OceanPredict '19

GODAE OceanView Symposium | 6-10 May 2019 Halifax, Canada

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POSTER ABSTRACTS

Theme 5:
Ocean Prediction Systems and Services

P57 - **Abstract ID: 3550119**

Development of a new operational ocean system for monitoring and forecasting coastal and open ocean states around Japan

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A new operational system for the Japan Meteorological Agency to monitor and forecast coastal and open ocean states around Japan is developed at the Meteorological Research Institute. This new system called MOVE/MRI.COM-JPN consists of a high-resolution forecast model and an analysis model for data assimilation. The forecast model has horizontal resolution of about 2 km in the seas around Japan. The explicit tidal forcing and depression/suction by sea level pressure are incorporated into the forecast model to represent realistic sea level variations. The analysis model uses a 4-dimensional variational scheme for the North Pacific Ocean model with horizontal resolution of about 10 km. The assimilated observations are in-situ temperature and salinity profiles, satellite-based sea surface temperature (SST) and along-track sea surface height anomaly derived from satellite altimeters. Initialization for the forecast model is conducted by incremental analysis updates (IAU) scheme. Temperature and salinity increments for the forecast model are calculated against the results of the analysis model. Temporal and spatial filters are applied for the forecast model when calculating the increments not to weaken the high temporal-spatial variations in the forecast model.

We conducted an analysis experiment (JPN-IAU) from 2008 to 2017 by using MOVE/MRI.COM-JPN system. Compared with satellite-based SST and in-situ observations, SST biases in JPN-IAU is small around not only open ocean but also coastal areas. Sea level variations without tidal and sea level pressure effects in JPN-IAU are compared with observation at the tide-gauge stations. Capture ratio and correlation for sea level variations between JPN-IAU and observation are mostly about 70 to 80 % and over 0.8, respectively. Especially, sea level variations influenced by the Kuroshio path are largely improved compared with a free-run simulation. Kuroshio large meander (KLM) occurred in 2017 autumn is represented well in MOVE/MRI.COM-JPN system. Although development of KLM in 2017 is highly depended on the initial conditions, forecast experiments can represent transition process of KLM due to baroclinic instability and have about one-month lead time. In addition, MOVE/MRI.COM-JPN system has a potential to forecast warm Kuroshio-water intrusions at the coasts south of Japan within a month which are smaller spatial and shorter temporal scales than meso-scale Kuroshio variability. Assimilation of sea ice concentration applied by using nudging scheme succeed to reproduce fine-scale distribution of sea ice concentration in the Okhotsk Sea.
Keywords: Systems - Integration of coastal systems in large-scale systems, Systems - Prediction system performance & evaluation, Models - Downscaling, DA - Shelf-seas and coastal data assimilation, Applications - Ocean products for scientific, economic and societal use

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P58 - **Abstract ID: 3550808**

Operational ocean data assimilation/prediction system for the western North Pacific at JMA

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Office of Marine Prediction (OMP) at Japan Meteorological Agency (JMA) has been routinely operating an ocean data assimilation and prediction system for the western North Pacific (MOVE/MRI.COM-WNP*) since March 2008. This system aims to represent ocean characteristics such as the movement of the Kuroshio/Oyashio current and meso-scale eddies. The MOVE/MRI.COM-WNP consists of an ocean general circulation model (MRI.COM) and an objective analysis scheme (MOVE). MRI.COM of this system is a free-surface, depth-coordinate ocean-ice model that solves primitive equations using Boussinesq and hydrostatic approximation. The model resolution is horizontally 0.1 within 15N-50N, 117E-160E, vertically 54 layers from surface to 6300 m (27 layers for upper 600 m). MOVE system uses 3D-VAR scheme with vertical coupled Temperature-Salinity (T-S) EOF modal decomposition with area partition. Incremental Analysis Updates (IAU) technique is used to correct the model fields toward the analysis result. The near-real time observational data such as satellite sea level anomalies, in-situ temperature and salinity profiles, and analyzed SST data (Merged satellite and in situ Global Daily Sea Surface Temperature) are assimilated. Atmospheric forcings are 3-hourly data from Japanese 55-year Reanalysis for the assimilation, daily data from Global Ensemble Prediction System of JMA for the prediction. In operational system, the 10-day prompt assimilation and 30-day prediction are executed on a daily basis. Delayed mode assimilation are conducted every 5 days for the period from 54-day to 10-day before the besetime. Using MOVE/MRI.COM-WNP, OMP provides ocean state information of major currents around Japan (Kuroshio/Oyashio/Tsushima-Warm-Current) and water temperatures in the western North Pacific mainly through the JMA website. MOVE/MRI.COM-WNP successfully forecasted the Kuroshio large meander that occurred in August 2017. The data are also used for JMAs oil spill prediction model at serious accidents. Grid data on ocean currents and several layers of subsurface water temperatures from 1982 are available on the NEAR-GOOS Regional Real Time Database (https://www.data.jma.go.jp/gmd/goos/data/database.html) for research users. These information and data are used for various marine industries and fisheries.

JMA has a plan to introduce a new coastal ocean assimilation/prediction system (MOVE/MRI.COM-JPN) in 2020. In the system, a high-resolution (2 km) prediction model (MRI.COM-JPN) covers whole Japan coast and a 4D-Var assimilation system (MOVE-4DVAR) covers the North Pacific with an eddy-resolving (10 km) model. MRI.COM-JPN, initialized using MOVE-4DVAR analysis, is expected to reproduce sub-meso scale events, in addition to several days scale variation of major currents.

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

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P59 - **Abstract ID: 3550878**

Activities on coastal forecasts for using COMPIRA

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Japan Aerospace Exploration Agency (JAXA) is working on a conceptual study of altimeter mission named Coastal and Ocean measurement Mission with Precise and Innovative Radar Altimeter (COMPIRA), which will carry a wide-swath altimeter named Synthetic aperture radar (SAR) Height Imaging Oceanic Sensor with Advanced Interferometry (SHIOSAI). A framework called Coastal forecast core team has started to aim at developing coastal forecast through pre-launch activities toward COMPIRA.

One of the main targets is predicting the Kuroshio/Kuroshio Extension (KE), which have an impact not only on social activities, such as fishery and ship routing, but also on local weather. There is a demand to assess their quality comprehensively and make the best out the available products. In the present study, several ocean data assimilation products and their multi-ensemble product were assessed by comparing with satellite-derived sea surface temperature (SST), sea surface height (SSH), and in-situ hydrographic sections. The Kuroshio axes were also computed from the surface currents of these products and were compared with the Kuroshio Axis data produced analyzing satellite-SST, SSH, and in-situ observations by Marine Information Research Center (MIRC). The multi-model ensemble products generally showed the best accuracy in terms of the comparisons with the satellite-derived SST and SSH. On the other hand, the ensemble products didnt result in the best one in the comparison with the hydrographic sections. It is thus suggested that the multi-model ensemble works efficiently for the horizontally 2D parameters for which each assimilation product tends to have random errors while it does not work well for the vertical 2D comparisons for which it tends to have bias errors with respect to in-situ data. The comparison of Kuroshio axes is summarized as follows. The KE and its meander give rise major discrepancies between each model and reference data, which is attributed to the difference of the Mean Dynamic Topography related to the quasi-stationary meander of the KE. Except the KE, the multi-ensemble product resulted in the least error. On the other hand, the spatial resolution of the present assimilation products we used is not fine especially for submesoscale processes including coastal predictions. The following items are required to be developed/prepared for using COMPIRA: A coastal model and an assimilation method for wide-swath SSH, in-situ observation systems applied for shallow waters, which are used for assimilation/validation, and evaluation system handling multi-products.

Keywords: Systems - General ocean monitoring (including those based on ocean DA and prediction systems), Systems - Prediction system performance & evaluation, , ,

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P60 - Abstract ID: 3551478

An assessment of the Brazil Current structure and variability based on Ocean Prediction Systems and in situ measurements along the NOAA AX97 High-Density XBT transect

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The Brazil Current (BC) is the Western Boundary Current that closes the South Atlantic Subtropical Gyre. As the BC flows southward along the Brazilian continental margin, it shows a very distinct vertical structure and mesoscale activity. Between 20S and 28S, the BC can be described as a warm and saline southward flow that ranges from the surface to depths of 400550 m, increasing its transport by approximately 1.6 Sv per degree of latitude, from 19S to 32S.

Most of the previous studies at BC were typically limited in terms of temporal coverage, and lack of spatial cross-flow resolution. This gap can now be filled with the NOAA AX97 High Density XBT transect at ~22S, with bimonthly sampling since 2004, which is one of the longest sustained monitoring system of the BC. To estimate geostrophic velocities along the AX97 XBT transect, the relative dynamic height is calculated from the temperature profiles and updated salinity estimates, assuming a reference level at z = 500 m, which is approximately the interface between the Central and Intermediate waters near the = 26.8 kg/m3 isopycnal surface. The absolute dynamic height DH(z) is calculated by imposing at the reference depth the respective Argo-based monthly climatology value of absolute dynamic topography. Finally, absolute geostrophic velocities from the AX97 data are derived from DH(z) using the thermal wind relation.

Numerical models are increasingly being used for ocean, weather and ecosystems forecast along the Brazilian coast. Given the importance of the BC variability for these applications, it is paramount to assess how realistic these models are in the region. Numerical models, however, face several challenges to represent the BC at that latitude, because of the strong interaction of the flow with bathymetric features, coastal upwelling, eddy variability and recirculation gyres. The main goal of this work is to assess the structure, location and variability of the BC in ocean prediction systems and eddy-resolving numerical model simulations in comparison with the AX97 data. More than 50 XBT transects as well as remote sensed data, are compared against publicly available global and regional ocean prediction systems, and with simulations derived from the Brazilian Oceanographic Modeling and Observation Network (REMO).

Keywords: Models - Model assessments and verification, Observations - International ocean observation projects (e.g. YOPP, TPOS2020, etc.), Observations - Ocean monitoring based on observing systems, Applications - Climate change research, Evolution - Enhancing community collaboration (observations, modelling, operations, users)

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P61 - **Abstract ID: 3559378**

A Multi-scale ocean forecasting service: The KOOFS(Korea Ocean Observing and Forecasting System)

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KHOA(Korea Hydrographic and Oceanographic Agency) has been operating KOOFS(Korea Ocean Observing and Forecasting System) since 2012. KOOFS runs 23 prediction models not only for ocean forecasting but also for atmosphere and wave forecasting in various spacial scales(from bays to the north pacific). Each prediction model provides 72 hours forecasts of temperature, salinity, sea-level heights and currents for public use. KOOFS uses WRF model for the atmospheric forecasting, ROMS and MOHID for the oceanic forecasting, and WW3 for the wave forecasting. To improve accuracy of forecast products, we applied two data assimilation methods of 4DVAR and EnOI. KHOA also has established Korea Ocean Modelling VAlidation System(KOMVAS) to evaluate daily model prediction results since 2015. KOMVAS compares the prediction data with real-time observation data from tidal stations, HF-radars, and ocean buoys. All products from KOOFS and KOMVAS are being released on web sites with graphical user interface.

Keywords: Systems - Prediction system performance & evaluation, Systems - Implementation of Ocean Prediction Systems, Systems - Ocean reanalysis, DA - Performance and cost of data assimilation, Models - Model assessments and verification

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P62 - **Abstract ID: 3560458**

Developing the next-generation operational global ocean data assimilation system at JMA

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This talk will show a current status of development of next-generation global ocean data assimilation system (MOVE-G3) in JMA/MRI. MOVE-G3 adopts a four-dimensional variational (4DVAR) scheme, rather than current operational three-dimensional variational (3DVAR) scheme, and a sea-ice assimilation component is newly introduced into the system. The oceanic temperature and salinity field of the analysis model will be used not only for monitoring global ocean but also for initializing ocean part of JMAs next generation seasonal forecasting system (JMA/MRI-CPS3), which contains a higer resolution (eddy-permitting) ocean model, using incremental analysis update (IAU) technique. In this talk, some preliminary results of experiment using MOVE-G3 and JMA/MRI-CPS3 will be presented.

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

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P63 - **Abstract ID: 3560875**

Surge induced by monsoon during high tides at the Southeast coast of Vietnam - Numerical model for Prediction

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In this study, surge induced by monsoon during high tides at the Southeast coast of Vietnam is analyzed based on observation tide data at the Vung Tau station in the period of 1997-2016. Specifically, the surge is determined by removing the astronomical tide from the observed total water level. The two-dimensional ROMS model is applied to simulate surge induced by monsoon during spring tide. The results indicate that the change of peak surge did not follow a clear trend in time of increasing or decreasing. A peak surge of over 40 cm appeared mainly in October and November, although the peak of astronomical tide was higher in December. The ROMS 2D model simulates relatively well the surge induced by strong winds during high tides and is recommended for use in operational forecasts in this area.In this study, surge induced by monsoon during high tides at the Southeast coast of Vietnam is analyzed based on observation tide data at the Vung Tau station in the period of 1997-2016. Specifically, the surge is determined by removing the astronomical tide from the observed total water level. The two-dimensional ROMS model is applied to simulate surge induced by monsoon during spring tide. The results indicate that the change of peak surge did not follow a clear trend in time of increasing or decreasing. A peak surge of over 40 cm appeared mainly in October and November, although the peak of astronomical tide was higher in December. The ROMS 2D model simulates relatively well the surge induced by strong winds during high tides and is recommended for use in operational forecasts in this area.

Keywords: Models - Wave and tide modelling,

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P64 - Abstract ID: 3561734

Assessments of an Operational Wave Forecast for the Brazilian Coast

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The Brazilian Navy Hydrographic Center (CHM) operates the Marine Meteorological Service (SMM), which generates daily weather forecast products for the sake of the Safety of Navigation and in compliance with the responsibilities of Brazil according to the Convention for the Safety of Life at Sea (SOLAS). In partnership with CHM operates the Oceanographic Modeling and Observation Network (REMO), which is a Brazilian effort towards operational oceanography that is in permanent improvement by researchers from different institutions in Brazil. Our study presents a detailed multivariate assessment of a wave prediction system developed by CHM-REMO. The operational wave forecast is run with two cycles per day, at 00Z and 12Z, using three different forcing winds: the NCEP Global Forecast System (NCEP/GFS); ICON (Icosahedral Nonhydrostatic Model); and a downscaling simulation using COSMO (Consortium for Small-scaleModeling) which has boundary conditions from ICON. The WAVEWATCH III spectral wave model has been implemented and calibrated to simulate accurate wave fields using a multi-grid scheme with multiples domains. The forecast accuracy of surface winds and significant wave heights is analyzed, in order to study the behavior and distribution of model uncertainties as a function of: i) the forecast range (up to 5 days), ii) the percentiles (severity), iii) the location, and iv) the input winds. A period of one year (2017) was considered for these analyses. Several quality-controlled observations have been selected for the assessment, including six buoys from National Buoy Program (PNBOIA), a Brazilian Navy initiative, and four satellite missions: JASON2, JASON3, CRYOSAT, and SARAL, obtained from AVISO and NESDIS databases. Eight error metrics are calculated to obtain a detailed description of the uncertainties, separating the systematic bias from the scatter component of the error. Results show that under calm to moderate conditions, within the first three days of forecast, the wind and wave model skill is very high. The correlation coefficients of significant wave heights are in between 0.8 to 0.9, and scatter indexes range from 0.12 in the first forecast day, to 0.20 for the fifth day. However, above the 90th percentile and beyond the third forecast day, the predictability drops significantly, as expected. This feature is captured by the increase of the scatter component of the error at longer forecast ranges. The operational wave forecast addressed is made publicly available by the Brazilian Navy at www.marinha.mil.br/chm/.

Keywords: Models - Model assessments and verification, Models - Wave and tide modelling, Systems - Implementation of Ocean Prediction Systems, Systems - Prediction system performance & evaluation, Systems - Prediction system validation/ intercomparisons

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P64 - Abstract ID: 3566848

A Global Multi-Resolution Probabilistic Ocean Current Forecasting System Based on Scale Recursive Estimation

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We present a multi-resolution probabilistic ocean forecasting system developed to support offshore energy operations worldwide. The system is based on a multi-resolution data assimilation framework that enables efficient ocean state estimation and prediction at a hierarchy of scales - from global to local. It is composed of an integrated suite of ocean circulation models including a global model of 25 km resolution, Atlantic and Indian Ocean models of 6 km resolution, and 8 fine scale models (< 3 km resolution) for high-priority regions such as the Gulf of Mexico, offshore Brazil, West Africa, and the Caribbean. These models are arranged as multi-level tree structures where each level of the tree represents a certain scale (resolution) and are linked to levels above and below in the tree, essentially providing a connection between processes represented at different scales. Standard Kalman analysis formula is used for obtaining estimates at any given level. These estimates at each level are then linked to each other along the nodes of the tree with an up sweep and a down sweep steps using appropriate prolongation and restriction operators. Starting from the lowest node, restricted estimates computed at lower levels are used as priors for the next coarser level and then up on reaching the top the estimates are propagated back down the tree in a smoothing downward pass using prolongation operators. All component models incorporate information from satellite and in-situ observations and additionally incorporate proprietary measurements if and where available. Finally, the regional scale models are also used in an ensemble mode to provide probabilistic forecasts for specific regions of interest.

The system has been validated for consistency, quality, and accuracy against a suite of publicly available models and field observations (remotely-sensed observations, ARGO in-situ data and drifting buoy data). Results show that the system compares favorably to other leading ocean current forecasting systems such as HYCOM and the Mercator system. The system has been operational since the beginning of 2017, providing daily 7-day forecasts of ocean currents. We believe that it expands on current ocean prediction systems by: 1) better addressing the multi-scale nature of the problem, 2) making improved use of the available observations, and 3) assimilating highly local and non-standard data streams. It is expected that ocean current hindcasts and forecasts through this system will translate to increased situational awareness, higher efficiency, improved environmental protection, and greater safety.

Keywords: Models - Ocean model configurations, Systems - Probabilistic forecasting, DA - Hybrid data assimilation, Models - Numerical methods, DA - Hybrid data assimilation

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P66 - Abstract ID: 3572060

Use of Oceanic Reanalysis to Improve Estimates of Extreme Storm Surge for the Northeast Pacific

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Storm surges from 1980 to 2016 for the northeast Pacific have been simulated using a 2-D nonlinear barotropic Princeton Ocean Model forced by hourly Climate Forecast System Reanalysis (CFSR) wind and sea level pressure. Validation of the modelled storm surges using tide gauge records has indicated that there are extensive areas of the coast where the model does not capture the processes that determine the sea level variability on the intra-seasonal and inter-annual time scales. Some of the discrepancies are linked to large-scale fluctuations, such as those arising from major El Nio and La Nia events. We have applied an adjustment to the modelled storm surges using ocean reanalysis. The variance of the error of the adjusted surges is significantly reduced by 50% compared to that of the modelled surges. Extreme value analyses show that the 10-year return levels of adjusted surges is increased by 10 cm. The importance of baroclinic dynamics and steric effects to accurate storm surge forecasting in this coastal region is demonstrated, as is the need to incorporate decadal-scale, basin-specific oceanic variability into the estimation of extreme coastal sea levels. The results improve long-term extreme water level estimates and allowances for the west coast of Canada in the absence of long-term tide gauge records data.

Keywords: Systems - Ocean reanalysis, Systems - Prediction system performance & evaluation, Systems - Prediction system validation/ intercomparisons, Applications - Climate change research, Applications - Ocean products for scientific, economic and societal use

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P67 - Abstract ID: 3573807

Met Office global ocean forecasting at 1/12th degree resolution

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The Met Offices Forecasting Ocean Assimilation Model (FOAM) global system has been run operationally with a 1/4 degree resolution (FOAM-ORCA025) for a decade, alongside nested regional 1/12th of a degree configurations for the North Atlantic, Mediterranean and Indian Ocean. FOAM uses a multivariate incremental variational data assimilation scheme called NEMOVAR which assimilates SST, temperature and salinity profile, altimeter SLA and satellite sea ice concentration observations with a 1 day assimilation window. We are developing a 1/12th of a degree version of global FOAM (FOAM-ORCA12) with the intention of replacing the current 1/4 degree resolution global and various nested regional configurations operationally in 2020. We will describe the FOAM-ORCA12 configuration and two different approaches to data assimilation for this new system. The first uses a lower 1/4 degree resolution grid for calculating the assimilation increments, the second uses the 1/12th of a degree grid. We will present results from FOAM-ORCA12 and compare these to results from the1/4 degree FOAM system. We will also assess the performance of the two data assimilation approaches.

Keywords: Systems - Implementation of Ocean Prediction Systems, Systems - Prediction system performance & evaluation, DA - Variational data assimilation, ,

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P68 - Abstract ID: 3574578

Multi-resolution modeling and assimilation applied to the South Atlantic Ocean

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Ocean forecasting systems such as the ones being developed for the REMO project at the Physical Oceanography Lab of the Federal University of Rio de Janeiro - Brazil, have diverse applications, ranging from climate studies to operational support for the offshore industry. Such modeling and forecasting systems are required to produce consistent estimates of the ocean state across a range of scales, so that the system outputs are relevant to a diverse set of applications. As a central component of the numerical operational systems developed in our Lab, we have been exploring the use multi-resolution modeling, and scale-recursive estimation techniques. In particular, we have developed a multi-resolution system, exploring different model configurations that include global domain eddy-permitting resolution, Atlantic basin domain eddy-resolving resolution, and regional domains along the Brazilian coast, in the western South Atlantic, including tides. These models can be thought as multi-level tree structures, where each level represents a certain scale (resolution) and are linked to levels above and below in the tree, essentially providing a connection between processes represented at different scales. A data assimilation system based on Optimum Statistical Interpolation (T-SIS), was implemented for these models within the scope of the REMO project. The models assimilate ARGO profiles, surface temperature (SST) and sea surface height anomalies (SSHA) derived from satellites. We present details of a hindcast experiment. Results show that assimilation, besides dating the meso scale features, both at the surface and in depth, was able to improve the representation of the mean circulation, and to reduce the errors through out the water column. These result indicate that the system presented here can be used to tackle environmental issues in the ocean, and can be successfully implemented as an ocean forecasting system.

Keywords: Systems - Implementation of Ocean Prediction Systems, Systems - Prediction system performance & evaluation, DA - Data assimilation applications, Applications - Oil & gas industries,

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P69 - Abstract ID: 3574685

Using Neural Network to improve storm surge forecast in the Brazilian coast

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The main objective of this study is to investigate the application of neural networks to improve storm surge prediction along the Brazilian south-southeast coast. Worldwild, storm surge is considered on of the most catastrophic natural disasters. Even small surges can have strong impact upon coastal processes, such as beach erosion and estuarine circulation. Accurate forecasting of storm surge is therefore crucial for planning actions efficiently, and reducing risk in coastal regions. Process based, or hydrodynamic models, which solve complex physical equations to simulate a dynamic system, are traditionally used to forecast storm surges. These models, however, may have inaccuracies related to inadequate physical formulation, numerical approximations, spatial and temporal discretization, initial and boundary conditions, forcings and smaller scale processes. Recently, data-based models such as neural networks have gained much attention as an alternative approach, combining measured data with statistical techniques in order to identify patterns of behavior, and to extrapolate them to the future in the form of predictions. These models are highly dependent on the quality and quantity of the input data. A coupled approach, applying both process-based and data-based models, allows for the integration of all available knowledge to generate more reliable forecasts. Using data-based models to update the outputs of process-based models, in order to correct errors, is one of the coupling alternatives, and is the one investigated in the present study. The coupled model uses outputs of the hydrodynamic model (Hycom) as the input for a neural network, which corrects the nonlinear signal associated with the physical phenomenon. Time series of coastal sea level at three stations (Canania, Ilha Fiscal and Imbituba) along the Brazilian coast, and meteorological data from CFSR reanalysis were used to train the data-based model. Correlation maps between coastal sea level and the atmospheric forcings were calculated, and the areas of highest correlation were defined for different frequency bands. The results show that the coupled model improves sea level prediction, reducing the error in 50%. This work is part of the Brazilian Oceanographic Modeling and Observation Network (REMO) initiative to produce more accurate results for operational forecast.

Keywords: DA - Model and observation systematic errors, Models - Future trends in ocean modelling, DA - Hybrid data assimilation, Systems - Probabilistic forecasting, Systems - Coupled systems

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P71 - **Abstract ID: 3581145**

Introduction to the KMA operational ocean data assimilation system and evaluation of its global analyses

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In this study the Global Ocean Data Assimilation and Prediction System (GODAPS) of KMA (Korea Meteorological Administration) is introduced and results from one-year analysis integration are presented. The GODAPS consists of NEMO (Nucleus for European Modelling of the Ocean), CICE (Los Alamos sea ice model), and NEMOVAR data assimilation scheme, and it is based on the Forecast Ocean Assimilation Model (FOAM) system of UK Met Office. The GODAPS is forced by 3-hourly surface fluxes from the KMA NWP system, and it assimilates in-situ and satellite observations of temperature, salinity, sea level anomaly, and sea ice concentration with 24-hour assimilation window. The system produces operationally daily global ocean analyses and 1-day forecasts with 0.25 degree resolution. The innovation statistics based on the one-year integration indicate that the GODAPS compares well with observations though relatively large errors distribute near high variability regions. Globally averaged rms errors of temperature and salinity profiles reach their maxima of about 1.0 degree C at 100 m depth and 0.17 psu at the surface layer, respectively. In comparison with non-assimilative model results, the GODAPS reduces about 58, 40, and 43 percent of rms errors for sea surface temperature, temperature, and salinity, respectively. In particular, the improvement is significant in the North Pacific and Atlantic. Also this comparison clearly demonstrates that the assimilation using NEMOVAR has a strong impact on the reproduction of mesoscale features.

Keywords: Applications - Ocean products for scientific, economic and societal use, DA - Variational data assimilation, Models - Model assessments and verification, Systems - Prediction system performance & evaluation, Observations - Observation impacts

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P72 - **Abstract ID: 3592031**

Ocean Navigator: A webserver prototype for increasing access and use of operational oceanography observation and prediction output

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Operational Ocean Prediction systems were conceived in the mid to late 90s, and have progressed since then through GODAE and GODAE OceanView activities to mature prediction systems. These systems are evolving as part of an overall trend towards seamless environmental prediction as is seen with present WMO evolution. As the output from these new ocean and environmental prediction systems grow in size and detail, accessibility and visualisation tools are vital in enabling and empowering end user marine applications, increasing end use and end use confidence.

Herein we present a web server prototype, titled the Ocean Navigator that enables end users to discover, access, verify, extract and better understand ocean and ice prediction output. The Ocean Navigator amplifies the utility, discovery and uptake of oceanographic information from environmental prediction systems through an interface for both scientists and non-scientists. It provides a seamless interface to explore marine environmental information from original NETCDF files (from forecasts or observation systems). This interface can also be adapted to also read atmospheric and wave forecasts. This tool is publically accessible via the URL link, http://navigator.oceansdata.ca. It is currently used within the Government of Canada CONCEPTS initiative as part of the solution enabling service delivery of coupled environmental prediction systems over the ocean.

This poster describes the Ocean Navigator functionality and explores its suitability for various groups of end users both current and potential.

Keywords: Systems - Visualisation, Systems - Ocean product and data formats, Systems - Prediction system validation/ intercomparisons, Systems - Research-to-operations delivery chain, Systems - Ocean product distribution/dissemination and accessibility

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P73 - **Abstract ID: 3595763**

OCEAN FORECAST SYSTEM IN THE BRAZILIAN NAVY AND IN THE OIL INDUSTRY IN BRAZIL

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Due to its constant demands for oceanographic information, PETROBRAS grouped a selected team of Brazilian universities (UFRJ, UFBA, FURG and USP) together with the Brazilian Navy to create the Oceanographic Modeling and Observation Network (REMO) aiming to develop ocean modeling with focus in short-term forecasts. REMO started to produce operational daily ocean forecasts in February 2010, going through successive improvements until now. The first forecast system was based on a 21 sigma-theta hybrid vertical layers of HYCOM with 1/4, 1/12 and 1/24 horizontal resolutions covering the Atlantic Ocean, the METAREA V and the Southwestern Atlantic, respectively. Today, the system assimilates vertical T/S profiles from ARGO, SST from OSTIA and along-track SLA from AVISO employing the Ensemble Optimal Interpolation method. The system runs operationally at the Brazilian Navy Hydrographic Center and PETROBRAS disseminates the daily forecasts to all sectors of the company through an opendap server.

In addition to its effort in ocean modeling, PETROBRAS has been also working on ocean monitoring, maintaining current meters installed in some production platforms, focusing on their main offshore production basins, Campos and Santos. Based on these current measurements and publically avaliable oceanographic data, as SST from MUR and SSH from AVISO, the oceanographic team produces the best possible nowcasts to support a wide variety of maritime activities. The ocean nowcasts are also used to evaluate REMO and other public ocean forecasts, such as HYCOM/NCODA and MERCATOR, in order to identify the best short-term prediction for PETROBRAS specific needs.

At the moment, the REMO forecast system is being upgraded to a model configuration with 32 sigma-2 hybrid vertical layers of HYCOM using 1/12 and 1/24 horizontal resolutions for the Atlantic Ocean and METAREA V, respectively. The new system is planned to start running operationally at Brazilian Navy by the end of 2019. Long-run experiments have already shown great improvements in model results, particularly at the intermediate circulation levels of the Southwestern Atlantic, a region of major interest for the oil industry in Brazil.

Keywords: Applications - Ocean products for scientific, economic and societal use, Applications - Oil & gas industries, Systems - Prediction system performance & evaluation, Systems - Research-to-operations delivery chain, DA - Data assimilation applications

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P74 - **Abstract ID: 3600442**

Reconstruction and prediction of global surface ocean CO2 partial pressure using a neural network model

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Over the last decade, the global ocean took up 22% (2.4 0.5 GtC/yr) of total anthropogenic CO2 emissions to the atmosphere (Le Qur et al., 2018). This global figure hides an important spatial and temporal variability of the ocean CO2 sink, which is largely driven by the response of the ocean carbon cycle to natural modes of climate variability. Understanding the evolution of the global carbon budget and of its perturbation over time therefore implies assessing the spatio-temporal variability of air-sea CO2 fluxes. The exchange flux of CO2 at the air-sea interface is a function of the difference in CO2 partial pressure between the atmosphere and the ocean times the wind speed. While direct measurements of CO2 fluxes are rare, an international coordinated effort by the ocean observation community focusing on the in-situ measurement of ocean-surface CO2 fugacity resulted in a vast database known as the Surface Ocean CO2 Atlas (SOCAT, https://www.socat.info/). Despite this ongoing effort, data coverage is still sparse over large areas of the ocean and the reconstruction of surface ocean pCO2 fields requires some gap-filling method.Recently,methodsincluding data interpolation, statistical regression, andartificialneural networkhave been developed to estimatesurfaceoceanpCO2values for all periods and areas.However, existing methods still suffer from large systematic errors, and are hardly able to assess output uncertainties.Here we propose a new neural network approach that addresses these issues.We apply this method to recover surfaceocean pCO2 data on a regular grid (11) with a monthly resolution from 2001 to the end of 2016. In addition, and as a strong test of its skill, we predict surfaceocean pCO2for2017 and compare it to the release of SOCAT data for that year. The capacity to predict surface ocean pCO2 through a neural network-based approach could complement coupled physical-biogeochemical model prediction systems. Furthermore, once established and further validated, the system could be extended to other variables of the carbonate system, including surface ocean pH and saturation state with respect to carbonate minerals.

Keywords: Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Systems - Prediction system validation/ intercomparisons, Applications - Ocean products for scientific, economic and societal use, Systems - Prediction system performance & evaluation, Systems - Earth-system models

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P75 - **Abstract ID: 3600602**

Towards a pan-Arctic Ocean biogeochemcal reanalysis by EnKF data assimilation system

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Thr Arctic Ocean biogeochemical reanalysis system is under development at Nansen Center (NERSC) as part of CMEMS ARC-MFC program. The system is based on the TOPAZ4 coupled ocean-ice-biogeochemical modelling system, HYCOM-CICE-ECOSMO II, and the NERSC Ensemble Kalman Filter (EnKF) data assimilation system. Ocean color Chla product is the most important source of observation to be assimilated over the Arctic domain, but its rate of coverage is genrally poor due to severe weather condition and sea ice. Joint estimaiton of state and model parameters with in-situ nutrient and Chla data then becomes important approach in the Arctic Ocean to overcome this under-constrained problem. In the preliminary studies, the joint estimation system was tested with TOPAZ over the Arctic domain and 1D column ocean model GOTM at station M. However, in situ nutrient data used in the past data assimilaiton studies are distributed only in the Nordic Seas and our analysis is still heavily under constrained over the majority of the Arctic domain. Towards real pan-Arctic biogeochemical reanalysis production, we have compiled pan-Arctic nutrient data for the last two decades and the rate of observation coverage is significantly improved. Together with a new ocean color product, CMEMS OC-TAC Chla data, the new Arctic Ocean biogeochemical reanalysis is near to its production stage. In this presentation we will report its preliminary result and quality validation.

Keywords: DA - Biogeochemical data assimilation, DA - Ensemble data assimilation, Models - Ecosystem/BGC modelling, Observations - Observation impacts, Systems - Ocean reanalysis

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P76 - Abstract ID: 3600603

Post validation of the Four-dimensional Ocean Reanalysis of the Western North Pacific over 30 years (FOR A-WNP30)

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Eddy resolved (1/10 degree), long term (1982-current) ocean reanalysis data, FORA-WNP30, over the Western North Pacific Ocean (WNP; 117E-160W, 15N-65N) was produed using cycled 4DVar data assimilation system with 10 day assimilation period (Usui et al., 2016). Post validation studies show that temporal variation of Kuroshio meandering path off the southern coast of Japan and extreme Oyashio southern intrusion events off the east coast of Japan are well reproduced throughout the entire analysis period. These findings support that this new reanalysis data is capable of reproducing variations of meso-scale ocean structures nearby Japan coasts during the pre-satellite altimetry era. The ocean observig system over WNP has experienced major update during the three decades at approximately every 10 years and cluster distribution of Chi-square values from assimilation cycles reveals clear impact of the observing system to quality of the reanalysis in each decade. Observation sensitivity experiment conducted in parallel to the main reanalysis calculation also reveals geographical region where the meso-scale features can be reproducible without altimeter data in our reanalysis system. In this presentation, detail information on the reanalysis system set-up, performance of the reanalysis system and validation of the reanalysis product are reported.

Keywords: Applications - Ocean products for scientific, economic and societal use, DA - Variational data assimilation, Observations - Observing system assessments and design, Systems - Ocean reanalysis, Models - Model assessments and verification

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P77 - Abstract ID: 3602646

Joint evaluation of global and regional forecasting systems from NMEFC and MOI in the South China Sea

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The data assimilation tunings of South China Sea Operational Forecasting System (SCSOFS) from Natinonal Marine Environmental Forecasting Center (NMEFC) were evaluated by performing a series of sensitivity tests. In the continuation of Zhu et al (2016) and following the GODAE IV-TT validation methodology, a set of CLASS 1-2-3-4 metrics was defined in order to assess the consistency of the ocean circulation features (large scale and mesoscale), and the accuracy with respect to observations of each of the experiments. The sensitivity experiments were also systematically compared to global forecasting systems (CGOFS from NMEFC, PSY4V3 from Mercator Ocean). This study shows how the intercomparison and validation framework defined by GODAE can be used to assess the consistency between global systems and nested regional systems, and how improving this consistency is crucial to improve the skill of downscaled applications.

Keywords: DA - Data assimilation applications, Systems - Prediction system validation/ intercomparisons, Models - Downscaling, Systems - Implementation of Ocean Prediction Systems,

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P78 - Abstract ID: 3603401

The development of a global eddy-resolving ocean forecast system in China

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A global eddy-resolving forecast system, named LICOM Forecast System (LFS), has been built based on LASG/IAP climate system ocean model version 3 (LICOM3) with the cooperation with National Marine Environmental Forecasting Center (NMEFC). LICOM is developed as a climate ocean model in LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, for about 30 years. This ocean model is used to be a tool for climate and physical processes studies. This is the first time to forecast synoptic ocean state globally using an eddy-resolving LICOM3. In this presentation, the configurations of the model and the system have been introduced. A half year (June 1st 2014-December 31st 2014) 8-day forecast experiments has been conducted to test the performance of the model. The statistic of all 8-day forecast has been evaluated following the IV-TT Class 4 protocol and compared with the results from other 7 forecasted systems. The results show that the new forecast system has a very good performance for 8-day forecast.

Keywords: Systems - Prediction system performance & evaluation, Systems - Prediction system validation/ intercomparisons, Systems - Implementation of Ocean Prediction Systems, Models - Current scientific challenges of ocean modelling, Models - Coupled modelling

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P79 - **Abstract ID: 3603475**

The Copernicus Marine Service for the Black Sea: products for user needs, modelling challenges and future perspectives

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The Black Sea Monitoring and Forecasting Centre (BS-MFC) provides regular and systematic information about the physical state, marine ecosystem and wave conditions in the Black Sea area, keeping efficient operations, advanced technology and high quality modeling products, to serve the specific user needs. It is operational since 2016 in the framework of Copernicus Marine Environment and Monitoring Service (CMEMS). The BS-MFC products for the Physics, Biogeochemistry and Waves components are classified as: a) Near Real Time (NRT) analysis and forecast products, updated at daily frequency; b) Multi-Year Products (MYP), updated at yearly frequency. The BS-MFC high level architecture is defined by: a) Physics, Biogeochemistry and Waves Production Units (PU) and related backup and archiving units (AU/BU) for service reliability; b) the Local Service Desk, connected to CMEMS Service Desk and BS PUs for service management; c) the Technical Group for implementing interfaces between the BS PU and the CMEMS Dissemination Unit (DU). The BS-MFC implementation over period 2018-2021 will evolve according to the main scientific and technical challenges to address, such as: 1) upgrades of the core models used for the BS-MFC hydrodynamics, biogeochemistry and waves modeling frame (NEMO, WAM) , 2) revised implementations of the data assimilation core as a prerequisite for the improvement of the NRT and MY products quality, 3)use of interannual datasets and forecast data for the Danube River freshwater input, 4) evolution of the validation tools for assessing the monitoring and forecasting capabilities of the BS-MFC products, 5) implementation of the optimal interface between the BS-MFC and the Mediterranean Sea Monitoring and Forecasting Centre (Med-MFC) thought the Marmara Sea. The main characteristics of the BS-MFC production units will be extensively described, with a focus on the observations (in-situ and satellite) available through the CMEMS catalogue, and their use in the data assimilation system and for the validation of the BS-MFC products.

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

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P80 - **Abstract ID: 3605505**

Forecasting ocean extremes and their significance

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The detection of anomalous ocean states is an important forecast product with many practical applications including hazardous warnings and safe operations at sea. An important companion product for anomalies is the expected variance or percentiles to characterise their significance and determine their relative extremity. Therefore forecasting of ocean extremes introduces two additional challenges in addition to forecasting an accurate estimate of the ocean state: an accurate estimate of the expected ocean mean and variance. Observational ocean climatologies (e.g., world ocean atlas) provide an estimate for the seasonal mean however the quality of the estimate varies according to the temporal and spatial sampling rate of the observations relative to the ocean variability. Although the objective estimates for the mean may be satisfactory, anomalies based on an ocean forecast system relative to these observational analyses retain both the systematic biases of the forecast system and the biases of the objective analysis. Further observational based estimates of variance are of lower quality and are considered unreliable as a measure of significance.

We introduce an alternative estimation of the ocean mean and variance based on a 20 year data assimilating ocean reanalysis. The reanalysis is based on the same ocean model and data assimilation method and observational datasets. A seasonal cycle is constructed by time averaging all 20 years into a single 365 day annual cycle for all five prognostic variables and the full model grid. A singular value decomposition is performed on the annual cycle to generate the 9 leading vectors which explain the majority of the variance. The eigenvalue time series of these vectors closely approximate the mean, annual, semi-annual and seasonal modes. It is hypothesised that this seasonal cycle will include a systematic bias that will approximately cancel that of the ocean forecast system when forming seasonal anomalies.

The ocean variance of each prognostic variable is estimated from the population of seasonal anomalies for each day of the year, each grid point (plus the adjacent northern, southern, eastern and western wet cells) over the 20 years creating a maximum sample size of 100. The use of adjacent cells improves the sample size at the cost of reducing the effective spatial resolution of the estimate. We examine the properties of this reanalysis based climatology and some recent examples of extreme events.

Keywords: Systems - Prediction system performance & evaluation, Applications - Disaster & risk management, , ,

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P81 - Abstract ID: 3612587

Evaluating upper ocean currents simulated by the Navy Earth System Prediction Capability and the Global Ocean Forecast System

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A data set of more than 1500-drifting buoys from the National Oceanic and Atmospheric Administration (NOAA) Global Drifter Program are used to evaluate simulated upper ocean currents in the fully coupled Navy Earth System Prediction Capability (Navy ESPC), and the Global Ocean Forecast System (GOFS) without air-sea coupling. The differences between the modeled upper ocean currents of the two systems are a result of: 1) the coupled/uncoupled characteristics of the systems, 2) the consequent difference in the heat and momentum fluxes (between the ocean and atmosphere) of the two systems, and 3) the fact that no ocean currents are assimilated into the systems. Due to the fully coupled nature of Navy ESPC, it more realistically represents air-sea exchanges than GOFS. Do Navy ESPCs coupling physics translate into better upper ocean currents performance? This presentation focuses on the answer to this question.

Keywords: Systems - Prediction system validation/ intercomparisons, , , ,

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P82 - Abstract ID: 3615647

SOCIB ocean prediction systems and applications in the Western Mediterranean Sea

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SOCIB (Balearic Islands Coastal Observing and Forecasting System, www.socib.es) operates three ocean prediction systems in the Western Mediterranean Sea. These systems aims to predict the short-term evolution of (1) ocean temperature, salinity, sea level and currents (2) waves and (3) meteotsunamis. Their outputs are being disseminated on the web and integrated in a number of SOCIB products and services tailored to the needs of specific sectors and end-users.

1) The Western Mediterranean Operational System (WMOP) is a 2km-resolution ocean circulation model based on ROMS. It provides every day a 72-hour prediction of ocean temperature, salinity, sea level and currents aiming to represent the ocean variability from the coastal to the meso- and basin-scale. WMOP is nested in the larger scale forecast model from the Copernicus Marine Environment Mediterranean Monitoring Forecasting Centre and is driven by high-resolution atmospheric forcing from the Spanish Meteorological Agency. It assimilates data from along-track satellite altimetry, SST maps, ARGO temperature and salinity profiles as well as the Ibiza Channel High-Frequency (HF) radar surface currents. The model outputs are systematically evaluated against satellite observations, HF radar data and in situ measurements including gliders. The behavior of the system is also continuously monitored through ocean indicators in the major sub-regions of the Western Mediterranean Sea.

2) The Wave Forecast Automatic System (SAPO, from the Spanish Sistema Autnomo de Prediccin de Oleaje) is 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 (Simulating Waves Near-shore Model) model and it is run operationally twice a day. It provides 3-day forecasts of significant wave height, wave period and direction around the Balearic Islands, with a systematic evaluation against measurements from local buoys.

3) The Balearic Rissaga Forecasting System (BRIFS) aims at quantitatively predicting the occurrence of extreme sea level oscillations associated with meteotsunamis in the Menorcan harbour of Ciutadella (also locally known as rissaga phenomenon). It uses a WRF-ROMS ocean-atmosphere modelling system involving multiple nested grids. It is run with very high temporal resolution to simulate the wave amplifications over the continental shelf and in Ciutadella inlet.

This presentation will overview these three prediction systems, their dissemination and applications through specific products, focusing in particular on the sectors of marine conservation, fisheries assessment and management, maritime safety and beach lifeguards.

Keywords: Systems - Implementation of Ocean Prediction Systems, Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Systems - Prediction system performance & evaluation, Systems - Ocean product distribution/dissemination and accessibility, Systems - Visualisation

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P83 - **Abstract ID: 3559790**

Practical ocean information services based on KOOFS (Korea Ocean Observing and Forecasting System)

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KHOA(Korea Hydrographic and Oceanographic Agency) is providing practical application services based on KOOFS(Korea Ocean Observing and Forecasting System). POIS(Port Oceanographic Information System) supports for safe ship routing around port areas. OceanGrid(Ocean Data in Grid Framework) service provides forecasting information and observational data through a grid system. SAR(Search And Rescue) system can simulate trajectories of people fallen overboard or drifted things in the Korean territorial seas. Ocean weather index and Ocean weather chart are being provided as ocean weather information on KHOA websites, through which End-users can use most of the information and an openAPI data-providing platform.

Keywords: Applications - Ocean products for scientific, economic and societal use, Applications - Disaster & risk management, Applications - Coastal protection, Applications - Search and rescue, Applications - Environmental assessment

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