Modeling the effects of climate change on Southern Ocean sea ice

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undergraduate poster showcase

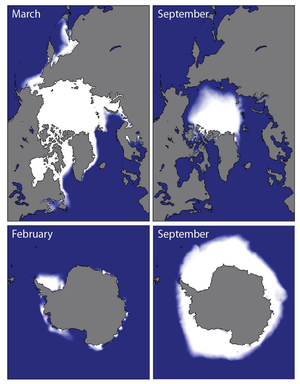
Abstract

Antarctic sea ice plays a major role in the global climate system. There is evidence of several major, ongoing changes in the Southern Ocean with the potential to impact sea ice: runoff, temperature, and wind. Using an idealized configuration, the effects of each of these factors are modeled, and a dataset of key oceanographic variables is generated. Results suggest that under pessimistic projections, a tipping point is likely to be reached.

Introduction

Sea ice background

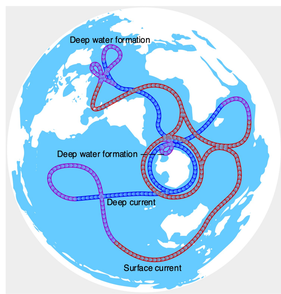
- Forms directly at ocean surface or from ice sheets
- Undergoes seasonal cycles
- Arctic vs. Antarctic
- Antarctic - simpler system to model



National Snow and Ice Data Center

The Southern Ocean interacts with global climate

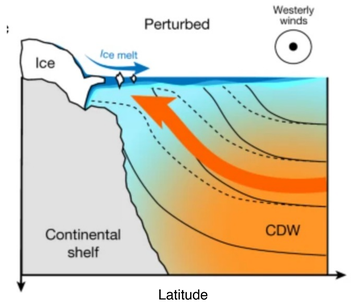
- Overturning circulation driven by sea ice
- Slight increase in sea ice extent (Turner and Overland, 2009)
- Ongoing changes expected to continue



International Hydrographic Organization

Likely factors affecting sea ice

- Antarctic Ice Sheet Runoff (Bronselaer et al., 2018)
- Temperature (CMIP6)
- Wind (Sigmond & Fyfe, 2010)



Bronselaer et al., 2018

Central Questions

How strong are the effects of each individual factor?

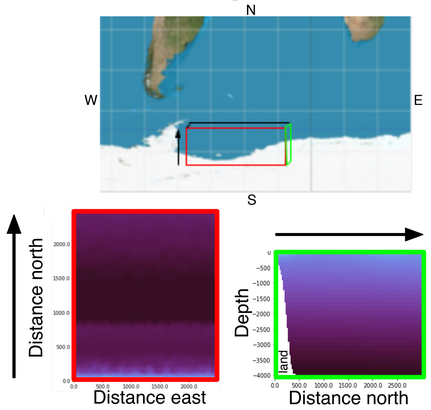
Which one dominates in the long run?

Are we approaching a tipping point?

Methods

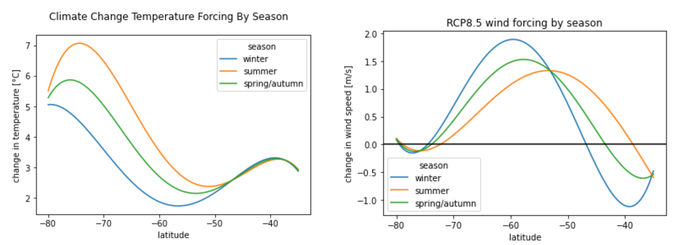
Idealized model configuration:

- Built around basic physical laws
- Simple, controlled environment
- Computationally inexpensive



Simulations varied different parameters

1. Increased runoff (Depoorter et al., 2013)
2. Increased temperature (CMIP6)
3. Increased wind (CMIP6)
4. Combination of all three

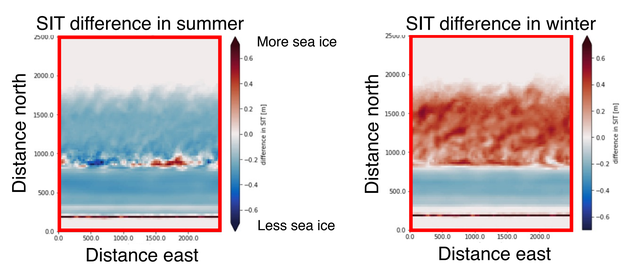


Results

Runoff 1

Stronger seasonal fluctuations in Sea Ice Thickness (SIT)

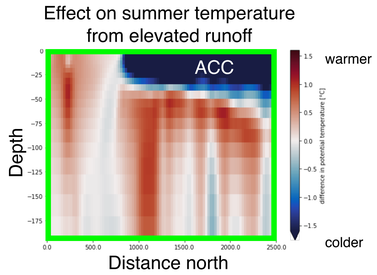
- Ice even thinner in summer and even thicker in winter



Runoff 2

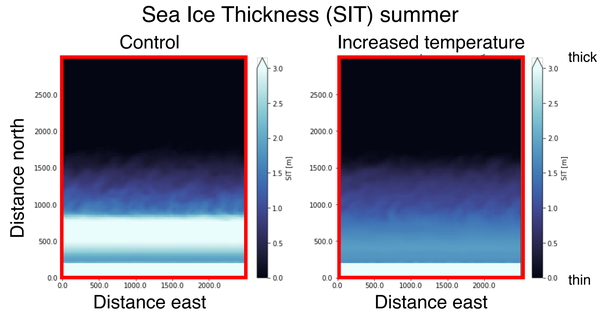
In Summer elevated runoff results in:

- Warming at depth
- Cooling of Antarctic Circumpolar Current (ACC) near surface
- Summer decreases in salinity, density

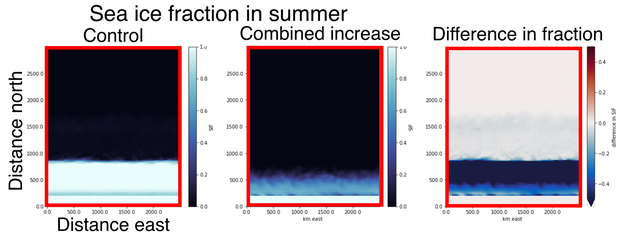


Temperature

Straightforward: Sea ice loss



Combination of Runoff, Temperature & Wind



- Decrease in sea ice fraction and thickness
- Potentially non-linear: feedbacks?

Next Steps

Investigate seasonality in runoff simulation

Investigate non-linear effects

Effect of distance from shore, depth

Analyze preliminary data on sea surface height, horizontal velocity, density

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