OceanPredict '19
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Theme 5: Ocean Prediction Systems and Services

Session 2: Biogeochemical, waves and storm surge

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SalishSeaCast: Coupled bio-chem-physical Ocean Model with downstream Waves, Near-shore Circulation and Oil Spill Model

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SalishSeaCast is an integrated coastal forecasting system for the Salish Sea on the West Coast of Canada. Examples of forecast and nowcast products available or under development include storm surge and wave height, near-surface extreme currents, aragonite saturation state, and oil spill tracking. The ocean physics model is a NEMO regional configuration with a coupled lower trophic level biological model (SMELT) and a coupled carbon cycle model (SKOG). The model is run daily in real-time. It is forced with real-time Environment Canada HRDPS winds, Fraser River flow and turbidity measurements, boundary conditions from a larger configuation model and sea surface height from a storm surge forecast model. After completion of the NEMO run, its current fields are used for a WAVEWATCH III (r) model and to construct boundary conditions for an FVCOM model. The FVCOM model resolves near-shore areas including the lower Fraser River and Vancouver Harbour. We are now adding an oil spill model (MOHID). In this talk we will briefly introduce the configuration of each component and focus on the methods of coupling and automation. We will discuss methods of distribution of results to different types of stakeholders. We will highlight the benefits and future benefits of this coastal forecasting system including storm surge forecasting for ports, near-surface extreme currents for pilots, aragonite saturation horizon depth for shellfish farmers and oil spill risk for community planners.

Keywords: Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Applications - Ocean products for scientific, economic and societal use, Models - Ecosystem/BGC modelling, Models - Wave and tide modelling, Applications - Disaster & risk management

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The MULTI OBSERVATION Thematic Assembly Centre of the Copernicus Marine Environment Monitoring Service

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Complementary to ocean state estimate provided by modelling/assimilation systems, a multi observation-based approach is available through the MULTI OSERVATION (MULTIOBS) Thematic Assembly Center (TAC) of the Copernicus Marine Environment Monitoring Service (CMEMS).

CMEMS MULTIOBS TAC proposes products based on satellite in situ observations and state-of-the-art data fusion techniques. These products are fully qualified and documented and, are distribution through the CMEMS catalogue (http://marine.copernicus.eu/services-portfolio). They cover the global ocean and, physical and biogeochemical (BGC) variables. They are available in Near-Real-Time (NRT) or as Multi-Year Products (MYP) for the past 10 to 25 years.

Satellite input observations include primarily altimetry but also sea surface temperature, sea surface salinity as well as ocean color. In situ observations of physical and BGC variables are from autonomous platform such as Argo, moorings and ship-based measurements. Data fusion techniques are based on multiple linear regression method, multidimensional optimal interpolation method or neural network.

MULTIOBS TAC provide the following products at global scale:

- 3D temperature, salinity, geopotential height and geostrophic current fields, both in NRT and as MYP (Guinehut et al., 2012; Mulet et al., 2012);
- 2D sea surface salinity and sea surface density fields, both in NRT and as MYP (Buongiorno Nardelli; 2012; Droghei et al., 2016);
- 2D total surface and near-surface currents, both in NRT and as MYP (Rio et al., 2014; Rio et al., 2016);
- 3D Vertical velocity fields as MYP (Buongiorno Nardelli et al., 2018);
- 2D surface carbon fields of FCO2, pCO2 and pH as MYP (Sommer et al., 2017);
- Nutrient vertical distribution (including Nitrates, Phosphates and Silicates) profiles as MYP (Sauzde et al., 2017);
- 3D Particulate Organic Carbon (POC) and Chlorophyll a (Chl-a) fields as MYP (Sauzde et al., 2016).

Furthermore, MULTIOBS TAC provides specific Ocean Monitoring Indicators (OMIs), based on the above products, to monitor the global ocean 3D hydrographic variability patterns (water masses and currents) and the global ocean carbon sink.
MULTIOBS system, products and performances are described through various applications: system intercomparison, ocean state estimate, mesoscale eddies studies, water mass formation.

Keywords: Systems - General ocean monitoring (including those based on ocean DA and prediction systems), Observations - In-situ ocean observing systems, Observations - Satellite ocean observing systems, Observations - Ocean monitoring based on observing systems,

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Operational biogeochemical modelling at the UK Met Office: developments and challenges

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The UK Met Office creates biogeochemical analysis and forecast products for the North West European Shelf, publicly available through the Copernicus Marine Environment Monitoring Service, as well as long-term reanalysis. The products are created using the European Regional Seas Ecosystem Model (ERSEM , developed and maintained at Plymouth Marine Laboratory) coupled to the Met Offices FOAM forecasting system. The system is currently being updated to the most recent version of ERSEM and FOAM, enabling the introduction of a number of new features:
provision of pH and pCO2 by the inclusion of the carbonate system;
an IOP-based model of light attenuation by phytoplankton, water and coloured detrital matter;
assimilation of chlorophyll estimates from ocean colour satellites using the 3D-Var NEMOVAR scheme; future work will extend this is to assimilation of chlorophyll split by plankton functional type.

Results from all these developments will be presented, using data from the reanalysis published in autumn 2018 and the operational system due to go live in 2019.
Current challenges for improving the system will also be discussed. The FOAM system now includes assimilation of sea surface temperature, temperature and salinity profiles and sea surface anomaly data from altimetry, and this assimilation degrades the biogeochemical products in the off-shelf area. Analysis and forecast of the physical system is moving from 7 km resolution to 1.5 km, and at this resolution it is not practicable to run the biogeochemical model. What is the best way to manage the trade-offs between improved skill and resolution in the physical product and developing the skill of biogeochemical forecasts? In addition, the shortage of data to perform validation of biogeochemical products remains a chronic problem.

Keywords: Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Systems - Ocean reanalysis, Models - Ecosystem/BGC modelling, Models - Model grid structure and resolution,

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Toward the assimilation of biogeochemical data in the CMEMS BIOMER coupled physical-biogeochemical operational system

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The operational production of data-assimilated biogeochemical state of the ocean is one of the challenging core projects of the Copernicus Marine Environment Monitoring Service (hereafter CMEMS). In that framework, Mercator Ocean International is in charge of improving the realism of its global coupled physical-biogeochemical simulations, analyses and re-analyses, and to develop an effective capacity to routinely estimate the biogeochemical state of the ocean, including, amongst others, the implementation of biogeochemical data assimilation. Primary objectives are to enhance the time representation of the seasonal cycle in the real time and reanalysis systems, and to provide a better control of the production in the equatorial regions. In that framework, Mercator Ocean International has successfully updated its global biogeochemical analysis and forecasting system with an Ocean Color data assimilation capability. In this system, the biogeochemical model (NEMO/PISCES) is offline coupled with the dynamical ocean (1/12 coarsened to 1/4 resolution) at a daily frequency, and benefits from the assimilation of satellite (SSH-SST-SIC) and in situ physical data. The dedicated assimilation of biogeochemical data relies on a simplified version of the SEEK filter, where the forecast error covariances are built from a fixed-basis - but seasonally variable - ensemble of anomalies computed from a multi-year numerical experiment (without biogeochemical data assimilation) with respect to a running mean. Regarding Ocean Colour observations, the system relies, as a first step, on the CMEMS Global Ocean surface chlorophyll concentration products, delivered in NRT. This system shall be commissioned in 2019. The objective of this presentation is thus to provide (1) a detailed overview of the implementation of the aforementioned data assimilation methodology in the forecasting system - e.g. log-transformation of the analysis state, multivariate Chlorophyll-Nutrient control vector, surface analysis and projection on the vertical etc.; (2) a synthesis of the performance assessment of this future analysis and forecasting biogeochemical operational system, by cross-comparing the free (i.e. not assimilated) and assimilated simulations with various datasets, both spatial and in situ (e.g. BGCArgo); and (3) a focus on how the data assimilation process in the dynamical forcing can impact the biogeochemical processes, and some scenarios under investigation to handle these issues.

Keywords: DA - Biogeochemical data assimilation, Systems - Prediction system performance & evaluation, DA - Performance and cost of data assimilation, Systems - Implementation of Ocean Prediction Systems, Systems - General ocean monitoring (including those based on ocean DA and prediction systems)

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The CMEMS Mediterranean biogeochemical operational system: new features and uncertainty of model results

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The Copernicus Marine Environment Monitoring Service (CMEMS) Mediterranean biogeochemical operational system (MedBFM) features the coupled physical-biogeochemical OGSTM-BFM model and the 3DVarBio variational assimilation scheme for satellite chlorophyll. The system has been recently upgraded in several components. A new coastal data assimilation framework allows to improve chlorophyll estimates in shelf seas, specifically in the representation of the spatial and temporal variability. A carbonate system has been included in BFM to simulate air-sea CO2 exchanges and pH evolution. The OGSTM transport model includes now a free surface dynamics formulation and open boundary conditions at the Dardanelles Strait.

The quality of the upgraded version of the MedBFM is here assessed following a mixed validation protocol that exploits different reference data from satellite, historical datasets, literature and biogeochemical Argo floats. The validation protocol is based on two complementary phases: 1) the pre-operational qualification run (short period reanalysis covering the last recent years), and 2) the operational skill performance workflow (started in April 2018). Such protocol shows that different products can be validated at a different level of accuracy depending on the availability of data. The accuracy of CMEMS products can be achieved from basin-wide and seasonal scale to mesoscale and weekly scale.
New metrics specifically designed to exploit the richness of the BGC-Argo floats data and to evaluate the model capability to reproduce the key elements of the vertical profiles of chlorophyll and nitrate (i.e., deep chlorophyll maximum, nitracline, integrated vertical values) are also proposed allowing for a relevant enhancement of the validation framework of operational biogeochemical products.

Keywords: Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Systems - Prediction system performance & evaluation, Models - Ecosystem/BGC modelling, Models - Model assessments and verification, DA - Biogeochemical data assimilation

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Validation of the NCEP WAVEWATCH III® Global Wave Model

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The National Center of Environmental Prediction, part of the National Weather Service, is an operational center mandated to produce ocean wave forecasts on a daily basis. To this end, the WAVEWATCH III(r) model is run side-by-side with the GFS model 4 times per day producing forecasts extending to 180 hours. Driven by the NCEP ice analysis and the GFS winds, the wave model uses nine two-way nested grids that vary in resolution from a degree global grid to 1/12th of a degree in coastal US waters, and includes a North Polar stereographic grid with 18 km resolution.

Recent directives towards a unified verification system that can be applied equally to the results of all the wave models run at NCEP, have driven the development of a series of simple comparative metrics between model results and in-situ buoy and along-track satellite data. This validation suite is run for the 0 hour forecast (nowcast) and for each 24 hour increment up through 168 hours. This same suite can be applied to either a single model, or to comparisons between several models. The procedure is set up such that it can be run automatically on a cron or at-will, and the graphics produced are uploaded and displayed on a website. Here we will focus only on the daily validation of the operational global wave model versus buoy and satellite data.

Keywords: Systems - Prediction system validation/ intercomparisons, Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Models - Wave and tide modelling, Models - Model assessments and verification, Systems - Visualisation

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The operational model system of the BSH for German coastal waters – status, products and outlook

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The Federal Maritime and Hydrographic Agency (BSH) has been operating an operational model system for German coastal waters for more than 30 years. The main applications have always been the support of BSHs water level prediction service, the support of search and rescue applications, as well as the prediction of oil drift paths and pollutant distributions.
In recent years, however, the need for information on the current state of coastal waters in Germany has increased considerably. The offshore industry (especially wind farms) and also various authorities in connection with water quality or directives like the Marine Strategy Framework Directive require a wide range of different, additional up-to-date data and forecast products.

In order to provide qualified information on all these different topics, the model system of the BSH has been continuously expanded and currently consists of the components circulation model, surge model, Lagrangian dispersion model, Eulerian dispersion model and an ecosystem model. In addition, within the Copernicus program BSH is collecting various model results from other European partner institutes and presents them in a multi-model ensemble together with observational data in order to estimate the uncertainties of each model involved.

This presentation describes the current state of the operational model and validation system from forcing data to final products, shows the interfaces between the individual model components and gives an outlook on the potential for further improvement of existing model components and on the development of new model components.

Keywords: Systems - Ocean product and data formats, Models - Model assessments and verification, Systems - Multi-model ensemble systems, Models - Ocean model configurations, Models - Downscaling

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