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Chukchi and Beaufort Seas circulation in 2013–2023 from satellite radar altimetry

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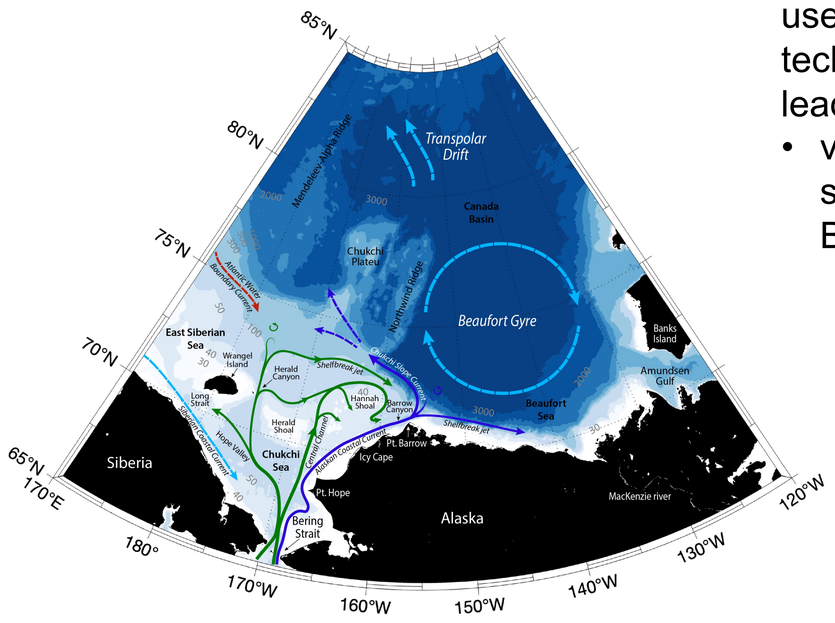
▲ *Retreating sea ice cover in the Chukchi Sea in 2012*

Motivation The Chukchi Sea is an important transition region for Pacific-origin waters flowing northwards through Bering Strait and bringing heat, freshwater, and nutrients to the Arctic Ocean. Accumulation and/or release of heat and freshwater from the Beaufort Gyre, the largest freshwater reservoir in the Arctic, can influence the major Arctic circulation patterns (Timmermans and Toole, 2023).

Monitoring processes in the region is crucial for understanding the variability of the Arctic Ocean. However, the Arctic is challenging to observe. A novel long-term dataset based on satellite altimetry allows us to monitor and analyze interannual, seasonal, and synoptic variability of the sea level and geostrophic currents in the region.

Dataset and region

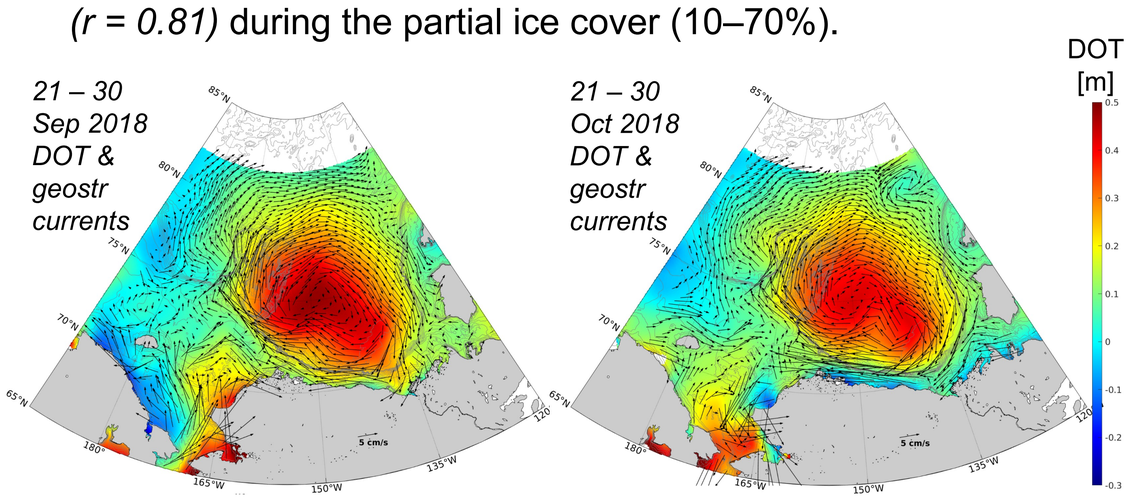
- Dynamic Ocean Topography (DOT) and geostrophic currents derived from SARAL (,) along-track radar altimetry data for 2013–2023, interpolated on a 10d/8km grid up to 82˚N;
- processed with recent advanced algorithms for sea surface height determination in the sea-ice-covered ocean and adapted with the use of special techniques for reliable lead detection;
- validated against in-situ data in the Bering Strait.



◄ *Schematic circulation of the Chukchi and Beaufort seas*

Synoptic variability of the Bering Strait throughflow

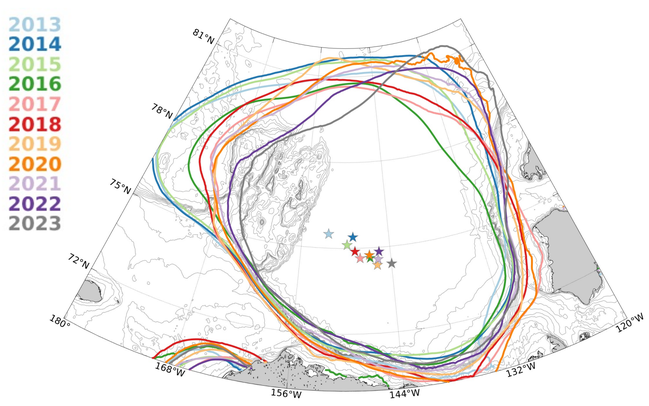
- Mean northeasterly winds in the region oppose the mean flow.
- High SLP gradient over the region, caused by the enhanced anticyclonic centers of action over the Arctic, but primarily by the intensified and shifted eastwards Aleutian Low (AL), can cause anomalously strong storms during the cold season.
- In response to a northerly storm, an Ekman transport of the surface waters from the Alaskan coast westwards can occur, and the current through the strait reverses.
- 62 flow reversals were identified over 2013–2023 (9.2%).
- While the strongest reversal events and most accounts of the southward flow happened during fall, the wind forcing in winter was stronger or comparable to fall forcing.
- The response of the along-strait flow to anomalously strong along-strait northerly winds is distinct during fall in the absence of sea ice and well-correlated during winter *(r = 0.62)* and spring *(r = 0.81)* during the partial ice cover (10–70%).



▲ *DOT overlaid by geostrophic currents (top panel) and SLP overlaid by 10-m winds (bottom)*

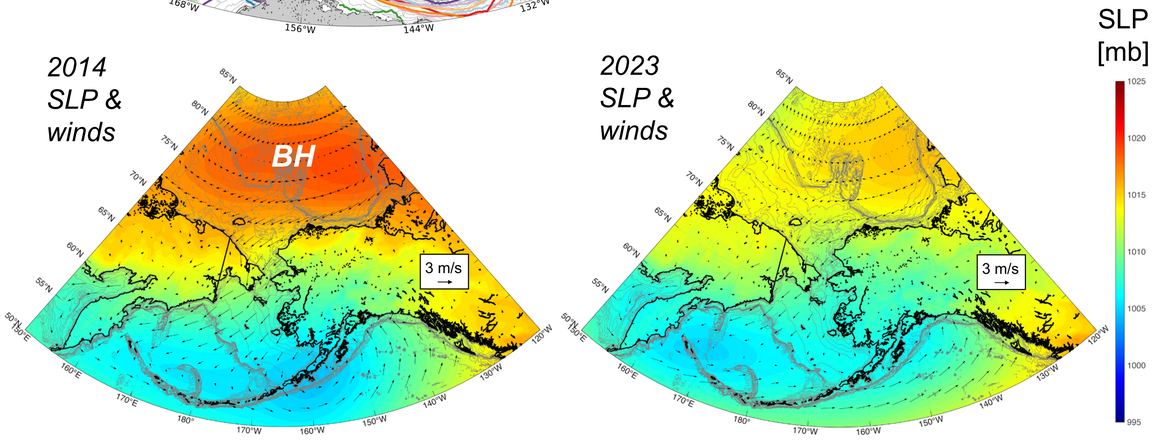
Beaufort Gyre interannual variability

- Beaufort Gyre (BG) center has shifted southeastwards over 2013–2023, compared to the northwestward shift of the previous decade (reported by Regan et al., 2019).
- BG had the largest area in 2013, 2014; smallest in 2016, 2023.
- High sea level pressure (SLP) of the Beaufort High (BH) causes the expansion of the BG.

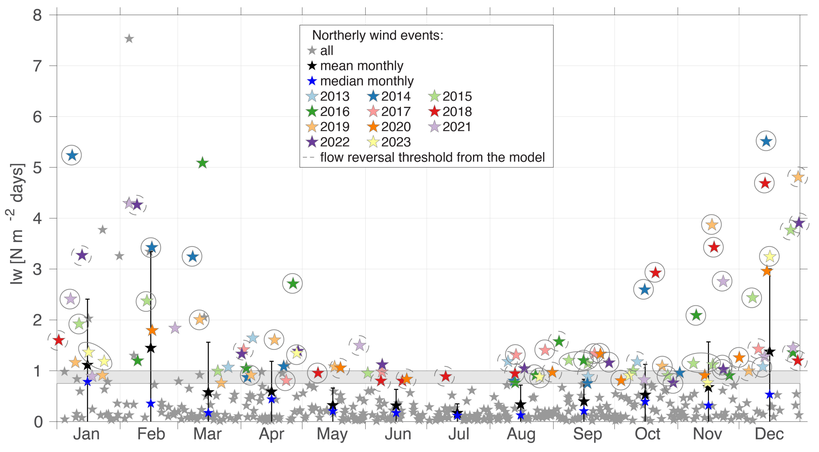


◄ *The average position of the BG center and its extent for each year for 2013–2023*

▼ *Yearly mean SLP and 10-m winds for 2014 (left) and 2023 (right)*



► *Time integral of the windstress (Iw) in Bering Strait for the wind events for 2013–2023.*
The grey circles denote the flow reversals/ weakening of the northward flow



Summary

- Carefully processed satellite radar altimetry allows us to resolve interannual, seasonal, and synoptic variability of DOT and geostrophic currents in the Arctic Ocean.
- Beaufort Gyre accumulates freshwater when high sea level pressure prevails; the shift in the atmospheric patterns can lead to the release of freshwater into the Arctic.
- Cold season reversals of the Bering Strait throughflow (contributing to the Beaufort Gyre heat and freshwater content) happen due to the influence of anomalously strong northerly winds over the region.

References and Acknowledgements:

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