Bering Strait Ocean Heat Transport Drives Decadal Arctic Variability

in a High-Resolution Climate Model

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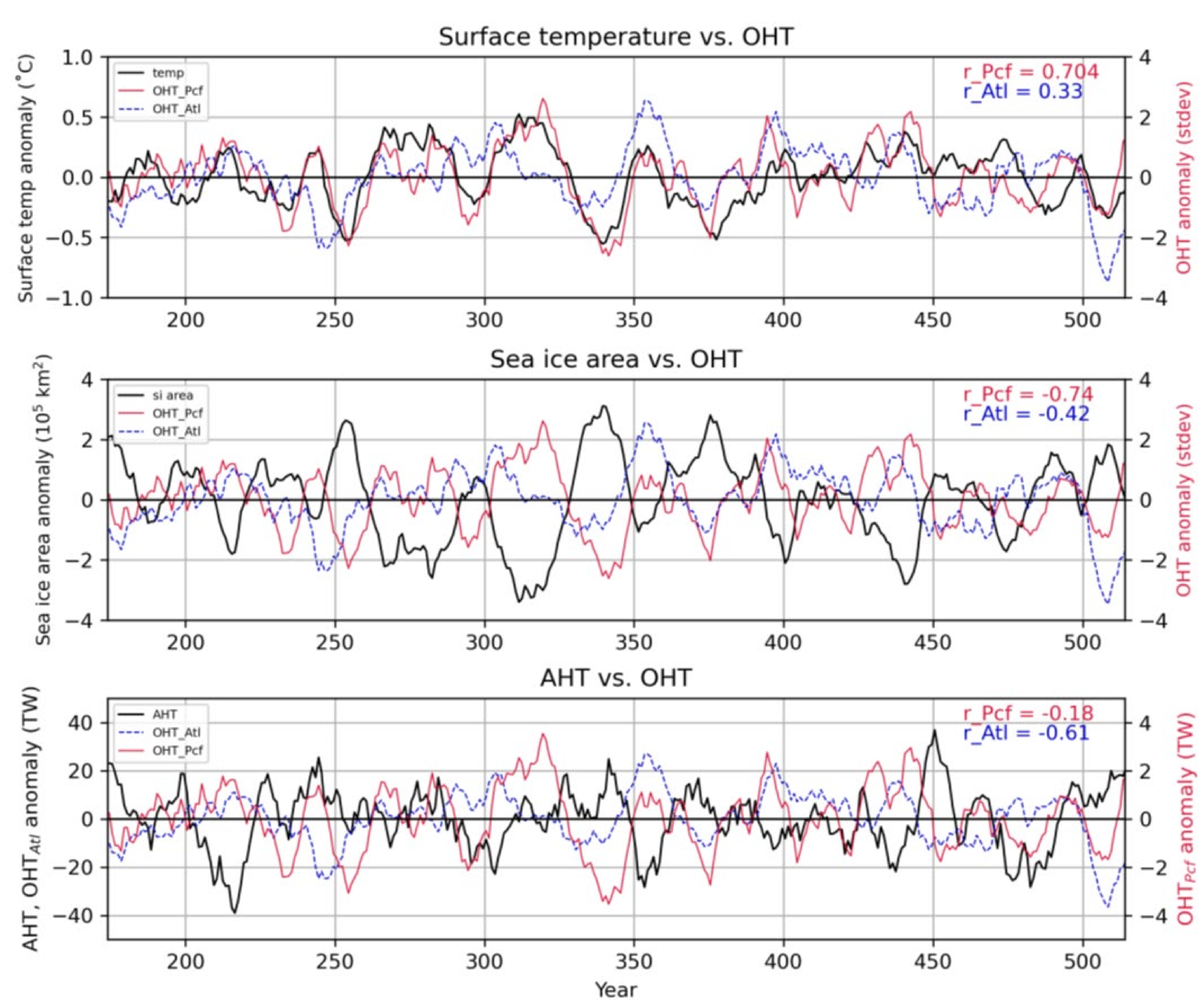
Bjerknes Compensation

- Bjerknes Compensation (BjC) is the tendency of the atmosphere to respond to *ocean heat transport (OHT) anomalies* with *opposing anomalies in atmospheric heat transport* (AHT).
- Kurtakoti et al. (2024) found that the ice-albedo and cloud feedbacks play a critical role in BjC.
- Here we investigate BjC in a high-resolution climate model.
- We find that:
  - OHT through the Bering Strait has an outsized impact on Arctic temperatures compared to Atlantic OHT.
  - Bering Strait OHT is amplified strongly by the ice-albedo feedback, creating a strong atmospheric heat anomaly.
  - This heat anomaly is not transported away but stays in place, balanced by outgoing longwave radiation.
  - BjC takes place in the Atlantic sector only.

Timeseries Analysis

- Arctic surface temperatures (*r = 0.7*) and sea ice (*r = -0.7*) are highly correlated with Bering Strait OHT; correlations with Atlantic OHT are much weaker (*r = 0.3/-0.4*)
- Atlantic OHT is strongly correlated with AHT (*r = -0.61*), while Bering Strait OHT is not (*r = -0.18*)



Bering Strait (red) and Atlantic (blue) OHT anomalies alongside Arctic surface air temperature (top), sea ice area (middle) and AHT (bottom). Correlation coefficients are given in the top right.

References

- Chang et al. (2020): An unprecedented set of high-resolution earth system simulations for understanding multiscale interactions in climate variability and change. *Journal of Advances in Modeling Earth Systems*, **12**, e2020MS002298.
- Kurtakoti et al. (2024): Sea Ice and Cloud Processes Mediating Compensation between Atmospheric and Oceanic Meridional Heat Transports across the CMIP6 Preindustrial Control Experiment. *Journal of Climate*, **37**, 505-525.

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Approach: CESM1.3

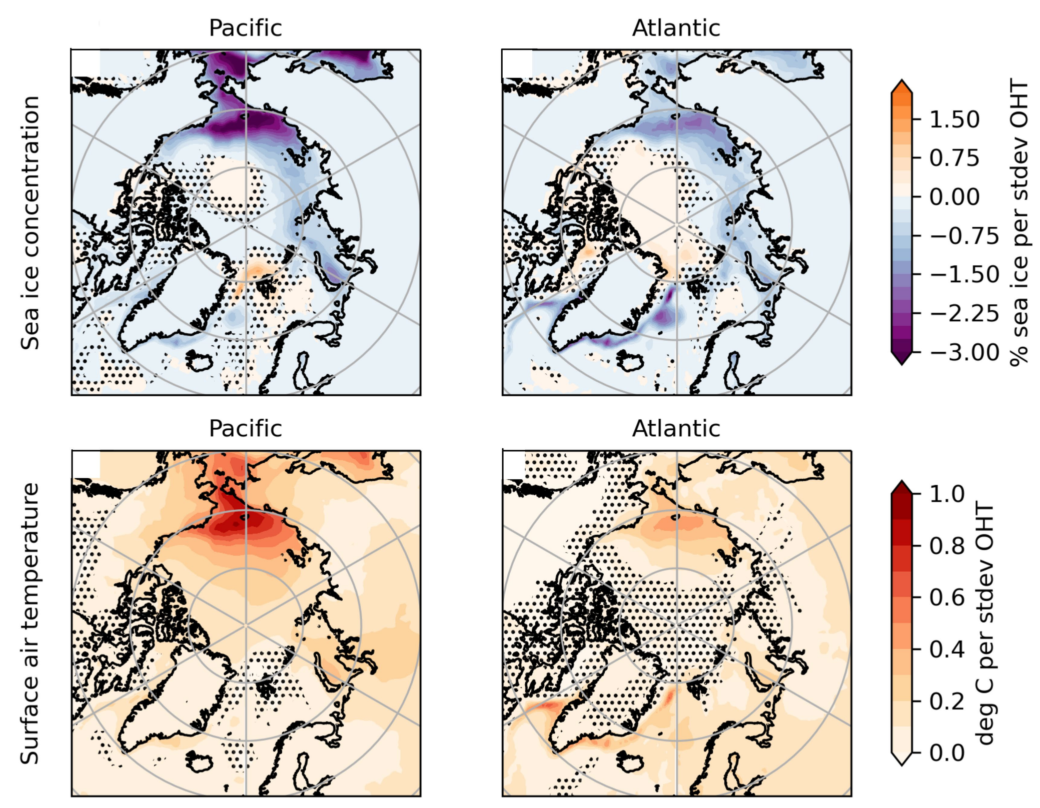
- We analyze 350 years from a 500-year pre-industrial control simulation of CESM1.3 (Chang et al. 2020)
- Resolution
  - 0.25° in the atmosphere and land
  - 0.1° in the ocean and sea-ice
- We infer atmospheric heat transport across 65°N by integrating surface and Top-of-the-Atmosphere fluxes zonally and southward:

$$\mathrm{AHT}(\theta) = \int_{\theta}^{\pi/2}\int_{0}^{2\pi} (\mathrm{LW_{sfc}} + \mathrm{SW_{sfc}} + \mathrm{LHF} + \mathrm{SHF}) - (\mathrm{LW_{TOA}} + \mathrm{SW_{TOA}})\, dA$$

- The model has an accurate representation of Bering Strait heat transport (see poster by Gaopeng Xu) and a realistic representation of sea ice cover.

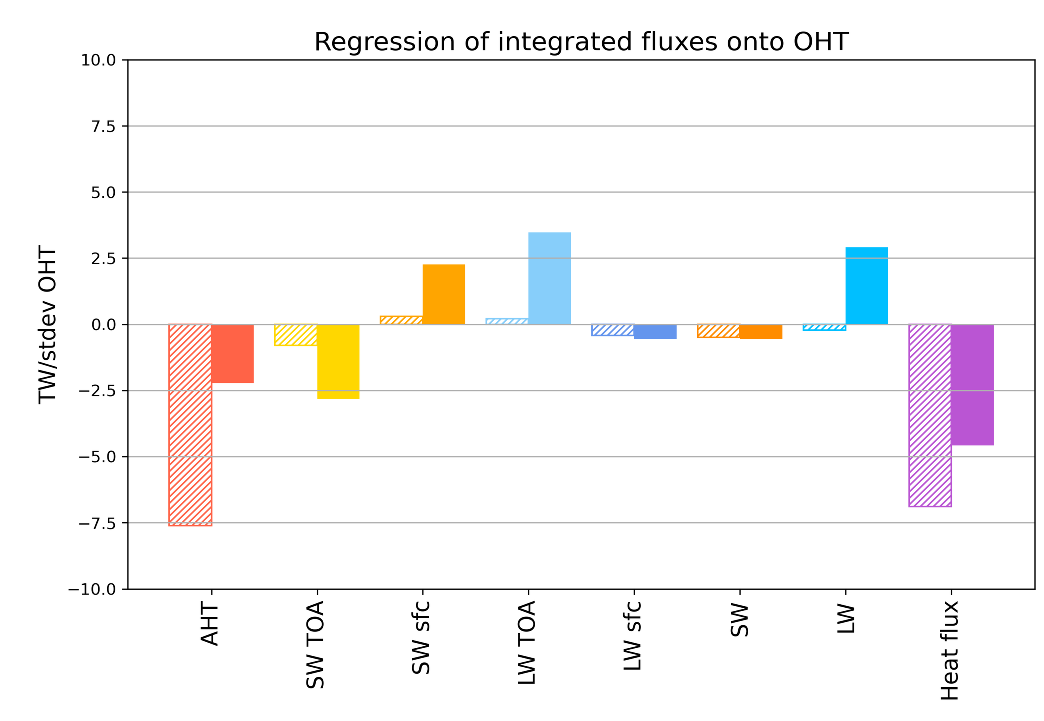
Atmospheric Response

- Surface air temperature and sea ice concentration show a strong sensitivity to Bering Strait OHT in the Chukchi Sea. The Response to Atlantic OHT is much weaker.



Regression of OHT from the Pacific (left) and Atlantic (right) on sea ice concentration (top) and surface air temperature (bottom).

- The atmospheric response to OHT variability is shown below as regressions of OHT on contributions to AHT (red). Negative regressions hence strengthen Bjerknes Compensation.
- Atlantic OHT (dashed) *is* compensated: ocean heat is transferred to the atmosphere by turbulent fluxes (Heat flux) and carried away (AHT); shortwave (SW) and longwave (LW) contributions are small.
- Pacific OHT (solid) is *not* compensated: ocean heat and the ice-albedo feedback (SW sfc) generate an atmospheric heat dome that is balanced by outgoing longwave radiation (LW TOA).



Linear regression slopes of area-integrated heat flux anomalies onto standardized ocean heat transport. Dashed bars are fluxes regressed onto Atlantic OHT, while solid bars are fluxes regressed onto Bering Strait OHT.