Freshwater Processes and the Atlantic Meridional Overturning Circulation (AMOC)

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on behalf of the collaborating teams

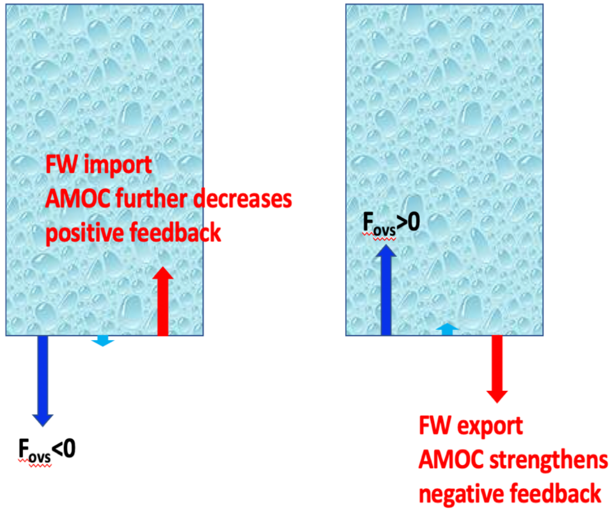
DOE RGMA PI meeting, October 15, 2020

- jointly supported by RGMA and NOAA CPO CVP programs
- with university, NCAR and lab participants
- contributing to the HiLAT SFA

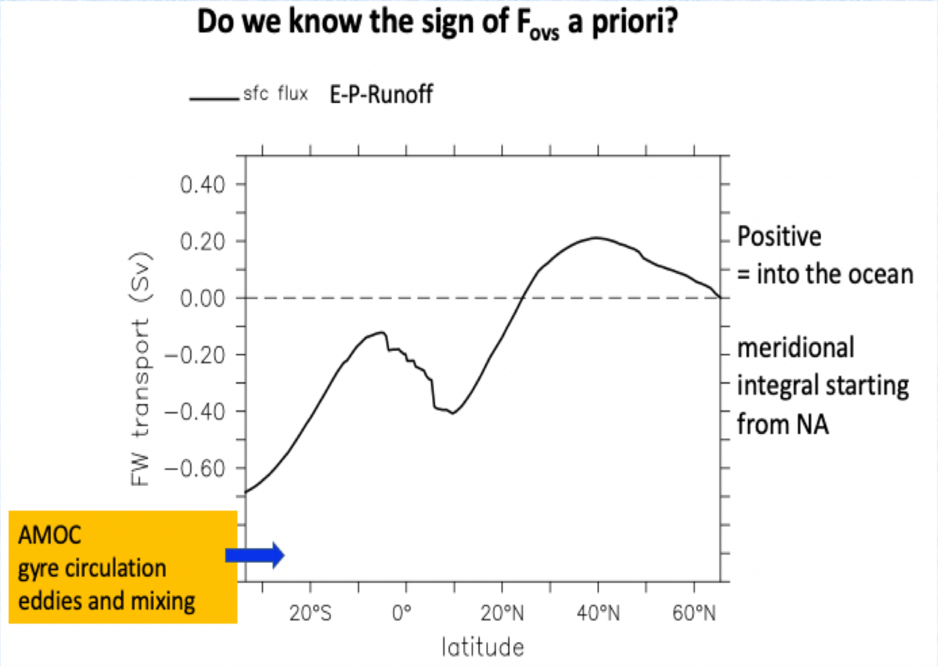
Motivation:

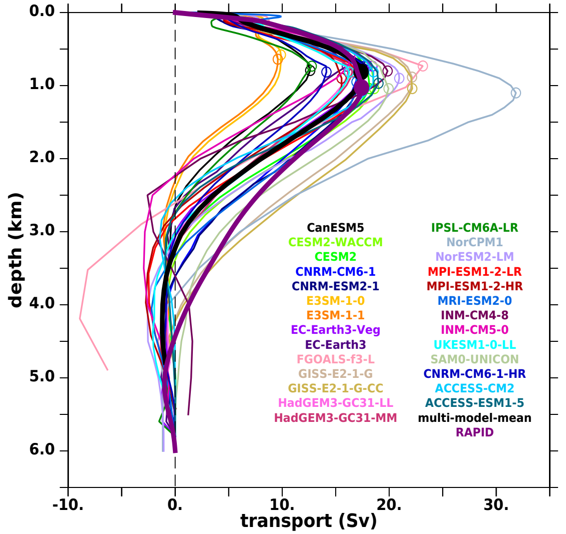
- freshwater processes regulate AMOC mean state, variability, and stability
- AMOC stability threshold is a potential trigger to tipping point

salt-advection feedback
sign + or -



F_{ovs}: freshwater transport by the AMOC at the southern end of the Atlantic Ocean





Weijer et al. (2020)

Collaborative Research: Understanding the Freshwater Budget of the Atlantic Ocean: Controls, Responses, and the Role of the AMOC

PIs: Wei Cheng (lead PI), Dongxiao Zhang, University of Washington
John Chiang, University of California, Berkeley
Gokhan Danabasoglu, Steve Yeager, National Center for Atmospheric Research
Wilbert Weijer, Los Alamos National Laboratory

Objective: understand the interplay between surface FW flux and inter-basin exchanges. This project is wrapping up.

- Cheng, W., W. Weijer, W. M. Kim, G. Danabasoglu, S. G. Yeager, P. R. Gent, D. Zhang, J. C. H. Chiang, and J. Zhang (2018). Can the salt-advection feedback be detected in internal variability of the Atlantic Meridional Overturning Circulation? *J. Climate*, **31**, 6649-6667, doi: 10.1175/JCLI-D-17-0825.1.

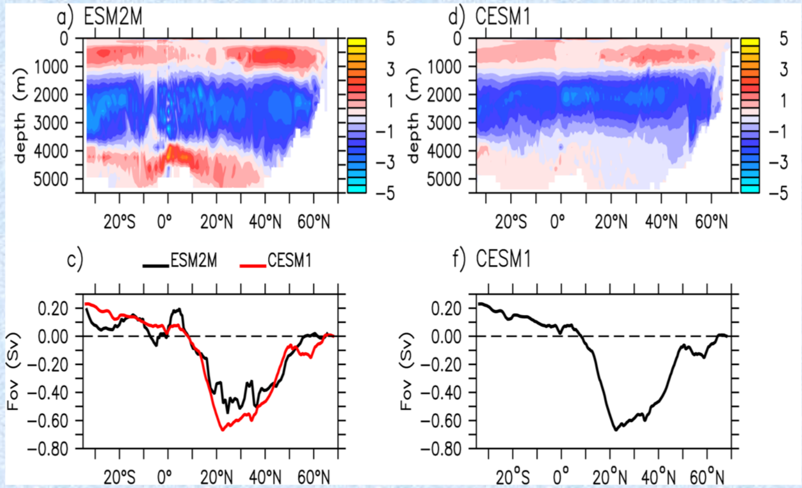
- Danabasoglu, G., L. Landrum, S. G. Yeager, and P. R. Gent (2019). Robust and non-robust aspects of Atlantic meridional overturning circulation variability and mechanisms in the Community Earth System Model. *J. Climate,* **32**, 7349-7368, doi: 10.1175/JCLI-D-19-0026.1.

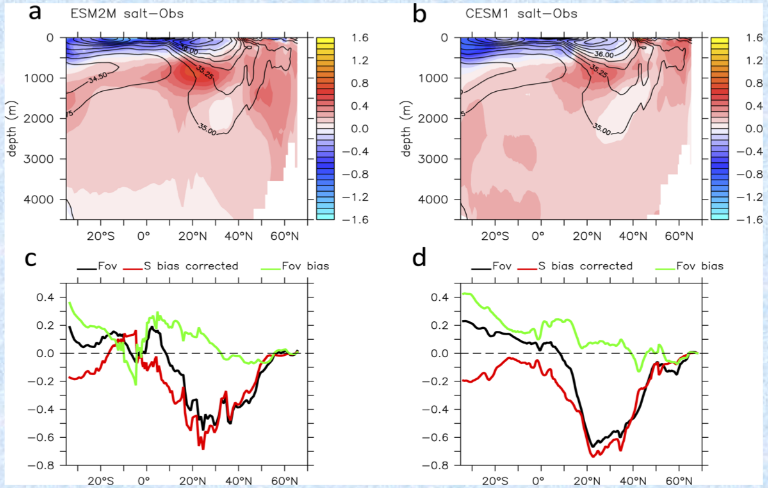
- Weijer, W., W. Cheng, S. S. Drijfhout, A.V. Fedorov, A. Hu, L. C. Jackson, W. Liu, E. L. McDonagh, J. V. Mecking, and J. Zhang (2019). Stability of the Atlantic meridional overturning circulation: A review and synthesis. *JGR-Oceans*, **124***,* 5336-5375*,* doi: 10.1029/2019JC015083.

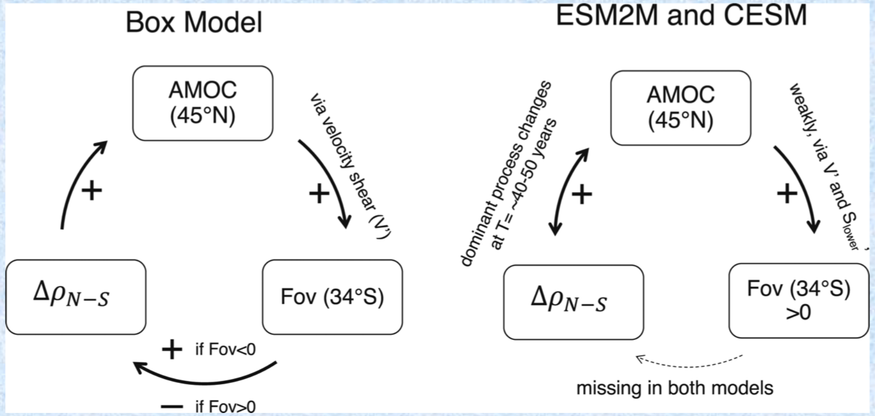
- Kim, W. M., S. Yeager, and G. Danabasoglu (2020). Atlantic multidecadal variability and associated climate impacts initiated by ocean thermohaline dynamics. *J. Climate,* 33, 1317-1334, doi: 10.1175/JCLI-D-19-0530.1.

- Weijer, W., W. Cheng, O.A. Garuba, A. Hu, and B.T. Nadiga (2020). CMIP6 models predict significant 21st century decline of the Atlantic Meridional Overturning Circulation. *Geophys. Res. Lett.* https://doi.org/10.1029/2019GL086.

Cheng et al. (2018)

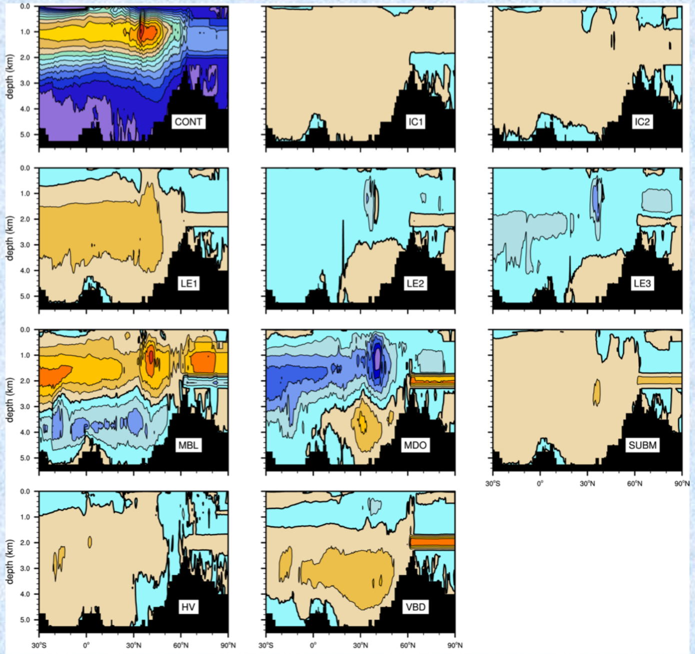


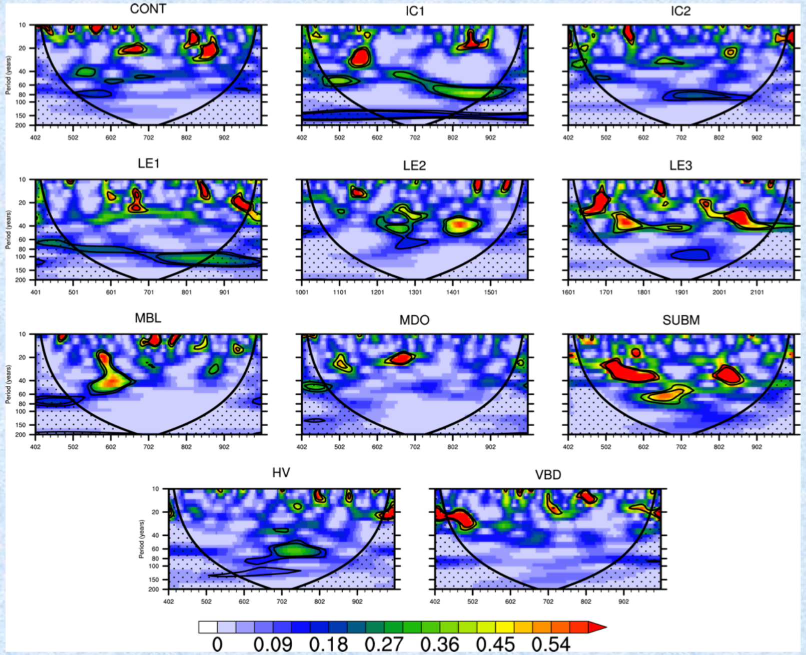




salt advection feedback on multidecadal timescales

Danabasuglo et al. (2019)





Arctic freshwater pathways and their impact on North Atlantic deep water formation in a hierarchy of models

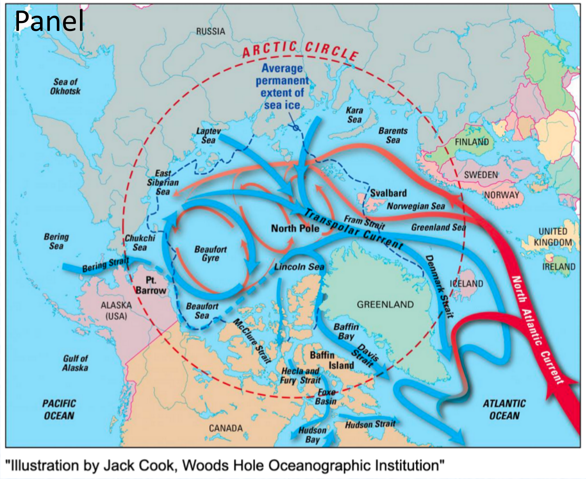
Wei Cheng Mike Steele Wilbert Weijer Jiaxu Zhang Dongxiao Zhang

Objective: investigating freshwater pathways (both oceanic and ice) between the Arctic and subpolar North Atlantic, their controlling mechanisms, and interactions with North Atlantic deep water formation and AMOC.

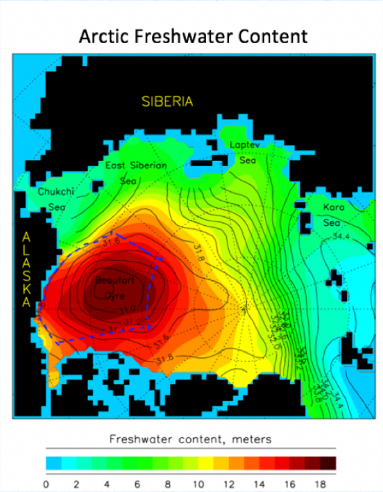
This is addressed through E3SM v1 and other CMIP6 model diagnosis, evaluating modeling results with observations, and performing global ice-ocean perturbation experiments with passive tracer releases. *ongoing.*

Beaufort Gyre freshwater content anomalies

CLIVAR /CliC Northern Oceans Region Panel



"Illustration by Jack Cook, Woods Hole Oceanographic Institution"

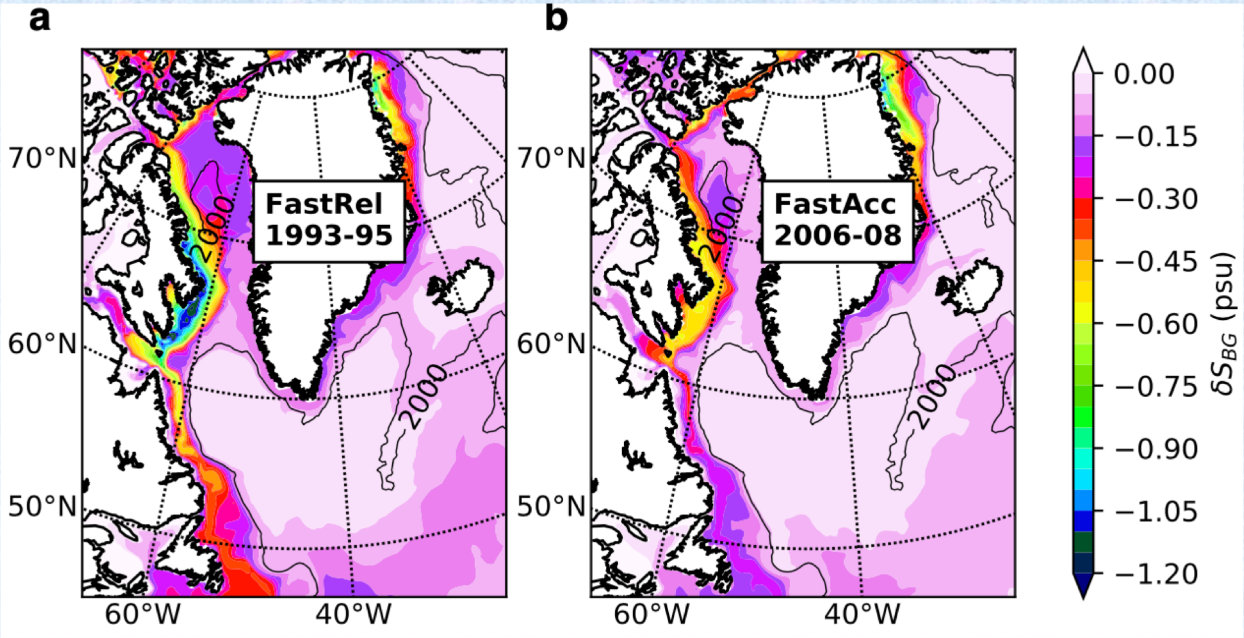


Proshutinsky et al. 2009

Question: what impact does BG FW release have on subpolar NA salinity?

Approach: combine salinity and dye tracer release to isolate and quantify BG FW downstream impact

Zhang et al. 2020. Labrador Sea freshening linked to the Beaufort Gyre freshwater release. in review. Jiaxu's HiLAT talk yesterday.

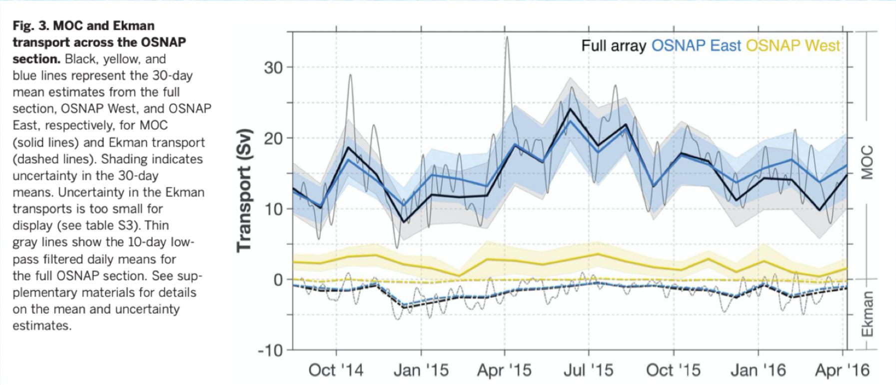


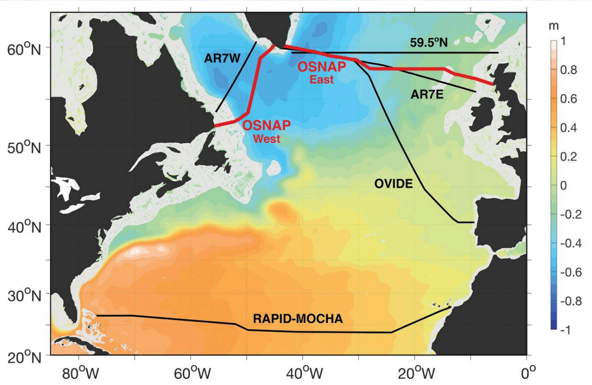
		Surface				Upper 200 m			
		S	S_{nBG}	δS_{BG}	$\Delta\delta S_{BG}$	S	S_{nBG}	δS_{BG}	$\Delta\delta S_{BG}$
Western Shelves	FastRel	32.81	33.07	-0.27	**-0.12**	33.58	34.02	-0.43	**-0.20**
	FastAcc	33.13	33.28	-0.15		33.81	34.05	-0.23	
Eastern Shelves	FastRel	34.45	34.57	-0.11	**-0.04**	34.58	34.71	-0.13	**-0.05**
	FastAcc	34.72	34.79	-0.07		34.80	34.88	-0.08	
Labrador Sea Interior	FastRel	34.82	34.85	-0.03	**-0.01**	34.88	34.91	-0.03	**-0.01**
	FastAcc	34.89	34.91	-0.02		34.96	34.98	-0.02	

Arctic freshwater content diagnosis

$$FWC = \int_{z(Sref=34.8)}^{0\,m} \frac{(S_{ref} - S)}{S_{ref}}\,dz = \int dz - \frac{1}{S_{ref}} \int S dz$$

Subpolar AMOC





Lozier et al. (2019)