Polar Climate Working Group Updates

THE 27th ANNUAL CESM WORKSHOP

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NCAR

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Polar Climate Working Group Overview

Model Development

- Improved coupling to ocean (MOM) & atmosphere (CAM7)
- Exciting new physics
- Incorporating observations

Science Highlights

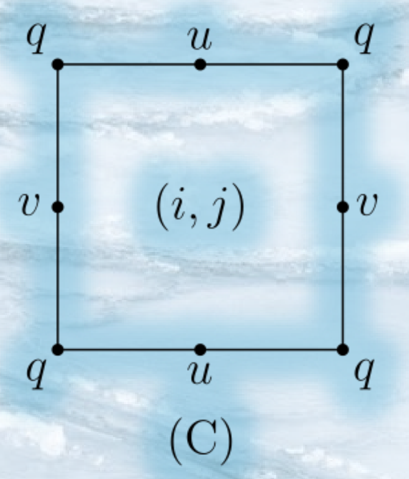
- Winds and circulation
- Aerosol Forcing
- Sea ice predictability
- Actionable Science

From CICE5 to CICE6: *Improvements in Coupling & Grid Updates*

- Interactive Salt Fluxes
  - Coupling prognostic sea ice salinity (from mushy thermodynamics) to MOM6
  - Frazil ice freshwater and brine need to be computed in CICE, not the ocean model

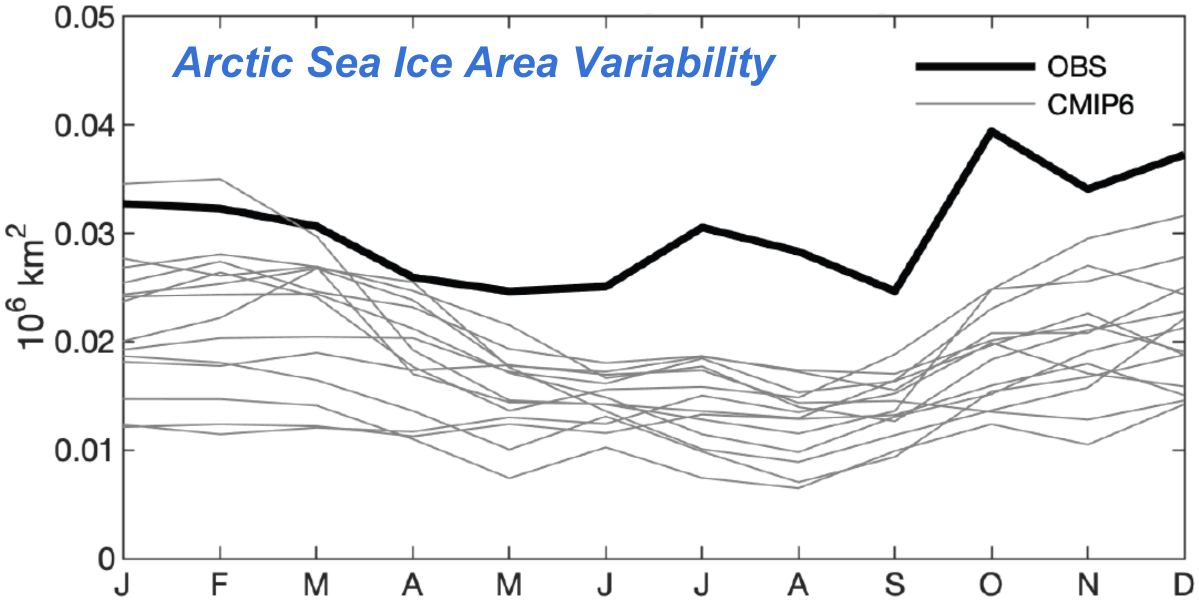
- Consistent Heat Fluxes
  - Consistent accounting of temperatures of rain and snow that fall on the ice
  - Consistent accounting of temperatures of meltwater and brine

Arakawa C Grid



From CICE5 to CICE6: *Exciting New Physics*

- Land-fast sea ice
- Sea ice floe size distribution
- Interactions between sea ice and ocean waves



Blanchard-Wrigglesworth et al (2021)

From CICE5 to CICE6: *Using Observations to Improve Model Physics*

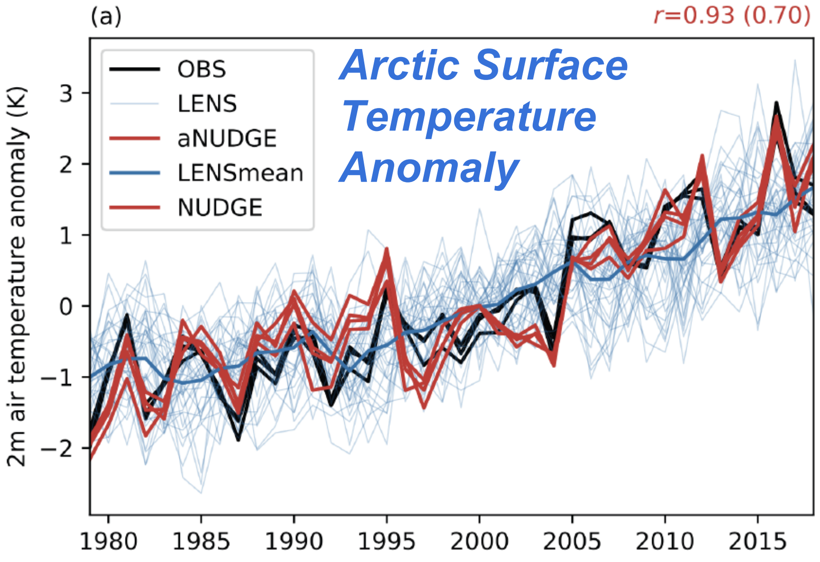
Improving sea ice parameterizations using MOSAiC observations

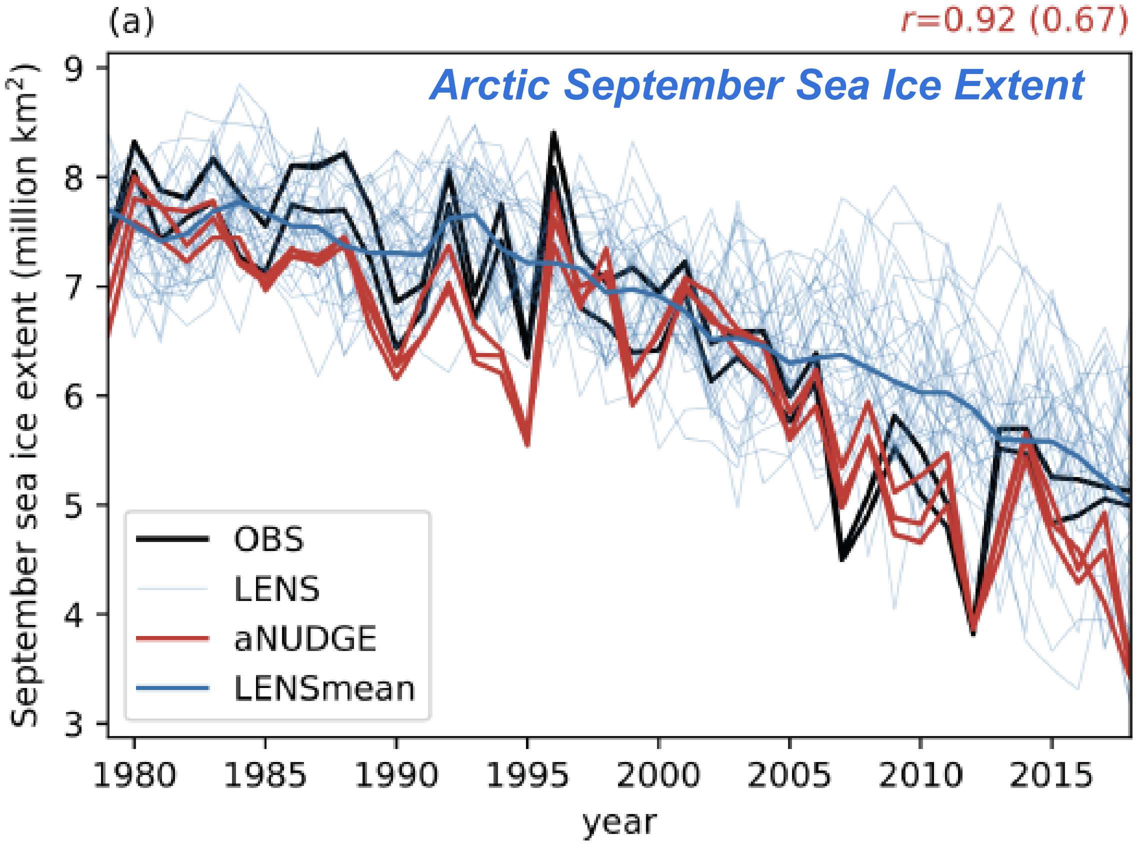
- **Albedo** improvements (optical properties, spectral resolution)
- **Snow** heterogeneity, redistribution, aging, rain on snow
- Better **melt pond** parameterizations

MOSAiC International Arctic Drift Expedition

Research Highlights: *Arctic Sea Ice Decline Impacted by Surface Winds*

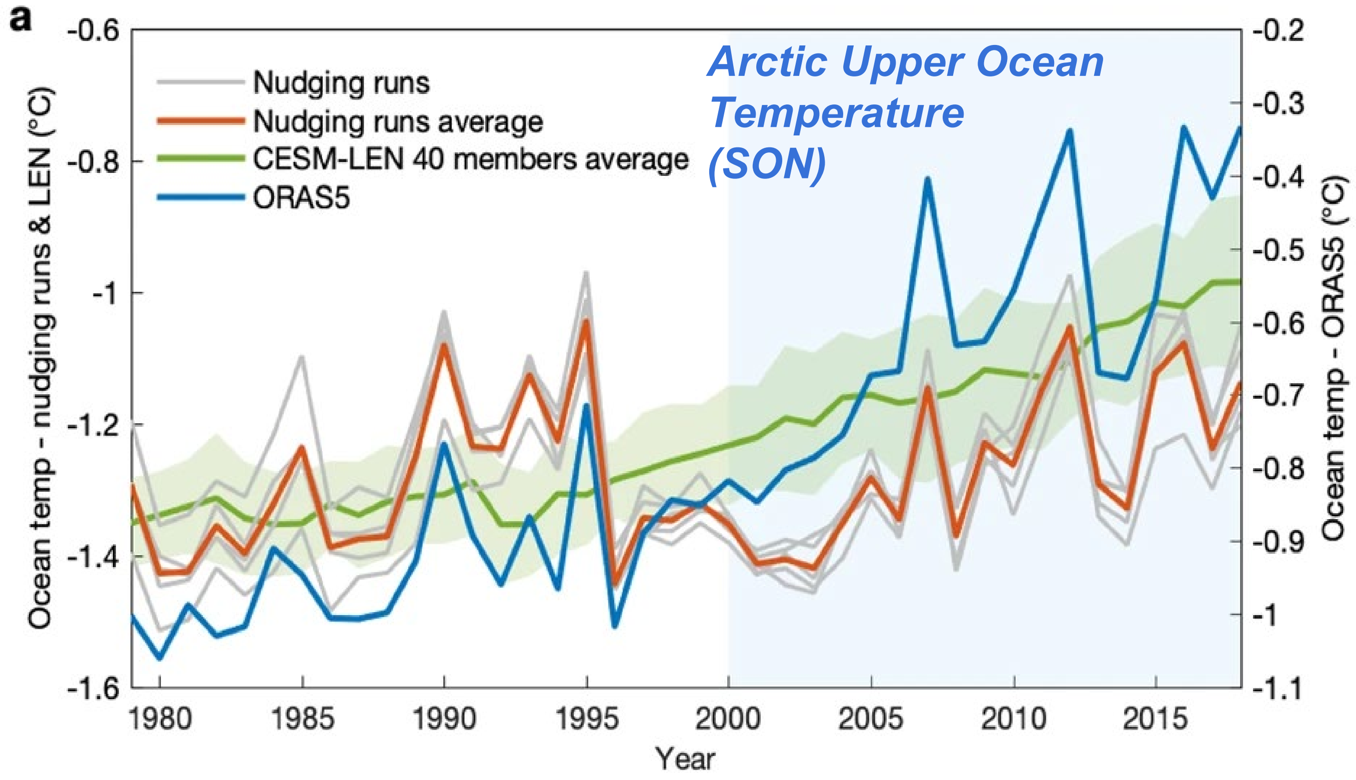
Nudging CESM1 surface winds in the Arctic to **observed winds** greatly improves agreement between model simulations and observations.





Roach & Blanchard-Wrigglesworth (in review)

Research Highlights: *Arctic Sea Ice Decline Impacted by Surface Winds*

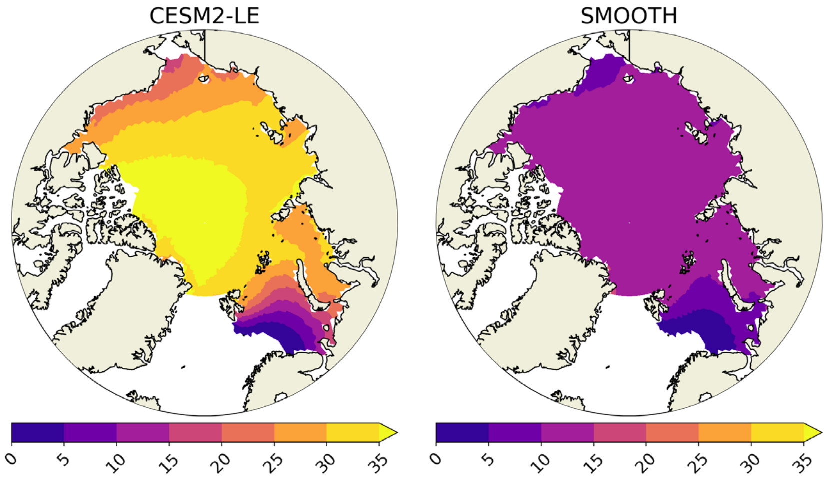


Li et al (2022, Nature Communications)

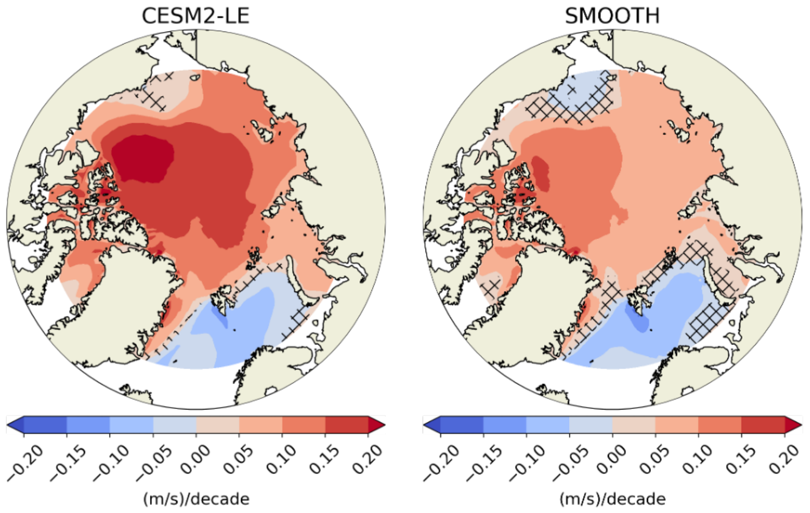
Surface wind changes account for:

- At least ¼ of the increase in Arctic upper ocean temperatures over the last 40 years
- Over ½ of the increase in Arctic upper ocean temperatures from 2000 to 2018

Sea Ice Roughness



Autumn 10m Wind Speed Trend: 2020-2100



DuVivier et al (2022, in prep)

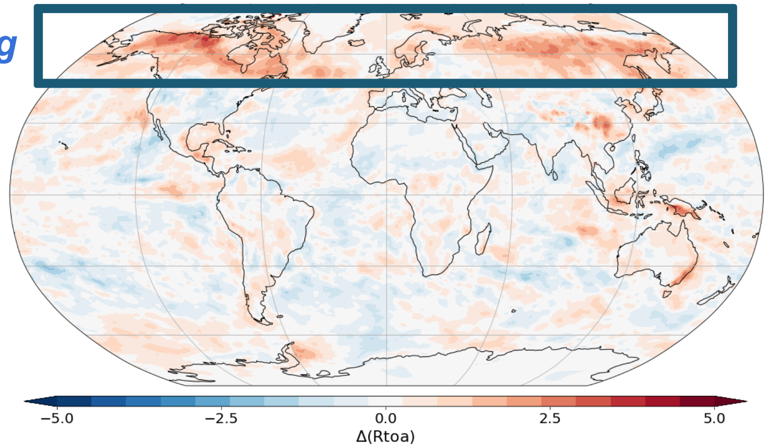
Research Highlights: *Increased Surface Winds over the Arctic*

Decreased surface roughness, which occurs when sea ice area declines, explains **30% to 60%** of the increase in surface wind speeds over the Arctic.

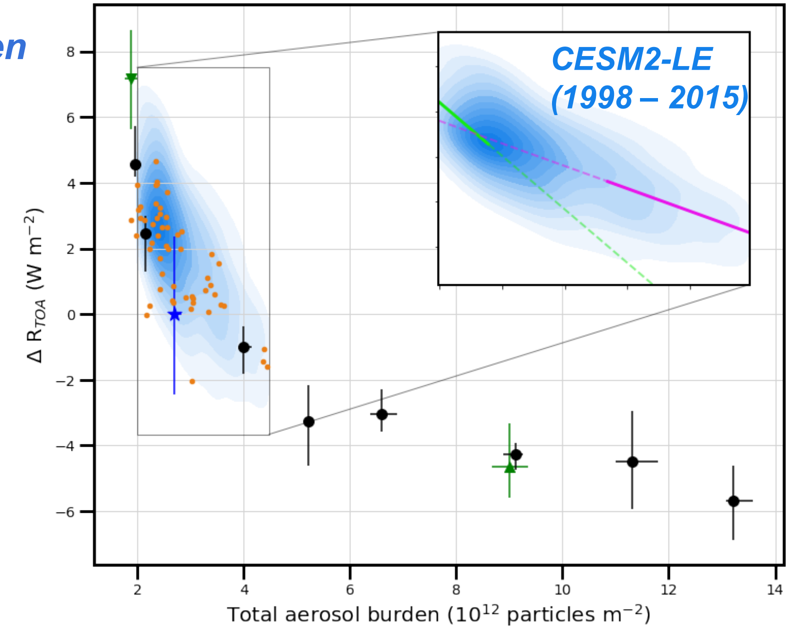
Decreased static stability in the boundary layer with sea ice loss likely explain the rest of the decline.

Research Highlights: *Aerosol Forcing Nonlinearities over the Sub-Arctic*

Radiative Forcing due to Biomass Burning Aerosol Emissions Variability



Aerosol Burden versus TOA Forcing (40N to 70N)



Heyblom et al (2022, in prep)

CESM2 fixed SST experiments show that **forcing** due to **biomass burning emissions** strongly depends on the **variability** of these emissions.

There is a **2.4 W/m^2 radiative forcing** difference due to variability in biomass burning aerosol emissions from 50N to 70N in JJAS.

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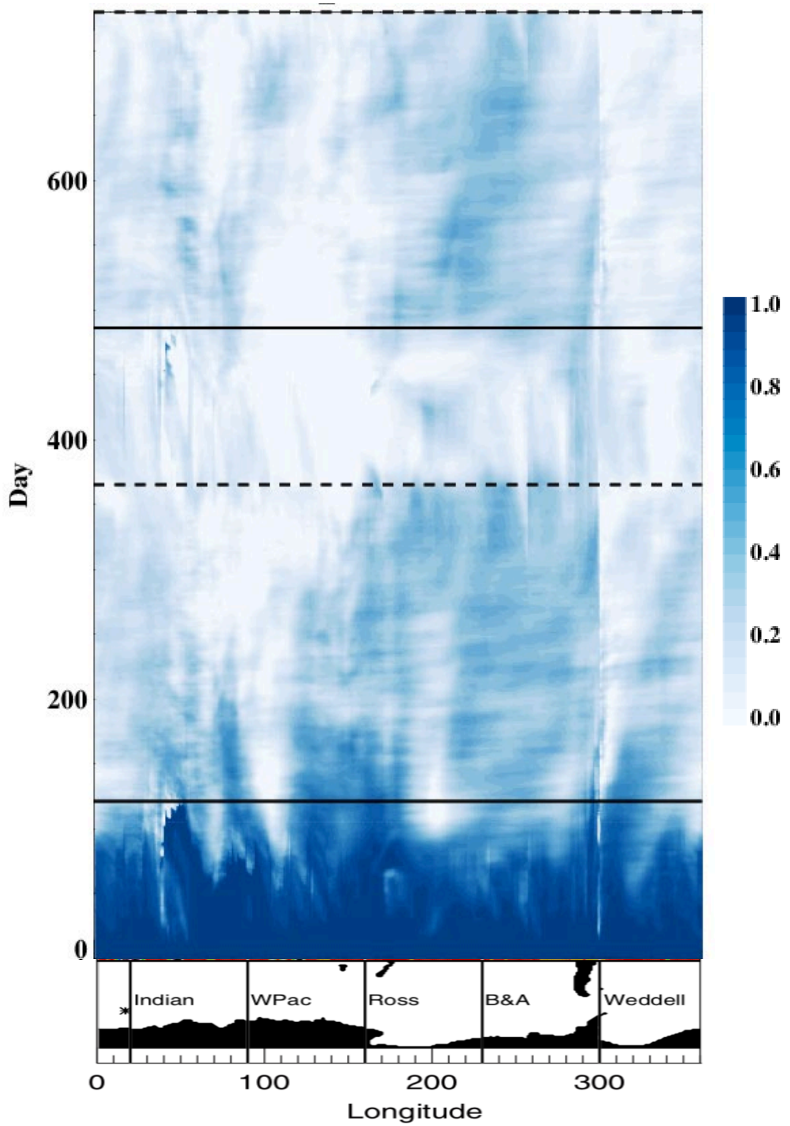
Research Highlights:
Antarctic Sea Ice Predictability

Perfect model prediction ensembles show:

- Predictability is high for first several months following initialization
- Predictability is **lost in summer** (DJF)
- In some regions, predictability **re-emerges the following winter** (JJA)

How does predictability depend on when the model is initialized (month) or the climate state (2010 versus 2030)?

Anomaly Correlation Coefficient: Ice Area

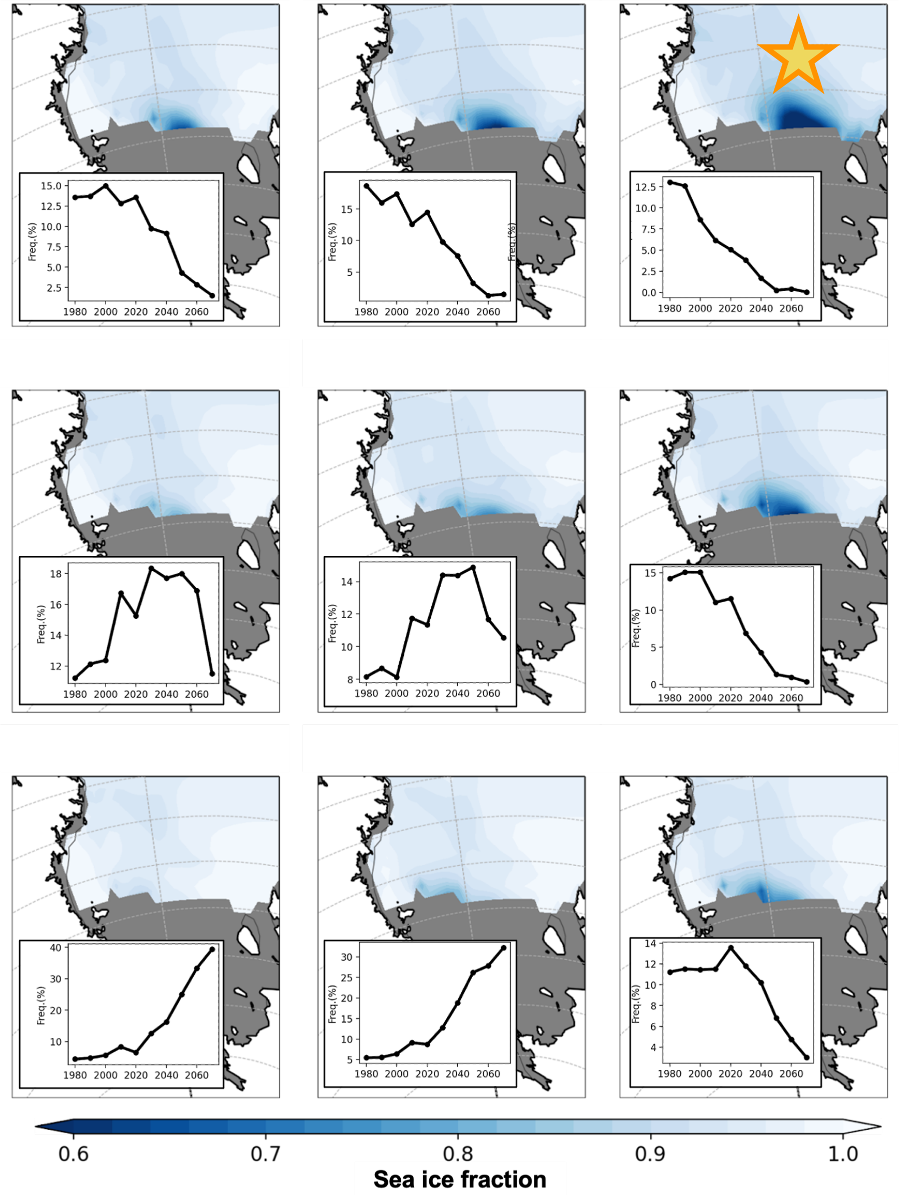


Holland et al (work-in-progress)

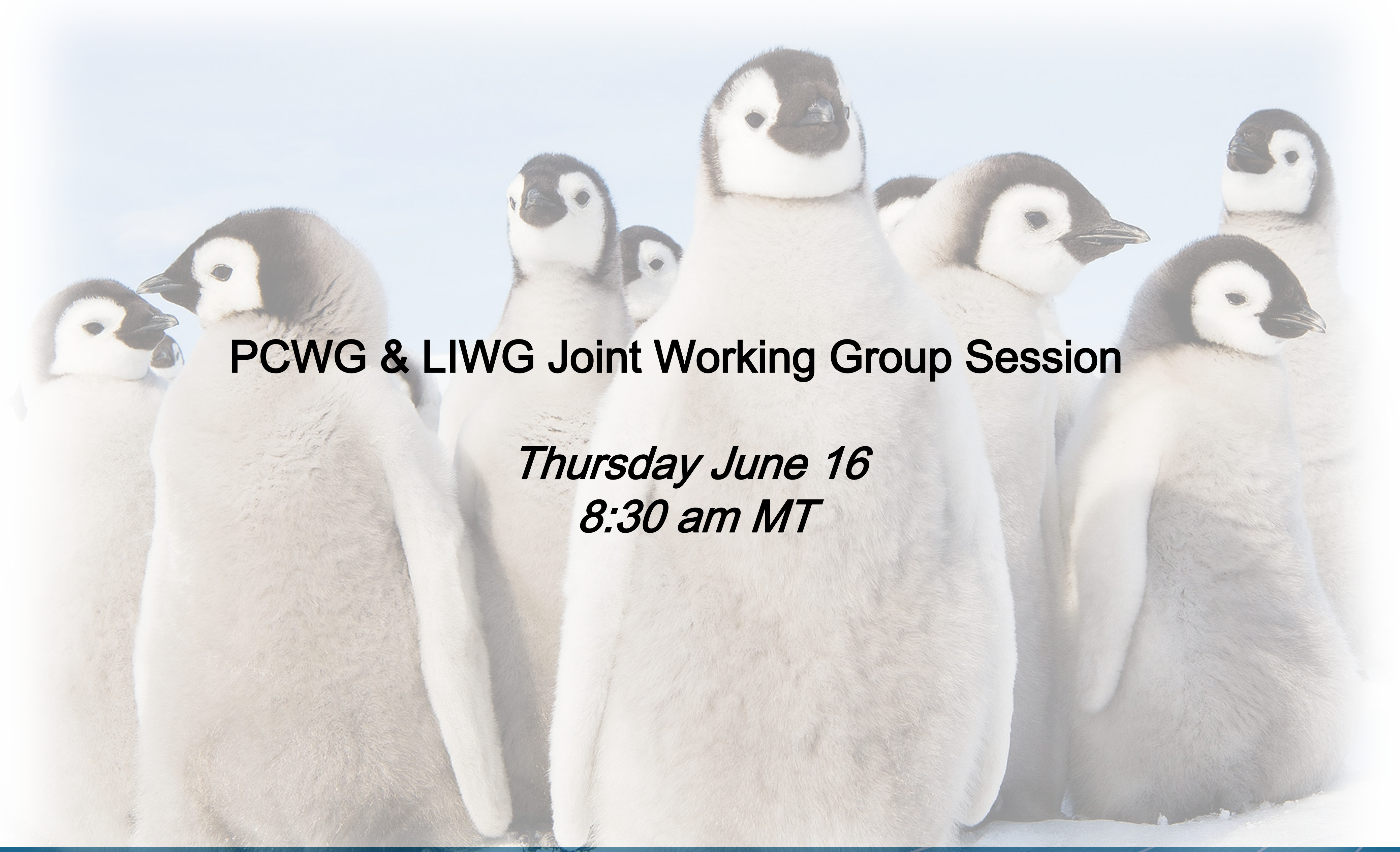
Research Highlights:
Antarctic Polynyas and Implications for Protected Areas

Will sea ice in coastal protected areas change in the future?

A **Self-Organizing Map Neural Network** algorithm applied to CESM2 future projections shows that patterns with **large coastal polynyas ( )** **decrease** in frequency.



DuVivier et al (2022, in prep)



PCWG & LIWG Joint Working Group Session

Thursday June 16
8:30 am MT