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

# Theme 3: Numerical Modelling

## Session 2: Forecasts and nowcasts from models of ocean, atmosphere, and ice II

**Abstract ID: 3576211**

### Latest hindcast of the CONCEPTS 1/12th degree resolution Arctic-North Atlantic ice-ocean configuration

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The Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) has developed a 5km Regional Ice-Ocean Prediction System (RIOPS) based on NEMO-CICE. The system, run operationally with an experimental status, produces four 48h iceocean forecasts per day and provides hazard warnings in ice-infested regions. RIOPS includes in particular explicit tides and a landfast ice parametrization based on the effect of grounded ice ridges (Lemieux et al. 2015) and on an increased resistance to tension and shear in the ice rheology (Lemieux et al. 2016). In support of the physics used in the operationally-run model, we run regular hindcasts of the model. This lastest hindcast forced by the Canadian Global ReForecast was run from October 2001 to December 2016 in order to test a series of innovations: 1) extended domain covering the North Pacific Ocean (hence, the three Canadian oceans are now covered), 2) higher vertical resolution in the deep ocean, 3) WOA2013 initialization, 4) an update of the NEMO code to v3.6, 5) effect of reducing the diffusion and viscosity to molecular values. In general, it was found that ice velocities have a low RMS error against buoys, despite a slight negative bias. The ocean stratification in the Beaufort Sea is much improved, although the ratio of atmospheric to ocean drag does not allow for as much subduction of the upper ocean as observed. A large drop in September total ice area and volume starting in 2009 is seen and warrants further investigation of the radiation bias present in numerical weather prediction models used at ECCC.

**Keywords:** Models - Model assessments and verification, Models - Ocean model configurations, Models - Ocean processes and parameterisation, Systems - Prediction system performance & evaluation, Systems - Coupled systems

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# Southeastern Gulf of Mexico processes affecting basin-wide connectivity and hydrocarbon transport: the role of mesoscale eddies and upwelling near Cuba

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Despite great advances in the understanding of Gulf of Mexico (GoM) dynamics, parts of the southeastern GoM have not received much attention. This particularly applies to GoM waters off northwestern Cuba due to lack of accessible in situ observational studies in Cuban waters. No studies to date have analyzed to what extent loop current evolution is impacted by oceanographic processes in this region, especially data detected warm-core and cold-core mesoscale eddies, evolving over persistent coastal upwelling. In addition, this is an area of oil exploration; activities in Cuban waters have already taken place and are expected to resume soon. Here we present long term simulations over several years of continuous surface spills around Cuba to statistically identify the regions in GoM and the Caribbean which are the most likely stranding locations. An open source oil drift model (OpenDrift) is applied with high resolution hydrodynamical forcing from HYCOM ocean models setups and ECMWF atmospheric and wave models. Significant year to year variability is identified.

**Keywords:** Applications - Coastal protection, Models - Ocean model configurations, Models - Ocean model boundary conditions and forcings, Models - Ocean processes and parameterisation, Applications - Environmental assessment

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## Predictability in the Straits of Florida: the role of eddies and coastal upwelling near Cuba

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A near real time prediction system has been providing high resolution (~900 m) ocean forecasts around the Florida Straits since 2014. Recent developments in the understanding of the local dynamics with basin-wide implications have improved the model predictability. In particular, mesoscale anticyclonic eddies, usually formed along the northwestern Cuban coast (CubANs), have been found to substantially contribute to the variability of the Loop Current / Florida Current (LC/FC) system, in addition to cyclonic mesoscale eddies north of the FC. Two main types of such anticyclonic eddies have been identified along the northwestern Cuban coasts: type A CubAN within the core of the LC during retracted phase conditions and type B CubAN which is an individual, distinct anticyclonic eddy that is released from the main LC core and is advected eastward, along the northern Cuban coast. A type A CubAN can also be present in tandem with one or more eastward progressing type B eddies. Herein, we investigate the local and regional processes that contribute to the formation of these two types based on characteristic events derived from a long-term high resolution simulation (2010-2017), in tandem with respective satellite (ocean color) and in situ observations. We seek to understand both how CubANs form and what is their role on the basin-wide Gulf of Mexico (GoM) dynamics. Moreover, we investigate the interaction of these anticyclones with local dynamics such as coastal upwelling along the Cuban coast under favorable easterly winds, which brings waters of high nutrient content to the surface. The offshore transport of these upwelled waters, due to the synergy between eddies, may introduce strong temperature gradients in the Straits that may have substantial effects on reefs, Marine Protected Areas and areas of future oil exploration. It is found that each CubAN type is related to different formation pre-conditions. Type B CubAN eddy activity coincides with northern displacements of the FC along the Straits similarly to its meandering due to the cyclonic eddies that evolve along the northern Straits. These anticyclones influence the general circulation in the Florida Straits, with implications on basin-wide ocean forecasting.

**Keywords:** Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Applications - Coastal protection, Applications - Oil & gas industries, DA - Shelf-seas and coastal data assimilation, Models - Current scientific challenges of ocean modelling

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# Forcing mechanisms and predictability of ocean variability based on high-resolution model simulations for shelf waters around Canada

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Through collaborative efforts during the past decade, a series of high-resolution ocean forecasting models have been developed for the global ocean, and also the basins, shelf seas and coastal waters around Canada, based on the Nucleus for European Modelling of the Ocean (NEMO). Besides applying these models for operational forecasting, we also carry out long-term (multiple years to decades) hindcast simulations without data assimilation. Evaluation of the hindcast simulations with observational data enables the quantification of model accuracy, while exploring the causes of biases also helps further model improvement. In this talk, we present further analyses of the model results to reveal the forcing mechanisms and hence the predictability of the variations of temperature, salinity, sea levels and currents in shelf seas, based on the combination of dynamic and statistical approaches. Highlights of the new findings include the identification of the roles played by local and remote atmospheric forcing, the signals carried by ocean currents and shelf waves, and also the interaction between shelf seas and the deep ocean.

**Keywords:** Models - Downscaling, Models - Model assessments and verification, Models - Ocean processes and parameterisation, Models - Ocean model configurations,

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# Impact of small-scale coupled atmosphere-ice-ocean interactions: Results from the Canadian high-resolution forecasting system for YOPP

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In the context of the Year of Polar Prediction (YOPP, 2017-19), a pan-Arctic coupled atmosphere-ice-ocean model has been developed to investigate the impact of coupled interactions in daily 48h forecasts produced in real-time during YOPP. The atmospheric component, the Canadian Arctic Prediction System (CAPS), runs over a regional domain with a 3 km grid spacing and has the latest innovations from the Global Environmental Multiscale (GEM) model, including a new Prediction Particle Properties (P3) microphysics scheme (clouds, precipitation). During the forecast, the atmospheric model is coupled at each time step to an ice-ocean model running over a regional 3-8 km resolution domain, covering the Arctic and North Atlantic regions, namely the Regional Ice-Ocean Prediction System (RIOPS). RIOPS uses the NEMO-CICE ice-ocean model and includes explicit tides, a landfast ice parametrization based on the effect of grounded ice ridges (for improved representation over shallow waters), and an increased resistance to tension and shear in the ice rheology (for improved representation in land-locked areas). Each time step CAPS sends its surface state variables to RIOPS that computes in exchange detailed surface fluxes (momentum, heat and moisture) over the open ocean and the ice pack, aggregating them over the multi-thickness ice distribution. Results from the YOPP Special Observing Periods are presented from coupled and uncoupled forecasts showing the impact of coupled interactions at regional and basin scales. In particular the effect of lead fractions and wind channeling in the Canadian Arctic Archipelago are discussed. Additionally, it is shown that details of sea ice model physics can affect small-scale sea ice features (coastal polynyas, ridging) which in turn result in a tangible impact on atmosphere-ice-ocean fluxes of heat and moisture.

**Keywords:** Models - Coupled modelling, Systems - Coupled systems, Models - Model grid structure and resolution, Evolution - International and intergovernmental collaboration, Systems - Prediction system validation/ intercomparisons

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