Objective: To analyze circulation and interannual variability of the freshwater pathways in the Pacific sector of the Arctic Ocean during the International Polar Year and previous years.

Introduction: During the last decade, the Pacific sector of the Arctic Ocean (AO) has experienced a pronounced environmental change. The most well-known events have been tremendous ice retreats in 2007 and 2012. Morison et al. (2012) argued that the observed BG circulation through the assimilation of all available observations. We apply a hybrid SIOM-assimilation procedure to the cyclonic (1989-1996) and anticyclonic (1972-1978, 1997-2006) phases of the AOO. Largrangian analysis of the optimized solution suggests that the freshwater (FW) accumulation in the Beaufort Gyre has a negligible contribution from the East Siberian Sea and is likely caused by the enhanced FW export from the region north of the Canadian Archipelago/Greenland. The inverse modeling results are confirmed by validation against independent altimetry observations and in situ velocity data from NABOS moorings. It is also shown that presented results are in significantly better agreement with the data than the output of the PIOMAS model run utilized as a first guess against independent SSH observations.

Models and approach: 1. Sea-ice and Ocean Assimilation (SOIA) was designed specifically for the implementation of 4d-Var methods into regional models controlled by currents at the open boundaries and by surface flux. SOIA is a modification of the Madec et al. (1998) model. The 4dVar data assimilation system has been implemented successfully for the reconstruction of the summer circulation in the Chukchi and Beaufort seas (Fermeko et al., 2006).

2. The AOO-Var Oceanic Simulation System (AOOS) was developed at the Polar Science Center, University of Washington. This is a coupled parallel ocean and sea ice model capable of assimilating sea ice concentration and velocity data. PO4D is configured to cover the AO above 43°N. The model grid is a generalized orthogonal curvilinear coordinate system with the northern grid point displaced into Greenland.

Validation (PIOMAS & SIOM) 2008 circulation:

- Basic features of the AOO 2008 circulation:
  a) Anticyclonic-AOO phases (72-78, 97-06) are characterized by a more pronounced BG with minimum SSH values of 18 and 16 cm, respectively.
  b) Our results indicate a general increase of the total transport in this region from 2.1 Sv to 7.8 Sv during 97-06. The model reproduces well the observed SSH fields averaged over respective periods.

  a) Anticyclonic-AOO phases (72-78, 97-06) are characterized by a more pronounced BG with minimum SSH values of 18 and 16 cm, respectively. It is worth noting that during the 72-78 and 97-06 periods, there is more pronounced SSH depression during the 72-78 period.
  b) Our results indicate a general increase of the total transport in this region from 2.1 Sv to 7.8 Sv during 97-06. The model reproduces well the observed SSH fields averaged over respective periods.

Conclusions:

1. Validation of the results against independent SSH and velocity observations demonstrated a significantly better consistency with the data compared to the PIOMAS system, whose output was utilized as a NAr game solution for subsequent 4d-Var analysis.

2. The 4d-Var reanalysis for periods of 72-78, 89-96, and 97-06, support and further quantify the concept of Proshutinsky and Johnson (1997). Our results indicate that AOO + phases are characterized by AOO-Var oceanic simulations suggest a significant increase of the total transport in the Canadian Basin over a long-term perspective.

3. We found indications of FW accumulation in the East Siberian Sea during the cyclonic AOO phase (1972-1979), C1 (1989-1996) and C2 (1997-2006). The red vector bar near 120°E indicates the section across the continental shelf break where the total transport has been computed. The FW accumulation area is marked by the red rectangular sector. Yellow circles denote the Bering Strait location.

4. Analysis of the circulation and FW content in BG during 2003-2006, and 2008 indicates:
   a) A reversal of the total transport in the AW inflow region of -2.3 Sv in July-August which later relaxed to an eastward transport of 0.8-1 Sv. Agrees with NABOS observations.
   b) Formation of a prominent SSH trough extending from the eastern Laptev Sea to the Bering Strait. A similar and even stronger structure was obtained in the PIOMAS solution and is indirectly evidenced by two NABOS moorings located on the continental slope of the Laptev Sea. The 2008 SSH depression also agrees with the analysis of the force balance in the Bering Strait, revealing an increased role of baroclinic waves over the continental slope.
   c) A significant increase of the FW content in the Beaufort Gyre from 16,700 km3 in 2003 to 21,500 km3 in 2008. The analysis of the FW transports across the BG boundaries indicate that FW accumulation in the Beaufort Gyre has a negligible contribution from the East Siberian Sea and is likely caused by the enhanced FW export from the region north of the Canadian Archipelago/Greenland. The inverse modeling results are confirmed by validation against independent altimetry observations and in situ velocity data from NABOS moorings. It is also shown that presented results are in significantly better agreement with the data than the output of the PIOMAS model run utilized as a first guess against independent SSH observations.

5. The main conclusions of the study are as follows:
   a) The 4d-Var reanalysis for periods of 72-78, 89-96, and 97-06, support and further quantify the concept of Proshutinsky and Johnson (1997). Our results indicate that AOO + phases are characterized by a more pronounced BG with minimum SSH values of 18 and 16 cm, respectively.
   b) The AOO-Var oceanic simulations suggest a significant increase of the total transport in the Canadian Basin over a long-term perspective.
   c) We found indications of FW accumulation in the East Siberian Sea during the cyclonic AOO phase (1972-1979), C1 (1989-1996) and C2 (1997-2006). The red vector bar near 120°E indicates the section across the continental shelf break where the total transport has been computed. The FW accumulation area is marked by the red rectangular sector. Yellow circles denote the Bering Strait location.