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Modeling the **biological response** to changing *sea ice* and *ocean* conditions in the Beaufort and Chukchi Seas

Michael Steele (PSC/APL/UW)

Jinlun Zhang

Wenli Zhong

Yvette Spitz

Carin Ashjian

Robert Campbell

Axel Schweiger

…& others

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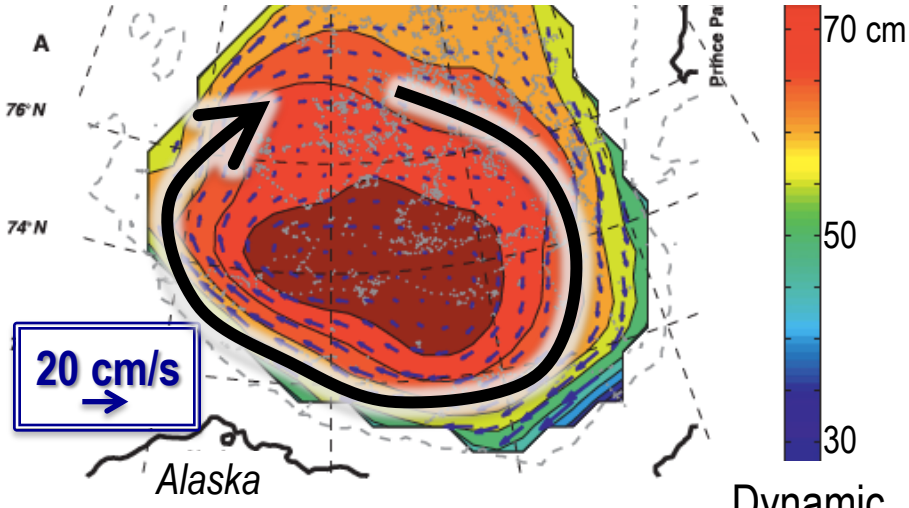
Beaufort Gyre "spin up"

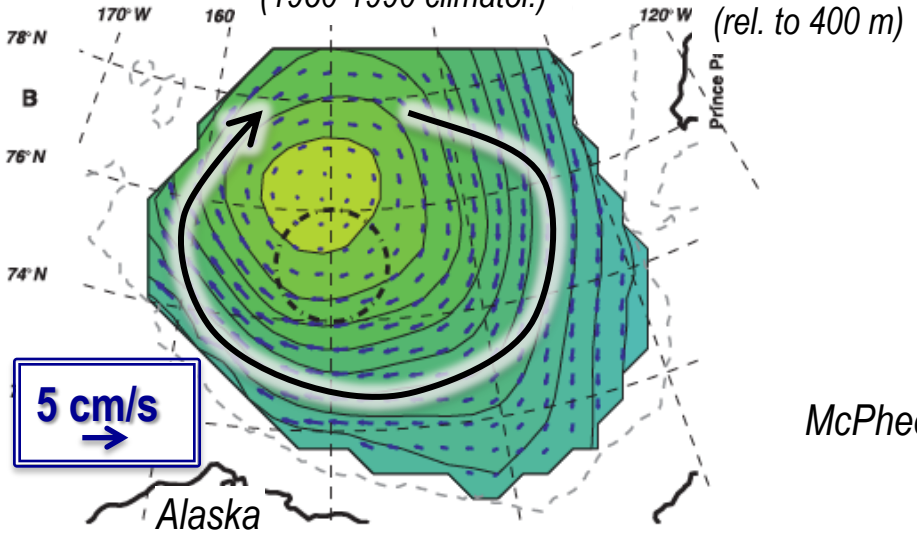
Geostrophic current *(in situ obs)*

(2008-2011)



Dynamic height
(rel. to 400 m)

(1950-1990 climatol.)



Lots of BG… lots of physics…

McPhee (GRL, 2012)

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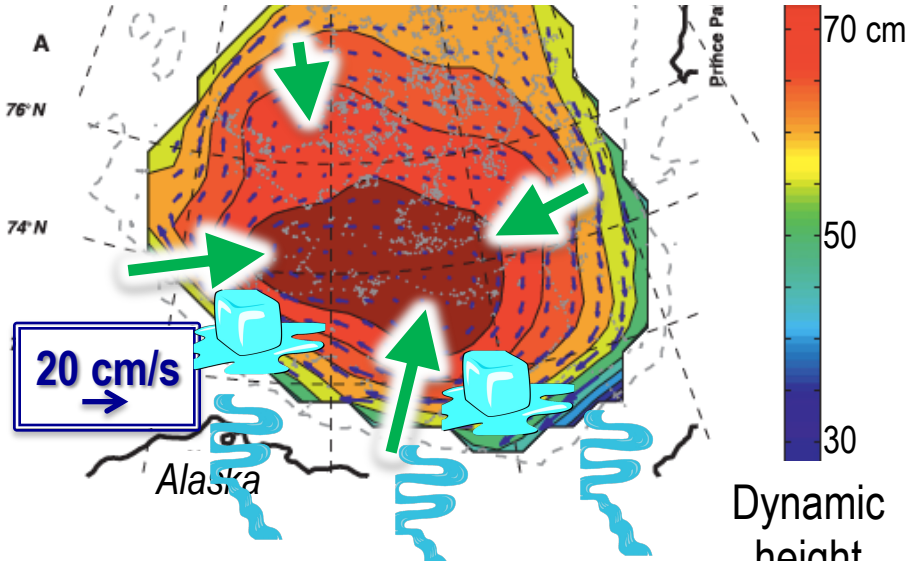
Beaufort Gyre "spin up"

Geostrophic current *(in situ obs)*

(2008-2011)



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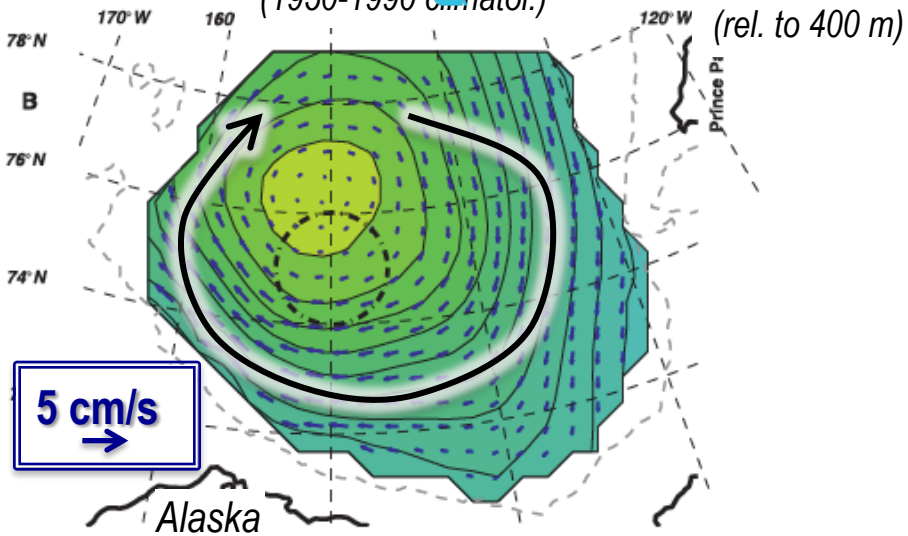
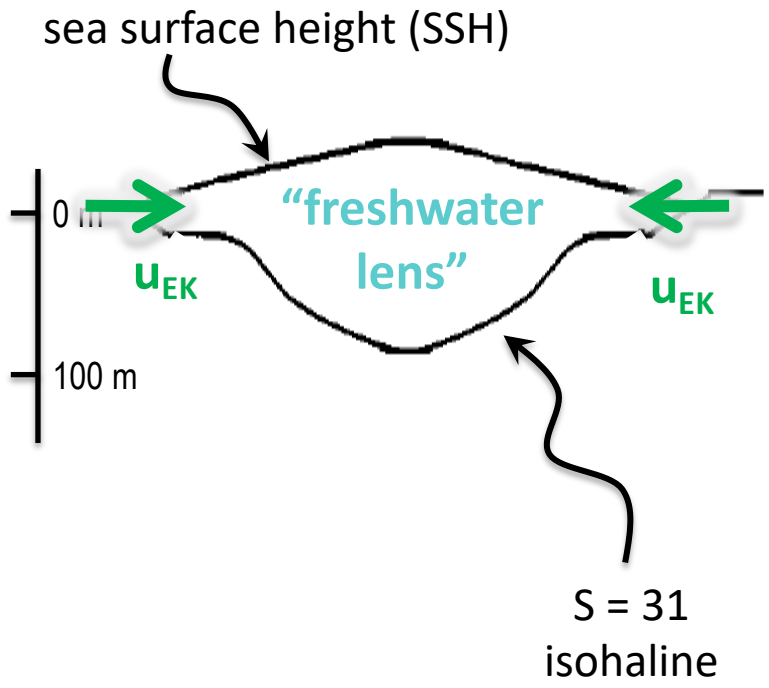


Side view:



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Beaufort Gyre "spin up"

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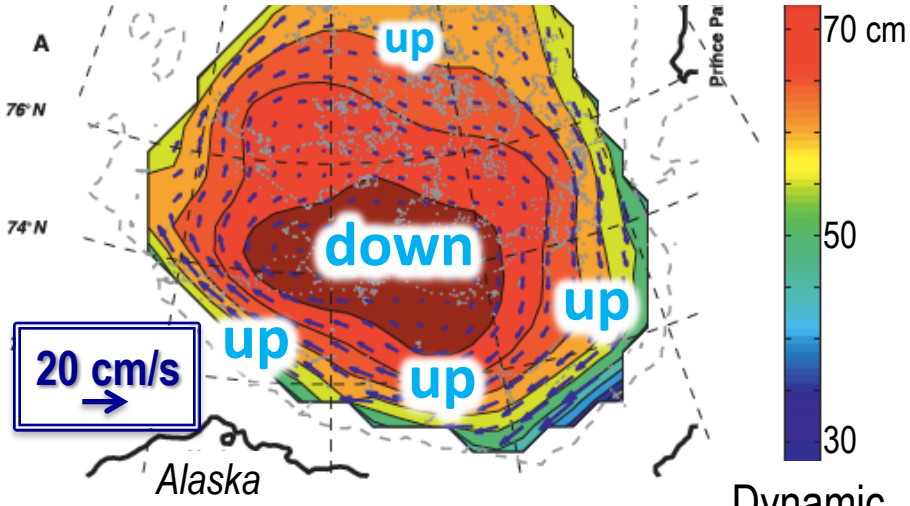
(2008-2011)



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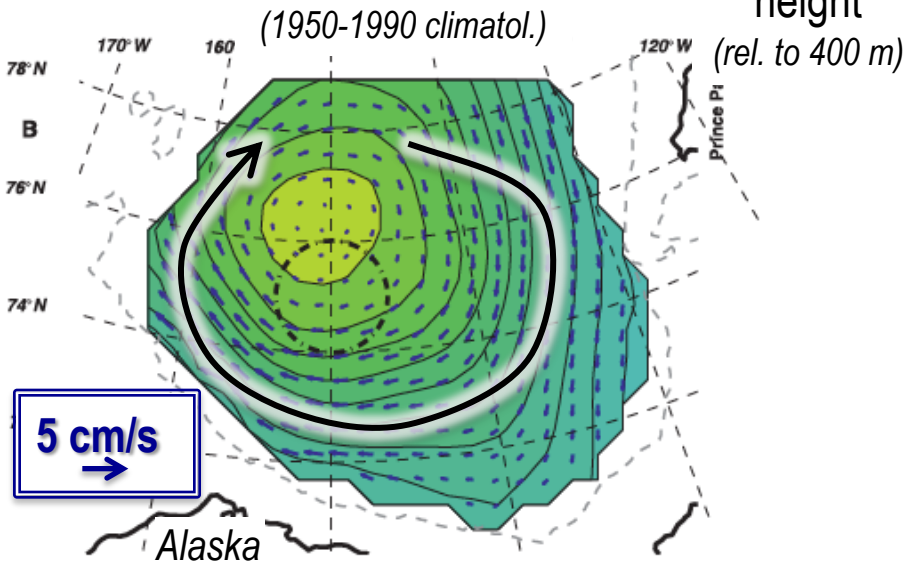

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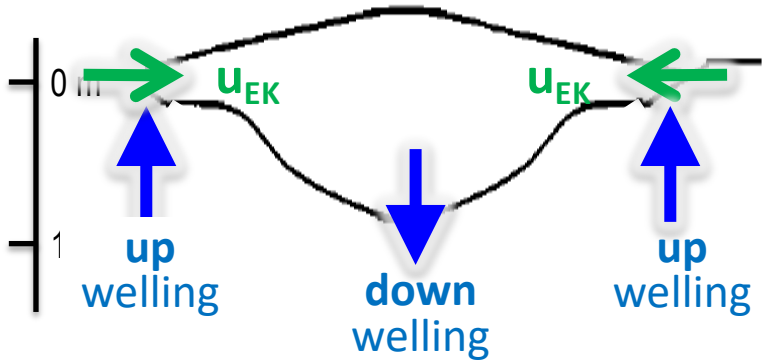

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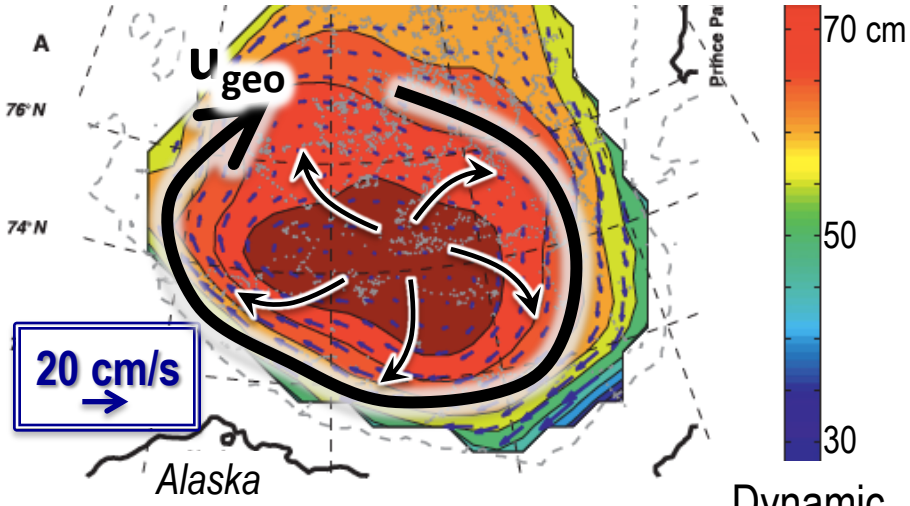
Beaufort Gyre "spin up"

Geostrophic current *(in situ obs)*

(2008-2011)



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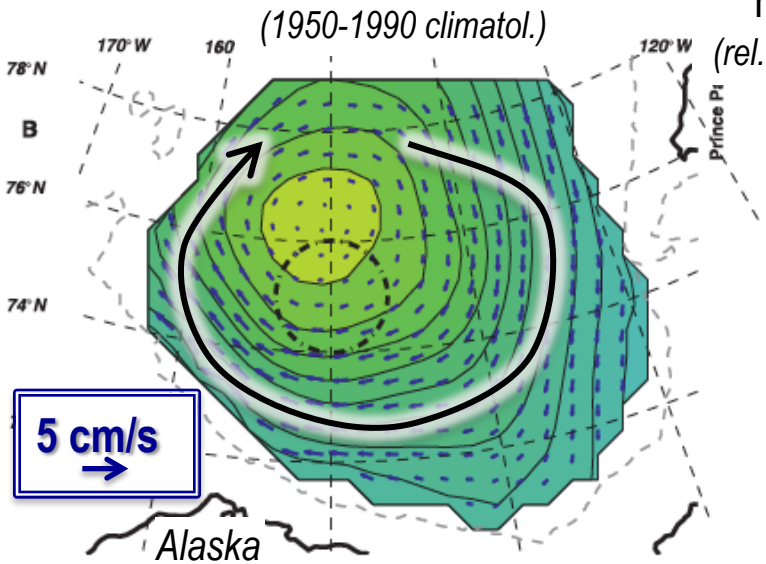
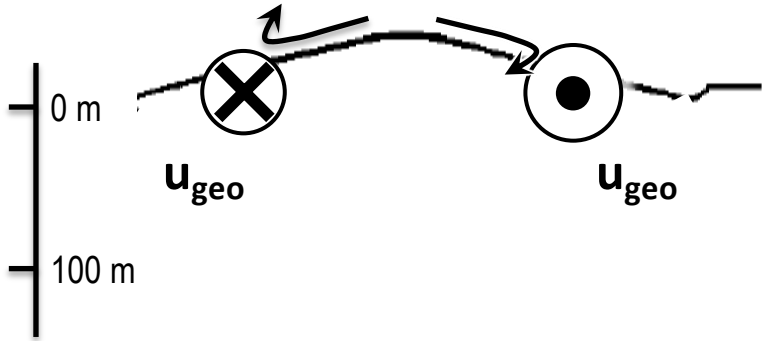


Side view:



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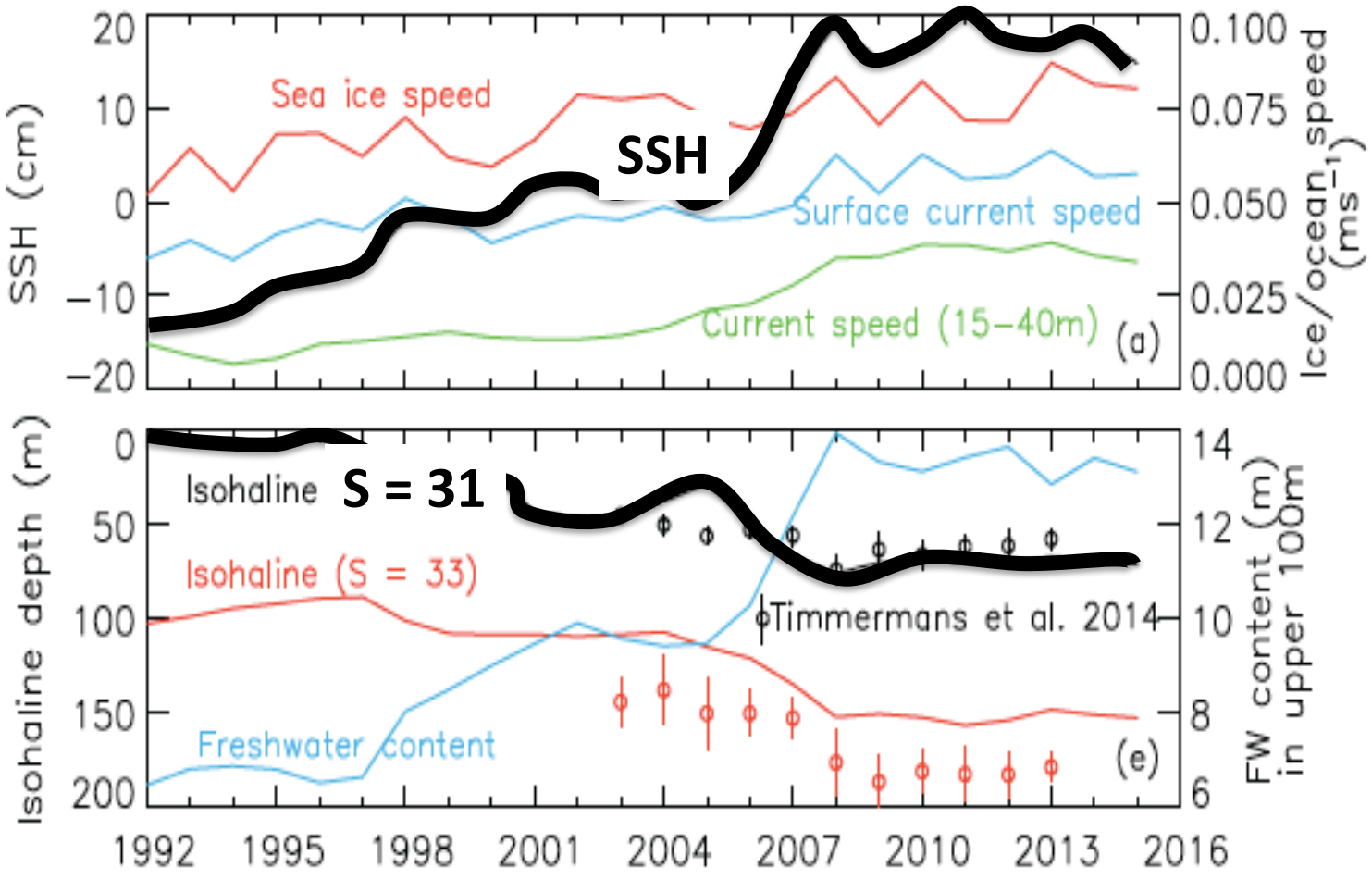
Beaufort Gyre "spin up"



Zhang et al. (JGR, 2016)

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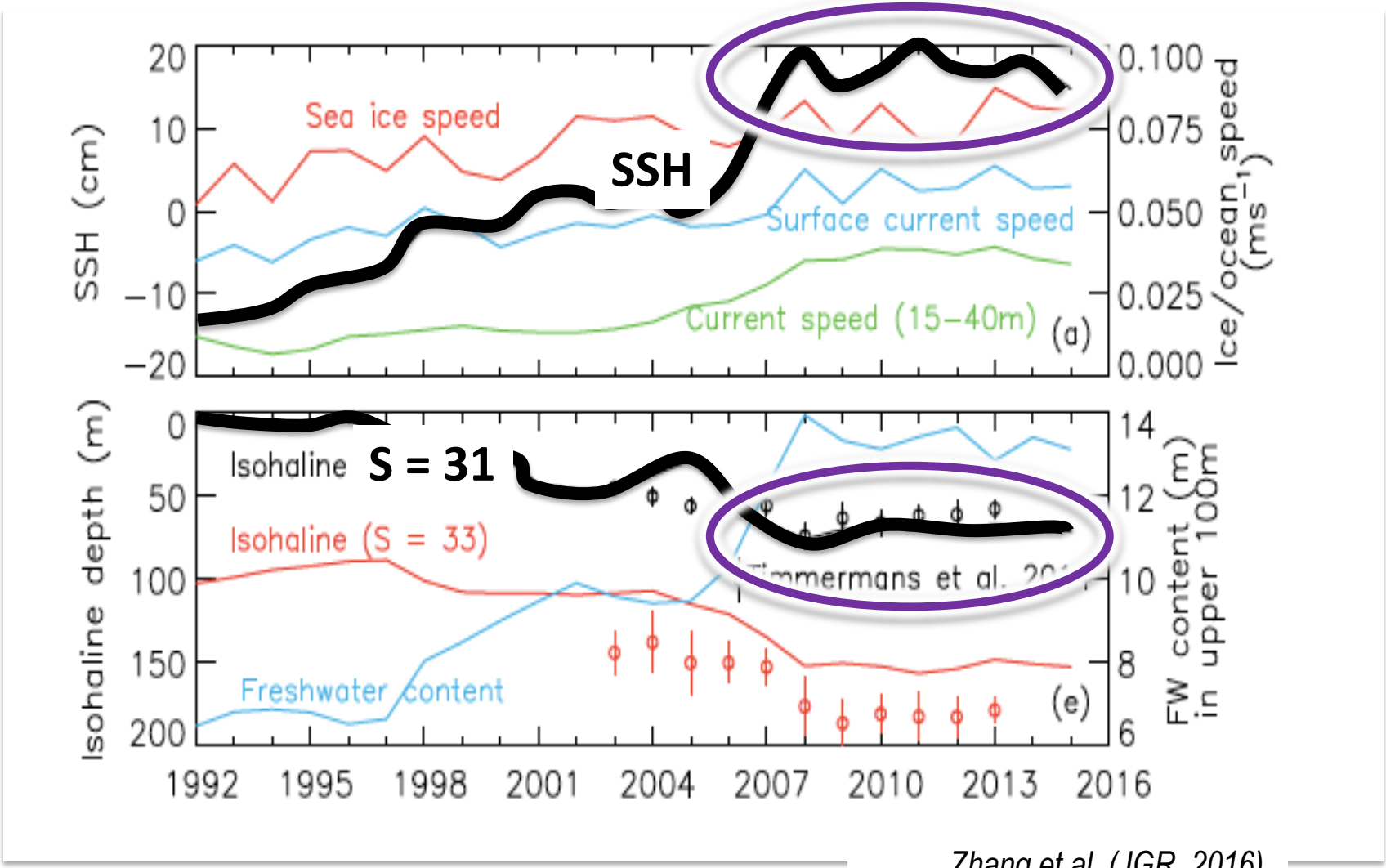
Beaufort Gyre "spin up"



Zhang et al. (JGR, 2016)

Actually: "The Beaufort Gyre intensification & ***stabilization…***"

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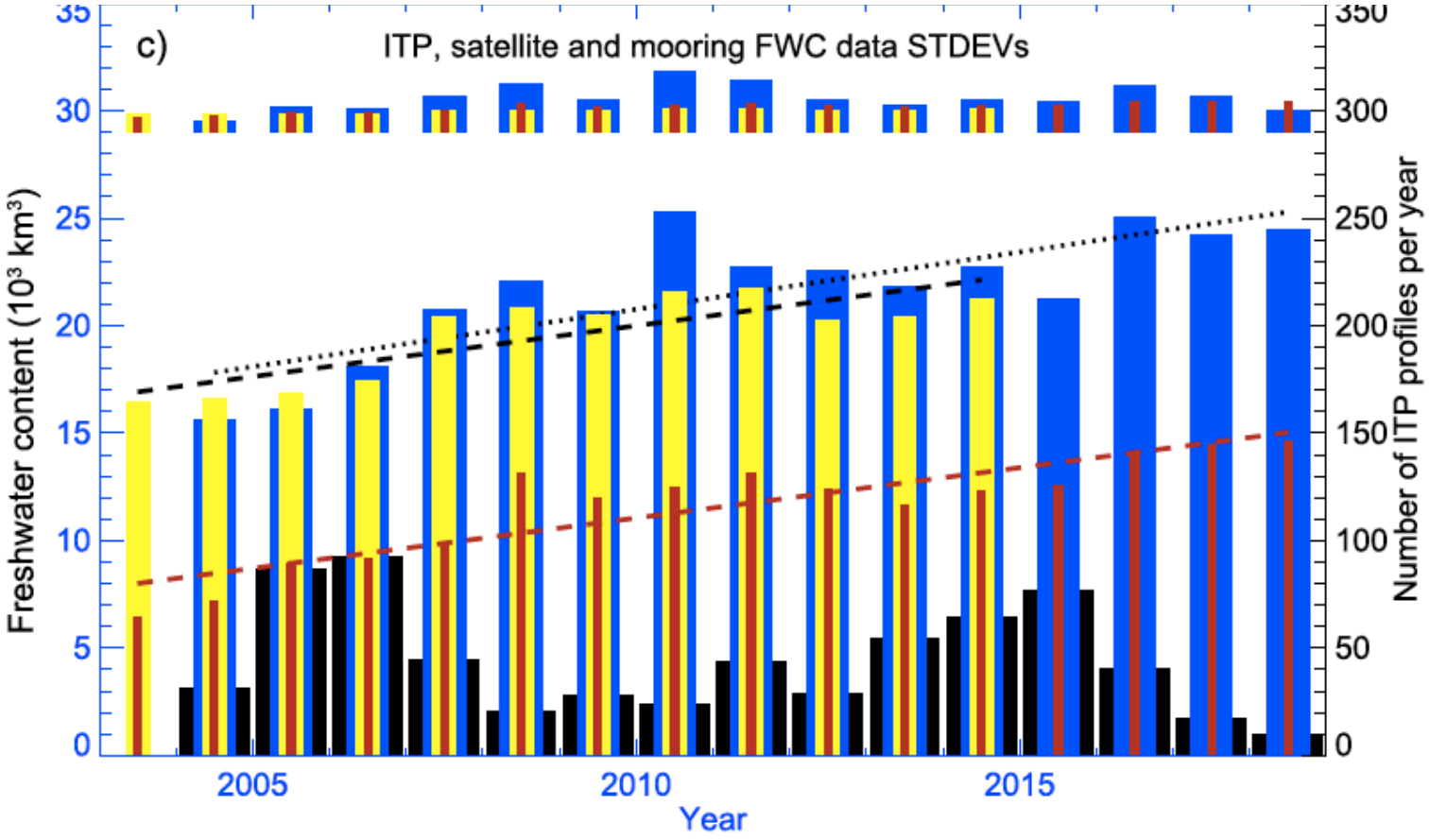
Is spin-up **linear**?



Not really…

Proshutinsky et al. (JGR, 2019)

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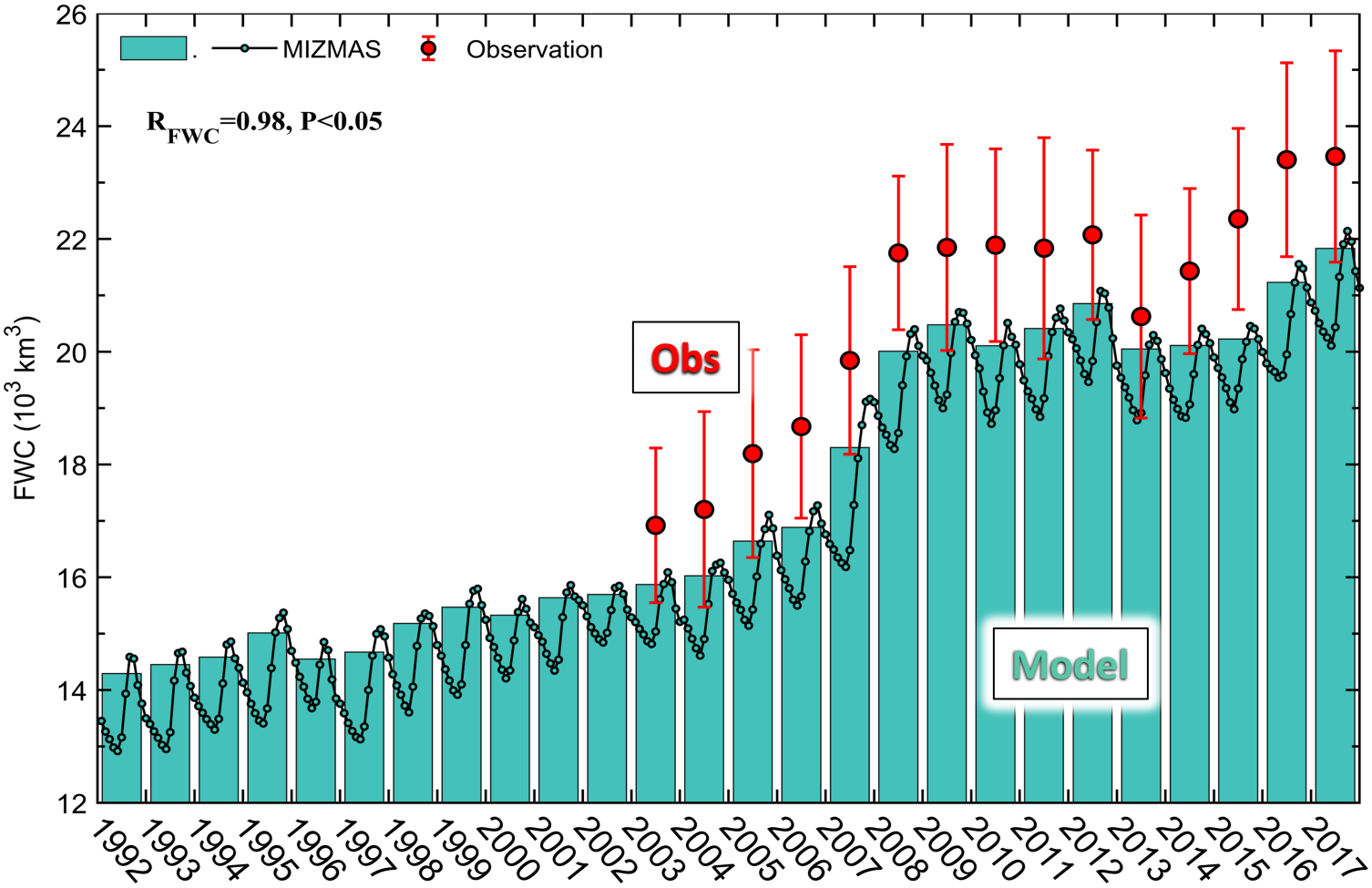
Is spin-up **linear**?



Not really…

Zhong et al. (GRL, 2019)

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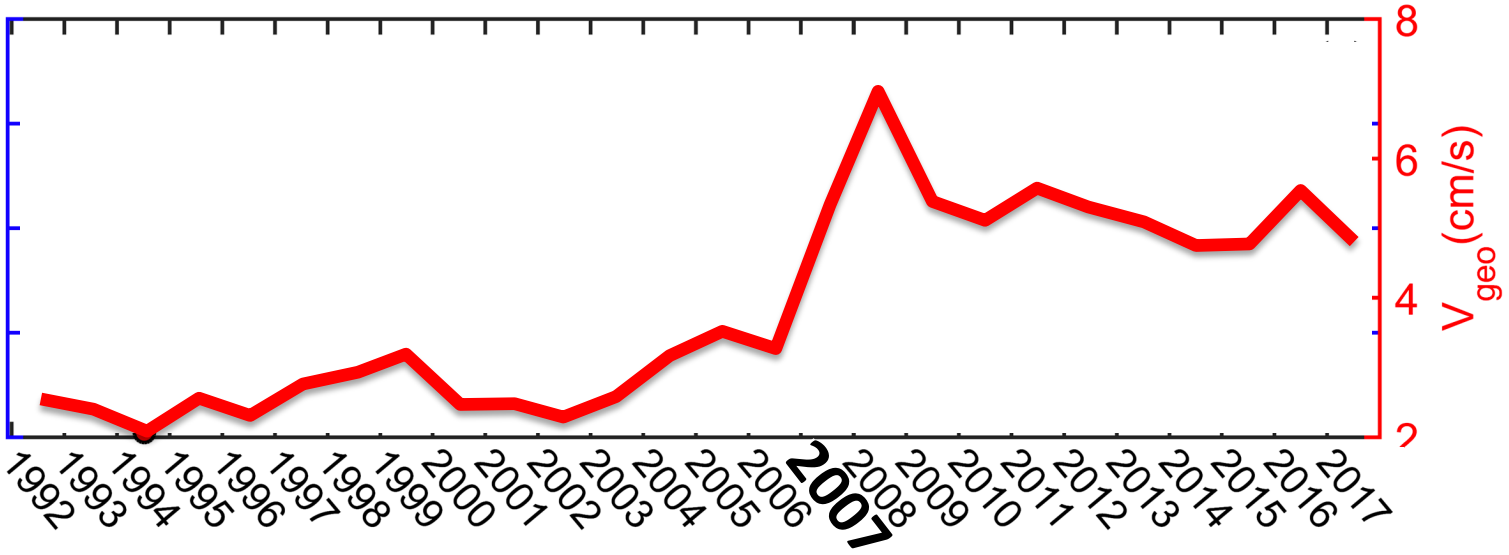
Spin-up is ***episodic***



<u>2007/2008</u>: **Step** increase

Zhong et al. (GRL, 2019)

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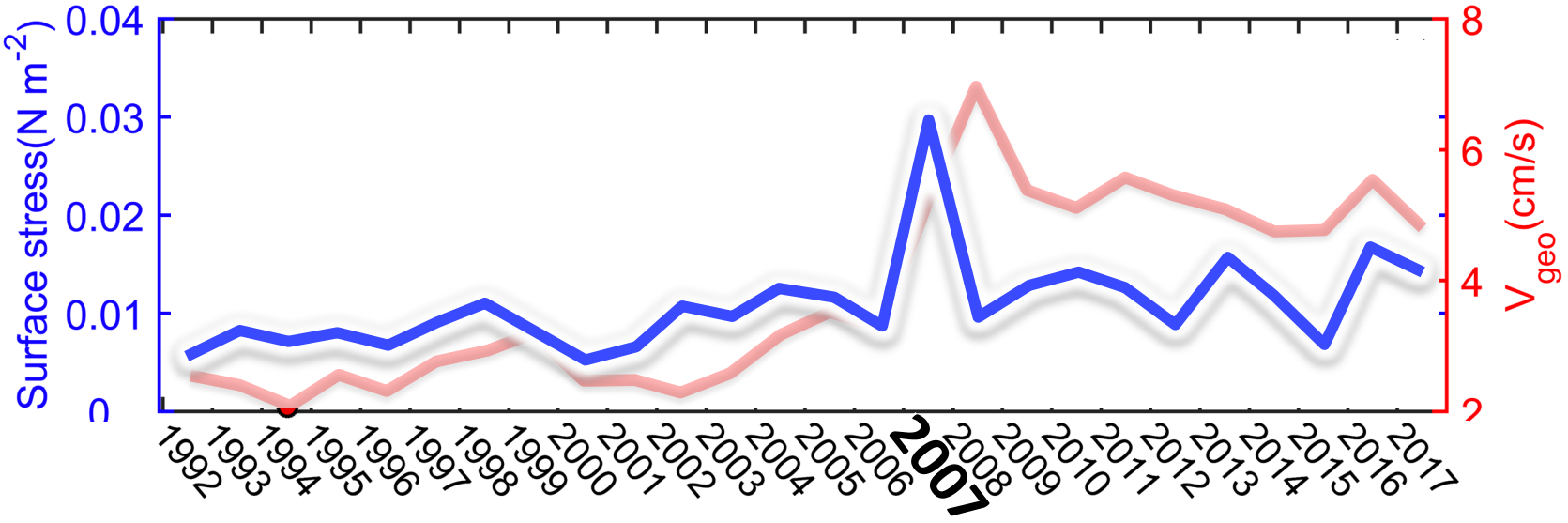
Spin-up is ***episodic***



Summer 2007: **Impulse function**

Early ice loss *(low concentration, then retreat)*

-> lots of freshwater collection

Zhong et al. (GRL, 2019)

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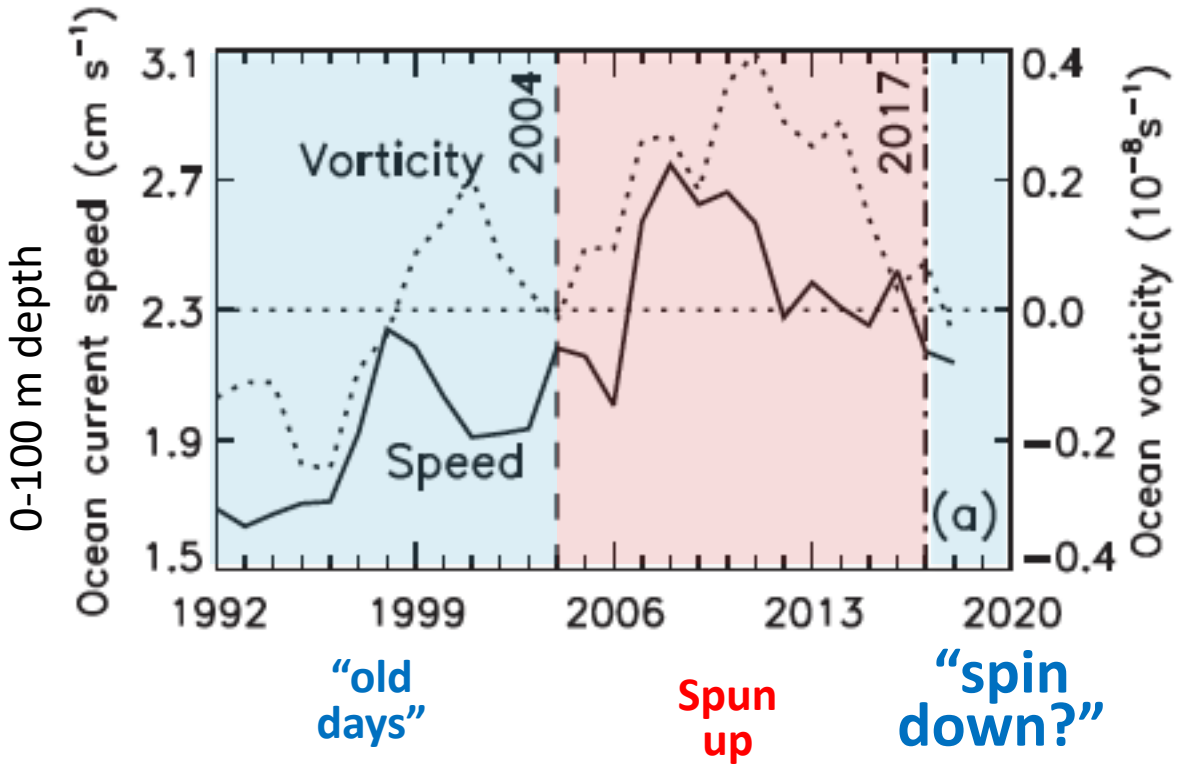
Beaufort Gyre "spin **down**?"



Zhang et al. (GRL, 2020)

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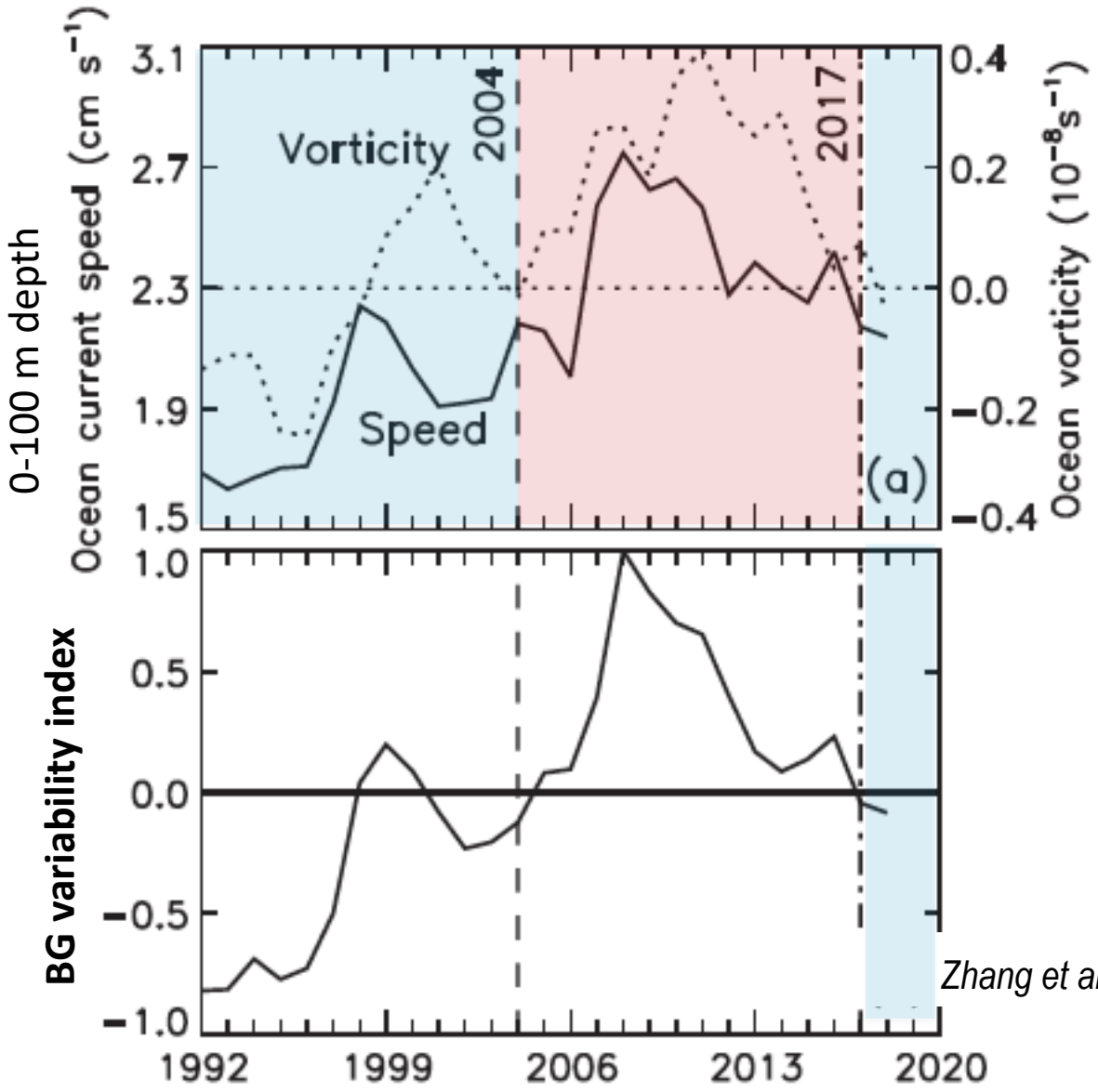
Beaufort Gyre "spin **down**?"



Zhang et al. (GRL, 2020)

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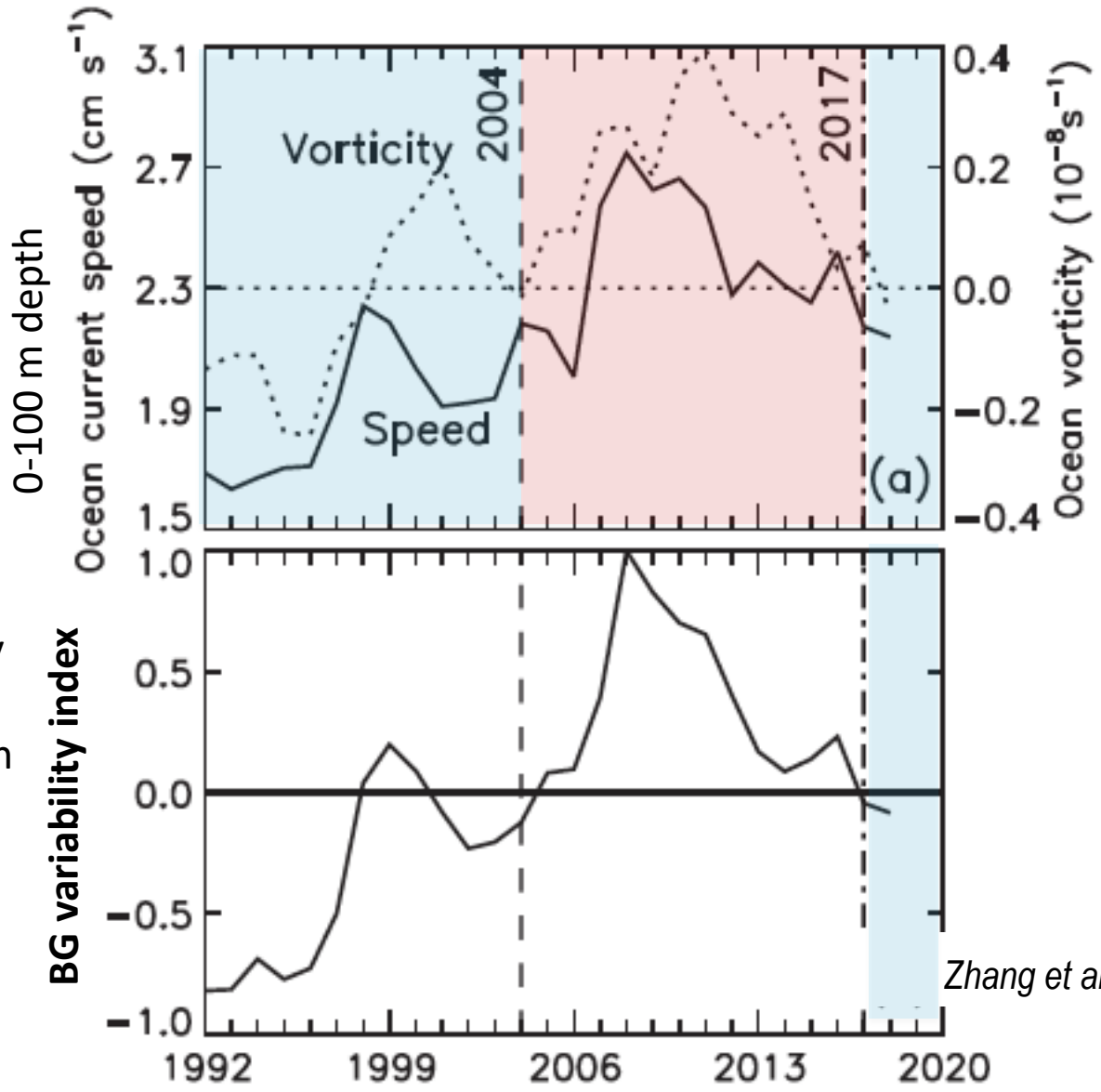

Fancy-schmancy normalized, central BG-mean **S = 31 isohaline depth anomaly**

Zhang et al. (GRL, 2020)

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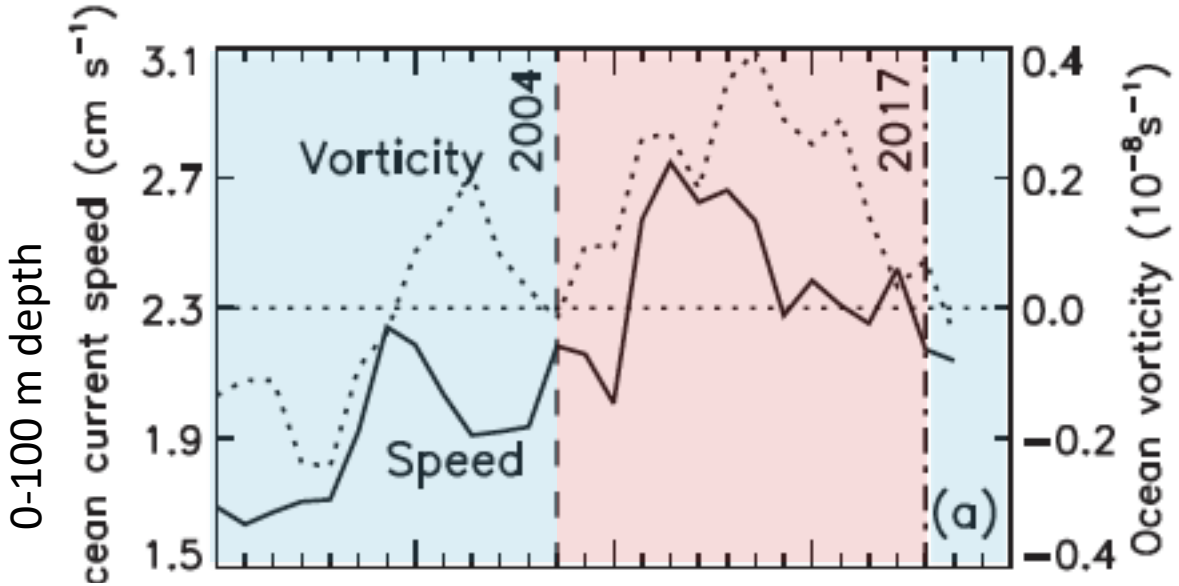
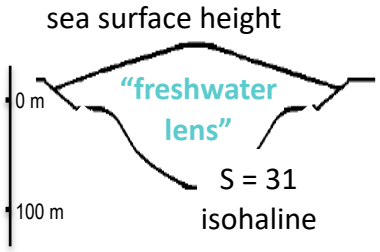
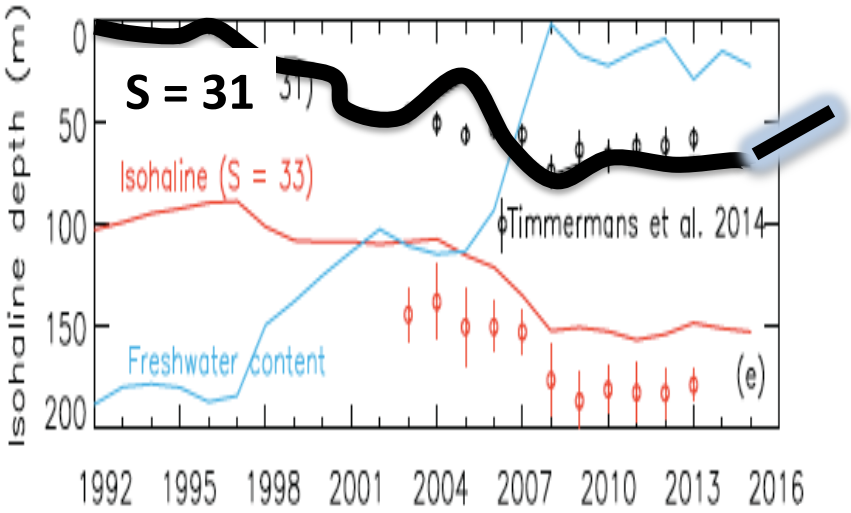
Beaufort Gyre "spin **down**?"







Central BG pycnocline is rising

Zhang et al. (GRL, 2020)

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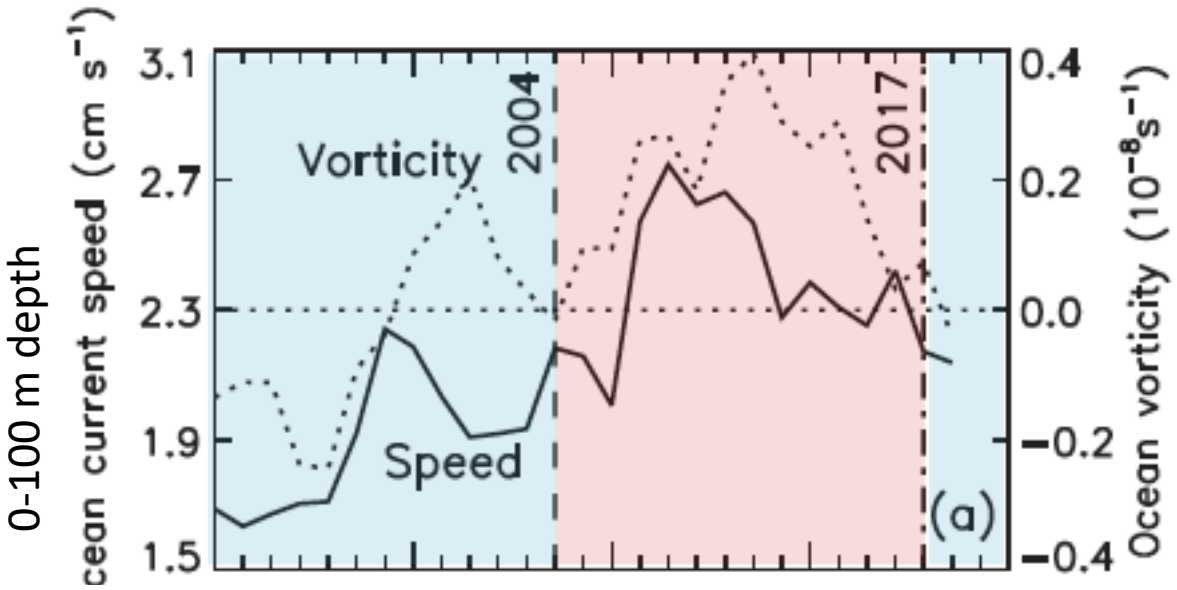
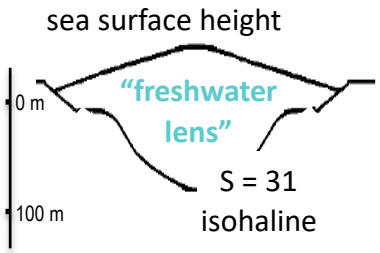
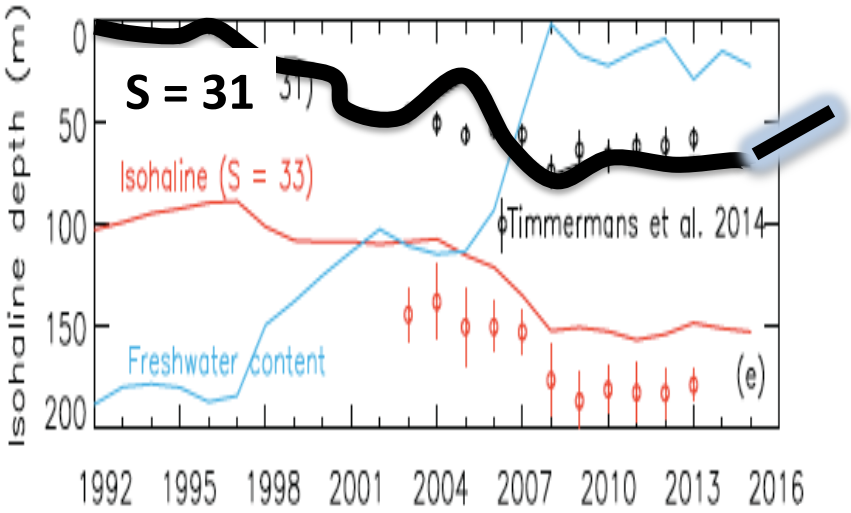
Beaufort Gyre "spin **down**?"







Central BG pycnocline is rising

WHY?

Zhang et al. (GRL, 2020)

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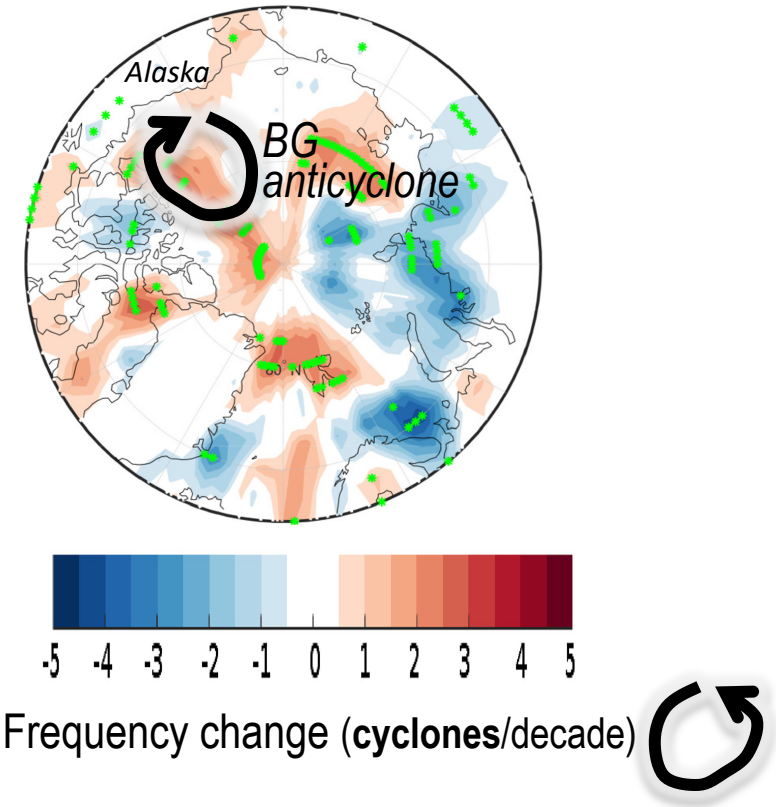
What's spinning down the BG?

*ice-ocean friction, eddies, … **wind**?*



Zahn et al. (JGR-Atmos, 2018)

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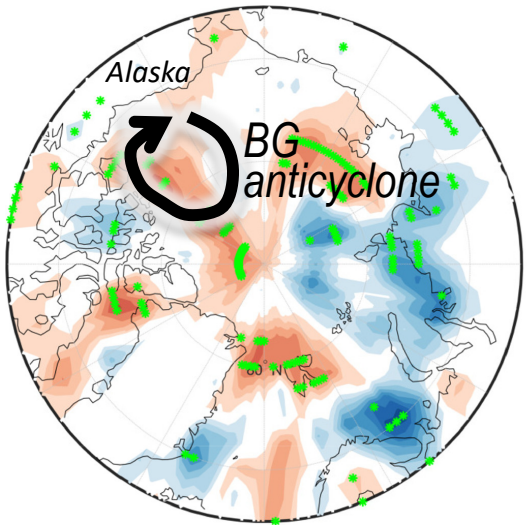
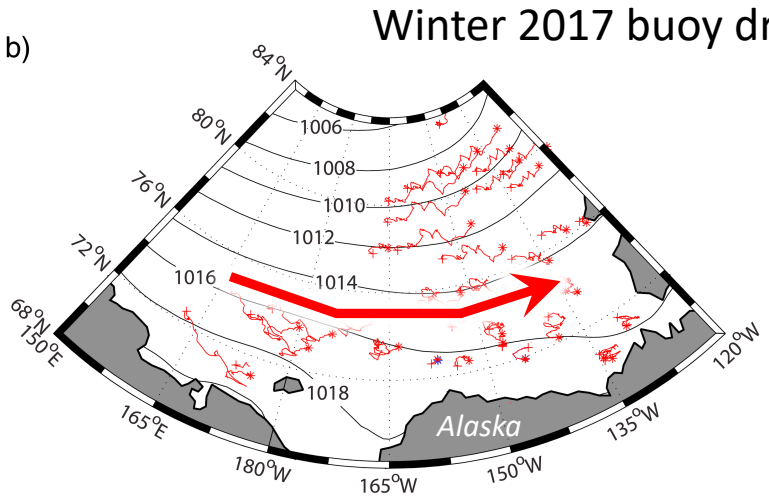
What's spinning down the BG?

*ice-ocean friction, eddies, … **wind**?*



Zahn et al. (JGR-Atmos, 2018)



Cyclonic!

Moore et al. (GRL, 2018)

Beaufort High weakening?

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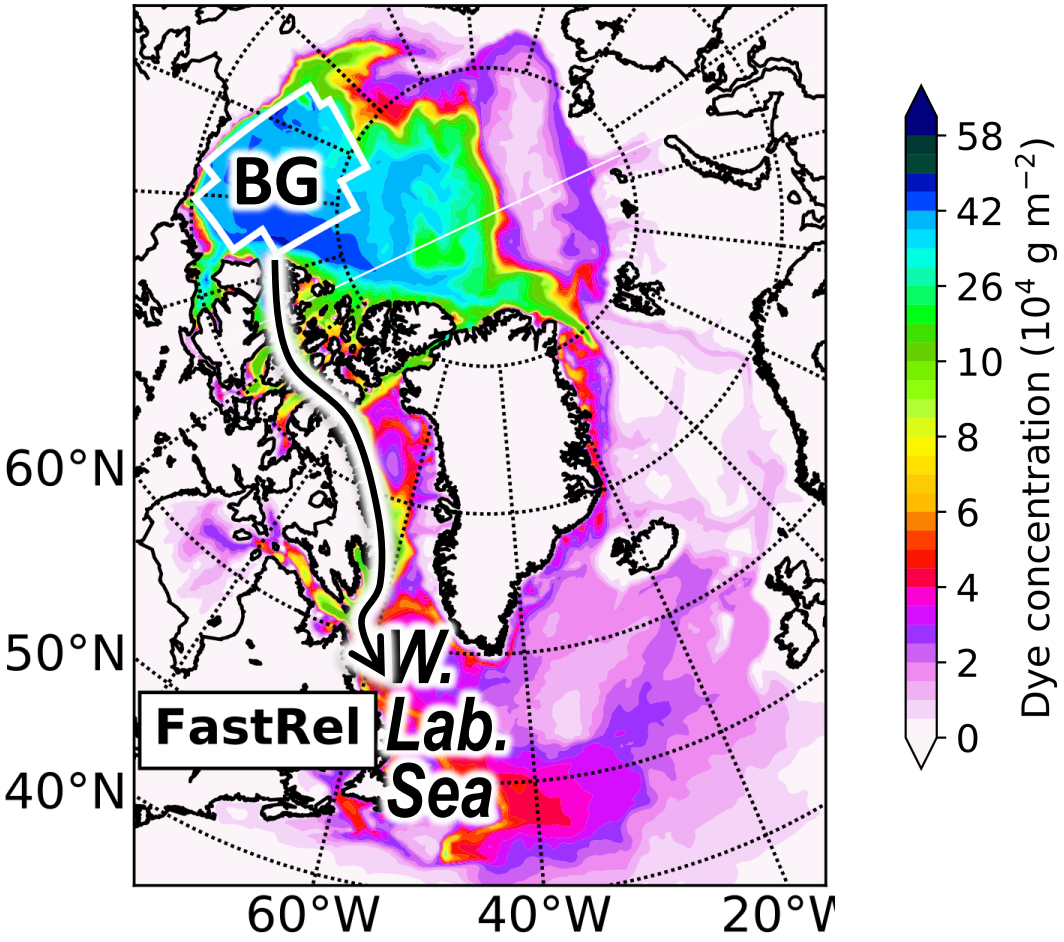
Release of BG freshwater



Influence on deep convection in the Labrador Sea

Jiaxu Zhang, Wilbert Weijer, Michael Steele, ***Wei Cheng****,*
Tarun Verma (in prep, 2020)

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"Beaufort Gyre changes!"

physicist

"Who cares?!"

biologist

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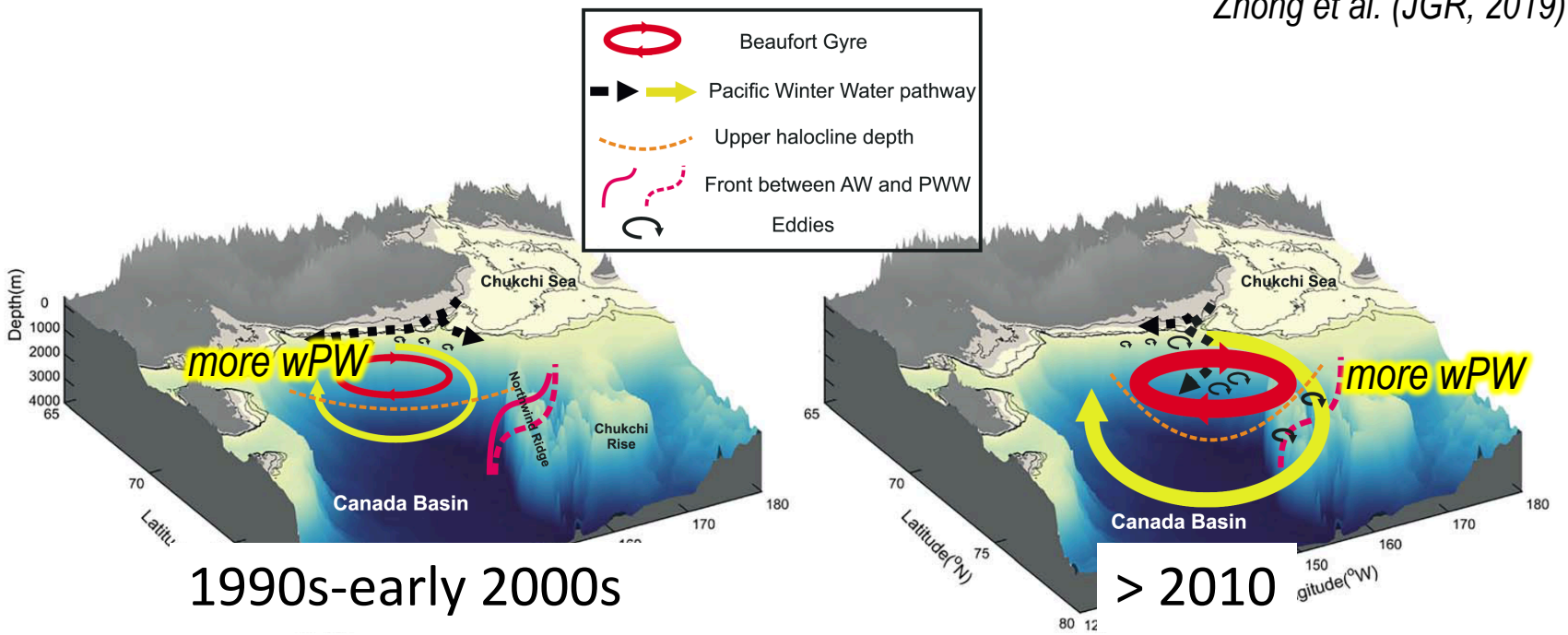
Circulation of wPW

Zhong et al. (JGR, 2019)



1990s-early 2000s

> 2010

Nutrient-rich **winter Pacific Water** gets pushed around by the **BG**

Influence on upwelling nutrients?

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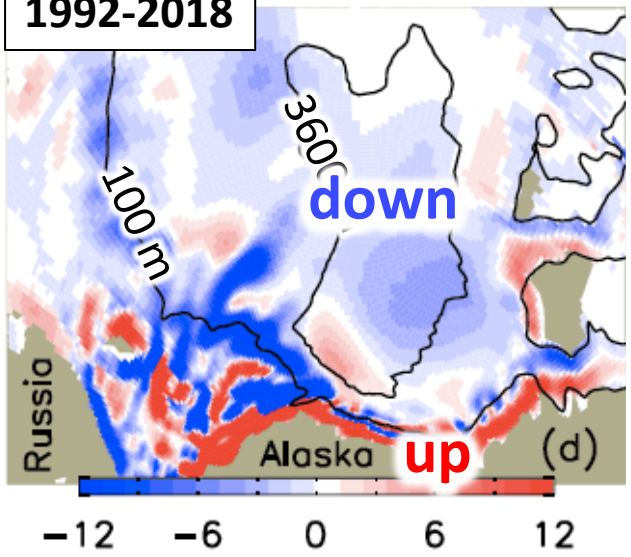
Up/downwelling

Zhang et al. (GRL, 2020)

1992-2018



cm/day

Beaufort Sea:
The BG…

Chukchi Sea:
It's complicated!

Jinlun's BIOMAS model

(sea ice / ocean / bio)

- Atmos forcing: NOAA's CFS
- Resol: 4-10 km, 5 m upper

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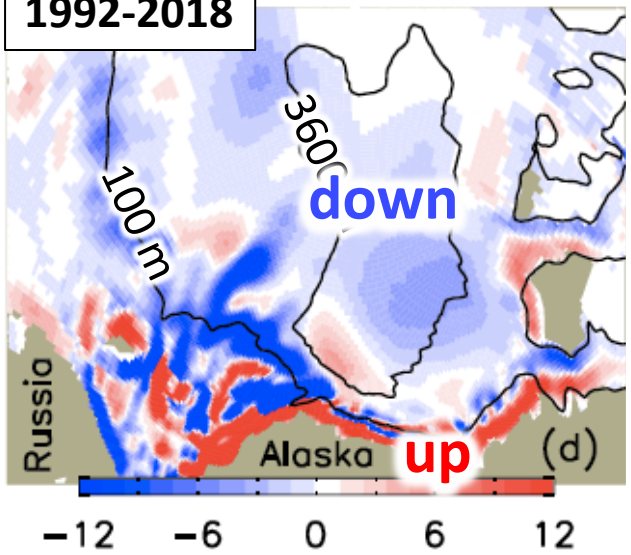
Up/downwelling

Zhang et al. (GRL, 2020)

1992-2018



Jinlun's BIOMAS model

(sea ice / ocean / bio)

Beaufort Sea:
The BG…

Chukchi Sea:
It's complicated!

Downwelling at N. Chukchi shelf break: *hmmmm….*

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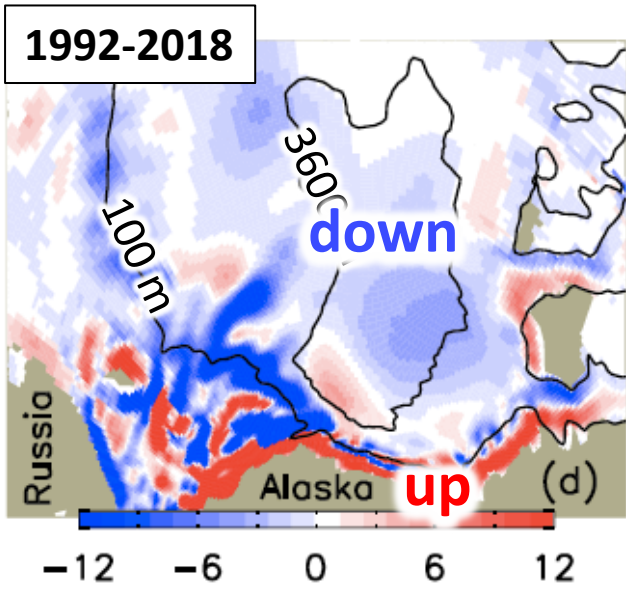
Up/downwelling

Zhang et al. (GRL, 2020)



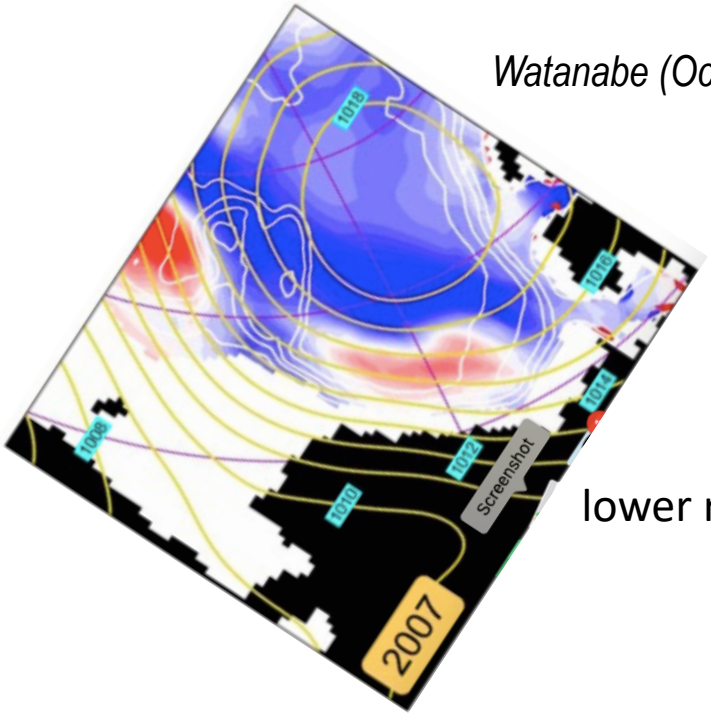
Beaufort Sea:
The BG…

Chukchi Sea:
It's complicated!

Jinlun's BIOMAS model

(sea ice / ocean / bio)

Watanabe (Ocn Modelling, 2013)



lower resol…

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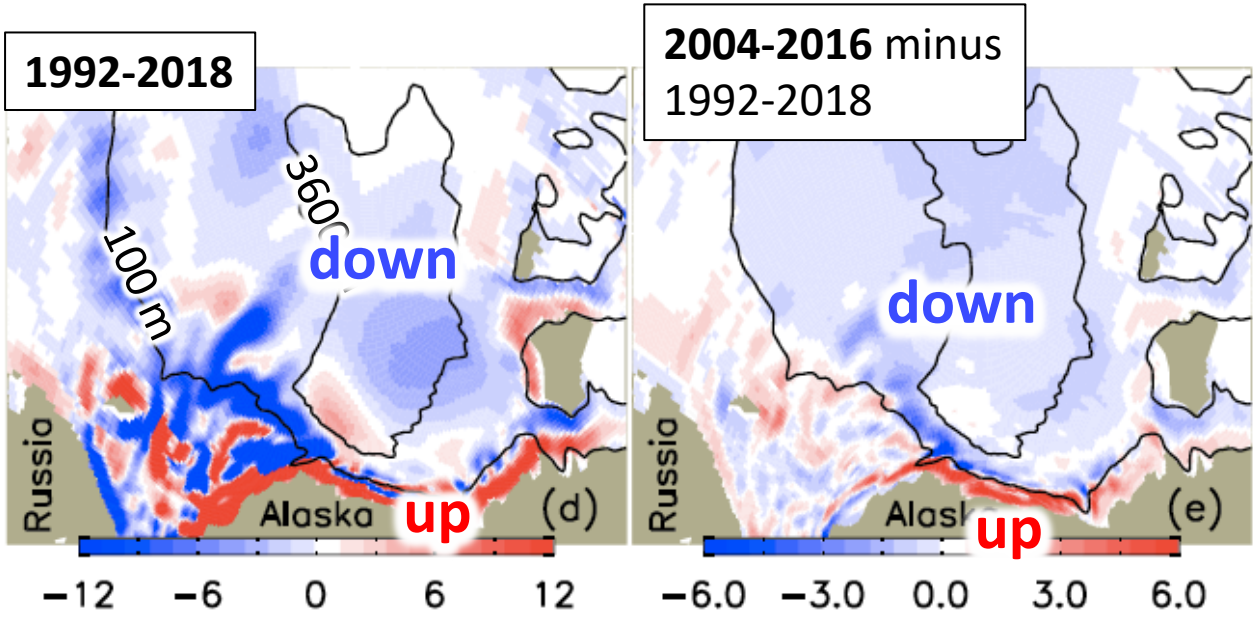
Up/downwelling

Zhang et al. (GRL, 2020)



cm/day

cm/day

Beaufort Sea:
The BG…

Beaufort Sea:
Spin up

Chukchi Sea:
It's complicated!

Chukchi Sea:
Not a huge signal

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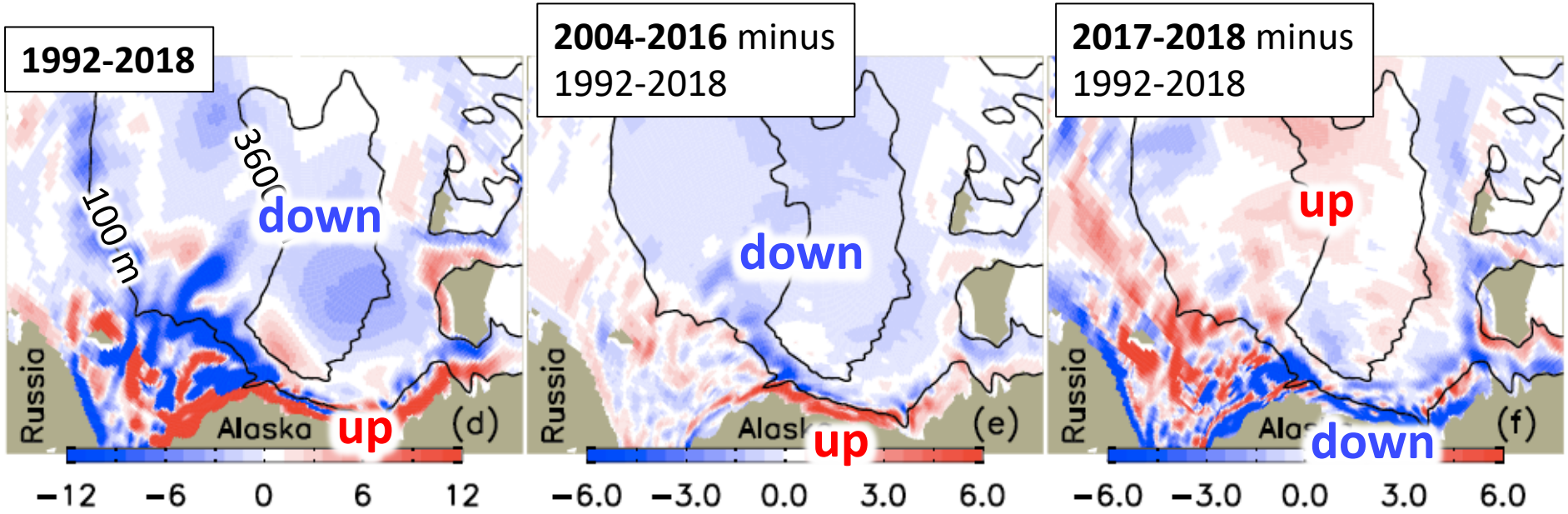
Up/downwelling

Zhang et al. (GRL, 2020)



<u>Beaufort Sea:</u> The BG…	<u>Beaufort Sea:</u> Spin up	<u>Beaufort Sea:</u> Spin down
<u>Chukchi Sea:</u> It's complicated!	<u>Chukchi Sea:</u> Not a huge signal	<u>Chukchi Sea:</u> Hmmm….

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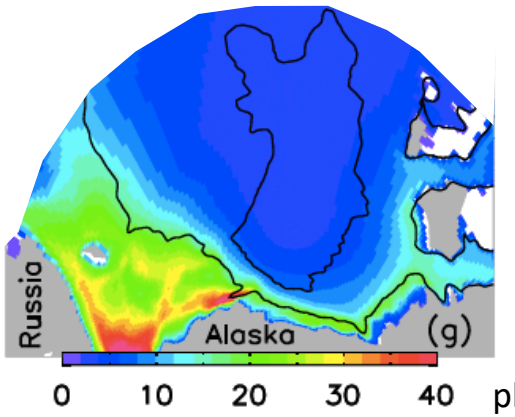
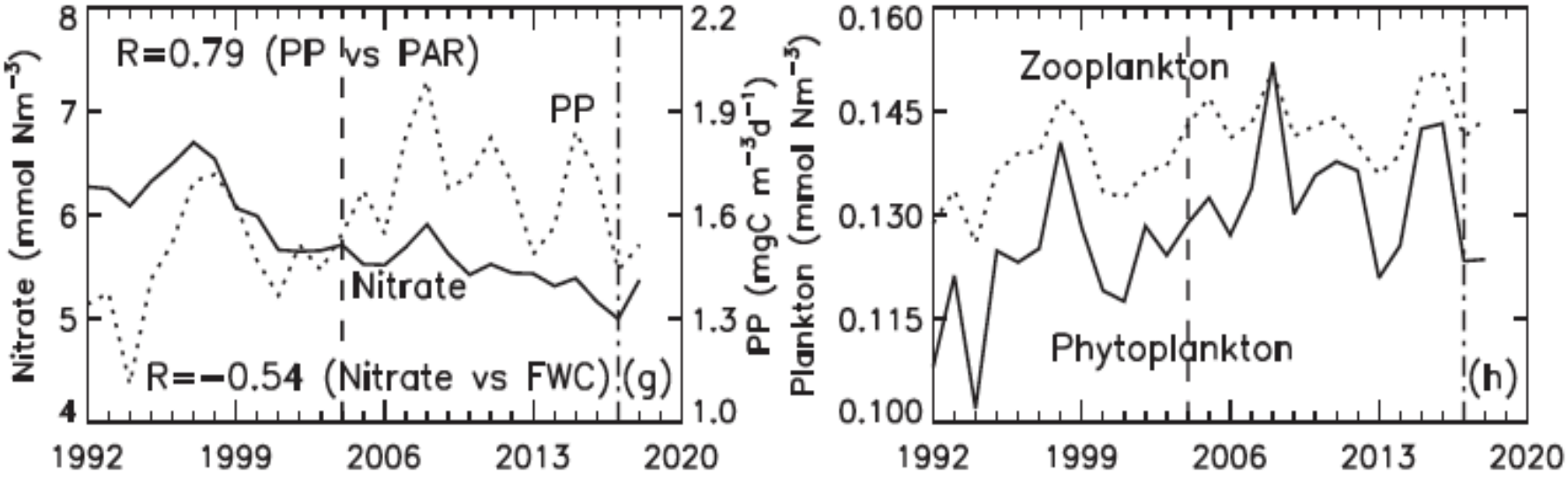
What controls the bio?



phyto biomass
(mmol-N m^2)
1992-2018 mean



Bio time series **~** BG **physics** spin up/down time series

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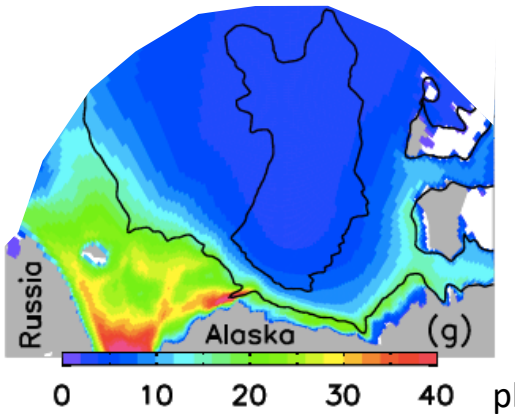
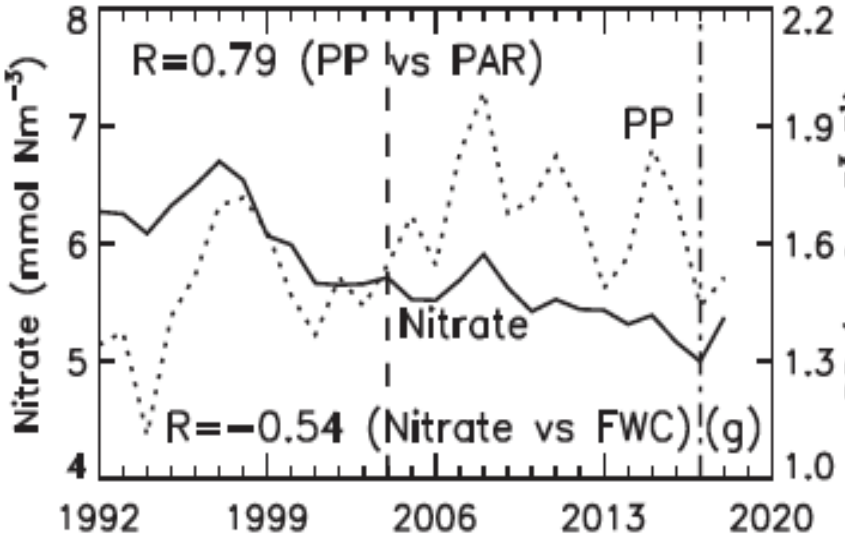
What controls the bio?

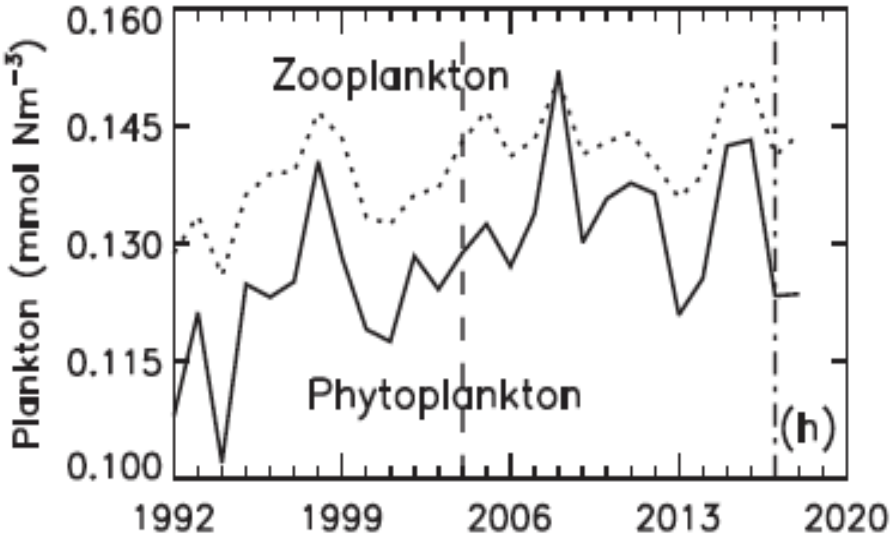


phyto biomass
(mmol-N m^2)
1992-2018 mean

Domain-mean bio controlled by:

- BG spin up/down
- Shelf conditions





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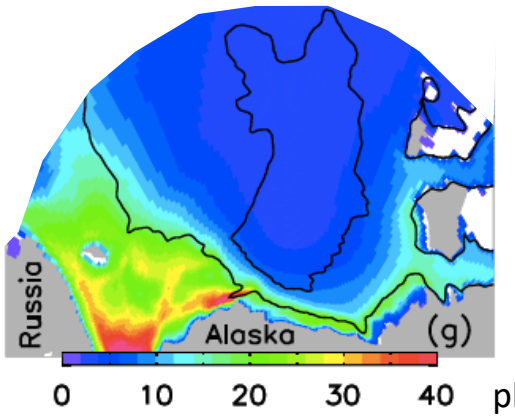
What controls the bio?

High/low bio ↔ **strong**/weak BG



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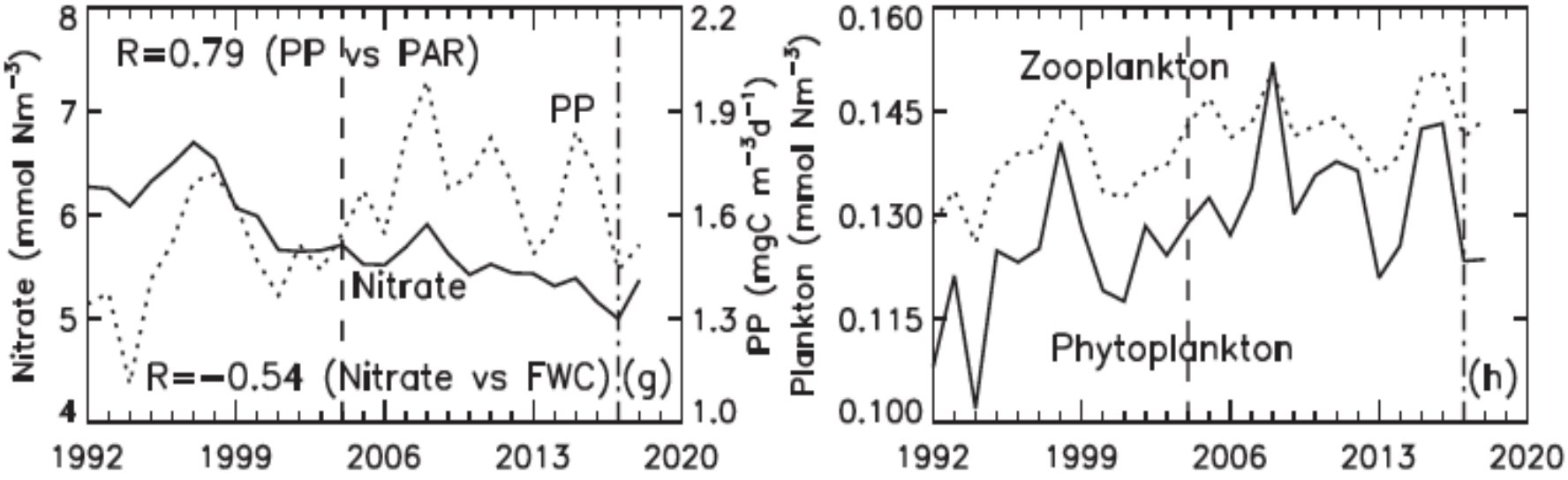

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Other stuff

Modeling **melt ponds**: *(Zhang et al., JGR 2018)*

- Declining *total* area, but *no Δ per area of ice*

Sea ice **seasonality**: *(Steele et al., NSIDC 2019)*

- Public data set on the timing of N. Hemisph. melt, retreat, freeze, advance, etc.

doi: https://doi.org/10.5067/KINANQKEZI4T

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extra

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University of Washington

Thank you

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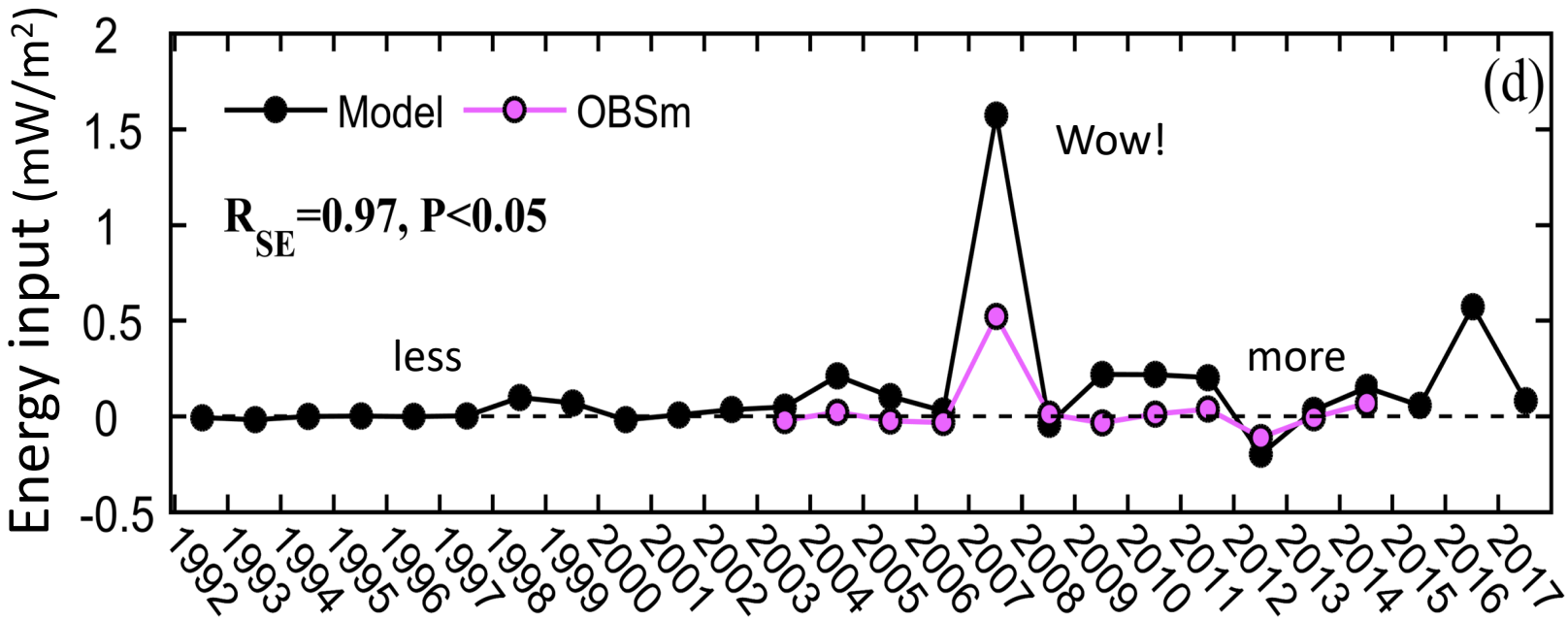
Spin-up is ***episodic***



Wind/ice energy input = surface **stress** * surface **currents**

2007:

Early ice change (low concentration, retreat) -> lots of energy input

Zhong et al. (GRL, 2019)