

“Causal Mechanisms of Rising Sea Level and Increasing Freshwater Content of the Beaufort Sea”

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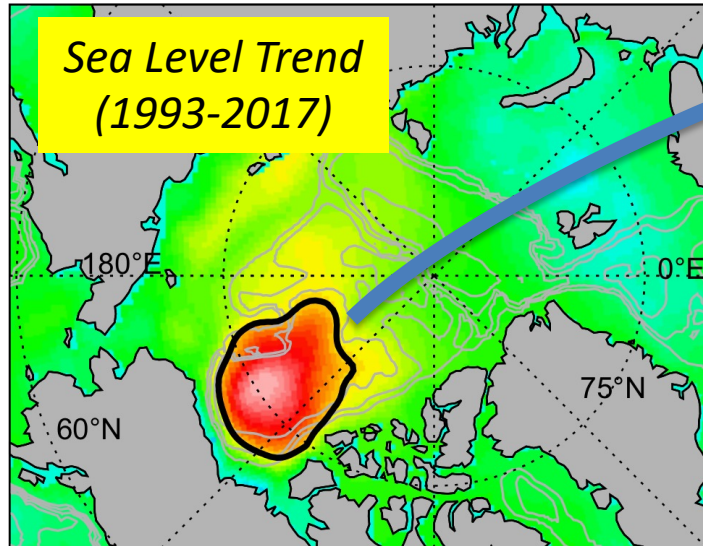
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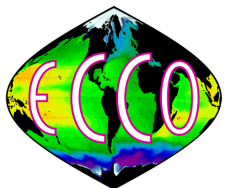
Changes in the Beaufort Sea

Sea level and freshwater content have risen dramatically, which ECCO resolves consistently.

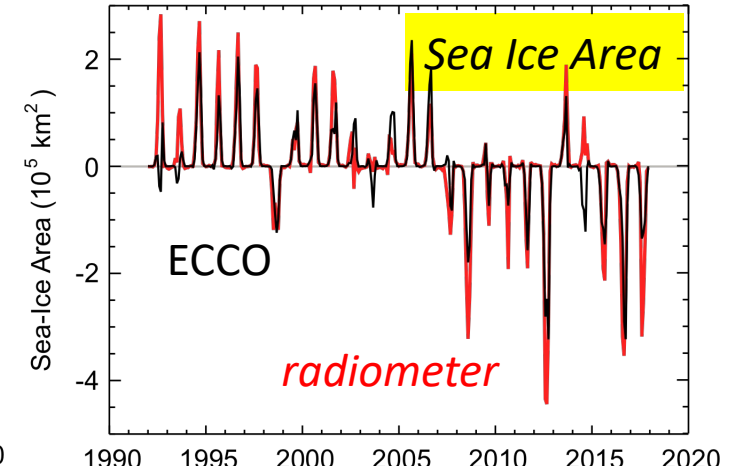
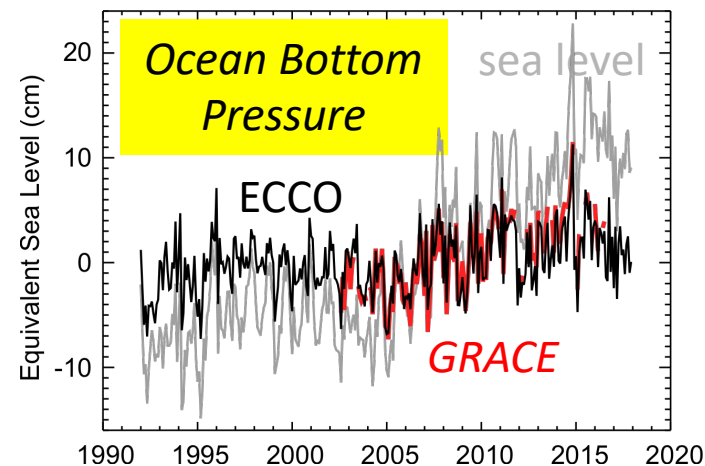
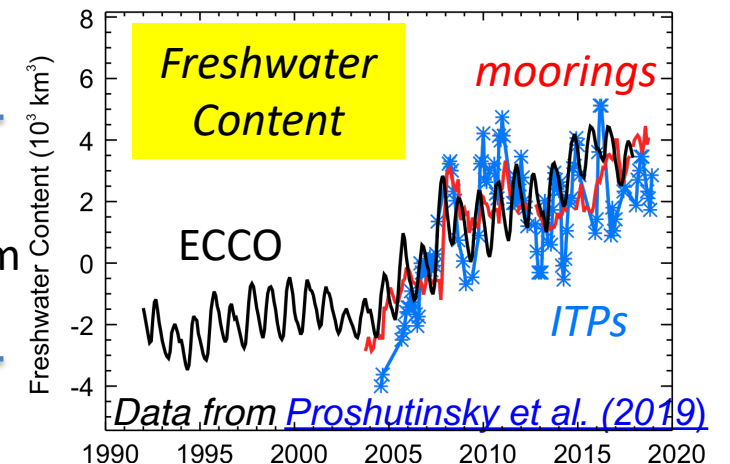
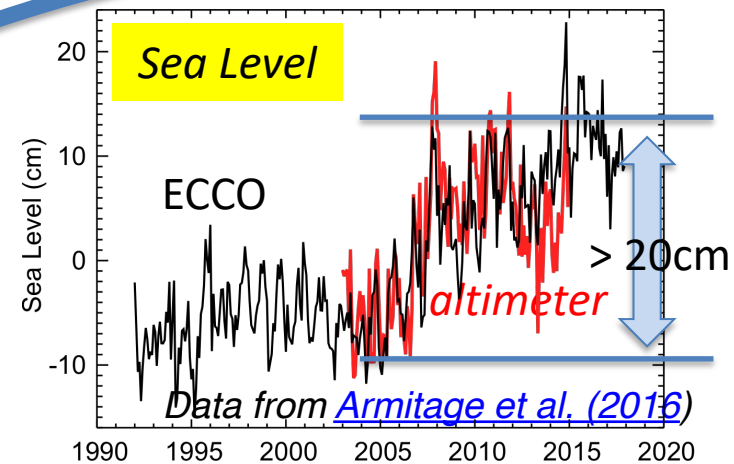


“Estimating the Circulation and Climate of the Ocean” (ECCO)
Data-Constrained
Ocean & Sea Ice Model
(Version 4 release 4)

<https://www.ecco-group.org/>



Time-series of “Gyre-mean” quantities



Identify Responsible Forcing Using Model's Adjoint

Adjoint Gradient Decomposition

Beaufort Sea
mean sea level

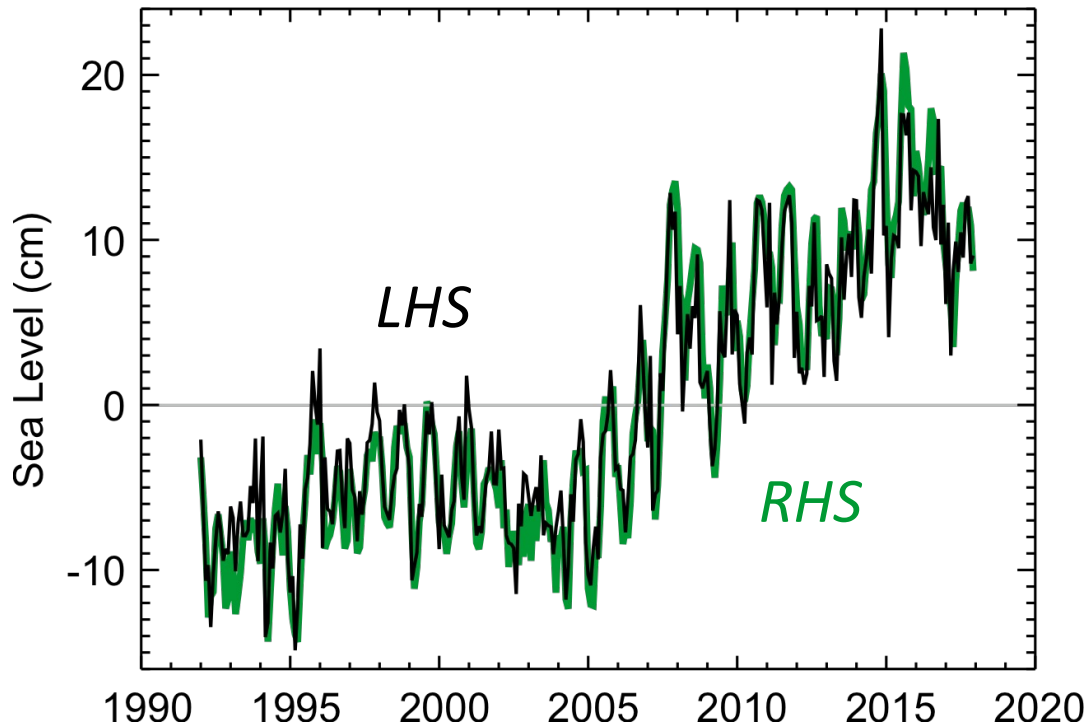
$$\delta J(t) \approx \sum_i \sum_{\mathbf{r}} \sum_{\Delta t} \frac{\partial J(t_g)}{\partial \phi_i(\mathbf{r}, t_g - \Delta t)} \delta \phi_i(\mathbf{r}, t - \Delta t)$$

Sensitivity (adjoint gradient)
of J to forcing i

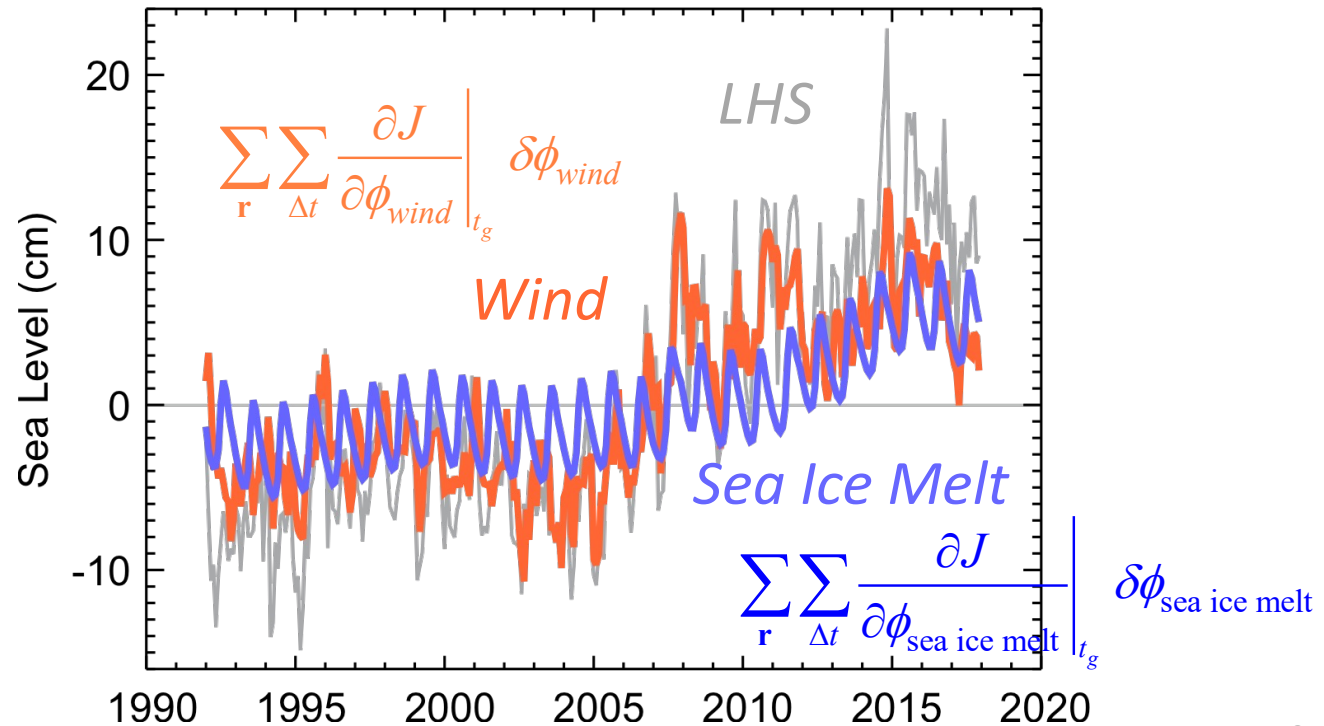
Forcing i

Type Location Lag

Beaufort Sea Mean Sea Level



Decomposition



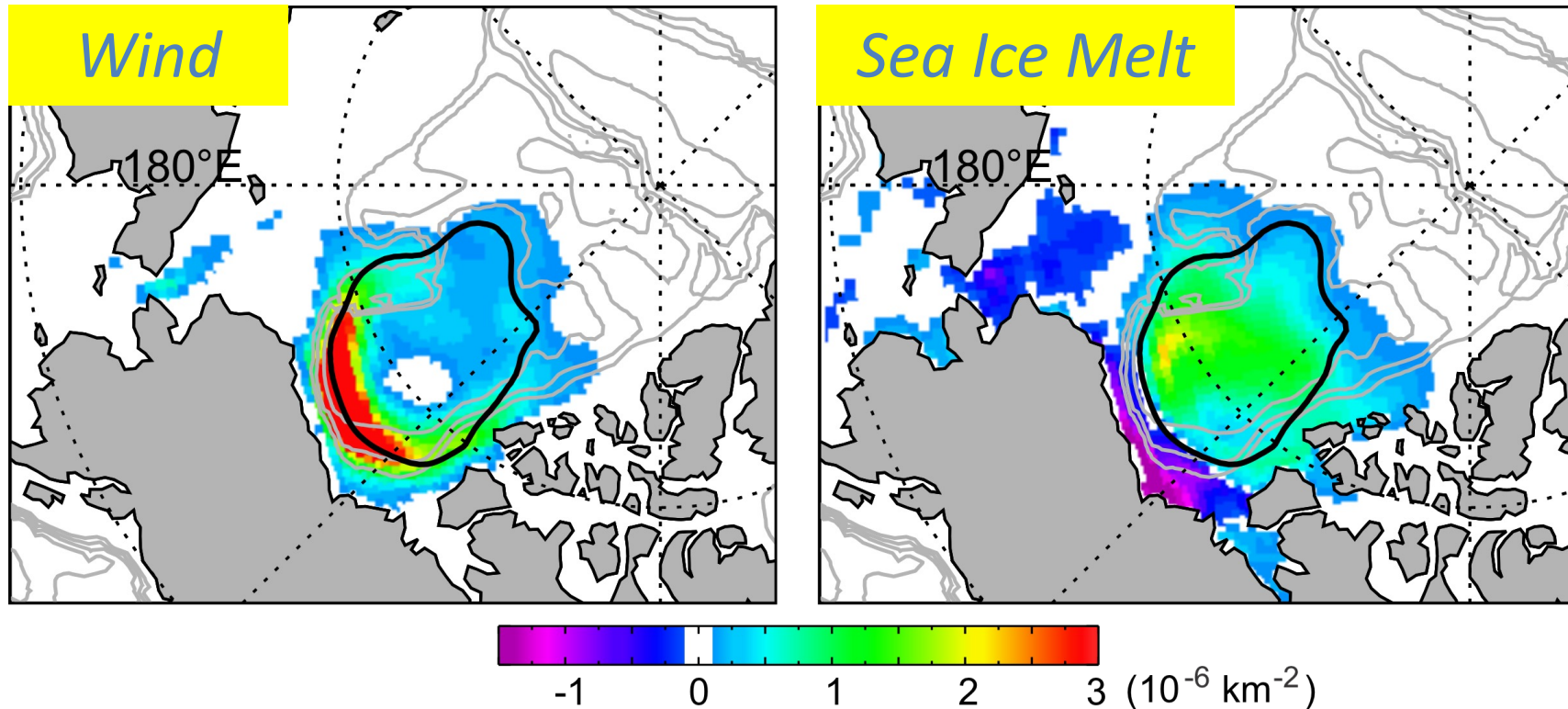
Where is the Forcing Contribution Taking Place?

Wind-driven Ekman transport from the surrounding area and sea ice melt within the Gyre are responsible for the steric change.

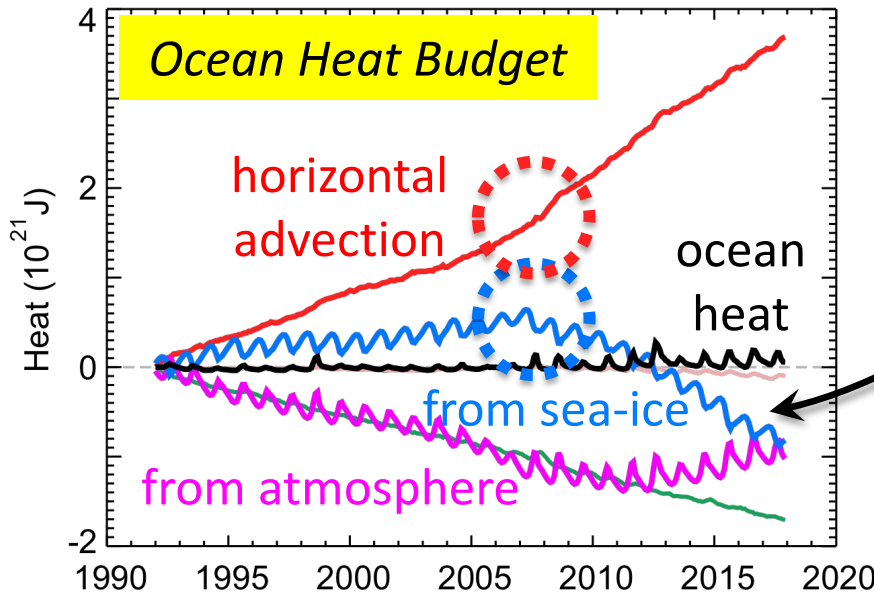
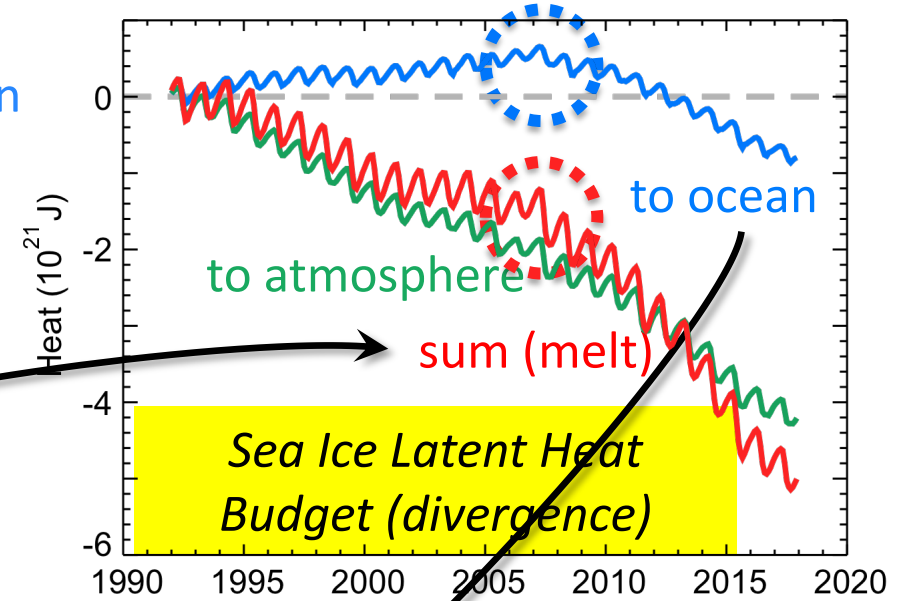
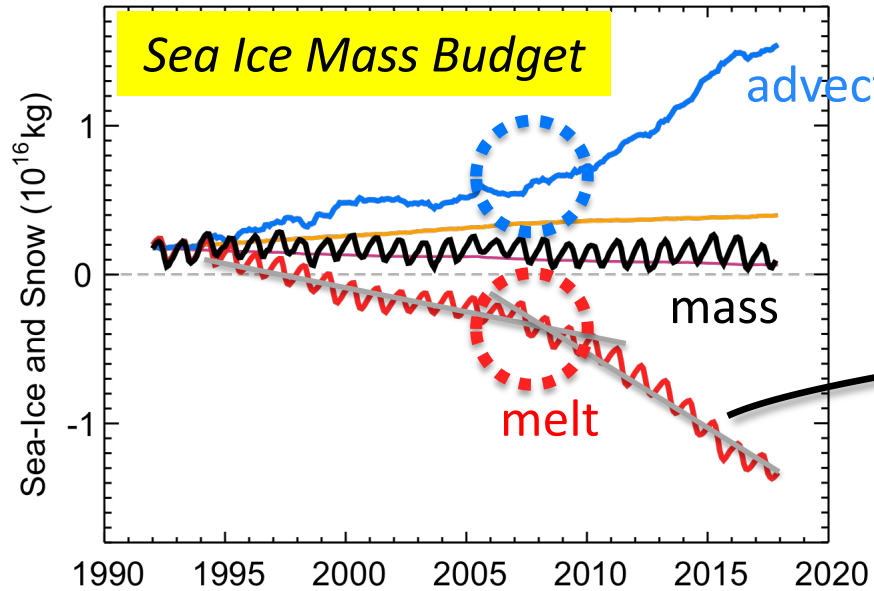
Beaufort Sea's halosteric variance explained at different locations \mathbf{r} by particular forcing i

$$E_i(\mathbf{r}) \equiv \frac{1}{dS(\mathbf{r})} \times$$

$$\left[\frac{\text{var} \left\{ J_{halosteric}(t) - \sum_{\Delta t} \frac{\partial J(t_g)}{\partial \phi_i(\mathbf{r}, t_g - \Delta t)} \delta \phi_i(\mathbf{r}, t - \Delta t) \right\}}{\text{var} \{ J_{halosteric}(t) \}} \right]$$



What is Driving Sea Ice Melt in the Beaufort Sea?



Increasing wind that's responsible for sea level rise is also increasing *sea ice convergence* & *ocean heat convergence* resulting in increasing *sea ice melt*.

Summary

Strengthening **wind** and increasing **sea ice melt** are jointly responsible for Beaufort Sea's multi-decadal sea level rise;

- 1) Strengthening **winds** intensify lateral Ekman convergence of fresh near-surface water,
- 2) The **winds** also enhance convergence of sea ice and ocean heat that increase the region's **sea ice melt**.

