MODELING THE WIND AND BUOYANCY-DRIVEN CIRCULATION AND ICE INTERACTION IN THE SEA OF OKHOSTK

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LONG TERM GOAL

The long-term goal of this proposed study is to develop a comprehensive understanding of the dynamics, the hydrography, and ocean-ice interaction in the Okhotsk Sea, and in subpolar marginal seas in general.

OBJECTIVE

The objective is to use coupled ocean-ice numerical models to study the basin-scale ocean circulation and ocean-ice interaction in the Okhotsk Sea, and to examine important processes that maintain the unique oceanographic setting, such as the Okhotsk Dichothermal Layer (ODTL) in this large marginal sea.

APPROACH

Our approach includes using a hierarchy of models, from a basin-averaged column model of ocean-ice interactions (Yang and Honjo, 1996) to a 3-D primitive equation ocean general circulation model coupled with a dynamical and thermodynamical sea-ice model. Meanwhile, we have analyzed some unpublished *in-situ* observations (mainly hydrography records from the Japanese Hydrography Office), satellite SSM/I data of sea-ice concentration, and meteorological observations (from Comprehensive Ocean and Atmosphere Data Sets (COADS) and from the Japan Meteorology Agency) to examine ocean-ice interactions and mechanisms for inter-annual variations.

ACCOMPLISHMENT

We extended the basin-averaged coupled ocean-ice model (Yang and Honjo, 1996) to further examine the Okhotsk Sea's responses to variations in the surface forcing fields and in water-mass exchanges with the Sea of Japan and the Pacific Ocean. Dr. S. Honjo at WHOI and I are preparing a manuscript based on this modeling study. Meanwhile, a major effort has been devoted to the 3-D model development. The model set-up and the preparation of the forcing fields are going smoothly with progress. We are concentrated on the implementing the inflow/outflow conditions through Soya Strait from the Sea of Japan and through the Kurile straits, and calibrations of model parameters. We are focused on modeling the seasonal cycle but will extend to include interannual

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variations in the future. Dr. S. Honjo and I have been working on some newly available hydrography and geochemical tracer data (unpublished previously) collected by R/V Shoyo (Shoyo cruise 9007 and 9105) of the Hydrography Office of Japan during August, 1990 and 1991. Significant changes in potential temperature, salinity and dissolved oxygen content were observed between 1990 and 1991. We therefore analyzed the satellite sea-ice observations and COADS meteorological data to examine the causes for these interannual variations. A manuscript, co-authored with S. Honjo and entitled "Atmosphere-Ocean-Ice Interactions in the Okhotsk Sea", was written based on these analyses.

SCIENTIFIC/TECHNICAL RESULTS

Our modeling results show that the water Okhotsk Dichothermal Layer is renewed by winter convective mixing when brine rejection associated with sea-ice formation destabilizes the water column. In the summer, the low salinity (due to spring melting of sea ice) and high temperature water in the mixed layer prevents the vertical mixing to reach the dichothermal layer, and therefore, the near freezing layer is able to sustain. However, our study also shows that the seemingly net-zero-gain process of winter freezing and summer melting can result in interannual variations in the ODTL and in sea-ice extent. Our study indicates that the strong seasonal variation in the atmosphere forcing fields is primarily responsible to some of the unique observed features in the Okhotsk Sea, such the the existence of the near freezing ODTL.

Meanwhile, we have examined observations of hydrography, tracers, surface and air temperature, and satellite sea-ice concentration to study the responses of a coupled ocean-ice system to variations in the atmosphere forcings. It was found that, the ODTL water in the central Okhotsk basin, between 50°N and 55.4°N in latitude, was considerably warmer and fresher in 1991 than in 1990. Figure 1 shows the differences of the potential temperature between August 1991 and August 1990 along the western Shoyo section at 149.15°W and at the eastern Shoyo section at 149.50°W. The COADS data showed that the northwesterly wind from Siberia was much stronger in the winter of 1990 than in 1991. Therefore, the air temperature was more than 5 deg C colder over most of the basin in January of 1990 than in the same month in 1991. The satellite SSM/I data showed that the sea-ice concentration in the central basin was up to 60% higher in 1990 than in 1991 (Figure 2). Therefore, the more vigorous convective mixing in 1990 was likely the cause for the observed difference in potential temperature and salinity. Yang and Honjo's (1996) model confirmed our analyses. This indicates that the coupled ocean-ice system in the Okhotsk Sea is very sensitive to variations in the atmosphere, especially in the winter season when convective mixing occurs. It also suggests that a predictive skill can be developed which can be used to infer the oceanographic conditions based on winter atmospheric conditions.

TRANSITIONS

The results from our on-going 3-dimensional model are anticipated to be available within 3 months. The 3-D model will be used to examine the observational studies described in the previous section.

RELATED PROJECTS

None.

PUBLICATIONS:
Yang, J. and S. Honjo, 1996: Modeling the near-freezing dichothermal layer in the Sea of Okhotsk and its interannual variations. *Journal of Geophysical Research*, Vol. 101, 16,421-16,433.
Yang, J. and S. Honjo, 1997: Atmosphere-Ocean-Ice Interactions in the Okhotsk Sea, *Deep-Sea Research*, to be submitted.

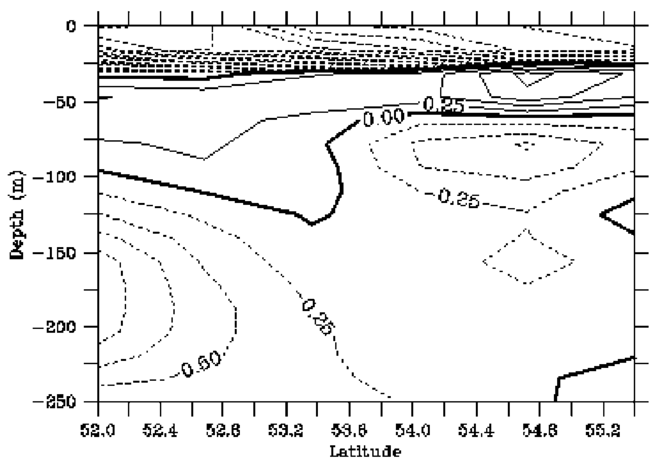

Figure 1(a) Temperature Difference (1991−1990) at 149°15W

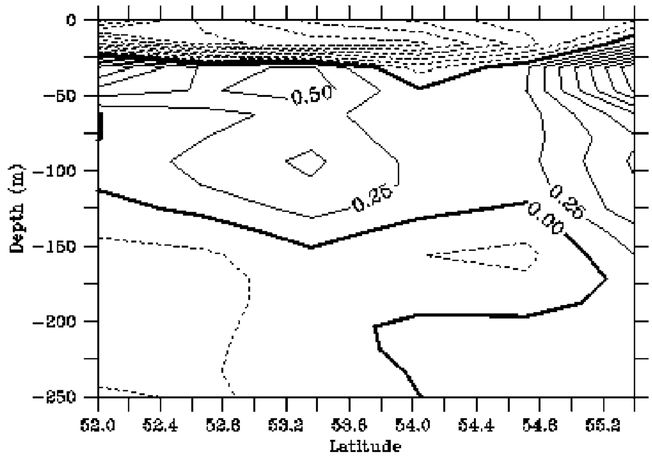

Figure 1(b) Temperature Difference (1991−1990) at 149°50W

Sea–Ice Concentration Difference: 1990–1991 (March)