Error assessment of sea surface temperature satellite data relative to in situ data: effect of spatial and temporal coverage.

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A comparison between satellite and in situ sea surface temperature (SST) data in the Western Mediterranean Sea in 1999 is shown. The aim of this study is to better understand the differences between these two data sets, in order to compute merged maps of SST using satellite and in situ data. When merging temperature from different platforms, it is crucial to take the expected RMS error of the observations into account and to correct for possible biases. Different in situ data sensors and platforms (CTD, XBT, drifter, etc) are available for the comparison, each with specificities in the nature of the measurement (accuracy and precision of the measures), and with different spatial and temporal distributions. A comparison with satellite data needs to take these factors into account. Statistics about the differences due to the hour of the day, the month of the year, the type of sensor/platform used and the spatial distribution is therefore realised through a combination of error measures, diagrams and statistical hypothesis testing. The data used are Advanced Very High Resolution Radiometer (AVHRR) SST day-time and night-time satellite data, and in situ temperature data from various databases (World Ocean Database'05, Coriolis, Medar/Medatlas and ICES).

Complex oceanographical studies of the coastal zone north-eastern part of the Black Sea

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Department of Oceanology, Geography Faculty of Moscow State University has oceanographic research in the coastal zone of north-eastern part of the Black Sea more than 15 years, in summer and winter. The purpose of research - the study of mesoscale variability of oceanographic fields in the coastal zone of the Black Sea. During the expedition the following tasks are: • monitoring of major oceanographic and meteorological parameters, as well as monitoring the regime of small rivers in the Blue and Gelendzhik Bays; • study and analysis of the hydrological and hydrochemical water structure Gelendzhik and Blue Bays in the summer and winter under different synoptic conditions; • environmental monitoring of coastal waters of north-eastern part of the Black Sea. The solution of these problems is based on the following hydrometeorological observations: • stationary continuous monitoring of meteorological parameters by using an automatic weather station installed at the end of the 150 m pier in Blue Bay, with a 5 minutes step; • continuous monitoring with stationary increments 5 minutes for the main hydrological and hydrochemical parameters (temperature, salinity, pH, redox potential, dissolved oxygen, etc.) with the oceanographic probe mounted on the end of the pier at a depth of 1 m; • monitoring river regime and small streams and Blue & Gelendzhik Bays, as well as monitoring of pollution Gelendzhik Bay; • comprehensive oceanographic polygon in Gelendzhik Bay (more than 30 stations). At stations probe CTDplus 1000 (discrete 0.1decibar) and YSI 6600 (step of 1 sec) Carried out measurements of temperature and salinity from surface to bottom. With the probe FSI 2D-ACM was measured currents. Water samples from the surface to determine the hydrochemical parameters (pH, alkalinity, oxygen content, concentrations of phosphate, silicate and nitrate concentrations of some pollutants such as petroleum products) in laboratory conditions, as well as sampling of phytoplankton; • hydrological and hydrochemical observations of small watercourses for the influence of continental runoff to the chemical structure of Gelendzhik Bay water.

Decadal variability of anthropogenic carbon penetration in the Mediterranean Sea : comparison of several approaches

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To study the temporal evolution of anthropogenic carbon penetration in the Mediterranean sea and especially in the Algerian basin, we have used the two approaches: TrOCA and ΔC*.

Taking advantage of METEOR 51/2 data sets, we derived the typical age of the main water masses in the Mediterranean Sea. We also used these data to compute a multi-parameter equation linking dissolved inorganic carbon to temperature, salinity and oxygen, whereas alkalinity is directly linked to salinity.

Our approach is to recompose the natural carbon in the Mediterranean Sea, and compute the temporal evolution in both natural and anthropogenic components by applying several sets of equations and assumptions on a 40-year climatology derived from MEDAR/MEDATLAS data. Some modifications have been made regarding, for example, the special state of N/P ratio in the Mediterranean sea which is about 20-22.

The approach has been validated on independent observations (e.g. DYFAMED data) before generalization to the whole Mediterranean Sea. Preliminary results show that TrOCA approach might overestimate the anthropogenic carbon in that region.

Monitoring Morphological Changes using near-bed ADV Altimetry.

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Morphological changes of the bottom is of interest to many coastal and offshore applications such as engineering works (windmills, harbour construction, dredging), aggregate extraction, the underwater heritage protection and the object burial in general. The objective of this study is understanding seabed morphodynamics, comprising several spring/neap tidal cycles. Continuous time series were made available from a Sontek Acoustic Doppler Velocimeter (ADV) mounted on a multisensor tripod, at different locations on the Belgian Continental Shelf (RBINS-MUMM). Most measurements are conducted in near coastal shallow waters, though also offshore locations have been targeted. Data from the nearshore moorings clearly show dynamic trends in accretion and erosion. The results are statistically related to time-series of tidal forcing, wind and wave stresses using cross- and multi-spectral analyses and wavelet transforms. Furthermore, the data are coupled to time series of an optical backscatter sensor (OBS) to detect occurrences of near-bed fluffy layers and fluid mud sheets.

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Correcting surface winds by assimilating High-Frequency Radar surface currents in the German Bight

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Surface winds are crucial for accurately modeling the marine circulation in coastal waters. In the present work, it is shown how high-frequency (HF) radar surface currents can be used to reduce the uncertainty in surface winds. Surface currents are assimilated into to a primitive equations model (GETM) of the German Bight using an ensemble-based assimilation scheme in order to obtain a surface wind correction taking ECMWF (European Centre for Medium-Range Weather Forecasts) winds as a first guess into account. The method is validated directly by comparing the analyzed wind speed to independent *in situ* wind measurements at Helgoland and Sylt. At both stations, the RMS error of the wind field is reduced by the assimilation of HF radar currents. The approach is also validated indirectly by assessing the impact of the corrected winds on model sea surface temperature (SST) relative to satellite SST.

The Arctic deep-sea observatory HAUSGARTEN, results of multidisciplinary investigations since 1999

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Time-series measurements, especially those of biological parameters, in the Arctic are rare. This lack of information is mainly caused by the inaccessibility of vast areas in the Arctic Ocean which can only be studied by means of expensive modern infrastructure and instrumentation. In 1999, the Alfred Wegener Institute for Polar and Marine Research (AWI) established "HAUSGARTEN", the first and only long-term deep-sea observatory at high latitudes. It comprises 16 permanent sampling stations along a bathymetric transect from the Vestnesa Ridge to the Molloy Hole (1000-5500 m) and a latitudinal transect along the 2500 m isobath. They cross at the central HAUSGARTEN station at ~ 79° N and 04°E, which is used for biological and biogeochemical long-term experiments and deployments. Originally planned to shed light on possible causes for diversity in deep-sea organisms, the HAUSGARTEN also serves as an observatory for ongoing changes of the marine environment in an area susceptible to the effects of global warming.

Sampling campaigns and the long-term deployments of moorings and free-falling systems (bottom landers) has been conducted on an annual basis since 1999 and yielded an unrivalled time-series data set. Here, we will present results of biological, physical, chemical and biochemical time series measurements from the pelagic and benthic realm. We will discuss changes which occur even at great water depth at HAUSGARTEN observatory.

Decadal changes of carbon dioxide in the Scheldt estuary.

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Since late 2002, we have carried continuous measurements of the partial pressure of CO_2 (pCO_2) at a fixed station in the upper Scheldt estuary, allowing a detailed description of the seasonal and inter-annual variability. This time-series reveals overall stable pCO_2 conditions from 2003 to 2006, and a major decrease of pCO_2 from late 2006 to early 2007 that is maintained during 2008 and 2009. To further investigate the propagation of these changes in the whole Scheldt estuary, we have carried out a monthly survey of pCO_2 since January 2008 covering the estuary from freshwater to the mouth. Comparison with a similar monthly data-set obtained in 1997/1998, shows that a major decrease of pCO_2 occurred in estuary in zone from 0 to 15 salinity. Drivers of these changes are discussed.

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Multiplatform observation of the surface circulation of the Gulf of Naples (Southern Tyrrhenian Sea)

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The circulation of the Gulf of Naples (Southern Tyrrhenian Sea) presents features typical of both coastal systems and open waters. The Gulf of Naples is also a highly urbanised area, where human activity and natural factors (e.g., river runoff, water exchange with adjacent basins) can strongly affect the water quality.

In this work we show how surface transport can affect the distribution of sediment of terrigenous origin, and more in general how it can promote or hamper the renovation of water masses. To this aim, we carried out a multiplatform analysis by integrating HF radar current fields, satellite data and modelling results. The surface current fields recorded by a CODAR system installed in the Gulf of Naples at a resolution of 1 Km are used to feed a model simulating the transport of particles released in the medium (GNOME - General NOAA Oil Modeling Environment). Several scenarios accounting for the relative effect of advection, diffusion and windage are tested, and the model simulations are then compared with satellite images of chlorophyll distribution. This integrated approach permits to investigate the concurrent effect of surface dynamics and wind forcing in determining the distribution of passive tracers over the basin of interest, thus identifying key mechanisms supporting or preventing the renewal of surface waters.

The EuroSITES E2M3A Observatory in the Southern Adriatic Sea: a tool to monitor the dense water formation process

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The convection process takes place due to a well known sequence of events, involving both the atmosphere and the ocean dynamics, reasons why convective areas are rather rare in the World Ocean. Their peculiar sensitiveness to meteorological and ocean forcing make them suitable field laboratory for the study of the variability of the ocean-atmosphere coupled climatic system. The Southern Adriatic is the area where the thermohaline deep cell of the Eastern Mediterranean originates, through a process of open-ocean convection. Local wintertime heat loss together with buoyancy advected from the Eastern Mediterranean condition the convective overturning and the formation of deep and oxygenated water (ADW) that exiting through the Otranto Strait spreads into the Ionian bottom layer contribute to the EMDW. The upper-layer cyclonic or anticyclonic circulation in the Ionian very likely has an important impact on the water masses that enter the Adriatic. Yet, the area exhibits a very high interannual variability induced by convective-advective feedback independently of the atmospheric forcing driving to a very high variability of water masses formation rates [*Borzelli et al, 2009*]. The high spatio-temporal variability of the deep convection and its interaction with other processes makes difficult its study.

The need of high-frequency sampling to resolve events and rapid processes and the long sustained measurements of multiple interrelated variables from sea surface to seafloor is provided by the observatory E2M3A located in the area of the Southern Adriatic Pit at 41°29.7'N, 17°42.1'E. The payload of the site consists of CT and CTD sensors at different depths, an ADCP and a RCM11 together with a meteorological station, which allows to individuate water mass formation and buoyancy fluxes from the simultaneously measured simultaneously physical, chemical and meteorological parameters. The site has been working continuously since 2006 providing precious information on the interannual variability of the water formation processes.

A completely redesigned surface buoy system has been developed during 2008-2009 and it was deployed in late summer 2009. The system recently has become part of an integrated network of deep European observatories developed in the framework of EuroSITES (http://www.eurosites.info/) project (EU-FP7) that will coordinate the European contribution to OceanSITES global array (www.oceansites.org). The deployment of pCO2 sensor together with a pH sensor within the mixed layer will allow to estimate the carbon system at the site. Additionally, a surface buoy in a separated new mooring line communicates with the instrumental mooring through hydro-acoustic modems allowing the real time data transmission from the platform to the land station. The new system is equipped with Iridium satellite link, ARGOS (1-way comm.) and acoustic modem link to collect data from instruments placed on the deep mooring.

Applying the optimum multiparameter analyses (OMP) we have investigated spatial distribution of water masses in the area using cruise data in order to quantify interannual and decadal variability of the deep convection processes. Observations collected from the Ionian and Adriatic Sea are utilised, mainly to detect well-documented property changes that have occurred in the water masses present in the Southern Adriatic Pit, but also possible fluctuations in water mass contributions as a whole. Since the analysis is conducted over a limited ocean region, we assume that the restricted temporal scales of the involved advective-diffusive processes prevail over biochemically induced

concentration changes [*Manca et al, 2006*], so we exclude the use of the Redfield ratio and the relative extended OMP version. The results show prominent variability in the spatial structure and in the contributions of Levantine Intermediate Water (LIW) and in the Adriatic Dense Water (ADW) between 2006 and 2008.

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Evaluation of metabolic rates in various communities in the Bay of Calvi using optodes based on different approaches.

CHAMPENOIS W[1], LEPOINT G[1], DELILLE B[1], COMMARIEU MV[1], GREGOIRE M[1], BECKERS JM[1],AND BORGES AV[1]

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In the Bay of Calvi (Mediterranean Sea), we investigate since late-2006 metabolic rates (gross primary production (GPP) and community respiration (CR)) related to various communities (*Posidonia oceanica* seagrass meadow, *Posidonia oceanica* litter, epilithic macro-algae) using optodes based on different approaches (moorings and benthic incubations). Since August 2006, we maintained a shallow mooring at 10 m depth with an array of 3 optodes logging temperature and oxygen hourly. Based on oxygen mass balance, GPP and CR values were derived daily for the last 3 years, allowing analysis of seasonal and inter-annual variability of GPP and CR over the *Posidonia oceanica* seagrass meadow. This variability is discussed in relation to variable climatic forcings : mild versus average winter conditions, stormier versus average fall conditions, etc... We also used optodes on benthic chambers over *Posidonia oceanica* seagrass meadow, *Posidonia oceanica* litter, epilithic macro-algae. Over the *Posidonia oceanica* seagrass meadow, these incubations allow to analyse changing rates of nighttime CR, and to evaluate the difference between daytime and nighttime CR. Over the *Posidonia oceanica* litter, these incubations reveal surprisingly highly variables GPP and CR values. Finally, these incubations also allow deriving GPP and CR values from epilithic macro-algae, the second most important benthic compartment of in the Bay of Calvi.

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Joint analysis of the seasonal and spatial variability of carbon dioxide, methane and nitrous oxide in the Scheldt estuary.

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Since January 2009, we have carried out monthly surveys in the Scheldt estuary to measure the partial pressure of carbon dioxide (pCO_2), methane (CH_4) and nitrous oxide (N_2O). Measurements of pCO_2 were carried out underway with an equilibrator coupled to an infra-red gas analyser, while the concentration of CH_4 and N_2O were carried out with a gas chromatograph on discrete samples. The dynamic range of seasonal changes and horizontal spatial gradients of these three green house gases (GHGs) are one to two orders of magnitude higher than in the open ocean. The drivers of the seasonal and spatial gradients of these GHGs are discussed, among which primary production (in the tidal river and the marine zone), nitrification (in the oligohaline zone), etc…

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Detection of Red Tide in the Western Japan Sea Coastal Waters Using MODIS Fluorescence Data

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In complex coastal environment such as the western Japan Sea coastal waters, the band-ratio chlorophyll product of either MODIS or SeaWiFS might not provide information on red tide due to large range of chlorophyll-a concentration (Chl in mg m-3) from 0.02 to 18 mg m-3. We used near real-time data from the MODIS satellite sensor to detect a harmful algal bloom (HAB), or red tide, in the northwest Japan Sea coastal waters from 2000 – 2005. MODIS florescence line height (FLH in W m-2 sr-1) data showed that the highest correlation with near-concurrent in situ chlorophyll-a concentration (Chl in mg m-3). The ratio between MODIS FLH and in situ Chl was derived. The red tide that formed from in April 2001 in the NW Japan Sea coastal waters was revealed by MODIS FLH imagery, and was confirmed by in situ data. The FLH imagery also showed the development of the bloom. Possible biophysical mechanisms causing the bloom are also presented.

Meridional Overturning Circulation (MOC) Detected from In-Situ and Argo Measurements

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A global dataset consisting of three-dimensional monthly varying temperature, salinity, velocity fields from 1990-present has been developed after reconstructing the Global Temperature-Salinity Profile Program (GTSPP) and Argo profile and track data together with the Navy's Master Observational Oceanographic Data Set (MOODS), at spatial resolution equal to or higher than the standard product (1o 1o). To improve the temporal and spatial resolution, the Ocean Surface Current Analyses – Real Time (OSCAR) derived from satellite altimeter and scatterometer are also used.

The optimal spectral decomposition (OSD) method (Chu et al., 2003a, b) is used to reconstruct these data. After decomposition, a three-dimensional field is represented by a set of Fourier coefficients. The OSD method has three components: (1) determination of the basis functions, (2) optimal mode truncation, and (3) determination of the Fourier coefficients. Determination of basis functions is to solve the eigen-value problem. The basis functions only depend on the geometry of the ocean basin and the boundary condition. This is to say, the basis functions can be pre-determined before the data analysis. For data without error, the more the modes, the more the accuracy of the processed field. For data with error, this rule of the thumb is no longer true. Inclusion of high-order modes leads to increasing error. The Vapnik variational principal is used to determine the optimal mode truncation. After the mode truncation, optimal field estimation is to solve a set of a linear algebraic equation of the Fourier coefficients. This algebraic equation is usually ill-posed. The rotation method (Chu et al., 2004) is developed to change the matrix of the algebraic equation from ill-posed to well-posed such that a realistic set of the Fourier coefficients are obtained.

With the reconstructed three dimensional ocean fields for the two decades (1990-present), temporal and spatial variability of the Atlantic meridional overturning circulation (AMOC) is identified. The corresponding overturning streamfunction is calculated. Since rapid changes in the AMOC could have implications for regional changes of climate, correlation analysis between our reanalyzed datasets (3D ocean fields) and the surface atmospheric data (such as NCEP reanalyzed wind stress, air-ocean heat and moisture fluxes) will improve understanding of the physical mechanisms behind fluctuations in the MOC. A more flexible and user-driven data processing and distributing system will be discussed, to optimize data use by both the scientific and operational communities.

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Changes of Heat and Freshwater Contents in World Oceans (1990 – 2009) Identified from In Situ and Argo Measurements

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It has been recognized that the ocean is critical to the Earth's climate system. Previous studies show evidence of warming of the global ocean using conventional measurements such as the expendable bathythermographs (XBT), bottle, mechanical bathythermographs (MBT), and Conductivity-Temperature-Depth (CTD) casts. A new strategy (Lagrangian type) was developed to sample the world ocean as the Argo floats first came into practice in early 1990s. Currently, there are 3264 Argo floats all over the world ocean.

The global temperature and salinity profiles observed from in situ measurements and Argo floats from 1991 to 2009 were used to estimate the ocean heat content (OHC) and freshwater content (FC) for the world ocean as well as individual ocean basin (Atlantic, Pacific, Indian Oceans). Some new characteristics have been found. For example, the upper ocean heat content (surface to 700 m depth) OHC700 has an evident linear upward trend (with 95% confidence interval) of 1.3X10 <sup_22> J yr-1, which is much larger than previous estimated values by Levitus et al. (2005) for 1955-2008. Interpretations of the observational results will also be presented.

Constraining model setup in a narrow shelf simulation using different data sources

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It is widely known that the set of parameters that constitute the configuration of a model run, play a decisive role in its output. Additionally, the impact of the choice of a particular option is a common issue of uncertain answer. At the initial stages of a study, some parameters are chosen based on past experiences, tradition or default values, but sometimes little is known in advance about the impact of a specific selection. Data collected by observational systems provides a way to address this question.

During a series of simulations in the Spanish and Portuguese Atlantic and Cantabrian coast using the ROMS model that our group has been performing in the last years, we have found that the characteristics of our area (continental slope with a narrow shelf, presence of a Mediterranean water vein, etc.), and the different temporal and spatial scales involved in the dynamics of the area, make the model prone to high sensitivity to small variations of several factors, such as the vertical distribution of layers, the smoothing of the bathymetry, boundary conditions, slope parameters, etc. Furthermore, while some configurations result in clear melioration or deterioration of the output, it was sometimes difficult to compare the improvements and worsenings that some set-ups produced in the results.

In this contribution we will present a sensitivity study of a simulation in the Iberian West coast using the ROMS model attending to different θ_b parameters, Haney numbers, resolutions and smoothing techniques. The period of interest is the autumn transition in 2005 when a strong HAB outbreak in the area occured. Variability of shelf circulation in response to variations in meteorological forcing played a role in the along and across-shore propagation of HAB species, and the modelled circulation is sensitive to variations in model setup. The results will be compared both to a "reference" configuration, based on standard or commonly accepted choices, and to real data obtained through different channels (moorings, cruise data and satellite data, meteo-marine buoys), by means of Taylor diagrams and other statistical analysis. The aim of this study is to use the observational system in the area for assessing the contribution of model set-up choices in the variation of the results, and for searching for a way to determine the best choice among the configurations.

Surface current dynamics in the North Eastern Adriatic Sea from high-frequency radar observations and high-resolution wind fields

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The dominant processes governing the circulation in a 40 km x 60 km area off the Italian coast and the Istrian peninsula, Northern Adriatic Sea, are assessed using surface current measurements from high-frequency radars and high resolution wind fields for the period September 2007 – August 2008. The combined use of high resolution current observations and wind data provide a detailed and unique mean to investigate the flow patterns and their variability. Time-averaged flow pattern shows a persistent cyclonic circulation scheme with weaker currents in the southern part of the domain, and an intensification along the Italian coast to the North where water is shallower and wind influence is stronger. This pattern repeats over time, with only minor departures from the basic scheme. Tides are weak, since they represent a small fraction of the overall flow variance. High-frequency non tidal oscillations, namely inertial oscillations and diurnal-period wind-driven currents, are present and show different patterns in time and space. Inertial motions and non-tidal diurnal-period oscillations increase their contribution during spring and summer seasons, when the water column is stratified. They show an opposite trend in variance distribution within the radar domain. Diurnal-period currents have their maximum variance in the Northern part towards the Italian coast and the Trieste Gulf entrance, while n the other hand inertial oscillations show their maxima towards the centre of the Northern Adriatic basin. Current vorticity is prevalently positive and related either to current shear to the North, or to current rotation to the South. Wind stress curl is the major source of surface flow vorticity for time scales longer than the local inertial period. For these time scales wind stress curl is balanced by an increased surface flow divergence. The dominant wind regimes in the area, namely the bora and the scirocco winds, drive two different current patterns. Bora enhances the coastal jet along the Italian coast and introduces a strong cyclonic recirculation in the southern area. Scirocco on the other hand homogenizes the flow pattern and forms small-scales eddies along the Italian coastline in the Northern sector.

MyOcean Global Ocean analysis and forecasting system and need for new independent data

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The operational oceanography European project MyOcean is part of the Global Monitoring for Environment and Security GMES program. During the next 3 years, 61 European partners in 29 different countries will work to build a pan European ocean monitoring and forecasting capacity. The marine core service will be produced by ocean forecast centers and data centers working together. MyOcean is particularly attentive with the setting of quality control, including the scientific validation of the products.

In this framework, a global ocean monitoring and forecasting system is run at Mercator-Ocean which is based on the ocean and sea ice modelling system NEMO and on an assimilation system based on Kalman filter/SEEK. It is declined in eddy permitting and eddy resolving configurations: The current version of the global system has a $1/4^o$ horizontal resolution, with a North Atlantic (including the tropics) and Mediterranean zoom at $1/12^o$, and a global $1/12^o$ system is under development which will be the reference global system at the end of MyOcean. This system will also deliver real time estimations of biogeochemical quantities at low resolution.

A quality report is built which gives a synthetic view of the accuracy of the ocean estimations (hindcast and forecast) with various statistical scores and direct visual data comparisons. The inter-comparison of these scores between the various systems is done with an ensemble of metrics defined in the context of MERSEA and GODAE. This quality report (which will be updated on a quarterly basis) is meant to foster interactions with the scientific community and other users so that they can derive the level of confidence (or the correction to apply) for the use of the products in their own specific application.

Measuring the quality of the systems shows that it is critical to improve the real time observation network. We need a sustainable high resolution spatial and temporal coverage, as an input for ocean analysis and forecast systems as well as for validation purposes. The extent has to be global with minimum sparseness from the surface to the deep ocean, but also targeted toward key areas for the validation of key oceanic processes.Thus we must take into account new sensors and multivariate data products into our validation process as soon as possible, and the future observations networks should take into account the specific needs of operational oceanography. We also need reliable references like long ocean reanalyses in order to validate the systems on past periods but also to provide useful information

such as interannual or decadal anomalies. For instance, we show that comparing model estimations with or without data assimilation with multivariate ocean products appears to be an interesting approach to propose new ocean indicators.

Concentrations of some radionuclides in the near shore sediments Southeast Mediterranean Coast, Egypt.

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Abstract:

Four radionuclide elements ($^{234+235}U$, ^{232}Th, ^{40}K and ^{137}Cs) were measured in the near shore sediments along the Egyptian Mediterranean Coast between Alexandria and Salloum near the Libyan borders. The measured data showed that, the activity concentrations of the natural radionuclides; $^{235+234}U$, ^{232}Th, and ^{40}K are found within the world average values. Sidi Krir station recorded the highest $^{234+235}U$ and ^{40}K concentration levels (166.5±7.73, 356.8±2.29 $Bq.kg^{-1}$ dry weight) followed by El-Max station (150.94±, 337.1±8.07 $Bq.kg^{-1}$ dry weight). El-Max recorded the highest ^{232}Th (22.7±0.62 $Bq.kg^{-1}$ dry weight) indicating that these radionuclides may accumulate in the particulate forms from the drainage systems of the fertilizers, petrochemical and paper industries, the agriculture drainages and salines as well as the particulate radionuclides that come from the neighbor localities with the marine currents. The lowest $^{234+235}U$ concentration was recorded at Salloum, ^{232}Th and ^{40}K were recorded El-Hammam (61.6±5.4 and 7.68±0.2 $Bq.kg^{-1}$ dry weight) indicating that the natural radionuclide activities are decreasing westward.

The western stations recorded high concentration levels for ^{137}Cs. the highest of ^{137}Cs recorded at Salloum (7.92±0.4 $Bq.kg^{-1}$ dry weight), the lowest level was recorded at El-Dabaa (1.11±0.01 $Bq.kg^{-1}$ dry weight). The eastern stations (Sidi Krir and El_Max) recorded intermediate values ranging between (3.4±0.27 and 5.05±0.09 $Bq.kg^{-1}$ dry weight). This high concentrations of ^{137}Cs in the western stations may indicate that these radionuclides may come with the marine currents from the northern localities that contains the nuclear power stations in the eastern coasts of Spain and the southern coasts of France and Italy as well as using the depleted uranium in the Middle East clashes.

The samples were collected during 2008 and they were analyzed at the Atomic Energy Authority, Second Research Reactor ETRR2, Abu Zaabal, Egypt using low-level gama-ray spectrometer with high purity germanium detector.

Marine slicks associated with coastal currents

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Field studies of slick bands on the sea surface were carried out in the coastal zone of the Black Sea for better understanding of the relation between marine slicks and non uniform currents. The current velocity profiles were measured from a boat using a 600-kHz acoustic Doppler current meter (ADCP). Additionally, current velocities in the thin upper water layer (about 5 mm thickness) were measured when recording trajectories of special surface floats with GPS receivers. Samples of surfactant films inside/outside the slicks were collected using a net method, and the films were characterized when studying in laboratory the action of collected films on characteristics of gravity-capillary waves. The slick bands were also detected in the Envisat SAR imagery. The slick bands were shown to be characterized by the accumulation of surfactants, and to be oriented along the coastal currents and approximately along the bottom topography slope. The slick bands in accordance with theory were located in the areas of convergency of weak transverse current components, marking the non uniformity of the currents in the upper layers. In particular, results of two case studies are presented demonstrating slick bands formation in the zone of merging of two surface currents of slightly different directions, and in the zone where a bottom current below a thermocline changed its direction when meeting the bottom slope. This work was supported by INTAS (Projects MOPED, DEMOSSS), the Russian Foundation of Basic Research (Projects 08-05-00634, 08-05-97011), and RAS (Program “Radiophysics”).

Scientific activities at the NEMO-SN1 cabled observatory

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NEMO-SN1, located in Western Ionian Sea off Eastern Sicily (at 2100 m depth, 25 km off the harbour of Catania), is a prototype of a cabled deep-sea multiparameter observatory, the first real-time operating in Europe since 2005. NEMO-SN1 is one of the node of the incoming European large-scale research infrastructure EMSO included in the ESFRI Roadmap (http://cordis.europa.eu/esfri/roadmap.htm). EMSO, the European Multidisciplinary Seafloor Observatory, is a network of seafloor observatories mainly cabled for long-term monitoring of environmental processes related to ecosystems, climate change and geo-hazards. NEMO-SN1 has been implemented thanks to Italian resources and to the EC project ESONET NoE that is funding the LIDO Demonstration Mission (http://www.esonet-emso.org/esonet-noe/). NEMO-SN1 is devoted to neutrino detection, geophysical and environmental monitoring. Specifically the long-term monitoring of earthquakes and tsunamis and the characterisation of ambient noise, marine mammal sounds and anthropogenic sources.

SPM dynamics measured with an automated tripod in the Belgian nearshore area: natural dynamics and anthropogenic effects

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Large amounts of sediments are dredged in the Belgian nearshore area to maintain ships' access to ports and harbours. The EU Marine Water Framework Directive provides a framework that embodies the principles of environmental protection, improvement and restoration on an integrated basis. In addition, the WFD specifies that there must be no temporal deterioration in chemical and biological status for many water bodies, and identifies (Annex VIII) 'material in suspension' as one of the main pollutants. When human activities occur in habitats characterised by cohesive seabed sediments or by high turbidities, resuspension of material or dredging and dumping can result in higher concentrations of suspended particulate matter (SPM), which can spread over large areas. The manner in which the system reacts to engineering works needs to be understood to ensure cost-effective operations at sea, to better gauge the human footprint, and to develop environmental policies aiming at a more sustainable management of the marine environment. Reference situations are rarely available in the marine environment and, therefore, true impacts are difficult to be assessed unambiguously.

In situ data have been collected near Zeebrugge in the framework of a scientific experiment that was set up by the Ministry of the Flemish Community during May 2009 in order to evaluate an alternative dredging method for the Albert II dock (port of Zeebrugge). The dredged matter was directly pumped outside the port and the SPM concentration and other parameter were measured using a tripod at about 2 km from the dumping site. Data have been collected before, during and after the dredging works. Mounted instruments on the tripod include a SonTek 3 MHz ADP, a SonTek 5 MHz ADV Ocean, a Sea-Bird SBE37 CT system, two OBS (one at 0.2 and another at 2 m above bed (mab), a LISST 100 and two SonTek Hydra systems for data storage and batteries.

In order to measure changes of a natural highly dynamic quantity it is of primary importance to choose a sampling method, providing a representative sub-sample of the population in the time- and space domain. If long-term variations, induced by natural changes or anthropogenic effects, need resolving, overprinting tidal, neap-spring as also seasonal signals need filtering. This requires sufficiently dense sampling in time and long data series together with the uncertainty, introduced by the sampling method and instrumentation. The aim of the measurements was to investigate the effects of dumping works on the SPM concentration and to evaluate the temporal SPM heterogeneity in the Belgian nearshore, using a large set of SPM concentration. Statistical methods, based on probability density and auto correlation functions are used to evaluate the data sets.

Argo: A decade of success, so what comes next?

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At the time of writing the Argo steering team is tracking more than 3300 floats. These floats are reporting data every 10 days from every ocean basin. The advertised object was to make data freely available in near real-time and we are almost achieving this objective. Currently 90% of all profiles are available for download from the Global Argo Data Centres within 24 hours of their acquisition. So far 25 nations have deployed floats in support of Argo and this is likely to grow in the near future, indeed it this likely will have grown significantly by the time this talk is actually presented.

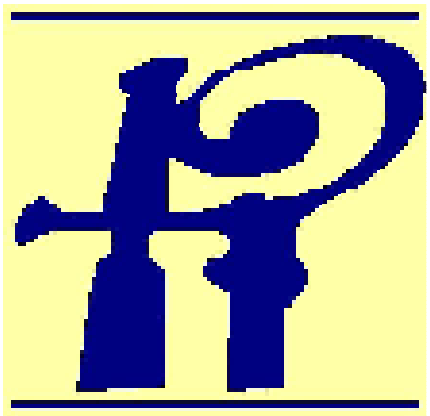
I will review the experience gained by the Argo collaborators over the last 10 years as we built a global ocean climate observatory. Some mistakes have been made, but now, 10 years after OceanObs'99, we do have the global array in place and use of the array is growing rapidly. Though 90% of profiles are available in near real-time it appears to be an overwhelming challenge to get the remaining 10% reporting quickly. We promised a delayed-mode quality control system, and this is working fairly well, but some substantial challenges remain and these will be described. We promised global access, and while this is available in principle, in practice many scientists in developing nations have only weak access to high-speed internet and so find the challenge of downloading many 10 MByte files to be an overwhelming challenge. These are generic problems that will be familiar to any group that has tried to make large data sets uniformly available.

The performance of the Argo collaborators during the first decade was subject to healthy and constructive criticism at OceanObs'09. There were many proposals to "improve" Argo and some have already been adopted by the Argo community, some make sense and likely will be adopted, and some will not be adopted for reasons either technical, financial or political. It is clear that as Argo enters its second decade it will change; I will endeavour in this talk to outline my own opinion of how Argo is likely to evolve over the next 5 years.

42nd International Liège Colloquium on Ocean Dynamics

(26 – 30 April 2010)

Multiparametric observation and analysis of the Sea



Abstracts 2010

Practical aspects and data analysis of 2 years-long water quality and current monitoring in an estuary

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The Simpatico system is an autonomous environmental monitoring module operating continuously since March 2008 at the Guadiana Estuary (southern Portugal-Spain border). The health of this estuary is compromised due to the recent (February 2002) closure of the Alqueva dam on the Guadiana River with subsequent water flow reduction. The Simpatico system includes a surface floating buoy equipped with batteries loaded by solar panels, a data logger and a multi-parameter probe (YSI V6200-4) that measures temperature and conductivity (hence salinity), dissolved oxygen, turbidity, chlorophyll and pH. In addition, an Acoustic Doppler current Profiler (ADP, Sontek Argonaut XR 750KHz) is bottom-mounted nearby the buoy, providing current velocities along the water column and pressure. Recorded data are automatically uploaded to a central server through cellular communication and exported on a daily basis to a web database. Although still relatively rare, the deployment of autonomous systems for long-term environmental monitoring in estuaries is bound to increase, in relation with the implementation of tight legislations (e.g. EU Directives) and increasing awareness towards nature preservation. Practical aspects and example of the results of such system are discussed in this contribution, based on the 2 years-long experience gained with the Simpatico at the Guadiana Estuary. The requirements for system maintenance are detailed and discussed, together with their associated costs. Special attention is given to the biofouling issue and how it affects the data. An overview of the 2 years-long records is provided with examples of causes for erroneous and missing data. Then, a preliminary analysis of the dataset is presented. The measured parameters are cross-correlated and analyzed at various frequencies (from intra-tidal to seasonal). The results are discussed in term of natural variability and anthropogenic disturbance related mainly to changes in the estuarine hydrodynamics induced by the Alqueva dam.

Deducing an upper bound to the horizontal eddy diffusivity using a stochastic Lagrangian model

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A novel method for estimating the upper bound of the horizontal eddy diffusivity using a stochastic Lagrangian model is presented. First, a mixing barrier is identified from a priori evidence (e.g., aerial photographs or satellite imagery) and a Lagrangian diagnostic, for instance, the relative dispersion. Second, a spatially non-trivial, time-dependent velocity field with an added stochastic component advects the particles. The stochastic component represents sub-grid stochastic diffusion and depends on the value of the eddy diffusivity. Lagrangian trajectories are computed for increasing values of the eddy diffusivity until the mixing barrier is no longer visible. The value at which the mixing barrier disappears provides an upper bound for the eddy diffusivity. The erosion of the mixing barrier is observed visually and quantified by computing higher moments (for instance, skewness and kurtosis) of the probability density function of the relative dispersion for each value of the eddy diffusivity. This method is applied to the well-studied double gyre circulation model and to high frequency radar observations from the Gulf of Eilat.

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STARESO

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STARESO (Station de REcherche Sous marine et Océanographique) is the marine and oceanographic research station of the University of Liège (Belgium) managed by the French company STARESO S.A.. Constructed in 1969, it is located near Calvi (Corsica, Western Mediterranean Sea) in an oligotrophic area chosen for the exceptional quality of its coastal waters

STARESO offers to the oceanographers, by diving or with boats, a direct access to the sea. The variety of the accessible ecosystems is remarkable and unique in the Mediterranean basin:

• the Bay of Calvi is characterized by healthy and very diverse biocenosis (e.g. Posidonia meadows, rocky and sandy communities, . . .);

• a steep submarine canyon, with depths greater than 1 000 meters, is accessible in 15 minutes of navigation;

• the Liguro-Provençal front, a major hydrologic structure, is situated between 10 and 15 miles of the coast.

STARESO is accessible all the year for everybody and is functioning like an oceanographic research vessel. The Station is a platform for all oceanographic disciplines with a scientific expertise widely based on a long tradition of interdisciplinary work, and a direct access to time series of physical, chemical and biological data registered with automated systems and variety of sensors deployed in the Bay of Calvi since 30 years. This platform provides the opportunity to reach coastal, pelagic, benthic, deep systems with a manageable cost and ship requirements in a pristine zone.

The multiparametric and interdisciplinary data-bases now available can be used in studies of ecosystems or processes like ecology of seagrass bed; biodiversity of macroalgae; study of trophic food webs ; marine ecotoxicology; impact of climate changes on phyto- and zooplankton dynamics; jellyfish dynamics in changing waters; carbon cycle and air - water CO2 fluxes; statistical data analysis and modelling into assimilation approaches, including nested coastal models; development of ecological quality criteria for measuring ecosystem quality and effectiveness of management applications...

The Ship Of Opportunity Program

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The Ship Of Opportunity Program (SOOP) is an international World Meteorological Organization (WMO)-Intergovernmental Oceanographic Commission (IOC) program that addresses both scientific and operational goals to contribute to the building a sustained ocean observing system. The SOOP main mission is the collection of upper ocean temperature profiles using eXpendable BathyThermographs (XBTs), mostly from volunteer vessels. A multi-national review of the global upper ocean thermal networks carried out in 1999 recommended an evolution from broad-scale XBTs transect sampling to increased spatial and temporal transect-based sampling anticipating the implementation of the Argo float network and continued satellite altimetry observations. A review of XBT transects was carried in 2010, in which the status of networks against the objectives set in 1999 and new perspectives for the future were presented, and key scientific contributions of the XBT observations were highlighted.

The XBT deployments are designated by their spatial and temporal sampling goals or modes of deployment (Low Density, Frequently Repeated, and High Density) and sample along well-observed transects, on either large or small spatial scales, or at special locations such as boundary currents and chokepoints, all of which are complementary to the Argo

global broad scale array. Currently with the evolution of the XBT network, techniques for analyzing and synthesizing the datasets, including ocean data assimilation modeling, have progressed substantially. The commercial shipping industry has itself changed in the past decade, toward fewer routes and more frequent changes of ships and routing. In spite of these changes, many routes now have, in addition to XBT sampling, measurements from ThermoSalinoGraph (TSG), eXpendable Conductivity Temperature and Depth (XCTD), partial CO2, Acoustic Doppler Current Profiler (ADCP), Continuous Plankton Recorders (CPR), marine meteorology, fluorescence, and radiometer sensors. The ongoing value of the Ship Of Opportunity networks is viewed through their extended time-series and their integrative relationships with other elements of the ocean observing system including, for example, profiling floats, satellite altimetry, and air-sea flux measurements. Improved capabilities in ocean data assimilation modeling and expansion to support large scale multi-disciplinary research will further enhance value in the future. Recent studies of XBT fall rate are being evaluated with the goal of optimizing the historical record for global change research applications.

Use of a Small AUV to Examine Fine and Microstructure Physical and Biological Processes

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A series of measurements of fine and microstructure processes have been made in the past four years using the small Autonomous Underwater Vehicle, T-REMUS. T (turbulence) - REMUS is a custom designed REMUS 100 vehicle manufactured by Hydroid Inc., containing the Rockland Microstructure Measurement System (RMMS), an upward and downward looking 1.2 MHz ADCP, a FASTCAT Seabird CTD, and a WET Labs BB2F Combination Spectral Backscattering Meter/ Chlorophyll Fluorometer. In addition, the vehicle contains a variety of "hotel" sensors which measure pitch, roll, yaw, and other internal dynamical parameters. The vehicle is operated both at a constant depth and in a cycling yoyo mode with aspect angles varied from 1 to 5 degrees. Typical deployment times are between 2 and 8 hours. This suite of sensors on T-REMUS allows quantification of the key dynamical and kinematical turbulent and fine scale physical processes. The turbulence measurements are made concomitantly with very high spatial resolution measurements of temperature, salinity, pressure and water current. The BB2F sensor system measures chlorophyll fluorescence and optical backscattering at 470 nm and 700 nm wavelength. The turbulent and fine scale parameters which can be estimated from the data collected by the T-REMUS include: the turbulent dissipation rate, the buoyancy Reynolds number, fine scale velocity shear, and fine scale stratification, the latter obtained only in a cycling yoyo mode. As examples of the type of data collected and analyses possible from the T-REMUS two cases of the effect of turbulence on the evolution of "thin" phytoplankton layers will be presented. In each of these two cases turbulence was generated by two different mechanisms, one from vertical straining associated with the trailing edge of an internal solitary wave train, and one from direct shear instability generation due to the occurrence of a strong tidal current. For the former case the turbulence itself was confined to a thin layer by the large surrounding stratification of the local environment. The turbulence produced by the internal solitary wave train acted like a stratified wake eventually collapsing in the vertical. The phytoplankton thin layer was embedded within the turbulent field and behaving as a Lagrangian tracer also collapsed vertically. For the second case, the turbulence generated by shear from strong tidal flow, vertical diffusion gradually weakened the thin layer as it evolved. We also examine the conditions under which turbulence had no discernable effect on thin layer evolution and develop criterion for this occurrence. We show that the two key dynamical quantities in determining the role of turbulence on thin layer evolution are the buoyancy Reynolds number and the turbulent eddy velocity.

Operational in situ monitoring for water quality assessments

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Assessments of eutrophication are necessary to meet the requirements of a range of international (OSPAR) and the EU legislative drivers. This requires a marine monitoring programme designed to meet the requirements of formal assessment procedures whose outcome may be challenged in court. Historically, monitoring programmes have relied on survey vessels to collect water samples offshore and carry out in situ measurements. Survey vessels provide good spatial coverage but low spatial resolution. In order to improve the evidence base for eutrophication assessments new monitoring strategies have been introduced to resolve the higher frequency and episodic variability characteristic of our coastal waters. To provide high frequency data from discrete locations, Cefas has developed SmartBuoy, an autonomous, instrumented mooring which provides high frequency measurements of physical, chemical, biological and ecological variables in near surface coastal waters and at multiple depths in offshore stratified waters. Data are returned in near real-time and published on the internet (www.cefas.co.uk/monitoring).

SmartBuoys have been deployed operationally in the southern North Sea since 2000 and in the Irish Sea since 2002 and the network currently comprises seven SmartBuoys. The data obtained to date from SmartBuoy illustrate the importance of high frequency (> daily) measurements of variables such as dissolved nitrogen concentration (TOxN) and chlorophyll concentration to resolve the full scale of variability, including episodic events, in chemical and biological parameters in coastal seas. The wide range of concentrations encountered over short periods of time, especially during the winter period, means that low frequency ship-based observations fail to capture the full range of environmental variability. The high frequency multi-variable data sets from SmartBuoy are also important for calibration and validation of hydrodynamic and ecosystem models and satellite derived estimates of chlorophyll and suspended particulate matter. The SmartBuoy network is a key part of the UK marine monitoring strategy which integrates observations from in situ platforms, ships and satellite images.

Please send your abstract by e-mail to oceanphys@ulg.ac.be

Please indicate hereafter if you need special technical equipment for your presentation(s)

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On the use of satellite altimeter data in Argo quality control

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Multi-observations CalVal (Calibration/Validation) methods are widely used between in-situ and satellite data to assess the quality of the latest. The stability of the different altimeter missions is, for example, commonly assessed by comparing altimeter sea surface height measurements with those from arrays of independent tide gauges [*Mitchum,* 2000]. Other examples include the validation of altimeter velocity products with drifter data [*Bonjean and Lagerloef*, 2002; *Pascual et al*., 2009], or the systematic validation of satellite SST with in-situ surface temperature measurements from drifting buoys.

Comparison of in-situ and satellite data can also provide an indication of the quality of the in-situ data. A new method has been developed to check the quality of each Argo profiling floats time series [*Guinehut et al.*, 2009]. It compares collocated sea level anomalies from satellite altimeter measurements and dynamic height anomalies calculated from the Argo temperature and salinity profiles. By exploiting the correlation that exists between the two data sets along with mean representative statistical differences between the two, the altimeter measurements are used to extract random or systematic errors in the Argo float time series. Different kinds of anomalies (sensor drift, bias, spikes, etc) are identified on real-time and delayed-mode Argo floats. The limitations of the method in terms of pressure and salinity signals that can be detected have also been studied. The method is currently deployed in near real-time in order to separate rapidly suspicious floats for more careful examination.

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Decadal changes of carbon dioxide in the Southern North Sea.

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Since late 2000, we have acquired partial pressure of CO_2 (pCO_2) data underway with an equilibrator coupled to an infra-red gas analyser on all the cruises carried out on *RV Belgica*. Here, we discuss the decadal changes of pCO_2 during winter-time in the Southern North Sea. The trends are faster than those reported in open oceanic waters, although strongly modulated by inter-annual variability that seems to be related to the North Atlantic Oscillation.

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Poster: Benthic multidisciplinary time-series at the Arctic deep-sea observatory HAUSGARTEN

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The past decades have seen remarkable changes in key arctic variables, including a decrease in sea-ice extent and sea-ice thickness, changes in temperature and salinity of arctic waters, and associated shifts in nutrient distributions. To detect and track the impact of large-scale environmental changes in the transition zone between the northern North Atlantic and the central Arctic Ocean, the Alfred Wegener Institute for Polar and Marine Research (AWI) established in 1999 about 150 km west of Svalbard the deep-sea long-term observatory HAUSGARTEN, which constitutes the first, and until now only open-ocean long-term station in a polar region. 16 permanent sampling sites along a depth transect between 1000 – 5500 m, and along a latitudinal transect following the 2500 m water depth isobath are revisited yearly. Multidisciplinary research activities at HAUSGARTEN comprise biochemical analyses to estimate the input of organic matter from phytodetritus sedimentation and activities and biomasses of the small sediment-inhabiting biota as well as assessments of distribution patterns of benthic organisms (covering size classes from bacteria to meiofauna as well as megafauna) and their temporal development and food web structure. Preliminary results of our time-series data reveal first trends. Over recent years the Arctic has seen a decrease in sea ice cover, correspondingly, we have seen an increase in bottom-water temperatures. There was also a decrease in phytodetritus at the seafloor until 2006. But the input has increased at most depths since then. For meiofauna densities, we observe no consistent trends for all stations, however, we see decreasing densities during 2000-2004 at five out of nine stations. Increasing meiofauna densities at 2500 and 5500 m water depth coincides with a slight increase in phytodetrital matter at those stations. We also observe a decrease in megafaunal densities between 2002 and 2004, but analysis of new samples is required to verify this. There has been a decrease in the trophic level of demersal fish. This indicates that there have been some changes at lower trophic levels or the quality of the baseline.

Air-sea ice CO_2 fluxes measurement with eddy covariance micrometeorological technique.

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Sea ice covers about 7% of Earth's surface at its maximum seasonal extent, representing one of the largest biomes on the planet. For decades, sea ice has been considered by the scientific community and biogeochemical modelers involved in assessing oceanic CO_2 uptake as an inert and impermeable barrier to air-sea exchange of gases. However, this assumption is not supported by studies of the permeability of ice to gases and liquids, which show that sea ice is permeable at temperatures above 10°C. Recently, uptakes of atmospheric CO_2 over sea-ice cover have been reported supporting the need to further investigate pCO_2 dynamics in the sea-ice realm and related CO_2 fluxes.

We aims at a follow up of the CO_2 exchange between sea-ice and the ocean during the winter and spring season. We used the eddy covariance micrometeorological technique which allows at the same time good temporal resolution (half-hour) and spatial representativeness (several hectares) for the estimation of air-ice CO2 fluxes. Due to concerns about using open-path analyzer in cold environment (Burba et al., 2008), the mast was equipped with a CO_2 closed-path analyzer together with a C-SAT 3D sonic anemometer. A meteorological mast equipped for eddy-covariance measurements was installed on land-fast sea-ice near Barrow (Alaska), 1 km off the coast, from the end of January 2009 to the beginning of June 2009, before ice break-up. These data were supported by continuous measurements of solar radiation, snow depth, ice thickness and temperature profile in the ice. Biogeochemical data necessary for the understanding of the CO_2 dynamics in sea-ice were obtained through discrete ice coring. After data screening, the final dataset consisted 2178 half-hours segments of reliable CO_2 flux data.

First results coming from this campaign show that the resolution of the eddy-covariance technique in these conditions is high enough to measure CO_2 fluxes that are typically below 1 µmol m^{-2} s^{-1}. These fluxes are analysed in relation with physical and bio-chemical properties of the ice and snow cover.

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HF radar measurements of residual circulation in the Liverpool Bay region of fresh water influence.

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Liverpool Bay in the eastern Irish Sea is a region influenced by fresh water input from the rivers of northwest England and strong tidal forcing; the semi-diurnal tidal range reaches 10 m and tidal currents exceed 1 m s^{-1}. Stratification within the bay, controlled by freshwater induced density circulation, tidal and wind mixing varies over a range of different time scales, from semi-diurnal frequencies, caused by tidal straining of the density field, to more enduring periods of stability associated with the spring-neap cycle.

A shelf sea thermohaline front marks the western-most extent of stratification in the area. Analysis of satellite sea surface temperature data reveals westward propagation of the front out to 4°W as neap tides approach, and the subsequent retreat of stratified waters eastward as tide induced vertical mixing increases toward springs. Residual circulation within the bay resulting from these changes in water column structure is not yet fully understood. Using measurements of sea surface currents from a 12-16 MHz WERA HF radar deployed in Liverpool Bay, as part of the Liverpool Bay Coastal Observatory (http://coastobs.pol.ac.uk), we investigate changes in the residual circulation over the spring neap-cycle.

Liverpool Bay is subject to a range of human industrial, agricultural, fishing and recreational activities. Understanding of the fate of freshwater in the eastern Irish Sea is therefore important to both coastal zone managers and shelf-sea modelers.

Comparison of the quality of atmospheric data from ships and buoys

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Ship and buoy reports of wind, air pressure, temperature, humidity and sea surface temperature have been compared with values from the operational Met Office Numerical Weather Prediction system and statistics for the last three years are presented. In general manual ship reports have rather mixed quality, automated ship reports are better and in most respects buoy reports have the best quality. Subsets of ship data show variations in quality, some of them unexpected - for example aspirated temperature and humidity measurements appear slightly worse than non-aspirated measurements. A small proportion of drifting buoys report wind speeds estimated from underwater acoustic spectra. Unfortunately the speeds from this relatively new technique display quality problems in practice and cannot be used operationally. The air temperatures from Arctic ice buoys were found to be of reasonable quality (compared to other high latitude measurements - snow/ice cover increases temperature sensitivity) and will shortly be assimilated operationally.

Development of a high resolution analyser for the measurement of ammonium in seawater

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In this work, we describe a high resolution fluorometric shipboard analyser for the determination of NH4+. The system has a high resolution of 0.07 nM measured at 1 Hz (per root hertz equivalence) at concentrations around 50 nM, a good precision (1%-4%) and a high performance over a wide dynamic range up to 25 μM. The calculated limit of detection (LOD) is around 0.2 nM at 1 Hz. The methodology of NH4+ analysis is based on the fluorescent product formed between o-pthaldialdehyde (OPA) and NH4+ in the presence of sulfite. The developed analyser was successfully demonstrated in the North Atlantic Ocean, off the Canary Islands, an area of known oligotrophic, low NH4+ oceanic waters.

Advanced dense ocean floor network for earthquakes and tsunamis around the Nankai Trough mega thrust earthquake seismogenic zone in Southwestern Japan
-Real time monitoring of the seismogenic zone to understand recurrence cycle of mega thrust earthquakes-

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Earthquake and Tsunami Research Project for Disaster Prevention,
Japan Agency for Marine-Earth Science and Technology, JAPAN

Abstract

The Nankai Trough southwestern Japan is well known as the mega thrust earthquake over M8, generating large tsunamis. These earthquakes have occurred with the interval of 100-150 years. The latest cycle of mega thrust earthquakes is1944 Tonankai and the 1946 Nankai earthquakes around the Nankai trough. In this earthquakes cycle, the first rupture was starting from the Tonankai seismogenic zone, and in 1854 Ansei mega thrust earthquake, first rupture was starting from the Tonankai seismogenic zone also. Furthermore, previous simulation researches based on structural studies indicate that first ruptures were starting from the Tonakai seismogenic zone in each earthquake cycle too. Therefore, we have been developing the dense ocean floor observatory network system around the Tonankai seismogenic zones , to monitor crustal activities using broadband seismometer, accelerometer and precise pressure gauges etc.
The development of Oceanfloor network is carrying out as MEXT project.
The ocean floor network is significant and important to monitor the crustal activities around mega thrust earthquakes precisely.

1. Introduction

In the Nankai trough, mega thrust earthquakes over M8 have occurred with the interval of 100-150 years. There are three mega thrust seismogenic zones such as the Tokai, Tonankai and Nankai seismogenic zone. In the past two earthquakes, 1944/1946 Showa earthquakes and 1854 Ansei earthquake, first ruptures were starting from the Tonankai seismogenic zone. In these cycles, Tonankai earthquake occurred ahead of the Nankai seismogenic zone with intervals of 32 hours in 1854 and 2years in1944/1946.

In many researches, the structural researches using refractions and reflections seismic has succeeded to image the key structures such as the irregular structure, subducting ridges and the subducted seamount to

understand recurrences cycle of mega thrust earthquakes around the Nankai trough. Moreover, results of mega thrust earthquake recurrence cycle simulation show that first ruptures are occurring around the Tonankai earthquake rupture zone in each recurrence cycle too.

According to previous researches, the Tonakai seismogenic zone is very important and significant area to understand the recurrence cycle of these mega thrust earthquakes around the Nankai trough. Therefore, the ocean floor network system is developing for real time monitoring around the Tonankai seismogenic zone.

2. Previous studies

The 1944 Tonankai and the 1946 Nankai earthquakes, each hypocenter was located off the Kii peninsula. So, the imaged irregular structure such as a key structure at the segment boundary between the Tonankai and Nankai earthquake rupture zone seems to be the controller of the Nankai Trough mega-thrust seismogenic zone system (Fig.1).

Furthermore, the results of recent simulation study of mega thrust earthquakes recurrence cycles indicates that these irregular structures seem to act as a controller of recurrence cycle and pattern of mega thrust earthquakes in the Nankai trough (Fig.2). And in these simulation cycles, the first ruptures are starting form the Tonankai seismogenic zone ahead of the Nankai seismogenic zone.

These results are consistent with the past two earthquakes in 1854, 1944/1946. (Table1)

veasr	Nankai	Tonankai	Tokai
684	●	○	○
887	●		
1096/ 1099	●	●	○
1361	●		
1498	○	●	●
1605	●	●	
1707	●	●	●
1854		●	●
	●		
1944/ 1946		●	
	●		

Table1: Historical earthquakes around the Nankai trough.

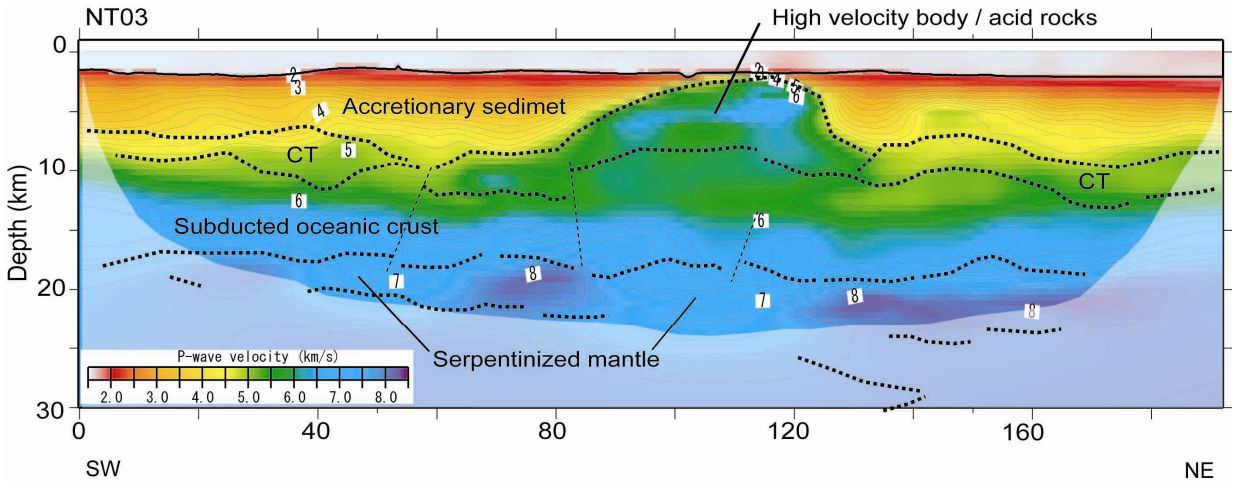

Fig.1 Imaged irregular structures around the Nankai trough

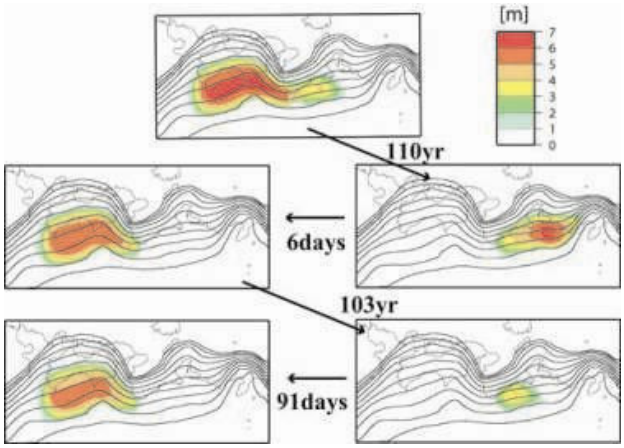

Fig.2 The result of recurrence cycle simulation .The red/yellow colors indicates earthquakes.

3. The Dense Ocean floor Network for Earthqukakes and Tunamis(DONET)

According to previous researches, the Tonankai seismogenic zone is important to understand the system of Nanaki trough mega thrust earthquake occurrences. Therefore, we proposed and have been starting to deploy the dense ocean floor observatory network system equipped with multi kinds of sensors such as seismometers, pressure gauges etc. around the Tonankai seismogenic zone (Fig.3). Especially, precise multi pressure gauges will be most useful sensor to monitor ocean floor deformation with long term observation. These ocean floor deformation data will be applied to the data assimilation to improve recurrence cycle simulation.

This observatory system will be the one of most advanced scientific tools to understand the mega thrust earthquakes around the Nankai trough.

This advanced dense ocean floor observatory network system has useful functions and purposes as follows,

1) Redundancy, Extension and advanced maintenance system using the looped cable system, junction boxes and the ROV/AUV etc (Fig.4).

2) Multi kinds of sensors to observe wide range phenomena such as long period tremors, low frequency earthquakes and strong motion of mega thrust earthquakes over M8.(Fig.5)

3) Speedy evaluation and notification for earthquakes and tsunamis (Fig.6). This function is most important for disaster reduction /mitigation.

4) Provide observed data such as ocean floor deformation derived from pressure gauges to improve the simulation and modeling researches about the mega thrust earthquakes. These ocean floor deformation data are quiet necessary for the data assimilation to improve simulation models.

5) Understanding of the interaction between the crust and upper mantle around subduction zone.

6) Development of advanced ocean floor network technology.

This project is scheduled from FY 2006 to FY 2009/2010 as MEXT project which is Japanese government funded project.

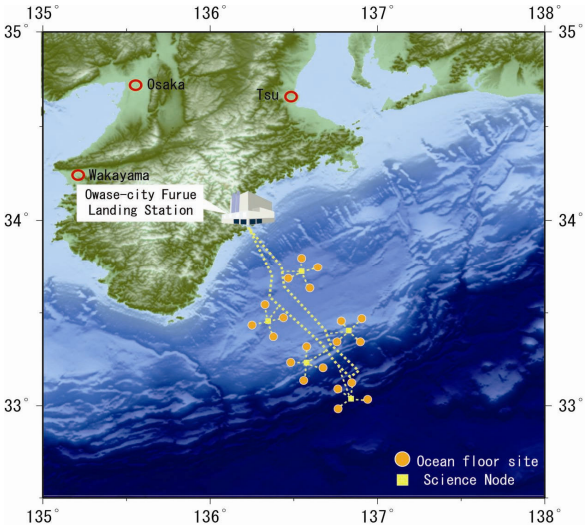

Fig.3 The outline of advanced ocean floor network around the Nankai Trough

This ocean floor network is equipped with 20 observatories with seismometer and precise pressure gauge.

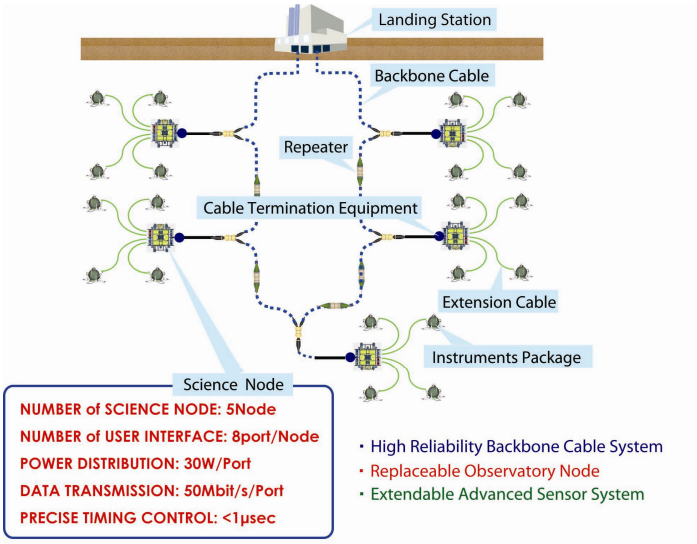

Fig.4 The concept of advanced ocean floor network system

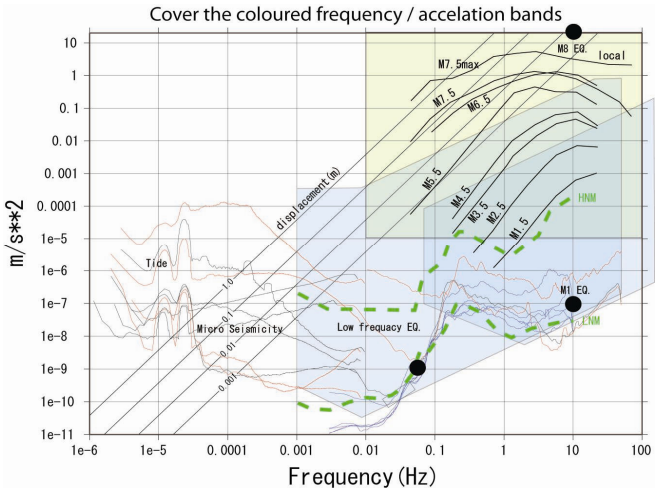

Fig.5 Estimated phenomena based on the frequency bands

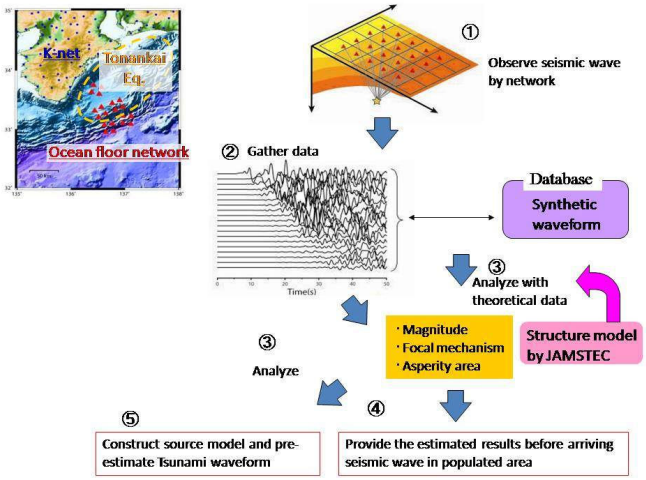

Fig.6 Flow of speedy evaluation and notification for earthquakes and tsunamis

4. Future

We will deploy the advanced ocean floor network off Kii peninsula not only the Tonankai seismogenic zone but also the Nankai seismogenic zone as a local network system.

To extend ocean floor network around the Nankai trough, we are developing the advanced DONET with high voltage system (Fig.7). By the advanced DONET system, we will deploy about 20 nodes and 100 observatories. Then, we have to apply the data from networks to disaster mitigation and seismological research including advanced simulation researches and data assimilations (Fig.8).

In the second step, we would like to develop and deploy the advanced ocean floor network as a regional system and integrate ocean and land network data (Fig.9), and in the next step, we would like to collaborate with international network systems as the global network to progress geosciences and contribute the early warning system for huge earthquakes and tsunamis (Fig.10).

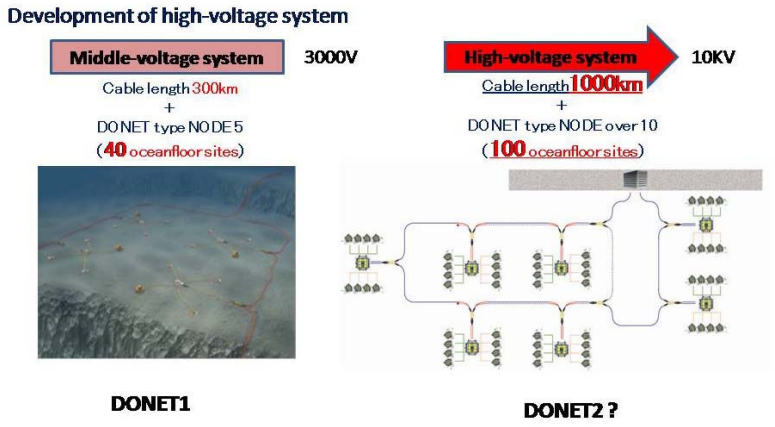

Fig.7 Data assimilation to improve the simulation models

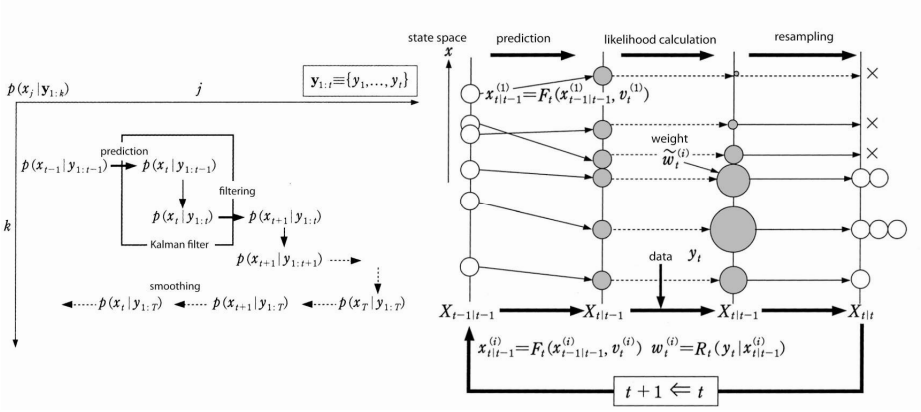

Fig.8 Data assimilation to improve the simulation models.

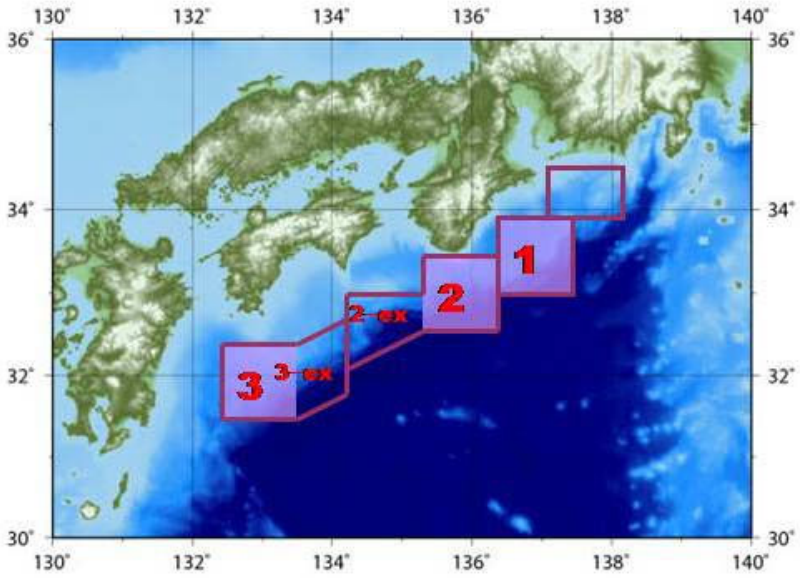

Fig.9 Future plan for Geosciences and disaster mitigation

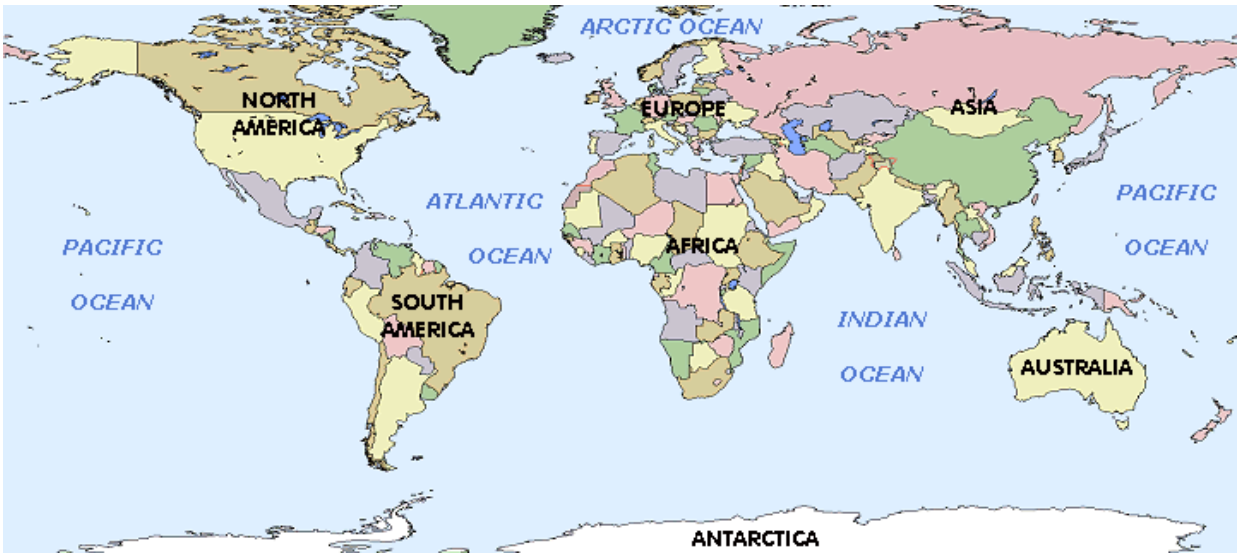

Fig10. Conecept of global netowork

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Kaneda, Y., AGU Fall Meeting209, Poster session, U.S.A.

MODOO: A modular and mobile deep ocean observatory and its application to the Porcupine Abyssal Plain

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Many of todays scientific questions require to observe the various processes in the ocean in parallel and from the air/sea interface to the sea-floor interior. Moreover, socioeconomic as well as scientific requirements may even demand to excess data in real time for example for marine safety or to adapt the instrumentation to episodic environmental conditions. Here we describe a muti-disciplinary deep ocean observatory that has been designed within the European FP6 ESONET Network of Excellence to meet todays scientific and socioeconomic requirements for ocean observatories. MODOO, the Modular and mObile Deep Ocean Observatory, combines underwater acoustic modules with a surface telecommunication module to access and combine a variety of instrumentation from the sea surface to below the sea floor.

MODOOs first application will be at the Porcupine Abyssal Plain: here a BOBO deep sea lander will be connected to a full water depth (4800m) deep sea mooring with meteorological package that belongs to the European FP7 EuroSITES network. The main scientific mission of this MODOO configuration is to investigate physical and biogeochemical processes that control the propagation and impact of near surface events (e.g. chlorophyll bloom) to the deep sea. For this mission we make use of physical (T/S recorder, current meters/profilers) and biogeochemical sensors (nitrate, fluorescence, oxygen, turbidity, particle flux/composition) combined with deep sea photography. Scientific guest missions will be seismic records and passive acoustics to detect deep sea marine life. The first MODOO installation is planned to be installed by the end of May 2010 for a three month test.

The MODOO instrumentation is not simply mounted together but part of the MODOO concept is to add a common time stamp to the individual instrumentations data set. All instrumentation that is directly connected to the acoustic modems - for the PAP application this will be T/S/turbidity, ADCP, seismometer, oxygen, sediment trap, photography - will receive a common time stamp generated by the modems electronics. This synchronization approach is expected to facilitate the joint interpretation of the diverse data sets. Further details of the MODOO data concept and possible future applications will be presented.

Preferred presentation: oral or poster

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Does resolution matter? Comparison of a glider and ship survey through the Eastern South Pacific oxygen minimum zone

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Hydrographic and biogeochemical data was acquired in January/February 2009 along a section at 14°S in the South East Pacific oxygen minimum zone. Observations were made from the research ship RV METEOR and with a deep (1000m) AUV SLOCUM electric glider. The ship sampled full water-depth with nominal 35 nm station spacing while the glider sampled the upper 1000m but with a projected station distance of typically less than 3 nm.

The ship observations comprise a variety of parameters and measured with high accuracy. The glider observations comprise only a limited parameter set with comparably low accuracy but with rather high resolution. The data sets are compared based on general as well oxygen minimum zone specific requirements. The comparison gives specific attention to role of small scale feature, as for example thin filaments, which are of potential importance to maintain extreme zones, like the Eastern South Pacific oxygen minimum zone.

Preferred presentation: oral

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COMPLEX SATELLITE MONITORING OF THE ARAL SEA REGION

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Desiccation of the Aral Sea in the so-called anthropogenic period (since 1961) led not only to considerable changes in its morphometric, physical, chemical, biological and other parameters, but to disappearence of the infrastructure in the coastal zone as well, including meteo and sea level gauge stations. The current lack of reliable in situ measurements and time series for sea surface temperature (SST), sea level and ice cover parameters since the mid-1980-s may be successfully replaced by using corresponding satellite information available through the World data bases. In particular, Multi-Channel Sea Surface Temperature (MCSST) data (since November 1981) and data of the Pathfinder project (a joint NOAA/NASA project devoted to the production of a high quality global SST dataset from 1985 to the present) can be the base of tracing of long-term variability of SST in different parts of the Aral Sea. These data bases with high spatio-temporal resolution (1 km, daily) and temperature resolution (0.1^{o}C) are based on measurements of Advanced Very High Resolution Radiometer (AVHRR) onboard satellites of National Oceanic and Atmospheric Administration (NOAA). Radar altimeters from the TOPEX/Poseidon (T/P) and Jason-1 (J1) satellites provide reliable, regular, frequent, and weather-independent data for monitoring of sea level in the Large and Small Aral seas since 1992. Altimeter data as well as data of the Special Sensor Microwave/Imager (SSM/I) radiometer enable us to study interannual variability of ice regime of the Aral Sea. Images from AVHRR NOAA and MODIS (onboard Terra and Aqua satellites) radiometers provide a possibility to follow the changes in the sea coastline and observe interesting phenomena in water, atmosphere and on the dried parts of the Aral Sea. The report discusses dynamics of various parameters of the Aral Sea during its desiccation which was traced with different type of satellite information. The consideration includes changes in morphometric characteristics (shoreline, sea area and volume), sea level, SST, and ice regime. Besides, we look at phenomena associated with changes in the Aral Sea coastline and salinity, such as upwelling along the eastern coast of the western Large Aral Sea formed due to shallowing of the sea, occasional Amudarya water inflow in the eastern Large Aral, freezing of fresh Amudarya runoff over cold and saline Aral water, etc.

CHARACTERISTICS OF THE COASTAL MARINE ZONES FROM MULTISPECTRAL OPTICAL SATELLITES

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The big importance of the coastal marine zones for economy (industry, transport, agriculture, tourism, recreation) on the one hand and vulnerability of their ecology with another are the reasons of that these zones are the object of the enhanced attention from the many international and national scientific organizations, and also from many experts. The major problems of such zones are the coastal erosion, eutrophication, hypoxia, sedimentation, pollution. These phenomena are connected by various ways with the optical characteristics of the water environment which can be determined from the multispectral measurements by optical satellites such as SeaWiFS, MODIS, Landsat etc. [*Khanbilvardi et al., 2005; Kushnir & Stanichny, 2006; Kushnir, 2009]*.

One of the feature of the remote sensing of the marine coastal zones is rather high turbidity of water environment because of significant concentration of the mineral and organic suspension, phyto- and zooplankton which essentially change the form of spectra and intensify of the brightness of the water leaving radiation (WLR) in a long-wave part of the spectrum, including red and infra-red areas. It means inefficient of the widely used methods of the optical satellites data processing for rather transparent sea water and dictates necessity of new methods for the coastal marine areas. One of such methods is considered in this work. The color index $I_{wn}(0.469/0.555) = L_{wn}(0.469\mu m)/L_{wn}(0.555\mu m)$ spatial distribution for the normalized WLR signals $L_{wn}(\lambda)$ on waves lengths of $\lambda = 0.469\mu m$ and $\lambda = 0.555\mu m$ lays in its base.

Atmospheric correction of the satellite signals is carried out on the basis of the statistical maximum-likelihood method (MLM) for a range of the waves lengths from $0.8585\mu m$ up to $2.13\mu m$, and the boundary length of the wave is determined from the condition of absence of significant correlation between WLR and signals of the long-wave part of the spectrum ($\lambda \geq 0.8585\mu m$) which are determined by aerosol and molecular light scattering in the atmosphere. Such approach was used for determination of the mineral and organic suspension concentration, transparency and other optical characteristics in the Northwestern Black Sea and in the Azov Sea. The comparisons of the received results with the available data of the direct measurements are discussed.

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EuroSITES: Integrating and enhancing Europe's *in situ* ocean observation

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EuroSITES is a 3 year (2008-2011) collaborative project (3.5MEuro) with the objective to integrate and enhance the nine existing open ocean fixed point observatories around Europe (www.eurosites.info). These observatories are multidisciplinary and make *in situ* observations within the water column as the European contribution to the global array OceanSITES (www.oceansites.org). Some seafloor sites are also actively supported and enhanced. In the first 18 months, all 9 observatories have been active and integration has been significant through the maintenance and enhancement of observatory hardware. Highlights include the enhancement of observatories with sensors to measure O_2, pCO_2, chlorophyll, and nitrate in near real-time. During 2010 extensive field work is planned at many of the observatories. This includes the deployment, in collaboration with the UK Met Office, of a new full depth mooring at the PAP site with meteorological sensors to complement the suite of water column and seafloor sensors and samplers.

EuroSITES also promotes the development of innovative sensors and samplers in order to progress capability to measure climate-relevant properties of the ocean. In 2009 EuroSITES partner CNRS conducted successful *in situ* deployments of an oxygen consumption device ($IODA_{6000}$) in both coastal (ANTARES) and open ocean (PAP) environments. This device will revolutionise our understanding of the mesopelagic zone (100-1000m depth band), the biological carbon pump and the oceans' role in the carbon cycle. Another key variable is mesozooplankton abundance and diversity. To develop this, EuroSITES partner NOCS is trialling and improving a device for long-term sampling in the Atlantic and possibly Mediterranean in 2010. Measuring the pH is also key to monitoring the levels and impacts of ocean acidification. EuroSITES is supporting development of a novel pH sensor with high reproducibility and accuracy for long-term oceanic deployment. Having successfully demonstrated the instrument during trials, the sensor, now commercialised, will be deployed at the ESTOC site in early 2010. Many of these science missions are directly related to complementary activities in other European and international projects such as EPOCA, HYPOX and ESONET.

Although much of the focus of EuroSITES is on the water column, significant development of seafloor capabilities has taken place. Two autonomous seafloor platforms have been deployed in the Mediterranean, one for tsunami detection and one to monitor fluid flow related to seismic activity and slope stability. Seafloor science missions in 2010 include monitoring benthic biological communities and associated biogeochemistry as indicators of climate change in both the Northeast Atlantic and Mediterranean. In 2010 a direct collaboration including *in situ* field work will also take place between ESONET and EuroSITES. The demonstration mission MODOO will be implemented in 2010 at the EuroSITES PAP observatory. Field work will include deployment of a seafloor lander system with various sensors which will send data to shore in real time via the EuroSITES water column infrastructure.

EuroSITES maintains the OceanSITES philosophy of open access to data in near real-time. With a common data policy and standardised data formats (OceanSITES NetCDF) EuroSITES is increasing the potential users of *in situ* ocean datasets and the societal benefit of these data. Data management is led by NOCS, UK with CORIOLIS as the Global Data assembly centre (GDAC) for EuroSITES and OceanSITES data. As a result, since the start of EuroSITES all available near real-

time temperature and salinity observations have been presented to be sent to the World Meteorological Organization Global Telecommunication System (WMO/GTS), as TESAC bulletins, thus making EuroSITES data available to a wide audience of potential users, and the products and services they generate. As the Global Data Assembly Centre (GDAC) for the OceanSITES network, CORIOLIS has also been central to EuroSITES ever increasing contribution as an upstream data provider to the GMES project MyOcean (both real-time and delayed-mode data). EuroSITES outreach and knowledge transfer has also developed considerably with a dedicated outreach website, Fact Sheet, cruise diaries and educational tools being developed in the first 18 months. In 2010 a film will be produced to represent the network and this will be distributed to a wide audience through the European network of aquaria and at other outreach events.

By the end of EuroSITES in April 2011, the 9 core ocean observatories will be well integrated. Each observatory will have enhanced infrastructure to include both physical and biogeoechemical sensors. Science missions in the ocean interior and seafloor/subseafloor will have progressed European ocean observational capability significantly. Collaborations will have taken place or will be at an advanced stage of planning with related European and international projects including ESONET FP6 NoE and the NSF funded Ocean Observatories Initiative (OOI) (400M $ over 5 years). EuroSITES will continue to develop it’s contribution to the ocean component of the Group on Earth Observations (GEO) through task AR-09-03c 'Global Ocean Observing Systems' and related societal benefit areas.

Long-term time-series from the EuroSITES Porcupine Abyssal Plain (PAP) sustained observatory

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The Porcupine Abyssal Plain (PAP) sustained observatory (SO) in the Northeast Atlantic (49ºN, 16.5ºW) is the longest running deep ocean interdisciplinary observatory in Europe. The site has produced a high-resolution dataset linking climate, environmental and ecologically relevant parameters from the surface to the benthos for over twenty years. Since 2002 a fixed-point mooring has been in place with autonomous sensors and in 2007 the mooring was enhanced with a surface buoy. The PAP-SO is led by the National Oceanography Centre, Southampton, UK and is one of 9 open-ocean observatories within the EuroSITES network, the European contribution to the OceanSITES global array (www.oceansites.org). Through OceanSITES PAP-SO contributes significantly to the *Group on Earth Observations* (GEO) as part of task AR-09-03c 'Global Ocean Observing Systems'.

Autonomous datasets produced in the past 8 years include euphotic zone measurements of temperature, salinity, chlorophyll-a fluorescence, nitrate and pCO_2. Many of these data are sent in near real-time from the upper 1000 m through satellite telemetry to shore stations. In addition time-series in the mesopelagic and seafloor environments include deep ocean particle flux and benthic process studies. These combined time-series results enable various temporal processes to be further understood including short-term (daily to seasonal) variation and longer-term trends (climate driven). In addition, a continuous high resolution time series allows episodic events, which are otherwise missed, to be sampled. These episodic events including storm surges, eddies and phytoplankton blooms, often significantly shape the marine environment and ecosystem. The full depth and multidisciplinary nature of the datasets are also vital for addressing the interconnections and feedbacks between the climate, surface productivity, carbon export, biogeochemical cycling and benthic community dynamics.

In 2009 the PAP-SO was the location for EuroSITES process studies and sensor trials. This included the first open-ocean deployment of the oxygen consumption sensor $IODA_{6000}$. Developed by EuroSITES partners CNRS, this sensor should revolutionise our understanding of carbon cycling in the mesopelagic zone, the biological pump and the oceans' role in the carbon cycle. In addition, EuroSITES coordinator NOCS is currently developing a device for long-term sampling of mesozooplankton abundance and diversity. The plankton sampler will be deployed at the PAP site in 2010 and possibly in the Mediterranean. Other major field work planned at the PAP-SO in 2010 includes the deployment, in collaboration with the UK Met Office, of an improved full-depth mooring. This will include meteorological sensors to complement the suite of multidisciplinary physical and biogeochemical sensors. In 2010 the PAP site will also be the demonstration site for an *in situ* collaboration between EU projects EuroSITES and ESONET. The ESONET demonstration mission MOdular Deep-Ocean Observatory (MODOO) will enhance EuroSITES infrastructure at the PAP-SO with a seafloor lander system and sensor suite. This will send physical, biogeochemical, and ecological data to shore in near real-time via acoustic telemetry through EuroSITES water column infrastructure. These enhancements to the PAP-SO will contribute to progressing Europe's capability

to monitor ocean processes and the oceans'response to climate change beyond the current state-of-the-art.

An analysis of multiparametric observations in the Gulf of Finland (Baltic Sea)

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Classical observations of the sea are performed with low frequency or episodically while remote sensing methods do not reveal the vertical structure of the water column. Thus, essential phenomena and mechanisms may remain unnoticed. New observation tools introduced within the last 10-20 years, which enable to measure with high resolution the fine structure of marine ecological state variables, are significantly improving the existing understanding of the ecosystem functioning and may be applied operationally. We present the multiparametric observations in the Gulf of Finland (Baltic Sea) including an autonomous system installed on board a ferry, a moored water column profiler and an ADCP deployed in the gulf, and measurements and water sampling on board a research vessel. Surface layer temperature, salinity and Chl a fluorescence are recorded twice a day along the ferry line Tallinn-Helsinki (time step 20 s, spatial resolution 150 m) and water samples for Chl a, nutrient and phytoplankton analyses are taken once a week at 17 locations. In July-August 2009 high resolution vertical profiling of temperature, salinity and Chl a fluorescence was carried out with a time step of 3 hours using the automated profiling system deployed close to the ferry line. Vertical flow structure was registered using an ADCP and water sampling for Chl a, nutrient and phytoplankton analyses was performed. An analysis of the collected data together with wind data from the area enabled us to characterise the structure and variability of hydrophysical fields, nutrients and phytoplankton and to relate the observed changes to the forcing and key processes.

Regional variability in sea level over 2002 – 2009 based on satellite altimetry, Argo float data and GRACE ocean mass.

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The global mean sea level budget over 2003-2008 was studied in a few recent papers using satellite altimetry, Argo and GRACE observations. Here we investigate the regional variability in sea level over 2002-2009 with different data sets provided by different research teams (in particular from Argo). Spatial patterns in observed (from satellite altimetry) and steric (from Argo) sea level agree quite well over the studied time span. An EOF analysis of observed and steric sea level displays leading modes driven by ENSO in the tropical Pacific and by three successive Indian Ocean Dipole events that affected the Indian Ocean in 2006, 2007 and 2008. We also compare spatial patterns in ocean mass from GRACE (based on different data sets) and from the difference 'altimetry-based minus steric sea level'. The agreement is reasonably good in several regions, in particular North West Pacific Ocean, Atlantic Ocean and West Indian Ocean. Finally we investigate the year-to-year variability in global mean sea level (corrected by steric effects) and ocean mass inferred by GRACE.

Strong currents intensification in the Catalonian Coast

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Knowledge of coastal currents is essential for shipping, sediment transport, harbour design and understanding of coastal processes such us upwelling. In this work, currents measured with four meteo-marine coastal buoys belonging to the XIOM network [*Bolaños et al.,* 2008] have been analysed in order to characterise currents in the Catalonian Coast. The northern buoy is settled in the Roses Bay, where the coastline protection prevents the formation of strong currents. Analyses, in the other three buoys have revealed episodes with very intense current velocities ($v > 50$ cm/s) if compared to mean currents in this area [*Castellón et al.,* 1990]. Similar intensification episodes have been found in the analysis of current data obtained from previous ADCP measurements in the area. As shown by cross-wavelet analysis, the intensification episodes measured in the three buoys appear to be related to wind stress. Coherence analysis will be applied to support and confirm this hypothesis. Thus, the relationship between these episodes and other type of structures such us eddies or filaments [*Send et al.,* 1999], that can be observed offshore with regional forecasting systems such us MFSTEP [*Pinardi and Tonani,* 2005], could be discarded. To study the origin of these surface currents and to find out their structure during these episodes, wind-forced coastal numerical models are to be used.

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Global comparison of sea surface currents from drifter and altimetry observations

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A global comparison of sea surface currents is conducted between in situ drifter velocities and currents from satellite altimetry. Drifter velocities are lowpassed to remove inertial and tidal fluctuations and decomposed into time-mean and time-varying components. Ekman motion is estimated using an empirical model and removed to produce drifter-derived geostrophic velocity anomalies. Coincident (within one day) measurements between the drifters and altimetric sea level anomaly estimates are identified for each time a drifter crosses a satellite groundtrack. Earlier comparisons between drifters and altimetry have used optimally interpolated altimetry, with consequent smoothing of mesoscale features and potential impacts upon correlations and gain coefficients. This limitation is overcome here using the alongtrack altimetry data, focusing on the acrosstrack component of velocity. Results indicate that the correlation between drifter and altimeter-derived geostrophic velocity anomalies is large ($>$0.6) in regions where EKE exceeds 300 cm^2/s^2. Regions of low correlation exist where the signal-to-noise ratio is very small, such as in the eastern subtropics, and throughout the North Pacific subpolar gyre. Altimetry-derived estimates of EKE are larger than those from drifters, presumably due to different time and space filtering. These results can be used to estimate the potential bias in satellite-derived currents as a function of the observing system and satellite constellation configuration.

The Wave Glider: Enabling a New Approach to Persistent Ocean Observation and Research

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Henry Stommel's visionary article, The Slocum mission, was published in Oceanography in 1989. Now, 21 years later, his vision for the ocean of the future is nearly upon us. Stommel anticipated fleets of autonomous vehicles roaming the ocean over long time scales and collecting unprecedented new oceanographic data sets. With the ongoing success of autonomous gliders, and the deployment of thousands of Argo floats, Stommel's vision has been demonstrated to be possible. But there is room for new unmanned platforms in that vision and this paper presents one such new tool.

The Wave Glider wave-powered unmanned maritime vehicle (UMV), represents a novel and unique approach to persistent ocean presence. Wave Gliders harvest the abundant energy contained in ocean waves to provide essentially limitless propulsion while two solar panels continuously replenish batteries that are used to power the vehicle's control electronics, communications systems, and payloads.

Wave Glider is a hybrid sea-surface and underwater vehicle in that it is comprised of a submerged "glider" attached via a tether to a surface float. The Wave Glider vehicle is propelled by the purely mechanical conversion of ocean wave energy into forward thrust, independent of wave direction. Engineering prototypes and the first product generation of the Wave Glider vehicles have logged a combined total of more than 50,000 nautical miles at sea, with the longest continuous mission lasting 365 days and continuing on after only two hours of on deck maintenance.

In this paper, we give an overview of the design of this new platform and present results from the extensive engineering sea trials conducted with several prototype and production versions of the vehicle. The vehicle's performance in a variety of ocean conditions — varying sea state, wind speed, and surface currents — is discussed. The vehicle's robustness and capabilities for extended mission durations are also examined. Results of missions such as a transit from Monterey (California) to Alaska are presented.

In addition to the Wave Glider technology we will present results from a variety of ongoing scientific demonstration programs. Wave Gliders have been engaged in meteorological and oceanographic (METOC) studies including open ocean METOC, coastal monitoring of the Mendocino (CA) current and support of tsunami warning buoys. Results from test deployments of an acoustic Doppler current profiler (ACDP) will be discussed, as will plans for deployment of a CO2 sensor for open ocean carbon measurements.

Real time monitoring of Nazare Canyon (W Portugal)

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Large submarine canyons are among the most challenging ocean environments to be explored. Incising large fractions of the continental margins, they have profound impact on the coastal environment either by modifying the shelf and slope circulation, by promoting large transfers of particles and water properties between the coast and the deep-ocean, or by focusing surface wave energy. A good understanding of their role and impact is then needed in order to characterize the coastal areas where they are inserted. However, the extreme topography of submarine canyons marked by abrupt slopes and short spatial scale features, and the highly energetic processes they host both render extremely difficult the monitoring of these regions and often require the use of innovative strategies and sensors. Off the western Portuguese coast, the Nazare Canyon is one of such areas of exceptional interest. Extending from more than 270km, from abyssal depths over 5000m to about a few hundred of meters from shore, the Nazare Canyon is the largest submarine canyon of the European margin. It incises a rather sensible continental margin, characterized by the presence of a protected area for marine life (Berlengas marine reserve), the proximity of important routes for maritime traffic, the existence of traditional fishery centers and the strong development of the touristic sector during the last years. Since 2002, the Portuguese hydrographic office, Instituto Hidrográfico (IHPT) is maintaining a monitoring program of the Nazare Canyon conditions, co-financed by major European projects such as EUROSTRATAFORM (2002-2005), HERMES (2005-2009) and presently HERMIONE (2009-2012). The program is focused on the upper and middle sections of the canyon and nearby environments and involves the maintenance of an array of currentmeters/ADCP moorings, complemented by multidisciplinary surveys conducted on regular basis. The interest raised by this monitoring program among the local authorities and general public and the recognition of the exceptional conditions of the area to act as laboratory for the studies of interactions between the coastal and deep-ocean areas motivated recently the step forward towards the building of real-time monitoring and operational forecasting capacities in the Nazare Canyon area. This effort is being developed presently by IHPT in the framework of Project MONICAN (MONItoring of the Nazare CANyon), financed by the EEA Grants mechanism. The real time system integrates an array of two multi-parametric buoys, one coastal meteorological station and two coastal tide gauge stations, all providing data transmission. The set of multi-parametric buoys is the central component of the system and was started in April 2009, with the deployment of a first, deep water buoy, in a position along the canyon axis, by 2000m depth. This will be followed, in April 2010, by the deployment of a second, shallow water buoy, in a position over the mid-shelf area north of the canyon, by 100m depth. Each multi-parametric buoy integrates: a directional wave gauge which provides wave measurements (height, direction, period and spectral wave parameters), an array of oceanographic sensors (water temperatures at 5 different depths and current measurements with ADCP), mete-

orological sensors (air temperature, atmospheric pressure, relative humidity, wind speed, direction and gust) and environmental sensors (oxygen, chlorophyll-a and oil spill). Every hour, the buoy sends to IHPT, via Inmarsat-C satellite, wave and meteorological parameters, sea temperatures, and environmental data. Additional parameters such as wave spectra are archived using the storage capacity of the buoys. The ADCP data from the deep buoy is also stored while the data collected by the shallow buoy will be transmitted in real time. A key aspect of the MONICAN project is the public dissemination of the data collected by the real-time monitoring system, which is accomplished through a free access web portal. This required the implementation of a data quality control procedure: A first step of this procedure is done by the measurement system, which applies a validation window to the data, on the characteristics of each sensor. The second step of quality control is done at IHPT and comprises the validation within acceptable values for each parameter and the checking for differences between consecutive items. The flagged data is stored in Oracle databases, from where is distributed through the web portal. In complement to the MONICAN system, other less conventional observing solutions are also being tested and operated at Nazare Canyon. Among these, the CORSED platform, developed at IHPT, integrates ADCP's and currentmeters and uses a combined acoustic and radio link to real-time data transmission. The versatility of low cost sensors (both in trawled or moored configuration) to provide measurements in the area using ships of opportunity is also, presently, under evaluation. On the very near future, additional capacities will be implemented in the area of Nazare Canyon observatory. This includes the installation of an HF radar system during 2011, in the framework of a national funded project (SIMOC).

Dynamic Source Process of Earthquakes in Caspian Sea

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The Caspian Sea and surrounding area is an important part of the Alp-Himalaya tectonic belt. Some of large and destructive earthquakes have been occurred in this region along last centuries. One of the most important tools for taking information about earthquake source is study about dynamic features of seismic events. Preliminary results about these features in Caspian sea show that over the entire depth between 4≤ h≤76 km, the total duration (τt) is related to seismic moment (Mo) by log τ_t = (0.2642 ± 0.001) log M_o _8.9119 (±.0.194). Deep seismic sounding data reveal that the crust of the Caspian sea consist of a thick (15-20 km) low velocity (Vp3.5-4.0 km/s) sedimentary section in the southern part of the basin and resting on a high velocity (Vp> 6.6 km/s) layer . The high velocity crustal layer of the Caspian Sea has been assumed by many to be oceanic-like crust. The age of the oceanic basement is uncertain.

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Subsurface circulation in the Mediterranean Sea based on Argo data

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The trajectories of Argo floats, deployed in the Mediterranean Sea since October 2003, were used to create a dataset of velocities at 350 m and to study the subsurface circulation in regions with good data coverage. These floats were programmed to execute 5-day cycles, to drift at a neutral parking depth of 350 m and measure temperature and salinity profiles from either 700 or 2000 m up to the surface. At the end of each cycle the floats remained at the sea surface for about 6 hours, enough time to be localised and transmit the data to the Argos satellite system. The Argos positions were used to determine the float surface and subsurface displacements. At the surface, the float motion was approximated by a linear displacement and inertial motion. Subsurface velocities estimates were used to investigate the Mediterranean circulation at 350 m, to compute the pseudo-Eulerian statistics and to study the influence of bathymetry on the subsurface currents. Maximum speeds, as large as 33 cm/s, were found northeast of the Balearic Islands (Western basin) and in the Ierapetra eddy (Eastern basin). Typical speeds in the main along-slope currents (Liguro-Provençal-Catalan, Algerian and Libyo-Egyptian Currents) were 20 cm/s. In the best sampled regions, the pseudo-Eulerian statistics show typical subsurface circulation pathways which can be related to the motion of Levantine Intermediate Water. Fluctuating currents appeared to be usually larger than the mean flow. Subsurface currents were found to be essentially parallel to the isobaths over most of the areas characterized by strong bathymetry gradients, in particular, in the vicinity of the continental slopes.

Combining gliders, satellite SST and ocean models in 3-D Super Ensemble forecasting

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The Super Ensemble (SE) technique was shown to provide improved forecasts of environmental conditions in coastal areas ([Rixen et al., JMS 2009]). The technique consists in the optimization, in terms of the distance to observations, of the weighted linear combination of several ocean models during a specified learning period (typically a few days). The weights are then used to combine model predictions and generate the SE ocean forecast. Based on the idea that individual model skills may be spatially variable, an evolution of the technique, called 3-D Super Ensemble (3DSE), has been developed. The three-dimensional variability of model weights is introduced in the 3DSE. The new method is evaluated using: (i) glider profiles taken during the LSCV08 oceanographic campaign (Ligurian Sea, October 2008); (ii) satellite and in-situ processed SST data; and (iii) three ocean circulation models. Whereas model weights at the surface are mainly influenced by satellite SST information, their vertical variability is constrained by profile observations. Profiling gliders, which enable an autonomous sampling of the area of interest with a relatively easy deployment, then constitute a key ingredient of this forecasting system. Forecast skills are improved compared to individual models and their Ensemble Mean (EM). Over a 4-day forecast period, the surface and vertical temperature biases are respectively reduced by 79% and 60% compared to EM. The unbiased Root-Mean Square Difference and the linear correlation coefficient with temperature observations are similar to those of the EM forecast in our experiments. The method is also shown to be sensitive to initial weight error covariances, which are used to spatially propagate the information from observation points to the whole ocean domain. Various sensitivity tests and further improvements are discussed.

Temporal and spatial variability of hydrological variables in Guadalquivir River Estuary through a real time telemetry network

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Two years (2008–2009) of hydrological and hydrodynamic data are used to document the temporal and spatial variability of the physical-biogeochemical coupling in the Guadalquivir River Estuary. In order to study the whole range of temporal scales (semidiurnal, diurnal, fortnightly and seasonal scales), a real time telemetry network have been deployed in the river stream between Seville and the river mouth [Gutierrez et al, 2009]. This network consists of eight hydrological monitoring stations, able to measure temperature, conductivity, dissolved oxygen, turbidity and chlorophyll fluorescence at four depths. Moreover, there are deployed six stations for hydrodynamics, performing 20-cell water column current profiles, and a meteorological station at the river mouth to understand the atmospheric interactions. Completing this data set, there are eight additional tide-gauges to study the sea level in the estuary. Different physical forcing sources, such as wind, tide-associated current velocity and river discharge, are responsible for the temporal and spatial turbidity and salinity pattern in the estuary. These variables force the distribution of biogeochemical variables such as dissolved oxygen and chlorophyll fluorescence. In particular, episodes of elevated turbidity (suspended particle matter concentration $>$ 3000 mg/l) have been detected by the network along with episodes of descending values of salinity and dissolved oxygen, with all these patterns being related to river discharge and tidal dynamics (spring/neap and high/low tide).

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Time series of MERIS and MODIS Total suspended matter, their reconstruction by DINEOF and validation with autonomous platform data

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In situ measurements of Total Suspended Matter (TSM) over the period 2003-2006, collected with three CEFAS SmartBuoys measuring the optical backscatter (OBS) and located in the Southern North Sea, are used to assess the accuracy of the TSM time series extracted from satellite data. Since there are gaps in the remote sensing (RS) data, due mainly to cloud cover, the Data Interpolation by Empirical Orthogonal Function (DINEOF) of (Sirjacobs et al 2009) is used to fill in the TSM time series and build a continuous daily "recoloured" data set.

The RS data sets consist of TSM maps from MERIS imagery using the neural network technique of (Schiller and Doerffer 1999) and from MODIS using the bio-optical model of (Nechad et al 2009). The latter study showed consistency between TSM time series and TSM maps from the two sensors, despite the different atmospheric correction methods and the TSM algorithms.

In this study, the DINEOF time series are compared to the in situ data at the three locations: West Gabbard, Warp (TH1) and in the coastal Liverpool Bay. The discrepancies between instantaneous RS, DINEOF-filled RS data and in situ data are analysed in terms of: TSM algorithm uncertainties, space-time variability and DINEOF reconstruction uncertainty.

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ELEMENTS OF THE TSUNAMI PRECURSORS' PHYSICS: SEISMO-HYDRO-ELECTROMAGNETICS

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A mathematical model of seismo-hydro-electromagnetic geophysical field interaction is formulated basing upon the theory of elasticity, electrodynamics of slowly moving media, hydrodynamics, irreversible thermodynamics and geophysical data. The authors show that the initial boundary value problem for the system of partial differential equations (PDF) of the model is well-posed though the differential operators included in the system of the PDFs are of different mathematical types, according to different physical nature of interacting fields (above).

Then the authors traced numerically and visualized generation and propagation of ultra-low frequency (ULF) electromagnetic (EM) signals in a seismically disturbed moving model medium with a lithosphere zone, a marginal sea and an atmosphere zone up to the lower boundary of the ionosphere. Demonstrated are sequential stages of the physical process of transformation of a seismic excitation in geological structures beneath the sea bottom into EM signals in the atmosphere: generation of an ULF EM wave in a seismically deformed conductive domain of the ocean lithosphere (similar domains are known to be typical for tectonically active lithosphere zones, both continental and oceanic ones); a spatial modulation of the generated long EM wave by the seismic wave , "freezing" of the EM wave (arrived at the top of the sedimentary layer) before going over from the lithosphere into the sea depth with its high electric conductivity (4 S/m); the delayed seismic P wave's shock into the deep part of the sea bottom, arising of a vertical hydrodynamic flow and a surface long (about 150 km) tsunami wave of a small (up to 15 cm) amplitude far from the shore), EM emission from the sea surface.

As a result, it is shown that measurable ULF EM signals (hundreds of pT at the sea bottom and the sea-atmosphere interface by the frequency spectrum similar to one of the initial seismic excitation) do arise in atmosphere during development of a seismo-hydro-EM process initialized by a rather moderate (precursory) seismic excitation in the form of elastic displacements with main frequencies 0.1 to 10 Hz and the amplitude and duration of the order of a few cm and sec respectively in the upper mantle under the sea bottom. The quantitative characteristics of the computed seismo-hydro-EM process (e.g. the amplitudes of the EM, temperature and tsunami waves, the delay of the EM signal in regard to the beginning of a seaquake etc) correspond to observations. The scheme of a multilevel multifunctional lithosphere-ocean-atmosphere-ionosphere monitoring system is given.