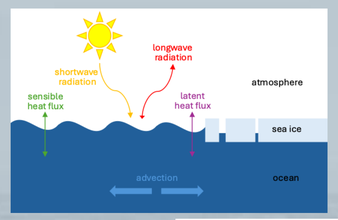
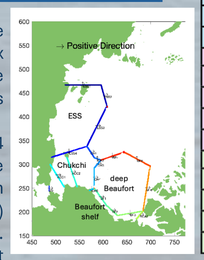
On the sensitivity of the Pacific Arctic sea ice and ocean to the flow through Bering Strait

Jaclyn Clement Kinney[1], Casey Burgener[1], Younjoo Lee[1], Wieslaw Maslowski[1], Robert Osinski[2] and Anthony Craig[3]

[1]Naval Postgraduate School, Monterey, United States; [2]Institute of Oceanology Polish Academy of Sciences, Sopot, Poland; [3]Independent contractor, Seattle, United States

Heat Flux Terms

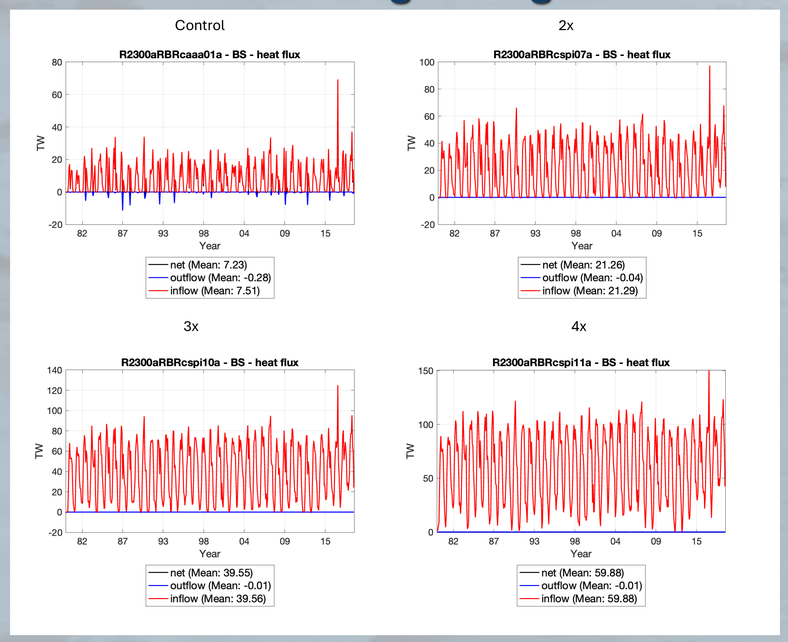




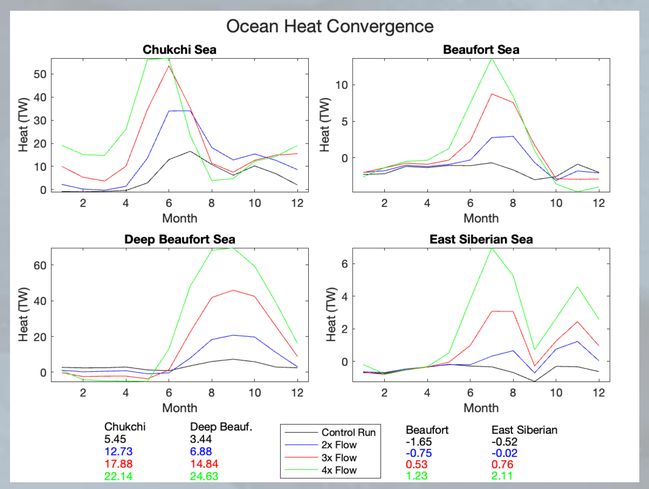
Schematic figure showing the heat flux terms that are quantified in this study.
->Locations of the 4 regions and a table of the long-term mean (1980-2018) heat flux terms (TW). (OHC=ocean heat convergence)

Run	Sensible	Latent	Longwave net	Shortwave net	OHC
Chukchi Sea					
Control	-6.45	-5.61	-6.33	18.23	5.45
2X	-10.13	-9.02	-8.79	20.33	12.73
3X	-13.31	-12.30	-11.51	23.65	17.88
4X	-16.21	-15.22	-14.18	27.30	22.14
Beaufort shelf					
Control	-0.78	-0.74	-1.37	4.56	-1.65
2X	-1.10	-1.03	-1.66	4.81	-0.75
3X	-1.58	-1.54	-2.11	5.23	0.53
4X	-2.01	-2.03	-2.54	5.66	1.23
Deep Beaufort					
Control	-2.26	-1.52	-2.75	13.55	3.44
2X	-3.87	-2.68	-3.90	14.55	6.88
3X	-7.03	-4.99	-6.00	16.52	14.84
4X	-10.91	-7.95	-8.55	18.70	24.63
East Siberian Sea					
Control	-2.93	-2.35	-3.99	18.33	-0.52
2X	-3.29	-2.64	-4.31	18.95	-0.02
3X	-3.96	-3.24	-4.90	19.96	0.76
4X	-4.92	-4.11	-5.72	21.24	2.11

Heat flux through Bering Strait



Timeseries of monthly mean heat flux through Bering Strait for the 4 different runs, as labelled from 1980-2018. Overall mean values (TW) are given in each legend for the net, outflow (southward), and inflow (northward) components.



Ocean heat convergence (TW) annual cycles for each of the four regions for each of the four model runs. The ocean heat convergence tells us how much heat is accumulated or lost in each region. These figures show the mean annual cycle from the years 1980-2018.

Abstract

Bering Strait is a narrow and shallow water passage that connects the Bering Sea to the Chukchi Sea. As the only Pacific connection to the Arctic Ocean, the flow through Bering Strait is responsible for contributing to several water masses including the halocline of the Arctic Ocean, which separates the Arctic Surface Water from the warmer and saltier Atlantic Layer found deeper in the water column. Historical observations of the flow through Bering Strait estimate a mean volume transport of ~0.8 Sv northward that is primarily driven by the large-scale gradient in sea surface height. In recent years, near-bottom mooring observations have indicated an increasing trend in the volume, heat, and freshwater fluxes from the Pacific Ocean to the Arctic Ocean through the Bering Strait.

We have designed a series of model experiments to test the sensitivity of the Pacific Arctic oceanic heat convergence, heat exchange with the atmosphere, and impact on sea ice cover to the flow through Bering Strait. Utilizing the fully-coupled Regional Arctic System Model (RASM) we will compare four runs that have increasingly higher mean volume transport through Bering Strait. These include the control run (which approximates the historical mean volume transport), as well as runs with doubled, tripled, and quadrupled mean volume transport. All of these runs cover the time period from 1980-2018. Results on the heat terms within the ocean and into/out of the atmosphere from these experiments help quantify the heat budget of the Pacific Arctic, which includes the Chukchi, Beaufort, and East Siberian seas. This work will address questions related to the Bering Strait's importance and connection with melting of sea ice in the Pacific Arctic, which is an area that has experienced a dramatic loss of sea ice cover in the past two decades. We find that doubling the volume transport through Bering Strait produces a threefold increase in the oceanic heat convergence into the Pacific Arctic. However, instead of causing a large impact on the melting of sea ice, much of this heat is released to the atmosphere as it transits the shallow Chukchi Sea shelf. This indicates that although the flow through Bering Strait has a modest local impact on sea ice, other large-scale factors appear to play a greater role on the loss of sea ice in the Pacific Arctic.

Conclusions

- Doubling the volume flow through Bering Strait increases the heat flux by a factor of 3.
- As the Bering Strait volume increases, ocean heat convergence shows a significant increase in the Chukchi Sea in summer and the deep Beaufort Sea in autumn.
- As flow through Bering Strait is advected over the Chukchi shelf, a large amount of heat is released to the atmosphere (particularly in autumn and early winter). At the same time, a large amount of heat is gained by the ocean via shortwave in summer.
- Sea ice volume is impacted by the increased heat fluxes with stronger Bering Strait flow, especially in the Chukchi Sea.

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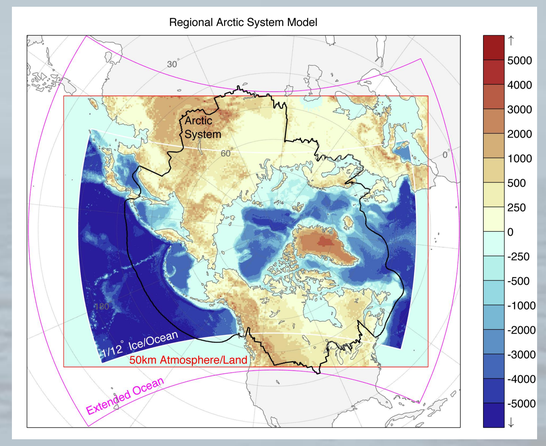
Regional Arctic System Model (RASM)

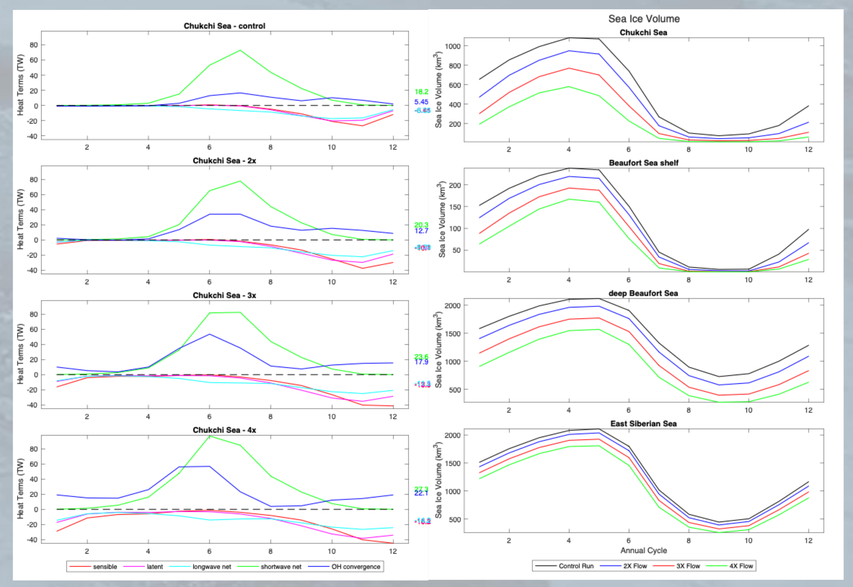


← We utilize results from the Regional Arctic System Model (RASM) to examine the effects of increasing the flow through Bering Strait. RASM is a high-resolution atmosphere-ice-ocean-land regional model with a domain encompassing the entire marine cryosphere of the Northern Hemisphere, including the major inflow and outflow pathways, with extensions into the North Pacific and Atlantic oceans. RASM has been developed over the past 15 years, and each component, as well as the fully coupled system, has been evaluated substantially.

Component	Code	Configuration
Atmosphere	WRF3	50km, 40 levels
Land	VIC	50km, 3 soil layers
Ocean	POP2	1/12° (~9km), 45 levels
Sea Ice	CICE6	1/12° (~9km), 5 thickness categories
Coupler	CPL7x	Flux exchange every 20 min

←Details on the components of RASM including the code and configuration for each component. While this table shows the RASM setup for this study, multiple configurations are available.

Annual Cycles of Heat and Sea Ice Volume



Mean annual cycles of heat terms, including, sensible, latent, longwave, shortwave, and ocean heat convergence for the Chukchi Sea for the four model runs.

Mean annual cycles of sea ice volume for the four regions in each of the four regions.