Arctic Responses to Polar Sea Ice Loss and CO_2 Forcing:

A preliminary analysis of coupled climate models

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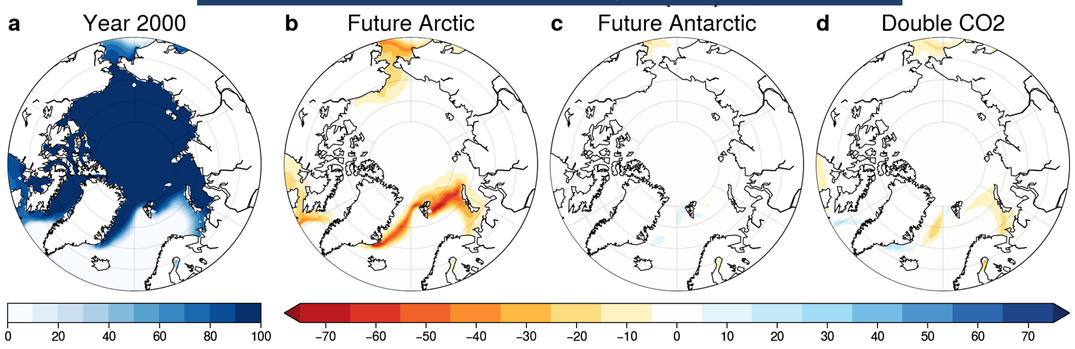
Applied Forcing

Simulations use the SC-WACCM4 framework, where the ocean and atmosphere are dynamically coupled. Three kinds of forcing are applied:

1) **Sea Ice Loss is imposed in the Arctic;** Antarctic Sea Ice, CO_2 content are held constant
2) **Sea Ice Loss is imposed in the Antarctic**; Arctic Sea Ice, CO_2 content are held constant
3) **Atmospheric CO_2 levels are doubled**; Polar Sea Ice is held constant

Sea Ice Concentration: *Control vs Responses (Arctic, Dec-Feb)*



Simulations in context

Sea Ice Loss

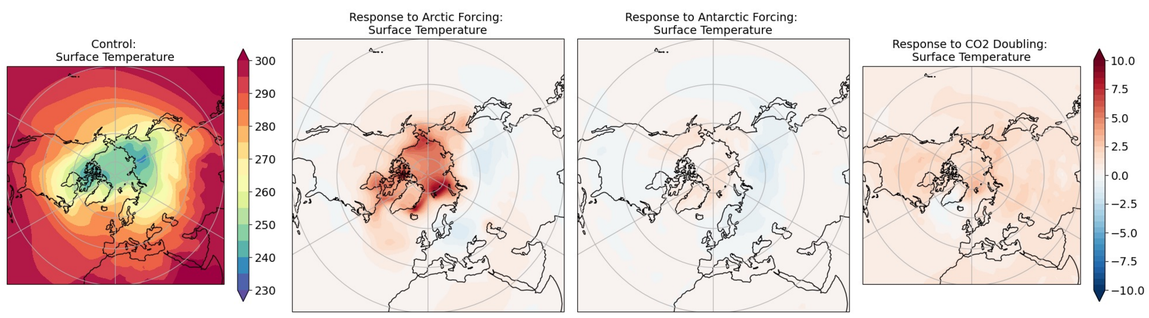
- Sea Ice Loss leads to polar warming, weakening the equator-to-pole temperature gradient, thereby reducing thermally-driven winds
- In these runs, sea ice is controlled with applied heat fluxes and nudging of sea ice concentration

Existing Work

- Research shows that including a dynamic ocean facilitates a more hemi-spherically symmetric warming response
- Emerging evidence suggests that Antarctic Sea Ice Loss can induce a warming signal in the Arctic, and made possible by ocean and atmospheric heat transport

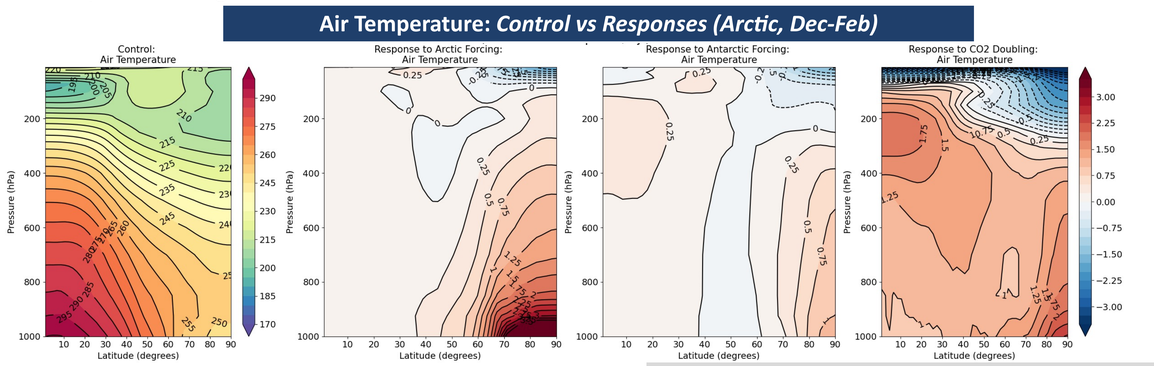
Temperature Response

Surface Temperature: *Control vs Responses (Arctic, Dec-Feb)*



Above: With ice loss, local Surface Temperature increases drastically while Eurasian cooling is evident.
Below: Polar Amplification signals are observed even when Arctic sea ice is held constant. Doubled CO_2 induces stratospheric cooling.

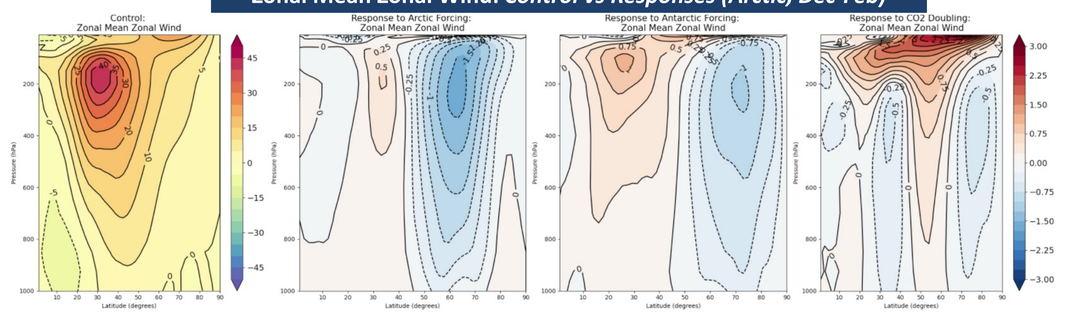
Air Temperature: *Control vs Responses (Arctic, Dec-Feb)*



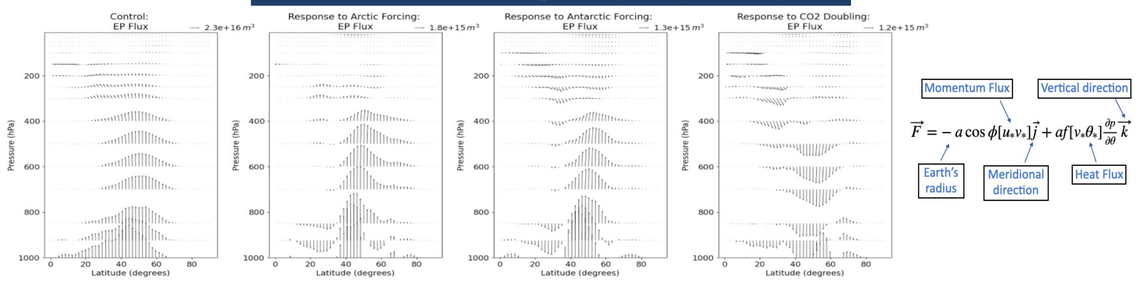
Note that all plots shown are of the Northern Hemisphere in Boreal winter (Dec-Feb)

Rossby Wave Activity

Zonal Mean Zonal Wind: *Control vs Responses (Arctic, Dec-Feb)*

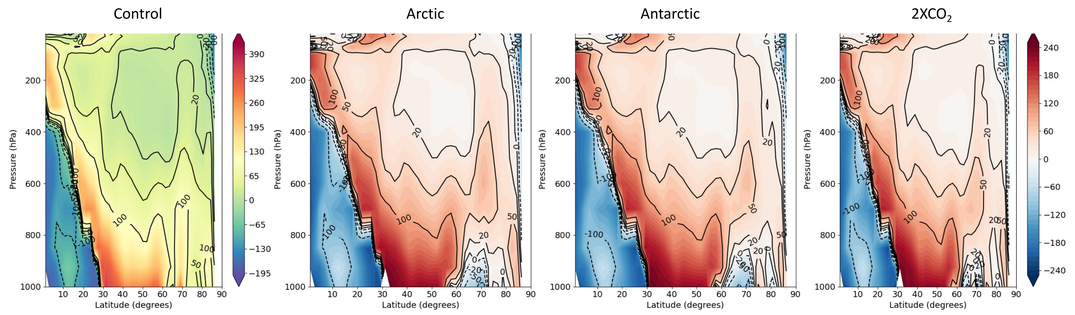


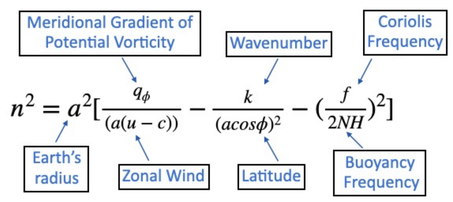
EP Flux: *Control vs Responses (Arctic, Dec-Feb)*



- **Rossby Waves move upward and equatorward.**
- EP Fluxes measure the effect of eddies on zonal wind, from heat and momentum fluxes. They are parallel to the local group velocity for Rossby waves, so they can be used as a basis for Rossby Ray Tracing.

Refractive Index: *Experiments (Arctic, Dec-Feb)*





- Wave activity tends towards regions or large, positive n^2 and away from negative n^2
- Negative n values could indicate easterly winds, as is the case near the equator, but there are many factors that determine the sign of the refractive index (see left.)

Key points and references

Key Points

- Changes in the Antarctic can have significant effects on the Arctic
- Sea Ice Loss and CO_2 increases may produce competing effects
- Rossby Waves propagate upward and equatorward

References

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