A barotropic mechanism for the response of jet stream variability to Arctic Amplification and sea ice loss

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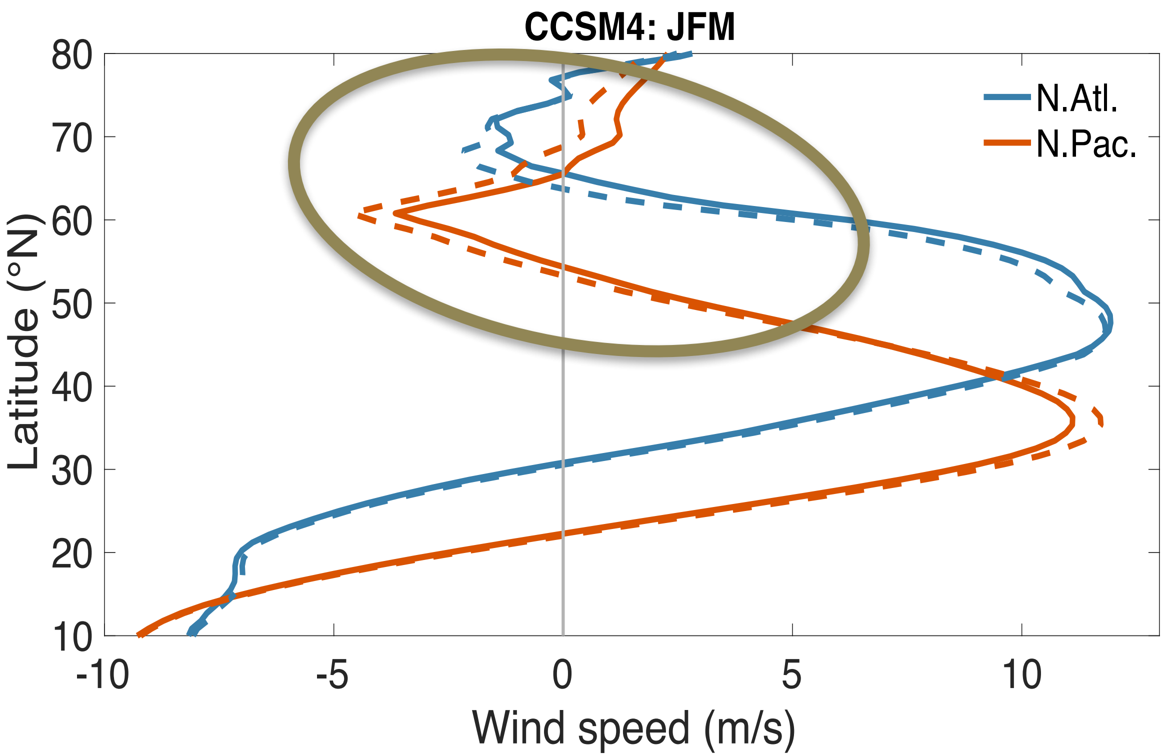
ATS681 – Term Project

Research Questions

1. How does the mean state and internal variability of the midlatitude jet respond to Arctic Amplification and sea ice loss?
2. How does this response depend on initial jet position?

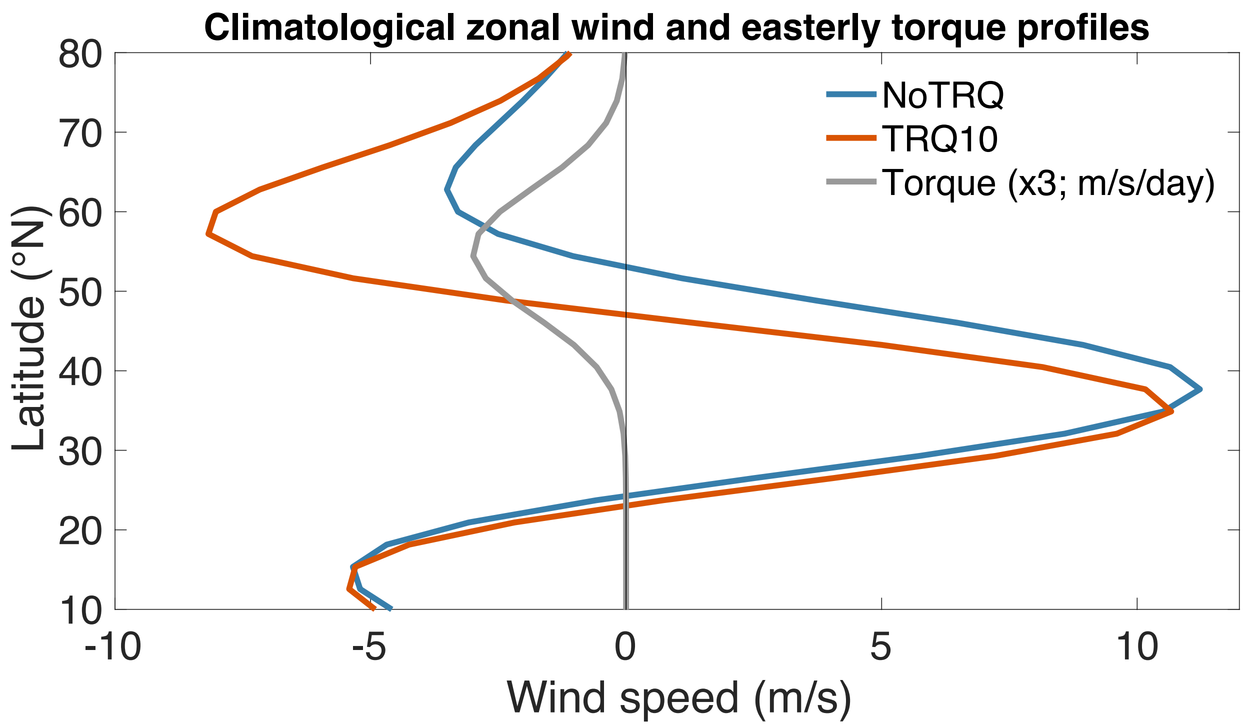
Mean state response

- Deser et al. (2015) ran sea ice loss simulation using the CCSM4.[1]
- We analyzed the zonal mean zonal wind results in the two northern ocean basins:



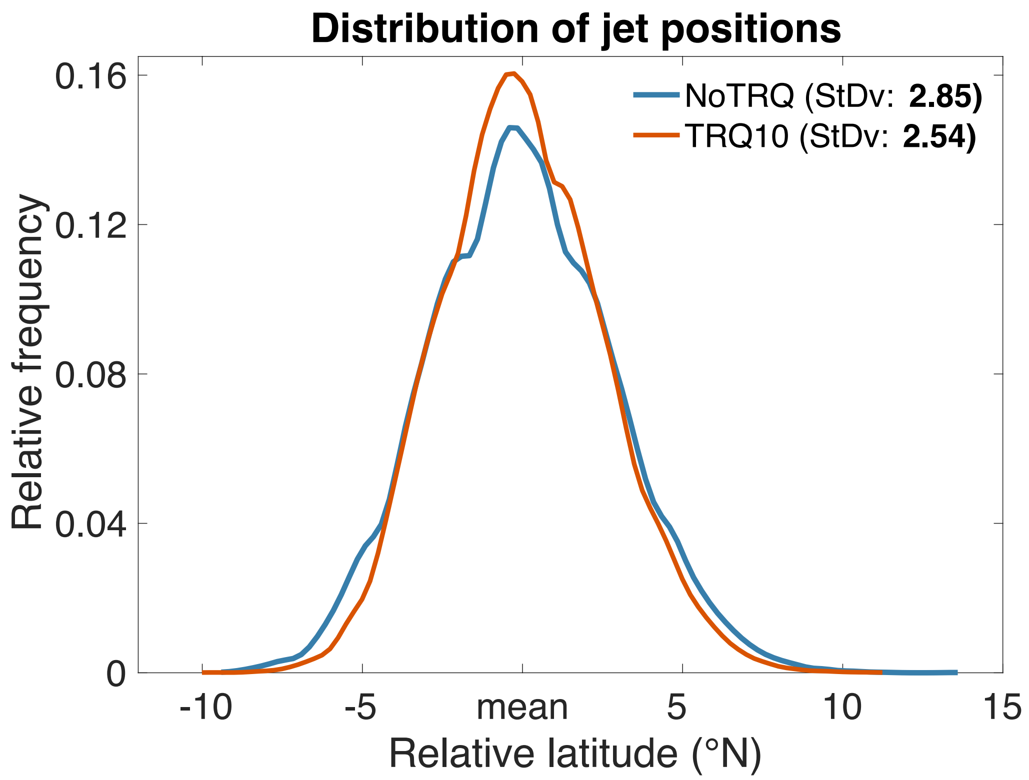
Mean state response

- Anomalous easterlies along the poleward flank of the jet were observed in all seasons.
- Therefore, we applied an easterly torque[2] poleward of the stirring latitude[3,4] in the barotropic model to simulate this response:



Jet positional variability response

- Define jet positional variability as the standard deviation of daily jet position (latitude of maximum winds)



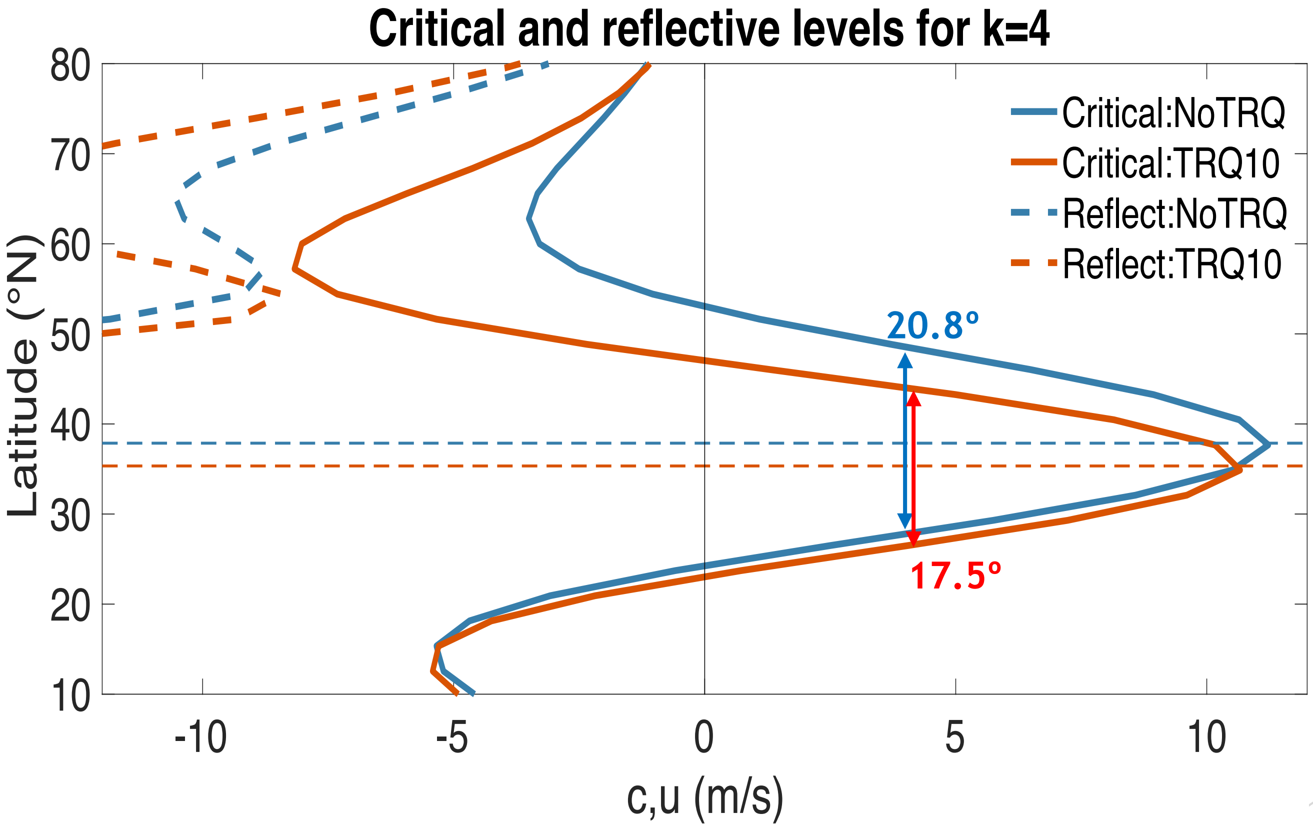
-> The jet positional variability decreases significantly.

Jet positional variability - Rossby waves

- Why does the jet positional variability decrease?
- Hypothesis: Rossby wave breaking:
  - The zonal winds determine where waves propagating out of the jet core break or turn (wave propagation width) -> impacts the jet position and speed.
  - The anomalous easterlies on the poleward flank of the jet leads to asymmetrical narrowing of the jet profile, which limits Rossby wave propagation.

Jet positional variability - Rossby waves

- Rossby waves propagate out from the jet core, both poleward and equatorward.
- The distance they travel depends on their size (wavenumber, k) and speed (phase speed, c).

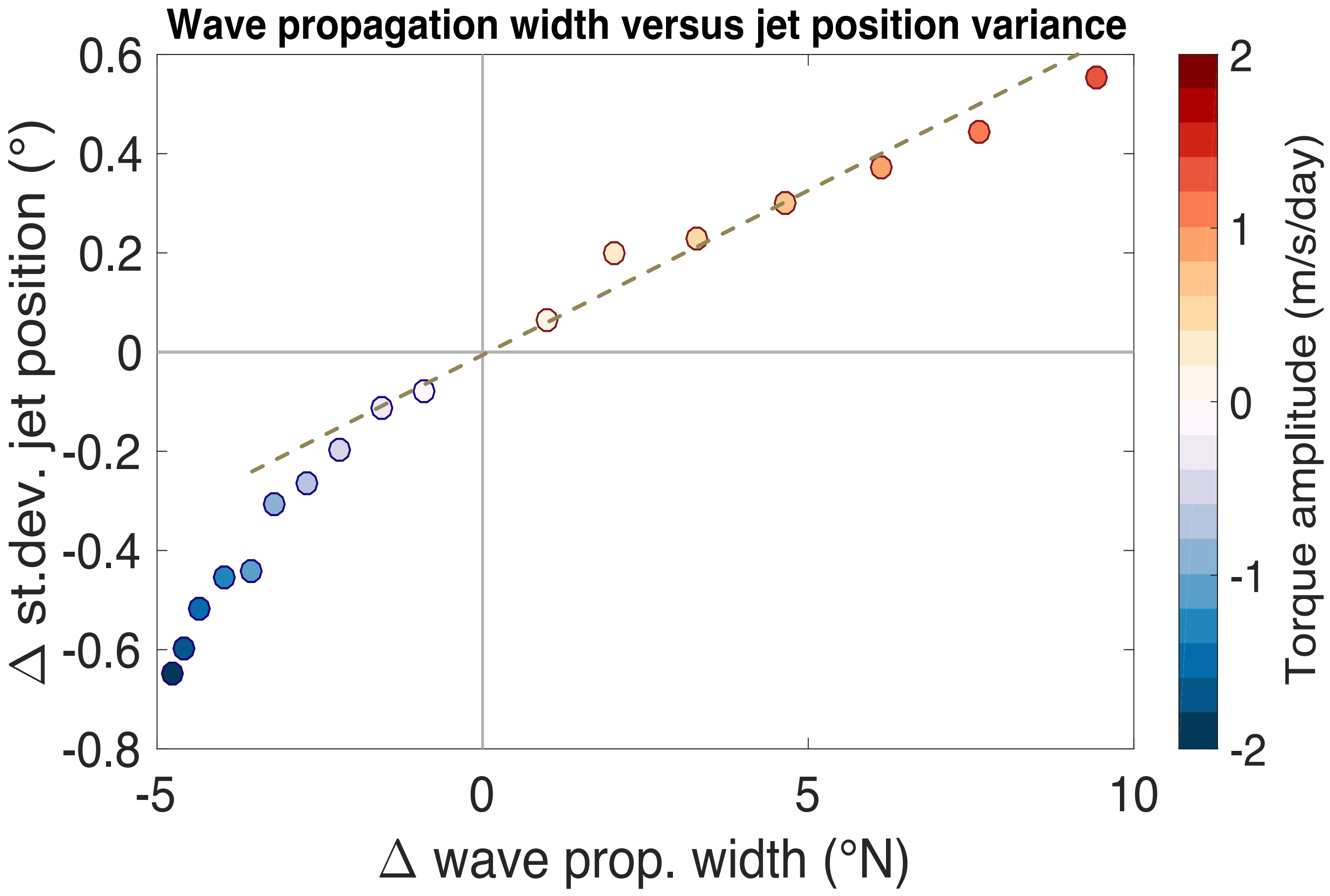


Rossby wave propagation

- Hypothesis:

  Arctic Amplification -> easterlies on poleward flank -> asymmetrical narrowing of the jet -> limits wave propagation -> decreased jet positional variability.

Variance vs Wave Propagation Width



Wavenumber k=4
Phase speed c=4 m/s

Conclusions

- The variance in jet position is reduced in the forced barotropic model runs.

- Rossby wave theory indicates wavebreaking is occurring closer to the jet core on the poleward flank: this is a possible mechanism for the decreased latitude range of the jet in the forced model runs.

- Our results and conclusions here are also supported by two supplemental models of greater complexity:

i. Dry dynamical core GCM[5]

ii. Fully-coupled GCM (CCSM4)[1]

References

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Acknowledgments

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Dependence on latitude