

The Role of the Russian Shelf in Seasonal and Interannual Variability of Arctic Sea Surface Salinity and Freshwater Content

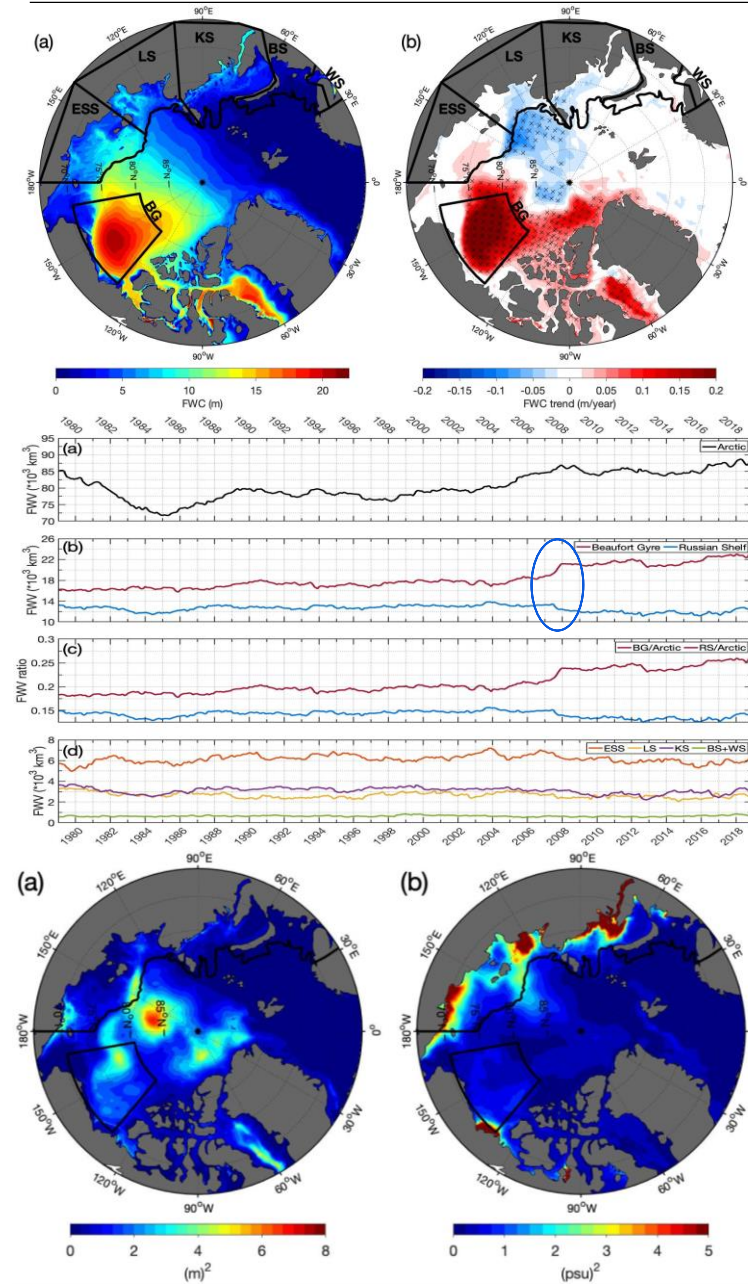


Figure: top
Spatial maps of Ocean Reanalysis System 5 (ORAS5) Arctic Ocean (a) mean freshwater content (FWC; m) and (b) FWC trend (m/yr) between 1979 and 2018 with the 200 m (black line) bathymetric contours between 30°E and 180°E and Russian regions as described in Figure 1 and the Beaufort Gyre (BG; black box) region labeled. Stippling shows the statistically significant FWC trend at the 95% confidence level.

Figure: middle
Timeseries of deseasoned total Freshwater Volume (FWV; km³) between January 1979 – December 2018 for (a) Arctic Ocean above 66°N, (b) the Russian Shelf and the Beaufort Gyre regions, (c) total FWC ratio of the Russian Shelf (RS) and the Beaufort Gyre (BG) regions to the Arctic Ocean region, and the (d) FWC of the subset regions that make up the Russian Shelf including the East Siberian Sea (ESS), the Laptev Sea (LS), the Kara Sea (KS), the Barents Sea (BS), and the White Sea (WS). Blue circle highlights the regime change in late 2007.

Figure: bottom
Variance of deseasoned and detrended (a) freshwater content (FWC; m²), and (b) sea surface salinity (psu²) between 1979–2018 from ORAS5. Russian Shelf and Beaufort Gyre boundaries are outlined in black lines.

Technology Question: Knowledge of the spatial and temporal distributions of salinity and fresh water variability, is paramount for Arctic Ocean research. Fresh water plays a pivotal role in the Arctic Ocean's climate, as salinity governs upper ocean stratification, convection, and the promotion of seasonal sea ice growth or melt. The Arctic is receiving an increased inflow of freshwater in the last few decades, this is not uniform to the entire region. The Beaufort Gyre (BG) contains a significant amount of fresh water; however, there is limited understanding of the role that the Russian Arctic Shelf plays in the Arctic Ocean's freshwater content (FWC) and volume (FWV). High-latitude observations over the Russian Shelf are more scarce than regions like the BG or Nordic Seas.

Data & Results: We employed the European Centre for Medium-Range Weather Forecasts' Ocean Reanalysis System 5 (ORAS5), over the years 1979–2018 to examine the trends, variance, and other statistical analysis of salinity and freshwater (salinity reference = 34.8 psu) over the Russian Shelf (30°E–180°E; shallower than 200 m depth), in the BG (130°W–170°W, 70.5°N–80.5°N), and over the Arctic Ocean and subarctic seas (northward of 66°N). Satellite and *in situ* observations were also used for comparisons/validation. We find that the Russian Shelf's FWV is near 16% (~12,574 km³) of the Arctic Ocean (80,7623 km³) and with a negative trend of -15.63 km³/yr during this 4 decade long period. Our results indicate a significant regime shift of FWC in the Arctic Ocean during 2007, especially over the Russian Shelf (decrease) and BG (increase). This work urges future observational programs in the Arctic and Russian shelf region, as neglecting this Russian shelf region region in freshwater volume studies may lead to an error up to 25% during a transition such as the one in 2007.

Broader significance or implications: This work also highlights the important connection of ocean dynamics with atmospheric changes over the northern high-latitudes, where variations of the Arctic Oscillation influences average dynamic height, vorticity, and Ekman divergence (positive phase). Focus on the Russian shelf in the sense of the Arctic dipole is key to understanding circulation pathway changes, with special note on the Makarov Basin. Freshwater export to the Atlantic Meridional Overturning Circulation is susceptible to strengthening stratification, leading to a reduction in overturning authoritative to global climate regulation. A Russian Shelf 'proxy' may help for lack of present observations and should be considered in future studies. Focus on improved measurements and understanding of the Russian shelf will help motivate current Arctic Projects/Research (e.g. ONR's Arctic and Global program, NASA's SASSIE project).

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