and 14 µmol.kg-1 for pHT, total alkalinity and dissolved organic carbon respectively.

CANYON-MED will therefore generate "virtual" data of parameters not yet measured by BGC-Argo floats. Applied to the large Argo network, CANYON-MED may contribute to quality control and delayed mode processing for nitrates and pHT as well as to increase the amount of biogeochemical data in the Mediterranean Sea, fill the gaps in time-series, dramatically improving our understanding of nutrients, pH and pCO2 variability of the basin.

7/ LONG-TERM VARIABILITY OF THE BLACK SEA COLD INTERMEDIATE LAYER PROPERTIES

Nadezhda Valcheva [1], Veselka Marinova [1]

1 Institute of Oceanology - Bulgarian Academy of Sciences

valcheva(at)io-bas.bg

Representing the interface between surface and deep waters, the Cold Intermediate Layer is a distinctive feature of the Black Sea thermo-haline dynamics. The presence of cold intermediate waters is extremely important for the Black Sea ecosystem because they are rich in oxygen and mark the upper boundary of the anoxic zone. Therefore, more than 5000 temperature profiles originating from both in-situ shipboard and Argo profiling floats observations were used to explore spatial and temporal variability of various cold intermediate layer properties such as thickness and core temperature at mesoscale and seasonal to inter-annual scales.

The main finding is that the cold intermediate layer thickness shows a steady decreasing trend as it dropped by more than half in the course of the study period, with 35 to 60 m depending on season and subregion. The analysis shows this is primarily related to shoaling of the layer's lower limit. This is considered as a consequence of not efficient cooling, which weakens ventilation of intermediate waters and results in only a partial replenishment with cold waters. Ever since 1995, the intensity of this process has been reducing with several exceptions observed in 2003, 2004, and 2006, which corresponds to mean climatic conditions. The layer even disappeared in 2011 and 2015-2016.

Concurrently, the core temperature has risen with about 2.0°C over the study period. This growth is related to the increased surface warming during the past 10 years. It can be concluded that the upper layer thermal properties are modified as a result of temperature rise. After the disruption in 2015-2016, the layer has recovered but its cooling potential is considerably reduced. This represents a major threat since it can negatively affect the Black Sea thermo-haline balance and ecosystem function.

8/ MOCCA PROJECT

Romain Cancouët [1] and MOCCA consortium

1 Euro-Argo ERIC, Brest, France

Romain.cancouet(at)euro-argo.eu

Presentation of the MOCCA project, outcomes and developments undertook in WP4 data processing

9/ ARGO MISSIONS AND SYNERGIES WITH OTHER PLATFORMS IN MARGINAL SEAS: THE NORTH AEGEAN AND SOUTH IONIAN TEST CASES

Dimitris Kassis [1] and Gerasimos Korres [1]

1 Hellenic Center for Marine Research, HCMR, Anavyssos, Greece

dkassis(at)hcmr.gr

Being one of the strategic targets of Euro-Argo ERIC, the monitoring of marginal seas has accentuated during the last five years. In-line with this agenda, single Argo missions or synergetic deployments with additional monitoring platforms have been carried out that focus on areas of specific oceanographic interest. In this work the preliminary results and outcomes of two such missions in the north Aegean and south Ionian areas are presented. Both floats were deployed by the Greek Argo Research Infrastructure team under the framework of MOCCA project which is coordinated by the Euro-Argo ERIC and is co-funded by the European Maritime and Fisheries Fund (EMFF). The first float, which was deployed in April 2017, has been acquiring profiles in the coastal area of northwest Aegean and providing interesting information on the alternation of the dominant water masses and thermohaline variability in the area; its trajectory highlighted mesoscale circulation features of the area following a cyclonic system for more than a year Furthermore, its mission has shown that an Argo float can successfully operate in shallow waters.. The second float was deployed in May 2018, 15 km offshore south-west Peloponnese coast, along with the deployment of the EMSO - Hellenic Arc seabed cabled observatory. The float was configured to perform daily profiles down to 1600 m depth sampling the deep oceanic environment next to the multidisciplinary sea-bed platform. The results of such joint monitoring have shown to be in good agreement with both temperature and salinity records amongst the two platforms. Moreover, this mission has been the first step towards a close collaboration between Euro-Argo and EMSO, the two largest Research Infrastructures regarding ocean monitoring. Such collaboration will advance the monitoring capacity of both physical and biogeochemical processes ranging from the sea surface to the seabed.

10/ SYNECHOCOCCUS IN THE BLACK SEA – AN ALTERNATIVE EXPLANATION OF THE DEEP RED FLUORESCENCE SIGNAL

Presented by Nadezhda VALCHEVA

Cristiana Callieri [1], Violeta Slabakova [2], Nina Dzhembekova [2], Nataliya Slabakova [2], Elisaveta Peneva [3], Pedro J. Cabello-Yeves [4], Andrea Di Cesare [1], Ester M. Eckert [1], Roberto Bertoni [1], Gianluca Corno [1], Michaela M. Salcher [5,6], Lyudmila Kamburska [2], Filippo Bertoni[7], Snejana Moncheva [2]

1 National Research Council CNR-IRSA, Microbial Ecology Group,Verbania, Italy

2 Institute of Oceanology "Fridtoff Nansen"-Bulgarian Academy of Sciences, Varna, Bulgaria

3 Sofia University "St. Kliment Ohridski, Faculty of Physics, Sofia, Bulgaria

4 Evolutionary Genomics Group, Departamento de Producción Vegetaly Microbiología, Universidad Miguel Hernández,San Juan de Alicante, Spain

5 Department of Earth, Environmental and Life Sciences, University of Genoa, Genoa, Italy

6 Limnological Station, Institute of Plant and Microbial Biology, University of Zurich, Kilchberg, Switzerland

7 Museum für Naturkunde, Berlin, Germany

valcheva(at)io-bas.bg

The Black Sea is known as the largest anoxic basin in the world. The dissolved oxygen concentration decreases very rapidly to zero below ~100 m depth due to the strong stratification and limited winter convection. Several autonomous Argo floats equipped with a Chlorophyll *a* (Chl *a*) sensor were deployed since 2013 and revealed an unexpected signal increase below 200 m down to 1000 m depth. The profiles showed consistently the same pattern over the whole basin. This performance was attributed to the poorly understood fluorescence signal called "deep red fluorescence", a (Chl *a*) like signal found in deep dark oceanic waters. Samples taken in two cruises in 2015 and 2016 found up to 103 cells ml^{-1} of picocyanobacteria at 750 m depth in these waters. We isolated two phycoerythrin-rich *Synechococcus* sp. strains (BS55D and BS56D) from these mesopelagic waters. Tests on BS56D revealed its high adaptability, involving the accumulation of Chl *a* in anoxic/dark conditions and its capacity to photosynthesize when re-exposed to light. This study supports early speculations associating the "deep red fluorescence" signal to viable picocyanobacteria populations in the deep oxygen-depleted oceans, suggesting a reconsideration of the ecological role of a viable stock of *Synechococcus* in dark deep waters.

11/ HIGH-FREQUENCY VARIABILITY OF TEMPERATURE AND SALINITY PROFILES IN THE MEDITERRANEAN SEA AS REVEALED BY ARGO FLOATS

P.-M. Poulain [1], G. Notarstefano [1] and M. Pacciaroni [1]

1 National Institute of Oceanography and Experimental Geophysics, OGS, Sgonico (TS), Italy

ppoulain(at)inogs.it

Since 2014 a few Argo floats have been operated in the Mediterranean Sea (Northern Adriatic, Sicily Channel, Ligurian Sea and Alboran Sea) with a cycling period of 3 or 6 h in order to measure the variability of the thermohaline properties due to internal waves and tides. Two float designs were used: the Arvor-C and the Arvor-I. They provided data with a vertical resolution of 1 m between the surface and 150-350 m depth. The strongest high frequency signals were measured in the western Alboran sea with internal semidiurnal tides (M2) as large as 30 m in the thermocline between 50 and 150 m. In April 2019, a float even measured an extreme event (soliton) displacing the 27 sigma-theta isopycnal from less than 60 m to more than 130 m in about 6 h. Further to the east in the Mediterranean, in particular in the Sicily Channel, internal waves precluded with amplitudes of 5-10 m. These results reveal that Argo data sampled with the standard cycling period of 5 or 10 days can be drastically biased in sea areas where internal waves/tides dominate.

12/ ADAPTING ARGO FLOATS TO THE BALTIC SEA: LESSONS LEARNED

Simo Siiriä [1], Laura Tuomi [1], Petra Roiha [1], Pekka Alenius [1], Noora Haavisto [2], Tero Purokoski [1]

1 Finnish Meteorological Institute, FMI, Helsinki, Finland

2 University of Helsinki, Tvärminne Zoological Station, Helsinki, Finland

simo.siiria(at)fmi.fi

Baltic Sea presents unique challenges and opportunities for Argo operations not present on open oceans. The shallow brackish water, relatively small area and strong haloclines require careful consideration of where, and how the floats can be operated. As FMI has been operating the Argo floats in the northern Baltic Sea since 2012. Most of these challenges have been overcome, and the experimentation is turning into operational infrastructure.

Main challenges are confining the float to given area, preventing drifting on-shore or excess bottom contacts, and ensuring the capability of the float to dive through haloclines in the planned area. Float's diving frequency and depth can be controlled during the mission with the two-way communication. This helps to confine the float to target area, although it does require active controlling. The floats used are balanced specifically for each basin, to ensure they can operate on the densities present. Advantages of the Baltic Sea operations is, that it is possible to recover the floats at the end of their lifetime and thus reuse them.

Further developments will include developing more automatic controlling of the Argo floats and defining good practices of under-ice activities. Ice-avoidance is important on the northern Baltic Sea, and it works as a good test-bed for the Arctic and Antarctic. Another area of development is the quality-control of the data, as the typical QC algorithms are unsuitable for Baltic Sea conditions. All these challenges are being addressed on the E-ARISE project.

SESSION 3: EXTENSION OF ARGO TO BIOGEOCHEMISTRY

13/ IS IT POSSIBLE TO DETECT EMILIANIA HUXLEYI BLOOMS WITH BIOGEOCHEMICAL-ARGO FLOATS?

Louis Terrats [1], Griet Neukermans [1], Marin Cornec [1], Antoine Mangin [2] & Hervé Claustre [1]

1 Sorbonne Université, CNRS, Laboratoire d'Océanographie de Villefranche, LOV, Villefranche-sur-mer, France

2 ACRI-ST, Sophia Antipolis, France

louis.terrats(at)obs-vlfr.fr

Coccolithophores are calcifying phytoplankton which produce calcite plates that surround their cells and called coccoliths. Emiliania huxleyi is the dominant coccolithophore species in high latitudes environments. It can form extensive blooms which, when they collapse, release large amounts of detached coccoliths in surrounding waters. Accumulations of these highlyrefractive coccoliths are responsible for an increase in light back-scattered from the surface ocean and hence for milky-turquoise color waters discernable from space. Here we address the possibility to track E. huxleyi blooms from Biogeochemical-Argo (BGC-Argo) floats. We started our analysis with the few floats that measured, in addition to the Chlorophyll-a concentration ([Chla]) and the particle backscattering coefficient (bbp), the particle attenuation coefficient (cp, measured through a transmissiometer). The ratio of bbp/cp is indeed a proxy of the particle backscattering ratio, itself a proxy of the particle refractive index. Based on a match-up analysis using satellite detection of E. huxleyi blooms, we identified two floats that were drifting in patches of E. huxleyi blooms. We evidenced the strong correspondence between the satellite detection of E. huxleyi blooms and the associated increase in bbp/cp measured in-situ. We then widened the approach of the in-situ detection of E. huxleyi blooms to the ratio of particle backscattering to chlorophyll-a concentration, bbp/[Chla]. This ratio is the only potential proxy measurable by the whole BGC-Argo fleet (transmissometers being not core sensors). We showed that bbp/[Chla] allows distinguishing E. huxleyi bloom waters from others, e.g. diatom-dominated ones. Our results open a new field of research applications by enabling the study of a single species with the BGC-Argo fleet. Furthermore, it might support new research dedicated to E. huxleyi blooms, not only concerning the environmental control of their development but also in their implication on carbon export.

SESSION 4: NEW DATASETS, ANALYSIS METHODS AND SERVICES TO USERS

14/ OSNET: OCEAN STATE NEURAL NETWORK

Sean Tokunaga [1] & Guillaume Maze [1]

1 Ifremer/LOPS, Plouzané, France

sean.tokunaga(at)ifremer.fr

In order to determine the ocean's low frequency variability (sub-annual and beyond), it is necessary to define a reference state, i.e. a climatology. This requires information about the ocean's three-dimensional thermo-haline structure from in-situ observations. This has historically been synthesized using optimal approaches based on linear Gaussian statistics that have a significant drawback: a strong smoothing resulting in a loss of information. Developing ocean climatologies that can retain as much signal as possible from observations remains a statistical challenge.

Here, we propose a new approach we call OSnet ("ocean state neural network"). We will present OSnet and its possible applications in physical oceanographic studies as well as in data management of in-situ observations (quality control).

OSnet is a model that takes only localization parameters (longitude, latitude, pressure) and possibly sea surface height, as inputs and predict thermo-haline properties anywhere in the ocean. The specific and added value of OSnet compared to other models is that (i) it does not rely on an interpolation of observations onto a regular grid (ii) it can take into account dynamical information provided by altimetry and (iii) it automatically and implicitly determines the best covariance scales, limiting the amount of unnecessary smoothing.

OSnet is based on a fully connected neural network trained on 15 years' worth of ARGO data quality controlled for research (2001 - 2016). At this point, OSnet is able to predict sub-annual variations with similar accuracy to state of the art ocean state climatology (eg: ISAS15). We will present an evaluation of OSnet's performance in terms of seasonal predictions and description of gradients in frontal regions like the Gulf Stream and Kuroshio. We will also present a method to determine OSnet's prediction errors based on an ensemble of neural networks.

15/ DEVELOPMENT OF ICE SENSING ALGORITHMS FOR ARGO FLOAT DEPLOYMENTS IN POLAR REGIONS

Katrin Latarius [1,2], **Ingrid Angel-Benavides [1]**, Birgit Klein [1]

1 Bundesamt für Seeschifffahrt und Hydrographie, BSH, Hamburg, Germany

2 Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

ingrid.angel(at)bsh.de

With the decline of sea-ice in the high northern latitudes the operation of Argo floats in the marginal ice zones becomes more feasible. To protect the floats from being crashed in ice they need to be equipped with an ice-sensing algorithm (ISA) that prevents their ascent to the surface in ice conditions. Ice-sensing algorithms have been used successfully in the Southern Ocean where they basically look for temperatures in the mixed layer during ascend of the float to the surface. If these are close to freezing point temperatures they are taken as indication of sea ice formation and the ascent is aborted. In the high northern latitudes the inflow of warm Atlantic water close to the surface makes conditions more variable and new thresholds for the ISA have to be defined. This is tested for the Nordic Seas and Barents Sea based on hydrographic measurements and sea ice concentration maps.

16/ JCOMMOPS 3D VISUALISATION TOOL AND MONITORING SYSTEM

Anthonin LIZE [1]

1 JCOMMOPS, Plouzané, France

alize(at)jcommops.org

3D Visualisation tools demonstration (TV Screen)

SESSION 5: TECHNOLOGICAL INNOVATIONS: PRESENT & FUTURE

17/ ADVANCING HYPERSPECTRAL RADIOMETRIC OBSERVATIONS ON ARGO FLOATS

Oliver Zielinski [1], Daniela Voß [1], Rohan Henkel [1], **Ahlem Jemai** [1]

1 University of Oldenburg, Germany

ahlem.jemai(at)uni-oldenburg.de

The availability of hyperspectral radiometry on BGC Argo-floats can be of key relevance for supporting ocean color products, in both case1 and case 2 waters. Continuous hyperspectral information on ARGO floats provides a large data set and therefore enables a better understanding of the underwater light field and it's drivers in different parts of the ocean. To retrieve this goal APEX multi-mission floats will be equipped with hyperspectral RAMSES irradiance sensors (TriOS, Germany). We will explore BGC Argo data in combination with further field studies in order to measure light distribution in depth. In the next step, the data will be used to predictive approaches and validate algorithms that can be used to derive necessary information from satellite data for uniformed evaluation at a global scale. The development of novel algorithms to exploit hyperspectral radiometric information on BGC Argo floats will, therefore, open new opportunities for bio-optical long term studies of global ocean change and its relevance for the carbon cycle.

18/ TOWARDS A NEW PHASE FOR EURO-ARGO PROGRAMME: EURO-ARGO RISE PROJECT

Estérine EVRARD[1] and Euro-Argo RISE Consortium.

1 Euro-Argo ERIC, Plouzané, France

Esterine.evrard(at)euro-argo.eu

A new step is ongoing for Argo at the European level: Euro-Argo RISE (Euro-Argo Research Infrastructure Sustainability and Enhancement) project has been launched in January 2019 for a 4-year duration. Funded by the EU Framework H2020 Programme, its overarching objective is to secure and improve the current network. Besides this objective for the core Argo system (Temperature and Salinity parameters), innovation will be implemented to set up and organise on the long-term new components. Biogeochemistry, greater depth, partially ice-covered and shallower water regions will be major technological and scientific challenges tackled by Euro-Argo RISE. Extending Argo observations and providing essential ocean observations is now a high level priority for the future to answer new societal and scientific challenges. Strong collaboration within partners during Euro-Argo RISE project will thus demonstrate the long-term sustainability and importance of this comprehensive network.

19/ PRESENTATION OF THE EURO-ARGO MONITORING TOOL WEBSITE DEVELOPED DURING THE MOCCA PROJECT

Euro-Argo ERIC

Euro-Argo monitoring tool demonstration (TV Screen)

Romain.cancouet(at)euro-argo.eu

20/ IMPACT OF WAVES IN ARVOR FLOATS BEHAVIOR (GPS POSITIONING, IRIDIUM TRANSMISSION AND SURFACE GROUNDING)

Andrea GARCIA-JUAN [1] and Romain CANCOUET [1]

1 Euro-Argo ERIC, Plouzané, France

Andrea.garcia.juan(at)euro-argo.eu

The aim of the present study is to determine if waves have an impact in three aspects of Arvor floats behavior: GPS positioning, Iridium transmission and surface grounding events. A failure in one of this three aspects imply a loss of profile data or a gap in the trajectory. So, determining the reasons of failure will provide important information on how to improve float efficiency.

This analysis was made by using technical data send by the floats and representative of GPS positioning (time to get a GPS point and GPS point successful or not), Iridium transmission (number of send message per minute) and cycles with a failure (Iridium transmission incomplete and grounding occurring at < 10 dbar). Technical data was colocalize with waves hindcast data from a model of 0.5° and 3h resolution (IOWAGA, Ifremer) and a value of hs (significant wave height) and t01 (waves mean period) was associated to each cycle. Technical and waves data were statistically analyzed to determine correlations.

Any correlation between GPS successful positioning and waves parameters was found. Time to get a GPS point increase with hs (for the first 3 min), but even with big waves float is able to get the GPS point. Correlation between waves parameters and number of packages send per minute during an Iridium transmission is weak (r = 0.044), and cycles with incomplete transmissions are not related with big waves events (mean hs is 1.3 m). Surface grounding events, when float is in global ocean, are most of the times related with big waves (mean hs = 4,3 m), but it is not the case in marginal seas.

These results reveal that sea-state is not the reason of GPS positioning and Iridium transmission failures, so other causes should be investigated, such as satellite coverage or Iridium antenna failure. Key configuration parameters that have been set up to avoid waves effects can be now optimized. Surface grounding seems to be caused by waves, so a change in a key configuration parameter is being tested to avoid this effect.

This study tends to be the beginning of a series of best practices in Arvor floats configuration settings conceived to ensure an efficient float behavior, an efficient monitoring and the sustainability of the fleet.

21/ COMPACT LIGHT-WEIGHT CAMERA SYSTEM FOR ARGO EXTENSION APPLICATIONS.

M. Pettas [1], I.G. Priede 2, A. Kalampokis [1], C. Frangoulis [1], M. Ntoumas [1], G. Petihakis [1]

1 Hellenic Center for Marine Research, HCMR, Anavyssos, Greece
2 University of Aberdeen, Aberdeen, United Kingdom

mpettas@hcmr.gr

To extend the capabilities of ARGO, the ability to acquire and record images is a major challenge that has the potential to provide information on biodiversity and the surrounding environment that is unobtainable in any other way. A prototype autonomous dual camera package, known as JELAB2, small enough to be carried on an ARGO float, has been developed. The package weighs 2.1 kg in air, 0.375 kg in water and is 350 mm long and 100mm wide. The system is based on two Raspberry Pi Camera Modules v2, with Sony IMX219 8-megapixel sensors which are capable of high definition video, still shots and time-lapse sequences. Camera 1 is oriented horizontally, designed for capturing images of particles in the water-column during descent or ascent. Camera 2 looks downwards obliquely to view an area of sea floor when the float is parked on the bottom. The two Raspberry Pi boards are controlled by a low consumption Arduino Pro Mini microcontroller. The compact design is achieved by avoiding conventional instrument housings. The system is embedded in resin; a method widely used in animal-mounted instrument packages. Embedded LED panels provide lighting when below the depth of maximum penetration of solar light. The cameras and lights are fully software programmable for a variety of missions. In the prototype, inputs from pressure and temperature sensors are recorded and can be used to control image capture. Images cannot be transmitted in conventional ARGO messages so data retrieval depends on recovery of the float. The design and performance characteristics of the JELAB2 prototype are presented and the variety of applications of this and similar compact camera systems is discussed.

22/ DEEP-ARVOR PROFILING FLOAT

Xavier André [1]

1 Ifremer, Plouzané, France

Xavier.andre@ifremer.fr

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