OceanPredict '19
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Theme 3: Numerical Modelling

Session 6: Other advances in numerical ocean modelling

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Numerical Study of Modulation of Near-Inertial Oscillations by Low Frequency Current Variations on the Scotian Shelf

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High-frequency radar and ADCP observations on the Scotian Shelf reveal strong near-inertial oscillations (NIOs) associated with the passage of storms. A three-dimensional shelf circulation model is used to examine the frequency modulation of NIOs by low frequency current variations over the study region. Analyses of model results demonstrate that NIOs with speeds exceeding 0.25 m/s occur in the offshore region but their amplitudes decrease shoreward within about 40 km of the coast. The NIOs have spatial scales of ~80 km and ~40 km in the along and cross-shore directions respectively. The spatial distribution of the phase of simulated NIOs suggests northeastward propagation, consistent with the typical movement of winter storms in this region. Evolving rotary spectral analysis reveals that the peak frequency of the NIOs varies through time by about 7% of the local inertial frequency. This frequency modulation can be mostly explained in terms of variations in the background vorticity associated with changes in the strength and position of the Nova Scotia Current, an unstable baroclinic boundary current that runs along the coast to the southwest.

Keywords: Models - Downscaling, Models - Model assessments and verification, Models - Ocean processes and parameterisation, Models - Ocean model boundary conditions and forcings, Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.)

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Multi-scale coastal circulation in the Bay of Biscay

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The Bay of Biscay, in the North-eastern Atlantic, is considered as a natural laboratory to explore the coastal dynamics at different spatial and temporal scales. In this region, the coastal circulation is constrained by a complex topography (e.g. varying width of the continental shelf, canyons), river runoffs, strong tides and a seasonally contrasted wind-driven circulation.

Based on different numerical model experiments (from 1km to 4km spatial resolution, from 40 to 100 sigma vertical layers using the MARS3D model), different features of the Bay of Biscay circulation are assessed and explored. Those simulations are covering an 11 year time period from 2000 to 2010 with a spatial domain including continental shelf, shelf break and open ocean regions. Four simulations (4km/1km and 40levels/100levels) performed in the same conditions (e.g. forcings, open boundary conditions) will be presented to highlight the impact of the resolution on the circulation and the hydrological contents at interannual time scales. A specific focus is proposed on the variability of fine scale features (e.g. fronts, filaments, eddies). The understanding of the evolution of such processes will improve our ability to predict interannual evolutions. Furthermore, observing such fine scales remain an ongoing challenge. In the framework of the near future altimetry missions (e.g. SWOT mission), the surface signature of fine scale features will be discussed.

This result overview in the Bay of Biscay aims illustrating the input of coastal modelling activities in understanding multi-scale interactions (spatial and temporal).

Keywords: Models - Model grid structure and resolution, Models - Ocean model configurations, Models - Ocean processes and parameterisation, Models - Current scientific challenges of ocean modelling, Observations - Observing system needs and future challenges

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Assessing the use of JRA-55 and DFS 5.2 reanalysis atmospheric forcing products in a ROMS model of the Benguela upwelling system

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Given the poor resolution of the nearshore satellite wind fields and therefore the windstress curl, model simulations of upwelling regions frequently contain persistent nearshore sea surface temperature (SST) biases. The JRA-55 (Japanese 55-years Ranalysis Daily) and DFS 5.2 (Drakkar Forcing Set version 5.2) atmospheric reanalysis products are assessed alongside the Quickscat satellite product with respect to how well an ocean model reproduces known features, when forced by each of them separately. Three Regional Ocean Modelling System (ROMS) simulations of the Southeastern Atlantic Ocean are run. They differ only by the surface atmospheric forcing product of momentum, either JRA-55, DFS 5.2 or Quickscat satellite winds. The output of each simulation is comapred with satellite SSTs to assess how well each forcing product reproduces the nearshore upwelling regime in an ocean model. A cool coastal bias in the Bengulea system that persists in both the Quickscat and DFS 5.2-forced ocean model is not present in the JRA-55-forced model, but a >~1.5o warm bias extends from the coast to a few hundred kilometers offshore in the latter model simulation. For the larger South-East Atlantic domain, the DFS 5.2 forced model reproduces the SSTs most accurately, aside from the coastal cool bias an warm biases of up to ~1.5oC off Lderitz (~27oS) and the Angola Benguela Frontal Zone (~16oS). The extent to which the three different products reproduce the seasonal cycle of key the features of the Benguela System is also investigated.

Keywords: Systems - Ocean reanalysis, Models - Ocean model boundary conditions and forcings, Models - Model assessments and verification, ,

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A 1D atmospheric boundary layer model to improve air-sea interactions for ocean models

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High-resolution ocean-atmosphere coupled models are able to realistically simulate air-sea interactions taking place at mesoscale between ocean eddies and fronts and the lower atmosphere. These coupled processes have the potential to improve oceanic simulations by modulating wind work input and vertical velocities. However, in the context of operational ocean forecasts at eddying resolution and with data assimilation, the computational cost and the complexity of such global coupled models is prohibitive and inadequate.

Here, we propose an alternative approach based on a one-dimensional vertical atmospheric boundary layer (ABL) model driven by large-scale atmospheric data (forecasts or reanalysis). This model is able to represent the oceanic current and thermal feedbacks on the wind stress while keeping a good consistency with the atmospheric forcing. Its limited computational cost (~10%) and intermediate complexity between a bulk parameterization and a full atmospheric model makes this approach well suited to operational oceanography.

Firstly, the model is tested against atmospheric analytical testcases. Then, two prototypes are developed to illustrate the feasibility of our approach: a global configuration at 0.25 and a regional configuration at 1/36 resolution covering western Europe. Preliminary results will be presented and the different possibilities to drive the ABL model such as the nudging and the geostrophic guide will be discussed.

Keywords: Models - Coupled modelling, Models - Ocean model boundary conditions and forcings, Models - Ocean model configurations

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Forcing mechanisms of sea level variations in shelf waters off the coast of British Columbia

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Sea level variations in the northeast Pacific during 2007-2016 are simulated with a high-resolution regional ocean model. After removing tides and the inverse-barometer component due to atmospheric pressure forcing, the monthly-mean time series are derived. The model-simulated spatial distributions of the amplitude and phase of the seasonal cycle, and the standard deviations of the de-seasoned sea level anomalies, are consistent with those derived from satellite altimeter observations. The modelled sea levels agree well with coastal tide gauge observations. The sea level variations can mostly be accounted for by the steric height, including at the sites of coastal tide gauges. On the shelf, the halo-steric component is more dominant than thermo-steric component. Time series of both the halo- and thermo-steric components are regressed to surface wind stress and buoyancy fluxes over the Pacific Ocean. This regression analysis reveals that sea levels along the coast of British Columbia are significantly influenced by remote winds offshore near 38 N and in the central tropical Pacific Ocean.

Keywords: Models - Model assessments and verification, Models - Ocean model boundary conditions and forcings, Models - Ocean model configurations, Models - Ocean processes and parameterisation, Models - Numerical methods

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Typhoon Prediction in the Korea Operational Oceanographic System using the Hurricane WRF Model

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Improving track and intensity predictions for tropical cyclones is essential to prevent future marine disasters. The Korea Operational Oceanographic System (KOOS) has used the Weather Research and Forecasting (WRF) model as the atmospheric model to provide atmospheric forcing for ocean models, including ocean circulation, wave and storm surge. However, in October 2016, the WRF model failed to predict that typhoon Chaba would make landfall over the Korean Peninsula, until only 36 hours beforehand. As with most atmospheric prediction models, WRF has an underestimation bias in intensity. This causes prediction errors in oceanic wave and storm surge modeling. To overcome this underestimation bias, the Hurricane Weather Research and Forecasting (HWRF) system uses storm size correction and storm intensity correction. The HWRF modelling system was developed based on the Non-hydrostatic Mesoscale Model (NMM) core of the WRF model, to improve prediction skills for tropical cyclone tracks and intensity. The HWRF system uses differing approaches for representing the ocean in the various tropical cyclone basins. In the Western Pacific (WP) region, the HWRF employs the Message Passing Interface Princeton Ocean Model-Tropical Cyclone (MPIPOM-TC). Subsequent tests conducted by Environmental Modelling Center (EMC) using 2015 typhoons indicated that intensity forecasts were substantially improved in the WP basin when HWRF was coupled to MPIPOM-TC. The National Centers for Environmental Predictions global operational Real-Time Ocean Forecast System (RTOFS) nowcast product was used to initialize the ocean model for the WP region. The main purpose of coupling a 3-D ocean model to HWRF is to create an accurate sea surface temperature (SST) field for input into the atmospheric model. The SST field is subsequently used by the atmospheric model to calculate the surface heat and moisture fluxes from the ocean to the atmosphere. This presentation shows the ocean coupling effect on typhoon track and intensity over the WP. This presentation includes case studies of air-sea interaction analysis for landfall typhoons Soulik and Kong-rey.

Keywords: Models - Coupled modelling, Systems - Coupled systems, Models - Model grid structure and resolution, Systems - Implementation of Ocean Prediction Systems, Models - Ocean model configurations

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