FRESHWATER DISTRIBUTION AND ITS VARIABILITY IN THE ARCTIC OCEAN DEDUCED FROM HISTORICAL HYDROCHEMISTRY

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1. INTRODUCTION

Variability of freshwater input and sea ice formation/melting in the Arctic Ocean has a key role in the regional and also the global climate through affecting the heat transport by changing the extent of surface stratification and also the deep convection. The historical and recently acquired data of two chemical tracers, oxygen isotope ratio ($\delta^{18}O$) and alkalinity in seawater, are used in this study 1) to distinguish the freshwater sources, and 2) to investigate their variability in the Arctic Ocean.

The isotope ratio in seawater has been successfully used to separate contributions of meteoric water and sea ice melt water in the Arctic Ocean in the past, because the arctic meteoric water has very low $\delta^{18}O$ value, while sea ice melt water is close to standard sea water composition. The total alkalinity (TA) is found to be also different among freshwater sources. Arctic river contains relatively high TA and TA in natural sea ice is low. Therefore, TA data is examined in order to distinguish freshwater sources in the Arctic Ocean.

2. DATA

The historical $\delta^{18}O$ data in the Arctic Ocean since 1966 comes from the "Global seawater oxygen-18 database, V1.12" [Schmidt et al., 1999]. We also used substantial data of TA since 1935, from "Hydrochemical Atlas of the Arctic Ocean" [2001] and WOD01. Data from three cruises in the Canadian Basin in 1999, 2000, 2002 are also used. TA data from these cruises is kindly provided by Drs. Murata, Shimada, and Takizawa, JAMSTEC, Japan, and $\delta^{18}O$ are measured by ourselves with precision of ± 0.02 ‰.

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3. RESULTS AND DISCUSSIONS

3-1. Comparison of estimates from $\delta^{18}O$ and TA

We have calculated fraction of sea ice meltwater (**SIM**) and other freshwaters (**OF**) in seawater from each pair of salinity-$\delta^{18}O$ and salinity-TA. The OF includes river runoff, precipitation and salinity deficit of inflowing Pacific water. Estimated fractions from TA agreed well with those from $\delta^{18}O$ (Figure 1). Therefore, results from salinity-TA and salinity-$\delta^{18}O$ are combined together to estimate SIM and OF distributions in the entire Arctic Ocean.

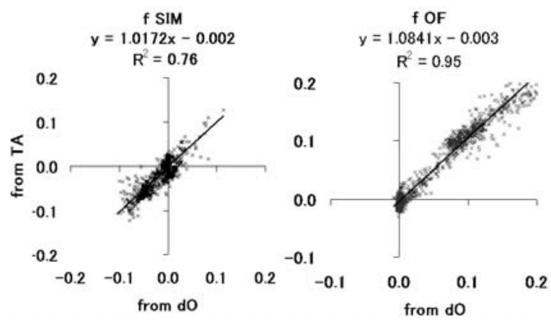

Figure 1. Fractions of SIM (left) and OF (right) estimated from $\delta^{18}O$ (x-axis) vs. from TA (y-axis).

3-2. Distribution of freshwater

Figure 2 shows distribution of SIM and OF at 10 m water depth. Surface waters in Chukchi Sea and in the region from the Fram Strait to the Kara Sea contain relatively large fraction of SIM

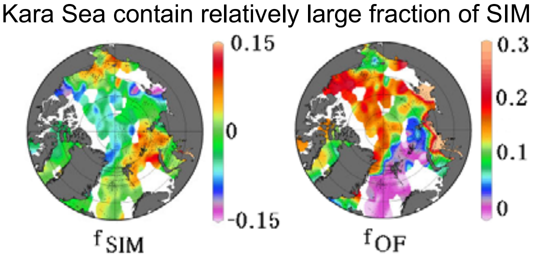

Figure 2. Distribution of fractions of SIM and OF at 10 m depth.

(more than 3 % in summer) and the Chukchi Sea has the small amount of the Arctic meteoric water.

On the other hand, the surface water in Siberian and American coastal areas contains more than 20 % of OF and large fraction of OF (>10 %) distributes over the Canadian Basin (Canada and Makarov Basins) and over the Lomonosov Ridge. In the Fram Strait, fraction of OF is high in the western part and low in the eastern part, showing the significant influence from the outflow of rivers in the East Greenland Current. The calculated freshwater inventory in upper 300 m of water column suggests that the water inflowing from the Atlantic Ocean through the eastern part of the Fram Strait will exit along the western part of the Strait after experiencing 5 m water depth equivalent of freshwater removal due to net ice formation and receiving 10 m water depth equivalent input of OF within the Arctic Ocean. The large inventory and deeper penetration of OF and brine formed during freezing sea ice are found in the Canada Basin as compared with the Eurasian Basin. Our calculation shows that the water at 150 m depth of the Canada Basin is formed from relatively fresh surface water having initial salinity of 31-32 but rising to 33 by brine injection. This means that the water from shallow shelves enters into the intermediate depths to renew the halocline layer and characterize the Canada Basin as the reservoir of both OF and brine.

3-3. Change in freshwater distribution between cyclonic and anticyclonic regimes

Proshutinsky and Johnson [1997] presented the existence of two circulation regimes of wind-driven circulation in the modeled Arctic Ocean; cyclonic and anticyclonic regimes. To examine changes in distribution of SIM and OF between tow regimes, our results have been divided into two groups of cyclonic years and anticyclonic years according to Proshutinsky and Johnson [1997]. In the Canadian Basin, changes between cyclonic and anticyclonic regimes are found in the size of distribution of low salinity and high OF water from the surface to the 150 m depth (Figures 3 and 4). At 150 m depth, content of brine is also change with regime changes. Higher contents of OF and brine in anticyclonic years may suggest more active formation of dense shelf water in the anticyclonic regime than cyclonic regime.

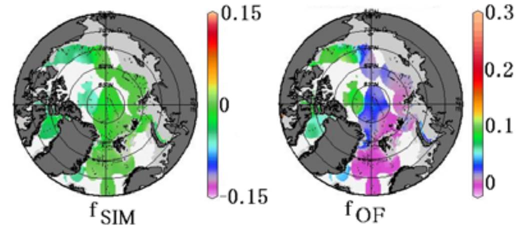

Figure 3. Distribution of fractions of SIM and OF at 150 m depth in cyclonic years.

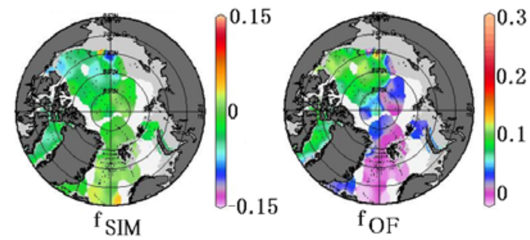

Figure 4. Distribution of fractions of SIM and OF at 150 m depth in anticyclonic years.

Acknowledgments

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References

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