Evaluating the role of air-sea interactions in Bering Sea warming

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Introduction

Anomalous events (2010-present) in the Bering Sea:

- Extreme low sea-ice concentrations
- Elevated sea surface temperature (SST)
- Air-sea heat flux anomalies

How does atmospheric variability affect the surface ocean through air-sea heat fluxes?

Stabeno & Bell 2019; Danielson et al. 2020

Image credit: NASA Visible Earth

Reduced sea ice extent

- Extreme low sea ice extent in 2018 and 2019
    - Associated with
        - altered radiative forcing
        - wind pattern anomalies

Jones et al. 2020; Stabeno & Bell 2019;

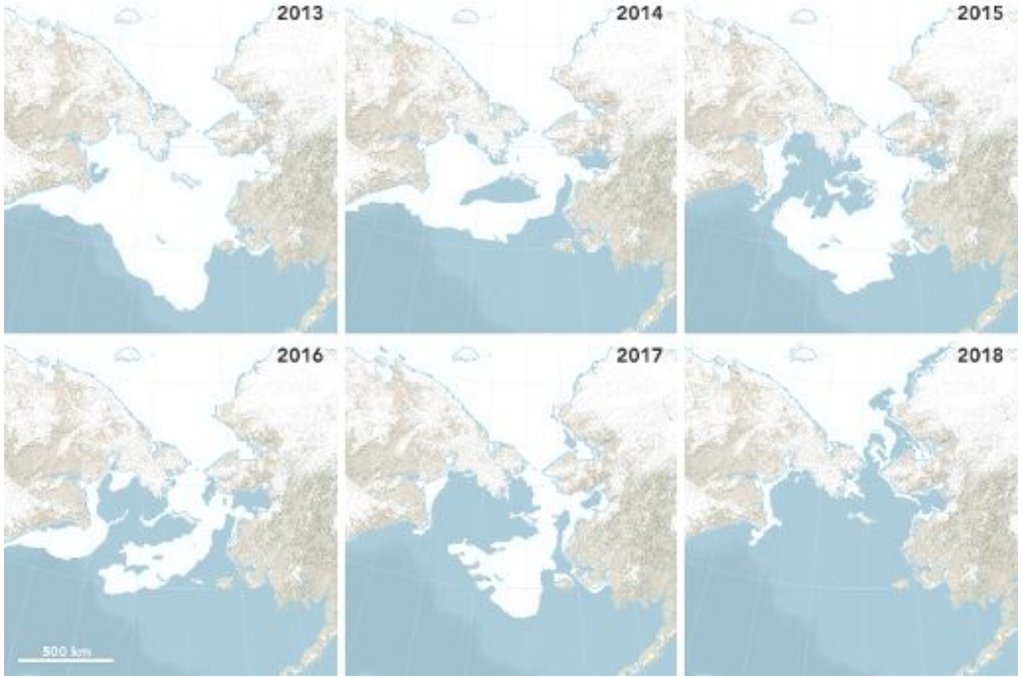
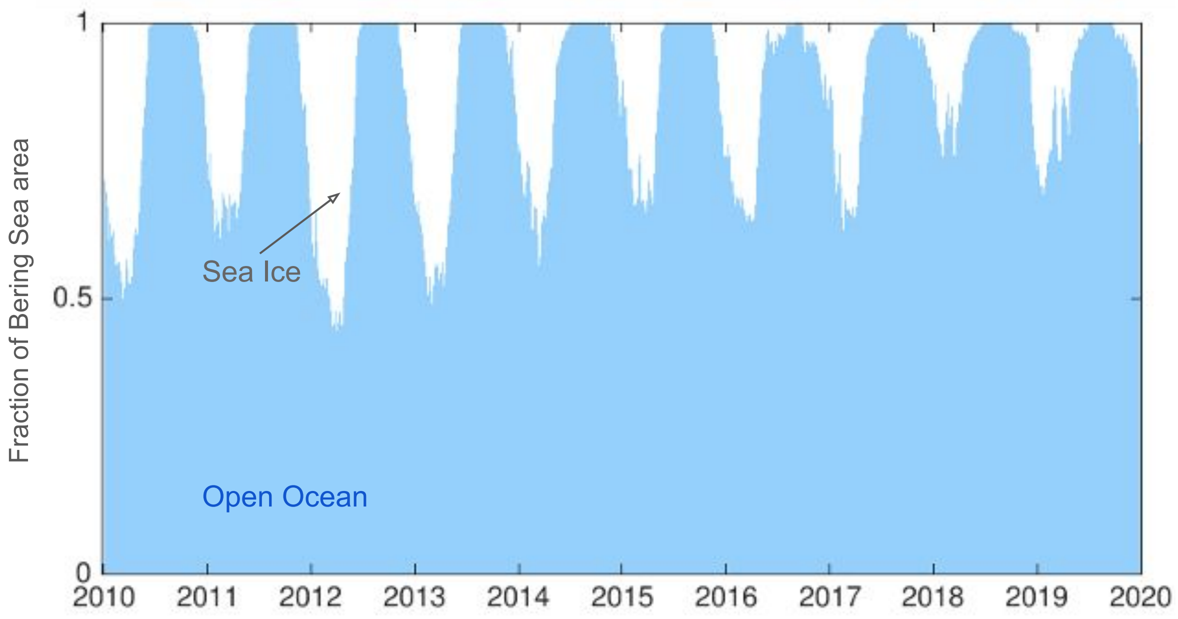


Image credit: NASA Visible Earth

Reduced sea ice extent (cont.)

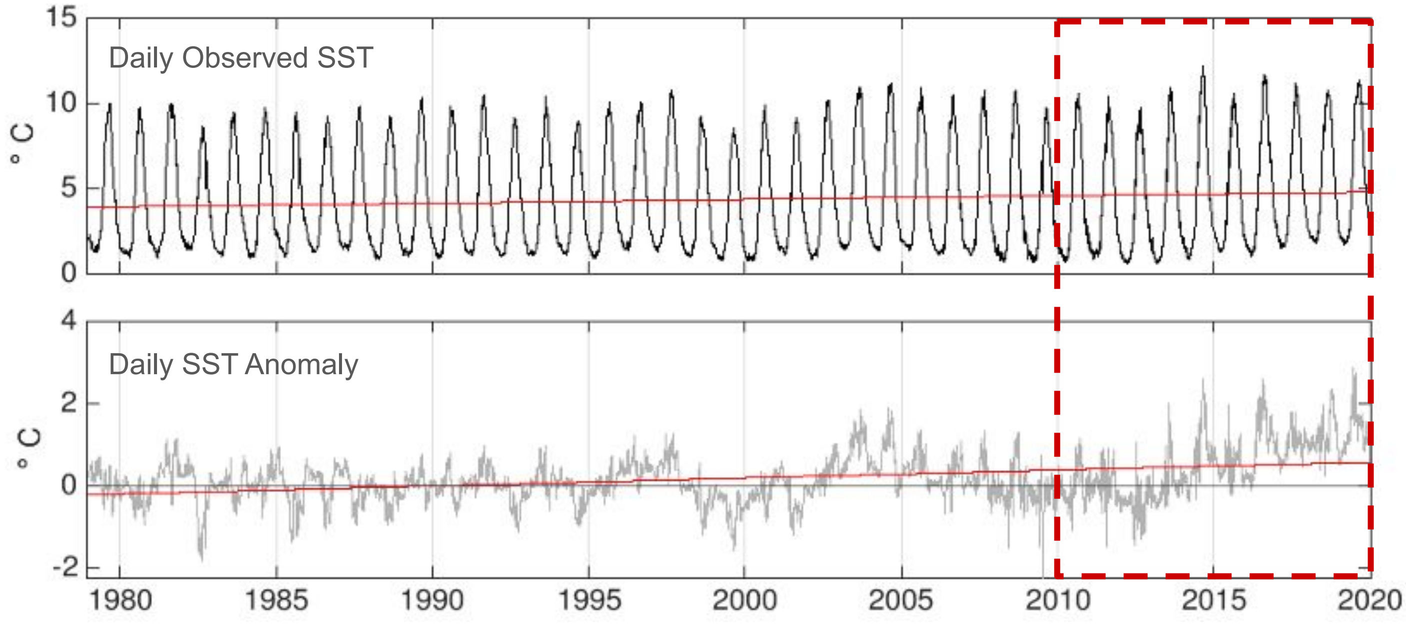
Hypothesis:

- Decreased sea-ice coverage leads to increased air-sea heat exchange and warming of the surface Bering Sea



Fraction of Bering Sea surface area that is open water (blue) and ice-covered (white).

Elevated SST over the last decade



Time series of daily SST (1979-2019) from ERA5 reanalysis data. Upper plot shows spatially-averaged SST for the ice-free Bering Sea, with the red line indicating a best fit straight line with slope 0.2 ± (0.2 x 10^{-3})°C/decade. The lower plot shows spatially-averaged SST anomalies over the same region, and the red line again indicates a best fit line with slope 0.2 ± (0.2 x 10^{-3}) °C/decade.

Air-sea heat flux anomalies over the past decade

Net heat flux anomalies:

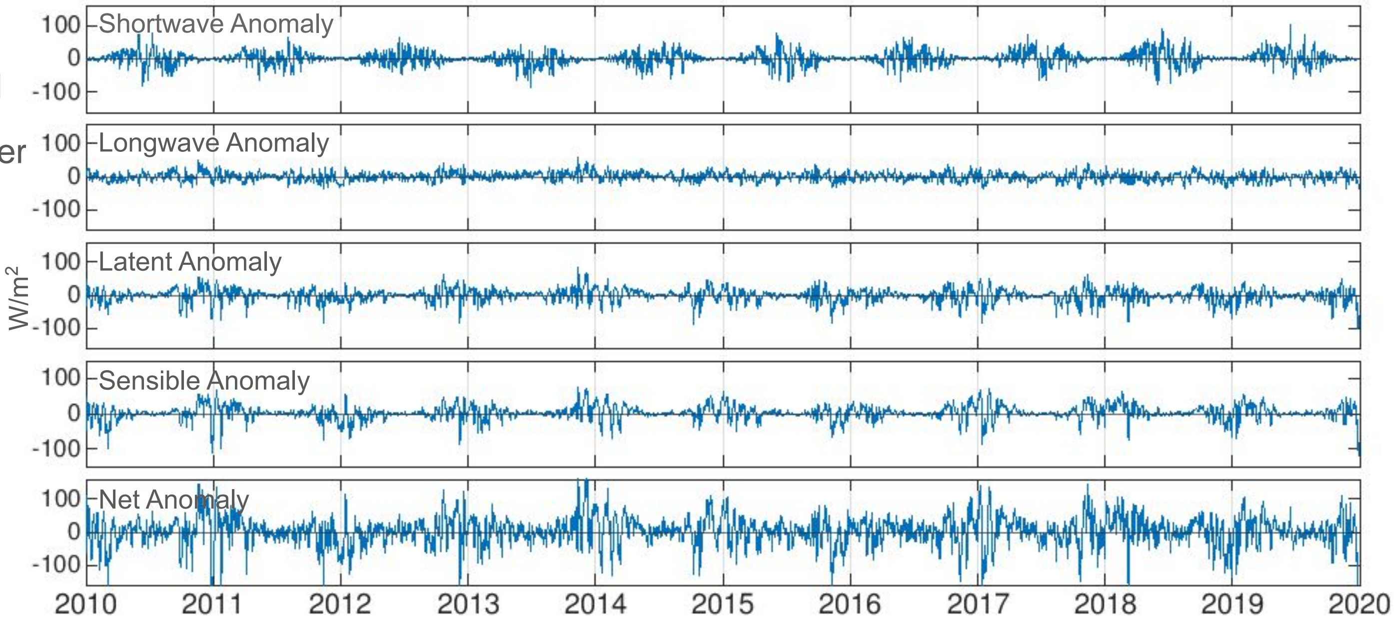
- Positive indicates anomalous downward (into ocean) flux
- Largest from late winter into early spring

Shortwave:

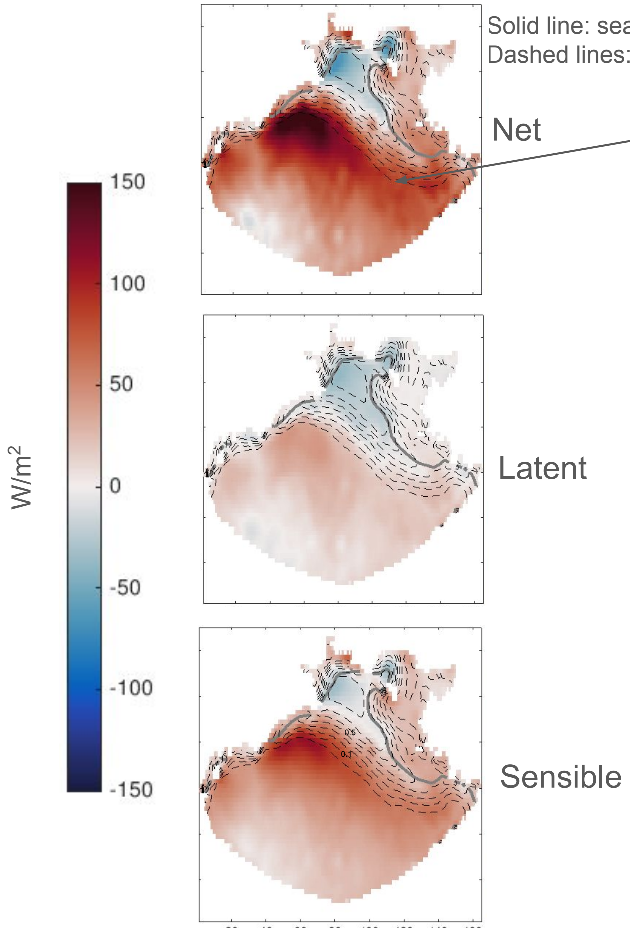
- Dominant during the summer

Turbulent:

- Dominant during the winter



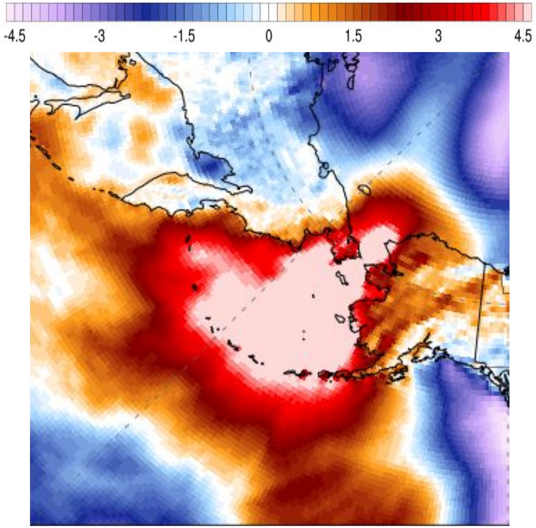
Example strong warming air-sea heat flux anomaly (Feb. 2018)



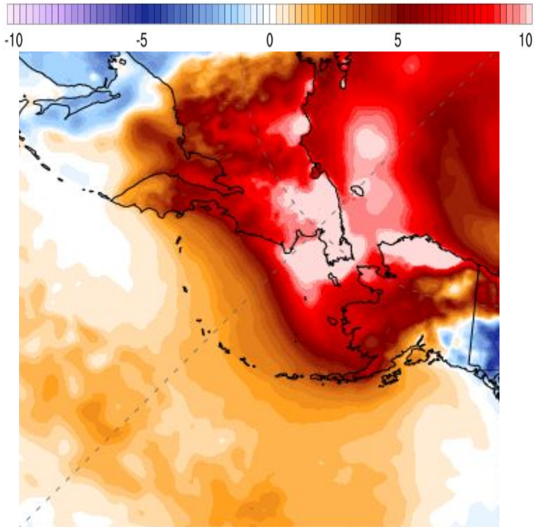
Solid line: sea-ice edge
Dashed lines: sea ice concentration anomaly

- Strong, positive net heat flux anomaly along climatological sea ice edge
- Sensible heat flux anomaly dominates the signal
- Northward wind velocity anomaly
- Northward advection of anomalously warm air

10m V-wind Anomaly (m/s)



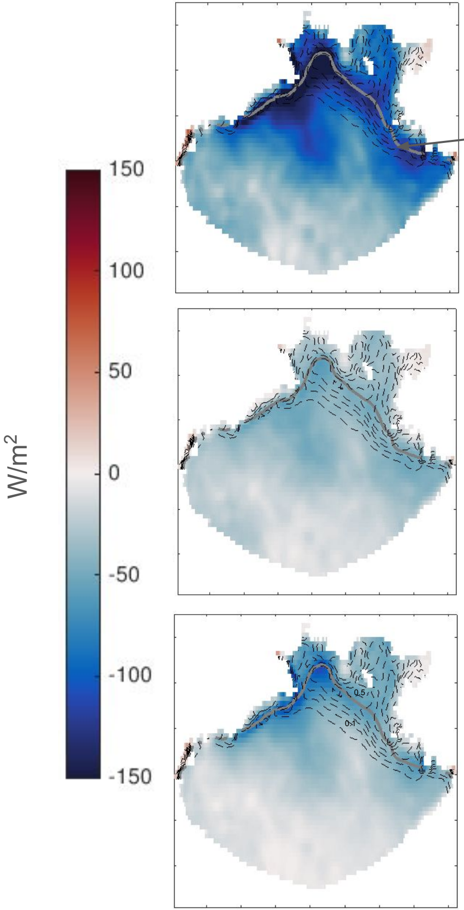
2m Air Temperature Anomaly (°C)



ERA5 Reanalysis Fields from ClimateReanalyzer.org

Example strong cooling air-sea heat flux anomaly (Dec. 2018)

Solid line: sea-ice edge
Dashed lines: sea ice concentration anomaly



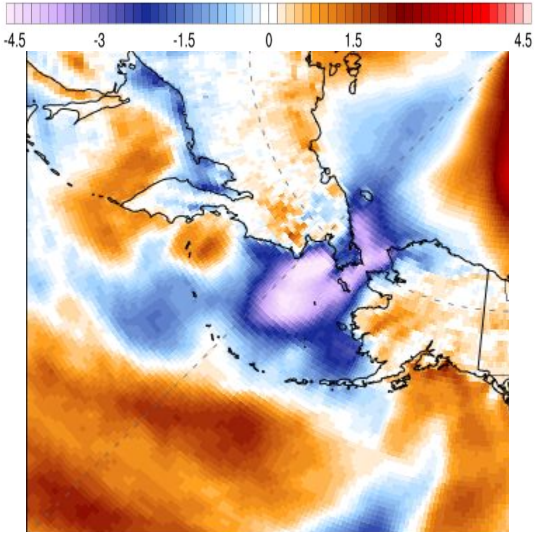
Net

Latent

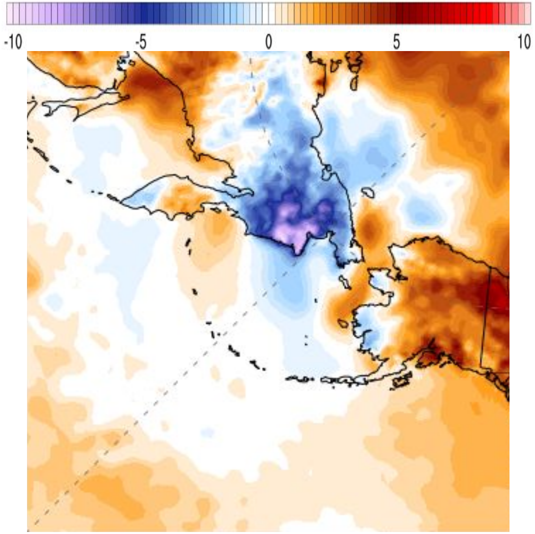
Sensible

- Strong, negative net heat flux anomaly along actual sea ice edge
- Sensible heat flux anomaly dominates the signal
- Southward wind velocity anomaly
- Southward advection of anomalously cool air

10m V-wind Anomaly (m/s)



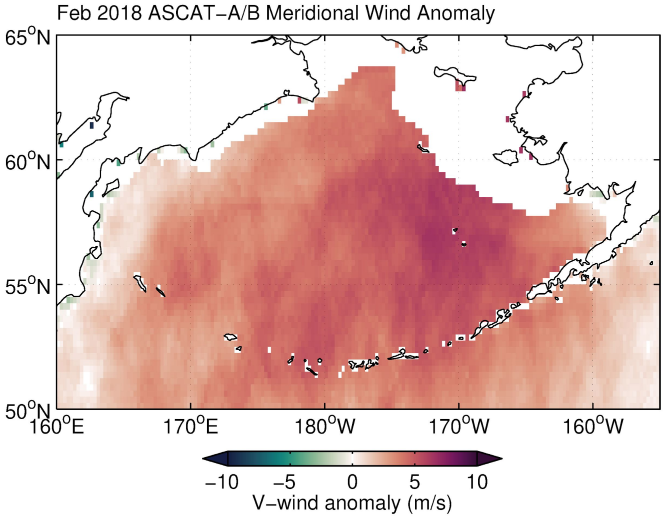
2m Air Temperature Anomaly (℃)

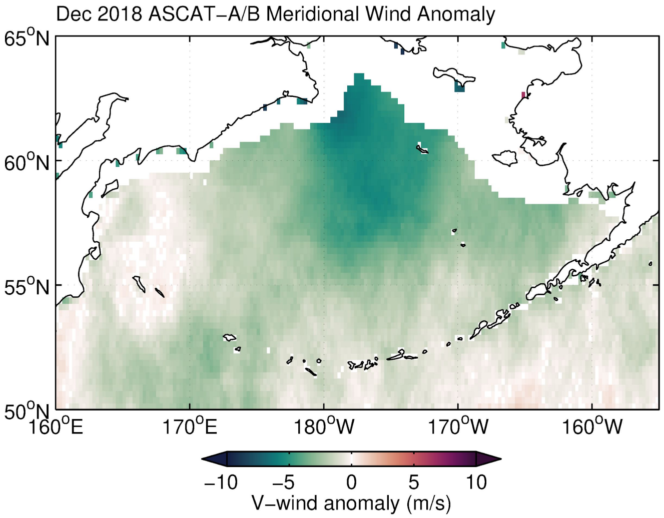


ERA5 Reanalysis Fields from ClimateReanalyzer.org

Initial Results

- **Results suggest that ocean surface wind velocity anomalies are contributing to Bering Sea warming** by altering sea-ice extent [Stabeno & Bell, 2019] **<u>and</u> by altering** sensible heat flux into the ocean
    - Northward wind anomaly (02/2018) results in a positive sensible heat flux anomaly through anomalously strong advection of anomalously warm air
    - Southward wind anomaly (12/2018) results in a negative sensible heat flux anomaly through anomalously strong advection of anomalously cool air





Ongoing Work

- Quantify how surface turbulent and radiative heat fluxes have changed in recent years using ERA-5, MERRA-2, and OAFLUX, and determine if the heat fluxes have the potential to explain the observed warming trend
- Determine the relative contribution of air temperature and wind speed anomalies to turbulent surface heat flux anomalies
  - Use L2 swath ASCAT data to resolve spatial variations in wind not resolved by ERA-5

Acknowledgements

Funded by:

- NASA Ocean Vector Winds Science Team grant 80NSSC18K1611
- OSU Provost Distinguished Graduate Fellowship