Editors' Vox

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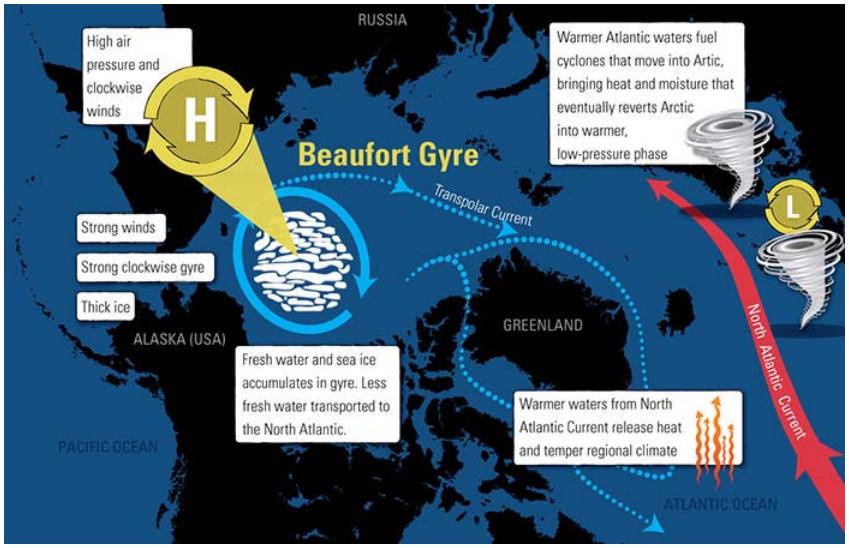
In a Spin: New Insights into the Beaufort Gyre

A new special collection in *JGR: Oceans* presents results from studies of the Beaufort Gyre, an oceanic circulation system in the Arctic that has far-reaching influence on the global climate.

An international team of observers, theoreticians, numerical modelers, engineers and icebreaker crew members from the USA, Canada and Japan studying the Beaufort Gyre from their base on the *CCGS Louis S. St-Laurent*. Credit: Gary Morgan

By Andrey Proshutinsky and Richard Krishfieldon 8 April 2019

The Beaufort Gyre (BG) is a unique sea ice and water circulation component of the Arctic Ocean that rotates clockwise under the influence of prevailing anticyclonic winds. These winds act as a giant pump that collects low salinity water from the Arctic Ocean surface layer in the center of the gyre.



The Beaufort Gyre is just one of the interconnected movements of wind, ice and currents in the Arctic that influences the region's climate. Credit: Eric S. Taylor (Woods Hole Oceanographic Institution)

Currently, the BG contains about 23,300 km^3 of fresh water. This volume is practically identical to the volume of water in Lake Baikal in Russia, and is comparable to the volume of all Great Lakes in North America. It would take five years for all Arctic rivers to fill the BG reservoir with its observed fresh water volume.

Although the Beaufort Gyre is located in the Arctic region, it has impacts on the climate further afield in two ways:

First, fresh water accumulates in the Beaufort Gyre which results in a deficit of fresh water flowing into the North Atlantic. This deficit creates the conditions for deep convection of ocean waters and heat release from the ocean to atmosphere in the subpolar regions; it also promotes intensification of the Atlantic Ocean Meridional Circulation (AOMC).
Second, when there are prevailing counter-clockwise winds over the Arctic, fresh water released from the Beaufort Gyre region inhibits the processes of deep convection, reduces intensity of the AMOC and results in climate cooling. Such periodical releases of fresh water from the Arctic Ocean, which have occurred in the 1970s, 1980s, and 1990s, are known as 'Great Salinity Anomalies' (Dickson et al., 1988 (https://doi.org/10.1016/0079-6611(88)90049-3); Belkin et al., 1998 (https://doi.org/10.1016/S0079-6611(98)00015-9)).

Scientists have been studying this region for many years. The Beaufort Gyre Exploration Program (http://www.whoi.edu/beaufortgyre) (BGEP) has been collecting data for the past 16 years and the first collection of papers (https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-9291.BEAUFORTG1) describing BG as a climate system was published in *JGR: Oceans* in 2010.

In addition, the ten-year long Arctic Ocean Model Intercomparison Project (http://www.whoi.edu/projects/AOMIP) (AOMIP) followed by the Forum for Arctic Ocean Modeling and Observational Synthesis (http://www.whoi.edu/projects/famos) (FAMOS) project have brought together scientists who observe, model and theorize about the Arctic marine and sea ice environment and contributed to better understanding of the BG phenomenon.

With many results from AOMIP published in *Journal of Geophysical Research: Oceans* (https://agupubs.onlinelibrary.wiley.com/journal/21699291) special collections (https://eos.org/editors-vox/aomip-and-famos-for-enhancing-understanding-of-arctic-changes) in 2007 (https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-9291.AOMIP1) and 2012 (https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-9291.AOMIP2), the tradition continues with another new special collection (https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-9291.FAMOS2) in 2019 presenting more than forty papers on the results of FAMOS and BGEP.

Participants at the 2018 annual FAMOS meeting in Bergen, Norway. Credit: Matthew

Barton (Woods Hole Oceanographic Institution)

The majority of the papers are focused on the analysis of the Beaufort Gyre multicomponent system processes and mechanisms responsible for decadal, interannual and seasonal variability.

The 2003–2018 time series of the atmospheric, sea ice, oceanic, and biogeochemistry data collected by the Beaufort Gyre Observing System (BGOS) are publicly available at the project website and NSF's Arctic Data Center (https://arcticdata.io/). These data, combined with Arctic coupled ice-ocean modeling, have been used to: investigate the major causes, consequences and rates of BG freshwater accumulation and release events; identify the major sources of fresh water and the fresh water pathways from the sources to the BG region; explain the major patterns and regimes of the surface, Pacific and Atlantic water layers circulation; and to reveal the physics of mechanical and thermal mixing under influence of wind, internal wave and tidal forcing.

Drilling through ice in preparation for deployment of an Ice-Tethered Profiler Buoy (http://www.whoi.edu/page.do?pid=20756).
Credit: Gary Morgan

Other papers in the collection examine the role of sea ice conditions, major features of ice variability and methods of sea ice prediction in the BG. Ecosystem and biogeochemistry analysis targeting estimation of biological production rates in both water and sea ice, and characteristics of dissolved organic and inorganic matter are another focus, with papers employing synthesis of multi-model experiments in combination with collected data analysis.

Meanwhile, several papers describe processes of the BG relationship with the northern parts of the Pacific and Atlantic Oceans showing how the BG region influences, and is influenced by, climate change including the increase of Greenland glacier melting and modification of Atlantic water circulation.

Methodologically, a new approach known as "Arctic climate response function" analysis is used in several papers to better understand processes of the Arctic and subarctic variability and to predict causes and consequences of future Arctic changes.

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As demonstrated in this special collection, the coordinated cross-discipline community approach to the analysis of Arctic processes is an optimal way to assess the degree of uncertainty in the results and conclusions made by different scientific teams.

One of the highest impacts of this special collection is educational because it provides guidelines for critical analysis of the existing data, models, and methods, and encourages new generations of Arctic scientists to improve understanding and predicting of Arctic changes.

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