IPY Oslo 2010
Paper-1025

Forcing Mechanisms of Seasonal Flows through Barrow Strait

Jie Su(1,2, sujie@ouc.edu.cn), Youyu Lu(2), Simon Prinsenberg(2), Gilles Garric(2), Zeliang Wang(2), and Roger Pettipas(2)
1. Key Lab of Polar Oceanography and Global Ocean Change, Ocean University of China, Qingdao, Shandong, China
2. Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, NS, Canada

Introduction

Barrow Strait (BS) is a main channel in the Canadian Arctic Archipelago (CAA). It is one of the major expected shipping routes of the "Northwest Passage" as a consequence of sea-ice decrease under global warming. Continuous monitoring of flow and hydrography in BS started in 1998 by the Department of Fisheries and Oceans of Canada (Prinsenberg et al., 2005).

In this paper, we first analyze the mooring observations in BS to derive seasonal variations of flow and transport; and make direct comparison between observations and model results. Then we analyze the large-scale structures of the model simulated fields and explore the link between seasonal variations in BS and those upstream in the Beaufort Sea and Bering Strait.

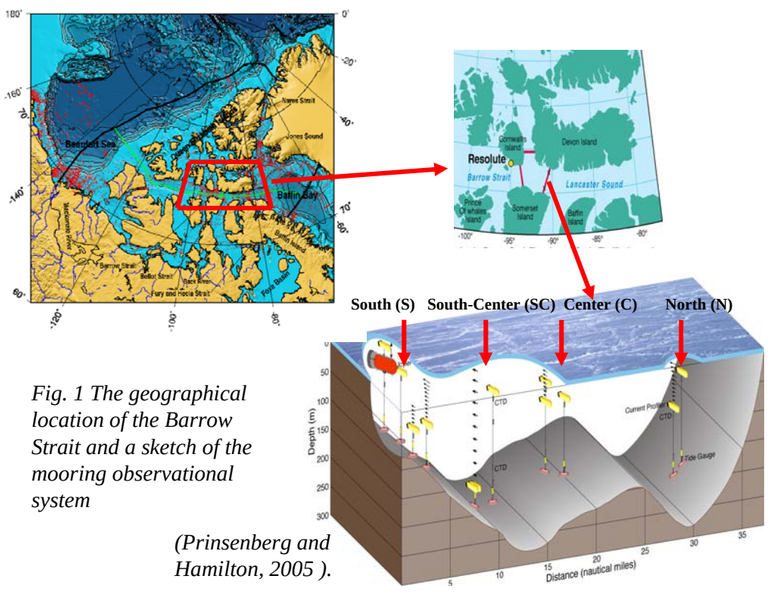

Fig. 1 The geographical location of the Barrow Strait and a sketch of the mooring observational system

(Prinsenberg and Hamilton, 2005).

Observed and model simulated flow and volume transport in Barrow Strait

Eight-year current observations, from August 1998 to August 2006, are analyzed. The "mean" seasonal cycle of currents is obtained by averaging the monthly values from the same month of different years.

The mooring observations in BS reveal complicated seasonal variations of velocity. The downstream flow (from Arctic to Baffin Bay) intensifies toward the southern coast of the strait. This is the main contributor to the total downstream volume transport in BS. Along the northern side of the strait upstream flow occurs in summer, and in the other months the flow is weak in both the upper and lower layers.

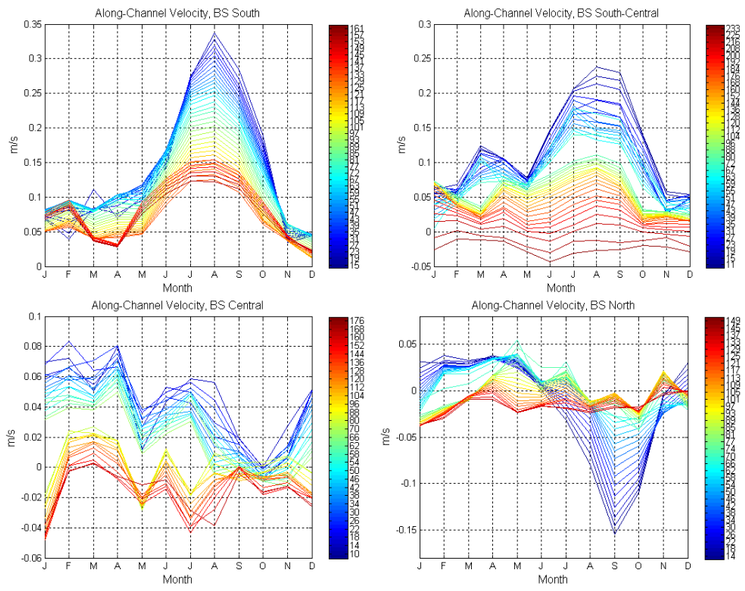

Fig.2 Mean seasonal cycles of flows in the Barrow Strait derived from 8-year mooring observations, at S, N, SC and C locations.

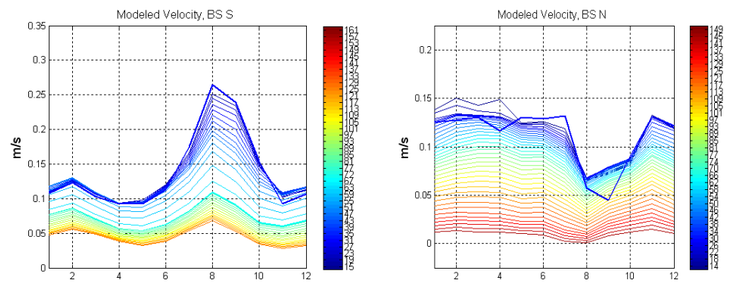

Fig.3 Model results of flows at S and N stations.

In each panel of Fig. 2 and Fig 3, the color axis denotes water depth in meters (blue in shallow layers and red in deep layers). The vertical axis denotes flow magnitude (in m /s).

The results from a global ice-ocean models based on the Nucleus for European Models of the Ocean (NEMO) with the resolution of 1/4° and 50 levels in the vertical give climatological simulation of seasonal variation of along channel velocity.

The model simulated seasonal variation of the volume transport through BS agrees well with the estimate derived from 4 stations of mooring observations. The model reproduces the summer peak in August. It misses the rapid decrease in fall (September to December), hence only obtains half of the observed magnitude of seasonal variation.

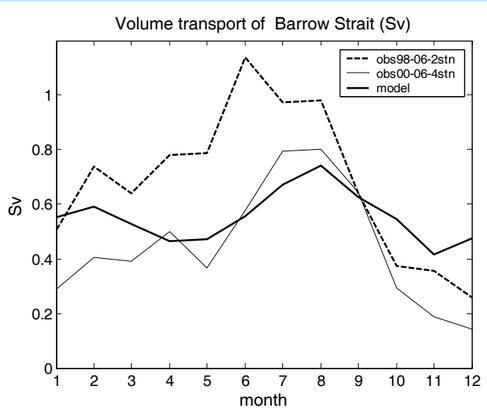

Fig. 4 Modeled and Observed Volume transport of Barrow Strait

Forcing mechanisms of Barrow Strait seasonal transport

1.The link to large-scale circulation and sea level gradient

The volume transport in BS mainly comes from the inflow into the M'Clue Strait from the Beaufort Sea. The anti-cyclonic Beaufort Gyre corresponds to a "high" in SSH distribution. From the entrance of the M'Clue Strait to the Baffin Bay the SSH decreases. Across the channel the SSH is high along the southern side and low along the northern side. The seasonal variations of the SSH gradient across the Barrow Strait are highly correlated with that of the volume transport, with later leads the former by one month. There is also good correlations between the along-channel SSH gradient with the volume transport, with a lag of 2 months during April and December.

The SSH gradients can be caused by the density changes (baroclinic effect) and wind and depth-integrated flows (barotropic effect). For both the cross-channel and along-channel SSH differences, the barotropic contribution is dominant.

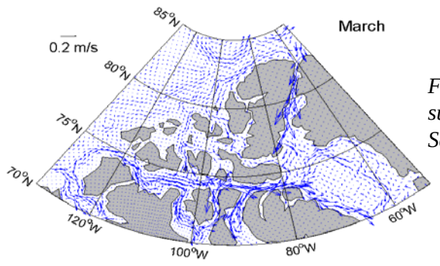

Fig. 5 Modeled Sea surface current in September

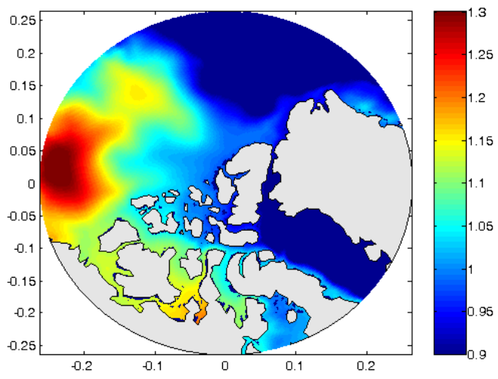

Fig.6 Modeled annual mean SSH

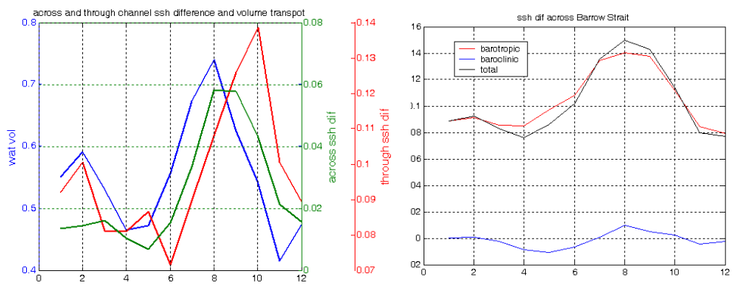

Fig.7 The seasonal variations of the cross-channel and along-channel SSH gradients and the volume transport through the Barrow Strait

Fig. 8 Seasonal variations of the barotropic and baroclinic contributions to the cross-channel SSH gradients

2.The link to atmospheric forcing

The "Beaufort High" high-pressure system has a seasonal variation. The strength of the Beaufort High has a high anti-correlation with the BS volume transport. From winter to summer, the center of the Beaufort High (where the maximum SLP occurs) moves progressively from the central Canada Basin into the Beaufort Sea. In July and August, the center of the Beaufort High is located to the west of the entrance to the M'Clure Strait in the Beaufort Sea. As a result, in these two months the wind has a significant component nearly parallel to the coast (44º rotated from east) near the entrance to the M'Clure Strait.

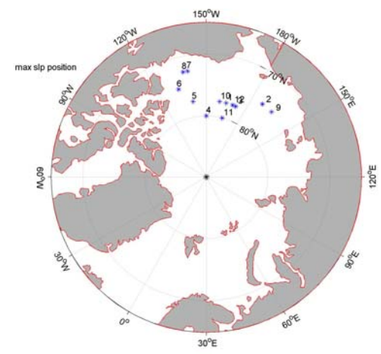

Fig. 9 The position of the maximum high pressure in each month

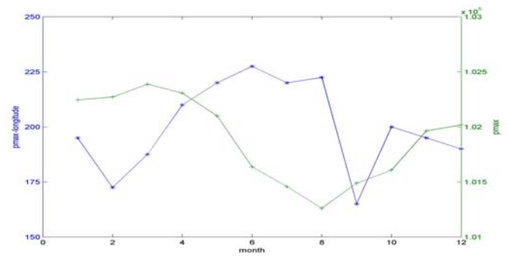

Fig. 10 Beaufort high SLP maximum (green line) and Beaufort high central position longitude (blue line)

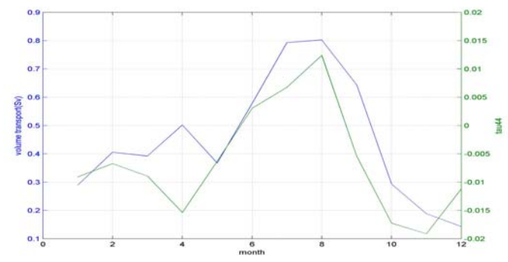

Fig. 11 Local wind stress at the direction parallel to the coast near entrance of M'Clure Strait (green line) and observed volume transport of Barrow Strait (blue line)

3.The link to transport in the Bering Strait

The seasonal variations of the volume transport in Barrow Strait have good correlation with those in Bering Strait. The peaks in Bering Strait transport occur in June-July, 1-2 month ahead of the transport in Barrow Strait. The (lagged) correlation between the transports in the two straits may be related to that the same atmospheric circulation system (dominated by the Beaufort High) which is the primary forcing for causing the seasonal variations of the flows in both straits.

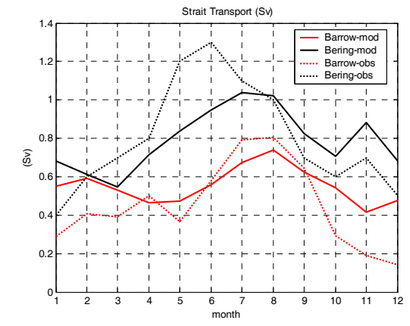

Fig. 12 Observed and modeled volume transports in Barrow and Bering Straits

Conclusion

- The solutions of a fine-resolution global ice-ocean model capture the observed seasonal variations with the summer peak in volume transport, but underestimates its magnitude of seasonal variation.
- The seasonal variations of volume transport are well correlated the sea level differences across BS, and along the flow direction between the entrance of M'Clure Strait to Baffin Bay. The seasonal variations of transport in BS are mainly associated with barotropic dynamics.
- Changes in the strength and positions of the center of the Beaufort High are well correlated with the seasonal BS volume transport.
- A good correlation between volume transports in BS and the Bering Strait is identified.

Acknowledgements

Thanks the support of NSERC of Canada and the National Natural Science foundation of China (No.40876003) and Cooperate project (No. 40810104046)