Challenges in Monitoring the Coastal water of Sea of Oman and Arabian Sea.

ADNAN AL AZRI[1]

[1] *Department of Marine Sciences and Fisheries*

The extensive coastline of the Sultanate of Oman has shaped its culture, economy, history and its people for millennia. Today, even with an oil-driven economy, coastal marine resources are still of great economic importance and continue to influence and sustain the lifestyle of the people of Oman. Marine living resources along the coast of Oman are an endowment of biodiversity, provide abundant food and energy resources and opportunities for tourism and recreation. Unfortunately, the continuous pressure of development threatens this marine environment primarily via over-fishing, global climate change, habitat modification and destruction and land based sources of marine and coastal zone pollution. In order to achieve conservation and long-term sustainable use of marine living resources we need to build a fundamental understanding of the coast through continuous monitoring and research that will allow us to differentiate between anthropogenic and natural variability. Hence, routine monitoring and assessment of the physical and biological parameters changes in our coastal ecosystems become a major challenge as we lack proper seagoing vessels and in-situ measurements equipment.

We have been collecting data from three monitoring sites, two of which are located in the Sea of Oman and one in Arabian Sea at Masira. With the lack of Sea going research vessel, we have been collecting data from ship of opportunities and using satellite images to monitor and assess physical and biological changes along the coastal waters of Oman. Data collected includes phytoplankton diversity, and hydrographic parameters such as temperature, salinity, nutrients and oxygen that will not only provide us with baseline data necessary for future studies on anthropogenic impacts on this ecosystem but also a better understanding of the seasonal and interannual changes associated with monsoonal forcing. In this paper we address the challenges of monitoring the coastal water of Oman and using data from time series, remote sensing and ships of opportunities to arrive at conclusions about how the physical and biological changes could impact this ecosystem.

OpenDA-NEMO framework for Ocean Data Assimilation

M. U. ALTAF[01], NILS VAN VELZEN[01], M. VERLAAN[01], A. W. HEEMINK[01]

[1] *Delft University of Technology, The Netherlands*

Data assimilation (DA) provides a mean to handle the modelling errors and uncertainties in sophisticated ocean models. Traditionally, DA algorithms are implemented in model specific form. This requires the knowledge of the numerical core and additional programming to perform DA experiments. OpenDA is an open source data assimilation toolbox that contains a number of state-of-the-art data assimilation algorithms to easily set up a forecasting system with data assimilation capabilities. Here, we present a flexible approach to setup an ocean prediction system based on OpenDA-NEMO framework unlocking the data assimilation tools available in OpenDA for use with NEMO models. This includes data assimilation methods, automatic parallelization and a recently implemented automatic localization algorithm. A number of assimilation experiments with the NEMO ocean modeling system is performed to demonstrate the capabilities of the coupled OpenDA-NEMO approach. From the experiments we can conclude that the OpenDA-NEMO framework performs as expected and that the automatic localization significantly improves the performance of the data assimilation algorithm by successfully removing spurious correlations. Based on these results it looks promising to extend the framework with new kinds of observations and work on improving the computational speed of the automatic localization technique such that it becomes feasible to include large number of observations.

Etude de la structure et de développement des communautés périphytiques sur substrats durs soumis une pollution urbaines : Cas du lac Sidi Mhamed Benali (ouest de l'Algérie)

YOUCEF AMAR[1], SARA BOUCHRA AMAR[1], ZOUBIR BELMOKHTAR[1], DJAHED BENYOUNES[2]

[1] *Laboratoire d'Hydrobiologie et pollution, Univ. De Sidi Bel Abbes*

[2] *Laboratoire de cancer et environnement, Univ. De Sidi Bel Abbes*

This study is based on the general assumption that a change in the physico-chemical parameters of aquatic environments and climatic factors, may result in dynamic changes and / or structure, composition and operation of the periphyton thus its response to the presence of polluants. Following the sensitivity to environmental stress, periphyton is a very good indicator of the organic quality of the environment, and can be a tool for bio-monitoring of lake ecosystems. The periphyton study of Sidi Mohamed Benali's lake was carried out in two coastal stations with two samples per month from March in May 2014. In this study, the periphyton of hard substrates exposed to surface current and substrates protected against water movements are studied as a function of the water quality. Meanwhile, a water sample is taken from each station in view of the physico-chemical analysis. The qualitative and quantitative analysis of periphyton revealed a population consisting mainly of micro algae or diatoms namely: Chlorophyceae, Bacillariophyceae, the Myxophycées the Desmidiacées the Euglénophycées and micro-invertebrate community including: rotifers, the hair, copepods and cladocerans. The second shows the continuing dominance of Chlorophyceae, Bacillariophyceae and Myxophycées. The Desmidiacées and Euglénophycées appear with seasonal dominance. Furthermore, rotifers usually dominate the settlement of micro-invertebrate periphyton the lake. The results of physicochemical analyzes consistent with the biological study show that the binding of periphyton is higher in the absence and presence of the current, as well as species richness appears more remarkable in the station S1 (south of lake near the Mekerra wadi) from the station S2. It should be noted that changes in periphyton biomass during the study period appear to be strongly influenced by hydrological changes occurring and the impact of surrounding anthropogenic inputs. Keywords : Périphyton - Sidi Mhamed Benali lake - Physico-chemicals Analysis - Diversity -

Assimilation Experiments for the Fishery Observing System in the Adriatic Sea

ALI AYDOĞDU[1,2], NADIA PINARDI[3], JENNY PISTOIA[4], MICAELA MARTINELLI[5], ANDREA BELARDINELLI[5], STEFANIA SPARNOCCHIA[6]

[1] *Centro EuroMediterraneo sui Cambiamenti Climatici-CMCC, Bologna, Italy*
[2] *Ca Foscari University of Venice, Italy*
[3] *University of Bologna, Italy*
[4] *Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy*
[5] *Istituto di Scienze Marine, Ancona, Italy*
[6] *Istituto di Scienze Marine, Trieste, Italy*

The impact of a ship of opportunity observation system such as the Fishery Observing System (FOS) in the Adriatic Sea is assessed for year 2007. The temperature and pressure observations were made by seven purse seiners and mid-water trawlers in the northern and middle Adriatic Sea, collecting data in the first 100 m of the water column. The assimilation of FOS observations corrected the temperature fields significantly, reducing the temperature root mean square error by 50% during the summer with respect to the simulation. Moreover, it is found that data gathered by 4 out of the 7 vessels would be enough to show the improvement. An Observing System Simulation Experiment (OSSE) methodology was implemented to investigate the possible impacts of the introduction of a CTD sensor. The overall study suggests that the FOS observations are useful for assimilation and they reduce the simulation root mean square error for both temperature and salinity in the range of 20-30%.

Constraining a coastal ocean model by SST and SSH observations using an Ensemble Kalman Filter

N.K. AYOUB[1], P. DE MEY[1], P. MARSALEIX[2], J. LAMOUROUX[3], C. DE NICOLA[4]

[1] *LEGOS, CNRS/University of Toulouse, France*
[2] *Laboratoire d'Aérologie, CNRS/University of Toulouse, France*
[3] *Noveltis, France*
[4] *SHOM, France*

We present a modeling study of the surface circulation in the Bay of Biscay where we explore the impact of assimilating sea surface temperature (SST) and sea surface height (SSH) data. We use the SYMPHONIE coastal circulation model (Marsaleix et al., 2009) on a 3kmx3km grid, with 43 sigma levels. Ensembles of about 50 members are generated by perturbing the wind forcing to analyze the model error subspace in response to wind forcing uncertainties. The assimilation method is a 4D Ensemble Kalman Filter algorithm with localization. We use the SEQUOIA code of De Mey (2007). We present here data assimilation tests in twin experiments mode, where pseudo-observations of daily SST and SSH on a regular spatial grid are generated from a reference simulation. Our objectives are 1/ verify that the model can be effectively constrained by these surface data and 2/propose physical mechanisms to explain the constraint brought by the data. We show that the impacts of data assimilation over the shelf and over the abyssal plain are significantly different. We discuss these differences in connection with the circulation regimes and with the sensitivities to wind perturbations as inferred from the ensemble statistics.

Use of survey assessment to calibrate a larval transport model of sole

LÉO BARBUT[12], ANDREAS VANDEN BAVIÈRE[23], SOPHIE DELERUE-RICARD[23], JOHAN ROBBENS[3], FILIP A.M. VOLCKAERT[2], GENEVIÈVE LACROIX[1]

[1] *Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environments (OD Nature), Belgium*

[2] *Biodiversity and Evolutionary Genomics, Katholieke Universiteit Leuven (KU Leuven), Belgium*

[3] *Institute for Agricultural and Fisheries Research, Oostende, Belgium*

Inter-annual variability of sole (Solea solea) recruitment in the North Sea is high. Among many fish taxa, the early life stages are critical in determining recruitment. With a Lagrangian larval transport model, coupling a physical model with an Individual-Based Model (IBM), it has been shown that hydrodynamics explains part of the year-to-year variability of sole larval recruitment (Lacroix et al. 2013). IBMs require a good knowledge of the biological processes governing larval dispersal. However, it is difficult to obtain observations of life history traits of early fish; their estimates may strongly influence larval connectivity / retention and successful migration as predicted by the model. Various assumptions about larval traits and behaviours (larval duration, vertical migration, mortality) can be tested by comparing simulation results with field data. Here, a hundred of test cases with various parametrizations were simulated and compared to ICES (International Council for the Exploration of the Sea) recruitment assessments to identify the most plausible model parametrization. It represents a first step towards the calibration and improvement of a larval dispersal model of sole in the North Sea and the development of a tool for fisheries management.

References

Lacroix G, Maes GE, Bolle LJ, Volckaert FAM (2013) Modelling dispersal dynamics of the early life stages of a marine flatfish (Solea solea L.). Journal of Sea Research 84:13-25

Finding the needle in the haystack: navigating the landscape of monitoring drivers, capabilities, challenges and opportunities

R. BARCIELA[1], D. FORD[1], R. MCEWAN[1], J. TINKER[1], R. WOOD[1]

[1] *Met Office, United Kingdom*

A number of recent regulatory developments (e.g. Marine Strategy Framework Directive (MSFD), Common Fisheries Policy (CFP), Marine Conservation Zones (MCZs) and Marine Protected Areas (MPAs) are leading to increasing demands for scientific, evidence-based management of the marine environment, at a time of rapid environmental change and increasing financial pressures. Recent developments in modelling, data assimilation and observational technology mean that evolving monitoring goals are achievable. However, there exists a disconnection between these emerging monitoring capabilities and their exploitation by policy makers. Specific challenges include collecting, assembling and interpreting the required data, from observations and models, to detect important changes, to interpret those changes in the context of multiple drivers and devise effective management measures. One additional challenge is posed by the common users' perception that environmental data either do not exist or are of insufficient quality. This presentation will clearly explain the landscape of policy drivers, the key challenges and specific barriers for efficient and effective monitoring and the extant gaps in the scientific evidence required by policy makers. We will also thoroughly explore the present and future scientific capabilities required to respond to two emerging scientific themes, relevant to policy, with a specific focus on: (a) climatic and non-climatic change and variability and (b) value and skill of daily-seasonal-interannual predictions, including uncertainty, for day-to-day management. The above points, when posible, will be illustrated by case studies focussed on bridging the gap between data producers and end users.

Assimilation of sea surface temperature, sea ice concentration and sea ice drift in a model of the Southern Ocean

ALEXANDER BARTH[1], MARTIN CANTER[1], BERT VAN SCHAEYBROECK[2], STÉPHANE VANNITSEM[2], FRANÇOIS MASSONNET[3], VIOLETTE ZUNZ[3], PIERRE MATHIOT[4], AIDA ALVERA-AZCÁRATE[1], JEAN-MARIE BECKERS[1]

[1] *GeoHydrodynamic and Environmental Research (GHER), University of Liège, Liège, Belgium*
[2] *Koninklijk Meteorologisch Instituut (KMI), Brussels, Belgium*
[3] *Georges Lemaitre Centre for Earth and Climate Research, Earth and Life Institute, Université catholique de Louvain, Louvain-la-Neuve, Belgium*
[4] *British Antarctic Survey, Natural Environment Research Council, Cambridge, UK*

Current ocean models have relatively large errors and biases in the Southern Ocean. The aim of this study is to provide a reanalysis from 1985 to 2006 assimilating sea surface temperature, sea ice concentration and sea ice drift. In the following it is also shown how surface winds in the Southern Ocean can be improved using sea ice drift estimated from infrared radiometers. Such satellite observations are available since the late seventies and have the potential to improve the wind forcing before more direct measurements of winds over the ocean are available using scatterometry in the late nineties. The model results are compared to the assimilated data and to independent measurements (the World Ocean Database 2009 and the mean dynamic topography based on observations). The overall improvement of the assimilation is quantified, in particular the impact of the assimilation on the representation of the polar front is discussed. Finally a method to identify model errors in the Antarctic sea ice area is proposed based on Model Output Statistics techniques using a series of potential predictors. This approach provides new directions for model improvements.

Local ensemble assimilation scheme with global constraints and conservation

ALEXANDER BARTH[1], YAJING YAN[2], MARTIN CANTER[1], AIDA ALVERA-AZCÁRATE[1], JEAN-MARIE BECKERS[1]

[1] *GHER, University of Liège, Belgium*

[2] *LISTIC, France*

Ensemble assimilation schemes applied in their original, global formulation have no problem in respecting linear conservation properties if the ensemble perturbations are setup accordingly. For realistic ocean systems, only a relatively small number of ensemble members can be calculated. A localization of the ensemble increment is thus necessary to filter out spurious long-range correlations. However, the conservation of the global property will be lost if the assimilation is performed locally since the conservation requires a coupling between model grid points, which is filtered out by the localization.

In the ocean, the distribution of observations is highly inhomogeneous. Systematic errors of the observed parts of the ocean state can lead to spurious systematic adjustments of the non-observed part of the ocean state due to data assimilation. As a result, global properties which should be conserved, increase or decrease in long-term simulations.

We propose an assimilation scheme (with stochastic or deterministic analysis steps) which is formulated globally (i.e. for the whole state vector) but where spurious long-range correlations can be filtered out. The scheme can thus be used to enforce global conservation properties and non-local observation operators. Both aspects are indeed linked since one can introduce the global conservation as a weak constraint by using a global observation operator. The conserved property becomes thus an observed value.

The proposed scheme is tested with the Kuramoto-Sivashinsky model which is conservative. The benefit compared to the traditional covariance localization scheme (with an ad-hoc step enforcing conservation) where observations are assimilated sequentially is shown. The assimilation scheme is suitable to be implemented on parallel computers where the number of available computing cores is a multiple of the ensemble size.

Impact of the assimilation of high-frequency data in a regional model

M. BENKIRAN[1], G. REFFRAY[2]
[1] *CLS , Toulouse, France*
[2] *Mercator-ocean, Toulouse, France*

Mercator-Ocean has developed a regional forecasting system at 1/36° resolution over the North East Atlantic (IBI: Iberia, Biscay and Irish), taking advantage of the recent developments in NEMO. The model was forced by ECMWF products (every 3 hours) including the atmospheric pressure. In addition to atmospheric forcing, the model includes astronomical tidal forcing. This regional forecasting system uses boundary conditions from the Mercator-Ocean global reanalysis (GLORYS: GLobal Ocean ReanalYses and Simulations).The assimilation component of the Mercator Ocean system, is based on a reduced-order Kalman filter (the SEEK or Singular Extended Evolutive Kalman filter). An IAU method (Incremental Analysis Updates) is used to apply the increments in the system. The error statistics are represented in a sub-space spanned by a small number of dominant 3D error directions. A 3D-Var scheme corrects for the slowly evolving large-scale biases in temperature and salinity. The data assimilation system allows to constrain the model in a multivariate way with Sea Surface Temperature (AVHRR + Multi-satellite High resolution), together with all available satellite Sea Level Anomalies, and with in situ observations from the CORA-03 data base, including ARGO floats temperature and salinity measurements. The background SLA field accounts for the high frequency signal determined by the model and the forcing by atmospheric pressure.

Air-sea interaction and ocean waves.

J-R BIDLOT[1], PAEM JANSSEN[1], K MOGENSEN[1], O BREIVIK[2]

[1] *European Centre for Medium range Weather Forecasts, UK*

[2] *Norwegian Meteorological Institute, Bergen, Norway*

The global analyses and medium range forecasts from the European Centre for Medium range Weather Forecasts rely on a state of the art atmospheric model. In order to best represent the momentum exchange at the surface of the oceans, it is tightly coupled to an ocean wave model. Moreover, it is also coupled to an ocean circulation model for monthly and seasonal forecasts. Progress has been made to include the ocean model as part of the medium range forecasting system. In this new configuration, all model components are run as a single executable. This has allowed for more frequent and efficient exchanges of information between the different models. In this context, sea state (waves) effects on Upper Ocean mixing and dynamics were successfully added to the system. The first operational implementation of this system was with the ensemble prediction system and work in under way to implement the same system into the high resolution suite. The impact of adding these sea state effects will be discussed as well as the benefit of adding the active coupling with the oceans from day 0 in the forecasts.

Optimization of an ocean observing system at regional/coastal scales, some case studies from the SICOMAR project.

CARLO BRANDINI[1], STEFANO TADDEI[1], MARIA FATTORINI[1], BARTOLOMEO DORONZO[1], CHIARA LAPUCCI[1], ALBERTO ORTOLANI[1]

[1] *CNR-Ibimet & Consorzio LAMMA, Firenze, Italy*

The building of integrated observing and forecasting systems for coastal and sub-regional seas, requires a great effort of implementation that is rarely preceded by careful analysis of the conditions of the system to provide the best available data for environmental monitoring, or more reliable predictions to improve safety at sea. The integration of data and models, through data fusion procedures, can actually serve not only to improve forecast reliability, but also to substantially support the design of observation networks, as to understand the characteristics of the observation tools needed, to identify which areas should be covered by measures as a priority, and so on. Such design of observation systems, is not limited to the capability to observe some phenomena of particular interest in a given ocean area, but must ensure maximum benefits to analysis/prediction systems based on numerical models. The design of these observing systems takes a great advantage from the use of synthetic data, whose characteristics are as closer as possible to observed data (e.g. in-situ), in terms of spatial and temporal variability. This method, usually referred to as OSSE (Observing System Simulation Experiment), is a preferred way to test numerical data for assimilation into models as if they were real data, with the advantage of define different datasets for data assimilation at almost no cost. This applies both to the design of fixed networks (such as buoys or coastal radars), and to the improvement of the performance of mobile platforms, such as autonomous marine vehicles, floats or mobile radar, through the optimization of parameters for vehicle guidance, coverage, trajectories or localization of sampling points, according to the adaptive observation concept.

In the present work we present the results of some experimental activities recently undertaken in the coastal area between the Ligurian and Northern Tyrrhenian seas, that has shown a great vulnerability in recent years, due to a number of marine accidents and environmental issues. In this cross-border area an observation and forecasting system is being installed as part of the SICOMAR project (PO maritime Italy-France), in order to provide real time data at high spatial and time resolution, and to design interoperable, expandable and flexible observing platforms, that can be quickly adapted to the needs of local problems (e.g. accidents at sea). The starting SICOMAR network include HF coastal radars, Ferry-boxes onboard ships, and unmanned marine vehicles (e.g. a Wave Glider). We will show, through some numerical experiments, how data assimilation is essential both to reduce uncertainty in initial conditions estimates, and to support the observational network design and its future expansion. Different methods are assessed, from experimental verification of benefits of optimal/sub-optimal configurations, up to nonlinear stability analysis used to assess possible links between instability and need for sampling. The improvement in model forecast is assessed using the ROMS-4DVAR algorithm in different model configurations.

The concept of optimization of an observation network also applies to the case of existing networks that still have some degrees of freedom. This is the case of Lagrangian floats networks, whose driving parameters can be appropriately modified in order to improve the benefits for numerical models. In this case we will show some results of the Drive-Floats experiment, realized within the Argo-Italy project, to define some optimal values for floats driving parameters (parking depth, or frequency of CTD profiles), by using first the model results as a guide, and then by an experimental verification of results.

The Coastal Observing System for Northern and Arctic Seas (COSYNA): Challenges and Solutions for an Integrated Measurement and Modelling Approach

HOLGER BRIX[1], BURKARD BASCHEK[1], GISBERT BREITBACH[1], CHRISTIANE ESCHENBACH[1], JOCHEN HORSTMANN[1], WILHELM PETERSEN[1], ROLF RIETHMÜLLER[1], FRIEDHELM SCHROEDER[1], EMIL STANEV[1], JOHANNES SCHULZ-STELLENFLETH[1]

[1] *Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany*

The automated observing and modelling system COSYNA (Coastal Observing System for Northern and Arctic Seas) has been established in order to better understand the complex processes governing the Northern Seas and the Arctic coast and to assess the impact of anthropogenic changes. COSYNA provides a scientific infrastructure for measurements and data management. The principal objective of observations, instrument development, and modelling is to improve our understanding of the interactions between physics, biogeochemistry, and ecology of coastal seas, to investigate how they can be best described at present, and how they will evolve in the future.

In COSYNA, scientific questions related to topics such as environment effects of offshore wind farms, the importance of sub-mesoscale processes for the marine environment, coastal defence against storm surges, and morphology changes due to sediment transport, to name a few, are addressed. Data and knowledge tools are developed and provided for the use of multiple interest groups in industry, agencies, politics, environmental protection, or the public. These data and products support national monitoring authorities to comply with the requirements of the European Water Framework Directive and the Marine Strategy Framework Directive.

The choice of how to assign resources between measurements, modelling, data handling, outreach activities, and stakeholder interactions poses a formidable challenge for integrated systems like COSYNA. Here, we discuss our approach for using existing observing sites, modelling and data distribution to bring together multiple research groups and institutions with diverse interests ranging from physical to biogeochemical and biological topics for collaborative projects. Projects range from shared measurement campaigns to common procedures for data processing, quality control, data storage and access, as well as to leveraging knowledge tools to create societal and political impact. Hurdles for realising these projects include, beyond funding issues, getting diverse groups to adhere to common protocols, shifting the focus of efforts from instrument development to scientific questions and establishing an interaction and feedback framework with stakeholders.

Turbulence modelling in the operational circulation model HBM - Status and Outlook

THORGER BRÜNING[1], FRANK JANSSEN[1]

[1] *Federal Maritime and Hydrographic Agency (BSH), Germany Bernhard-Nocht-Str. 78, 20359 Hamburg*

The operational service at BSH bases its model systems on the 3D baroclinic circulation model HBM (HIROMB-BOOS Model), which provides the basic information for a couple of downstream services, like e.g. the sea level prediction and storm surge warning service for the German coast, or oil spill forecasting and search-and-rescue applications. HBM is using a k-ω turbulence model with a turbulence closure scheme using double diffusion which is based on [Canuto et al., 2002]. The parametrization of the whole turbulence model is well described in [Berg, 2012]. During the strong storms in December 2013 it turned out that the turbulence closure scheme leads to a physical instability during phases of high wind and therefore high-current speed which are revealed by unrealistic current profiles, which disappeared again with decreasing wind speeds. Several tests were made with different turbulent closure schemes which were based on [Umlauf and Burchard, 2005] and on [Canuto et al., 2010]. These tests showed that the closure schemes described in [Umlauf and Burchard, 2005] gave trustworthy results in all tested cases whereas unrealistic current profiles appeared with both Canuto based closure schemes. From a comparison of the different closure schemes it arose that missing additional stability criteria in the Canuto based schemes called realisabilty-criteria and described in [Umlauf and Burchard, 2005] were the reason for the unrealistic results. Unfortunately, in contrast to the closure schemes based on [Canuto et al., 2002] and [Canuto et al., 2010], all closure schemes in [Umlauf and Burchard, 2005] do not include double diffusion. Therefore we introduced new realisability-criteria to the turbulence closure scheme based on [Canuto et al., 2010] and obtained trustworthy results in all tested cases with this scheme, too. The presentation will provide an overview about the tested cases and the physical improvements which were made. In addition to that an outlook about planned improvements in the near future will be given.

REFERENCES

Berg, P., 2012. Mixing in HBM, Scientific Report, Copenhagen, Danish Meteorological Institute, 12-03.

Canuto,V.M.; Howard,A.M.; Cheng,Y. and Dubovikov,M.S., 2002. Ocean Turbulence. Part II: Vertical Diffusivities of Momentum, Heat, Salt, Mass and Passive Scalars., J. of Phys. Oceanograph., 32, p. 240-264.

Canuto,V.M.; Howard,A.M.; Cheng,Y.; Muller,C.J.; Leboissetier,A. and Jayne,S.R., 2010. Ocean turbulence, III: NewGISS vertical mixing scheme, Ocean Modelling, 34, p. 70-91.

Umlauf,L. and Burchard, H., 2005. Second-order turbulence closure models for geophysical boundary layers. A review of recent work, Continental Shelf Research, 25, p. 795-827.

ANALYSIS ON THE MAIN CLIMATE VARIATIONS ON EXTREME WINTER CONDITION ON THE ROMANIAN BLACK SEA WATERS

LUMINIŢA BUGA1[1], LUMINIŢA LAZAR[1], ALINA – DAIANA SPÂNU[1], MARIA - EMANUELA MIHAILOV[1]

[1] *1National Institute for Environmental Protection Research and Development, subunit National Institute for Marine Research and Development "Grigore Antipa" Constanta, Mamaia Blvd. No. 300, RO-900591, Constanta, Romania*

We present an analysis of the main decadal climate variations that have influenced extreme hydrological conditions in the Western Black Sea shelf. The occurrence of sea ice phenomena, a rarely event and without periodicity, is recorded when it is favored by the climatic and hydrological conditions. The monthly averages of the seawater temperature present remarkable differences of the values for the same month in different years. Results point to significant connections between the sea ice events on the Romanian coast and the negative indexes of North Atlantic Oscillation as well as the Arctic Oscillation. For the entire studied period, the following seawater temperatures are typical for sea ice formation on the Romanian Black Sea Shelf: - In January, the mean temperature was negative only in 1954 (-0.7°C) and below 1°C (when the daily minima were negative) in 5 years (1963, 1969, 1987, 1992, 1997) and the NAO and AO index were strongly negative except 1992, when the NAO and AO index were positive; - In February, the mean temperature of the seawater was negative in 3 years (1954, 1972, 1985) and below 1°C in 7 years (1956, 1963, 1969, 1976, 1987, 1996, 2003). The NAO and AO index were positive only for the year 1976; - In March, the mean temperature was negative only in 1985 (-0.7°C), but with positive NAO and AO indexes, and the monthly mean of the sea water temperature dropped below 1°C in two years (1954, 1987), with a negative NAO index.

Keywords: Black Sea, teleconnection, ice, severe winter

Numerical modelling of risks of oil pollution in the Southeastern Baltic Sea and in the Gulf of Finland

ELENA BULYCHEVA[1], ANDREY KOSTIANOY[2]

[1] *Laboratory of Geoecology, Atlantic Branch of P.P. Shirshov Institute of Oceanology of Russian Academy of Sciences, Russia*

[2] *Ocean Experimental Physics Laboratory, P.P. Shirshov Institute of Oceanology of Russian Academy of Sciences, Russia*

We present the results of using the HELCOM Seatrack Web oil drift forecasting system elaborated by the Swedish Meteorological and Hydrological Institute (SMHI) and the Danish Maritime Safety Administration (DAMSA) for the Baltic Sea. The Seatrack Web is based on the European operational atmospheric models ECMWF and HIRLAM and hydrodynamic model HIROMB, moreover, it includes the model for a drift and transformation of various types of oil spills, its volume and state. In addition to the location of the oil spill, the model calculates also volume of oil mixture with water, the percentage of oil volume which is evaporated, dispersed, settled to the bottom and reached the coast. The model also allows recovering the history of the oil spill drift up to 30 days ago. The backward calculation with integrated AIS allows to detect the possible polluter in the case of leakage from the ship. The assessment of risks of oil pollution in the Southeastern Baltic Sea around the oil platform D-6 operated by the "LUKOIL-Kaliningradmorneft" Ltd. and in the Gulf of Finland from the main shipping routes was made. Two examples of oil spills detected from Radarsat-2 satellite in the vicinity of D-6 were considered and their drift forecast was performed what allowed to identify the ships as possible polluters. The areas of the probable contamination of the waters around the platform D-6, as well as the beaches of Sambia Peninsula and the Curonian Spit are revealed. These oil contamination probability maps have been constructed basing on daily numerical experiments with a release of virtual oil spills from: (1) D-6 oil platform; (2) offshore oil pipeline connecting D-6 platform and Sambia Peninsula; (3) a shipping route westward of Sambia Peninsula; and (4) a "hot spot" located westward of Sambia Peninsula. In September-November 2014 61 numerical experiments with a uniform discharge of oil from the main shipping route in the Gulf of Finland were performed. We identified areas of potential risk of oil pollution of coasts and islands in Finland and Russia, among them the Hogland Island (Russia) is most at risk. Model results showed no cases of potential oil pollution of the coasts and islands of Estonia. We show also the results of the modeling of the drift and transformation of an oil spill detected by satellite on October 3, 2014 in the waters of Finland. The research was supported by the Russian Science Foundation under the project N 14-50-00095.

Spatial and temporal variability of oil pollution by satellite radar data in Southeastern Baltic Sea in 2004-2014

ELENA BULYCHEVA[1], ANDREY KOSTIANOY[2]

[1] *Laboratory of Geoecology, Atlantic Branch of P.P. Shirshov Institute of Oceanology of Russian Academy of Sciences, Russia*

[2] *Ocean Experimental Physics Laboratory, P.P. Shirshov Institute of Oceanology of Russian Academy of Sciences, Russia*

From 2004 to present, satellite monitoring of oil pollution of the sea surface of the Southeastern Baltic is carried out within the framework of the industrial environmental monitoring of the oil field "Kravtsovskoe" (offshore ice-resistant fixed oil platform D-6) of "LUKOIL-Kaliningradmorneft" Ltd., and in a number of Russian national and international research projects. This all the year round satellite monitoring is the only operational tool for monitoring of oil pollution of waters of the Russian Federation in the southeastern part of the Baltic Sea, because satellite and aircraft observations, as a part of the State ecological monitoring program of the Baltic Sea (including the waters of the Russian Federation in the Gulf of Finland), are not conducted. The main directions of this work are: (1) daily operational control of the appearance and drift of oil slicks at the sea surface from different satellites (SAR/ASAR at Envisat, Radarsat-1, Radarsat-2, and Cosmo-SkyMed); (2) the detection and identification of possible sources of oil pollution through an Automatic Identification System (AIS) for ships; (3) forecast of a direction and velocity of oil spills drift with the help of operational numerical model of the Swedish Meteorological and Hydrological Institute (SMHI) Seatrack Web, which is officially recommended by HELCOM to the Baltic Sea states; (4) collection and analysis of auxiliary hydro-meteorological and oceanographic information, systematization of data sets. The results of satellite monitoring of oil pollution in the Southeastern Baltic Sea in 2004-2014 are discussed in the presentation. Interannual and seasonal variability of oil pollution is investigated. From 2005-2006 to 2011 there was a steady decline in the number of the detected oil spills and their total area. A maximum of oil pollution is observed in spring and summer, which is probably due to favorable hydro-meteorological conditions for the detection of oil spills on radar images. Peculiarities of spatial distribution of oil pollution and areas of oil spills location are revealed. Areas of oil spill concentration partially correspond to the main shipping routes in the Southeastern Baltic Sea. The most polluted area are waters west of Sambia Peninsula, including the shipping routes to the Port of Baltiysk with approaches. According to the analysis of the shapes of the detected oil spills, it was concluded that the main polluters of the sea surface in the Southeastern Baltic Sea are vessels of different types. No oil spill originated from the oil platform D-6 was detected in 2004-2014. The research was supported by the Russian Science Foundation under the project N 14-50-00095.

Bias correction with data assimilation.

MARTIN CANTER[1], ALEXANDER BARTH[1]
[1] *AGO/GHER, University of Liège, Belgium*

With this work, we aim at developping a new method of bias correction using data assimilation. This method is based on the stochastic forcing of a model to correct bias.

First, through a preliminary run, we estimate the bias of the model and its possible sources. Then, we establish a forcing term which is directly added inside the model's equations. We create an ensemble of runs and consider the forcing term as a control variable during the assimilation of observations. We then use this analysed forcing term to correct the bias of the model. Since the forcing is added inside the model, it acts as a source term, unlike external forcings such as wind.

This procedure has been developed and successfully tested with a twin experiment on a Lorenz 95 model. Indeed, we were able to estimate and recover an artificial bias that had been added into the model. This bias had a spatial structure and was constant through time. The mean and behaviour of the corrected model corresponded to those the reference model.

It is currently being applied and tested on the sea ice ocean NEMO LIM model, which is used in the PredAntar project. NEMO LIM is a global and low resolution (2 degrees) coupled model (hydrodynamic model and sea ice model) with long time steps allowing simulations over several decades. Due to its low resolution, the model is subject to bias in area where strong currents are present. We aim at correcting this bias by using perturbed current fields from higher resolution models and randomly generated perturbations.

The random perturbations need to be constrained in order to respect the physical properties of the ocean, and not create unwanted phenomena. To construct those random perturbations, we first create a random field with the Diva tool (Data-Interpolating Variational Analysis). Using a cost function, this tool penalizes abrupt variations in the field, while using a custom correlation length. It also decouples disconnected areas based on topography. Then, we filter the field to smoothen it and remove small scale variations. We use this field as a random stream function, and take its derivatives to get zonal and meridional velocity fields. We also constrain the stream function along the coasts in order not to have currents perpendicular to the coast.

The randomly generated stochastic forcing are then directly injected into the NEMO LIM model's equations in order to force the model at each timestep, and not only during the assimilation step. The first results on a twin experiment with the NEMO LIM model will be presented.

A decision support system for water quality in the Wadden Sea

LUIGI CECCARONI[1,2], MEINTE BLAAS[3], MARCEL R. WERNAND[4], FILIP VELICKOVSKI[2], ANOUK BLAUW[3], LAIA SUBIRATS[2]

[1] *1000001 Labs, Spain*

[2] *Barcelona Digital Technology Centre, Spain*

[3] *Deltares, The Netherlands*

[4] *Royal Netherlands Institute for Sea Research, The Netherlands*

The Wadden Sea is a large-scale, intertidal marine system, where natural processes related to sediment transport and primary production define the basis of its internationally recognized cultural and ecological values. On the other hand, human pressures on the system abound: aquaculture, fishing, tourism and recreation, next to agriculture, mining activities and industry in the surrounding region. Nutrient inputs from rivers, growing tourism and large-scale fishery activities may create conditions that negatively affect human society, water quality and ecology. Satellites and in-situ monitoring are routinely used to collect information about water quality. Recently, smartphone-based tools and other citizen-science sensors have entered the arena to enable also citizens to collect scientifically-relevant data [Graham et al., 2011]. This paper describes ongoing work to build a decision support system (DSS) in the Wadden Sea to predict optical water-quality indicators e.g. for aquaculture, tourism and diving, but also for water managers. As information sources, the system uses MERIS satellite data, data collected with the Citclops – Citizen water monitoring app [Wernand et al., 2012] and physical data: waves, currents, river inputs and weather data for the period 2003-2015 (MERIS data available up to 2011; app data available in 2014-2015).

Inductive learning is used to analyse the data and provide predictions in terms of water colour, using the Forel-Ule (FU) scale, a comparative scale firstly developed in the 19th century. The Forel-Ule scale has an implicit relation to other water-quality properties such as turbidity, transparency, suspended particulate matter and chlorophyll [Wernand, 2011]. The DSS's ability to predict water quality can be useful in several applications. Next to the abovementioned short-term direct use of apps by citizens, it can help water managers in longer-term monitoring, system analysis and decision making about water use. It will provide information on the constraints and opportunities for sustainable use of the sea and coast but also guides risk analysis and response to early warnings. With the information sources mentioned above, an inductive learning element (decision trees) has been used to predict water colour in the following week. The design of the learning element takes into account three major issues: (1) which attribute is to be learned; (2) what feedback is available to learn this attribute; (3) what representation is used for the attribute.

The attribute to be learned is water colour. The type of feedback available for learning has determined the nature of the learning problem that the system faces: supervised learning, which involves learning a function from examples of inputs and outputs. The system learns a function from observations of MERIS satellite data, citizen data and

physical data to a discrete output (colour represented as FU). Finally, the representation of the learned information, propositional logic, plays a very important role in determining how the learning algorithms work. The last major factor in the design of the learning system was the availability of prior knowledge. The system begins with no knowledge at all about what it is trying to learn. It has access only to the examples in the data series. In this study, an algorithm for deterministic supervised learning is given as input the correct value of the unknown function for particular inputs and tries to recover or approximate the unknown function.

Decision tree induction is used in this study, being one of the most successful forms of learning algorithms and being a decision tree representation very natural for humans. The decision trees take as input a situation described by a set of attributes (from remote sensing, citizens and in-situ instruments) and return a decision: the predicted output value for the input, i.e., the prediction of the evolution of FU colour over a week's time. The input attributes are continuous. The output value is discrete; therefore this is a case of classification learning (the system is learning a discrete-valued function), wherein each example is classified according to the FU scale. The decision trees reach their decision by performing a sequence of tests. Each internal node in a tree corresponds to a test of the value of one of the attributes, and the branches from the node are labelled with the possible values of the test. Each leaf node in a tree specifies the value to be returned if that leaf is reached. The aim here is to learn a model for the target label FU-Colour. We set this up as a learning problem and state what attributes are available to describe examples in the domain, which are the ones on the following list: (1.) MERIS satellite data (2002-2011); (2.) FU data collected with the Citclops – Citizen water monitoring app; (3.) Optical water quality data collected in situ; (4.) Wave data (2003-2013); (5.) Current data (2003-2013); (6.) River inputs (2003-2013); (7.) Weather data (2003-2013).

The task of finding optimal decision trees when the input descriptors are continuous is an intractable problem: time grows exponentially with the amount of data. Heuristics are therefore used to find solutions (deciding the sequence of tests and the specification of each test) in an acceptable time, but they are not guaranteed to be optimal. The forecasting system is composed of different decision trees, which predict the FU colour over a week, close to diving spots, fishing grounds and WFD/MSFD monitoring station.

REFERENCES

- Graham, E. A., Henderson, S. and Schloss, A., 2011. Using mobile phones to engage citizen scientists in research. EOS Transactions American Geophysical Union, 92 (38): 313–315.

- Wernand, M. R., 2011. Poseidon´s paintbox, Historical archives of ocean colour in global-change perspective. PhD thesis, Utrecht University, pp. 240, ISSN 978-90-6464-509-9.

- Wernand, M.R., Ceccaroni, L., Piera, J. and Zielinksi, O., 2012. Crowdsourcing technologies for the monitoring of the color, transparency and fluorescence of the sea,

Proceedings of Ocean Optics XXI, Glasgow, Scotland, 8-12.

Toward the effective global ecological and biogeochemical observation planning - recommendation from the study on new ocean provinces

SANAE CHIBA[1], SAYAKA YASUNAKA[1], MTSUHIRO TORATANI[2]
[1] *JAMSTEC*
[2] *Tokai University*

With an increasing demand for better understanding of climate change impacts on the marine ecosystem and biogeochemical cycle, the international ocean science community has been seeking the best way to establish the global ecological and biogeochemical observation systems. Different from physical oceanography which parameters are globally measurable by already established methods, the bottleneck is how we could measure the complex ecological and biogeochemical parameters in basin to global scales in cost-effective ways. Our paper is to present an idea for designing the effective global ecological and biogeochemical observation plans based on the ocean provinces, which were newly developed through the NEOPS (New Ocean Paradigm for its biogeochemistry, ecosystem, and Sustainable use) project (http://ocean.fs.a.u-tokyo.ac.jp/index-e.html) funded by the Japan Society of Promotion of Science. We analyzed seasonality of biogeochemical properties (nutrients and pCO2) and phytoplankton abundance using VOS (Voluntary Observing Ship) data and satellite ocean colour data, respectively, which have been collected over 10 years since 2000. Then we divided the North Pacific into c.a. 10-15 ocean provinces based on the similarity in seasonal variations of the respective properties. Since we defined the provinces with the ”dynamic” rather than ”static” boundaries, locations of the boundaries between the provinces interannually varied both in the biogeochemical and phytoplankton province maps. Interannual shifts of the boundaries were detected in a larger extent in some regions, e.g. along the Kuroshio Extension and around the Gulf of Alaska, indicating that phonological changes in biogeochemical and ecological processes are particularly susceptible to climatic control in those regions. We also found high interannual variation in zooplankton community structure in the same regions. We expect the NEOPS new ocean provinces might be useful to propose the focal regions that should be intensively observed with relatively high temporal and spatial resolutions.

Ocean Data Assimilation without Background Error Covariance Matrix

PETER C. CHU[1], ROBIN TOKMAKIAN[1], CHENWU FAN[1]

[1] *Naval Postgraduate School*

Determination of background error covariance matrix is challenge in ocean data assimilation. Effective use of ocean topography, a new data assimilation method called the optimal spectral decomposition (OSD) has been developed with fields (e.g., temperature, salinity, and velocity) decomposed into generalized Fourier series, such that any ocean field is represented by linear combination of the products of basis functions (or modes) and corresponding spectral coefficients. This method has three steps: (1) determination of the basis functions, (2) optimal mode truncation, and (3) update of the spectral coefficients from innovation (or called observational increment). The basis functions only depend on the topography of the ocean basin and boundary conditions. For a rectangular basin, the basis functions are the sinusoidal functions. For a realistic ocean basin, the basis functions can be the eigen functions of the Laplace operator. The Vapnik-Chervonkis cost function is used to determine the optimal mode truncation. After the mode truncation, the model field updates due to innovation through solving a set of a linear algebraic equations of the spectral coefficients. Major benefits using the OSD data assimilation method include: (a) effective utilization of the ocean topographic data, (b) utilization of lateral boundary conditions of the assimilated variables, (c) no requirement of any a-priori information on a background error covariance field, and (d) orthonormal and predetermined basis functions which are independent on the assimilated variable. The capability of the OSD method is demonstrated through a twin-experiment using the Parallel Ocean Program (POP) model.

Assessing Ocean Colour products accuracy with in situ measurements: the case study of CONDOR seamount in the northeast Atlantic Ocean

E. CIANCIA[1,2], C.M. LOUREIRO[3,4], A. MENDONÇA[5], C. DI POLITO[1,2], T. LACAVA[1,2], N. PERGOLA[1,2], V. SATRIANO[1], V. TRAMUTOLI[1,2], A. MARTINS[3,4]

[1] *University of Basilicata, Potenza, Italy*

[2] *Institute of Methodologies for Environmental Analysis,National Research Council,Tito Scalo, (PZ), Italy*

[3] *Department of Oceanography and Fisheries, University of the Azores, Horta, Portugal*

[4] *CIBIO, Research Center in Biodiversity and Genetic Resources, InBIO Associated Laboratory, Department of Oceanography and Fisheries, Horta, Portugal*

[5] *Direção Regional das Pescas dos Açores, Secretaria Regional do Mar, Ciência e Tecnologia Colónia Alemã, Horta, Portugal*

Ocean Colour (OC) algorithms and products have been mostly developed for the analysis of open ocean waters (i.e. Case 1 waters). Nevertheless, most of these algorithms are global. Therefore, it is urgent to develop regional algorithms for Case 1 waters with different bio optical properties and varied ocean circulation schemes. The area investigated in this paper is located in the central group of the Azores islands (38° - 39° N; 27.5° - 29.5°W) where the North Atlantic Central waters are typically characterized by oligotrophic conditions, in which the main optical constituent is the phytoplankton (Case 1 waters). In this region seasonal variability is well pronounced in terms of near-surface chlorophyll a concentrations (chl-a), Sea Surface Temperature (SST), water stratification and mixing properties, even if, due to the large and persistent cloud coverage, these information are difficult to achieve by remote sensing data. To overcome this limit, in this work a preliminarily multi-temporal analysis of chl-a and SST products was carried out, in order to assess the interannual variability of these parameters. This analysis was based on the Robust Satellite Technique (RST) approach developed by Tramutoli (2007), a general methodology for the analysis of long-term historical series of satellite data. In particular, more than 10 years of MODIS/AQUA-derived OC and SST products have been analyzed. This method allows not only identification of the OC and SST trends with time but also their anomalies (in space and time). Furthermore, evaluation of the performance of MODIS/AQUA in respect to the derived-OC and -SST products, was performed through intercomparison of in situ measurements with concurrent satellite imagery based on the methodology developed and described in Mendonça et al. (2010). The in situ data was obtained within the framework of the 3-year project "CONDOR: Observatory for long-term study and monitoring of Azorean seamount ecosystems", co-financed by the EEA Grants Financial Mechanism - Iceland, Liechtenstein and Norway. The data were collected during five oceanographic cruises performed between 2009 and 2010 on/around Condor seamount (17 km southwest of Faial Island, Azores). Results of these comparisons shall be also presented in this work in respect to upper ocean

dynamics in the Condor seamount region.

REFERENCES

Mendonça, A., A. Martins, M. Figueiredo, I. Bashmachnikov, A. Couto, V. Lafon and J. Aristeguí, 2010. Evaluation of ocean color and sea surface temperature sensors algorithms using in situ data: a case study of temporal and spatial variability on two northeast Atlantic seamounts. J. Appl. Remote Sens, Vol. 4, 043506, 1-26p. (doi:10.1117/1.3328872). Accession No. WOS:000274267600002.

Tramutoli V. 2007. Robust Satellite Techniques (RST) for Natural and Environmental Hazards Monitoring and Mitigation: Theory and Applications. Proceedings of Multitemp 2007, Fourth International Workshop on the Analysis of Multitemporal Remote Sensing Images, Louven, Belgium,18-20 July 2007, DOI: 10.1109/MULTITEMP.2007.4293057, 2007

Acoustic data assimilation for estimating energy transfert parameters of a micronekton model

CONCHON ANNA[1], SENINA INNA[1], TITAUD OLIVIER[1], LEHODEY PATRICK[1]

[1] *CLS, Marine Ecosystems Department*

SEAPODYM Forage is a micronekton model used to simulate foraging fields of top predators (tunas, swordfishes, turtles, seals...). In this framework, micronektonic organisms are divided into 6 functionnal groups according to their diel vertical migration. Their dynamics is driven by temperature and oceanic currents. Micronekton production is modeled as a percentage of energy transfer from primary production to mid-trophic level ($E = 4\%$). This amount of energy is allocated to each group with transfert energy coefficients ($E'_n, n \in [1, 6]$). These coefficients are not reachable throught direct observations : this work uses data assimilation to assess them. Data assimilated into the model are ratios of biomass over the water column – calculated from 38kHz-acoustic density used as a proxy of micronekton biomass.

A negative log-likelihood function (mainly distance between observations and model estimations) is minimized with help of a gradient descent method (Quasi-Newton algorithm). Gradients are estimated with an adjoint code.

We present an illustration of assimilation experiments with multiple transects in various environments.

Building an operational forecasting system for the biogeochemical properties of the Mediterranean Sea coastal areas

G. COSSARINI[1], C. SOLIDORO[1], S. QUERIN[1], P. LAZZARI[1], S. SALON[1], A. TERUZZI[1], G. BOLZON[1]

[1] *Section of Oceanography, Istituto Nazionale di Oceanografia e di Geofisica sperimentale, Italy*

There is a growing interest in the assessment of the biogeochemical and ecological state of coastal areas, furthermore, it is already a requirement in regulative frameworks at both European and national levels.. Given the complexity and limitations related to in situ observations, a model-based forecasting system can represent a cost-effective complementary tool for a biogeochemical observing system, which could interpolate, in space and time, the available measurements and provide a synoptic description of the state of an area. In the framework of the MyOcean projects, a physical-biogeochemical forecasting system has been implemented for many regions of the world, including the Mediterranean Sea [Oddo et al., 2009; Lazzari et al., 2010]. The biogeochemical component produces weekly operational forecasts of the Mediterranean Sea conditions by assimilating satellite chlorophyll observations [Teruzzi et al., 2013]. The assimilation improves the model skill in terms of both mean chlorophyll concentrations and productivity over the Mediterranean sub-basins and spatial-temporal detection of local bloom events. However, the MyOcean Mediterranean observing system was designed to describe pelagic areas at a regional scale. Conversely, there is a growing demand for forecast, projection and reanalysis in areas closer to the coast (where most of the human activities occur) and with higher spatial resolution We have been developing a coastal biogeochemical forecasting system, with the aim of capitalizing on both the MyOcean experience and products and the availability of free of charge coastal observations provided by local and national authorities. Upgrades include a doubling of the spatial resolution to 1/16° for the Mediterranean modeling system, a new 3DVAR assimilation scheme for the biogeochemical observations in coastal areas, and, as part of the national Italian RITMARE project, a downscaling coupling with a very high resolution (1 km) physical-biogeochemical forecasting system for the northern Adriatic Sea. Specific modelling solutions for the assimilation scheme in coastal areas and the downscaling procedure, which uses a new coupling interface between the MITgcm and the BFM models, will be presented along with the validation of high-resolution products and indicators.

REFERENCES

Lazzari, P., A. Teruzzi, S. Salon, S. Campagna, C. Calonaci, S. Colella, M. Tonani, and A. Crise (2010), Pre-operational short-term forecasts for Mediterranean Sea biogeochemistry, Ocean Sci., 6(1), 25–39, doi:10.5194/os-6-25-2010.

Oddo, P., M. Adani, N. Pinardi, C. Fratianni, M. Tonani, and D. Pettenuzzo (2009), A nested Atlantic-Mediterranean Sea general circulation model for operational fore-

casting, Ocean Sci., 5(4), 461–473, doi:10.5194/os-5-461-2009.

Teruzzi A., Dobrici S., Solidoro C., Cossarini G., (2013), A 3-D variational assimilation scheme in coupled transport-biogeochemical models: Forecast of Mediterranean biogeochemical properties. J. of Geophys. Res: Oceans, 10.1002/2013JC009277

An operational hydrodynamic modelling system for Irish waters: description, validation and needs for further development

TOMASZ DABROWSKI[1], KIERAN LYONS[1], ALAN BERRY[1], GLENN NOLAN[1], MARCEL CURE[2]

[1] *Marine Institute, Rinville, Oranmore, Co. Galway, Ireland*

[2] *The Numerics Warehouse Ltd., Tyrone, Kilcolgan, Co. Galway, Ireland*

An operational modelling system for an area of the northeast Atlantic that encompasses all of Ireland's territorial waters has been developed. The system consists of a model at the regional scale and two local scale models nested offline. It is an implementation of the Regional Ocean Modelling System (ROMS) and uses operationally available atmospheric and boundary forcing and a global tide solution for tidal forcing. It is run in an operational framework to produce weekly hindcasts and daily 3-day forecasts which are published in a number of formats. Validation of tides, sea surface temperature (SST) and vertical structure of temperature and salinity is presented. The modelling system is shown to agree well with measured data, but problem areas have also been highlighted. The ability of the model to recreate significant hydrodynamic features is examined and shown to be effective. The system is also able to accurately model storm surges around Irish coast as demonstrated for particularly stormy winter of 2013/2014; areas for improvement are highlighted and include access to higher spatially and temporally resolved atmospheric forcing. It is shown that the model skill at reproducing the temperature field is improved by the implementation of SST nudging at the surface and the temperature and salinity nudging at open ocean boundaries. Finally, needs for further development are identified and supported by relevant results. These include the replacement of climatology freshwater runoffs with measured/modelled, specification of variable bottom roughness, wave-ocean model coupling in the coastal zone, higher resolution atmospheric forcing, as already highlighted, and assimilation of observational data. The operational system already underpins products and services for use both in scientific research, especially in the aquaculture industry, and by the general public, and it is expected that upcoming improvements to the system will improve its usefulness as a tool in the management of the marine resources around Ireland.

Operational Strom Surge Modelling at Irish Marine Institute

TOMASZ DABROWSKI[1], ALAN BERRY[1], KIERAN LYONS[1], GLENN NOLAN[1], GUY WESTBROOK[1]

[1] *Marine Institute, Ocean Science and Information Services, Rinville, Oranmore, Co. Galway, Ireland*

The Marine Institute run a number of hydrodynamic models in operational mode to simulate ocean state in Irish waters based on ROMS (Regional Ocean Modelling System) model. The primary operational model is a regional scale model, which encompasses a significant portion of the northeast Atlantic and has a variable horizontal resolution, ranging from a value of 1.1-1.6 km in Irish coastal waters to 3.5 km in the south of the domain. There are 40 sigma levels in the vertical with a concentration of levels at the surface and the bottom. Atmospheric forcing is provided by NOAA's GFS (Global Forecast System) at 0.5 degree horizontal resolution and a 3 hour temporal resolution. Tidal forcing at the boundary is obtained using OTIS, the Oregon State University Tidal Data Inversion Software (TPXO 7.2). The open ocean boundary conditions are obtained from an operational model run by Mercator Ocean in France. The winter of 2013/14 was notable for an exceptional run of storms, resulting in serious coastal damage and widespread flooding; the effects of the storms were exacerbated by very high tides. Predictions from the presented operational model for the period in question show good skill in predicting the total water levels and the surge residuals all around the coast of Ireland with mean surge RMSE of 9 cm. In forecast mode, the modelling suite contributes to a multi-model European storm surge forecasting system which uses a Bayesian Model Average technique to produce an optimal sea level forecast from an ensemble of operational models.

Ocean modelling for forensic investigations and search and rescue operations

TOMASZ DABROWSKI[1], KIERAN LYONS[1], GLENN NOLAN[1], GUY WESTBROOK[1], ALAN BERRY[1]

[1] *Marine Institute, Rinville, Oranmore, Co. Galway, Ireland*

Operational ocean modelling and monitoring systems frequently provide important downstream services, such as for safety at sea, pollution management, climate studies, indices for aquaculture and fisheries and other. However, the authors encountered an increase in model simulation requests for forensic investigations and search and rescue activities in recent years. This paper presents the application of the Irish Marine Institute's operational modelling system to three different investigations as requested by the police officers. First case concerns the reconstruction of potential paths of a body part found in Dublin Bay in early 2011. In the second case a confirmation of a transport pathway of a human body from a known entry site was sought. In the third case, the authors were requested to reconstruct a movement of a body in Galway Bay, and in particular to confirm the possibility of a displacement from the entering to the discovery site within given timeframe. The methodology is based on the particle tracking modelling and the authors provide details of the adopted approach in each of the above case studies along with a brief description of the operational modelling system set-up. The results prove that in relatively straightforward cases, a simple lagrangian approach provides useful services and confirms the suspected scenarios. The authors also present details of the ongoing developments of a high resolution (70m) coastal model of Galway Bay for search and rescue operations. This model is a 2nd level refinement grid from the operational regional North East Atlantic model and is currently nested offline with a target for 2-way online nesting in its donor, local scale model for mid-west coast of Ireland. Notable and already implemented improvements in the model include the wetting-drying functionality. Currently, the model undergoes validation against the ADCP measurements, water level and drifter tracks. Further experiments with drifters and a human body dummy are imminent and the results will be reported in this paper. Further needs for improvement include specification of measured river runoff from the significant freshwater source in the bay, namely the river Corrib, which is an important driver of local hydrodynamics. The approach will utilise the rating curve, which is currently under development and measurements of water level to derive the runoff in real time. Functionalities also include an offline particle tracking model linked to 1 hourly archive of the model output for fast and efficient execution of multiple scenarios in the investigations.

Marine and Atmospheric Forecast System for Nautical Sports in Guanabara Bay (Brazil)

A. D'AGOSTINI[1], L. P. ASSAD[1], H. T. DECCO[1], E. N. PASSOS[1], R. RANGEL[1], C. P. SOUZA[1], W. COSSICH[1], F. R. HOCHLEITNER[1], L. G. RIBEIRO[1], L. LANDAU[1], IAN CUNHA D'AMATO VIANA DRAGAUD, SIDNEY CAVALCANTE DA SILVA, JULIO CESAR DE NORONHA E SANTO

[1] *Laboratório de Métodos Computacionais em Engenharia (LAMCE), Universidade Federal do Rio de Janeiro (UFRJ)*

A marine and atmospheric forecast system for Guanabara Bay (GB) is under development to support Brazilian Olympic Sailing Teams and the Rio 2016 Olympics. This forecast system is composed by the Weather Research and Forecasting (WRF) [Skamarock, 2008] and by the Regional Ocean Modeling System (ROMS) [Shchepetkin; McWilliam, 2005], both daily executed, yielding prognostics of 72 hours. The forecasts consist of surface currents fields with 100 meters of horizontal resolution, and 10 meters wind fields with 3 km of horizontal resolution. WRF model uses the NOAA/NCEP Global Forecast System (GFS) Atmospheric Model [EMC, 2003] with horizontal resolution of 0.5o as initial and boundary conditions, and is configured with a three nested-grid scheme in which the lower horizontal resolution grid (27 km) covers the south and southeastern Brazilian coasts, the medium resolution grid (9 km) covers the Rio de Janeiro State, and the higher resolution grid (3 km) covers the GB region. The ocean model is implemented in barotropic mode using as atmospheric forcing conditions the 10 meters wind fields obtained from the WRF implemented in this project and as boundary conditions the astronomical tide derived from Finite Element Solution 2004 (FES2004) produced by Noveltis, Legos and CLS Space Oceanography Division and distributed by Aviso. In order to evaluate the models performances in situ data is being collected from an Acoustic Doppler Current Profiler (ADCP) installed in GB and atmospheric data from two airports inside the GB, additionally the project intends to install a meteorological station in central region of GB. Tidal currents dominate marine circulation in GB which has been observed in our ROMS simulations. Atmospheric circulation from WRF presented influence from synoptic systems such as cold fronts, besides local effects as the sea breeze. The forecast system described is operational since August 2014 and it has been consistently improved. As future developments, the increase of horizontal resolution for both models, improvement of tide boundary condition, increment of the data acquisition locals and upgrade the bathymetry field are the main goals.

4 decades of Belgian marine monitoring: uplifting historical data to today's needs – 4DEMON

K. De Cauwer[1], A.V. Borges[2], K. Deneudt[3], X. Desmit[1], B. De Witte[4], J. Gauquie[4], A. Goffin[3], R. Lagring[1], A. Nohe[5], K. Sabbe[5], Y. Stojanov[1], F. Strobbe[1], L. Tyberghein[3], D. Van der Zande[1]

[1] *Royal Belgian Institute of Natural Sciences, Operational Directorate Natural Environment, Belgium*

[2] *Chemical Oceanography Unit, University of Liège, Belgium*

[3] *Flanders Marine Institute (VLIZ), Data Centre Division, Belgium*

[4] *Institute for Agricultural and Fisheries Research, Belgium*

[5] *Protistology & Aquatic Ecology Laboratory, Biology Department, Ghent University, Belgium*

Within the last four decades, the Belgian scientific community has built up considerable expertise in marine sciences. Numerous research actions, programs and monitoring campaigns have resulted in a valuable set of scientific data and important publications on the Belgian Continental Shelf (BCS). Although these data are essential for understanding long-term changes in the quality of the marine environment, many valuable, historical data, sometimes only on paper and dispersed among various institutions, still remain inaccessible to the larger scientific community. In addition, most data need to be thoroughly quality-controlled and intercalibrated to allow us to compare with recent data. The 4DEMON project (www.4demon.be) aims to centralise, integrate and valorise data on contamination levels, eutrophication and ocean acidification for assessing environmental change on the BCS stretching back over a period of four decades. In this first phase, a lot of effort is devoted to searching and digitizing historical data at risk of being lost. In order to document and synthesize this large number of diverse data sources residing at different laboratories, a new data management tool has been developed. The Data Inventory and Tracking System (DITS) is a comprehensive tool that allows data managers to follow the (digital) status of the data sources. Chemical contaminant data collection is focused on heavy metals and PCBs in sediment and biota. Data need to be normalized for the effect of the difference in bulk sediment condition or lipid content in the case of biota. For eutrophication, data concerning plankton composition and biomass, chlorophyll-a, nutrients and total suspended matter are being digitized. Species lists need to be standardized for changes in taxonomic nomenclature. To assess change, and validate the results of historical model reconstructions related to ocean acidification, datasets of total alkalinity, pH, partial pressure of CO2 and dissolved organic carbon together with salinity and water temperature are being compiled. Intercalibration will consist of a.o. standardization of pH data and temperature normalization. Methodological changes need to be evaluated. The addition of recent data sources, like the continuous underway data (e.g. salinity, temperature, pH, nutrients and chlorophyll) and remote sensing chlorophyll a and turbidity, will help in the data interpretation and guide appropriate spatial and temporal clustering, as they have a much higher spatial and temporal resolution. The resulting quality-controlled data sets, from 1970 until today, will be used to assess long-term change in the BCS. The fully documented data will be securely archived

and integrated in the existing repositories at the Belgian Marine Data Centre (BMDC) and Flanders Marine Institute (VLIZ) and publicly disseminated via a data portal on the project website (4demon.be). This project is funded in the frame of the research program Belgian Research Action through Interdisciplinary Networks (BRAIN-be, Belspo) in the axis covering scientific heritage.

Scientific quality of MyOcean analyses and forecasts: from operational quality control to user oriented metrics

MARIE DRÉVILLON[1], BRUNO LEVIER[1], CHARLY RÉGNIER[1], RAY MAHDON[2], KATRIJN BAETENS[3], JAN MAKSYMCZUK[2], FABRICE HERNANDEZ[1], THE MYOCEAN CAL/VAL WORKING GROUP [0], AND MYOCEAN SCIENTIFIC TEAMS[0]

[1] *Mercator Ocean, France*

[2] *Met Office, Great Britain*

[3] *Royal Belgian Institute for Natural Science, Belgium*

MyOcean (Copernicus Marine Service) aims at providing high quality descriptions of the ocean from state-of-the-art operating systems. The information on products quality has to be scientifically sound and consistent, useful, and communicated effectively. Finally, the product quality assessment has to take into account users requirements and feedback. Each monitoring and forecasting center (MFC) or observational thematic assembly center (TAC) has its own scientific qualification protocol, depending on the nature of the validated product and on regional specificities. Since MyOcean2, a synthesis of the product quality assessment based on simple statistical metrics (mean, RMS) has been monitored on a web page. It is disseminated to users since 2014. The evolution of the scientific quality assessment and monitoring towards user oriented metrics is strongly requested by users. In the framework of a cross-cutting cal/val working group, new metrics have been developed and trialled, applying them to the archive of operational products. This presentation will first show some results of the delayed time validation of the global forecasting system at 1/12° for the year 2014, illustrating the scientific qualification protocols applied in each MyOcean monitoring and forecasting centre. We will then give a quick overview of the routine monitoring of MyOcean products quality, and show some results and prospects of the new metrics applied to several model products (analyses and forecasts).

WEST AFRICAN COASTAL REGION: INVESTIGATING THE ROLE OF ABRUPT CLIMATE CHANGE ON HUMAN CIVILIZATION IN WEST AFRICA.

EDIANG OKUKU ARCHIBONG[1], EDIANG ANIEKAN ARCHIBONG[2]

[1] *Marine Division, Nigerian Meteorological Agency, Nigeria*

[2] *The Nigerian Maritime Administration and Safety Agency, 6 Burmal Road, Apapa, Lagos,Nigeria.*

As a weather pattern, the Asian monsoon impacts the lives of more than a billion people. Regions affected by the monsoon have experienced rapid population and economic growth in the recent decade; thus, the coupling between the monsoon convection and changing surface emissions is of broad interest to the Atmospheric Composition community. This interest extends to possible feedbacks on the monsoon circulation through enhanced aerosol–cloud interactions. Satellites have further demonstrated the effectiveness of the monsoon circulation for transporting pollutants to the stratosphere. The monsoon system is therefore relevant to scales and processes bridging regional air quality, climate change, and global chemistry-climate interaction. Accurate representation of this system in global chemistry-climate models is critical to predicting how this evolving region may contribute to future change. Climate Change in West Africa, especially Nigeria is having a very real impact and needs urgent attention. Extreme weather as a manifestation of climate change is increasingly problematic for the people along the coastline of West Africa Countries . The complex coastal surface of Nigeria plays a great role in the formation and modification as well as distribution of weather in both countries. For this study, the aim of this investigations to get a better understanding of improving marine and ocean data and products for science and society and how it is related to the probable changes along the West Africa coast, taken Nigeria as a case study, depending on parameters that might change in a future climate. The results will help to identify vulnerabilities of e.g the shore protection along the Nigerian coasts and give us a chance to work on adaptation and risk mitigation necessitated under possible climate change. Also the paper conclude by drawing the attention that by targeting, specific proxies { paleo – tempest logy } or by increasing the appreciation of long documenting records available in Nigeria an improved basis for the characterization of some events could be developed.

OCEAN OBSERVATION NETWORK OVER NIGERIA COASTLINE

EDIANG OKUKU ARCHIBONG[1], EDIANG ANIEKAN ARCHIBONG[2]

[1] *Nigerian Meteorological Agency Marine Division,*

[2] *The Nigerian Maritime Administration and Safety Agency, 6 Burmal Road, Apapa, Lagos,Nigeria.*

Marine weather forecasting is concerned with extrapolation of future conditions of the ocean atmosphere interaction on the basic of the present & past conditions. Marine weather forecasting in West Africa has largely depended on the use of climatological techniques & persistence. But with the advent of global model charts and satellite images, a lot of improvements & accuracy had been achieved in terms of Nowcasting & Microforecasting. In this part of the world, Marine Weather and Ocean data scarcity is one of the major factors slowing down the process of understanding the variation of Ocean-Atmosphere systems especially in the developing countries like Nigeria, the scarcity of real time data in situ hindred validation of both Marine Weather / Ocean and atmospheric models, furthermore we have no access of extracting these data. Given this, a view back in time offers that Nigerian Meteorological Agency Marine Division intends to increase Ocean observation network for better understanding of the ocean dynamics. Thus support of the international scientific community to come on board to improve sea observation network is crucial.

Operational coastal forecast system in Southern Adriatic Northern Ionian seas based on unstructured-grid model

I. FEDERICO[1], N. PINARDI[1,2,3], P. ODDO [2,4], G. COPPINI[1], R. LECCI[1], T. VUKICEVIC[1]

[1] *Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), Lecce, Italy*
[2] *Istituto Nazionale di Geofisica e Vulcanologia (INGV), Bologna, Italy*
[3] *Università di Bologna, Italy*
[4] *Now at Nato Undersea Research Center, NATO, La Spezia, Italy*

The Southern Adriatic Northern Ionian coastal Forecasting System (SANIFS) is a short-term forecasting system based on unstructured grid approach. The model component is built on SHYFEM finite element three-dimensional hydrodynamic model (e.g. [Umgiesser et al., 2004], [Ferrarin et al., 2013]). The operational chain exploits a downscaling approach starting from the Mediterranean oceanographic-scale model MFS (Mediterranean Forecasting System, operated by INGV, e.g. [Tonani et al., 2008], [Oddo et al., 2014]).

The implementation set-up has been designed to provide accurate hydrodynamics and active tracer processes in the coastal waters of Southern Eastern Italy (Apulia, Basilicata and Calabria regions), where the model is characterized by a variable resolution in range of 50-500 m. The horizontal resolution is also high in open-sea areas, where the elements size is approximately 3 km. The model is forced: (i) at the lateral open boundaries through a full nesting strategy directly with the MFS (temperature, salinity, sea surface height and currents) and OTPS (tidal forcing) fields; (ii) at surface through two alternative atmospheric forcing datasets (ECMWF and COSMO-ME) via MFS-bulk-formulae (see e.g. [Pinardi et al., 2003]).

SANIFS open-sea features has been validated comparing model results with observed data, such as argo floats, CTD, XBT and satellite SST, and with the MFS operational products. The large-scale oceanographic dynamics reproduced by the model are fully consistent with MFS. A deeper investigation has been carried out in coastal waters where the SANIFS outputs have been verified with the sea level measured at the Italian tide-gauges stations. The tidal analysis shows that SANIFS is capable of reproducing most of the features of the diurnal and semi-diurnal components, in terms of both amplitude and phase.

The forecast quality of the system has been tested using the SANIFS model to provide forecast bulletins during operations in an oceanographic cruise campaign dedicated to Taranto Gulf and Mar Grande, which are areas some of the study areas investigated in detail by SANIFS

REFERENCES

Ferrarin, C., Roland, A., Bajo, M., Umgiesser, G., Cucco, A., Davolio, S., Buzzi, A., Malguzzi, P. and Drofa, O., 2013. Tide-surge-wave modelling and forecasting in the Mediterranean Sea with focus on the Italian coast. Ocean Modelling, 61, 34-38.

Oddo, P., Bonaduce, A., Pinardi, N., and Guarnieri, A., 2014. Sensitivity of the Mediterranean sea level to atmospheric pressure and free surface elevation numerical formulation in NEMO. Geosci. Model Dev. Discuss., 7, 3985-4017.

Pinardi, N., Allen, I., Demirov, E., De Mey, P., Korres, G., Lascaratos, A., Le Traon, P.-Y., Maillard, C., Manzella, G., and Tziavos, C., 2003. The Mediterranean ocean forecasting system: first phase of implementation (1998-2001). Ann. Geophys., 21, 3-20.

Tonani, M., Pinardi, N., Dobricic, S., Pujol, I. and Fratianni, C., 2008. A high-resolution free-surface model of the Mediterranean Sea. Ocean Science, 4, 1, 1-14.

Umgiesser G., Melaku Canu D., Cucco A. and Solidoro C., 2004. A finite element model for the Venice Lagoon. Development, set up, calibration and validation. Journal of Marine Systems, 51, 14, 123-145.

Perspectives on combining observations from autonomous platforms with biogeochemical models

KATJA FENNEL[1]

[1] *Department of Oceanography, Dalhousie University, Canada*

Biogeochemical models have developed rapidly over the past 2 decades. They are now routinely coupled to circulation models of ever finer spatial resolution and have themselves become increasingly sophisticated in terms of the range of essential nutrients and biogeochemical processes that are represented. These models often include multiple phyto- and zooplankton groups with different functional traits and ecosystem roles, and some describe the dynamics of inorganic carbon species and dissolved oxygen. However, a paucity of observations severely limits efforts to evaluate models, which is arguably the biggest impediment to improving biogeochemical predictions. New data sets from bio-optical and chemical sensors on autonomous platforms have enormous potential for overcoming some of the limitations by offering unprecedented temporal and spatial resolution for a continuously expanding suite of observable variables. These new streams of observations will undoubtedly spur the development of new methods for combining observations and models and possibly a new generation of biogeochemical models. I will present examples of such new data sets, how they can be used to inform modeling and how new techniques for combining observations and models can help.

Marine biogeochemical reanalysis for monitoring global air-sea CO_2 fluxes

DAVID FORD[1], ROSA BARCIELA[1]

[1] *Met Office, UK*

The only marine biogeochemical observations with routine global coverage are satellite ocean colour, with coverage still incomplete and limited to the sea surface. Models are therefore required to provide full spatial coverage, and through data assimilation can be combined with observations to create a reanalysis. This can then be used to investigate both observed and non-observed variables, including those relating to the carbon cycle.

As part of the Climate Modelling User Group (CMUG) within the European Space Agency's Climate Change Initiative (CCI) project, two global marine biogeochemical reanalyses have been produced by assimilating ocean colour-derived chlorophyll data into the FOAM-HadOCC model over the period September 1997 to July 2012. One reanalysis assimilated CCI products, the other assimilated GlobColour products, with a non-assimilative hindcast run for comparison.

Understanding contemporary oceanic carbon uptake, storage and transport is key to predicting the future evolution of atmospheric CO_2 levels at global and regional scales. This presentation will describe the reanalysis methodology, and focus on assessment of the carbon cycle, using the model to understand what the observations are telling us about the larger-scale context of past and current environmental changes driving observed changes. This includes validating the reanalyses against in situ observations, examining the cause of any biases and the impact of the data assimilation, and looking at inter-annual variability and how this relates to drivers in the physical climate system. Future improvements to the methodology will be discussed, along with the potential for a near-real-time carbon monitoring capability contributing to the Integrated Carbon Observation System (ICOS).

ECCO version 4 : an integrated framework for non-linear inverse modeling and global ocean state estimation.

GAEL FORGET[1]
[1] *MIT, Cambridge, USA*

Here I provide an overview of the ECCO version 4 non-linear inverse modeling framework and its baseline solution for the evolving ocean state over 1992-2011. Both components are publicly available and highly integrated with the MITgcm. They are both subjected to regular, automated regression tests. The modeling framework includes sets of global conformal grids, a global model setup, implementations of model-data constraints and adjustable control parameters, an interface to algorithmic differentiation, as well as a grid-independent, fully capable matlab toolbox. The baseline solution (namely ECCO-Production, release 1) is a dynamically consistent ocean state estimate, without un-identified sources of heat and buoyancy, which any interested user will be able to reproduce accurately. The synergy between modeling and data synthesis is asserted through the joint presentation of the modeling framework and the state estimate. A first assessment of the relative importance of external, parametric and structural model errors is presented. Parametric and external model uncertainty appear to dominate over structural model uncertainty. Parametric and external model uncertainties appear to be of comparable magnitudes – depending on the characteristic of interest, one predominates over the other. The results generally underline the importance of including turbulent transport parameters in the inverse problem.

The MEDGIB experiment, a valuable data set to test the MYOCEAN system in the Strait of Gibraltar and Alboran Sea

E. GARCÍA-LADONA[1], M. GARCÍA-SOTILLO[2], A. ORFILA[3], J. ISERN-FONTANET[1], P. RODRÍGUEZ-RUBIO[4], E. PADORNO[2], J. JIMÉNEZ-MADRID[1], D. CONTI[3], E. CAPÓ[3], A. LANA[3]

[1] *Dept. de Oceanografía Física y Tecnológica, Institut de Ciències del Mar (ICM-CSIC), Barcelona (Spain)*

[2] *Área de Medio Físico, Organismo Público Puertos del Estado, (PDE), Madrid (Spain)*

[3] *Instituto Mediterráneo de Estudios Avanzados IMEDEA (UIB-CSIC), Palma de Mallorca (Spain)*

[4] *Autoridad Portuaria Bahía de Algeciras (APBA), Algeciras, (Spain)*

The Gibraltar Strait is a hot spot area of maritime traffic being the natural door for the shortest route between Asia and Europe. 1/6 of the global marine trade is passing by the Gibraltar Strait every year. From an oceanographic point of view, the Gibraltar Strait is a challenging place for any operational system because it is the natural connection between the Mediterranean basin circulation and the Atlantic Ocean. On September 2014 an intensive drifter deployment was carried out in the Gibraltar Strait to validate the European MYOCEAN operational system on the frame of MEDESS-4MS project. The experiment consisted on deploying 35 satellite tracked drifters, mostly of CODE type equipped with temperature sensor and at sampling rate of 30 minutes, distributed along the strait and on both sides of the Gibraltar strait. Particular attention was put to perform a spatially quasi-synoptic deployment by coordinating four boats covering an area of about 340 $\mathrm{nm}\hat{2}$ in 6 h. Up to our knowledge, the obtained set of trajectories gives for the first time a comprehensive lagrangian view of the inflow of the Atlantic waters and their recirculation over the Alboran Sea constituting a valuable data set to validate the operational systems in such challenging area. We show results intercomparing the drifters trajectories against the MYOCEAN IBI system, the VHF surface radar fields and the regional high resolution SAMPA system. Additionally we test how surface quasigeostrophic theory (SQG) can be a very useful diagnostic tool to obtain operational velocity fields from direct processing of SST images.

Challenges to combine 40 years of marine contamination data within 4DEMON

J. GAUQUIE[1], K. DE CAUWER[2], R. LAGRING[2], B. DE WITTE[1]

[1] *Institute for Agricultural and Fisheries Research, Belgium*

[2] *Operational Directorate Natural Environment, Royal Belgian Institute of Natural Sciences, Belgium*

In 1970, systematic and coordinated marine research started in Belgium with 'Project Sea' (1970-1976). This was the beginning of more than 4 decades of research on contamination in the Belgian Continental Shelf (BCS). Since then, several research programs such as Concerted Research Actions "Oceanology" (1977-1982), monitoring in the frame of OSPAR (since 1978), and numerous amounts of smaller projects have produced large datasets of contamination, a.o. heavy metals and PCBs, in biota and sediment. Within one work package of the project 4DEMON (4 DEcades of Belgian marine MONitoring, www.4demon.be), the aim is to inventory, intercalibrate and analyse these contamination data statistically. In a first instance, historic data is being actively searched for, documented in an inventory and digitized before final integration in the database at the Belgian Marine Data Centre. Metadata, such as the applied sampling, pre-treatment and analysis method, sampling position and time, are crucial in this process. Furthermore, data for parameters associated with specific measurements, for example grain size fraction for sediment and lipid content for biota, are also recovered.

A major effort is needed for method reconstruction and specifically identifying and evaluating the impact of method changes. With the information encountered in publications, laboratory notes and information given by experts, an overview of the different methods applied over the last 4 decades is being reconstructed. Preliminary time series will allow a first evaluation of the influence of method changes. When possible, additional analyses will be performed comparing different methods. Otherwise, data will be analysed purely on a statistical manner.

Another issue that was identified is the distribution of the pollutant in the sediment and its high affinity with the fine sediment fraction ($<20\mu$m). Throughout the decades, contaminants have been analysed on different grain size fractions, resulting in the need to normalise the data before it can be compared. The most suitable normalisers for the Belgian Continental Shelf will be evaluated based on additional measurements of the considered contaminants on different grain size fractions in new samples. Sample locations are defined based on local mineralogy, average grain size distribution and sampling occurrence and frequency at the different locations during the last decades. The resulting normalisation model will be evaluated using existing data on varying contaminant concentration in different grain size fractions at the BCS. This model will be used to convert all the data to the same grain size.

The intercalibrated datasets will be the basis for the evaluation over time of the

pollutant levels in the BCS. For this assessment, the aspects of spatial clustering will be considered seen the shift in sampling locations over time.

Performance Comparison of Two Quality Control Methodologies for HF Radar Surface Current Data in the West Florida Shelf.

ROBERTO GOMEZ[1], THOMAS HELZEL[1], NICOLAS THOMAS[2], CLIFFORD MERZ[3], YONGGANG LIU[3], ROBERT WEISBERG[3]

[1] *Helzel Messtechnik GmbH, Germany*

[2] *Actimar SAS, France*

[3] *College of Marine Sciences, University of South Florida, United States of America*

HF Ocean Radars are shore based instruments easy to deploy and maintain. As these instruments provide data of large areas of the coastal ocean it is a very attractive tool for Ocean Observation Systems and the ocean modelling community. However, the complexity of the measuring technology is high and the data provided by HF radar is sensitive to radio interference, power-line disturbances, ship and ionosphere echoes. A combination of all these factors sporadically produces non-realistic current vectors in some areas, particularly at the outer edges of the range, which do not really correspond to the measured phenomena. Although there have been many efforts that successfully reduce the appearance of corrupted data, it is impossible to avoid some of it in the final data set. For this reason quality control (QC) of measured ocean data is a very intensive topic of research and development. In particular it is important to develop specific QC techniques for this kind of systems that can be applied in near real-time. Ultimately the data robustness of these remote sensing instruments should be similar to those of in-situ instruments. Reaching this level of reliability could signify new opportunities for the ocean modelling and prediction community that incorporate HF radar data assimilation schemes. The present paper will briefly summarize results of previous work [Gomez, 2014] in which the performance of the native QC of the WERA ocean radar to detect artefacts in current surface data was evaluated using measured data from a pair of WERA systems and an ADCP operating in the West Florida Shelf. Additionally, the paper will introduce a new software package for artefact detection, Arret© developed by Nicolas Thomas et al. The same data sets used in previous work will be processed with Arret© software to evaluate performance in identifying artefacts too. Similarities and differences will be outlined and a discussion comparing results from both methods is included.

Sampling aliasing in the Southern Ocean and its impact on uncertainties in the annual mean flux of CO_2

LUKE GREGOR[1,2], SCHALK KOK[3], MARINA LÉVY[4], SEBASTIAAN SWART [2], PEDRO M.S. MONTEIRO[2]

[1] *UNIVERSITY OF CAPE TOWN, SOUTH AFRICA*

[2] *COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH, SOUTH AFRICA*

[3] *UNIVERSITY OF PRETORIA, SOUTH AFRICA*

[4] *UNIVERSITY PIERRE AND MARIE CURIE, FRANCE*

Current estimates of air-sea CO_2 fluxes in the Southern Ocean find the region to be a sink. However, we are still not able to constrain Southern Ocean air-sea CO_2 fluxes without large uncertainties despite increased efforts [*Landschützer et al.*, 2014]. We investigate a potential overestimation of CO_2 air-sea fluxes in the Southern Ocean due to aliased sampling. Regions where CO_2sea is under-saturated are regions of CO_2 uptake; however, the magnitude of the sink depends on the upper water column dynamics. These mechanisms change the expected magnitude of CO_2 uptake potential of under-saturated waters if sampled infrequently. This effect could be a major cause for uncertainty in the Southern Ocean where sampling is sparse in both time and space. Here we compare in situ observations with NEMO-PISCES model output to assess the effects of aliasing on the air-sea fluxes of CO_2 in the Southern Ocean when sampled at different time scales. We also investigate the spatial distribution of optimal sampling intervals to work towards constraining air-sea fluxes of CO_2 while reducing the effort required.

REFERENCES

Landschützer, P., Gruber, N., Bakker, D.C.E., Schuster, U., 2014. Recent variability of the global ocean carbon sink. *Global Biogeochem. Cy., 28(9), 927–949*

Modeling the Turkish Straits System: Circulation and Mixing based on Inter-Basin Coupling

ÖZGÜR GÜRSES[1], ALI AYDOĞDU[2], NADIA PINARDI[3], EMIN ÖZSOY[1]

[1] *Institute of Marine Sciences, (IMS-METU), Mersin, Turkey*

[2] *Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), Bologna, Italy*

[3] *Istituto Nazionale di Geofisica e Vulcanologia (INGV), Bologna, Italy*

The modeling of the exchange flows across the Turkish Straits System (TSS), with the added development of operational forecasting in this highly energetic system presents itself as a grand challenge. Besides aiming to achieve inter-basin coupling between the Black and the Mediterranean Seas, the modeling approach also has to incorporate efficient treatment of complex hydrodynamical processes in the demonstrated strongly stratified, turbulent exchange flow subject to hydraulic controls and steep topography. The task is particularly complex because of the need to ultimately resolve the very narrow geometries of the two straits, the Bosphorus and Dardanelles, and the flow transitions within, to accurately represent the coastal or upper ocean intensified flows, while adequately representing the circulation within the Marmara Sea and the external domains. We adopt the FEOM, originally an unstructured grid global ocean model, enabling to simultaneously capture the fine and coarse scales of the entire TSS. A review of the modeling development is provided including the circulation, mixing and the sensitivity to selected parameterizations, starting from test cases with closed boundaries, extension to forced flows adjusted to the water budgets and hydrography of the adjacent basins and time-dependent response of the system to atmospheric forcing including water, heat, salt and momentum fluxes. Partial observational verification of the results is obtained by comparison to available data sets. The implications on the environmental status of the TSS are reviewed.

Evaluation of an operational ocean model configuration at 1/12° spatial resolution for the Indonesian seas: Physical/Biogeochemical coupling

GUTKNECHT E.[1], REFFRAY G[1], GEHLEN M[2]

[1] *Mercator Ocean, 8/10 rue Hermès, 31520 Ramonville, France*

[2] *LSCE, UMR CEA-CNRS-UVSQ, CEN de Saclay, L'Orme des Merisiers, 91191 Gif-sur-Yvette, France*

In the framework of the INDESO (**In**frastructure **De**velopment of Space **O**ceanography) project, an operational ocean forecasting center has been developed to monitor the state of the Indonesian seas in terms of circulation, biogeochemistry and fisheries. The forecasting system combines a suite of numerical models connecting physical and biogeochemical parameters to population dynamics of large marine predators. Developed by Mercator Ocean and CLS, the physical/biogeochemical coupled component (INDO12BIO configuration) covers a large region extending from the western Pacific Ocean to the Eastern Indian Ocean at 1/12° resolution. The OPA/NEMO physical ocean model and the PISCES biogeochemical model are coupled in mode "on-line" without degradation in space and time. The operational global ocean forecasting system (¼°) operated by Mercator Ocean provides the physical forcing while climatological open boundary conditions are prescribed for the biogeochemistry.

This poster describes the performances of the INDO12BIO configuration. They are assessed by the evaluation of a reference hindcast simulation covering the last 8 years (2007-2014). Confrontations to satellite, climatological and *in-situ* observations are commented. Diagnostics are performed on chlorophyll-α, primary production, nutrients and oxygen.

The model catches the main characteristics of the biogeochemical tracers in space and time. The seasonal cycle of chlorophyll-α and primary production is in phase with satellite-based products. The northern and southern parts of the archipelago present a distinct seasonal cycle, with higher chlorophyll biomass and production rates in the southern (northern) part during SE (NW) monsoon. Nutrient and oxygen concentrations are correctly reproduced in terms of horizontal and vertical distributions. The biogeochemical content of water masses entering in the archipelago as well as the water mass transformation across the archipelago conserves realistic vertical distribution in Banda sea and at the exit of the archipelago.

Biases of Global Coupled Atmospheric-Ocean Models in the Tropical Oceans

JULIA HAZEL[1], ROBERTO MECHOSO[1], JUSTIN SMALL[2], ENRIQUE CURCHISTER[3]

[1] *Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, CA, USA*

[2] *National Center or Atmospheric Research, Boulder, CO, USA*

[3] *Department of Environmental Sciences, Rutgers University, New Brunswick, NJ, USA*

The tropical climate simulated by coupled atmosphere-ocean general circulation models (CGCMs) shows significant biases. For example, simulations of sea-surface temperatures are too high and cloudiness is too low over the southeastern Pacific and Atlantic Oceans. The errors are strongest along the continents, and they demonstrate a broad westward extending. In addition, the equatorial cold tongue is too strong and extends too far to the west. Furthermore, the simulated precipitation generally shows a persistent double Intertropical Convergence Zone (ITCZ). Tremendous effort is being made to improve CGCM performance in general, and in particular, to address these tropical errors. CGCM errors are a major concern given that the models are essential tools for prediction of climate change.

The present paper diagnoses these CGCM biases and tests hypotheses of their generation. A particular emphasis is placed on studying the southeastern Atlantic. First, we explore the observed and simulated ocean heat budgets in this region and show that the required oceanic cooling contribution is too weak. We analyze the oceanic component of the models to gain insight into whether this feature is due to difficulties in the simulation of the mean flow or transient eddies. Next, we present model sensitivity experiments to the parameterizations of wind stress in the tropical oceans, convection over the adjacent continents, and lower level winds at location along the African coast. In these studies, we use models with different resolutions. The diagnostic studies are performed with the output of the CGCM that couples the Community Atmosphere Model (CAM; run at 1°, 0.5° and 0.25 resolutions) to the global Parallel Ocean Program Model (POP; run at 1° and 0.1° resolutions). We also use the Nested Regional Climate Model (nRCM) system, in which the Regional Ocean Modeling System 6 (ROMS6, run at 5-10 km) is nested to the CAM/POP in the SEA coastal region. The sensitivity experiments are performed with the UCLA CGCM.

Seasonal hypoxia in the context of continental shelf and bottom boundary layer dynamics

ROBERT D. HETLAND[1], WENXIA ZHANG[1], STEVEN F. DIMARCO[1], KATJA FENNEL[2]

[1] *Dept. of Oceanography, Texas A&M University, USA*

[2] *Dept. of Oceanography, Dalhousie University, Canada*

The areal extent of seasonal hypoxia in the northern Gulf of Mexico is known to be correlated with both nutrient load from the Mississippi/Atchafalaya river system as well as mean wind conditions in mid-summer. However, numerical studies have demonstrated that a simple parameterization of benthic respiration, independent of riverine nutrient loading, may create hypoxic regions with spatial patterns, seasonal evolution, and interannual variability similar to observations. Thus, despite strong correlations between the areal extent of hypoxia and nutrient loading, it is still unclear how the organic material associated with eutrophication may alter benthic processes. Hypoxia is typically associated with the bottom boundary layer over the continental shelf, particularly in the western regions where the areal extent of hypoxia is most variable. Bottom boundary layer processes are in turn affected by shelf circulation. The thickness of the bottom boundary layer may be modulated by submesoscale eddies over the Louisiana shelf. Also, convergence in the bottom boundary layer, in response to shelf circulation patterns, may cause an injection of hypoxic water into the mid-water column. Better understanding and prediction of bottom boundary layer processes, and their interaction with benthic oxygen demand, will allow us to better understand and predict the processes that determine the areal extent of hypoxia.

Infrastructure and Workflows for Australia's Integrated Marine Observing System

M.G. HIDAS[1], R. PROCTOR[1], S. MANCINI[1], P. BLAIN[1], G. GALIBERT[1]

[1] *Integrated Marine Observing System, University of Tasmania, Private Bag 110, Hobart, TAS 7001, Australia*

Australia's Integrated Marine Observing System (IMOS, imos.org.au) is a research infrastructure project to establish an enduring observing program for Australian oceanic waters and shelf seas. The observations cover physical, biological, and chemical variables to address themes of multi-decadal ocean change, climate variability and weather extremes, boundary currents and inter-basin flows, continental shelf processes and ecosystem responses.

IMOS consists of 10 national facilities based on various observing platform types, and operated by partner institutions around the country. One of the challenges is to standardise metadata, data quality and formats across a wide range of measured parameters, from a diverse group of data providers. In aid of this we have developed the IMOS Matlab Toolbox (code.google.com/p/imos-toolbox/), providing a consistent workflow to 1) read raw data in various instrument-specific formats; 2) read associated metadata data from a database; 3) perform conversions, corrections and compute derived variables; 4) apply quality-assurance/quality-control (QA/QC) tests; and 5) write self-describing NetCDF files according to the IMOS conventions (based on the Climate and Forecasting conventions). The processing and QA/QC procedures implemented in the Toolbox are continually developed in collaboration with the IMOS facility operators and other experts.

Data are transferred and archived within IMOS in Network Common Data Form (NetCDF). Key metadata and data are regularly harvested from these files into a database, and published as OGC-standard Web Map Services (WMS) and Web Feature Services (WFS) using GeoServer (geoserver.org). For gridded data sets, maps are generated directly from the NetCDF files using ncWMS (ncwms.sf.net), while a simple sub-setting and aggregation service developed by IMOS (github.com/aodn/go-go-duck) generates NetCDF files for download. Data collections are described by metadata records according to the Marine Community Profile (MCP v2.0) of the ISO 19115 standard, including links to specific WMS and WFS layers. The metadata records are managed and accessed using GeoNetwork (geonetwork-opensource.org).

The Open Geospatial Portal, an open-source software project developed by IMOS, provides a unified web interface to these components (code: github.com/aodn/aodn-portal; IMOS instance: imos.aodn.org.au/). Users can discover data collections using a faceted search, subset and visualise data on a map, and download their selection in multiple formats (currently NetCDF or CSV). Alternatively, the WMS and WFS services can be queried directly. The NetCDF files can also be browsed via a THREDDS Data Server (www.unidata.ucar.edu/downloads/thred and accessed remotely via OPeNDAP (www.opendap.org).

Integrating technologies for Oil Spill Monitoring in the South Iberian Coast

J. JANEIRO[1], A. NEVES[1], F. MARTINS[1], P. RELVAS[2]

[1] *Centro de Investigação Marinha e Ambiental, Universidade do Algarve, Faro, Portugal.*

[2] *Centro Ciências do Mar, Universidade do Algarve, Faro, Portugal*

Highlighting the importance of integrating oil spill monitoring and response technologies in the south Iberia coast, this work presents the use of an operational coastal modelling system, implemented using a downscaling approach, to backtrack a CleanSeaNet oil detection in the marine environment. Taking advantage of regional operational products available, the system in place provides the necessary resolution to go from regional to coastal scales, while a multi-grid methodology allows the lagrangian based oil spill model to span across model domains, taking full advantage of the increasing resolution between model grids. An extensive validation procedure, with both a good spatial and temporal coverage while spread along a multiplicity of sensors strengthens the operational system ability to accurately reproduce coastal scale processes. The lagrangian model is validated using available trajectories from satellite-tracked drifters. Errors found are included in the backtrack analysis allowing to identifying their possible origin by combining model backtrack results with ships trajectory supplied by Automated Identification System (AIS).

Mesoscale patterns and their role on oil spill trajectories in the Southwest Iberian coast

J. JANEIRO[1], P. RELVAS[2], A. NEVES[1], F. MARTINS[1]

[1] *Centro Investigação Marinha e Ambiental, Universidade do Algarve, Faro, Portugal*

[2] *Centro Ciências do Mar, Universidade do Algarve, Faro, Portugal*

Several mesoscale processes, including upwelling filaments and fronts, characterize the Southwest Iberia oceanography. These mesoscale features are tied up to the large-scale climatological variability between the Azores high-pressure cell and the Iceland low. This climatological variability presents seasonal patterns from spring to late summer and during winter, which influence and characterize the Iberia coast circulation. The region lies on the main maritime route from the Mediterranean Sea and Southern Hemisphere to the North of Europe with tankers representing a significant part of the vessel traffic. The occurrence of an oil spill has thus a strong probability to happen. The present research study analyses the effects of regional mesoscale patterns in the evolution of oil spill trajectories. Five years of SST images, retrieved form both MODIS Aqua and METOP-A satellites are used to identify five typical mesoscale patterns at the Southwest Iberian Coast. An operational oil spill model implemented for the region was used to simulate several oil spill hypothetical scenarios along dense navigation routs. Results obtained show the model ability to correctly reproduce the observed regional sea surface patterns, highlighting the importance of accurate atmospheric forcing to solve the regional mesoscale variability. The importance of regional mesoscale features in the dynamics of oil spills is emphasized, not only by their direct effect in driving 'event-specific' spills but also the potential use of its seasonal patterns in the regional 'exposure degree' to oil spills. This study reinforces the discussion regarding the importance of these regional mesoscale features in the scale of human activities, while opens ways for a possible integration of this knowledge and this techniques in future regional planning and response operations for oil spills.

Assimilation of remotely-sensed surface reflectance into a coupled hydrodynamic - biogeochemical model of the Great Barrier Reef, Australia.

E. JONES[1], M. MONGIN[1], M. BAIRD[1]

[1] *CSIRO: Oceans and Atmosphere, Australia*

The optically complex waters of the Great Barrier Reef (GBR), Australia, lead to substantial errors in the MODIS OC3 Chl-a product, making it unsuitable for assimilation into a biogeochemical model. A recent addition to the CSIRO coupled hydrodynamic – biogeochemical model has been the inclusion of a spectrally-resolved optics model. The model contains 19 optically-active constituents, from which we calculate in water Inherent Optical Properties (IOPs). Apparent Optical Properties (AOPs), such as surface reflectance, can then be predicted and used for assimilation purposes. Using this method, the CSIRO EMS model predicts the surface reflectance at 8 MODIS bands, circumventing the need to assimilate an error prone estimate of MODIS OC3 Chl-a. We present results from the eReefs BGC data-assimilation sub-project where surface reflectance's have been assimilated. Results indicate that observational biases have been removed and the analysis field independent RMS error is reduced by up to 50% when compared with using OC3 Chl-a. The inclusion of an in-water optics model has proven to vastly increase the available observational dataset to constrain coastal BGC models.

How do strong internal tides affect state estimates and predictions of the mesoscale circulation in the Philippine Sea?

COLETTE KERRY[1,2], BRIAN POWELL[2]

[1] *Coastal and Regional Oceanography Lab, School of Mathematics and Statistics, UNSW, Sydney, Australia*

[2] *Department of Oceanography, School of Ocean and Earth Sciences, University of Hawaii at Manoa, Honolulu, HI, United States*

In prediction of the atmospherically-forced eddying ocean circulation, the circulation has typically been simulated without tidal forcing as the deterministic barotropic tides can be removed from the observations for assimilation, and added to the model forecast. In regions of strong internal tides, this unresolved process constitutes a significant, non-deterministic, component of the observations and may have an important influence on the subtidal dynamics. In a circulation model without tidal dynamics, omitting key physical processes may limit the predictive skill of the model, and the internal tide signal becomes an error term, limiting the value of observations in constraining state estimates.

In the Philippine Sea, a region of energetic internal tides and dynamic mesoscale circulation, we find that including the tides in the simulations is important to achieve accurate predictions of the sub-tidal ocean state. We use 4-dimensional variational data assimilation (4D-Var), an advanced assimilation technique that uses the model dynamics to determine an optimum state estimate. Assimilating a variety of surface and subsurface observations, we assess how the internal tides affect estimates of sub-tidal dynamics. The results show that surface and subsurface mesoscale state estimation and predictability is significantly improved with the inclusion of tidal dynamics in the circulation model. This study highlights the importance of correctly representing the internal tides when estimating and predicting the subtidal circulation, and has significance for prediction in marginal seas and ocean basins around the globe.

WaveForUs: High-resolution Operational Forecast System of Oceanographic Features in the Thermaikos Gulf (Northern Aegean Sea, Greece)

KRESTENITIS Y.[1], ANDROULIDAKIS Y.[1], KOMBIADOU K.[1], MAKRIS C.[1], BALTIKAS V.[1], KALANTZI G.[1]

[1] *Laboratory of Maritime Engineering and Maritime Works, Civil Engineering Department, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece*

WaveForUs is a high-resolution forecasting system which delivers 3-day sea-state prognoses for the Thermaikos Gulf (North Aegean Sea, Greece). The forecasts concern storm surges, spectral wave characteristics and hydrodynamic circulation. The WaveForUs platform is intended for public use and can provide emergency alerts to the local authorities. The system's predictions are disseminated to the public via the research project's official web-page (wave4us.web.auth.gr), web-GIS applications (OMIKRON Ltd), and television broadcasts (DION TV). The platform is fully functional and aspires to provide users with an efficient tool for their sea-based activities in northern Greece. The simulations are based on a storm surge hydrodynamic model (Aristotle University of Thessaloniki Storm Surge Model; AUTSSM), an ocean circulation model (Princeton Ocean Model; POM) and a wave model (WaveWatch-III), while the necessary atmospheric forcing is provided by a well-validated meteorological model (Weather Research & Forecasting Model; WRF). In particular, the 2D shallow water equations model AUTSSM simulates the free surface elevation due to the combined effect of atmospheric features (sea level pressure and winds at 10 m) and tides. Results on coastal grid cells are super-positioned to the wave-induced setup time-series, which is calculated, based on the results of the spectral wave model. This is implemented in order to estimate the total sea level height along the coastline, combining storm surge maxima, tidal constituents and near-shore irregular wave breaking. Ultimate goal is the notification of users (authorities and public) in cases of high coastal inundation risk. AUTSSM produces results on three operational levels, namely the Mediterranean Sea, the Aegean Sea and finally the Thermaikos Gulf, in a one-way coupling order of downscaling simulations from larger and coarser domains to smaller and finer ones. Furthermore, the 3rd generation spectral wave model WaveWatch-III is applied in the North Aegean Sea and is two-way nested to the domain of the Thermaikos Gulf. The respective results are one-way coupled to AUTSSM and POM, including the effects of wave radiation stresses and Stokes drift velocities to the prognoses of the storm surge and circulation, respectively. Eventually, POM simulates the 3D hydrodynamic circulation, through the use of 16 vertical σ (sigma) levels, in the region of interest. It also takes into account the short-term forecasts of freshwater fluxes discharging into the Thermaikos domain by the main rivers in the area, namely Axios, Loudias and Aliakmon. The boundary conditions for thermohaline properties, surface elevation and current fields are obtained by the freely available, coarser domain system of MyOcean (www.myocean.eu). The computational grid for all models in the Thermaikos Gulf has a spatial resolution of 1/60º×1/60º. The area is of high en-

vironmental and socioeconomic value, with extensive low-elevation planes, protected sites and a broad spectrum of sea-based activities (tourism, aquacultures, marine transportations, maritime recreational activities, sports etc). The validation and calibration of the forecast system's models are based on hindcasting simulations; numerical results are satisfactory and correlate well with in-situ observations, satellite data, and other modelling output.

Projections of water balance elements of Curonian Lagoon and their uncertainty

JURATE KRIAUCIUNIENE[1], DARIUS JAKIMAVICIUS[1]

[1] *Laboratory of Hydrology, Lithuanian Energy Institute, Lithuania*

The Curonian Lagoon is the biggest fresh water basin in Lithuania influenced by the exchange of the fresh Nemunas and other smaller rivers' water and saline water of the Baltic Sea. The lagoon ecosystem is influenced by fresh, brackish and brackish water masses. A long-term water balance of the Curonian Lagoon was calculated for the period of 1960–2010. The sum river inflow is 21.85 km3/year, precipitation – 1.19 km3/year, evaporation – 1.01 km3/year, inflow of brackish water from the Baltic Sea to the Curonian Lagoon – 6.12 km3/year, and fresh water runoff from the Curonian Lagoon to the Baltic Sea – 27.65 km3/year. The lagoon water balance elements have been influenced by climate change. The water balance forecasting has been performed for the period of 2011–2100. The climate change impact on the water balance of the Lagoon has been evaluated using Global Climate Models (ECHAM5 and HadCM3), greenhouse gas emission scenarios (A2, A1B and B1), and hydrological modelling by HBV software. One scenario was selected for the prediction of the Baltic Sea water level. Considerable changes of the Curonian Lagoon water balance are forecasted in the 21st century. Increase of weather temperature and changes in precipitation will influence the elements of water balance of the Curonian Lagoon. In the end of period of 2011–2100, the river inflow and outflow from the Baltic Sea into the Lagoon will decrease respectively by 20.4% and 16.6% in comparison with the baseline period (1961–1990). The amount of precipitation and evaporation will increase respectively by 3.8% and 25.1%, while inflow from the Baltic Sea into the Curonian Lagoon will increase up to 39.7% in comparison with the baseline period. Uncertainties of some water balance elements were evaluated using software SUSA.

Approaching statistical assessment of a marine ecosystem model (Data-Model synthesis project)

S. KRISHNA[1]

[1] *GEOMAR, Helmholtz Center for Ocean Research Kiel, Germany*

Studies suggest that plankton dynamics in marine ecosystem changes, owing to variability in physical and biological-, and chemical environment. Investigations of ocean acidification effects on plankton were conducted with mesocosms, where enclosed water volumes were exposed to different CO2 concentrations, e.g. Pelagic Ecosystem CO2-Enrichment Studies (e.g. Riebesell et al., 2008, Biogeosciences 5, 1157–1164). I investigate different model approaches to resolve and explain plankton responses to variation in pH/CO2 and to temperature, which were observed in mesocosm experiments. Main technical objective of my project is to setup a mesocosm-modelling workbench for data-model synthesis that: a) facilitates mass budget calculations and meta-analysis of mesocosm experiments, b) statistical analyses of different ecosystem models and parameter optimizations. Model performance will be judged on the basis of parameter uncertainties and model complexity/redundancy. Model parameter optimizations are achieved with minimizations of cost functions that quantify the misfit between model results and observations.

The US West Coast Ocean Forecast System

A. L. KURAPOV[1], S. M. DURSKI[1], J. S. ALLEN[1], E. BAYLER[2], E. MYERS[3]

[1] *CEOAS, Oregon State University, USA*

[2] *Joint Center for Satellite Data Assimilation, NOAA, USA*

[3] *National Oceanographic Service, NOAA, USA*

The new West Coast Ocean Forecast System (WCOFS) is being developed at the National Oceanic and Atmospheric Administration (NOAA) in partnership with Oregon State University. It will stretch along the entire US West Coast and will provide updates of 3-10 day forecasts of ocean conditions in support of navigation, search & rescue, environmental hazard response, and fisheries. The model is based on the Regional Ocean Modeling System (www.myroms.org), at the 2-km horizontal resolution. We will present results of the multi-year assimilation-free model run and include discussion of model biases on coastal and regional spatial scales, based on comparisons against observations (satellite SSH, satellite SST, high-frequency radar surface currents, and mooring and glider temperature and salinity). Using results from this model and its precursor (Durski et al., 2015), we will analyze seasonal and interannual variability in coastal ocean conditions along the US West Coast, including the effect of the 2009-2010 El Nino and volume-integrated heat balance on the shelf.

REFERENCES

Durski, S., M., A. L. Kurapov, J. S. Allen, P. M. Kosro, G. D. Egbert, and R. K. Shearman, 2015: Coastal ocean variability in the U.S. Pacific Northwest region: Seasonal patterns, winter circulation and the influence of the 2009-2010 El Nino, Oc. Dyn., submitted.

Simulation of river runoff in Siberia and propagation of fresh water in the Arctic in XX and XXI centuries

V. KUZIN[1], G. PLATOV[1], E. GOLUBEVA[1], N. LAPTEVA[1]

[1] *Academy of Sciences Mathematical Department Novosibirsk Scientific Centre, Institute of Computational Mathematics and Mathematical Geophysics, Russia*

On the basis of climate model of river flow, a variations of river runoff is calculated for Siberian rivers: Ob, Yenisei, Khatanga, Anabar, Olenek, Lena, Yana, Indigirka and Kolyma. The model is a linear model of reservoirs with the surface, underground and river runoffs. At the first step for the validation of the model the river discharge for the XX century was simulated. Conditions of runoff formation were determined based on the results of the reanalysis ERA40 and GMAO MERRA. For comparison, we examined data from the direct measurements on the hydrometeorological stations. At the second step the results of the projections for the XXI century of CMIP-5 project were used as input. There were selected results of the model INMS5 (Russia) and CNRM (Meteo France). The results show the difference in the river discharge in the different models. At the next step the propagation of Siberian river waters In Arctic was modeled by the coupled model of the ocean and the sea-ice of the Arctic and the North Atlantic. The simulation results, based on calculated transport of above Siberian rivers, were compared with the results, obtained using mean climatological seasonal variation of their runoff. The specifics of how river water anomalies propagate in the Arctic and North Atlantic have been studied. The trajectories of the of the fresh water anomalies propagation are essentially depend of the signs of the AO and NAO indices. As a result,. there has been some redistribution of Arctic fresh water export between the Fram Strait and the Straits of the Canadian Arctic Archipelago. It was shown that river water plays an important role in regulating the vertical mixing both in the Arctic and in the North Atlantic.

Evaluation of some future updates of the global Mercator Ocean analysis and forecasting system.

O. LE GALLOUDEC[1], J.-M. LELLOUCHE[1], E. GREINER[2], R. BOURDALLÉ-BADIE[1], G. REFFRAY[1], G. GARRIC[1], C. RÉGNIER[1], M. DRÉVILLON[1], C.-E. TESTUT[1], M. BENKIRAN[2], Y. DRILLET[1]

[1] *Mercator Ocean, Ramonville Saint Agne, France*

[2] *CLS, Ramonville Saint Agne, France*

In May 2015, Mercator Ocean will open the Copernicus Marine Service (CMS) and will be in charge of the global ocean analyses and forecast at eddy resolving resolution. In this framework, R&D activities conducted at Mercator Ocean during MyOcean2 and MyOcean follow-on will continue throughout 2015 in order to update the 1/12° global system for the next CMS version in 2016. Complementary to a companion presentation describing the overall evolution of the data assimilation and the model, this presentation will focus on the assessment of the following updates and their specific impact on quality: 1. A new parameterization of the vertical mixing scheme in order to improve the representation of temperature and salinity in the Mixed Layer Depth. 2. A new Quality Control on the assimilated temperature and salinity vertical profiles based on integrated criteria. 3. An adaptive tuning of some observations errors in the data assimilation system. 4. A new Mean Dynamic Topography taking into account the last version of GOCE geoid. 5.The assimilation of sea-ice concentration observations.

Global oceanic simulations of trace elements

GUILLAUME LE GLAND[1], LAURENT MÉMERY[1], OLIVIER AUMONT[2], THOMAS GORGUES[3]

[1] *LEMAR, IUEM, Plouzané, France*

[2] *LOCEAN, IPSL, Paris, France*

[3] *LPO, IUEM, Plouzané, France*

The biogeochemical fluxes and ecosystem functioning are tightly controlled by the ocean dynamics and by a wide range of sources and sinks associated with biological, chemical and physical phenomena. Our knowledge of tracer distributions, which relies mostly on aliased observations in space and time, is flawed. It is mostly noticeable in models where parameterizations of subgrid processes, limited understanding of biogeochemistry, and imprecise atmospheric forcing hamper our capacity to realistically simulate the fluxes. One way to better constrain poorly known parameters in models is to use the integrated information contained in "proxy" tracers depending on only a few key processes.

In this study, we will model two trace elements at a global scale and a spatial resolution of 1° with ocean dynamics model NEMO (Nucleus for a European Modeling of the Ocean) and compare them with data from the GEOTRACES international program in order to better understand the cycle of carbon and associated elements. As a first step, complementary numerical tracers and water mass ages have been computed to understand the circulation model behavior and to better describe the time scales associated with ventilation processes and continental shelves – open ocean exchanges : these simulations will be used in the analyze the results.

Radium, a conservative tracer unaffected by chemistry, is emitted mainly by submarine groundwater discharge and sediments and removed only by radioactive decay. Because of its half-life of 5.75y, 228Ra is a good proxy of exchanges between the sediments and the open ocean. A consistent pattern will be searched for between model horizontal dynamics, radium data and boundary conditions. We will perform an inversion of the data into sediment fluxes by using the transport matrix of the model, and transposing it to reconstruct the transit time distribution and origin of water masses, as described in Khatiwala [1].

Thorium is produced by the decay of uranium, which is proportional to salinity, and removed by its own decay and by scavenging by particles, since thorium is much less soluble than uranium. With a half-life of 24.1h, on the same order of magnitude as the sinking time of large particles, 234Th is a proxy of biogenic particle dynamics and the carbon pump. A nonlinear inversion of the data will be performed to improve the biogeochemical parameterization of vertical particle dynamics.

[1] Khatiwala, S. (2007). A computational framework for simulation of biogeochemical tracers in the ocean. Global Biogeochemical Cycles, 21, GB3001, doi:10.1029/2007GB002923

First quality assessment of the next Copernicus Marine Service high resolution global ocean monitoring and forecasting products

J.-M. LELLOUCHE[1], O. LE GALLOUDEC[1], E. GREINER[2], R. BOURDALLÉ-BADIE[1], G. REFFRAY[1], G. GARRIC[1], C. RÉGNIER[1], M. DRÉVILLON[1], C.-E. TESTUT[1], M. BENKIRAN[2], Y. DRILLET[1]

[1] *Mercator Ocean, Ramonville Saint Agne, France*

[2] *CLS, Ramonville Saint Agne, France*

In April 2013, Mercator Ocean has performed a major upgrade of the global 1/12° high resolution system. This system currently delivers daily services (weekly analyses and daily forecast). Observations are assimilated by means of a reduced-order Kalman filter with a 3D multivariate modal decomposition of the forecast error. It includes an adaptive-error estimate and a localization algorithm. Along track altimeter data, satellite Sea Surface Temperature and in situ temperature and salinity vertical profiles are jointly assimilated to estimate the initial conditions for numerical ocean forecasting. A 3D-Var scheme provides a correction for the slowly-evolving large-scale biases in temperature and salinity. In May 2015, Mercator Ocean will open the Copernicus Marine Service (CMS) and will be in charge of the global ocean analyses and forecast at eddy resolving resolution. In this context, R&D activities conducted at Mercator Ocean during MyOcean2 and MyOcean follow-on projects will continue throughout 2015 in order to update the 1/12° global system for the next CMS version in 2016. The ocean/sea-ice model and the assimilation scheme will benefit among others from the following improvements: new parameterization of the vertical mixing, new Mean Dynamic Topography, new adaptive tuning of some observations errors, assimilation of sea-ice concentration observations, new freshwater runoff from ice sheets melting ... This presentation will not focus on the impact of each update, but rather on the overall behavior of the system integrating all updates. This first assessment will report on the products quality improvements, highlighting the level of performance and the reliability of the new system.

Bayesian Nonlinear Smoothing and Mutual Information for Adaptive Sampling

PIERRE LERMUSIAUX[1], TAPOVAN LOLLA[1]

[1] *MIT, Cambridge, USA*

New schemes are presented for optimal Bayesian nonlinear state estimation and adaptive sampling of nonlinear fluid and ocean dynamical systems, both forward and backward in time. The Bayesian nonlinear smoothing combines reduced-order Dynamically-Orthogonal (DO) equations with Gaussian Mixture Models (GMMs), extending linearized backward pass updates to a Bayesian nonlinear setting. Bayesian nonlinear adaptive sampling schemes are then derived to predict the observations to be collected that maximize the mutual information about variables of interest. Examples are provided for fluid and ocean flows. This is joint work with our MSEAS group at MIT.

Operational Oceanography in Europe: status, perspectives and challenges

PIERRE-YVES LE TRAON[1]
[1] *Mercator Ocean, France*

Over the past couple of years, Europe has been at the forefront of the development of operational oceanography capabilities with the setting up of the Copernicus Marine Environment Monitoring Service (CMEMS) at European scale and the development or consolidation of coastal and/or downstream services at national level. These developments have relied and should continue to rely on state-of-the-art science and a wide involvement of the research community. Integrated systems (in-situ and satellite observations, modeling and data assimilation, data and product dissemination and user service) at global, regional and coastal scales have been developed and are serving an increasing number of applications and users. Europe has also played a major role in the evolution of the satellite oceanography infrastructure (e.g. Copernicus satellite component) and in the development or consolidation of global (e.g. Euro-Argo) and regional in-situ observing systems (e.g. EuroGOOS ROOSes). An overview of these achievements will be given. Main perspectives and challenges for the coming years will then be discussed. These will cover both the development of the observation infrastructure (future satellite missions, European Ocean Observing System/EOOS) and the evolution of the CMEMS in response to existing and future user needs but also taking fully into account scientific and technological advances. Main scientific challenges for the CMEMS service evolution will be, in particular, discussed.

Skills of different hydrographic networks to capture changes in the Mediterranean Sea at climate scales

J.LLASSES[1], G.JORDÀ[1], D.GOMIS[1,2]

[1] *IMEDEA, Spain*

[2] *University of the Balearic Islands, Spain*

Climate monitoring is nowadays a crucial issue, particularly in "hot spot" regions such as the Mediterranean Basin, where climate changes are expected to be large. Adaptation to future climate scenarios in a fast and effective way requires of the combination of climate projections and a proper monitoring of the climate signal. In this work, the skills of five observational networks are explored in the context of the monitoring of climate signals in the Mediterranean Sea. Namely we explore the capabilities of hydrographic surveys and ships of opportunity, of ARGO buoys, of a (virtual) regularly distributed mooring network, of the present-day observational system (which makes use of the three kinds of observations) and of a targeted future system. The skills of each observational network are quantified as follows: first, the output of a realistic regional circulation model (considered here as the virtual truth) is sampled at the same time and location of the actual observations gathered by each observational network. An objective analysis scheme based on Optimal Statistical Interpolation is then applied to the pseudo-observations to obtain gridded products, which are compared to the model output in order to infer the capability of each sampling to capture the true fields. We do it for different periods (for the last decades 1962-2000 and for the whole 21st century) and for different parameters (temperature, salinity and the rate of deep water formation in the Western Mediterranean). Results indicate that the skills to reproduce large scale climatic signals depend on the depth and variable, ranging from more than a 90% of explained monthly variance and relative trend errors below 5% for the upper layer (0-100 m) and intermediate (100-400 m) temperature fields, to less than 60% of explained monthly variance and 30% relative trend errors for the upper layer (0-100 m) salinity field. When averaging temperature and salinity over the whole basin volume, both annual values and long term trends are properly captured by all the networks, though the Deep Water Formation rate in the Western Mediterranean is largely overestimated. Conversely, regional features are missed by all the sampling networks, since none of them has an adequate spatial distribution to capture small scale processes.

Optimal Path Planning for Swarms of Vehicles

TAPOVAN LOLLA[1], DEEPAK SUBRAMANI[1], PATRICK HALEY[1], PIERRE LERMUSIAUX[1]

[1] *MIT, Cambridge, USA*

The science of autonomy is the systematic development of fundamental knowledge about autonomous decision making and task completing in the form of testable autonomous methods, models and systems. In ocean applications, it involves varied disciplines that are not often connected. However, marine autonomy applications are rapidly growing, both in numbers and in complexity. This presentation reviews our recent interdisciplinary results in minimum-time path planning and energy-optimal path planning. Examples are provided for varied nonlinear fluid and ocean conditions, including optimal planning for coordinated groups of vehicles, maintaining formations and avoiding time-dependent obstacles in complex multiscale flows. The aim is to set a generic and rigorous basis for a large number of vehicles forming heterogeneous and collaborative underwater swarms that are smart, i.e. knowledgeable about the predicted environment and their uncertainties, and about the predicted effects of autonomous sensing on future operations. This is joint work with our MSEAS group at MIT

Developing a forecasting system of the North and Baltic Seas biogeochemistry

SVETLANA N. LOSA[1], LARS NERGER[1], INA LORKOWSKI[2], CAROLE LEBRETON[3], THORGER BRUENING[2], FRANK JANSSEN[2], CARSTEN BROCKMANN[3]

[1] *Alfred Wegener Institute Helmholtz Center of Polar and Marine Research, Bremerhaven, Germany*

[2] *Federal Maritime and Hydrographic Agency, Hamburg, Germany*

[3] *Brockmann Consult, Geesthacht, Germany*

A data assimilative forecasting system for the prediction of the North and Baltic Seas hydrography based on the HIROMB-BOOS circulation Model (HBM) has been extended by coupling with the ERGOM biogeochemical model. The system has been further augmented by MODIS satellite chlorophyll data product assimilation. Ensemble based data assimilation algorithms coded within the Parallel Data Assimilation Framework, PDAF (http://pdaf.awi.de), are used for the biogeochemical state and parameter estimation. We investigate the forecasting system performance and the forecast error statistics and sampling under different scaling of the biogeochemical components and combination of state and parameter estimation. The system is also evaluated by comparison of the biogeochemical forecast with independent in situ observations.

Dependence of meso-scale eddy variability on lateral mixing parameterization in high-resolution ocean model simulations

Y. LU[1], L. ZHAI[1], J. LEI[1], S. HIGGINSON[1], F. DUPONT[2], F. ROY[2], G. SMITH[2], F. DAVIDSON[3], J. CHANUT[4]

[1] *Bedford Institute of Oceanography, Fisheries and Oceans Canada*
[2] *Meteorological Research Division, Environment Canada*
[3] *Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada*
[4] *Mercator-Ocean*

Under the Canadian CONCEPTS program, a set of high-resolution regional ocean models are being developed for ocean and coupled ocean-atmosphere forecasting. These models cover the North Atlantic, Arctic and North Pacific Oceans, with horizontal resolutions of 1/12° and 1/36° in latitude and longitude. A series of multi-year and decadal hindcast simulations (without data assimilation) are carried out, and the results are assessed with a variety of in situ and satellite remote sensing observations. Model tests show that the simulated mean and eddy kinetic energy as well as the detailed structure of meso-scale eddies are very sensitive to the choice of lateral viscosity used in momentum equations. In particular, the higher (1/36°) resolution model only allows a small range of values for the viscosity coefficient, in order to maintain the level of total and eddy kinetic energy consistent with data assimilative models. Comparison of modelled and observed spectra of eddy variability, in both frequency and wavenumber domains, guides the need for further improvement of these models.

Assimilation of HF radar surface currents to optimize forcing in the northwestern Mediterranean Sea

J. MARMAIN[1,2], A. MOLCARD[1,2], P. FORGET[1,2], A. BARTH[3], Y. OURMIÈRES[1,2]

[1] *Université de Toulon, UMR7294, CNRS/INSU, IRD – Mediterranean Institute of Oceanography (MIO), UM 110, 83957 La Garde, France*

[2] *Aix Marseille Université, CNRS/INSU, IRD, Mediterranean Institute of Oceanography (MIO), UM 110, 13288 Marseille, France*

[3] *GeoHydrodynamics and Environment Research (GHER), AGO/MARE, University of Liège, Belgium*

HF radar measurements are used to optimize surface wind forcing and baroclinic open boundary condition (OBC) forcing in order to constrain model coastal surface currents. This method is applied to a northwestern Mediterranean (NWM) regional primitive equation model configuration. A new radar data set, provided by two radars deployed in the Toulon area (France), is used. To our knowledge, this is the first time that radar measurements of the NWM Sea are assimilated into a circulation model. Special attention has been paid to the improvement of the model coastal current in terms of speed and position. The data assimilation method uses an ensemble Kalman smoother to optimize forcing in order to improve the model trajectory. Twin experiments are initially performed to evaluate the method skills (not shown here). Real measurements are then fed into the circulation model and significant improvements to the modeled surface currents, when compared to observations, are obtained.

Comparing models of different complexities in 4DVAR biogeochemical data assimilation

JANN PAUL MATTERN[1], HAJOON SONG[2], CHRISTOPHER A. EDWARDS[1], ANDREW M. MOORE[1], JEROME FIECHTER[1]

[1] *Ocean Sciences Department, University of California Santa Cruz, USA*

[2] *Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, USA*

Data assimilation techniques have become important tools to improve the accuracy and forecasting abilities of coupled physical-biogeochemical ocean models. Yet much still needs to be learned about important aspects of biogeochemical data assimilation, such as the effect of model complexity and the importance of more realistic model formulations on assimilation results. We present the application of 4DVAR data assimilation to two biogeochemical ocean models: a low-complexity NPZD model with 4 biological variables and the more complex NEMURO model, containing 13 biological variables. Both models are coupled to a 3-dimensional physical ocean model of the US west coast based on the Regional Ocean Modelling System (ROMS). We assimilate satellite chlorophyll data and physical observations into the models and compare the impact based on various model metrics. We assess whether additional complexity in biogeochemical model formulation leads to improved results and better forecasting abilities of the data assimilation system.

A biogeochemical reanalysis of the North-West European shelf 1984-2012.

R.A. MCEWAN[1], R. BARCIELA[1], D.FORD[1]

[1] *Met Office, United Kingdom*

Satellite observations of surface chlorophyll in the European seas began in 1997 and have provided continuous temporal coverage since. However spatially the data are dependent on atmospheric conditions and tells us little about subsurface concentrations. For these reasons numerical models are valuable in providing a continuous temporal and spatial representation of chlorophyll in the ocean as well as suspended sediment and nutrient concentrations. As part of the MyOcean2 project a biogeochemical reanalysis of the North West European shelf has been produced for the period January 1984 – June 2012. The reanalysis uses the Nucleus for European Modelling of the Ocean (NEMO) ocean model [Madec, 2008] coupled to the European Regional Seas Ecosystem Model (ERSEM) [Blackford et al. 2004]. Sea surface temperature is assimilated using a 3DVar technique adapted from NEMOVAR [Morgensen, 2012] system. The reanalysis was performed in 3 sections in inline with the previous physical reanalysis. The preliminary assessment presented here will focus on products of interest to the Marine Strategy Framework Directive (MSFD) and fisheries policies, including a subset of variables prioritised by the Working Group on Operational Oceanographic Products for Fisheries and Environment (WGOOFE) [Berx et al. 2011]. The second reanalysis section results (03/01/1989 to 31/12/2003) are analysed for periods where observations are available. This includes analysis of surface chlorophyll and nutrient concentrations and utilises surface chlorophyll concentration from fluorometry at Western Channel Observatory (L4), GlobColour satellite products and World Ocean Atlas 2009 nutrient climatology. The in situ measurements were available from 1992 to 2003 and comparison to the reanalysis show that the model is capturing the seasonal variation of surface chlorophyll at this location well, as well as, the magnitude of winter minima and spring maxima, having an RMS error of 1.93 mg/m3 and model bias of 0.24 mg/m3. Comparison to Globcolour satellite imagery, available from 1998 to 2003, shows that over the whole domain RMS error was 0.667 mg/m3 with a negative bias of -0.143 mg/m3. When compared to monthly nutrient climatology the model captures summer depletion and winter recharge of nitrate, phosphate and silicate however this initial analysis has identified a reduction in nutrient concentrations over the period assessed.

REFERENCES Berx, B., Dickey-Collas, M., Skogen, M.D., De Roeck, Y.-H., Klein, H., Barciela, R., Forster, R.M., Dombrowsky, E., Huret, M., Payne, M., Sagarminaga, Y. and Schrum, C., 2011. Does operational oceanography address the needs of fisheries and applied environmental scientists? Oceanography 24(1), 166-171 Blackford, J.C., Allen, J.I., Gilbert, F.J., 2004. Ecosystem dynamics at six contrasting sites: a generic modelling study. Journal of Marine Sciences, 52 (1-4), 191-215 Madec,G., 2008. NEMO reference manual, ocean dynamics component, Institut Pierre-Simon Laplace, technical report. Mogensen, K. S., Balmaseda, M. A., and Weaver, A., 2012. The NEMOVAR ocean data assimilation

system as implemented in the ECMWF ocean analysis for System 4, ECMWF Tech. Memo. 668.

Transformation of model data to information - experiences with coastDat-data

MEYER, E.M.I.[1], WEISSE, R.[1]

[1] *Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany*

The history of coastDat has started 15 years ago. The idea of coastDat is to improve the data base in sparse observational marine regions and to increase data homogeneity and consistency. In doing so long-term model data of such as wind (e.g. storms), wind wave and tides surge hindcasts are developed and proofed for regions like North Sea and Baltic Sea. These data-sets are available in hourly resolution and highly spatial resolution to simulate the marine environment. The coastDat data sets are used for applications such as offshore wind industry (design & logistics), risk analysis and analysis of pathways of energy transition. More than 80 stakeholders have used coastDat data sets. They are composed of science networks (39%), economic actors (46 %) and administrating policy actors (15%). Here the data set and the history are briefly described, validation is reviewed, and an overview about recently uses of the data is provided.

NATURAL VARIABILITY OF THE COLD INTERMEDIATE LAYER ON THE ROMANIAN BLACK SEA SHELF

MARIA-EMANUELA MIHAILOV1[1], LUMINIŢA BUGA[1], LUMINITA LAZAR[1]

[1] *National Institute for Environmental Protection Research and Development, subunit National Institute for Marine Research and Development "Grigore Antipa" Constanta - Romania, Mamaia Blvd. No. 300, RO-900591, Constanta, Romania*

The long-term changes in the Cold Intermediate Layer and oxic layers structure during the last four decades (1971 – 2010) are analyzed using the monitoring data collected on the 55 km hydrological section along the 440 10'N (NIMRD data base). For the middle months for each season (February, May, August and November), the changes of the temperature and salinity vertical distribution from one decade to another are relatively small. The upper mixed layer becomes warmer (about 0.1°C/year) while the cold water mass temperature is practically constant. The air temperature increases with 0.05°C/year for the analyzed period. At the same time the salinity decreases by 0.02 – 0.03 PSU/year in the entire water column. The 8°C isotherm boundary of cold water mass is more appropriate for shallow waters as 70% of the upper limit densities are below 14.2 kg/m3 and the average cold water density in the summer period is only 14.24 kg/m3. Key words: Black Sea, Cold Intermediate Layer (CIL), upper mixed layer (UML), thermohaline structure.

Simulated Chla versus simulated MODIS OC3 in a biogeochemical model of the Great Barrier Reef (eReefs): implications for model calibration and data assimilation.

MATHIEU MONGIN[1], EMLYN JONES[1], MARK BAIRD[1]

[1] *CSIRO Ocean and Atmosphere Flagship , Hobart Tasmania Australia*

The eReefs modelling system includes a coupled, catchment, hydrodynamic, sediment and biogeochemical modelling effort for the entire GBR. One component of this modelling system is a spectrally-resolved optical model that considers absorption and scattering by clear water, coloured dissolved organic matter, non-algal particulates, benthos and phytoplankton cells, as well inherent optical properties (IOPs), such as total phytoplankton absorption at a specific wavelength. The optical model then solves for the apparent optical properties (AOPs), such as the spectrally resolved scalar irradiance, from the surface down-welling light field and the IOPs. Of most interest here is the calculations of surface reflectance, which can be used to calculate / simulate remotely sensed MODIS Chla (simulated MODIS OC3) using the same algorithm than the standard OC3 ocean colour products. Results for the GBR show large differences between simulated Chla and simulated OC3 Chla, which span more than the traditional offshore versus inshore differences due to bottom reflectance and non-algal matter. In near-shore waters, the simulated OC3 Chl-a is overestimated by a factor of up to 5 due to CDOM. While in the oligotrophic offshore waters, the reflectance from shallow reefs leads to an artificially and persistently high Chl-a concentration. This highlights the problem of over fitting to remotely sensed observations that could lead to improper calibration and issues with data assimilation procedures.

Western Mediterranean operational ocean forecasts at SOCIB

B. MOURRE[1], M. JUZA[1], A. ALVAREZ ELLACURÍA[1], R. ESCUDIER[1], J. TINTORÉ[1]

[1] *SOCIB, Spain*

SOCIB, the Balearic Islands Coastal Observing and Forecasting System, has been developing and is running on a daily basis three operational ocean forecasting systems in the Western Mediterranean Sea:

1) WMOP: a 2km-resolution ocean circulation model based on a regional configuration of the ROMS model implemented over the Western Mediterranean Sea. The model is nested in the larger scale Mediterranean Forecasting System and driven by high-resolution atmospheric forcing (5 km, 3 hours) from the Spanish Meteorological Agency. It produces every morning a 3-day forecast of ocean temperature, salinity, sea level and currents, representing the ocean variability from the (sub-)meso- to the basin-scale. The model outputs are systematically evaluated against remote sensing observations (sea surface temperature and surface geostrophic currents) and in situ measurements (temperature and salinity profiles, mooring time series). Moreover, the behaviour of the system is continuously monitored through ocean indicators (i.e. average temperature, salinity and kinetic energy, maximum mixed layer depth, heat content, transports across key sections) in the different sub-basins of the Western Mediterranean Sea.

2) SAPO: a local wave forecast system implemented around the Balearic Islands in collaboration with Puertos del Estado. The system is based on a 0.5-km resolution of the SWAN model and is run operationally twice a day. It provides 3-day forecasts of significant wave height, wave period and direction around the Balearic Islands, and is systematically evaluated against local buoys measurements.

3) BRIFS: a meteo-tsunamis (oceanic long waves with tsunami-like characteristics but of meteorological origin) forecasting system aiming at predicting extreme sea level oscillations in Ciutadella Harbour (Menorca, Spain). A coupled WRF-ROMS ocean-atmosphere system involving multiple nested grids is used to simulate the long wave amplifications over the continental shelf and in the Ciutadella inlet, intending to predict some of the occurrences of the extreme “rissaga” phenomenon.

These systems are continuously improved based on (i) the potential deficiencies revealed by their systematic evaluation against observations and (ii) dedicated process studies. The three systems are described and illustrated in this presentation, which also identifies some of the needs for their scientific development.

Model representation of observed subsurface eddies off Western Sardinia

B. MOURRE[1], A. FUNK[2], R. ONKEN[3], A. RUSSO[3], S. FALCHETTI[3], I. BORRIONE[3], J. CHIGGIATO[4], P. ODDO[3]

[1] *SOCIB, Spain*
[2] *WTD71, Germany*
[3] *CMRE, Italy*
[4] *ISMAR, CNR, Italy*

The REP14-MED sea-trial organized by the Centre for Maritime Research and Experimentation (NATO Science and Technology Organization) in the coastal waters West of Sardinia Island in June 2014 led to an impressive collection of measurements of physical oceanic variables. A fleet of 11 gliders was successfully deployed and provided complementary observations to the measurements from the CTD stations, shipborne ADCP, towed CTD chain, Scanfish, moorings and surface drifters. In particular, these observations have evidenced the presence of two subsurface eddies, the first one centered around 50m depth with a 40km diameter probably formed by instability of the Algerian current, and the second one found around 250m being characteristic of a Winter Intermediate Water lense with dimensions around 20 km. The proper representation of these eddies in ocean forecasts, which is important for operational applications, is still very challenging from a modelling and data assimilation point of view. In this context, we investigate the representation and evolution of these two eddies in high-resolution (1.5-2km) data-assimilative model forecasts. Different model configurations and data assimilation approaches are considered, as well as different datasets to constrain the model, isolating in particular observations from either CTD stations or underwater gliders.

Monitoring the Ocean State from the synergetic use of different observation types, satellite and in-situ data

S. MULET[1], S. GUINEHUT[1], M.-H. RIO[1,2], B.BUONGIORNO-NARDELLI[2], A. CONCHON[1], R. DROGHEI[2], G. LARNICOL[1], P. LEHODEY[1], P.P. MATTHIEU[3], I. SENNINA[1], J. STUM[1]

[1] *Space Oceanography Division, CLS, France*
[2] *ISAC-CNR, Italy*
[3] *ESRIN, Italy*

Producing comprehensive information about the ocean has become a top priority to monitor the ocean and climate change. Complementary to modeling/assimilation approaches, an observation-based approach is proposed here. It takes advantage of both satellite observations which provide a global, repetitive view of the surface ocean state and in-situ data that observe the subsurface ocean.

The method uses first a multiple linear regression method to derive synthetic T/S profiles from the satellite measurements (altimetry, sea surface temperature). These synthetic profiles are then combined with all available in situ T/S profiles using an optimal interpolation method. The thermal wind equation with a reference level at the surface is finally used to combine current fields from satellite (altimetry and GOCE gravimetric data) with the thermohaline fields to generate the global 3D geostrophic current fields. Global temperature, salinity, absolute height and geostrophic current fields are thus available at a weekly/monthly period from the surface down to 5500-meter depth and for the 1993-2012 periods. Our approach is the observation-based component of the Global Monitoring and Forecasting Center (MFC) of the MyOcean project and our product is called ARMOR3D.

In this study we describe ARMOR3D product and some application of this kind of observation-based product that is a simpler alternative to data assimilation in numerical models. First, an analysis of the ocean variability using the 20-years long time series of the global 3D-fields is performed. Second, the impact of each observing system (remote-sensing and in-situ data) is studied using metrics derived from a Degrees of Freedom of Signal analysis applied to the optimal interpolation method. Then, we present the OSMOSIS project that aims at demonstrating the feasibility to use temperature and current fields from ARMOR3D as inputs for modeling the distribution of micronekton organisms.

The role of the anthropogenic and natural components in the pollution of the seas of rassian part the Western Arctic by oil

NEMIROVSKAYA[1], KRAVCHISINA[2]

[1] *P.P.Shirshov Institute of Oceanology RAS*

Basing on the system biogeochemical approach, the regularities of the quantitative and qualitative distribution of anthropogenic and natural hydrocarbons (aliphatic, including alkanes, as well as polycyclic aromatic hydrocarbons) in all outer terrestrial spheres (atmosphere, kriosphere, biosphere, hydrosphere, lithosphere) are described in the White Sea. Studying of hydrocarbons is lead not only at a static level, but also definitions of a stream inside of geospheres and an exchange between spheres. The offered system of criteria of genetic interpretation of their structure, has allowed to define a degree of accumulation both natural, and anthropogenesis hydrocarbons in sea objects; their distribution and transformation in the basic geochemical barrier zones. In the impact area (Arkhangelsk) HC act in the form of aerosols and concentrate in a snow and in the top part of ices; at removal from sources of issue - in a barrier zone an ice-water (Chypa Bay of the White Sea, north part of the Barents Sea, Eastern Antarctic). Studying of markers in structure of HC has allowed to establish influence of various sources on structure aliphatic HC and polycyclic aromatic hydrocarbons (PAH). Comparison of distribution HC to such connections as the general by the maintenance of organic substance, lipids, chlorophyll and, the maintenance and structure of the weighed substance, biogenic elements is lead. Comparison of distribution HC in the Arctic and Antarctic snow-ice cover is lead. Data on distribution HC in a mouth of Northern Dvina during different seasons are processed.

Building Ensemble-Based Data Assimilation Systems for High-Dimensional Models

LARS NERGER[1], PAUL KIRCHGESSNER[1]

[1] *Alfred Wegener Institute, Helmholtz Center for Polar- and Marine Research, Bremerhaven, Germany*

Different strategies for implementing ensemble-based data assimilation systems are discussed. Ensemble filters like ensemble Kalman filters and particle filters can be implemented so that they are nearly independent from the model into which they assimilate observations. This allows to develop implementations that clearly separate the data assimilation algorithm from the numerical model.

For coupling the model with a data assimilation software one possibility is to use disk files to exchange the model state information between model and ensemble data assimilation methods. This offline coupling does not require changes in the model code, except for a possible component to simulate model error during the ensemble integration. However, using disk files can be inefficient, in particular when the time for the model integrations is not significantly larger than the time to restart the model for each ensemble member and to read and write the ensemble state information with the data assimilation program.

In contrast, an online coupling strategy can be computational much more efficient. In this coupling strategy, subroutine calls for the data assimilation are directly inserted into the source code of an existing numerical model and augment the numerical model to become a data assimilative model. This strategy avoids model restarts as well as excessive writing of ensemble information into disk files. To allow for ensemble integrations, one of the subroutines modifies the parallelization of the model or adds one, if a model is not already parallelized. Then, the data assimilation can be performed efficiently using parallel computers. As the required modifications to the model code are very limited, this strategy allows one to quickly extent a model to a data assimilation system. In particular, the numerics of a model do not need to be changed and the model itself does not need to be a subroutine.

The online coupling shows an excellent computational scalability on supercomputers and is well suited for high-dimensional numerical models. Further, a clear separation of the model and data assimilation components allows to continue the development of both components separately. Thus, new data assimilation methods can be easily added to the data assimilation system. Using the example of the parallel data assimilation framework [PDAF, *http://pdaf.awi.de*] and the ocean model NEMO, it is demonstrated how the online coupling can be achieved with minimal changes to the numerical model.

The SANGOMA Tools for Data Assimilation

LARS NERGER[1], UMER ALTAF[2], ALEXANDER BARTH[3], LAURENT BERTINO[4], JEAN-MICHEL BRANKART[5], PIERRE BRASSEUR[5], GUILLEM CANDILLE[5], PIERRE DE MEY[6], ALISON FOWLER[7], PAUL KIRCHGESSNER[1], PETER JAN VAN LEEUWEN[7], NILS VAN VELZEN[2], MARTIN VERLAAN[2], SANITA VETRA-CARVALHO[7], JEAN-MARIE BECKERS[3]

[1] *Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany*

[2] *TU Delft, Delft, Netherlands*

[3] *University of Liège, Liège, Belguim*

[4] *Nansen Environmental and Remote Sensing Center, Bergen, Norway*

[5] *CNRS/LGGE, Grenoble, France*

[6] *CNRS/LEGOS, Toulouse, France*

[7] *Department of Meteorology, University of Reading, UK*

The EU-funded project SANGOMA – Stochastic Assimilation of the Next Generation Ocean Model Applications –provides new developments in data assimilation to ensure that future operational systems can make use of state-of-the-art data-assimilation methods and related analysis tools. One task of SANGOMA is to develop a collection of common tools for data assimilation with a uniform interface so that the tools are usable from different data assimilation systems. The tool developments mainly aim at tools that support ensemble-based data assimilation applications like for the generation of perturbations, to perform transformations, to compute diagnostics, as well as further utilities. In addition, a selection of ensemble filter analysis steps is included. The tools are implemented in Fortran and as scripts for Matlab or Octave. They are provided as free open-source programs via the project web site [*http://www.data-assimilation.net*]. This contribution provides an overview of the tools that are available in the latest release V1 of the SANGOMA tools as well as the plans for the next release.

Temporal and Spatial Variability of Turbulent Mixing in the Pearl River Estuary and Plume Area as Revealed by a Numerical Modeling

J. PAN[1], Y. GU[2]

[1] *Institute of Space and Earth Information Science, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong, China*

[2] *2College of Information Science and Engineering, Ocean University of China, 238 Songling Road, Qingdao, Shandong, China*

The turbulent mixing in the Pearl River estuary and plume area is analyzed by using cruise data and simulation results of the Regional Ocean Model System (ROMS). The cruise observations reveal that the strong mixing appeared in bottom layer on larger ebb in the estuary. Modeling simulations are consistent with the observation results, and suggest that bottom stress be responsible for generation of the turbulence in the tidal plume area, for the re-circulating plume area, the mixing be caused by internal shear instability, and wind effects induce the surface mixing in the plume far-field. From modeling data, spatial distributions of the turbulent kinetic energy (TKE) production and buoyance flux driven by the bottom stress, internal shear instability, and wind are derived with a discrimination approach. These results indicate that the bottom stress-induced mixing appears in the estuary, the internal shear instability-induced exists in the plume recirculation bulge, and the surface mixing caused by wind effects occurs in the offshore area. The bottom stress-induced mixing is determined by the tidal strength and the internal shear instability mixing is affected by the wind forcing in the plume recirculation bulge area. The mixing efficiency is higher in the re-circulating plume area than that in the estuary. The analysis on mixing characteristic and the freshwater Froude number reveals that the Pearl River estuary is the salt wedge type.

Optimization of the high-frequency radar sites in the Bering Strait region

GLEB PANTELEEV[1], MAX YAREMCHUK[2], JACOB STROH[1], PAM POSEY[2], DAVID HEBERT[2]

[1] *International Arctic Research Center, UAF, AK, USA*

[2] *Naval Research Laboratory, Stannis Space Center, MS, USA*

Monitoring surface currents by coastal high-frequency radars (HFRs) is a cost-effective observational technique with good prospects for further development. An important issue in improving the efficiency of HFR systems is optimization of radar positions on the coastline. Besides being constrained by environmental and logistic factors, such optimization has to account for prior knowledge of local circulation and the target quantities (such as transports through certain key sections) with respect to which the radar positions are to be optimized.

In the proposed methodology, prior information of the regional circulation is specified by the solution of the 4d variational assimilation problem, where the available climatological data in the Bering Strait (BS) region are synthesized with dynamical constraints of a numerical model. The optimal HFR placement problem is solved by maximizing the reduction of a posteriori error in the mass, heat and salt (MHS) transports through the target sections in the region. It is shown that the MHS transports into the Arctic and their redistribution within the Chukchi Sea are best monitored by placing HFRs at Cape Prince of Wales and on the Little Diomede Island. Another equally efficient configuration involves placement of the second radar at Sinuk (Western Alaska) in place of Diomede. Computations show that 1) optimization of the HFR deployment yields a two-fold reduction of the transport errors; 2) error reduction provided by two HFRs is an order of magnitude better than the one obtained from three moorings permanently maintained in the region for the last five years. This result shows a significant advantage of BS monitoring by HFRs compared to more traditional technique of in situ moored observations. The obtained results are validated by an extensive set of observing system simulation experiments.

Hybrid ensemble-4DVAR data assimilation in a coastal ocean model

IVO PASMANS[1], ALEXANDER KURAPOV[1]

[1] *College of Earth, Ocean and Atmospheric Sciences, Oregon State University, USA*

4DVAR data assimilation implementations in near-real time ocean prediction systems are traditionally carried out as a sequence of estimates in relatively short time windows. Currently the background model error covariance used in these implementations is static in time and homogeneous in space. Such a choice for the background covariance may not be justified in highly dynamic coastal ocean environments, including the shelf area off Oregon/Washington (US West Coast) where the fresh water discharge of the Columbia River into the salty ocean and seasonal coastal upwelling create highly inhomogeneous conditions. Furthermore, the location of the strongest inhomogeneities changes rapidly in response to the wind. To include the dynamics of the region into the background covariance we have developed and tested a methodology in which the initial condition error covariance for the 4DVAR system is computed based on a localized ensemble of model forecasts. The method has been tested with a 2-km resolution coastal ocean circulation model that includes the Columbia River discharge, uses the Regional Ocean Modeling System (ROMS) as nonlinear forecast model and the AVRORA tangent linear and adjoint system, developed by our group at OSU, to calculate adjustments to the initial conditions. The test took place during summer upwelling conditions and used along-track satellite altimetry, satellite sea-surface temperatures and surface velocity from an array of land-based high-frequency radars for assimilation. We find that the spatial structure of the background covariance depends strongly on the river plume location. Next to that, comparison with independent mooring temperature-depth profiles shows that the assimilation of surface data yields improvement in near-bottom temperature on the shelf.

On the feasibility of data assimilation in estuarine systems. Ems Estuary.

J. PEIN[1], S. GRAYEK[2], J. SCHULZ-STELLENFLETH[2], E.V. STANEV[2]

[1] *Institut fuer Chemie und Biologie des Meeres (ICBM), Uni Oldenburg*

[2] *Institut fuer Kuestenforschung, Helmholtz-Zentrum Geesthacht*

One can expect that the footprints of observations in the tidal estuaries are limited in time and space. Even considering the periodicity of the processes, it seems unlikely that sparse observations could much contribute to the estimation of the hydrodynamical state. These expectations are supported by the analysis of numerical simulations carried out with an unstructured 3D model of Ems Estuary, which revealed complex non-linear interactions and intermittent phenomena that result in temporal and spatial asymmetries. In order to to investigate the contribution of data when statistically reconstructing the hydrodynamical state we performed a number of Observing System Simulation Experiments (OSSE). It is shown that in the studied case a well-chosen observation network enables a successful reconstruction of the system state. These results indicate that even in a highly dynamical coastal environment data assimilation is possible and feasible.

Applications of multi-level directed graphs in oceanography: the Mediterranean Sea case study

BORIS PETELIN[1], VLADO MALAČIČ[1], IGOR KONONENKO[2] AND MATJAŽ KUKAR[2]

[1]*National Institute of Biology, Slovenia*
[2]*University of Ljubljana, Slovenia*

Multi-level directed graphs for spatial analysis have proven to be very useful in analyzing the movement of water masses between neighboring sea areas in the domain of an oceanographic numerical model [*Petelin et al.,* 2013]. The groundwork for these graphs involve a huge number of trajectories of virtual particles, which were released in the velocity field of the numerical prognostic model. From the displacement of individual particles in a given time interval, we obtained the probabilities of particle transition from one sea area to another in a given domain. We accomplished this task through the use of spatial association rules and presented the resulting probabilities in the form of a directed graph. The latter may cover areas of various sizes and use different time intervals, that is, it may be constructed at various levels of spatial and temporal granularity.

The outlined methodology was applied to state-of-the-art outputs resulting from the numerical prognostic model Mediterranean Ocean Forecasting System (MFS) [*Tonani et al.,* 2008] for the period 1999-2011. In the multi-level directed graphs obtained from this model, we identified frequent substructures in the movement of water masses in the Mediterranean Sea, such as dynamic fuzzy paths and cycles [*Petelin et al.,* 2015]. The obtained substructures were similar to those presented by oceanographic experts in the literature [*Artegiani et al.,* 1997].

In addition to the abovementioned capabilities, multi-level directed graphs proved to be a solid basis for a range of applications which can assist oceanographic experts. In this contribution, we highlight the usefulness of the proposed methodology by providing two case studies. In the first, we studied the probability of the exchange of water mass and its seasonal variation in the surface layer between areas in the Mediterranean Sea (i.e. Adriatic Sea, Ionian Sea, etc) within one month. We showed that the oscillations of the above transitions have a period of 12 months, which confirms their seasonal nature. In the second study we examined the correlation between wind input and the probability of water mass exchange. Results demonstrated that the surface waters of the Adriatic and Tyrrhenian Sea remain more isolated from the Mediterranean Sea under wind input with duration of about 30 days, while in other areas of the Mediterranean Sea the exchange is more intensive.

REFERENCES

Artegiani, A., Bregant, D., Paschini, E., Pinardi, N., Raicich, F., Russo, A., 1997. The Adriatic Sea general circulation. Part II. Baroclinic circulation structure. *J. Phys. Oceanogr.*, 27, 1515-1532.

Petelin, B., Kononenko, I., Malačič, V., Kukar, M., 2013. Multi-level association rules and directed graphs for spatial data analysis. *Expert Syst. Appl.*, 40, 4957-4970.

Petelin, B., Kononenko, I., Malačič, V., Kukar, M., 2015. Dynamic fuzzy paths and cycles in multi-level directed graphs. *Eng Appl Artif Intell.*, 37, 194-206.

Tonani, M., Pinardi, N., Dobricic, S., Pujol, I., Fratianni, C., 2008. A high-resolution free-surface model of the Mediterranean Sea. *Ocean Sci.*, 4, 1-14.

---

[1]Marine Biology Station Piran, National Institute of Biology, Fornače 41, SI-6330 Piran.
[2]Faculty of Computer and Information Science, University of Ljubljana, Večna pot 113, SI-1001 Ljubljana.

Unstructured-mesh simulations of flow and sediment fluxes in the Mahakam land-sea continuum, Indonesia

C. PHAM VAN[1], E. DELEERSNIJDER[2,3], S. SOARES-FRAZAO[1], T. HOITINK[4], M. SASSI[5]

[1] *Institute of Mechanics, Materials and Civil Engineering (IMMC), Universit catholique de Louvain, 1 Place du Levant, Louvain-la-Neuve, Belgium*

[2] *Institute of Mechanics, Materials and Civil Engineering (IMMC) & Earth and Life Institute (ELI), Université catholique de Louvain, 4 Avenue Georges Lematre, Louvain-la-Neuve, Belgium*

[3] *Delft Institute of Applied Mathematics (DIAM), Delft University of Technology, Mekelweg 4, 2628CD Delft, The Netherlands*

[4] *Department of Environmental Sciences, Wageningen University, 4 Droevendaalsesteeg, Wageningen, The Netherlands*

[5] *Royal Netherlands Institute for Sea Research, NIOZ, Den Burg, The Netherlands*

[6] *Department of Hydrology and Hydraulic Engineering, Vrije Universiteit Brussel, 2 Pleinlaan, Brussels, Belgium*

The Mahakam land-sea continuum (Indonesia) exhibits various interconnected regions including a river and its tributaries, lakes, a delta, and the adjacent coastal ocean. In this domain, a wide range of temporal and spatial scales of motion can be observed due to the combined effects of riverine and marine forcings (e.g. river discharge, tides), mutual influences of natural processes (e.g. El Nino-Southern Oscillation, regional climatic variability, droughts, floods), and human activities. Indeed, because of the variation of the flow and different sediment sources, complex transport processes and pathways develop. Therefore, besides field measurements that are generally time-consuming and rarely obtained over long time intervals and at different locations due to the highly spatial and temporal variability of the phenomena, an integrated model that allows for reproducing the flow and sediment transport processes in the land-sea continuum is still necessary, to qualitatively compute the flow and sediment fluxes and to study related issues, e.g. morphology, assessing the ecological status of coastal waters. In this context, the unstructured-mesh, finite element model SLIM (www:climate:be=slim), which consists of hydrodynamic and sediment modules, is applied to reproduce the flow and sediment in the region of tidal influence of the Mahakam land-sea continuum. The depth and cross-section integrated shallow-water equations are coupled in the hydrodynamic module while the depth- and sectional-averaged advection-diffusion equations (including the influence of erosion and deposition rates) are combined in the sediment component. The modelling parameters in both modules are carefully determined, using the observations of the flow (e.g. flow velocity, water elevation, water discharge) and of sediment concentration at various locations in the system. The model is then validated against the field data measured in another period of time. Using numerical simulations, firstly, the interactions between interconnected regions are preliminary investigated, revealing that, for example, the lakes contribute about 20% of the mean annual river discharges in the considered low flow period. Secondly, the flow and sediment at several locations of interest along the Mahakam River and at two bifurcations around the delta

apex are also carried out for different river discharge and tidal conditions. Finally, spatial distribution of sediment concentration, especially in the deltaic region, are also explored and discussed.

Ocean prediction scientific paradigm and the development of the blue economy

NADIA PINARDI[1]

[1] *Dept. of Physics and Astronomy, University of Bologna, Italy*

Operational oceanography embraces the frontier research for ocean monitoring and forecasting, development of advanced modelling systems and data assimilative schemes. The objective to make the most accurate forecast of the ocean essential marine variables drives a whole chain of scientific and technological developments and produce the basic data for fundamental scientific studies of the ocean climate variability.

Today operational oceanography systems make available and deliver a set of basic, generic services based upon common-denominator ocean state variables and products that are required to help meet the needs for information of those responsible for marine environment management and protection, civil and military security at sea, monitoring of climate variability and change. It is the science based approach to the needs for ocean information from our society, organised as a meteorological office for the marine environment. The user community is large and several products for the development of the blue economy are emerging. Aspects of the market model related to this field of scientific innovation are discussed for the case of the Mediterranean operational oceanographic service as reported at: http://www.sea-conditions.com/en/.

ASSESSING NCOM AMSEAS AND GLOBAL HYCOM FORECASTING SKILL FOR NORTHEASTERN CARIBBEAN WATERS

LUIS POMALES[1], JULIO MORELL[1], SYLVIA RODRIGUEZ[1]

[1] *University of Puerto Rico at Mayagüez, Puerto Rico*

The implementation of a coastal ocean model yielding reliable forecasts of near coastal hydrodynamics for the US Caribbean Islands remains an elusive target. These are however of extraordinary importance to regional stakeholders. While the region is characterized by narrow insular shelves with steep slopes which present a particular challenge to regional modelling efforts, its location within a rich hydrodynamic field demands assessing the efficacy of available operational sources of boundary and initial conditions. CariCOOS proposes the operational deployment of a 1/100 degree Regional Ocean Modelling System nested in the 1/36 degree resolution Navy Coastal Ocean Model (AMSEAS), which itself is nested in the Hybrid Coordinate Ocean Model, a Global 1/12 degree data-assimilative hybrid isopycnal-sigma-pressure coordinates forecast system. Although CariCOOS-ROMS has progressed constantly, results indicate the necessity for identification of constraints to its performance. An inward approach has been adopted to assess the output of parent models against observations from satellites, drifters, gliders, sea level measurements, buoys, and high frequency radars. Hydrographic data from glider observations will be used to assess model prediction of pertinent seasonal phenomena such as, continental river plumes, advection of the subtropical underwater mass and displacement of pycnocline depth. Mixed layer drifter and HF radar data will be used to assess near surface current model forecast of regionally important cyclonic features. Sea surface height anomaly gridded altimetry estimates derived from satellite data and model output will be contrasted to available deep ocean pressure sensor observations. Results from said assessments will be analyzed in light of current knowledge of mesoscale processes occurring in the region.

Generation of an ensemble for the assimilation of wave glider data in the Belgian coastal zone.

S. PONSAR[1], P LUYTEN[1]

[1] *Royal Belgian Institute of Natural Sciences, Belgium*

Wave glider gliders belong to the last generation of measuring equipment. They provide data with high temporal and spatial resolutions. As they are moving, the amount of available data increases considerably. For the first time, a wave glider has been deployed for 20 days during spring 2013 in one zone of the Belgian waters. Amongst the collected data, this study focuses on temperature because it is a major forcing of the hydrodynamics and of the marine ecosystem.

As neither the models nor the observations do fully capture the true state of the ocean, our knowledge of coastal dynamics can be improved by combining the data with the model in a data assimilation approach. The objective is to assimilate the temperature data collected by the wave glider in the COHERENS model [Luyten, 2011] with an ensemble Kalman filter [Evensen, 2003].

The COHERENS model is a three-dimensional multi-purpose numerical model designed in particular for applications in coastal and shelf seas. The high variability of coastal dynamics is reflected in the way errors are propagated by the model. Prior to the assimilation of data into the model, the features of the model error must be identified. We analyse the role of initial conditions and of model parameters representing unresolved processes. These identified features are taken into account to generate the ensemble.

References

Luyten, P.: COHERENS – A coupled Hydrodynamical-Ecological Model for Regional Seas: User Documentation, 2011.

Evensen, G.: The Ensemble Kalman Filter: theoretical formulation and practical implementation, Ocean Dynamics, 2003.

Determination of Mean Dynamic Topography over the Mediterranean Sea from Jason-2 Altimetry Measurements and EGM2008 Data

ALI RAMI [1], SOFIANE KHELIFA[1]

[1] *Centre of Space Techniques, Oran Algeria*

The ocean surface must be surveyed in order to determine the dynamic topography, tides, time-variations etc... The ocean dynamic topography, which is the distance between the geoid and the instantaneous sea surface height and which reflects the ocean dynamics, is a primary oceanography unknown. The processing of 5 years of Jason-2 satellite altimetry measurements is done after the estimation of the environmental geophysical and orbital parameters corrections, permit us to determinate the sea surface height with 1 cm of precision, while using the Earth Gravitational Model EGM2008 (geoid) based on a combined data (GRACE, terrestrial and altimetry measurements,....) we can calculate the mean dynamic topography of the Western Mediterranean sea. The variation of the obtained mean dynamic topography is between -1.12 and 1.12m. The obtained surface is compared with the Mean dynamic topography provided by AVISO Altimetry (RioMed).

ALBOREX: an intensive multi-platform and multidisciplinary experiment in the Alboran Sea

SIMÓN RUIZ[1], ANANDA PASCUAL[1], JOHN ALLEN[2], ANTONIO OLITA[3], ANTONIO TOVAR[1], AMALA MAHADEVAN[4], MARIONA CLARET[5], CHARLES TROUPIN[2], PIERRE POULAIN[6], TEMEL OGUZ[2], JOAQUÍN TINTORÉ[2]

[1] *IMEDEA (UIB-CSIC), Esporles, Spain*
[2] *SOCIB, Palma de Mallorca, Spain*
[3] *CNR, Oristano, Italy*
[4] *WHOI, Woods Hole, USA*
[5] *McGill, Canada*
[6] *OGS, Trieste, Italy*

An intensive multi-platform and multidisciplinary experiment was completed in May 2014 as part of PERSEUS EU Project. 25 drifters, 2 gliders, 3 Argo floats and one ship were dedicated to sample an area of about 50x50 km in the eastern Alboran Sea during one week. The experiment, which also includes 66 CTD stations and 500 water samples (salinity, chlorophyll and nutrients), was designed to capture the intense but transient vertical exchanges associated with mesoscale and submesoscale features.

The vertical motion associated with mesoscale and submesoscale features such as ocean eddies, filaments and fronts plays a major role in determining ocean productivity, due to the exchange of properties between the surface and the ocean interior. Understanding the relationship between these physical and biological processes is crucial for predicting the marine ecosystems response to changes in the climate system and to sustainable marine resource management. However, to understand the links between mesoscale and submesoscale features and ecosystem responses, it is necessary to collect data at a range of temporal and spatial scales, and then combine these data with coupled physical and biochemical models.

Data from thermosalinograph revealed a sharp surface salinity front with values ranging from 36.6 (Atlantic Waters) to 38.2 (Mediterranean Waters) in conjunction with a filament in temperature. Drifters followed a massive anticyclonic gyre. Near real time data from ADCP showed coherent patterns with currents up to 1m/s. Gliders detected a subduction of chlorophyll located in areas adjacent to the front. We also present results on the horizontal strain rate, relative vorticity and quasi-geostrophic vertical motion to understand the dynamics of this intense ocean front.

Analysis of the up- and downscaling problem in the North Sea using a high resolution 2D barotropic model

JOHANNES SCHULZ-STELLENFLETH[1], EMIL STANEV[1]

[1] *Helmholtz Zentrum Geesthacht (HZG), Institute of Coastal Research*

Due to the shallow water in large parts of the North Sea small scale bathymetry features can have a significant impact on the circulation in particular in coastal areas. The length scales of the circulation are often not given by the Rossby radius, but by spatial scales of the bathymetry. Small scale dynamic features can also be an issue in the context of data assimilation where they may be added as corrections in the analysis scheme. Data from the Coastal Observing System for Northern and Arctic Seas (COSYNA) HF radar system will be used to illustrate topographic effects in the German Bight. In this study the local and regional influence of the topography is studied for different spatial scales using a 2d hydrodynamic model for the entire North Sea. The nonlinear model uses an explicit time stepping scheme and is run on quarter mile grid with 1 second time steps. Surface wind and air pressure data from the German Weather Service (DWD) are used as metereological forcing. Data from the operational MyOcean North West Shelf model were used as forcing for the open boundaries. The model has a drying and flooding scheme and was run in parallel mode on a linux cluster.

Different experiments are performed to study the effect of bathymetry smoothing either on the entire grid or parts of the domain like, e.g., the German Bight. By smoothing the entire grid except a particular coastal area a typical nested model setup can be simulated and compared to the full high resolution simulation. By comparing the different model runs both local and regional impacts of the spatial scales are investigated. The model runs span at least one month and can in particular be used to analyze neap and spring tide effects.

The data analysis is complemented by a theoretical study on the role of the nonlinear terms in the momentum equation. By defining respective source terms the local impact of small scale dynamics on the larger scale is quantified.

The study is of high practical relevance in particular in the context of data assimilation. Here the question is to which extent high resolution information gathered by instruments like HF radar can also be beneficial for the regional scale. This issue will be illustrated using data from the pre-operational HF radar assimilation system run as part of COSYNA. Model runs are performed to illustrate how small scale corrections applied in an assimilation scheme evolve in time on different spatial scales.

Monitoring tidal dynamics by a high resolution current mapping system

SENTCHEV A [1], YAREMCHUK M[2]

[1] *Laboratoire d'Océanologie et Géosciences (CNRS-UMR8187), Université du Littoral - Côte d'Opale, Wimereux, France*

[2] *Naval Research Laboratory, Stennis Space Center, MS, USA*

A low cost current mapping system for monitoring circulation in tidal basins with high spatial and temporal resolution is presented. The system is based on a broadband Acoustic Doppler Current Profiler (ADCP), mounted on a floating platform, coupled with a GPS navigation device, and towed by a light boat. In addition to the standard ADCP pre-processing software, the mapping system is equipped with the filter which removes the GPS positioning errors. The filtered velocity observations are synchronized and interpolated in space and time using inhomogeneous covariances deduced from simulations by the regional MARS-3D numerical model. The system is capable of providing accurate assessment of the spatio-temporal structure of the tidal currents in the surveyed area with explicit error estimates. Its performance has been tested in the Boulogne harbour (eastern English Channel, France) where several surveys during different stages of tide have been performed at the towing speeds of 4 to 8 knots. Due to high resolution of measurements and the model grid, the reconstructed velocity fields capture all the key features of circulation in the harbour, such as rapidly evolving transient eddy, tidal jet at the harbour entrance, and diffuse flow in the shallow water area. It is shown that the system can deliver robust estimates of the tidal currents, including velocity profiles, at very low cost and variable time and space scales. Possibilities and limitations of the further development of the system towards the full 4-dimensional surveying are discussed.

IT – OSRA: applying super-ensemble simulations to estimate the oil spill hazard associated to operational and accidental oil spills

ANTONIO AUGUSTO SEPP-NEVES [1], NADIA PINARDI[1], FLAVIO MARTINS[2], ACHILLEAS SAMARAS[3], LUCA GIACOMELLI[1], JOAO JANEIRO[2]

[1] *Laboratorio di Simulazioni Numeriche del Clima e degli Ecosistemi Marini (SINCEM) – University of Bologna, Italy*

[2] *ISE/CIMA – University of Algarve, Portugal*

[3] *Centro Interdipartimentale di Ricerca Industriale su Edilizia e Costruzioni – University of Bologna, Italy*

Every year, over 410,000 tonnes of oil are introduced to the oceans through accidental (26[*Sepp-Neves et al. (submitted to the Journal of Environmental Management)*] proposed a new OSRA framework based on the ISO 31000:2009 standard, obtaining significant improvements compared to the original standard and to other frameworks. In addition to the inclusion of operational spills in the calculation of risk, the authors employed, for the first time in the literature, ensemble oil spill simulations to address uncertainties in the calculation of the risk. Their positive results encouraged its application to a wider area and to a more complex risk scenario. Based on the methodology proposed by [*Sepp-Neves et al.*], so-called Information Technology (IT)-OSRA, we estimated the oil spill hazard represented by vessel-related operational and accidental spills in a traficked coastal area. Six ensemble members were generated covering different oil spill characteristics (i.e. oil density, spill volume and duration of the spill) and hydrodynamic forcings (operationally available outputs of MERCATOR, IBI-ROOS and MOHID-PCOMS systems) in order to address the main sources of uncertainties in oil spills events. Simulations were repeated along a release grid every 10 days throughout a year. The experiment was performed in the Southern Portuguese coast, Algarve. The area is known for its high ecological value and its high dependence on marine resources. Concomitantly, the area is exposed to one of the busiest maritime routes in the world in which over 200 million tonnes of oil flow yearly. The results obtained are paramount for the definition of necessary oil spill response equipment and for the positioning of traffic lanes.

REFERENCES

Sepp-Neves, A.A., Pinardi, N., Janeiro, J., Martins, F., Samaras, A., Zodiatis, G. and De Dominicis, M.,. Towards a common oil spill risk assessment framework : Adapting ISO 31000 and addressing uncertainties . Submitted to the *Journal of Environmental Management*.

Modelling the water and heat balances of the Mediterranean Sea using a two-basin model and available meteorological, hydrological, and ocean data

MOHAMED SHALTOUT[1]

[1] *Department of Oceanography, University of Alexandria, Faculty of Science*

The research presents a two-basin model of the water and heat balances of the Western and Eastern Mediterranean sub-basins (WMB and EMB, respectively) over the 1958–2010 period using available meteorological and hydrological data. The results indicate that the simulated temperature and salinity in both studied Mediterranean sub-basins closely follow the reanalysed data. In addition, simulated surface water in the EMB had a higher mean temperature (by approximately 1.6°C) and was more saline (by approximately 0.87 g kg−1) than in the WMB over the studied period. The net evaporation over the EMB (1.52 mm day−1) was approximately 1.7 times greater than over the WMB (0.88 mm day−1). The water balance of the Mediterranean Sea was controlled by net inflow through the Gibraltar Strait and Sicily Channel, the net evaporation rate and freshwater input. The heat balance simulations indicated that the heat loss from the water body was nearly balanced by the solar radiation to the water body, resulting in a net export (import) of approximately 13 (11) W m−2 of heat from the WMB (to the EMB).

Coupling of wave and circulation models in coastal-ocean predicting systems: A case study for the German Bight

JOANNA STANEVA[1], KATHRIN WAHLE[1], ARNO BEHRENS[1], EMIL STANEV[1]

[1] *Institute for Coastal Research, Helmholtz Zentrum Geesthacht (HZG), Germany*

This study addresses the coupling between wind wave and circulation models on the example of the German Bight and its coastal area called the Wadden Sea (the area between the barrier islands and the coast). This topic reflects the increased interest in operational oceanography to reduce prediction errors of state estimates at coastal scales. The uncertainties in most of the presently used models result from the nonlinear feedback between strong tidal currents and wind-waves, which can no longer be ignored, in particular in the coastal zone where its role seems to be dominant. A nested modelling system is used in the Helmholtz-Zentrum Geesthacht to producing reliable now- and short-term forecasts of ocean state variables, including wind waves and hydrodynamics. In this study we present analysis of wave and hydrographic observations, as well as the results of numerical simulations. The data base includes ADCP observations and continuous measurements from data stations. The individual and collective role of wind, waves and tidal forcing are quantified. The performance of the forecasting system is illustrated for the cases of several extreme events. Effects of ocean waves on coastal circulation and SST simulations are investigated considering wave-dependent stress, wave breaking parameterization, and Langmuir circulation during hurricane Xavier in December, 2013. Also the effect which the circulation exerts on the wind waves is tested for the coastal areas using different parameterizations. The improved skill resulting from the new developments in the forecasting system, in particular during extreme events, justifies further enhancements of the coastal pre-operational system for the North Sea and German Bight.

North Sea-Baltic Sea Ocean State Predictions by assimilating of temperature and salinity data

JOANNA STANEVA[1], SEBASTIAN GRAYEK[1], JOHANNES SCHULZ-STELLENFLETH[1], EMIL STANEV[1]

[1] *Institute for Coastal Research, Helmholtz Zentrum Geesthacht (HZG), Germany*

Integrated ocean observing systems closely link in-situ and remote measurements with numerical models enabling the reconstruction and forecast of key state variables with full spatial coverage. Such a nowcast/forecast model system has been developed for the North Sea-Baltic Sea. It is used to produce nowcasts and short-term forecasts of the circulation and physical properties in the North Sea/Baltic Sea One of the expectations is that the model can provide consistent temperature and salinity three-dimensional fields to fill in the gaps in observation and satellite observations and eventually produce reliable physical components to be used in further bio-geochemical/management/fishery applications. The three-dimensional primitive equation model GETM ("General Estuarine Transport Model") is used to simulate the circulation and salinity and temperature fields for the North Sea-Baltic Sea system. The atmospheric data from the German Weather Service (DWD) are used for the metereological forcing. This work presents a framework of the nowcast/forecast system, which includes an algorithm to assimilate temperature and salinity derived from measurements (such as FerryBox, MARNET stations, etc.) as well as satellite derived sea surface temperature (SST) for the North Sea- Baltic Sea The numerical performance of the North Sea-Baltic Sea model with the data assimilation method based on Kalman filter appears to be efficient enough to be used in an operational ocean forecast system. For the assessment of forecast skill of the regional ocean model we compare the free run and assimilation run with independent data from observations. Model-data comparison shows that the reanalysis produced by the data assimilation fairly well represents the physical properties in the Baltic Sea. The overall root-mean-square errors between temperature and salinity fields of reanalysis and observation are significantly reduced after the assimilation. Furthermore, seasonal variation in temperature is well reproduced and the predicted synoptic variation is significantly correlated with its counterpart from the mooring measured temperature. Of particular interest is the question how long the information from the measurements used in the model predicted system has an influence on the forecast.

Assessment of eutrophication status of the Gulf of Finland using autonomous devices

STELLA-THERESA STOICESCU[1], NATALJA BUHHALKO[1], INGA LIPS[1], URMAS LIPS[1]

[1] *Tallinn University of Technology Marine Systems Institute, Estonia*

In order to assess the state of the marine areas in regard of eutrophication effects and to give advice for the management different eutrophication indicators have been developed by the coastal states and regional sea commissions (e.g. HELCOM). For the Baltic Sea, core indicators based on nitrogen, phosphorus and chlorophyll-a content, water transparency and oxygen conditions have been suggested by HELCOM. In order to aggregate the results and to give an overall assessment on the status of the Baltic Sea, an assessment tool called HEAT (HELCOM Eutrophication Assessment Tool) was developed [HELCOM, 2014]. This tool takes into account all the above mentioned indicators and forms a final assessment result taking also into account the reliability of the data and thus gives an assessment with a confidence rating.

The main problem with such assessments and their confidence is lack of data with required resolution in time and space to make assessments with high confidence. Ordinary monitoring programmes are usually implemented as research vessel based sampling and analyses. However, in the Baltic Sea ferrybox-type of measurements are carried out since 1992 [Rantajärvi, 2005] and autonomous buoy profilers are applied since 2009 [Lips et al., 2011] to acquire environmental data with high temporal resolution. We suggest that inclusion of data from autonomous devices would significantly increase the confidence of assessment results.

The main aim of the present paper is to assess the eutrophication status based on chlorophyll-a and oxygen data collected by autonomous devices in the Gulf of Finland in 2009-2014. Chlorophyll-a data acquired by in-situ fluorometers as well as by laboratory analyses of automatically collected water samples are applied. Among others, the question of chlorophyll fluorescence quenching is discussed. The results are tested against the suggested reference conditions in the coastal and open sea and the improvement in confidence of assessment results is demonstrated.

Based on the vertical profiles of dissolved oxygen collected with the temporal resolution of 3 hours from sea surface to the seabed, approaches to develop further the HELCOM indicator of oxygen debt are shown. Assessment of oxygen conditions in the Gulf of Finland is made by applying this indicator. The ways to combine high-resolution in-situ measurements and operational model outputs for better (more confident) assessments is discussed.

REFERENCES

HELCOM, 2014. Eutrophication status of the Baltic Sea 2007-2011 - A concise thematic assessment. Baltic Sea Environment Proceedings No. 143

Rantajärvi, E. (Editor), 2002. Alg@line in 2003 : 10 years of innovative plankton monitoring and research and operational information service in the Baltic Sea. Report Series of the Finnish Institute of Marine Research, No. 48.

Lips, U., Lips, I., Liblik, T., Kikas, V., Altoja, K., Buhhalko, N., Rünk, N., 2011. Vertical dynamics of summer phytoplankton in a stratified estuary (Gulf of Finland, Baltic Sea). Ocean Dyn., 61, 903 - 915.

Effect of hydraulic gradient on overbanks wetting element in storm surge overtopping simulation

SEUNGWON SUH[1], HWAYOUNG LEE[1]

[1] *Dept. of Ocean Science and Engineering, Kunsan National University, Korea*

Threatening of typhoons or hurricanes is increasing due to global climate changes. Recently Hyein and Sandy caused severe damages. Storm surge simulation for the purpose of mitigating coastal disasters requires early warning system with precise understanding of inundation including wave runup and overtopping. In this study, we proposed a new coupling scheme of overtopping module EurOtop to ADCIRC+SWAN surge model accounting the effect of efficient hydraulic gradient in terms of a threshold value of wetting-drying on overbanks or dikes. Numerical simulations in idealized basin using hypothetical typhoons showed the importance of proper selecting the value of hydraulic gradient in wetting element rather than prevailing values of minimum depth or velocity in wet-dry treatment. Optimal gradient was adjusted in overtopping coupled model and applied to hindcast inundation simulation primarily due to wave overtopping during typhoon Maemi attacking to low-lying coastal city embankment area, Busan in Korea.

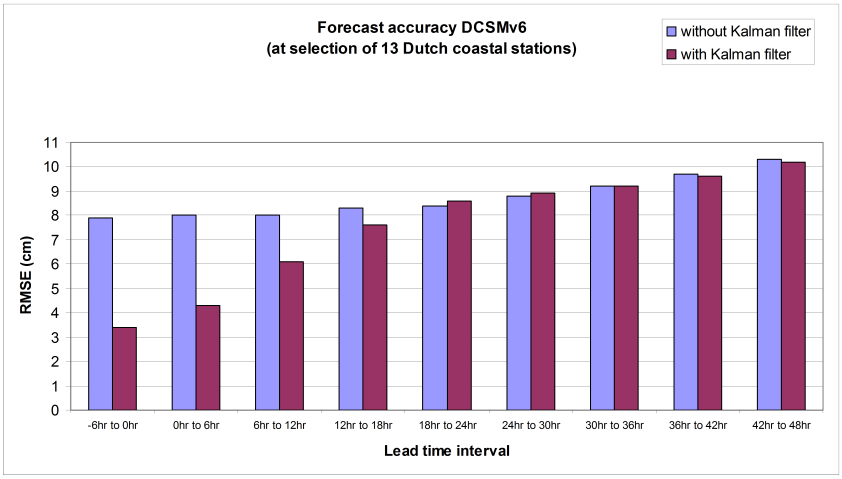
Steady state Kalman filter for operational storm surge forecasting system based on the Dutch Continental Shelf Model v6

JULIUS SUMIHAR [1], FIRMIJN ZIJL[1], MARTIN VERLAAN[1,2]

[1] *Deltares, P.O. Box 177, 2600 MH Delft, The Netherlands*

[2] *TU Delft, P.O. Box 5, 2600 AA, Delft, The Netherlands*

In the Netherlands, accurate sea level prediction is important. For example, during storm surge conditions accurate sea level prediction is needed to support the decision to close the storm surge barriers in the Eastern Scheldt and the Rotterdam Waterway, send out the dike watch or even activate an evacuation scenario. Sea level prediction is also important for computing tidal reduction for hydrographic survey. Since recently, the newly developed Dutch Continental Shelf Model v6 has been running operationally to produce the sea level prediction (Zijl et al, 2013). A steady state Kalman filter has been implemented for DCSMv6 to increase its short term forecast accuracy (Zijl et al, 2015). In this talk, the Kalman filter setup will be presented, including the choice of the noise model, the use of covariance localization, and the technique for computing the steady state Kalman gain as well as the selection of the assimilation stations, aided by modified ensemble-based observation impact analysis (Liu and Kalnay, 2008; Verlaan and Sumihar, 2015). The Kalman filter for DCSMv6 has been running operationally since 2013. Along the Dutch coast, it successfully improves on average the hindcast accuracy by around 50% and the forecast accuracy up to lead times of 9 – 15 hours after the last assimilated water level measurements. Crucially, the Kalman filter especially improves the forecast accuracy during storm events.



REFERENCES

Liu, J. and Kalnay, E., 2008. Estimating observation impact without adjoint model in an ensemble Kalman filter. Quart. J. of the Royal Meteorological Society, 134, 1327-1335.

Verlaan, M. and Sumihar, J., 2015. Observation sensitivity based on ensemble. in preparation.

Zijl, F., Verlaan, M. and Gerritsen, H., 2013. Improved water-level forecasting for the Northwest European Shelf and North Sea through direct modelling of tide, surge and non-linear interaction. Ocean Dynamics, 63, 823-847.

Zijl, F., Sumihar, J. and Verlaan, M., 2015. Application of data assimilation for improved operational water-level forecasting on the Northwest European Shelf and North Sea. Ocean Dynamics, submitted.

Application of the Equivalent Weights Particle Filter to a Marine Biogeochemical Model

SURSHAM D.[1], CIAVATTA S. [1], VAN LEEUWEN P.J. [2], BROWNE, P.[2]

[1] *Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 2LP, UK*

[2] *Department of Meteorology, Reading University, , Reading, RG6 6BB, UK*

The implementation of data assimilation techniques in marine biogeochemical models is essential for improving the accuracy of predictions and advancing our understanding of marine ecosystems. One of the more promising assimilation techniques for this field is the particle filter; an exact method which seeks to represent the entire non-Gaussian probability-density function, thus avoiding the inaccuracies arising from the linearity assumptions of approximate methods. The drawback of this method in such a field is that it is limited by high dimensionality of the state vector. The equivalent weights particle filter provides a solution to this problem [Van Leeuwen, 2010].

Using the combined biogeochemical and physical model, ERSEM-GOTM [Blackford et al., 2004], the effectiveness of the equivalent weights particle filter has been investigated. This has been achieved in two ways. First, a series of ensemble simulations were carried out within this model to investigate the distributions of the model state variables. This evaluates the necessity of an exact data assimilation method. Secondly, a data-assimilation framework, EMPIRE (Employing MPI for Researching Ensembles) was integrated with the model. "Twin experiments" were carried out by assimilating artificial observational data into the model, allowing us to test a variety of data assimilation methods: the Ensemble Kalman Filter, the SIR particle filter and the Equivalent Weights Particle Filter.

The results of identical twin experiments have been used to assess the quality of the data assimilation methods. The ensemble of distributions of model variables and the results of the different techniques were then compared, providing a qualitative justification for the implementation of the equivalent weights particle filter over alternative techniques in marine biogeochemical modelling.

REFERENCES:

Van Leeuwen, P., Q. J. R. Meteorol. Soc., **136**, 653, (2010).

Blackford, J. et al., J. Mar. Syst., **52**, 191-215, (2004).

A parametric optimization tool for the calibration of complex biogeochemical models

SARAH TAVERNEL[1], MARION GEHLEN[1], CHRISTIAN ETHÉ[1,2], OLIVIER AUMONT[2]

[1] *LSCE/IPSL, Laboratoire des Sciences du Climat et de l'Environnement, L'Orme des Merisiers, Bât. 712, 91191 Gif-sur-Yvette Cedex, France*

[2] *IRD-LOCEAN IPSL, 4 place Jussieu, 75252 Paris Cedex 05, France*

Marine biogeochemical models got increasingly complex over the past 10 years. As for today, they describe the first levels of the marine foodweb with multiple phytoplankton and zooplankton functional types. These models are getting standard tools for marine environmental monitoring and short-term forecasting, as well as assessing impacts of climate change on lower level trophic levels. Due to the increasing number of parameters, their interdependencies and inherent model non-linearities, model tuning gets increasingly difficult. We propose a variational optimization tool for the adjustment of parameters of biogeochemical models. The approach consists of a screening step which identifies a subset of parameters to be optimized based on model sensitivity to parameter change. Once the sub-set of parameters identified, these are optimized by a variational gradient-descent method minimising model-data distance. The tool is applied to the biogeochemical model PISCES, a biogeochemical model of intermediate complexity (Aumont and Bopp, 2006, BGC; Aumont et al., 2015, GMDD). In its standard version, the model represents the dynamics of major nutrients, 2 phytoplankton (nanophytoplankton and diatoms) and 2 zooplankton functional types, as well as of the marine carbonate system. Here we present an extended version of the model including picophytoplankton as a third phytoplankton group. Satellite derived chlorophyll_a and 3D nutrient fields with monthly resolution provide the data constraint. The model is optimised starting from a first guess of parameters based on 'expert judgment'. The skill of the optimized model version is assessed against independent data derived from remote sensing (phytoplankton groups), as well as in situ biogeochemical and biological observations.

Recent advances in the Mercator-Ocean reanalysis system: Application to an Arctic configuration

CHARLES-EMMANUEL TESTUT[1], GILLES GARRIC[1], JEROME CHANUT[1], CLEMENT BRICAUD[1], GREG SMITH[2]

[1] *Mercator-Océan, Toulouse, France*

[2] *Meteorological Research Division, EC, Dorval, Canada*

In the framework of the Myocean EU (FP7 and Horizon 2020) funded projects , Mercator Ocean, the French operational oceanography center, is in charge of the development and of the production of real time analysis and forecasts and reanalysis for the global ocean at the resolution of 1/12°. The operational systems are all based on the ocean and sea ice model NEMO and the multivariate data assimilation system SAM2 (Système d'Assimilation Mercator V2). The assimilation method is a reduced order Kalman filter based on SEEK formulation with bias correction scheme for temperature and salinity and an Incremental Analysis Update. The strong need of a realistic description of the mean state and variability of the rapid changing Arctic Ocean and its adjacent seas over the last decades motivated the use of the Canadian Arctic Ocean and Nordic seas configuration (CREG). This dedicated configuration at 1/12° developed by the Canadian research teams has been coupled to the multivariate data assimilation system SAM2. The objectives of this pan-Arctic platform is both to improve the sea ice assimilation method used in the Mercator Ocean and Canadian analysis and forecasting systems and to produce reanalysis over recent periods at lower numerical cost in order to prepare global higher resolution reanalysis. After a description of this Arctic reanalysis system, we present first results on the abilities of this configuration to reproduce sea ice extent and volume interannual variability without assimilation and, secondly, the impact of assimilating sea ice data on the sea ice cover with short hindcasts experiments.

A preliminary study into climate signal emergence in the North West European Shelf Seas

J. TINKER[1], J. LOWE[1], J. HOLT[2]

[1] *Met Office Hadley Centre, United Kingdom*

[2] *National Oceanography Centre, United Kingdom*

The monitoring network of the NW European Shelf seas is designed to capture changes within the environment. It is partly designed, and partly the results of ad hoc placement for historical reasons. The optimal placement for the observations may change as the shelf seas respond to climate change.

Shelf seas, like the wider climate system, are characterised by climate variability and the climate change signal. In order for the climate change signal to be detected in the observations and lead to climate impacts, it must emerge from the climate variability, thus, depending on the magnitude in these terms for a given location, a region with a strong climate change signal may emerge later than a region with a weaker climate change signal with less climate variability.

Using an ensemble of climate projections for the North West European Shelf Sea with a pre-industrial control run to characterise the natural variability, it is possible to investigate the spatial pattern of this climate signal emergence for a number of variables. We find that the temperature signal emerges rapidly from the natural variability, with the southern North Sea being one of the last places for the signal to emerge, despite its very strong warming trend. Conversely the salinity signal is very slow to emerge from the natural variability, and often does not within duration of the projections.

This information will give an important insight into multiple regulatory policy requirements, such as those dictated by the Marine Strategy Framework Directive (MSFD) and Marine Protected Areas. Specific scientific outcomes include evidence related to the assessment of how robust statutory targets are (e.g. under MSFD) to future environmental changes and the early identification of warning signs of future changes (e.g. tipping points) with the view to inform adaptive management targets and measures, which provide valuable information directly related to aid the design of the monitoring network delivering to multiple regulatory needs.

Investigating predictability in the North West European Shelf Seas

J. TINKER[1], R. BARCIELA[1], J. KRIJNEN[1], S. DYE[2]

[1] *Met Office Hadley Centre, United Kingdom*

[2] *CEFAS, United Kingdom*

Despite the North West European Shelf Seas (NWS) economic value, ecological importance and a host of legislative drivers, there is an important gap in the timescales of available shelf seas forecasts. Operational forecast provide predictions from hours to days, while climate projections are now able to project from 50-100 years into the future, there is currently no predictive skill in the intermediate period - from seasons to decades. Such time scales are of interest to a wide range of marine users: the oil and gas industry, for planning seasonal supply and decadal infrastructure development; marine management organisations setting fisheries quotas; to the planning of marine protected areas.

The Met Office seasonal to decadal (s2d) forecasting system, GLOSEA5, is a potential basis for a seasonal to decadal forecasts for the NWS. The system has demonstrated skill at forecasting the winter NAO, and as this is an important driver of variability on the NWE shelf, it stands to reason that such skill lend predictability to the shelf environment. However, and important first step is to evaluate a regional shelf seas model response to such climate drivers.

This presentation will focus on preliminary results from the Marine Predictability project (ForeDeck) which uses a hindcast and reanalysis of the NWE shelf sea, run with the Nemo Shelf model, to investigate how atmospheric, oceanic, riverine and climate forcings are related to the response of the shelf seas. We identify which regions are controlled by which drivers, and investigate the underlying mechanisms. By finding the relationship with predictable large-scale climate drivers, we are able to estimate how much predictive skill cascades onto the shelf.

This work is of value because it will assess whether the statutory targets (under Common Fisheries Policy, Marine Strategic Framework Directive) are robust to future environmental change and inform on how adaptive these targets may need to be.

Preliminary answers to the following scientific questions will be explored here:

- What are the scales of environmental variability in the NWS and what are the main drivers?

- How much of the observed NWS variability is driven by large-scale patterns?

- What level of predictability of these key drivers is there?

If the project concludes that it is likely that the conditions of the NW European Shelf Seas are predictable on seasonal to decadal timescales, the next obvious step would be to tentative direct downscaling of some of the GLOSEA5 hindcast simulations. Assess-

ment of such runs would be vital, and would rely heavily on observations from the current monitoring system.

Paradigm change in ocean studies: multi-platform observing and forecasting integrated approach in response to science and society needs

JOAQUÍN TINTORÉ, EMMA HESLOP, BAPTISTE MOURRE, MÉLANIE JUZA, CHARLES TROUPIN, BENJAMÍN CASAS, MARC TORNER, ARÁNZAZU LANA, VICENTE FERNANDEZ, JULIEN MARMAIN, ANANDA PASCUAL, ALEJANDRO ORFILA, SIMÓN RUIZ, TEMEL OGUZ, ANA MASSANET, EVA ALOU, DIEGO ALVAREZ, ROMAIN ESCUDIER, DAVID MARCH, LLUÍS GÓMEZ-PUJOL, AMAYA ÁLVAREZ-ELLACURIA, SONIA GÓMARA, KRISTIAN SEBASTIAN, SEBASTIÁN LORA, JOAN PAU BELTRÁN, BIEL FRONTERA, CARLOS CASTILLA, PAU BALAGUER, DAVID ROQUE, IRENE LIZARÁN, TOMEU CAÑELLAS, ANGELS GARAU, ROSA RODRIGUEZ, MIQUEL GOMILA, DANIEL CONTI, ESTHER CAPO, JUAN MANUEL SAYOL, EVAN MASON, JOHN ALLEN.[1]

[1] *SOCIB and IMEDEA (CSIC-UIB)*

The last 20 years of ocean research have allowed a description of the state of the large scales ocean circulation directly related to the development of two successful international initiatives that lead to new remote and in situ observing systems; the T/P satellite altimetry missions and the Argo in situ programme. As a result, we have concentrated on establishing the ocean circulation at large scales and from this, we have tried to downscale towards regional and local scales. However, it is also well known that there is no such thing as an ocean state and that the ocean varies a wide range of spatial and temporal scales. More recently, in the last 10 years, new monitoring and modelling technologies have emerged allowing quasi real time observation and forecasting of the ocean at regional and local scales.

Theses new technologies are key components of recent observing & forecasting systems being progressively implemented in many regional seas and coastal areas of the world oceans. As a result, new capabilities to characterise the ocean state and more important, its variability at small spatial and temporal scales, exists today in many cases in quasi-real time. Examples of relevance for society can be cited, among others our capabilities to detect and understand long-term climatic changes and also our capabilities to better constrain our forecasting capabilities of the coastal ocean circulation at temporal scales from sub-seasonal to inter-annual and spatial from regional to meso and submesoscale.

The challenge for the next 10 years is the integration of theses technologies and multiplatform observing and forecasting systems to (a) monitor the variability at small scales mesoscale/weeks) in order (b) to resolve the sub-basin/seasonal and inter-annual variability and by this (c) establish the decadal variability, understand the associated biases and correct them. In other words, the new observing systems now allow a major change in our focus of ocean observation, now from small to large scales. Recent studies from SOCIB -www.socib.es- have shown the importance of this new small to large-scale multi-platform approach in ocean observation. Three examples from the integration capabilities of SOCIB facilities will be presented and discussed. First the quasi-continuous high frequency glider monitoring of the Ibiza Channel since 2011, an important biodiversity hot spot and

a ‘choke’ point in the Western Mediterranean circulation, has allowed us to reveal a high frequency variability in the North-South exchanges, with very significant changes (0.8 – 0.9 Sv) occurring over periods of days to week of the same order as the previously known seasonal cycle. HF radar data and model results have also contributed more recently to better describe and understand the variability at small scales. Second, the Alborex/Perseus project multi-platform experiment (e.g., RV catamaran, 2 gliders, 25 drifters, 3 Argo type profilers & satellite data) that focused on submesoscale processes and ecosystem response and carried out in the Alborán Sea in May 2014. Glider results showed significant chlorophyll subduction in areas adjacent to the steep density front with patterns related to vertical motion. Initial dynamical interpretations will be presented. Third and final, I will discuss the key relevance of the data centre to guarantee data interoperability, quality control, availability and distribution for this new approach to ocean observation and forecasting to be really efficient in responding to key scientific state of the art priorities, enhancing technology development and responding to society needs.

A high-resolution North Sea ocean-atmosphere climatology

B. TINZ [1], M. BERSCH[2], R. SADIKNI[2], N. SCHADE[3], D. STAMMER[2], L. GATES[1]

[1] *Deutscher Wetterdienst, Hamburg, Germany*

[2] *Centrum für Erdsystemforschung und Nachhaltigkeit, Universität Hamburg, Hamburg, Germany*

[3] *Federal Maritime and Hydrographic Agency (BSH), Hamburg, Germany*

For the evaluation and assessment of high-resolution climate model simulations, high-resolution reference data based on observations are needed. The range of available re-analyses is often limited by relatively coarse spatial resolution of the data assimilation procedures used and the data scarcity in many oceanic regions. But how accurately can these re-analyses describe the present-day climate in a specific region, especially in near-coastal regions, where observation systems are in place that allow better spatial and temporal coverage? The KLIWAS North Sea Climatology was developed as a co-operation of the German Federal Maritime and Hydrographic Agency BSH, Deutscher Wetterdienst and the Integrated Climate Data Center in order to evaluate the description of regional characteristics. In its first version it provides long-term records of monthly mean and annual mean 2-m air temperature, dew point temperature and sea level pressure data on a horizontal 1° x 1° grid from 1950-2010, as well as hydrographic data on water temperature and salinity for the German North Sea region. All atmospheric products are based on high-quality-controlled data from the Centre for Global Marine Meteorological Observations operated by Deutscher Wetterdienst.

Quality Checking of Maritime Climate Data

B. TINZ[1], R. SEDLATSCHEK[1], T. LEIDING[1], H. OTTEN-BALACCANU[1], L. GATES[1]

[1] *Deutscher Wetterdienst, Hamburg, Germany*

Deutscher Wetterdienst maintains a global operational data centre for maritime meteorological data. Real-time data are added to the system via the Global Telecommunication System and non-real time data as well as historical data from ships' logs extend the record with a view to climate studies. Given the specific demands of maritime data collected by buoys, merchant volunteer ships and other platforms, a new routine was developed for quality checking of such data. The validat quality check performs a sequence of checks using a new land-sea mask, an improved tracking of the ship's position and course as well as speed. A second level of quality control employs a re-analysis background field for climatological boundaries as well as a spatial consistency check. During each stage of the procedure a separate quality byte is assigned. After quality checking, the data is archived and used in reanalysis efforts or the production of regional or global ocean climate datasets.

Ocean data assimilation with a simple nonlinear ensemble filter

JULIAN TÖDTER[1], PAUL KIRCHGESSNER[2], LARS NERGER[2], BODO AHRENS[1]

[1] *Institute for Atmospheric and Environmental Sciences, Goethe University Frankfurt/Main, Germany*

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

Ensemble Kalman filters are appealing assimilation techniques in ocean modeling because of their applicability in high dimensions with feasible ensemble sizes. As they assume a Gaussian forecast distribution, their analyses are suboptimal in nonlinear assimilation problems. However, fully nonlinear, non-Gaussian methods such as the particle filter (PF) usually require an extremely large ensemble size in high dimensions due to weight collapse, known as the curse of dimensionality. The recently proposed nonlinear ensemble transform filter (NETF) provides a second-order exact approximation to the PF. Its generic update mechanism resembles the ensemble transform Kalman filter (ETKF), allowing an efficient and simple implementation. This work assesses the large-scale applicability of the NETF by applying it to the NEMO ocean general circulation model with a state dimension of about $3 \cdot 10^5$. The experiment employs a realistic observation scenario and a challenging filter setup. The NETF remains stable and shows a consistent behavior with a small ensemble size. Additionally, its analyses exhibit low estimation errors that at least match the ETKF's performance and indicate potential improvements, particularly concerning the ensemble distribution. These results confirm that the filter can be applied successfully to high-dimensional ocean systems, even though the algorithm is only based on the particle weights at the analysis time. Thus, it is able to overcome the curse of dimensionality, even in deterministic systems. This proves that the NETF constitutes a valuable and user-friendly method for nonlinear ocean data assimilation.

Towards the characterization and removal/mitigation of scatterometer wind sampling errors

A. TRINDADE[1], M. PORTABELLA[1], W. LIN[1], A. STOFFELEN[2], A. VERHOEF[2]

[1] *Institut de Ciències del Mar (ICM - CSIC), Barcelona, Spain*

[2] *Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands*

Surface winds derived from Earth Observation satellites are increasingly required for use in operational monitoring and forecasting of the ocean. A drawback of space-borne wind observing systems, such as scatterometers, is that they provide time and space scales unsuitable for, among others, high- resolution ocean model forcing. As such, blended ocean forcing products combining scatterometer data and numerical weather prediction (NWP) output, are being developed over the past few years [Bentamy et al., 2009]. These products, which provide global coverage at increased temporal resolution, however generally resolve spatial scales closer to NWP (200 km) rather than scatterometer (25 km) scales. More recent techniques include the use of a simplified Boussinesq-type dynamical model, which is constrained by the ECMWF pressure field on the larger scales, to spatially and temporally propagate scatterometer winds [Harutyunyan and Stoffelen, 2011]. Preliminary results on the blended wind product show that it captures shorter scales than the ECMWF wind output, although it does not yet resolve the scatterometer scales. So far, a limitation of the blended product is that only the C-band ASCAT wind data have been used in the assimilation step. With the recent availability of the Ku-band Oceansat-2 (OSCAT) and HY-2A (HSCAT) scatterometer wind data, a substantial improvement of scatterometer data coverage, and thus of the blended product quality, is expected. Thus, to achieve a high resolution mapping of the daily cycle we intend to merge wind data from several scatterometers, and by that be able to resolve spatial scales of about 25 km.

Prior to merging different scatterometer data sources, a comprehensive characterization of the scatterometer sampling errors is required. Using data from 2013, we provide an assessment of the sampling errors for the tandem scatterometer dataset composed by ASCAT-A/B, Oceansat-2 and HY-2A, which, so far offers the most complementary orbits in terms of global daily coverage. We analyse these results both globally and for different oceanic regions, namely the Mediterranean Sea and the North Atlantic Ocean, and for each satellite swath, also addressing the relative importance of temporal versus spatial sampling. Preliminary results on different strategies used to remove/mitigate these sampling errors will also be presented.

REFERENCES

Bentamy, A., Croize-Fillon, D., Queffeulou, P., Liu, C., and Roquet, H., 2009. Evaluation of high- resolution surface wind products at global and regional scales. *J. Ocea. Operational*, 2,2, 15-27.

Harutyunyan, D., and Stoffelen, A. Spatial and Temporal Propagation of Scatterometer Winds. *EU GMES MyOcean Sea Ice and Wind (SIW) TAC R&D report (EU)*, available at http://www.knmi.nl/publications, KNMI, The Netherlands, 2011.

Institut de Ciències del Mar (ICM - CSIC) Passeig Marítim de la Barceloneta, 37-49, E-08003 Barcelona.

Oceanographic data at your fingertips: the SOCIB App for smartphones

S. LORA[1], K. SEBASTIAN [1], C. TROUPIN[1], J.P. BELTRAN[1], B. FRONTERA[1], S. GÓMARA[1], J. TINTORÉ[1]

[1]*Balearic Islands Coastal Ocean Observing and Forecasting System (SOCIB), Palma de Mallorca, Spain*

The Balearic Islands Coastal Ocean Observing and Forecasting System (SOCIB), is a multi-platform Marine Research Infrastructure that generates data from nearshore to the open sea in the Western Mediterranean Sea.

In line with SOCIB principles of discoverable, freely available and standardized data, an application (App) for smartphones has been designed, with the objective of providing an easy access to all the data managed by SOCIB in real-time: underwater gliders, fixed stations, beach monitoring, Lagrangian platforms, research vessel, HF Radar and numerical model outputs (hydrodynamics and waves).

The Data Centre, responsible for the acquisition, processing and visualisation of all SOCIB data, developed a REpresentational State Transfer (REST) application programming interface (API) called "*DataDiscovery*" (`http://apps.socib.es/DataDiscovery/`). This API is made up of RESTful web services that provide information on platforms, instruments and deployments of instruments.

It also provides the data themselves. In this way, it is possible to integrate SOCIB data in third-party applications, developed either by the Data Center or externally. The existence of a single point for the data distribution not only allows for an efficient management but also makes easier the data access for external developers, who are not necessarily familiar with the concepts and tools related to oceanographic or atmospheric data.

The SOCIB App for Android or iOS use that API as a "data back-end", in such a way that it is straightforward to manage which information is shown by the application, without having to modify and upload it again. The only pieces of information that do not depend on the services are the App "Sections" and "Screens", but the content displayed in each of them is obtained through requests to the web services.

The App strives to show all the data managed by SOCIB, be they from in situ platforms or from numerical models. It is freely available for Android and iOS, following the links from the Data Centre application web page: `http://apps.socib.es/`

Balearic Islands Coastal Ocean Observing and Forecasting System (SOCIB), Palma de Mallorca. Parc Bit, Naorte, Bloc A 2nd floor 3rd door, 07121 Palma de Mallorca, Spain

Selecting effective monitoring locations: guidance from multi-decadal modelling

S.M. van Leeuwen[1], P. Tett[2], D.K. Mills[1], J. van der Molen[1]

[1] *Cefas (Centre for environment, fisheries and aquaculture science), Pakefield road, Lowestoft, NR33 0HT, UK*

[2] *SAMS (Scottish Association for Marine Science), Scottish Marine Institute, Oban, PA37 1QA, UK*

Coastal marine monitoring typically involves measurements made from a combination of fixed platforms (e.g. buoys, seabed landers), mobile platforms (survey vessels, ships of opportunity, gliders) and for some variables satellite remote sensing. The marine system is highly variable in time and space and effective monitoring programmes require observations that resolve the spatial and temporal variability. This study uses model results to designate hydrodynamic regions that allow for selection of monitoring sites that are representative of a wider region. To this end, we analysed 51-years of simulated hydro-biogeochemical output from the GETM-ERSEM-BFM model for the North Sea, focusing on the most important large-scale physical feature in shallow shelf seas: density stratification of the water column. We identified 5 different stratification regimes (permanently mixed, intermittently stratified, seasonally stratified, permanently stratified, region of fresh water influence), which on average covered 71% of the North Sea area. The regions characterised by these regimes showed some inter-annual variability in geographical coverage, but were overall remarkable stable features within the North Sea. The spatial stability of the identified regimes indicates that carefully selected monitoring locations can be used to represent a substantive area of the North Sea, allowing for high temporal resolution measurements in key parameters for marine policy. In these results, 29% of the North Sea could not be classified as one of the identified regimes due to high local inter-annual variability. Results also showed differences in biological response to the dominant physical regime, with diatom-based food webs in areas with prolonged stratification to Phaeocystis-dominated food webs in areas experiencing short-lived or no stratification, allowing for targeted monitoring of biological properties.

Non-Gaussian Data Assimilation Methods

P.J. VAN LEEUWEN[1]

[1] *DARC/Department of Meteorology/NCEO, University of Reading, United Kingdom*

Most data-assimilation problems in the geosciences are nonlinear, either via a nonlinear model or via nonlinear observation operators. While fully nonlinear data assimilation methods have been around for almost a century, they could only be applied to very low-dimensional systems, up to a state dimension of perhaps 10. Geophysical problems are of much higher dimension, so the community has relied heavily on linear and/or linearised data-assimilation methods. These methods assume that the probability densities (pdfs) involved are close to Gaussian. Popular examples are the (Ensemble) Kalman Filter and variational methods like 3- and 4DVar. This has been quite successful as evidenced by e.g. numerical weather forecasting. However, with increasing model resolution and the inclusion of more and more physical (biological etc) processes the models are becoming highly nonlinear. Also observations such as remote sensing observations can be highly nonlinearly related to model variables. The result is that the whole data-assimilation problem is shifting into the highly nonlinear non-Gaussian regime, and linearised methods fail.

With increasing computer power and rapid development of sophisticated techniques, nonlinear non-Gaussian data assimilation is becoming a reality in the geosciences. Methods like Metropolis-Hastings and Langevin are becoming more popular and used extensively on problems of intermediate size. High-dimensional systems are attacked with Gaussian mixture models and particle filters. In a Gaussian mixture model the model pdf is described by a set of Gaussians that propagate with the model equations. Gaussian mixture models are attractive as they allow for a Gaussian update on each component of the mixture, so tools developed for e.g. ensemble Kalman Filters can be used directly. An issue is, however, that the width of each of the Gaussian in the mixture is unknown, and has to be determined by trail and error.

Another method gaining popularity is the particle filter. It makes no assumption on the shape of the pdfs, so is very general, but because of that not efficient. Recently, however, particle filters have been developed that work in systems of any dimension. However, they require tuning to work well, and the tuning exercise can be very expensive in high-dimensional systems. One research direction here is to generate robust particle filters, and a few candidates have been identified but need further testing.

People are also experimenting with combinations between particle filters and Ensemble Kalman Filters. This can be done in several ways. In one class of methods the particle filter is used as much as possible, but when it becomes inefficient the method relies on the Ensemble Kalman Filter update. The transition is done in a smooth way, to keep the filter as nonlinear as possible. In the second class of methods only part of the state vector, the most nonlinear part, uses a particle filter, while the more linear parts of the state vector employ an Ensemble Kalman Filter.

In this talk I will provide an overview of these non-Gaussian data-assimilation methods, show how they are connected, and suggest future lines of research in this exciting area.

The seamod.ro operational stochastic Black Sea forecasting system

L. VANDENBULCKE [1,2], A. BARTH[1], A. CAPET[3], M. GREGOIRE[4]

[1] *AGO/GHER, Université de Liège, Belgium*

[2] *seamod.ro, Jailoo SRL, Romania*

[3] *OGS, Trieste, Italy*

[4] *Laboratory of Oceanology, Université de Liège, Belgium*

Since the end of 2011, the GHER hydrodynamic model is ran daily to provide operational weekly forecasts of the Black Sea hydrodynamics, as well as the associated uncertainty. The model has # 4km horizontal resolution, 31 vertical layers, comprises 6 rivers with climatological fluxes, and is laterally forced with NCEP GFS atmospheric fields. The deterministic model has been extensively validated in previous studies. It presents all the expected features in the Black Sea, and has also been shown to run 40 years without nudging or data assimilation while conserving total quantities and maintaining the mixed layer depth and the halocline. The model has been transformed into an operational ensemble of models, by perturbing the initial conditions with the Weakly Constrained Ensembles algorithm, by perturbing the wind (and other atmospheric forcing fields) using additive noise obtained from an EOF decomposition, and by perturbing viscosity and diffusion coefficients, and river fluxes. SST images and ARGO profiles are then assimilated daily, using the Ocean Assimilation Kit. The short-term model forecasts are validated by analyzing the Rim Current, the presence of semi-permanent eddies, SST maps, mixed layer depth maps, and cross-shelf exchanges. The a priori model error, estimated by the ensemble spread, is also shown to correspond well to the a posteriori model errors (the difference between ensemble mean and independent observations). Future scientific developments needed to improve the forecasting system include better atmospheric forcing fields from a local model, the inclusion of a biological/optical model (critical for SST, mixed-layer depth, and hence also the whole circulation), a nested model in the shelf area, a non-gaussian and non-intrusive data assimilation scheme, and the inclusion of different hydrodynamic models in the ensemble.

Assimilation of HF radar in the Ligurian Sea: Spatial and Temporal scale considerations.

L. VANDENBULCKE[1], A. BARTH[1], J.-M. BECKERS[1]

[1] *AGO/GHER, University of Liège, Belgium*

An ensemble of ROMS models with 1/60 degree resolution, covering the Ligurian Sea, and nested in the Mediterranean Forecasting System, is coupled with two WERA high-frequency radars run by the NATO Undersea Research Center (now CMRE).

The following perturbations are applied to the members of the ensemble: the wind forcing field, the open sea boundary conditions, and a supplementary term in the momentum equation. An observation operator extracts the radial currents from the model currents, and smooths them in the azimuthal direction as a function of distance to the radar.

An ensemble Kalman (EnKF) filter is then used to assimilate hourly-averaged radial currents into the model. The estimation vector contains the obtained radial currents at one or more instants. In the latter case, the filter is equivalent to the Asynchronous EnKF. The estimation vector may also contain the wind forcing; the model can then be re-run with optimal wind forcings.

The HF radar observations are spatially dense, and not uncorrelated to one another, which is approximated in our experiment by increasing the observation error variance.

When assimilating a single observation, the correction obtained shows that the forecast error covariance represents inertial oscillations, as well as other meso- or large-scale processes.

We analyze which type of errors are mostly affecting the model, and how the radial velocity observations can correct them. We also analyze the influence of the length of the assimilation window in the AenKF, as well as the influence of the temporal frequency of observations.

Processing very high resolution satellite data for coastal applications.

QUINTEN VANHELLEMONT[1], KEVIN RUDDICK[1]

[1] *Royal Belgian Institute for Natural Sciences (RBINS), Operational Directorate Natural Environment, 100 Gulledelle, 1200 Brussels, Belgium*

On high resolution satellite imagery, human activities and their impacts on suspended sediment concentrations are clearly visible. Here we discuss the atmospheric correction of these data - an essential step in using them for water quality monitoring - and the new applications that become possible. Two satellite sensors will be considered specifically, the Operational Land Imager (OLI) on Landsat-8 (launched 2013) and the high resolution imager (PHR) on the Pléiades constellation (launched 2011 and 2012). OLI is a 9-band push-broom scanner with impressive signal-to-noise ratio, 8 bands at 30 m ground resolution and 1 wide panchromatic band at 15 m ground resolution. Imagery is freely available since mid-2013, and has shown promise for coastal applications. Thanks to the set of high quality bands in the shortwave infrared (SWIR) a robust atmospheric correction is now possible, even over extremely turbid waters. A comparison is made with established ocean colour sensors, and a preliminary validation is made using in situ data. A stand-alone version of the L8/OLI processor developed at RBINS, ACOLITE (Atmospheric Correction for OLI, lite), is publicly available, and allows anyone to process and use Landsat-8 imagery distributed by USGS. ACOLITE includes a Rayleigh and aerosol correction, and outputs marine reflectances and several parameters to maps or a NetCDF file suitable for further processing. The Pléiades constellation provides an on-demand tasking of new acquisitions at a reasonable price. The PHR has 3 visible bands (blue, green, red) and 1 near infrared (NIR) band at 2.8 m resolution, resampled to 2 m, and a panchromatic band at 0.7 m resolution, resampled to 0.5 m. Imagery can be atmospherically corrected using the red-NIR band pair over turbid coastal waters, by selecting an aerosol type, and, if necessary, aerosol reflectance, from nearby clear water pixels. Fixing the aerosol parameters for is appropriate for a Pléiades image due to its small swath width (20 km). New features on 2 m imagery include ships, turbid wakes, structures, shadows, individual waves and wave glint, foam, floating objects, etc. New applications of Landsat-8 data in the southern North Sea and the Belgian Coastal zone are discussed: the monitoring of turbid wakes in offshore wind farms, detection of dumping of dredged black sediments, and small scale sediment transport in and around ports. Several Pléiades images from the port of Zeebrugge are also analyzed in terms of new features and natural spatial variability.

Impact of currents and futures altimetric missions on ocean analysis and forecasting

S. VERRIER[1,2], E. REMY[1]

[1] *Mercator Océan*

[2] *Ifremer*

Mercator Ocean, as a major operational oceanography center, must adapt its modeling and data assimilation systems regarding new measurements technologies. As satellite altimetry is one of the major observing systems to constrain ocean models, it is a main concern to assess the impact of the current and future altimeter constellation. The study is based on the OSSE/OSE's (Observing System Simulation Experiments/Observing System Experiments) methods. OSSEs are carried out with a global 1/4° modeling and data assimilation system similar to the operational one but using simulated dataset of observations (altimetry here) in order to assess their contribution and to test the sensitivity of results to different parameters (errors, observation density, type of observations). The SAR technology allows a lower measurement noise close to 1 cm and much better than the LRM's 3cm noise. It is important to assess and quantify its impact on operational systems with data assimilation. Simulated data sets are extracted from a global free 1/12° run and assimilated in the global 1/4° modeling and data assimilation system. Using the 1/12° simulation is justified by the fact that mesoscale variability is better represented than in a 1/4° one. OSEs are carried using the operational system where some observations have been retrieved. This technic allows to assess wich is the contribution of each altimeter data set in the whole prediction/analysing system. The main goal is to assess how the reduction of measurement noise (SAR/LRM) and number of satellites impact the analysis and forecast errors at global and regional (i.e. Gulf Stream, Agullas Current) scales.

Towards an ensemble prediction method for Mercator Océan forecasting system: application to a regional configuration

VASSILIOS VERVATIS[1,2], CHARLES-EMMANUEL TESTUT[1], PIERRE DE MEY[2], NADIA AYOUB[2], JEROME CHANUT[1], YANN DRILLET[1]

[1] *Mercator-Océan, Toulouse, France*

[2] *LEGOS/CNRS, Toulouse, France*

In this work conducted within MyOcean2 and MyOcean Follow-On European projects, a twin-experiment is carried out introducing elements of an EnKF, to assess and correct ocean uncertainties in a high-resolution Bay of Biscay configuration. The experimental protocol presented here serves as a guide and an intermediate step in the migration of Mercator Océan data assimilation systems towards a Local Ensemble Transform Kalman Filter (LETKF) (Hunt et al., 2007) for realistic applications in the ocean.

Initially, a long-range ensemble is performed, by applying stochastic modelling of the wind forcing. The target of this step is to simulate the envelope of possible realizations in a regional configuration and to explore the robustness of the method on building ensemble covariances. The second step includes the integration of the stochastically enriched covariances into a data assimilative system. The Mercator Océan platform is remodeled to employ ensemble-based error estimates. In the context of a twin-experiment, synthetic observations are simulated from a member of the ensemble not used in the subsequent analyses, with the help of a rank histogram. Sensitivity experiments explore the relative performance of the ensemble approach, in order to identify the pros and cons of implementing the method in future operational systems.

Overall, inspection of results indicates that the ensemble method outperforms in many cases operational methods using static covariances in the chosen experimental protocol. We evaluate the relative performance of the system among different ensemble sizes, observational networks and inexpensive time-lagged techniques, investigating the assimilation impact on short-term predictability.

REFERENCES

Hunt, B.R., Kostelich, E.J., Szunyogh, I., 2007. Efficient Data Assimilation for Spatiotemporal Chaos: A Local Ensemble Transform Kalman Filter, Phys. D, 230, 112-126.

Using EMPIRE to assess the impact of a fully non-linear data assimilation method with NEMO

SANITA VETRA-CARVALHO[1], PETER JAN VAN LEEUWEN[1], PHILIP A. BROWNE[1]

[1] *University of Reading*

The SANGOMA (Stochastic Assimilation for the Next Generation Ocean Model Applications) project is aimed at harmonizing existing stochastic data assimilation tools and make them available to ocean forecasting community and importantly at further developing state of the art data assimilation methods and related analysis tools. At University of Reading we are mainly concerned about developing and implementing new advanced data assimilation methods which are suitable to apply for high-resolution non-linear ocean models.

One such a method developed recently is the EWPF (Equivalent Weight Particle Filter), which has now been developed and implements into SANGOMA partner toolboxes, including our own recently developed EMPIRE (Employing MPI for Researching Ensembles) system. EMPIRE is easily coupled via MPI to any dynamical model allowing to use the advanced data assimilation methods it contains (for example EWPF, LETKF) with ease with small or large models.

Recently we have coupled EMPIRE with NEMO ocean model with 1/4 degree resolution. We will show results of coupled EWPF and LETKF using NEMO in EMPIRE to access the impact a fully non-linear data assimilation method has when applied to NEMO model in comparison to a standard Ensemble Kalman Filter method.

The impact of wind on optimising fairways in the Gulf of Finland

BERT VIIKMÄE[1], TARMO SOOMERE[1,2], TOMAS TORSVIK[1]

[1] *INSTITUTE OF CYBERNETICS AT TALLINN UNIVERSITY OF TECHNOLOGY, ESTONIA*

[2] *ESTONIAN ACADEMY OF SCIENCES*

We address the possibilities of detection of coherent and semi-persistent patterns in the surface layer of seas and oceans and the possibilities for their use for environmental management of potentially dangerous offshore activities. The key tools to study the presence of semi-persistent patterns are Lagrangian trajectories of persistent parcels of water or pollution, passively advected by surface currents. Statistical analysis of large pools of such trajectories is employed to calculate the spatial distributions of probabilities and time it takes for such parcels to reach the coastal area (to exert a coastal hit). The resulting distributions are subsequently used for development of various options of environmental management of ship traffic and for specification of environmentally optimised fairways. The analysis is mostly based on trajectories evaluated by the TRACMASS code from velocity fields calculated by the RCO circulation model for 1965–2004 with a horizontal resolution of 2 nautical miles.

The simulation process involves specifying a certain number of water particles, their motion paths simulated during a certain time interval. The resulting trajectories are saved for further analysis and the simulations for the same initial positions of particles are restarted from another time instant. The process is repeated over the chosen time period. Finally, the outcome of simulations is averaged over all time windows. Alltogether our simulations cover a period of 40 years, with 72 time windows for each year and more than 3000 water particles for each time window. The outcome is about 9 million single trajectories.

A method is developed for establishing the location of the equiprobability line, from where the probability of current-driven propagation of pollution to the opposite coasts is equal. Spatial distributions of probabilities and of the time it takes for a pollutant to reach the nearshore are calculated based on 20-day-long trajectories.

The main outcome of this study in addition to the optimised fairways is the quantification of wind impact, performed by analysing the seasonal variability of the optimised fairways.

Contribution of EMODnet Chemistry to the management and visualization of marine chemical data

VINCI M.[1], GIORGETTI A.[1], LIPIZER M.[1], SCHAAP D.[2], BARTH A.[3]

[1] *OGS - Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - Borgo Grotta Gigante, 42/C - 34010 Sgonico (TS) - Italy*

[2] *MARIS – Koningin Julianalaan 345 A – 2273 JJ Voorburg – The Netherlands*

[3] *Université de Liège - Department of Astrophysics, Geophysics and Oceanography - Allée du 6 Août, 17, B-4000 Liège 1 (Sart-Tilman) Belgium*

EMODnet Chemistry is a thematic component of the European Marine Observation and Data Network launched by DG MARE in 2009 to improve the availability of high quality environmental data and support the Marine Strategy Framework Directive (MSFD) requirements. The aim is twofold: the first task is to make available and reusable the big amount of fragmented and inaccessible data, hosted in the European research institutes and environmental agencies, after processing them into interoperable formats, using agreed standards and vocabularies and assessing their accuracy and precision. The second objective is to develop visualization data products useful for the tasks of the MSFD. EMODnet Chemistry involves a European network of 46 institutes from 29 coastal countries, covering most European seas. Data managed by the EMODnet Chemistry distributed infrastructure include chemical properties measured in three matrices: seawater, sediment and biota and address three descriptors of Good Environmental Status (GES) defined by the MSFD: eutrophication, contaminants in the environment and in seafood. The pillars of the project include the assembly of data and metadata according to standardized procedures, the processing into interoperable formats, the definition of common quality control procedures, the assessment of data quality and the generation of suitable data products for all European sea regions, in agreement with the requests of the MSFD. The technical set-up is based on the principle of adopting and adapting the SeaDataNet pan-European infrastructure for ocean and marine data management which is managed by NODCs and relies on a distributed network of data centres. The quality of the data has appeared as a key issue when merging heterogeneous data coming from different sources. The data validation loop includes a first set of controls done by the data collators prior to the inclusion of the data in the infrastructure, a data aggregation and data quality control, performed in a coordinated way on the five Regional Data Buffers which are related to the Baltic Sea, the North Sea, the Atlantic area (including the Atlantic coast and the Macaronesia), the Mediterranean Sea and the Black Sea respectively. Regular reports are sent to the data collators to correct errors or anomalies in the master copy of the data, available from the EMODnet infrastructure, and to guarantee the data quality upgrading. Besides this, the consortium started the collection of quality information “ex-ante”, related to the source laboratories analysis (based on ISO/IEC 17025/2005). In order to test new strategies for data storage and reanalysis and to upgrade the infrastructure performances, EMODnet Chemistry has chosen the Cloud hosting offered by Cineca (the Consortium of Italian Universities and research institutes) to host the Regional Data Buffers and facilitate the analysis and visualization services. Finally,

beside the delivery of data and products, the results of the data harvesting by this Europe wide consortium of institutes for all the European Seas provide a useful starting point for a gap analysis to gain understanding where the future monitoring efforts should be focused.

Analysis of Vertical Mixing in the Northern Baltic Sea based on 3D Modelling and Data from Shallow-Water Argo Floats

A. WESTERLUND[1], L. TUOMI[2]

[1] *Finnish Meteorological Institute, Helsinki, Finland*

Vertical mixing remains a challenge for ocean models. Several studies have shown that 3D hydrodynamic models often produce considerable errors in mixed-layer depths regardless of chosen vertical turbulence parameterisations. These errors can be especially pronounced in areas with complex hydrography such as the Baltic Sea. For example, in the Baltic Sea there are high horizontal and vertical salinity gradients. Furthermore thermocline and halocline are located at different depths. This produces stratification conditions challenging for all ocean models.

In this work vertical mixing is studied in the Baltic Sea with modelling experiments and new observational data. NEMO 3D ocean model has been set up at Finnish Meteorological Institute (FMI) for the Baltic Sea, based on the NEMO NORDIC configuration, using FMI-HIRLAM atmospheric forcing. The model has been run for a Baltic Sea - North Sea grid with 2 nautical mile resolution and 56 vertical layers.

The observational data for Baltic Sea off-shore areas is very sparse and new methods are needed to collect data for model validation and development. FMI has been testing Argo floats in the Baltic Sea since 2011 in order to increase the amount of observed vertical profiles of salinity and temperature. This is the first time Argo floats have been successfully used in the brackish, shallow waters of the Baltic Sea. This new data set is well suited for evaluating the capability of hydrodynamic models to produce the vertical structure of temperature. It provides a time series of profiles from the area of interest with good temporal resolution, showing the structure of temperature in the water column throughout the summer.

Preliminary comparisons of model results to Argo measurements have shown that the model is able to describe the basic features of the vertical structure of temperature in the Bothnian Sea, Baltic Sea. Thermocline depths are reproduced with good accuracy, although measurements show steeper gradients in temperatures than the model. The old winter water or dicothermal layer is not produced correctly. Spring warming and autumn cooling in the mixed-layer seems to be slightly delayed in the model. Tuning of vertical mixing parameterisations available in the model is discussed in the light of the results.

The Met Office's new analysis system for diurnal SST

J. WHILE[1], C. MAO[1], M. MARTIN[1], J. ROBERTS-JONES[1], A. MCLAREN[1], P. SYKES[1]

[1] *Met Office*

Diurnal variations in skin Sea Surface Temperature (skin SST), which can be as large as several degrees, play an important role in determining the heat flux between the ocean and atmosphere. As such the Met Office has recently begun producing an analysis product of the diurnal cycle of SST (available through the MyOcean project). This product consists of three components: an underlying 'foundation' SST (based on the OSTIA analysis), a warm layer where solar heating is important, and a cool skin where cooling due to long wave radiation dominates.

A major development in the system is the use of a 4DVar data assimilation technique with multiple outer-loops to improve estimates of the warm layer. Observations assimilated come from the SEVIRI, GOES-W, MTSAT2, and NOAA-AVHRR infra-red satellite instruments. Through their assimilation, the observations act to update the applied heat and wind flux such that the diurnal cycle in the warm layer is improved.

In this talk we describe the diurnal analysis system and how it produces a skin SST product. Particular attention is paid to the data assimilation aspects and on the observation processing. The talk will conclude with a presentation of the results obtained from a preliminary validation of the skin SST produced.

Data Assimilative Modeling of the U.S. Mid-Atlantic Bight Shelf

JOHN WILKIN[1], JULIA LEVIN[1], JAVIER ZAVALA-GARAY[1]

[1] *Rutgers University*

Coastal ocean models are widely used to simulate the circulation of limited-area domains for studies of regional ocean dynamics, biogeochemistry, geomorphology and ecosystem processes. When operated as real-time now-cast or forecast systems, these models offer predictions that assist decision-making related to a range of maritime applications. Here we describe the configuration and operation of such a modeling system for the shelf waters of the Mid-Atlantic Bight (MAB). The MAB is relatively densely observed by the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS), which operates a CODAR radar network and deploys autonomous underwater glider vehicles (AUGV) to acquire subsurface CTD data.

We describe a real-time forecasting system using the ROMS model with 4D-Var data assimilation to adjust initial conditions, boundary conditions, and surface forcing in each analysis cycle. The data assimilated include CODAR velocities, satellite sea surface height (with coastal corrections), satellite temperature, in situ temperature and salinity from AUGV and National Marine Fisheries Ecosystem Monitoring voyages, and all in situ data reported via the WMO GTS network. Assimilation of hydrographic climatology and long-term mean velocity observations is also used to compute the Mean Dynamic Topography that augments altimeter sea level anomaly data in the forecast system.

Using withheld observations, we examine system performance in terms of the relative impact of satellite, CODAR and in situ observations on analysis skill, and in comparison to other MAB real-time systems.

Wave energies and wave-induced longshore currents in an unstructured-grid model – circulation in front of barrier islands

JÖRG-OLAF WOLFF[1], SEBASTIAN GRASHORN[2], KARSTEN A. LETTMANN[1], THOMAS H. BADEWIEN[1], EMIL STANEV[2]

[1] *Institute for Chemistry and Biology of the Marine Environment (ICBM), Carl von Ossietzky Universität Oldenburg, Germany*

[2] *Institute of Coastal Research, Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG), Geesthacht, Germany*

An unstructured-grid model coupled to a wave model (FVCOM - SWAVE) is used to investigate the hydrodynamic and wave energy conditions during a moderate and a storm situation in the southern North Sea. Two different setups are presented. One setup covers the whole North Sea with moderately increased grid resolution at the coast, whereas the other comprises a very high resolution East Frisian Wadden Sea setup, one-way coupled to the coarser North Sea model.

The results of both model setups are validated, compared to each other and analysed with a focus on longshore currents and wave energy. The results show that during storm conditions strong wave-induced longshore currents occur in front of the barrier islands of the East Frisian Wadden Sea, resulting in total current speeds up to 2 m/s. This effect is especially pronounced in the high-resolution setup.

The wave-current interaction also influences the sea surface elevation by raising the water level in the tidal basins. Calculated wave energies show large differences between moderate wind and storm conditions with time-averaged values up to 200 kW/m.

The numerical results indicate that wave-current coupling, albeit numerically expensive, cannot be ignored because it plays an important role in almost all near coastal transport phenomena (sediments, contaminants, bacteria, etc.).

Climate change and pelagic resources in south-central Chile: Landings forecast for the A2 scenario

E. YÁÑEZ[1], F. PLAZA[2], C. SILVA[1], F. SÁNCHEZ[1], M.A. BARBIERI[2], A.ARANIS[2]

[1] *Pontificia Universidad Católica de Valparaíso*

[2] *Instituto de Fomento Pesquero*

Abstract. Artificial neural networks are adjusted to predict landings of anchovy (Engraulis ringens), sardine (Strangomera bentincki) and jack mackerel (Trachurus murphy) in south-central Chile (32ºS-42ºS). Fishing effort (fe), landings and twelve environmental variables are considered from 1973 to 2012. The external validation for the best models with all variables shown in an R2 of 90% for anchovy, sardine for 96% and 88% for mackerel, with an efficiency of 0.89%, 0.96% and 0.88% respectively. To simplify the models, only fe and sea surface temperature of NOAA satellites (SST-NOAA) were considered, with the following lags for anchovy: fe(t-0), SST-NOAA(t-14), SST-NOAA(t-7) and SST-NOAA(t-2); sardine: fe(t-0), SST-NOAA(t-13), SST-NO0AA(t-1), SST-NOAA(t-18) and SST-NOAA(t-6); and mackerel: fe(t-0), SST-NOAA(t-50), SST-NOAA(t-14), SST-NOAA(t-38), fe(t-12) and fe(t-36). When comparing both all and reduced variables models, fitness and predictive capacity is maintained. With these simplified models and local SST projection for the A2 IPCC scenario, which implies an approximate 2°C increase in local SST, the estimated anchovy and sardine landings decrease 1% and 4% respectively, while jack mackerel landings increase 12%, due to climate change Nearby involve increased SST of about 2 ° C.
Keywords: forecast, landings, pelagic, south-central Chile, climate change.

Improving Global Observations for Climate Change Monitoring using Global Surface Temperature

HUAI-MIN ZHANG[1], BOYIN HUANG[1], JAY LAWRIMORE[1]

[1] *NOAA National Center for Environmental Information, Asheville, NC, USA*

Global surface temperature is one of the most widely used indicators for monitoring and assessing climate variability and change, due to the long history of in situ measurements (from ships, buoys and weather stations) and its influence on other aspects of the Earth's climate. For this reason the US National Oceanographic and Atmospheric Administration (NOAA) produces and releases climate reports using surface temperature. However, in-situ temperature measurement over the Earth's surface remains incomplete in some areas of the world, particularly in high latitude regions and developing countries. These observational data gaps have been partially attributed as a potential cause of the recent "Warming Hiatus" since 1997. In this presentation, we examine the data gaps' impact on the estimations of global temperature trends in the available major international global datasets, as an indication on how to optimize observational coverage in the future.

In addition to the long term historical in-situ observations from ships and buoys, remotely sensed satellite data have become available over the last three decades. It has become a research topic on how to effectively combine in-situ and satellite observations to maximize benefits while minimizing costs. Such an integrated system for global sea surface temperature (SST) has been designed, implemented and maintained by NOAA, but there are areas for improvement by collaboration with international partners. In this presentation, we will review the status of this integrated system and areas for improvement, and seek advanced ideas from the scientific community.