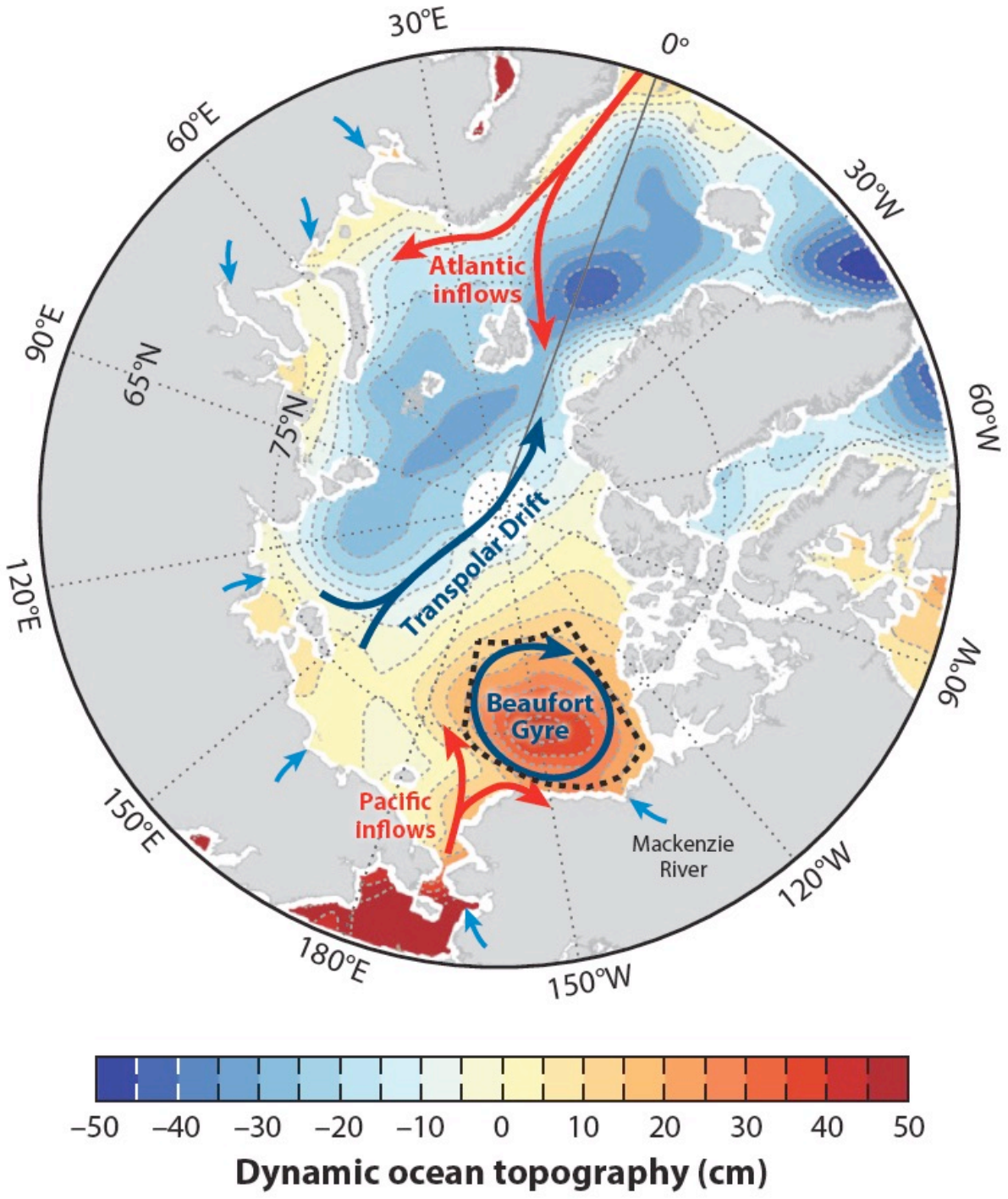
The Arctic Ocean's Beaufort Gyre



Mary-Louise Timmermans

Yale

Collaborators:

Andrey Proshutinsky

Rick Krishfield

Isabela Le Bras

John Toole

Bill Williams

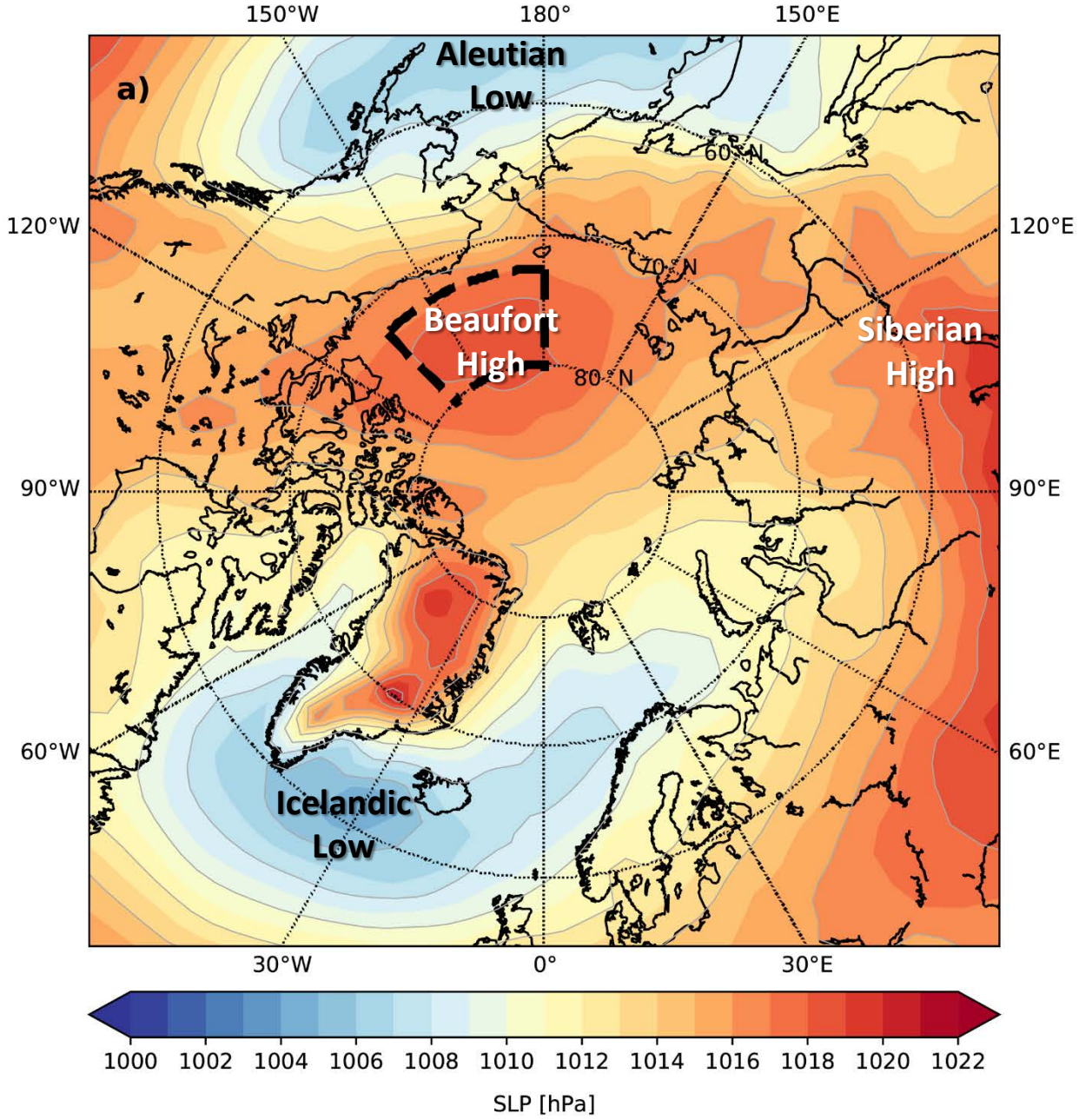
Sarah Zimmermann

Yale

Fisheries and Oceans Canada

Timmermans & Toole, 2022

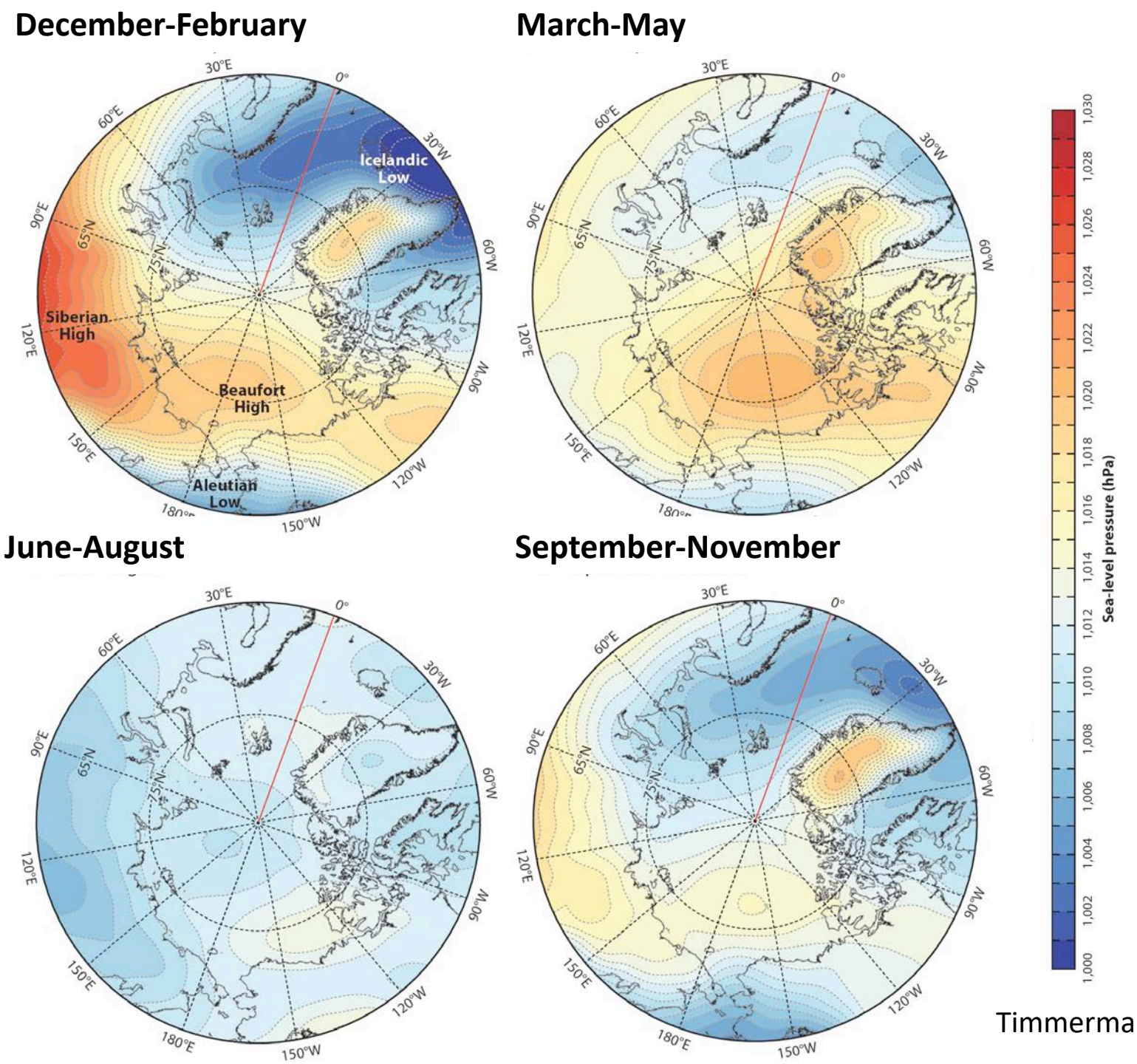
Atmospheric Centers of Action



Seasonality

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

(Gudkovich, 1961)



Timmermans & Toole, 2022

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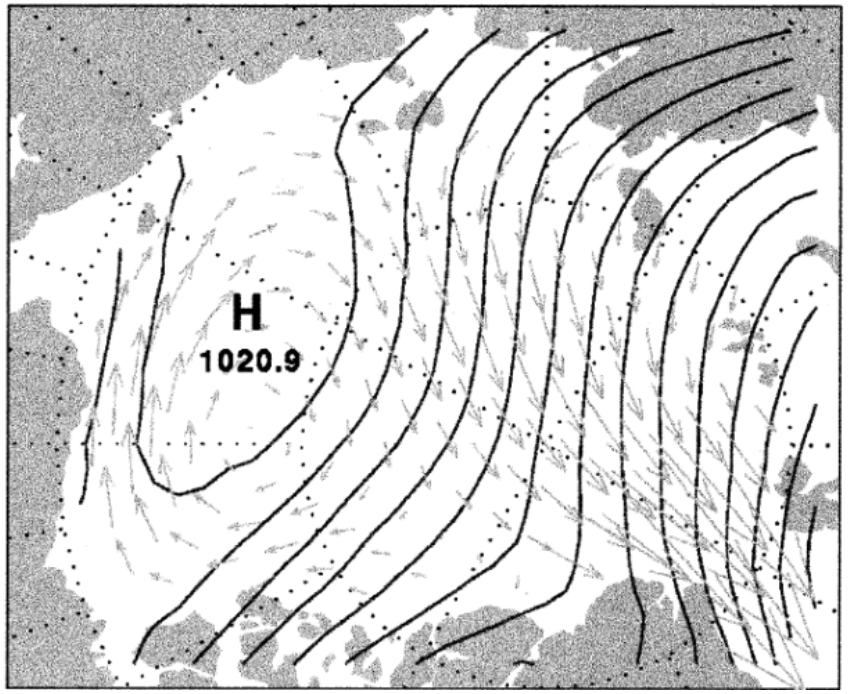
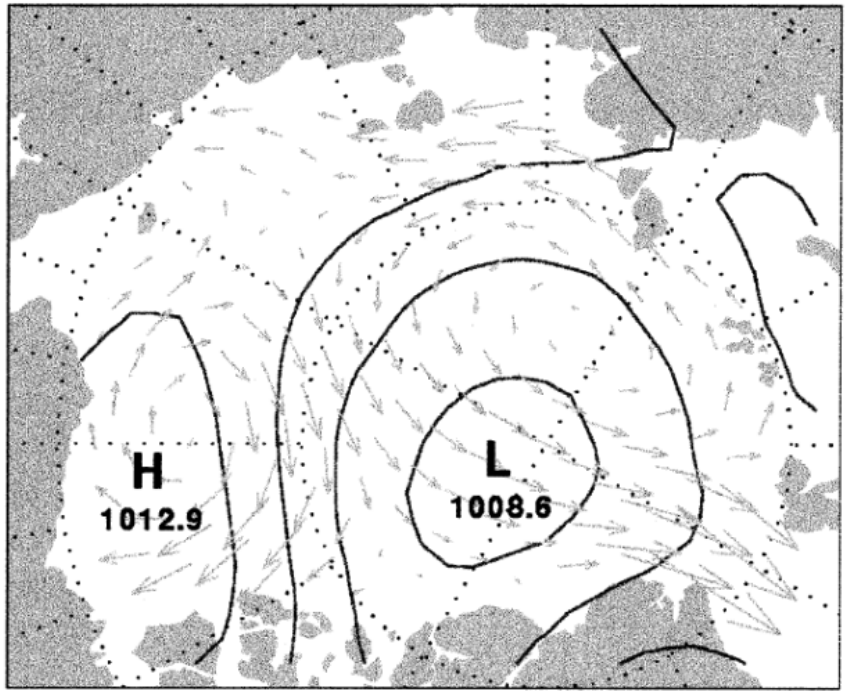


WINTER
January-March 1979-98



SUMMER
July-September 1979-98

Rigor, Wallace & Colony, 2002

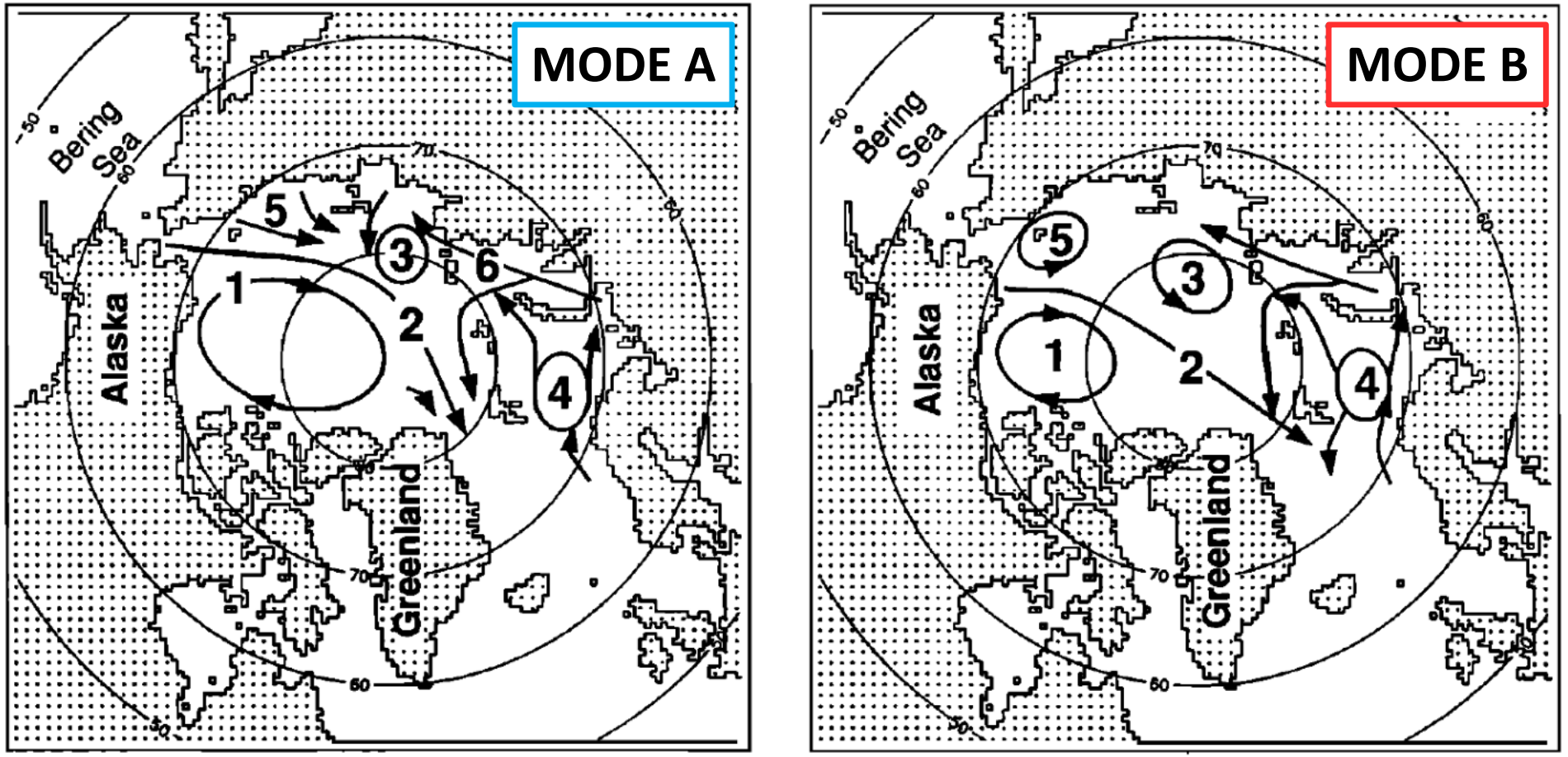
Regimes of circulation

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

Positive phase of AO: **Mode B**

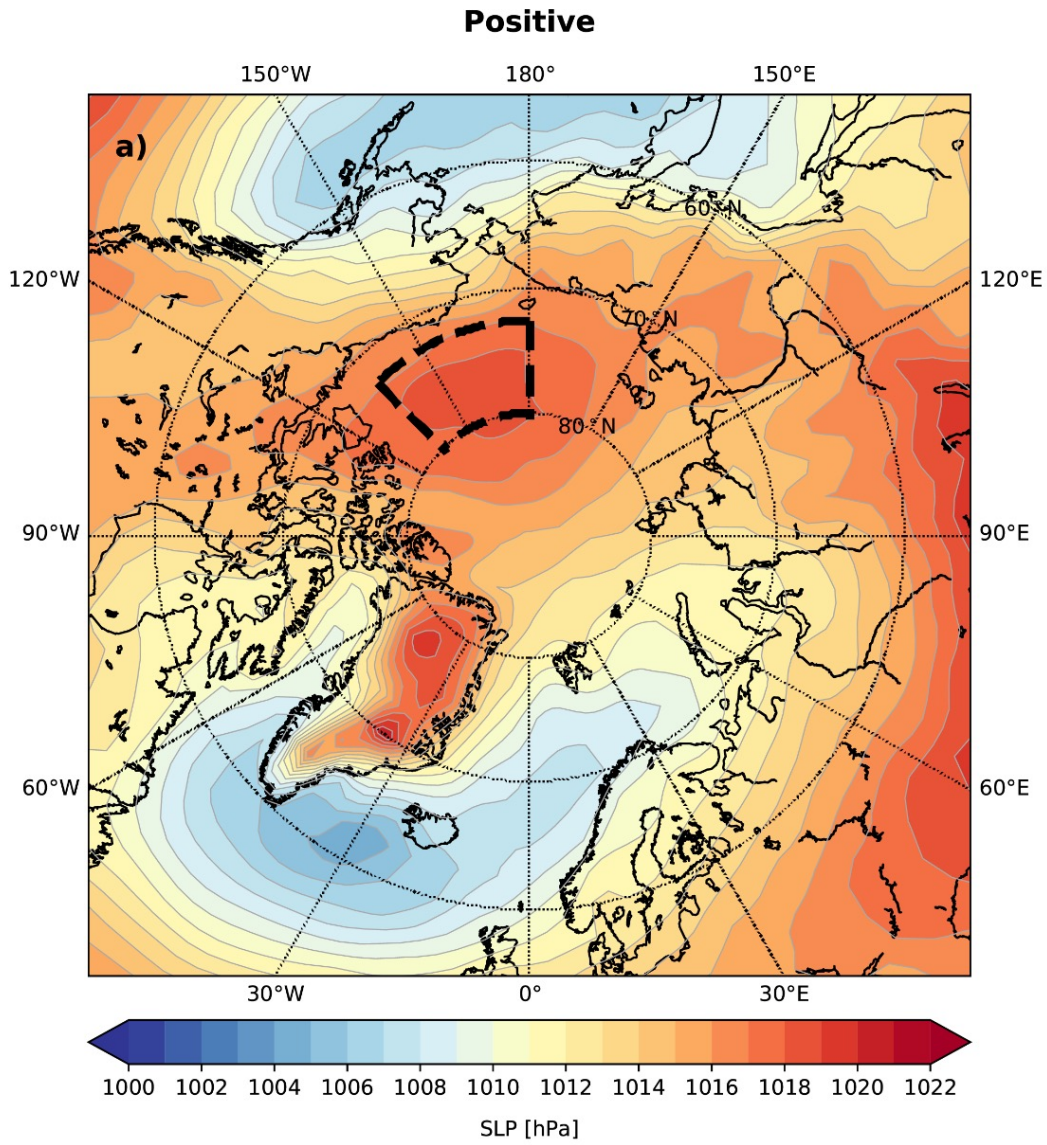
can alternate on timescales of a few years to decades
see Rigor et al. 2002

Surface currents and ice drift

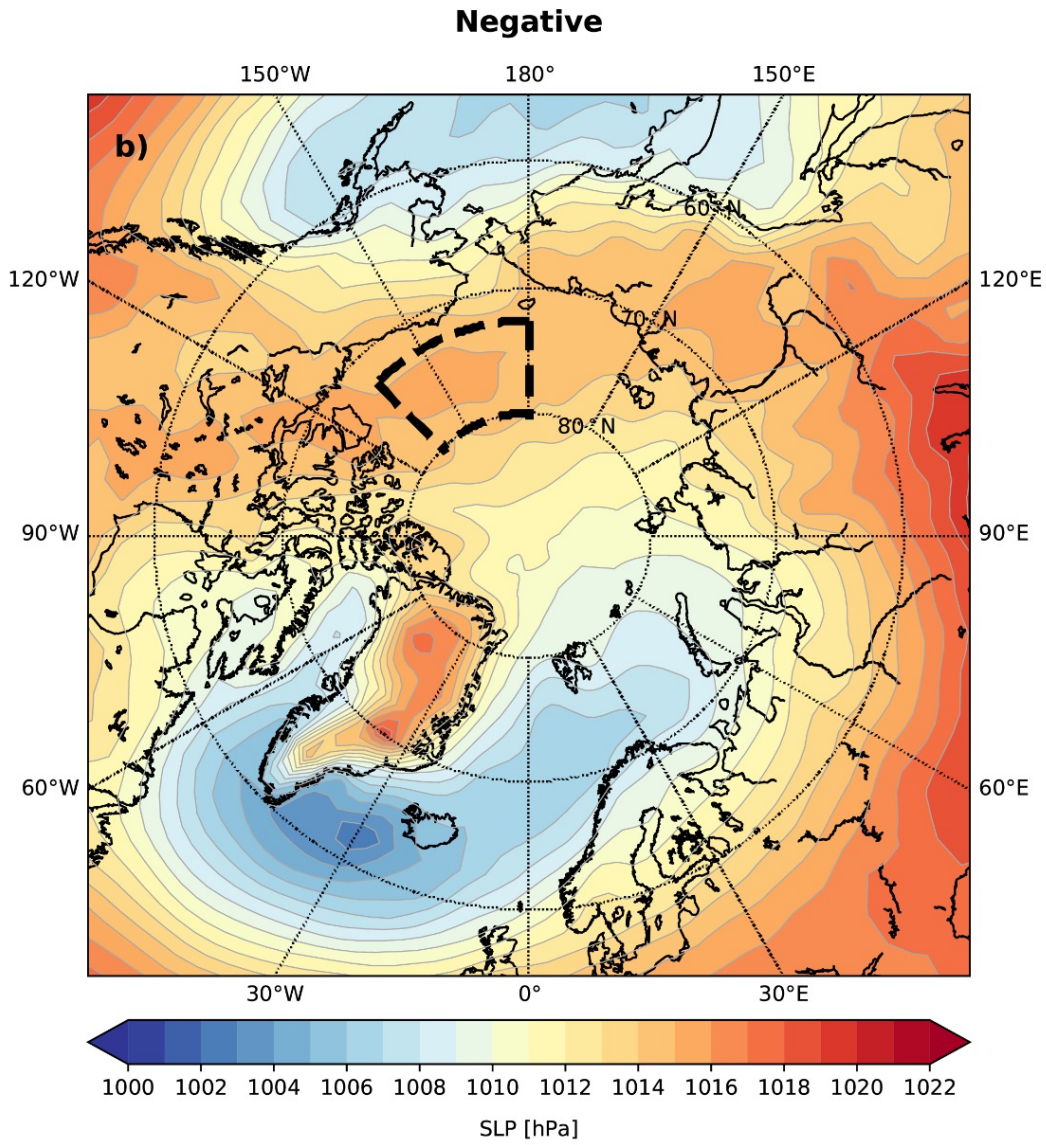


Proshutinsky & Johnson, 1997, & see Sokolov 1962

Strong Beaufort High

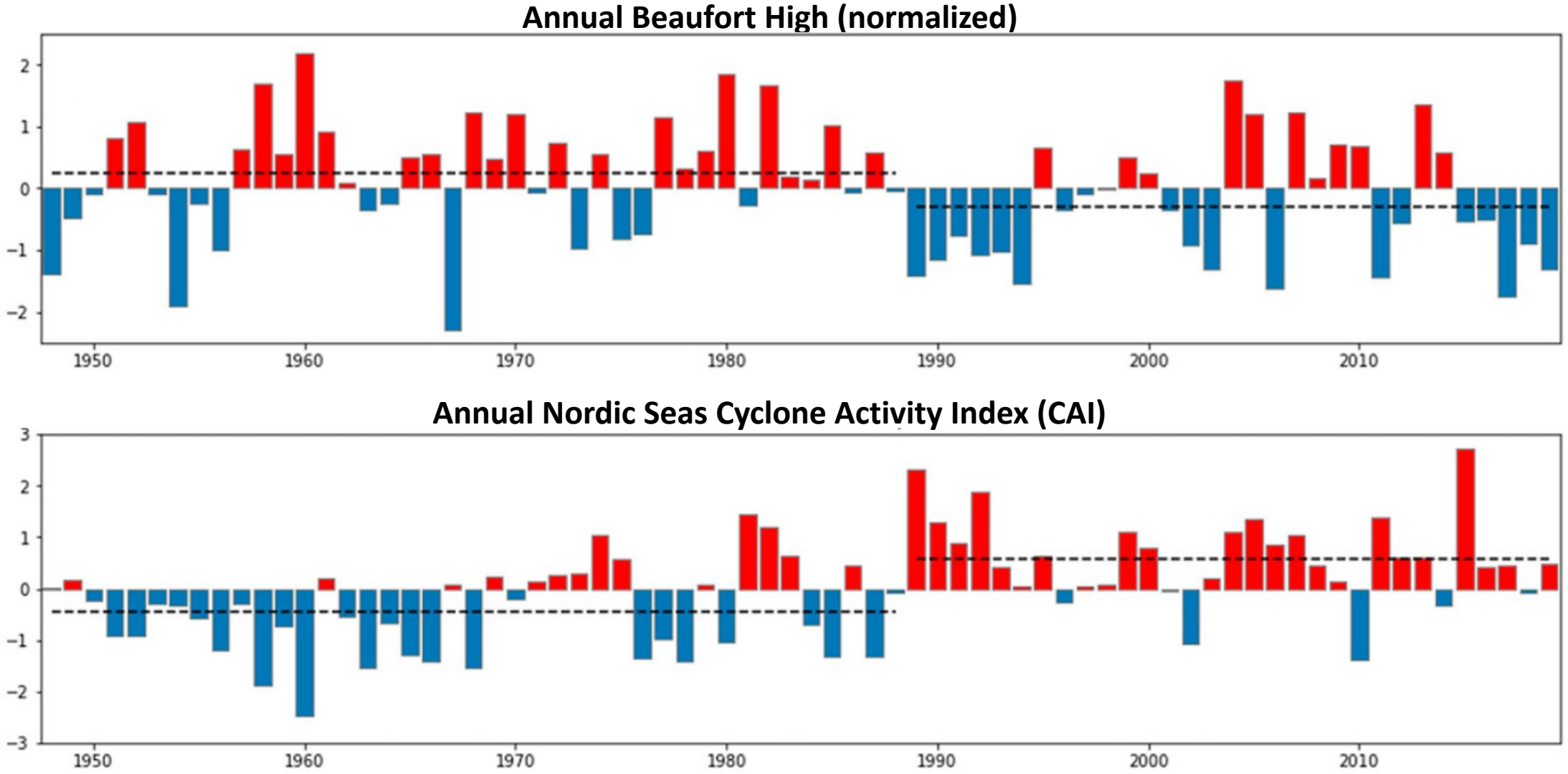


Weak Beaufort High



Kenigson & Timmermans, 2021

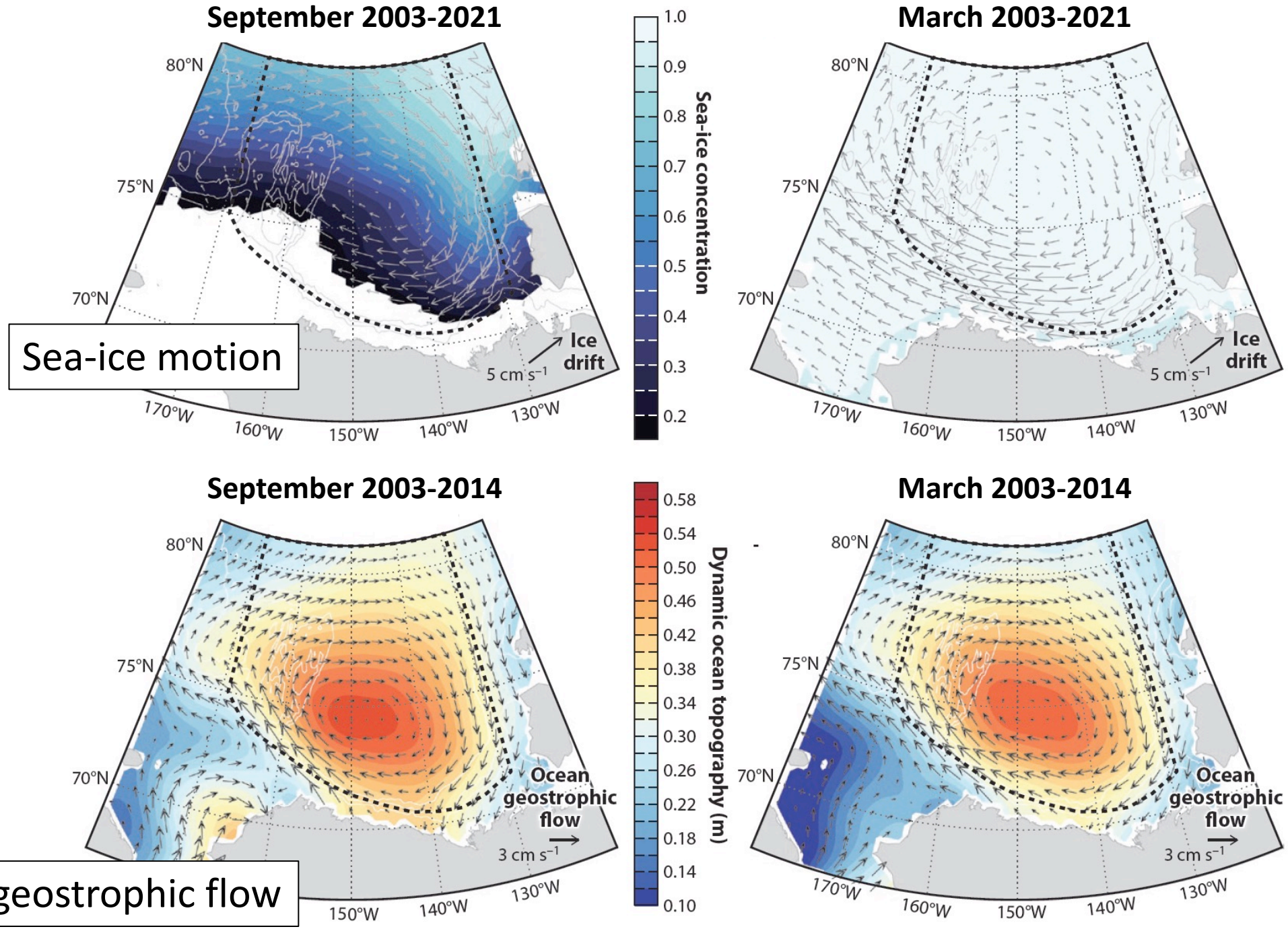
Transition from stronger BH in 1948-88 to weaker BH in 1989-2019



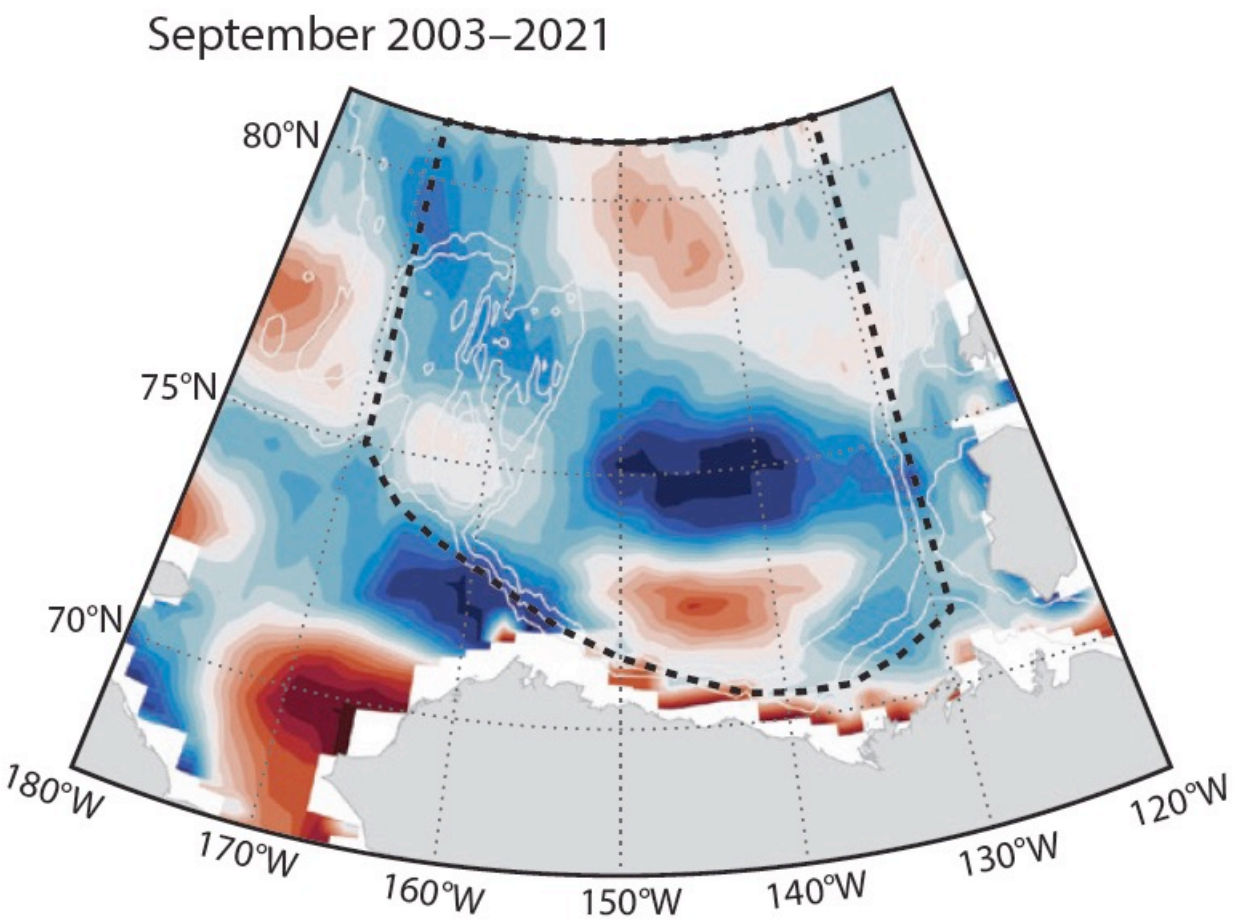
Zhang et al. (2019): BH weakening since late 1980s linked to Northern Hemisphere ozone depletion

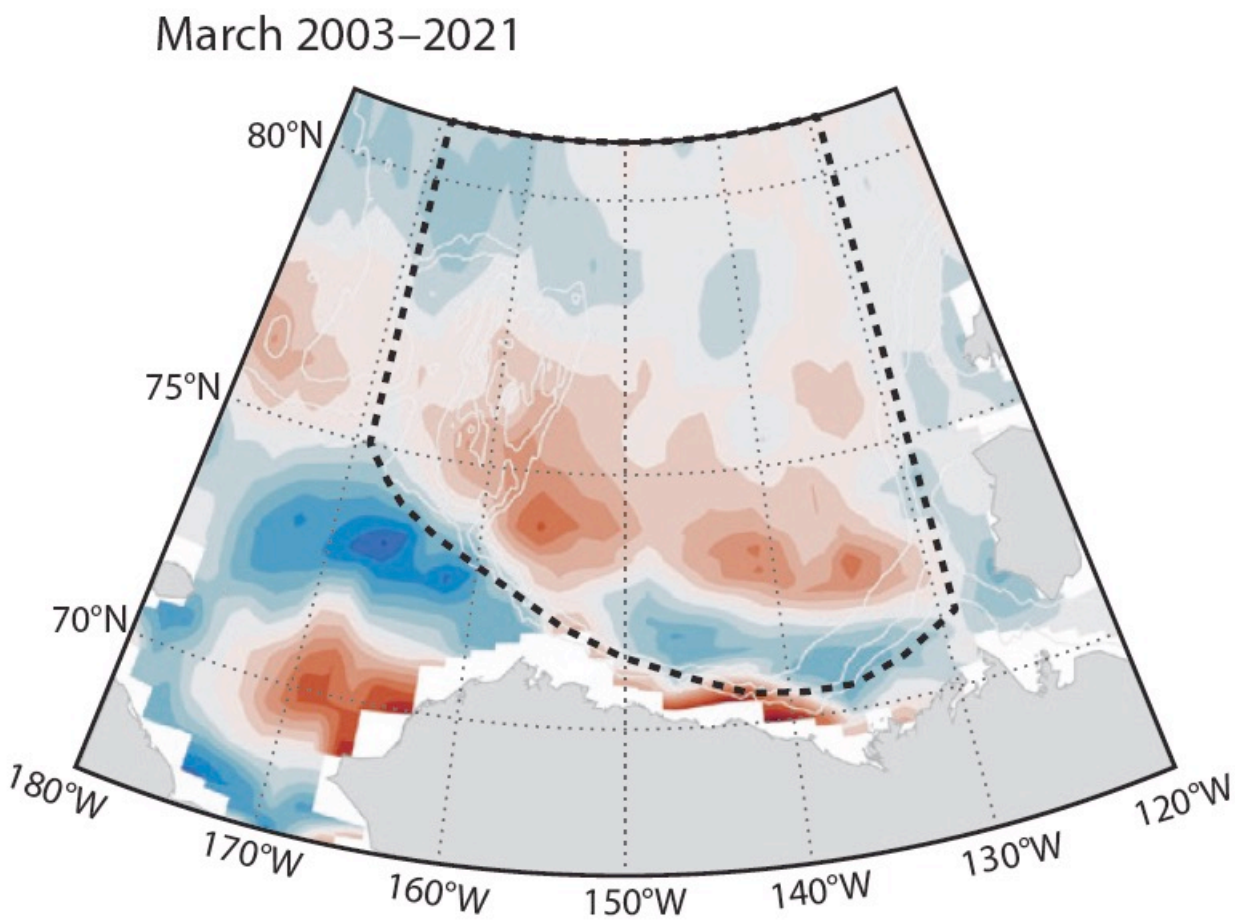
Kenigson & Timmermans, 2021

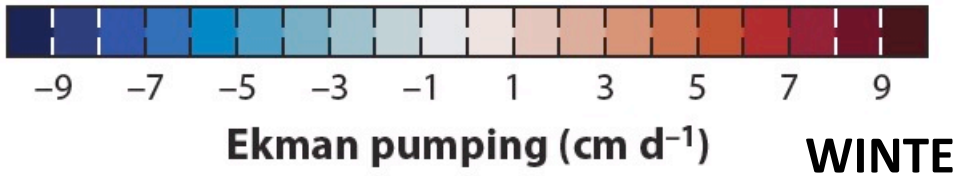
Seasonally changing surface stresses



Seasonally changing surface stresses



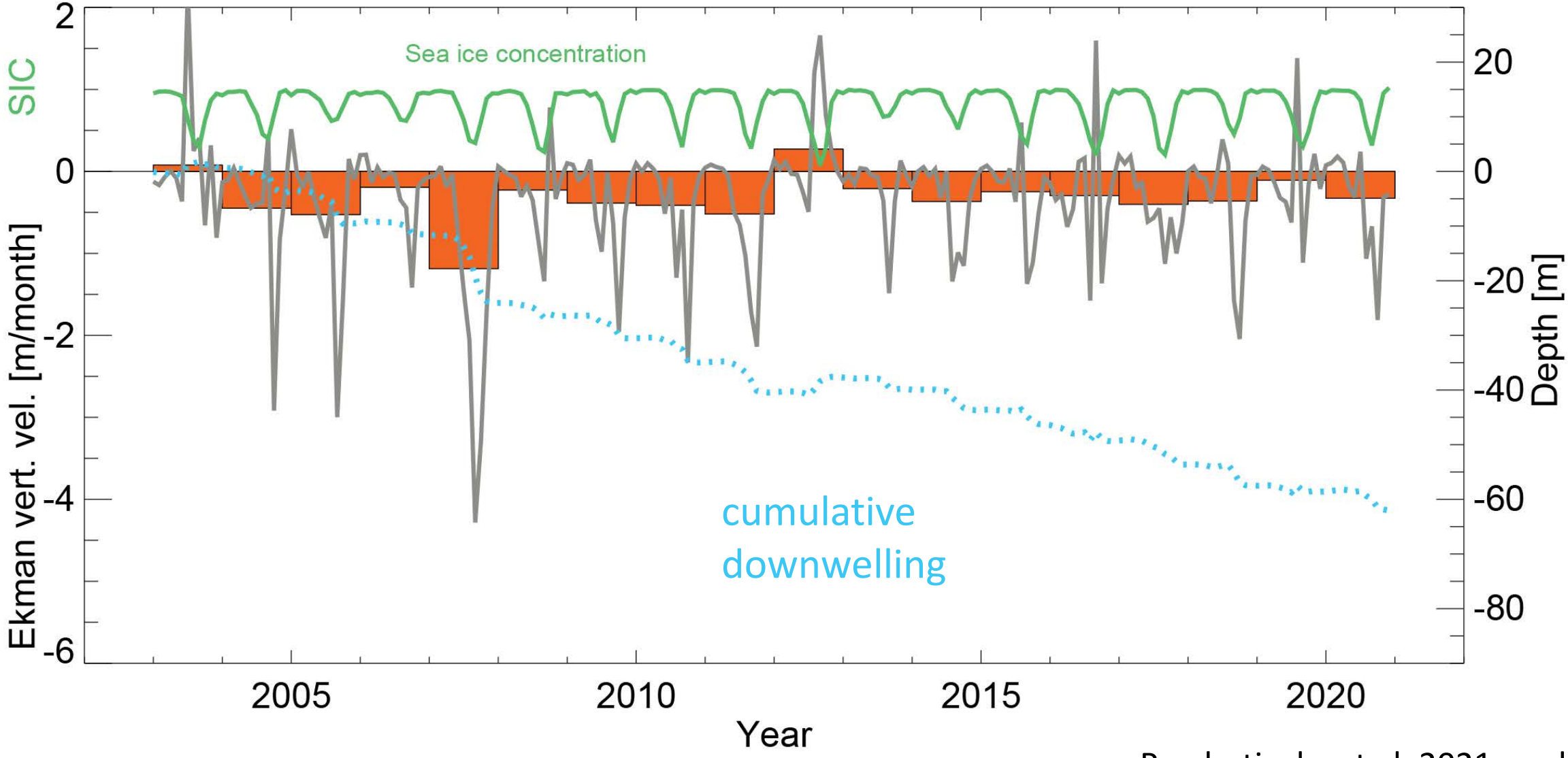




WINTER: friction at ice-ocean interface drives broad Ekman upwelling

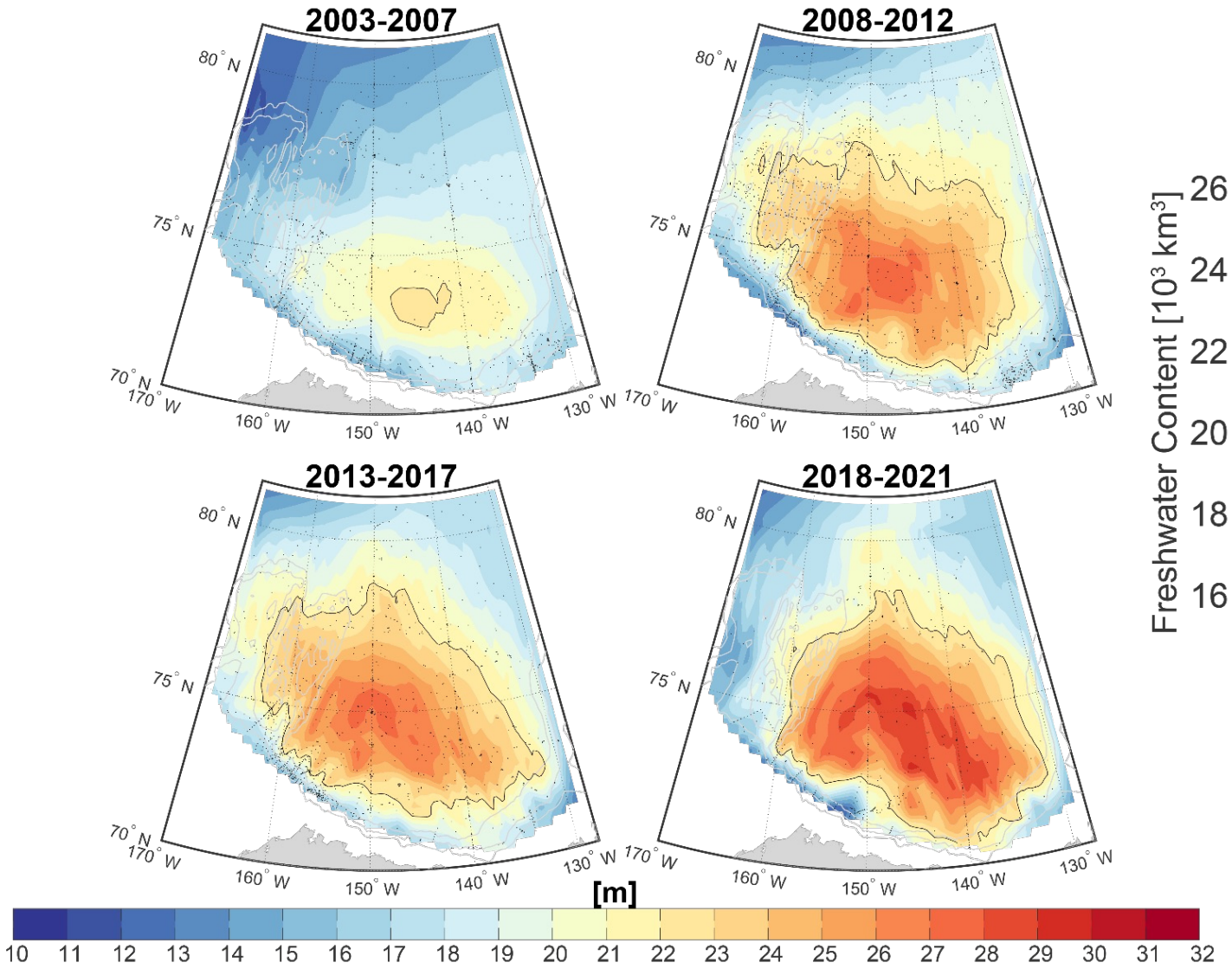
e.g., Meneghello et al. 2018; Dewey et al. 2018

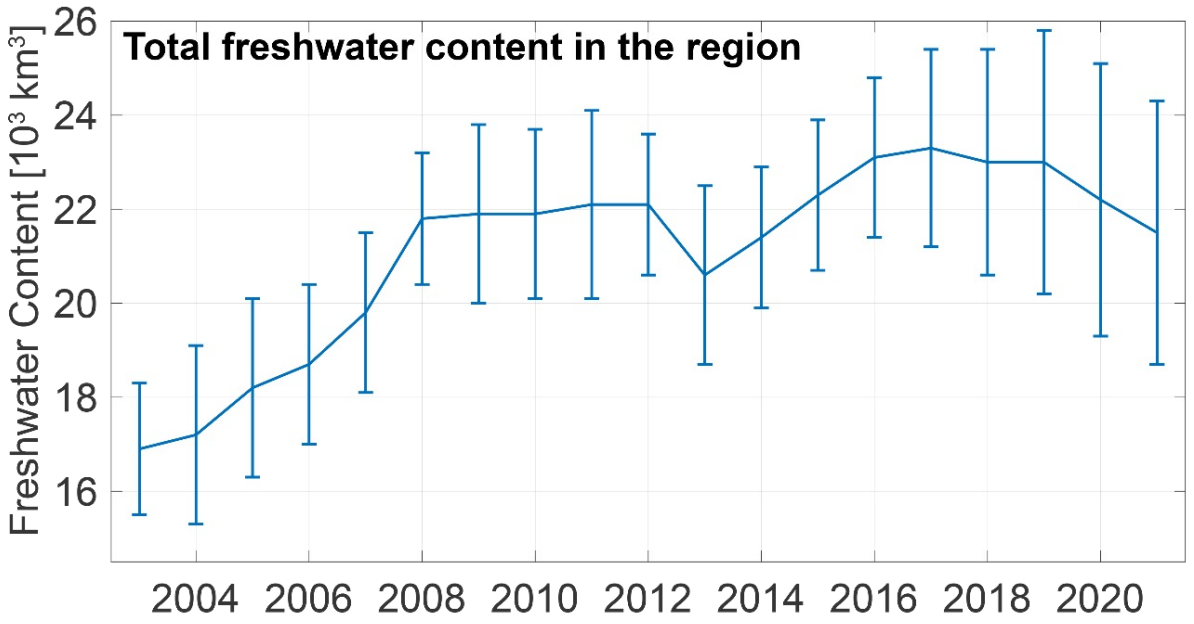
Ekman vertical velocity **monthly** and **annual** from winds, ice motion and concentration, and ocean geostrophic currents



Proshutinsky et al. 2021, updated

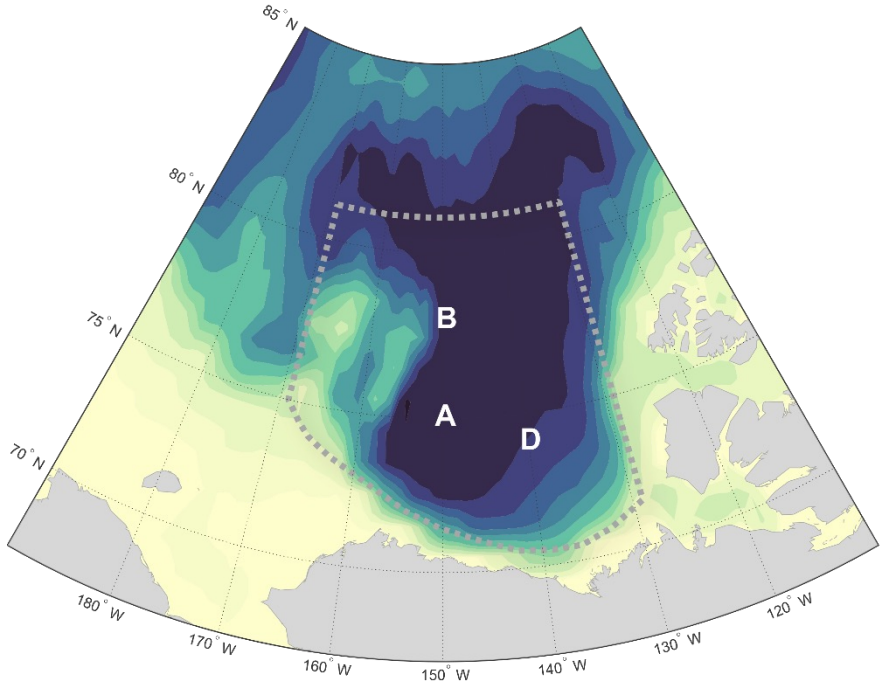
Freshwater Content

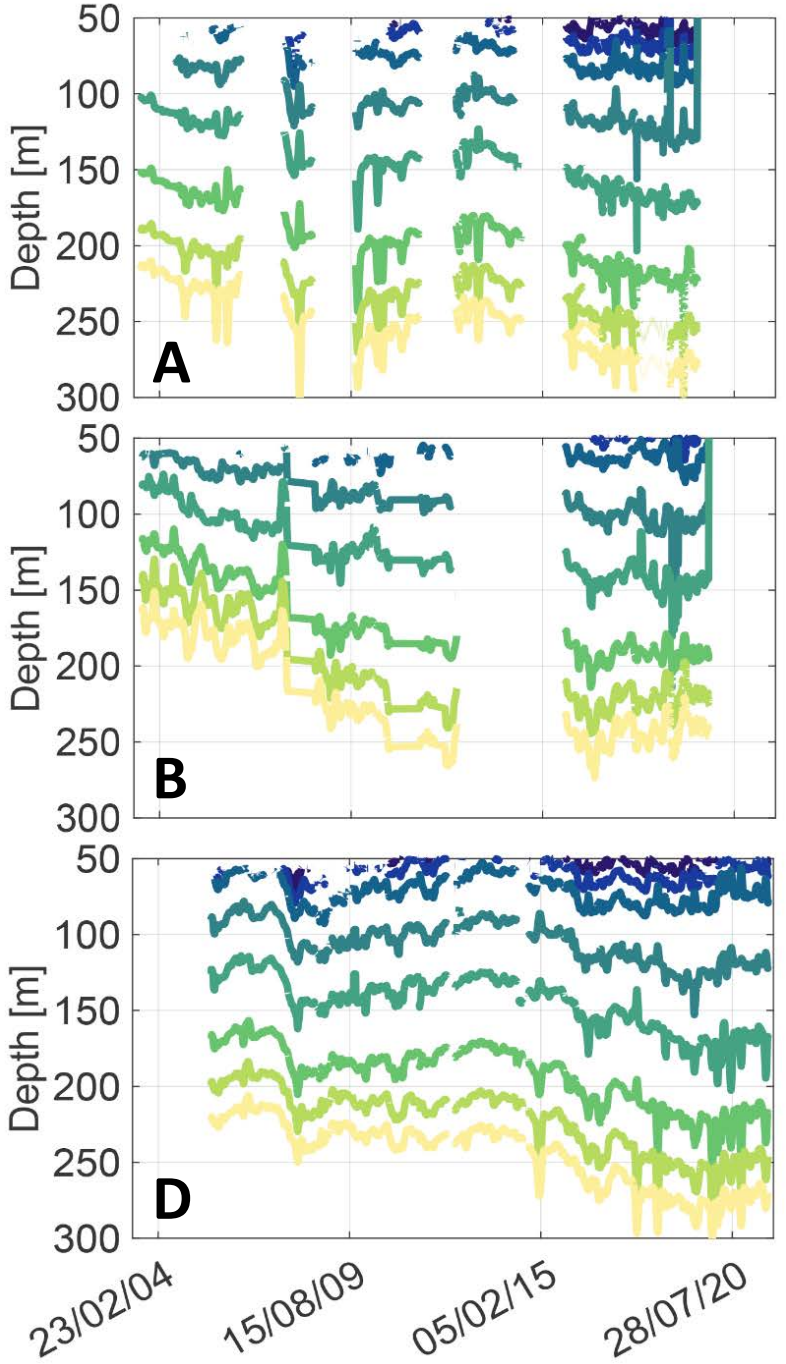


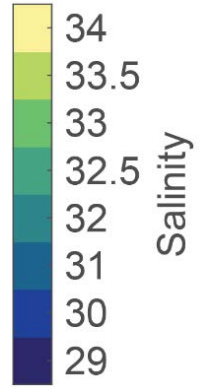


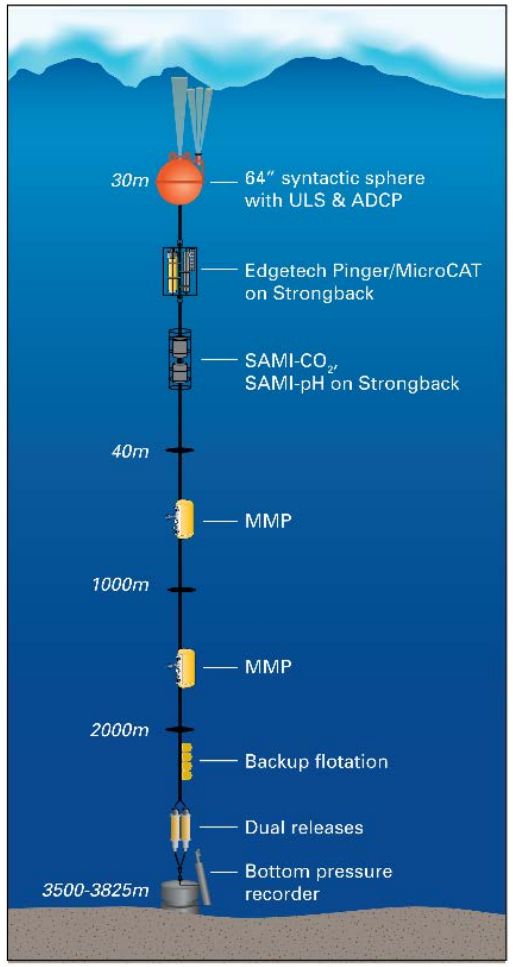
Proshutinsky et al. 2021, updated

Isohaline displacements sampled by **Beaufort Gyre Observing System** moorings (2003-2021)

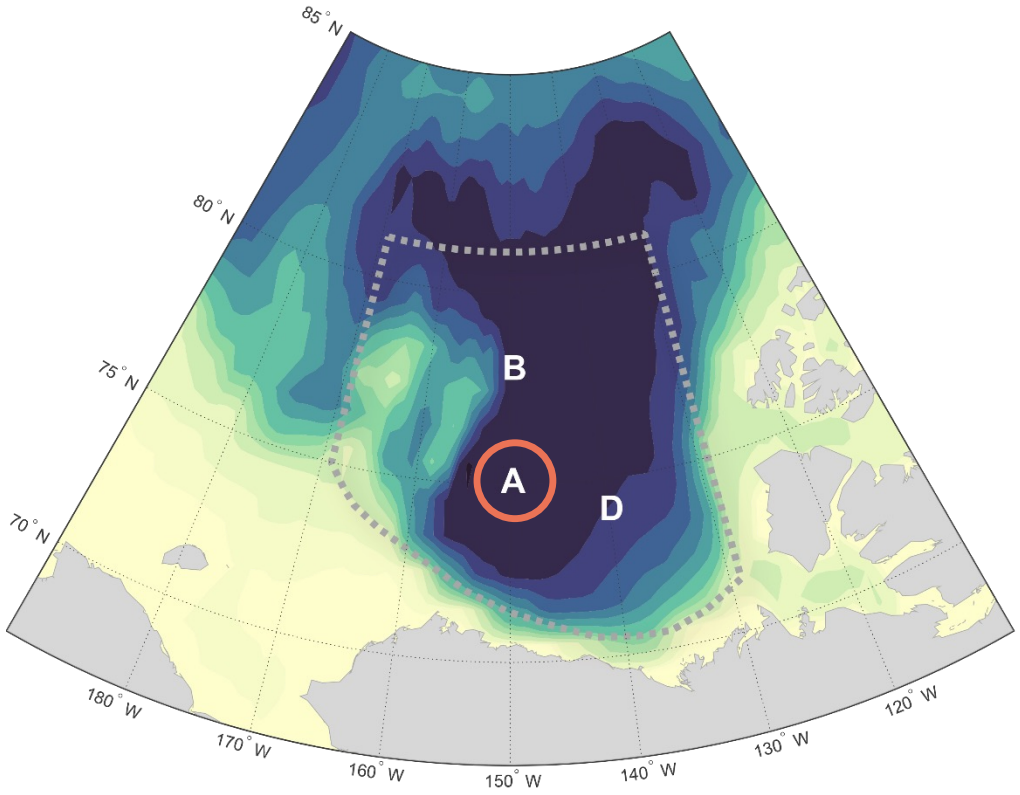






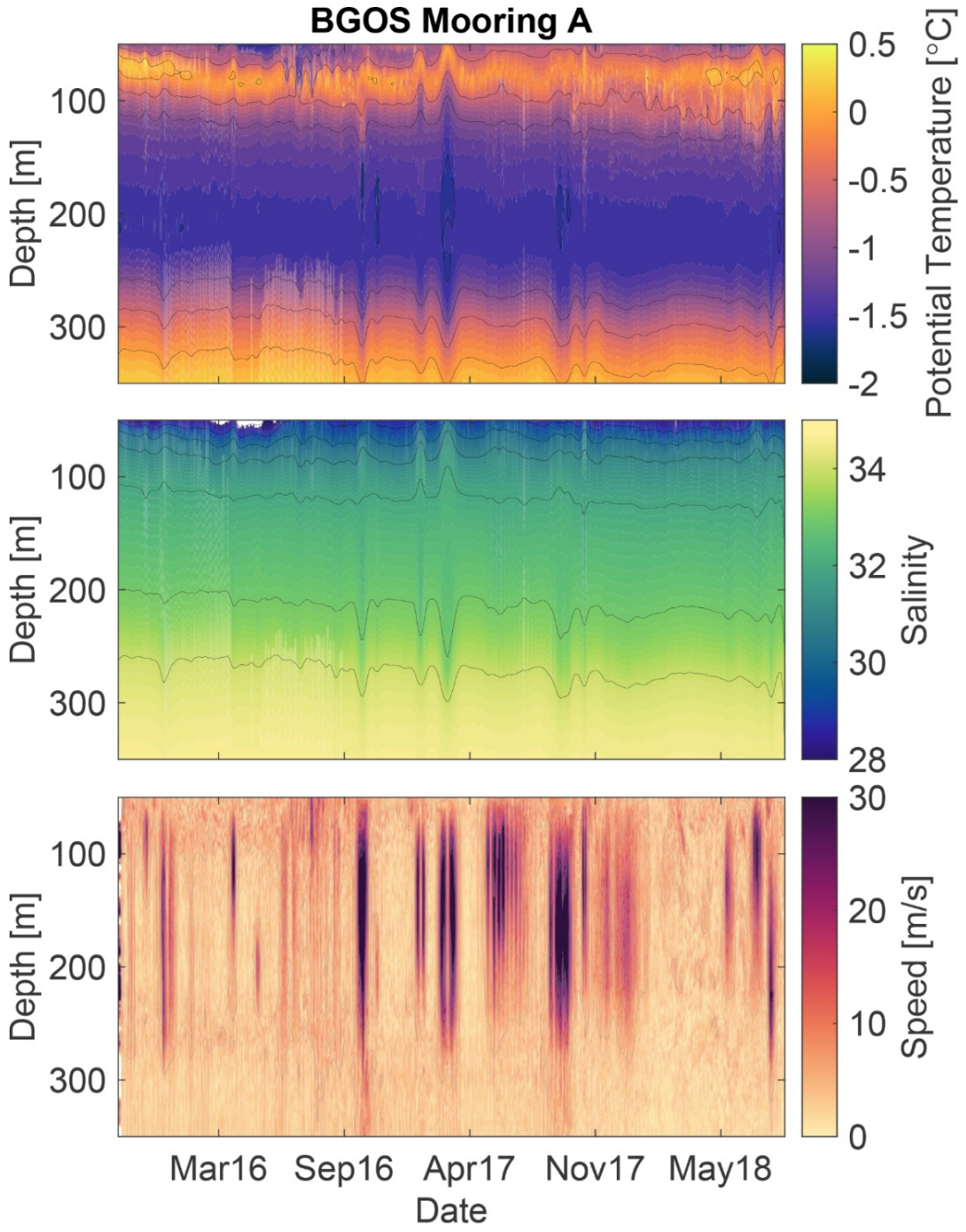


Eddy fluxes balancing wind-energy input

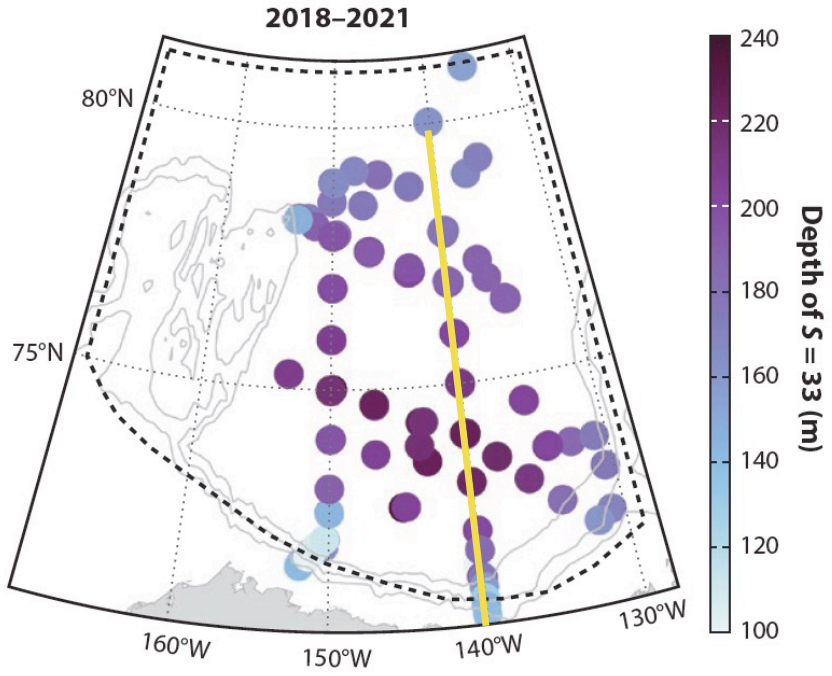


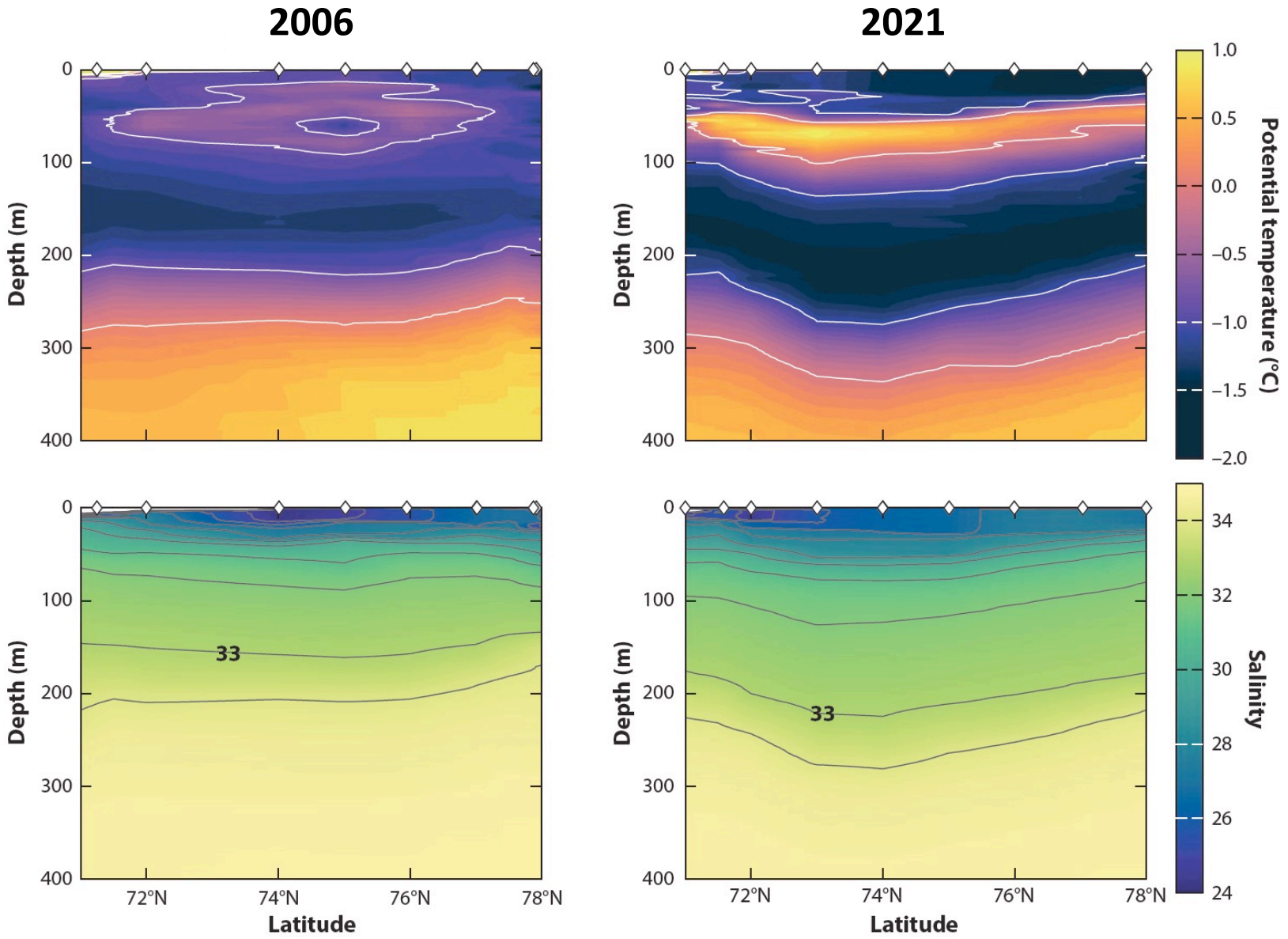
Eddies from baroclinic instability act as one balance on the wind's momentum flux.

e.g., Davis et al. 2014; Manucharyan et al. 2016; Dewey et al. 2018; Meneghello et al. 2017; Armitage et al. 2020

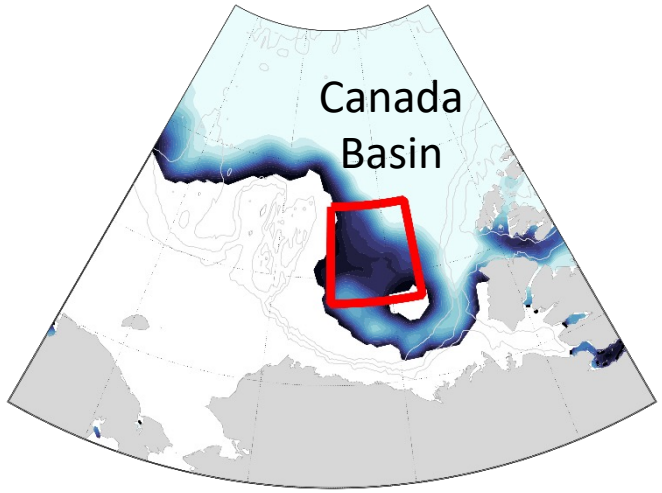


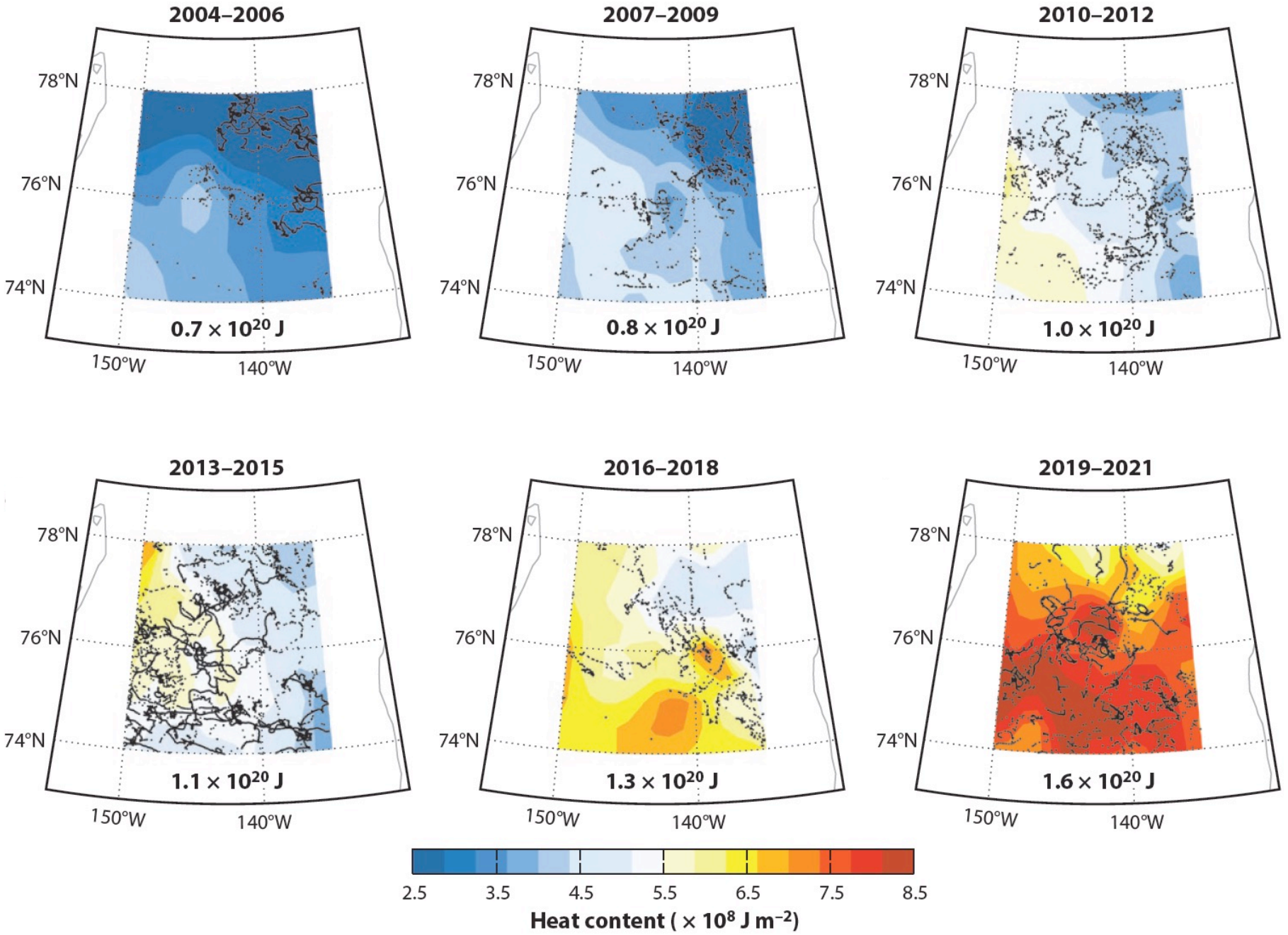
Changing Beaufort Gyre water column





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?

Linear trend flux of solar heat to ocean 1979-2021