Preliminary Analysis of Sea-Ice Variation and Oceanic Current in the Bering Sea

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Introduction

The Bering Sea is a semi-closed sea, where the lateral water exchanges with the open ocean take place only through the passes among Aleutian Islands on the south and the Bering Strait on the north. Located between the Siberia High and Aleutian Low, the Bering Sea experiences a strong seasonal variation in the surface momentum, heat, and fresh water fluxes, and sea ice cover as well (Stabeno et al, 1999). To study the variability in the physical processes in the Bering Sea, the Regional Oceanic Model System (ROMS) is being applied to simulate the oceanic circulation and sea ice variation in a regional model configuration with the horizontal resolution of about 5km, see Figure 1. In this poster, a global ROMS solution with the sea ice and its comparison with the SSM/I sea ice observational data are presented. To examine the sensitivity of the circulation in the Bering Sea to the model grid resolution and the presence of the sea ice, the global solution is also compared with a Pacific ROMS solution with 1/8 degree in the horizontal resolution and no sea ice.

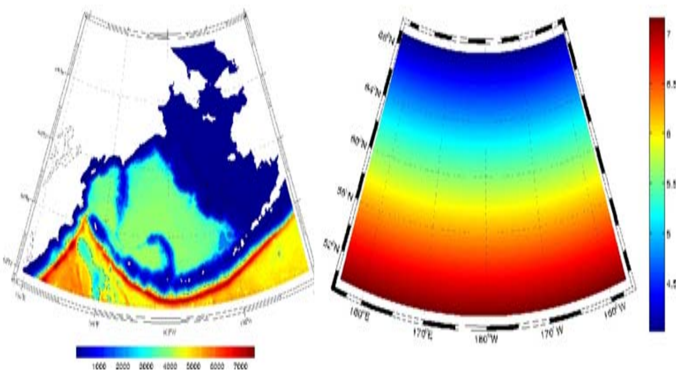

Figure 1. Left panel: the ROMS model domain in the Bering Sea. The color is the water depth (m). Right panel is the grid size .

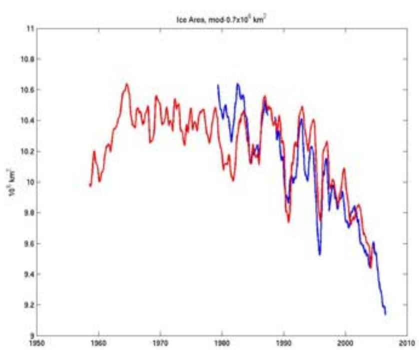

Figure 2: The sea ice are in the Northern hemisphere from the global model (red) and SSM/R and SSM/I (blue).

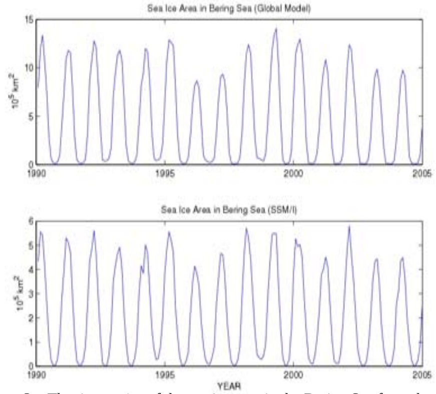

Figure. 3 The time series of the sea ice area in the Bering Sea from the global model (top) and the SSM/I (bottom).

The Sea-ice Global ROMS

ROMS solving the rotating primitive equations, is a split-explicit, free-surface oceanic model. In the global ROMS configuration with the sea ice (developed by P. Budgell), its horizontal resolution is 8.9km to 105km on a stretched spherical grid with Mercator projection and there are 35 levels in the vertical and stretched coordinate with enhanced resolution in the surface. The sea ice module includes the ice dynamics based on the elastic-viscous-plastic (EVP) rheology and ice thermodynamics. CORE (Common Ocean-ice Reference Experiment) data are used for the forcing, surface heat flux and momentum fluxes are computed using COARDS 3.0 bulk flux algorithms in ROMS. The model is run from 1958 to 2004 with the initial condition from NERSC MICOM. Figure 2 plots the time series of the sea ice variation in the northern hemisphere (for model data 0.7 x 10^6 km ^{2} is subtracted), showing a seasonal and inter-annual variability in sea ice coverage. Its good agreement with the SSM/R and SSM/I sea ice data demonstrates the capability of the sea ice model in ROMS to capture the sea ice dynamics.

Zoomed in the Bering Sea, Figure 3 shows the sea ice variation in 15 years from 1990 to 2004 from both the global model and SSM/I. The model can reproduce the time variation of the sea ice in the Bering Sea. The seasonal variability is very strong: during summer, the sea ice vanishes. During the ENSO year (1997-1998), the dramatic decrease in sea ice area can be seen in both the model and data. The sea ice area in winter from the model is larger than that in th observation. Figures 4 and 5 show the sea ice distribution from the model and the SSM/I respectively. The observational data show that sea ice is only seen in the eastern shelf area of th Bering Sea, where the water depth is less than 200m (Figure 5). The extra sea ice generated b the global model in Figure 4 is along the Kamchatka coastal area. The reason is because that th coarse resolution (20km-30km) in the Bering Sea in the global model can not resolve the Alask Islands which results in the failure of producing the Alaska Stream, see Figure 6.

Figure 6 is the mean surface circulation in March (averaged over 15 years) from the global model. The Bering Coastal Current and the Bering Strain outflow are presented, however the Alaska Stream is not resolved. The warmer water carried by the Alaska Stream entering the Bering Sea through the passes along the Aleutian Islands can significantly reduce the presence of the sea ice along the Kamchatka coast.

To examine the sensitivity of the oceanic current to the model resolution, we analyze a solution from our Pacific Ocean configuration with the higher resolution (1/8 degree) and no sea ice and the Bering Strait closed. Figure 7 plots the mean surface current (averaged over 15 years) in March. The Alaska Stream, the Bering Slope Current, and Kamchatka Coastal Current are presented in the solution. Due to the closure of the Bering Sea, it is not surprised that the circulation in the eastern part is different from the realistic current. The comparison between Figure 6 and 7 shows resolving the Aleutian Islands are very important to simulate the Bering Sea current system.

Summary and Future Work

The global ROMS solution in the Bering Sea is analyzed. Its comparison with the observational sea ice data shows a good agreement in the seasonal and inter-annual variations of sea ice coverage in the Bering Sea. The model-generated sea ice area is larger than that from the observation. The extra sea ice is found along the Kamchatka coastal area. The model with the coarse resolution (20-30km) can not resolve the Aleutian Islands, resulting in the failure to present the Alaska Stream (part of the warmer water carried by the stream enter the Bering Sea) in the solution. The argument is further confirmed by a Pacific ROMS solution with a higher resolution.

For the next step, we will apply a high-resolution regional configuration with sea ice to study the variation of the physical processes in the Bering using the ROMS.

References:

Stabeno, P., J. Schumacher and K. Ohtani, 1999, The physical oceanography of the Bering Sea, Dynamics Of the Bering Sea, Chapter 1.

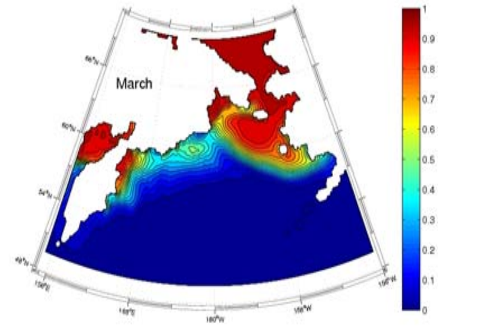

Figure 4. The mean sea ice concentration in the Bering Sea in March from the global ROMS.

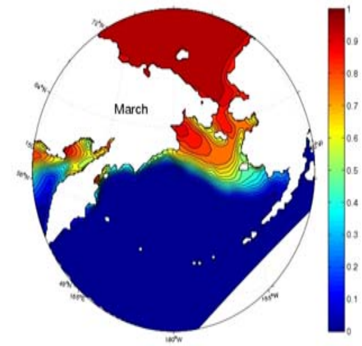

Figure 5. The mean sea ice concentration in the Bering Sea in March from SSM/I.

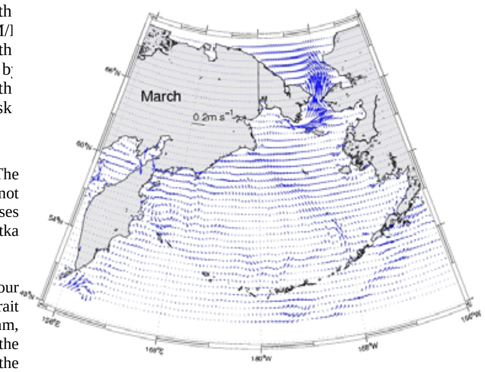

Figure 6. The mean sea surface current in the Bering Sea in March from the global ROMS.

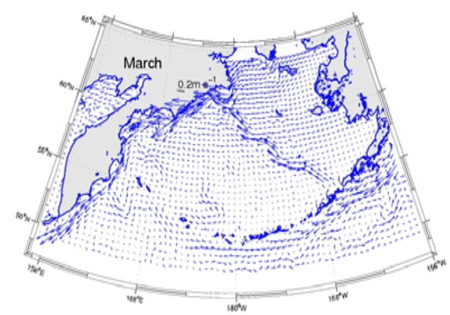

Figure 7. The mean sea surface current in the Bering Sea in March from the Pacific Ocean ROMS with the 1/8 resolution