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

Theme 3: Numerical Modelling

Session 4: Applications and advances in simulating sea ice

Abstract ID: 3598122

Sub-mesoscale modelling of the Labrador Sea

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

The Labrador Sea is a very dynamic region, with physical processes occurring at a variety of scales, from large scale gyre circulation to small scale convection processes. These small scale features are difficult to represent with numerical simulations due to high computational costs. We carry out a NEMO simulation incorporating two AGRIF nests to achieve 1/60 horizontal resolution (about 900m) in the Labrador Sea. We apply high spatial (about 30km) and temporal (hourly) atmospheric forcing from the Global Deterministic Prediction System produced by the Canadian Meteorological Centre.

This expensive simulation will be run over 2002-2018. We will showcase some results, primarily focused on the greatly improved spatial extent of convection, subduction of Labrador Sea Water, and resolved eddies including Irminger Rings. Four passive tracers have been included and will be discussed: Greenland runoff, Canadian Arctic outflow, Labrador Sea Water produced during convection, and Irminger Water which flows west past Cape Farewell. Furthermore, we will illustrate some of the challenges setting up such a simulation.

Keywords: Models - Model grid structure and resolution, 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

Abstract ID: 3567606

A numerical analysis of effects of contemporary sea ice loss on Arctic primary production

Bourgeois, Timothee[1], Fennel, Katja[1], Richaud, Benjamin[1], Luo, Xiaofan[2], Hu, Xianmin[3], Lu, Youyu[3] [1]Dalhousie University, Halifax, Canada [2]Tianjin University, Tianjin, China [3]Bedford Institute of Oceanography, Dartmouth, Canada timothee.bourgeois@dal.ca

The Arctic Ocean is changing at a dramatic pace with the melting of multi-year sea ice as one of the most obvious consequences of global warming. Developing integrated ocean forecasting systems for the Arctic Ocean is crucial to understanding these ongoing and future changes and to evaluate their socio-economics impacts such as changes in phytoplankton biomass and the fisheries resources relying on them. The reduction in sea ice coverage induces changes in light availability, freshwater cycling and ocean surface exposure to wind stress that result in modulations of phytoplankton activity. At the pan-Arctic scale, remote sensing- and model-based studies suggest a contemporary increase of Arctic primary production but differ in the extent of this change at both Arctic and regional scales. Here we use the coupled physical-biogeochemical model NEMO-PISCES to study the contemporary changes of Arctic primary production. With a horizontal resolution ranging from 10 to 20 km, our model domain covers the Arctic Ocean and extends to 45˚N in the Pacific and to 25˚N in the Atlantic Ocean. Based on a multi-decadal simulation, our model results describe both pan-Arctic and regional interannual changes in the primary production. Our model results show a 22 % increase in the Arctic primary production inventory from 1998-2002 to 2011-2015, reaching 314 Tg C yr-1. The main primary production increases occur in the Barents, Laptev and Chukchi Seas as well as along the coasts of Beaufort Sea. Although light availability is the main limiting factor for phytoplankton growth in our model, the frequency of nutrient limitation events increases during summer in some Arctic shelf seas in parallel to the long-term increase in sea ice retreat.

Keywords: Models - Ecosystem/BGC modelling, Models - Current scientific challenges of ocean modelling, , ,

Presenter:
Timothee Bourgeois
Dalhousie University
Halifax, Canada
timothee.bourgeois@dal.ca

Abstract ID: 3557888

Skill metrics for evaluation of numerical models

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

Evaluation of model performance is necessary for any numerical approach in order to assess the accuracy of representation of the simulated processes with respect to some reference (or control) state from observations or simulation. While qualitative methods (visual comparison) can be more informative, in many applications robust quantitative approaches are necessary. Here, several quantitative methodologies (skill metrics) that may be used to assess the skill of different numerical models (e.g., sea ice, hydrodynamic) against a control field are analyzed. The methodologies are Absolute Deviation, Root Mean Square Deviation, Mean Displacement, Hausdorff Distance, and Modified Hausdorff Distance. The methodologies are employed to quantify similarity between spatial distribution of the simulated and control scalar fields providing measures of model performance. To analyze their response to dissimilarities in 2-dimensional fields (contours), the metrics undergo sensitivity tests (scale, rotation, translation, and noise). Furthermore, in order to assess their ability to quantify resemblance of 3-dimensional fields the metrics are subjected to sensitivity tests where tested fields have continuous random spatial patterns inside the contours. The Modified Hausdorff Distance approach demonstrates the best response to tested differences, with the other methods limited by weak responses to scale and translation. Both Hausdorff Distance and Modifed Hausdorff Distance metrics are robust to noise, as opposed to the other methods. The metrics are then employed in realistic cases to demonstrate their performance. The metrics are used to evaluate simulated sea ice fields, oil spill distribution, and river plumes.

Keywords: Models - Numerical methods, Models - Model assessments and verification, Systems - Prediction system performance & evaluation, Systems - Prediction system validation/ intercomparisons,

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

Abstract ID: 3609621

A probabilistic parameterization of seabed-ice interaction

Dumont, Dany[1], Dumas-Lefebvre, Élie[1], Lemieux, Jean-François[2], Dupont, Frédéric[3] [1]ISMER/UQAR, Rimouski, Canada [2]RPNE/ECCC, Dorval, Canada [3]SMC/ECCC, Dorval, Canada dany_dumont@uqar.ca

A few years ago, we have introduced a simple parameterization to represent the grounding of pressure ridges in shallow water. Such a parameterization is required so that a sea ice model can properly simulate landfast ice in regions such as the Laptev Sea, the East Siberian Sea and along the coast of Alaska. This parameterization, which can be used for both single and multi-thickness category models, clearly improves the simulation of landfast ice in the coastal regions mentioned above. We here propose a more sophisticated and realistic scheme that takes advantage of the simulated ice thickness distribution (ITD). Based on a crude ITD (models are typically run with 5-10 categories), the ITD and importantly its tail are represented by a log-normal distribution. On the other hand, the ocean bathymetry is approximated by a normal distribution. The seabed stress, treated as an additional term in the sea ice momentum equation, is calculated as a joint probability between the two distributions. We will describe this new grounding scheme and compare its simulated landfast ice cover to the one obtained with the previous parameterization.

Keywords: Models - Ocean processes and parameterisation, Models - Numerical methods, Applications - Coastal protection, Applications - Ship navigation, Systems - Prediction system performance & evaluation

Presenter:
Dany Dumont
ISMER/UQAR
Rimouski, Canada
dany_dumont@uqar.ca

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

Abstract ID: 3610038

Wave – Ice Interactions in the Marginal Ice Zone of the Beaufort Sea

Perrie, Will[1], Toulany, Bash[1], Meylan, Michael[2] [1]Bedford Institute of Oceanography, Dartmouth, Canada
[2]University of Newcastle, Callaghan, Australia William.Perrie@dfo-mpo.gc.ca

The marginal ice zone (MIZ) is an interfacial region of ice floes which forms at the boundary of open water and continuous ice. Wave induced breaking is this process which defines the MIZ. However, wave action can only break up the continuous ice over an finite distance; wave energy is dissipated by scattering from the floes which form the MIZ. Thus, the MIZ is formed by wave-induced breaking of continuous ice, which shields the continuous ice from breaking. There are two aspects which need to be understood in this process: one is the wave-induced breaking of the continuous ice; the other is the wave scattering in the MIZ. Here, we model the latter process. Experimental studies of wave propagation in the MIZ show that there is strong exponential attenuation of energy, which decreases with increasing distance into the MIZ. Wave scattering in the MIZ is due to individual ice floes. To understand this process, we need to understand the scattering by individual ice floes. Moreover, the energy balance equation for waves is dependent on the scattering from individual floes, and it takes a different form in wave scattering of multiple floes. Determining the scattering from individual scatterers can take several approaches; one is the linear Boltzmann (or transport) equation, and the other, multiple scattering. The MIZ is slightly complex because of the random (geometry) nature of the scatterers and the ice floe motions; the scattering tends to be incoherent. However, all large-scale scattering theories are based on individual scatterers and basically assume that they are identical. Here, we apply this approach, including terms for wave generation, dissipation, and nonlinear wave-wave interactions, implemented in an operational wave forecast model WAVEWATCHIII (WW3), which leads to a realistic model for wave scattering in the MIZ, including multiple scattering theory. We consider rigid ice floes, which can be generalised to more general ice floes with flexure. We show that this model gives realistic results for test cases: (a) application to a hypothetical square-box ocean, with MIZ, and (b) implementation to the Beaufort Sea and comparisons to field observations of ice floes (thickness, length, concentration) wave scattering and attenuation as waves propagate into the observed MIZ from the open ocean, during a series of marine storms. This data was collected during the Sea-state Boundary Layer Experiment conducted in October-early November 2015.

Keywords: Models - Ocean processes and parameterisation, Models - Numerical methods, , ,

Presenter:
Will Perrie
Bedford Institute of Oceanography
Dartmouth, Canada
William.Perrie@dfo-mpo.gc.ca

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

Abstract ID: 3576539

Developing new high resolution coastal ice-ocean prediction systems for the northwest Atlantic and Gulf of St. Lawrence to support the Ocean Protection Plan

Roy, François[1], Paquin, Jean-Philippe[1], MacDermid, Sarah[2], Smith, Gregory[1], Lemieux, Jean-François[1], Dupont, Frederic[3], Lei, Ji [3], Lu, Youyu[4], Hu, Xianmin[4], Senneville, Simon[5], St-Onge Drouin, Simon[6], Chanut, Jérôme [7]
[1]MRD, Dorval, Canada [2]MSC, Halifax, Canada [3]MSC, Dorval, Canada [4]DFO, Halifax, Canada [5]UQAR ISMER, Rimouski, Canada [6]DFO, Mont-Joli, Canada [7]Mercator Ocean, Toulouse, France francois.roy3@canada.ca

In order to provide Canada with short-term ice-ocean predictions and oil spill fate and behavior forecasts for the Ocean Protection Plan, the Government of Canada CONCEPTS initiative (Canadian Operational Network of Coupled Environmental Prediction Systems) is developing new coastal ice-ocean prediction systems. Two configurations are being tested, a northwest Atlantic 1/36 degree (~2 km) resolution domain (NWA36) and a Gulf of St. Lawrence 500 m resolution domain (GSL500). The first domain covers the Gulf Stream region and the Canadian east coast including mainly the Grand Banks, the Scotian Shelf and the Gulf of St. Lawrence. The second domain covering the Gulf of St. Lawrence is bounded by Cabot and Belle-Isle straits. NWA36 and GSL500 use the NEMO-CICE ice-ocean model, both simulating explicit tides with a variable volume representation of the water column, storm surge forcing including the inverse barometer effect. Vertical mixing uses a general length scale scheme. The St. Lawrence River is represented using a one-dimensional hydrological model. The multi-category ice dynamics includes a landfast ice parameterization based on basal stress. In a first evaluation, we present free runs of both configurations focusing on results in the Gulf of St. Lawrence: tidal propagation, general circulation patterns, ice volume and concentration, water masses evolution, estuarine circulation and hydraulics, and freshwater and volume transports. It is envisaged that these configurations will eventually supersede the operational Gulf of St. Lawrence system, currently at 5 km resolution.

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

Presenter:
François Roy
MRD
Dorval, Canada
francois.roy3@canada.ca