OceanPredict '19
GODAE OceanView Symposium | 6-10 May 2019 Halifax, Canada
Advancing the science and application of ocean predictions

POSTER ABSTRACTS

Theme 3:
Numerical Modelling

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P33 - **Abstract ID: 3553649**

High-resolution modelling of a coastal harbor in the presence of strong tides and significant river runoff

Taylor, Stephanne[1], Paquin, Jean-Philippe[2], Lu, Youyu[1], Blanken, Hauke[3], Marcotte, Guillaume[2], Hu, Xianmin[1], Zhai, Li[1], Higginson, Simon[1], Nudds, Shannon[1], Chanut, Jérôme[4], Smith, Gregory[2], Bernier, Natacha[2] [1]Fisheries and Oceans Canada, Dartmouth, Canada [2]Environnement et changement climatique Canada, Dorval, Canada [3]Fisheries and Oceans Canada, Sidney, Canada [4]Mercator-Océan, Toulouse, France stephanne.taylor@dfo-mpo.gc.ca

Version 3.6 of the Nucleus for European Modelling of the Ocean (NEMO) is adopted to develop a circulation forecasting model for the Canadian harbour of Saint John, New Brunswick, which is located in the Bay of Fundy. The regional oceanography is characterized by the presence of strong tides and significant river runoff. One-way nesting is applied to link a series of model configurations covering basin-scale, shelf, coastal and nearshore regions, with horizontal resolutions of approximately 7.5 km, 2.5 km, 500 m and 100 m, respectively. The river forcing is introduced with observed time series of water level at the mouth of the river. Evaluation with observational data shows the models satisfactory performance in simulating tidal elevation and currents, non-tidal water levels and currents, temperature, salinity, and surface drifter trajectories. The complicated physical processes in the region, including oscillating tidal fronts, non-stationary tidal eddies, and movement and mixing of double salt wedges in the estuary, are qualitatively reproduced by the model.

Keywords: Models - Ocean model configurations, Models - Ocean model boundary conditions and forcings, Models - Model assessments and verification, Models - Model grid structure and resolution,

Presenter:
Stephanne Taylor
Fisheries and Oceans Canada
Dartmouth, Canada
stephanne.taylor@dfo-mpo.gc.ca

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Analyses of trends, sub-seasonal to interannual variability and extreme events in the Arctic Ocean from a physics-ice-biogeochemistry model

Richaud, Benjamin[1], Fennel, Katja[1], Oliver, Eric[1], Bourgeois, Timothée[1], Hu, Xianmin[2], Lu, Youyu[2] [1]Dalhousie University, Halifax, Canada [2]Bedford Institute of Oceanography, Dartmouth, Canada bn512787@dal.ca

The fast rate of sea ice decline in the Arctic Ocean, induced by climate change, has led to increases in ocean primary production and uptake of CO2. It could soon unlock new fisheries and will likely have other important socio-economic impacts. Therefore, a proper understanding of the behaviour of physical and biogeochemical properties of the Arctic Ocean is needed. Here, simulations of the coupled physics-ice-biogeochemistry numerical model NEMO-LIM-PISCES shed light on the variability of the afore-mentioned properties. The model has a spatial resolution ranging from 10 to 20 kilometers and covers the whole Arctic, as well as part of the North Atlantic and North Pacific Oceans. Daily model output over several decades is analyzed to investigate trends and sub-seasonal to interannual variability in the Arctic. Moreover, the model resolves some regional processes, such as river outflow and mesoscale eddies and fronts, that influence the physical and biogeochemical variables. Here, we present first results and highlight the potential of this model to reproduce processes already identified in the literature, at different spatial and temporal scales. We also present plans for future work aimed at estimating the consequences of an increased winter sea ice growth on CO2 uptake by the Arctic Ocean and linking this to the probability and amplitude of extreme events in physical and biogeochemical properties.

Keywords: Models - Ecosystem/BGC modelling, Models - Ocean processes and parameterisation, , ,

Presenter:
Benjamin Richaud
Dalhousie University
Halifax, Canada
bn512787@dal.ca

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Greenland freshwater fluxes from the Arctic Ocean HYCOM-CICE simulations

Dukhovskoy, Dmitry[1], Chassignet, Eric[1] [1]FSU, Tallahassee, USA ddukhovskoy@fsu.edu

Increased freshening of the subpolar North Atlantic is predicted under present climate conditions due to the amplified accumulation of fresh water, particularly from glacier melt in the Arctic and subarctic regions, with a consequent impact on convection driving thermohaline circulation. The cumulative Greenland freshwater flux anomaly has exceeded 5000 km3 since the 1990s, which is half of the freshwater volume propagating across the subpolar North Atlantic with the Great Salinity Anomaly between the 1960s1970s. Changes in the ocean salinity and water column stability caused by the Greenland freshwater anomaly have been the central idea in many studies investigating current and near-future climate change driven by accelerated melting of the Greenland ice sheet. Nonetheless, many elements of the suggested chain of processes connecting Greenland freshwater anomaly and climate variability are uncertain, speculative, or contradict observations. The uncertainty in the relationship between the Greenland freshwater anomaly and climate is related, in part, to insufficient knowledge about propagation pathways and the accumulation rate of Greenland fresh water in the subpolar seas. For examples, it still not known where and at what rate Greenland fresh water leaves the shelf and spreads into the deep basins. Greenland freshwater fluxes are analyzed from several numerical experiments conducted with a coupled Arctic Ocean HYbrid Coordinate Ocean Model (HYCOM) and Los Alamos National Laboratory Sea Ice CodE (CICE). The model is run in two configurations with 0.04-degree (~2 km) and 0.08-degree (~4.5 km) horizontal grids. The Arctic Ocean HYCOM-CICE is nested within the 0.08 Global HYCOM +NCODA GOFS3.0 reanalysis (for 19932005) and GOFS3.1 analysis (20062016), which provide more realistic ocean fields at the lateral open boundaries. Locations and discharge rates of the Greenland freshwater sources are derived from a 5-km gridded product that provides monthly land ice freshwater flux from the Greenland ice sheet. In order to track Greenland fresh water, a passive tracer is continuously released at the exact locations of the freshwater sources during the simulations. The model results are employed to analyze mean and eddy fluxes of Greenland freshwater and to look at vertical mixing of fresh water on the Greenland shelf.

Keywords: Models - Coupled modelling, Models - Numerical methods, Models - Model grid structure and resolution, ,

Presenter:
Dmitry Dukhovskoy
FSU
Tallahassee, USA
ddukhovskoy@fsu.edu

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P36 - Abstract ID: 3591618

Seasonal and interannual eddy variability in the Northeast Pacific from high-resolution regional model simulations

Horwitz, Rachel[1], Zhai, Li[1], Lu, Youyu[1], Hu, Xianmin Hu[1], Paquin, Jean-Phillippe[2], Pena, Angelica[3] [1]Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, Canada [2]Environment Canada, Dorval, Canada [3]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, Canada rachel.horwitz@dfo-mpo.gc.ca

Mesoscale eddy variability constitutes a significant component of the total kinetic energy of the ocean, and plays significant roles in mixing and transport of heat, salt, and nutrients. In the Northeast Pacific (NEP), the spatial variations of eddy energetics are related to their different origins and pathways, as has been shown in previous observational and modelling studies. In this study, we analyze the eddy variations from hindcast simulations with high-resolution regional models. The NEP area is divided into several sub-regions to derive the characteristics of the seasonal and interannual variations of eddy kinetic energy. Overall, the model simulated eddy variability is consistent with that derived from satellite altimetry observations. However, discrepancies still exist, and the model solutions are dependent on model parameters and numerical schemes. The linkages of eddy variability to the regional ocean dynamics and both local and remote forcing are explored.

Keywords: Models - Model assessments and verification, Models - Ocean processes and parameterisation, Models - Current scientific challenges of ocean modelling, ,

Presenter:
Rachel Horwitz
Bedford Institute of Oceanography, Fisheries and Oceans Canada
Dartmouth, Canada
rachel.horwitz@dfo-mpo.gc.ca

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P37 - Abstract ID: 3595538

Sub-seasonal to multi-decadal predictability of Antarctic oscillation using an Earth System Model

Beraki, Asmerom[1] [1]Council for Scientific and Industrial Research (CSIR) and University of Pretoria (UP), Pretoria, SOUTH AFRICA asmiefb@gmail.com

Many previous studies have shown the importance of mid- and high-latitude climate variability notably in connection of the Antarctic oscillation (AAO) on the southern hemisphere (SH) climate system. Notwithstanding, the ability of climate models that at least interactively couple the ocean and atmosphere in predicting the AAO is generally argued to be marginal irrespective of what the reason may be. This circumstance presents the flavour of test how the next generation climate models that assemble a complete climate system components will address the drawback. With this in mind, the study examines the predictability of the AAO at a range of timescales using the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Earth System Model (ESM) prototype of intermediate complexity. The ESM interactively couples an atmosphere, ocean, sea-ice and biosphere models all cast on a cube-based grid and can be applied either at quasi-uniform horizontal resolution to function as a global climate model (GCM) or in stretched-grid mode to function as a high-resolution regional climate model (RCM). The result reveals that the multi-decadal AAO variability is found to be highly predictable. This elevated predictability is presumably attributed to multiple-ways feedback mechanism stems from the of climate forcing interactions as confirmed from the sensitivity experiment that excludes the coupling of the ocean and seas-ice models. Notwithstanding, its sub-seasonal to interannual vacillation has a random trajectory which may strengthen the notion that its predictability may not be achievable even with the use of ESMs.

Keywords: Models - Coupled modelling, Systems - Earth-system models, Systems - Prediction system validation/ intercomparisons, Models - Downscaling, Applications - Disaster & risk management

Presenter:
Asmerom Beraki
Council for Scientific and Industrial Research (CSIR) and University of Pretoria (UP)
Pretoria, SOUTH AFRICA
asmiefb@gmail.com

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Monitoring and prediction of marine coastal environments: the OGS regional operational system for the Northern Adriatic Sea

Querin, Stefano[1], Salon, Stefano[1], Cossarini, Gianpiero[1], Teruzzi, Anna[1], Solidoro, Cosimo[1], Bolzon, Giorgio[1]
[1]OGS, Trieste, Italy squerin@inogs.it

The Northern Adriatic Sea (NAd) is the northernmost part of the Mediterranean Sea: its environmental conditions are determined by shallow bathymetry, extensive freshwater inputs dominated by the Po river, and strong evaporation in winter due to cold and dry winds which may cause dense water formation. Further, NAd coastal waters belong to a cross-border region (Italy, Slovenia, and Croatia) where tourism activities and marine resources exploitation depend on and influence the quality of the ecosystems, which in turn are strongly linked to nutrients loads and eutrophication phenomena. The implementation of a regional operational system for NAd marine environment is a key asset to provide services for different users involved in monitoring, management, and economic activities.

We are developing a pre-operational system for NAd that will extend the existing service implemented within the Copernicus CADEAU demonstration project, based on an integrated model downscaling of the regional Mediterranean Copernicus Marine Environment Monitoring Service (CMEMS), and presently providing information about the biogeochemical seawater conditions (http://medeaf.inogs.it/adriatic).

The system features a high-resolution (1/128), coupled MITgcm-BFM model, initialized and driven by the downscaling of CMEMS Mediterranean products. The MITgcm (http://mitgcm.org/) and the BFM (http://bfm-community.eu/) are widely used models for atmosphere/ocean dynamics and for ocean biogeochemistry, respectively. The system adopts a nudging data assimilation method, integrating in-situ datasets managed by the Italian Institute for Environmental Protection and Research (ISPRA), hydrological and meteorological data, and CMEMS satellite maps of sea surface temperature and chlorophyll. Model results reproduce the seasonal and interannual variability of the main hydrodynamic and biogeochemical properties of NAd, consistently with the national observing system data, literature references, and available climatologies.

Current products include short-term forecast provided as hourly maps of environmental variables (e.g. temperature, nutrients, chlorophyll, and oxygen). Derived products designed to support the assessment of the hydrodynamic and biogeochemical conditions and the evaluation of the Good Environmental Status in NAd to meet EU WFD/BWD/MSFD requirements are also supplied. The derived indexes can be useful tools to better manage potential sources of pollution, helping local administrations in assessing the impact of sewage discharges on bathing waters or assisting the management of aquaculture plants for the reduction of the impact of bacterial pollution on harvested products.

Foreseen system developments include revised modeling of optics-biology interactions and the assimilation of current velocity assimilation from radar data and biogeochemical coastal data.

Keywords: Models - Coupled modelling, Models - Ecosystem/BGC modelling, Systems - Coupled systems, Systems - Implementation of Ocean Prediction Systems,

Presenter:
Stefano Salon
OGS, Trieste, Italy
squerin@inogs.it

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P40 - **Abstract ID: 3598260**

Influence of atmospheric forcing on modelling the North Atlantic sub-polar gyre

Pennelly, Clark[1], Myers, Paul[1] [1]University of Alberta, Edmonton, Canada pennelly@ualberta.ca

The North Atlantic sub-polar gyre contains regions which experiences intense air-sea exchange during convective winter periods. With large amounts of buoyancy loss via both latent and sensible heat, there are weakly stratified regions within the sub-polar gyre capable of deep convection. Numerical simulations are excellent tools to examine the effects of deep convection in these regions, though the atmospheric forcing datasets available can differ significantly. We evaluated five atmospheric forcing datasets with different spatial and temporal resolution: DFS5, ERA-Interim, CORE2/NCEP, JRA55, and the Canadian Meteorological Centres Global Deterministic Prediction System (CGRF).

With variability between the five forcing fields, each dataset prescribes different conditions over the ocean. This will result varying heat transport between the atmosphere and the ocean, precipitation minus evaporation differences, culminating in varying levels of buoyancy removal over convective regions. We investigate both the differences between the atmospheric products as well as simulations forced by each product. We compare the differences carried out by these five simulations on convective regions around the sub-polar gyre, specifically focusing on the subduction rate and density class of the deepwater produced.

Keywords: Models - Ocean model boundary conditions and forcings, Models - Ocean processes and parameterisation, Models - Ocean model configurations, Models - Current scientific challenges of ocean modelling,

Presenter:
Paul Myers
University of Alberta
Edmonton, Canada
pmyers@ualberta.ca

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P42 - Abstract ID: 3606859

Modelling ocean-ice climate variability off Newfoundland and Labrador over 1979-2010

Han, Guoqi[1], Ma, Zhimin[1], Chen, Nancy[1] [1]Fisheries and Oceans Canada, St. John's, Canada guoqi.han@dfo-mpo.gc.ca

A coupled ice-ocean model with a horizontal resolution of 7 km is developed for the Newfoundland and Labrador Shelves to examine climate trend and variability of ocean and ice conditions over 1979-2010. Daily surface atmospheric forcing is applied and monthly open boundary conditions are prescribed. The model has reasonable skill in simulating interannual and decadal variability and long-term (1979-2010) trend for temperature, salinity, transport and ice over the Newfoundland and Labrador Shelves. The interannual variability and long-term trend of model temperature and salinity agree approximately with observations at an offshore monitoring station near St. Johns. The model sea ice extent south of 55N shows significant interannual and decadal variability and a declining trend consistent with observations. The volume transport of the model Labrador Current agrees approximately with that estimated from observations. The total Labrador Current volume transport is correlated with the North Atlantic Oscillation with time lags of 0-3 years, with the inshore branch having a positive trend while the shelf-edge branch having no trend. The inshore Labrador Current shows an increase of the freshwater transport associated with an increase of the volume transport due to large-scale baroclinic forcing, with its interannual and decadal variability dominated by the volume transport; while the shelf-edge transport shows a decrease of the freshwater transport associated with an increase of salinity, with its interannual and decadal variability dominated by salinity.

Keywords: Models - Coupled modelling, Models - Model assessments and verification, Models - Downscaling, ,

Presenter:
Guoqi Han
Fisheries and Oceans Canada
St. John's, Canada
guoqi.han@dfo-mpo.gc.ca

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P43 - **Abstract ID: 3613226**

Extrapolating Eulerian ocean currents for improving surface drift forecasts

Tamtare, Tamkpanka[1], Dumont, Dany[1], Chavanne, Cédric[1] [1]ISMER/UQAR, Rimouski, Canada
tamkpanka.tamtare@uqar.ca

Ocean surface drift forecasts are essential for numerous applications, from search and rescue and oil spill response operations, to environmental planning and management. The accuracy of surface drift forecasts depends to a large extent on the quality of ocean current and wind forecasts, but also on the drift model used. The standard Eulerian leeway drift model that is commonly used for operations considers that the drift is a linear combination of the top-layer ocean current and the wind velocity vectors. Such formulation assumes that the wind imposes a direct local force on the floating object or substance. However, the wind also generates waves and forces a vertical shear of the current near the surface, two effects that do not depend on the local wind and that both affect the drift. Here we describe drift models that make use of different extrapolation methods to better estimate the near-surface current and compare their performances with the a standard drift model. We assess the performance of the models using observations from drifting buoys deployed in 2014 and 2015 in the Gulf of St.Lawrence (GSL). Currents and winds are provided by the operational coupled atmosphere-ice-ocean regional prediction system of the GSL. The performance of drift models is evaluated based on a number of error metrics (e.g. speed, direction, separation distance between the observed and simulated positions) and skill scores of drift models are determined at different lead times ranging from 3h to 72h. Results show that significant improvements in drift forecast skills can be obtained at relatively low computation cost by extrapolating filtered ageostrophic ocean currents to the surface assuming an Ekman layer. If we explicitly consider the Stokes drift obtained from a spectral wave model in addition to extrapolated current, further improvement is achieved while the wind-dependent term is practically reduced to zero.

Keywords: Models - Ocean processes and parameterisation, Applications - Search and rescue, Models - Coupled modelling, Applications - Marine pollution,

Presenter:
Tamkpanka Tamtare
ISMER/UQAR
Rimouski, Canada
tamkpanka.tamtare@uqar.ca

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Change of hydrography and currents due to sea ice formation in the Bohai Sea and the Northern Yellow Sea

Myoung, Sung-Kwan[1], Choi, Byoung-Ju [1], Jung, Young-Joo[1], Kim, Jong-Kyu[2] [1]Chonnam National University, Gwangju, Republic of Korea [2]Gunsan National University, Gunsan, Republic of Korea wonder252@naver.com

Effects of the sea ice formation on the ocean temperature, salinity, and current have not been considered when the currents and hydrography were studied in the Bohai Sea and Northern Yellow Sea. This study focused on the local change of hydrography and current caused by sea ice formation in the Bohai Sea and the Northern Yellow Sea. The sea ice begins to form in December. The sea ice volume reaches its peak in January, and the sea ice completely disappears in March. Formation of sea ice and ocean circulation were analyzed from December 2010 to March 2011 using satellite images and numerical model simulations. The ocean circulation and sea ice were simulated using a coupled model of ocean circulation and sea ice (ROMS-CICE). Results from the Sea Ice Model (SIM) experiment with the coupling of sea ice and ocean circulation was compared with those from the No Ice Model (NIM) experiment without sea ice module. The results of the formation and extent of sea ice in the SIM experiment were validated using satellite images from MODIS-Aqua/Terra. To understand the salinity differences between SIM and NIM experiments, the Cumulative Freezing Rate (CFR, sea ice volume formed for 90 days at each grid point) and the Cumulative Melting Rate (CMR, sea ice volume melted for 90 days) were calculated. The square of the spatial correlation coefficient between the salinity difference and the CFR-CMR was 0.73. This indicates that the spatial salinity difference between the SIM and the NIM experiments is related to the formation and melting of sea ice. In the SIM experiment, relatively low salinity (less dense) water occupied along northern coast of Liaodong Bay compared to the offshore in December. However, in the January, seawater density distribution was horizontally reversed due to sea ice formation in the shallow coastal region, i.e., water density in the northern coastal regions of the Liaodong Bay and the West Korea Bay became higher than that in the offshore. The horizontal density reversal induced baroclinic current to the northwest in the SIM experiment. The baroclinic current weakened the currents flowing southeastward along the coastlines of the Liaodong Bay and the West Korea Bay. Due to the changes in surface net heat flux as well as currents, the temperature in the offshore of the Liaodong Bay and the West Korea Bay was higher about 0.8C in the SIM experiment than that of the NIM experiment.

Keywords: Models - Coupled modelling, Systems - Coupled systems

Presenter:
Byoung-Ju Choi
Chonnam National University
Gwangju, Republic of Korea
bchoi@jnu.ac.kr