The respective roles of ocean heat transport and surface heat fluxes in driving Arctic Ocean warming and sea-ice decline

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Introduction

The changes in the Arctic Ocean heat budget and the Arctic sea-ice heat budget are examined using 100-member Community Earth System Model v2 Large Ensemble (CESM2 LENS) over 1920-2100. The Arctic Ocean is defined to be bounded by **the Bering, Barrow, Nares, Fram Straits and Barents Sea Opening**, where the ocean heat transport into the Arctic are calculated.

III. Impact on the Atmospheric Warming

- In the annual mean sense, the heat loss to ocean becomes heat gain from ocean since 2050, but the increased heating from the ocean is nearly compensated by the reduced heating from the sea-ice (Fig. 4a).
- While the annual mean heat flux into atmosphere hardly changes, its seasonality increases (Fig. 4b), due to an enhanced seasonality of the ocean-to-atmosphere heat flux (not shown), likely due to more ocean exposure to the atmosphere.

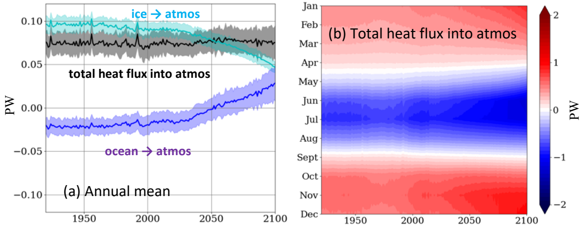

Figure 4: Heat flux into the atmosphere for (a) annual mean and (b) each month, respectively. The positive values indicate heat gain by the atmosphere.

I. Arctic Ocean Heat Budget

- Artic Ocean warming is primarily driven by the increased OHT into the Arctic, which is partly damped by the increased surface heat loss into the atmosphere and sea-ice (Fig. 1).
- Increased OHT is primarily due to warmer ocean temperature instead of the volume transport changes (not shown).
- The monthly mean Eulerian OHT through the Barents Sea Opening is primarily responsible for the increased OHT (Fig. 2).
- Increased heat loss to the atmosphere is primarily due to decreased sea-ice coverage (not shown).

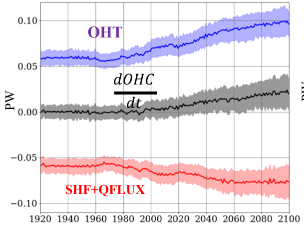

Figure 1: Arctic Ocean heat budget. Lines represents the ensemble mean and shadings indicate one ensemble standard deviation range of CESM2 LENS.

$$\frac{dOHC}{dt} = OHT + SHF + QFLUX + F_{residual}$$

OHC: Arctic Ocean heat content
OHT: Ocean heat transport into the Arctic
SHF: Surface heat flux into the Arctic Ocean from atmosphere and sea-ice
QFLUX: Heat flux due to frazil ice formation

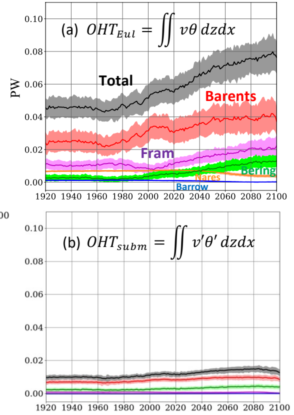

Figure 2: (a) Monthly mean Eulerian OHT and (b) submonthly transient OHT through each straits.

II. Arctic Sea-Ice Heat Budget

- In January, the heat loss from the sea-ice to atmosphere increases (Fig. 3a), driven by increased sensible and latent heat loss due to warmer ice temperature (not shown).
- In July, the ocean-to-ice heat flux becomes the dominant source for the sea-ice heat content increase by 2020 (Fig. 3b). The atmosphere-to-ice heat flux only increases slightly.

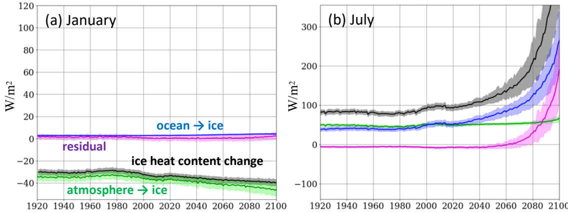

Figure 3: Arctic sea-ice budget for (a) January and (b) July, respectively. The positive values indicate heat gain by the sea-ice. Note the W/m² is used, as the PW is dominated by changes in the sea-ice area.

For the more complete story, please check out our paper:

Oldenburg, D., Y-O. Kwon, C. Frankignoul, G. Danabasoglu, S. Yeager, and W.M. Kim, 2024: The respective roles of ocean heat transport and surface heat fluxes in driving Arctic Ocean warming and sea-ice decline. *J. Climate*, in-press. https://doi.org/10.1175/JCLI-D-23-0399.1.

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The support from the NSF (OPP-2106190/2106228) is gratefully acknowledged.