Freshwater pathways of river runoff in the Arctic

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Introduction

Freshwater balance in the Arctic is increasingly recognized as a crucial factor influencing the global climate (Dickson *et al.*, 1996; Aagaard and Carmack, 1989). Its variability is partly driven by the surface circulation regime that is affecting the volume of freshwater stored in the Beaufort Gyre (Proshutinsky and Johnson, 1997 – PJ97) and the freshwater pathways of the main river runoff of the Siberian shelf.

Objectives

1. Determine the circulation regime from the EWG dataset
2. Link the freshwater pathways with the circulation regime
3. Compare observational results with model results

Data

For this study, we used the oceanographic summer season dataset developed under the auspices of the Environmental Working Group (EWG). The EWG was organized under the U.S.-Russia joint commission as part of a strong commitment by both sides to find ways of combining environmental data resources which had been previously restricted.

The main part of this project has been done during the *Nansen and Amundsen Basins Observational System* (NABOS) 2005 scientific expedition in the Laptev Sea and the *International Arctic Research Center* (IARC) Summer School aboard the Russian icebreaker *Kapitan Dranitsyn*.

Photo: Erica Key — *I/B Kapitan Dranitsyn*

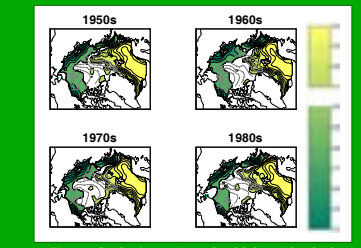


Figure 3. Surface salinity $S < 29.8$ and $S > 31.2$ [psu]. It visually determines where are the fresher (discharges) and the saltier waters (Atlantic)

1960

In an **anticyclonic** regime, freshwater is transported offshore in the transpolar drift…

1980

…while it stays on the shelf during a **cyclonic** regime

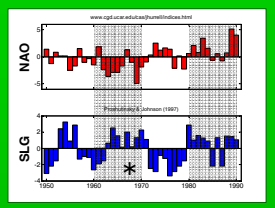
Two circulation regimes

NAO < 0

The Arctic atmospheric system is strongly linked to the North Atlantic characterised by the NAO index (figure below).

NAO > 0

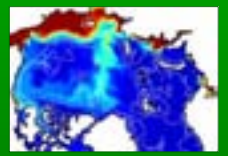
Atmosphere



Ocean

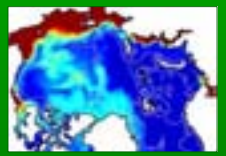
Using a **barotropic** ocean model PJ97 defined a Sea Level Gradient (SLG) index characterising the dominant circulation regime in the Arctic from 1946 to 1993 (figure above).

SLG > 0 cyclonic
SLG < 0 anticyclonic



River runoff tracer concentration during an anticyclonic regime…

Using a high resolution numerical model, Newton (2001) simulate the freshwater pathways forced by cyclonic and anticyclonic atmospheric circulation.



…and cyclonic regime.

Results

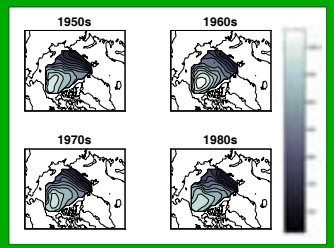


Figure 1. Summer dynamic height averaged over a decade [mm²/s²]

Decade	Circulation
1950	Mixed
1960	**Anticyclonic** (strong and large gyre)
1970	Mixed
1980	**Cyclonic** (weak and small gyre, cyclonic curvature)

The dynamic height contours are following the mean decadal geostrophic circulation in a cyclonic direction around lows and anticyclonic direction around highs.

∗ There is a contradiction of the data with the SLG index prediction during the decade 1960. There is however a good correlation with the NAO index.

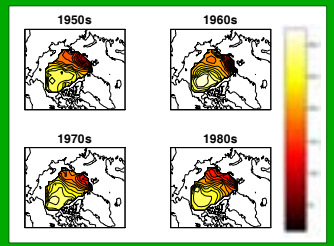
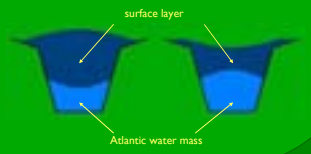


Figure 2. Atlantic layer depth defined by the 0°C isotherm [m]

In an anticyclonic gyre, there is convergence towards the center, downwelling and deepening of the pycnocline. It is the inverse in a cyclonic gyre.

The Beaufort Gyre is behaving as a reservoir that is storing and releasing freshwater according to the circulation regime.



Conclusions

1. The decades 1960 and 1980 are respectively characterised by anticyclonic and cyclonic regime. In average, the circulation in the Arctic is dominated by an anticyclonic regime of varying strength centered over the Canadian basin.

2. The freshwater pathways of the Siberian river runoff are affected by the circulation regime of the Arctic, by hugging the coast during cyclonic regime and by going off shelf in the transpolar drift during anticyclonic regime. These observations support the results of Newton (2001).

3. EWG data are contradicting the PJ97 barotropic model prediction for the decade 1960. Neglecting the baroclinic part of the circulation may be a key factor explaining this difference.

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Acknowledgments

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