Polar Climate Working Group Updates

THE 27th ANNUAL CESM WORKSHOP

Hansi Singh  
PCWG Co-chair

Marika Holland  
PCWG Co-chair

David Bailey  
CICE Consortium Liaison

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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
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)

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

**Surface wind changes** account for:
- At least $\frac{1}{4}$ of the increase in Arctic upper ocean temperatures over the last 40 years
- Over $\frac{1}{2}$ of the increase in Arctic upper ocean temperatures from 2000 to 2018

*Li et al (2022, Nature Communications)*
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.

*DuVivier et al (2022, in prep)*
Research Highlights: **Aerosol Forcing Nonlinearities over the Sub-Arctic**

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/m² radiative forcing** difference due to variability in biomass burning aerosol emissions from 50N to 70N in JJAS.

Heyblom et al (2022, in prep)
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