The Arctic Ocean’s Beaufort Gyre

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Timmermans & Toole, 2022
Atmospheric Centers of Action

- Beaufort High
- Icelandic Low
- Siberian High
- Aleutian Low
Seasonality

- Prominent Beaufort High in winter
- Weaker, contracted Beaufort High in summer

(Gudkovich, 1961)
Seasonality

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(Gudkovich, 1961)
Regimes of circulation

Negative phase of Arctic Oscillation (AO): **Mode A**

Positive phase of AO: **Mode B**

can alternate on timescales of a few years to decades

see Rigor et al. 2002

Proshutinsky & Johnson, 1997, & see Sokolov 1962
Transition from stronger BH in 1948-88 to weaker BH in 1989-2019

Zhang et al. (2019): BH weakening since late 1980s linked to Northern Hemisphere ozone depletion

Kenigson & Timmermans, 2021
Seasonally changing surface stresses

Sea-ice motion

Ocean geostrophic flow
Seasonally changing surface stresses

**WINTER**: friction at ice-ocean interface drives broad Ekman upwelling

e.g., Meneghelo et al. 2018; Dewey et al. 2018
Ekman vertical velocity **monthly** and **annual** from winds, ice motion and concentration, and ocean geostrophic currents.
Freshwater Content

2003-2007

2008-2012

2013-2017

2018-2021

Total freshwater content in the region

Proshutinsky et al. 2021, updated
Isohaline displacements sampled by Beaufort Gyre Observing System moorings (2003-2021)
Eddy fluxes balancing wind-energy input

Eddies from baroclinic instability act as one balance on the wind’s momentum flux. e.g., Davis et al. 2014; Manucharyan et al. 2016; Dewey et al. 2018; Meneghello et al. 2017; Armitage et al. 2020
Changing Beaufort Gyre water column
Halocline heat content

Timmermans & Toole, 2022
Some Future Questions

- Which atmospheric circulation patterns may be preferred in a warming Arctic?
- Under continued sea-ice losses, will sea ice still stabilize the Beaufort Gyre, or will eddy fluxes be the sole balance for wind driving?
- What will be the consequences of a seasonally-ice-free Arctic Ocean to Beaufort Gyre freshwater?
- How will the surface ocean warming (and feed backs to atmospheric forcing) influence pathways and dynamics of warm water ventilating the Beaufort Gyre?