On the importance of freshwater fluxes from the Arctic Ocean into the North Atlantic: the Nordic Seas versus Canadian Arctic Archipelago

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MODEL DESCRIPTION
In an effort to obtain past estimates of oceanic fluxes through various passages controlling oceanic flow between the lower latitude oceans, we analyze results from a high-resolution coupled ice-ocean model of the Pan-Arctic region. The model domain extends from ~90°N in the North Pacific through the Bering, Sea, Arctic Ocean, Nordic Seas, into the North Atlantic to ~45°N. At 5 km and 40-km resolution, the model allows realistic exchanged through important narrow passages. The model has been forced with winds from the European Centre for Medium-range Weather Forecast (ECMWF), including 1979-1993 reanalysis and 1994-2004 operational products. The model results are compared to observational data (Cayan et al. 2004; Clement et al. 2005). Volume, heat, salt, and freshwater fluxes are calculated from this integration, and allow for the interannual variability of the Arctic Ocean through the Northern Hemisphere.

Other Aspects of Concern in Ocean Models
Greenland ice sheet melt Extent 2005 – another recent year model

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VIEWPOINT

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ACKNOWLEDGEMENTS

REFERENCES

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Volume Flux

CONCLUSIONS
Based on calculations of 24-year mean volume transports through four major pathways, fluxes into and out of the Arctic Ocean is approximately 11.6 Sv. The small imbalance (0.004 Sv) is due to the Hudson Strait flux, which is not accounted for in the analysis in Table 1. Both Fram Strait and the Barents Sea have high volume fluxes in both directions and are the primary transport pathways. However, Bering Strait and Canadian Archipelago/Davis Strait allow significant freshwater fluxes in and out of the Arctic Ocean.

SUMMARY
The 24-year model output was used for analyses of freshwater export from the Arctic Ocean through the Canadian Arctic Archipelago, the Fram, Denmark, Hudson straits, and Cape Farewell to understand the circulation regime in these areas and to quantify the freshwater entering the Labrador and Irmingge seas. The importance of this study lies in the quantification of the freshwater export from the CAA into the Labrador Sea, in comparison with the freshwater export through Fram and Denmark straits into the North Atlantic. This is especially important when considering the recent increase of freshwater export via these routes, which could affect deep-water formation.

The combined volume fluxes from several sections compare favorably with known observational fluxes. Several important observations can be made from this study. First, the Canadian Arctic Archipelago is the largest freshwater contributor to the Labrador Sea and the Hudson Bay is the second largest. Comparison of the absolute freshwater fluxes suggests that the Hudson Bay’s freshwater input into the Labrador Sea is more significant than the Fram-Denmark straits and Cape Farewell pathways. Also, the variability of freshwater export into the Labrador Sea is dramatically affected by large-scale circulation patterns upstream in the Arctic Ocean, which are subject to change due to large-scale atmospheric forcing. This would support a hypothesis that atmospheric regime shifts in the Arctic possibly associated with global warming could hinder convection in the Labrador Sea.

Table 1. 26-year mean freshwater fluxes for various sections

<table>
<thead>
<tr>
<th>Section</th>
<th>FW Net (Sv)</th>
<th>Net into AO (Sv)</th>
<th>Net out of AO (Sv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fram Strait</td>
<td>19.12</td>
<td>19.12</td>
<td>0.00</td>
</tr>
<tr>
<td>Denmark Strait</td>
<td>11.68</td>
<td>11.68</td>
<td>0.00</td>
</tr>
<tr>
<td>Davis Strait</td>
<td>5.97</td>
<td>5.97</td>
<td>0.00</td>
</tr>
<tr>
<td>Barents Sea Opening</td>
<td>1.65</td>
<td>1.65</td>
<td>0.00</td>
</tr>
<tr>
<td>Davis Strait (solid)</td>
<td>11.68</td>
<td>11.68</td>
<td>0.00</td>
</tr>
<tr>
<td>Denmark Strait (solid)</td>
<td>5.97</td>
<td>5.97</td>
<td>0.00</td>
</tr>
<tr>
<td>Labrador Sea</td>
<td>13.77</td>
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<td>0.00</td>
</tr>
<tr>
<td>Barents Sea Opening</td>
<td>8.86</td>
<td>8.86</td>
<td>0.00</td>
</tr>
</tbody>
</table>

A Note on the importance of freshwater fluxes from the Arctic Ocean into the North Atlantic: the Nordic Seas versus Canadian Arctic Archipelago

Figure 1. (a) The area for melt/growth calculation (yellow rectangle) and two oceanic sections for the total on-shelf heat flux (black dotted lines). (b) Total monthly mean heat flux into the Greenland shelf (blue) and area-averaged monthly means of heat fluxes into the Labrador Sea (orange, dashed) and Fram Strait (red, solid). The smoothed lines represent a 15-month running mean. (From Stroeve & Maslowski, 2007). Melting of the Greenland ice sheet and subsequent runoff into the ocean is an additional source of freshwater (FW) in the northern North Atlantic, which is not accounted for in ocean models. This FW source is distinct from the Arctic Ocean sources described earlier. The heat flux is sensitive to ice melt and ice melting is negatively correlated with the Greenland heat flux and ice melt have recently accelerated.

Figure 2. (a) Monthly mean freshwater fluxes through four major sections showing only positive values. A black line indicates a change in flux direction. (b) Seasonal cycle of freshwater flux from Davis Strait.