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Theme 5: Ocean Prediction Systems and Services

Session 5: Global and Regional Prediction Systems III

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The Copernicus Marine Service ocean forecasting system for the Mediterranenean Sea

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The Mediterranean Monitoring and Forecasting Center (MED-MFC) is part of the Copernicus Marine Environment and Monitoring Service (CMEMS) and provides regular and systematic information on the time-evolving Mediterranean Sea physical (including waves) and biogeochemical state. The systems consist of 3 components: 1) Med-Physics, a numerical ocean prediction systems, based on NEMO model, that operationally produces analyses, reanalysis and short term forecasts of the main physical parameters; 2) Med-Biogeochemistry, a biogeochemical analysis, reanalysis and forecasting system based on the Biogeochemical Flux Model (BFM) which provides information on chlorophyll, phosphate, nitrate, primary productivity, oxygen, phytoplankton biomass, pH and pCO2; 3) Med-Waves based on WAM model and providing analysis, forecast and reanalysis products for waves. The systems have been recently upgraded at a resolution of 1/24 degree in the horizontal and 141 vertical levels.

The Med-Physics analysis and forecasting system is composed by the hydrodynamic model NEMO 2-way coupled with the third-generation wave model WaveWatchIII and forced by ECMWF atmospheric fields. The model solutions are corrected by the 3DVAR data assimilation system (3D variational scheme adapted to the oceanic assimilation problem) with a daily assimilation cycle of sea level anomaly and vertical profiles of temperature and salinity. The model has a non-linear explicit free surface and it is forced by surface pressure, interactive heat, momentum and water fluxes at the air-sea interface.

The biogeochemical analysis and forecasts are produced by means of the MedBFM v2.1 modeling system (i.e. the physical-biogeochemical OGSTM-BFM model coupled with the 3DVARBIO assimilation scheme) forced by the outputs of the Med-Physics product. Seven days of analysis/hindcast and ten days of forecast are bi-weekly produced on Wednesday and on Saturday, with the assimilation of surface chlorophyll concentration from satellite observations. In-situ data are mainly used to estimate model uncertainty at different spatial scales.

The Med-Waves modelling system is based on the WAM Cycle 4.5.4 wave model code. It consists of a wave model grid covering the Mediterranean Sea at a 1/24 horizontal resolution, nested to a North Atlantic grid at a 1/6 resolution. The system is forced by ECMWF winds at 1/8. Refraction due to surface currents is accounted by the system which assimilates altimeter along-track significant wave height observations. On a daily basis, it provides 1-day analysis and 5-day forecast hourly wave parameters.Currently, wave buoy observations of significant wave height and mean wave period along with satellite observations are used to calibrate and validate the Med-waves modelling system.

Keywords: Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Systems - Implementation of Ocean Prediction Systems, Systems - Prediction system performance & evaluation, Systems - Service providers, Systems - General ocean monitoring (including those based on ocean DA and prediction systems)

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The impact of a new high-resolution ocean model on the Met Office North-West European Shelf forecasting system

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The Met Office ha recently developed a new high-resolution, 1.5 km, operational forecasting system for the North-West European Shelf seas which is the replacement of the existing 7 km model.

The performances of the new system, assessed in pre-operational trial experiments against observations and the low resolution system. The model shows an improvement over the 7km forecasting system, in resolving fine-scale structures and variability. Validation at the basin scale and using daily means penalises the high resolution system and does not respect the superior performance of the high resolution system. The 1.5km improvements are evident from the validation against high-resolution observations, available in some selected area of the model basin.

The 1.5 km resolution is therefore an improvement in the capability to provide short term forecast in this area, with a better representation of dynamical features such as internal tides, frontal jets and mesoscale eddies that can vary in size from only a few kilometres in shelf-seas to tens of kilometres.

Keywords: Systems - Prediction system validation/ intercomparisons, Systems - Prediction system performance & evaluation, Systems - Implementation of Ocean Prediction Systems, ,

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Data Assimilation Systems for Operational Ocean Forecasting at NCEP

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The NOAAs NWS mission is to provide the best possible numerical guidance to a variety of customers including emergency managers, forecasters and the aviation community. The Next Generation Global Prediction System (NGGPS) at NWS/NCEP is aimed at building a state-of-the-art operational modeling system in a unified coupled system framework encompassing atmosphere, ocean, sea-ice, aerosols, land and waves, including those that target hurricanes.

Present version of the global Real-Time Ocean Forecasting System (RTOFS) at NCEP generates 8 days of ocean forecasts including sea-ice using the 1/12th degree HYbrid Coordinate Ocean Model (HYCOM) with restarts from US Naval Oceanographic Office (NAVOCEANO). A major development is in progress to build a variational ocean data assimilation system (through NCODA --Navy Coupled Ocean Data Assimilation) using observational data received at NCEP, which will provide the initial analysis fields for these ocean forecasts with a vision to put this system into operations.

Ocean observations from various sources (SST from satellites and in situ sources; SSH from altimeters; temperature and salinity profiles from Argo, XBT, gliders, drifters, moorings, and animal borne sensors; sea-ice concentration, thickness, and temperature from satellites) are collected and served via NCEP data-tanks to all its operational models. Tools have been developed to reformat ocean data from NCEP data-tanks to enable ingest into NCODA. NCODA has an advanced Quality Control (QC)/ Quality Analysis (QA) module which works in conjunction with its 3D variational (VAR) assimilation algorithm. At present, a complete data cycling system is being built to test the DA algorithm. Methods for incorporation of increments were examined and parameters were tuned to improve the assimilation of the data. The results of the QA/QC and the coupled assimilation with sea-ice will be presented and discussed. In addition, metrics to evaluate the model results will be presented.
Under a separate effort, a community-based unified data assimilation system is being developed at the JCSDA through the JEDI (Joint Effort for Data assimilation Integration) framework which also includes support for ocean data assimilation (SOCA Sea-ice Ocean Coupled Assimilation) needs at NCEP. The eventual transition to operations to a unified DA system based on JEDI for real-time ocean analysis will also allow for development of a coupled ocean-atmosphere-sea ice data assimilation system in the future. This unified DA system will be capable of providing initial conditions for all coupled modeling systems targeted for transition to operations at NCEP. Some salient features of this proposed unified DA system, which enable quick R2O, including preliminary results will also be discussed.

Keywords: DA - Data assimilation applications, DA - Variational data assimilation, DA - Model and observation systematic errors, Observations - Observation impacts, Observations - Observing system assessments and design

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New Zealand ocean forecast system - present and future

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New Zealands maritime domain is one of the largest on the planet, with an exclusive economic zone of approximately 4,300,000 km2 about 15 times its land area. The seafood sector alone brings $4.18B to NZ annually. Offshore oil and gas exploration provides about 30% of the countrys consumption, from 21 petroleum licenses in the Taranaki basin. Moreover, tourism is a growing industry accounting for about 5.9% of the GDP and often related to the countrys coastal landscapes. Therefore, having a reliable ocean forecast system is of critical importance to the countrys economy and to the safety and resilience of the community and environment. This includes the capability to model and forecast ocean processes at a range of spatial and temporal scales. To accomplish this, a sophisticated system including different ocean models and data dissemination platforms has been developed. The system is designed for rapid deployment of high-resolution model domains, kept up to date with state-of-the-art techniques, and portability between different platforms. At present, this system is mainly based on downscaling of global models (except for ocean waves) and a series of local nested model grids. A mix of Regional Ocean Modeling System (ROMS) and Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM) domains is used to evaluate and predict ocean circulation and state properties, while WAVEWATCH III (WW3) and Simulating Waves Nearshore (SWAN) are used for simulating surface gravity waves down to harbour scales. A micro-service architecture based on docker and controlled by a built-for-purpose distributed workflow scheduler ensures a stable, highly-available system. New developments underway include the use of un-structured model grids, 4DVar data assimilation of global and local observations on a national scale, waves-circulation coupling, and the use of cloud-based computational resources. Focusing mainly on the ocean circulation modelling, a general description of the system and capabilities at Metocean are presented together with ongoing developments and future plans.

Keywords: Systems - Implementation of Ocean Prediction Systems, Systems - Integration of coastal systems in large-scale systems, Models - Model assessments and verification, Systems - Ocean reanalysis, Models - Ocean model configurations

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The Arctic Monitoring and Forecasting Center from Copernicus Services

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The Copernicus Arctic Marine Forecasting Center (ARC MFC) provides 10-days forecasts of the ocean currents, sea ice, marine biogeochemistry and waves on a daily basis and a 26 years reanalysis of the Arctic Ocean, updated every year. The ARC MFC is powered by the TOPAZ configuration of the HYCOM model, coupled to the sea ice model CICE, the ecosystem model ECOSMO, and assimilating the following data with the Ensemble Kalman Filter: along-track sea level anomalies, sea surface temperatures, sea ice concentrations, sea ice drift, sea ice thickness and in situ temperature and salinity profiles. Waves are forecasted using an Arctic configuration of the WAM model. We review the present skills of the system and its ongoing developments: assimilation of ice thickness, increased horizontal and vertical resolution and the production of ocean climate indicators such as water transports in the Nordic Seas.

Keywords: Applications - Ocean products for scientific, economic and societal use, DA - Ensemble data assimilation, Evolution - GODAE and GOV legacy: overview of achievements, Observations - Observation impacts, Systems - Prediction system validation/ intercomparisons

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Evaluation and application of KIOST regional ocean prediction system in the Northwest Pacific

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KIOST (Korea Institute of Ocean Science and Technology) has been operating a regional ocean prediction system entitled as Ocean Predictability Experiment for Marine environment (OPEM). The OPEM is producing the analysis applying the ocean data assimilation and 10-days prediction from every Wednesday since March 1st 2017.

The OPEM has been developed based on the GFDL Modular Ocean Model (MOM) Version 5 and has the horizontal resolution of 1/24 degrees both in latitude and longitude, and has 51 vertical z-star levels. The data assimilation system applied in the OPEM is based on the DASK (Data Assimilation System of KIOST) applying the Ensemble Optimal Interpolation (EnOI) method.

In this paper, the performance of the OPEM has been evaluated by comparing with the HYCOM. Spatial and vertical distributions for temperature and salinity, volume transport and eddy kinetic energy (EKE) have been compared in the domain of the OPEM.

Both results of OPEM and HYCOM well reproduces the main characteristics of the circulation in the Northwest Pacific such as the western boundary current. The HYCOM generally shows the negative temperature bias whereas the OPEM has a positive bias. On the one hand, the OPEM underestimates the Sea Surface Salinity (SSS) while the HYCOM mostly overestimates the SSS. Even though both systems show the large RMSEs of temperature and salinity in the Kuroshio extension region where there is a large ocean variability, the RMSs in the OPEM are less in the open ocean than those in the HYCOM.

The volume transports through the Korea Strait, Tsugaru Strait and Soya Strait, where are main inlet and outlet of the East/Japan Sea, have been well reproduced by the OPEM rather than the HYCOM even though the difference between them is not great. Also, the surface mean EKE of both systems show similar horizontal distribution close to the observation from the AVISO. But, the HYCOM overestimates the EKE than those of the OPEM and observation.

The performance of the OPEM is comparable with that of the HYCOM even though it is various in time and space. Despite of its surface bias, the OPEM have been used to reveal the ocean phenomena in the Northwest Pacific. Case studies by using the OPEM will be introduced in this study. The ocean analysis and prediction results of the OPEM have been also provided to the allowed users (domestic agencies and companies) once a week by FTP service.

Keywords: Applications - Ocean products for scientific, economic and societal use, DA - Data assimilation applications, Systems - Prediction system performance & evaluation, ,

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