Relating winter NAO skill to jet variability across timescales

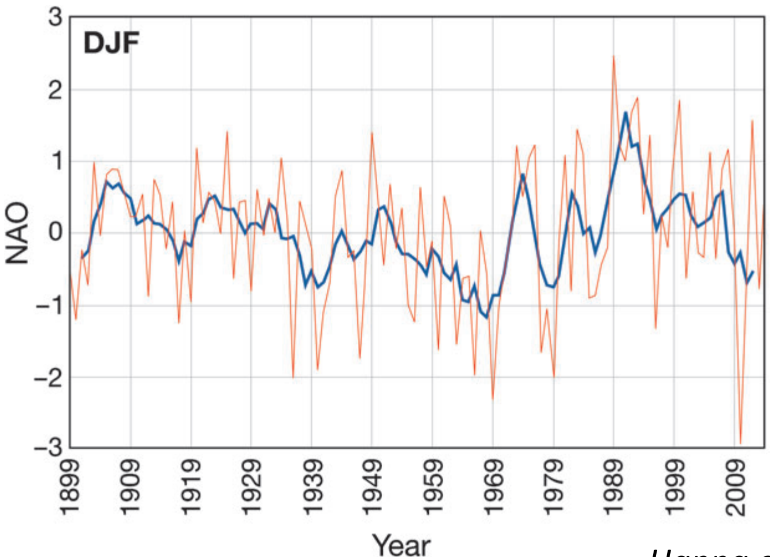
Tim Woollings

Dept. of Physics, University of Oxford

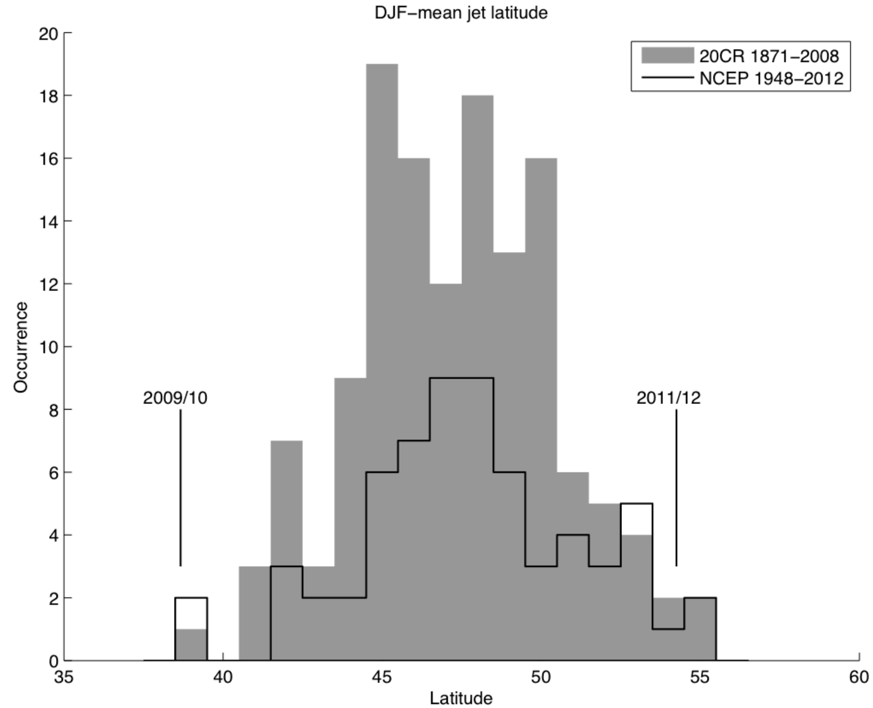
Tess Parker, Antje Weisheimer, Laura Baker, Len Shaffrey, Chris O'Reilly, Elizabeth Barnes, Brian Hoskins, Young-Oh Kwon, Robert Lee, Camille Li, Erica Madonna, Marie McGraw, Regina Rodrigues, Clemens Spensberger, Keith Williams, Hugh Baker and Cheikh Mbengue

Motivation

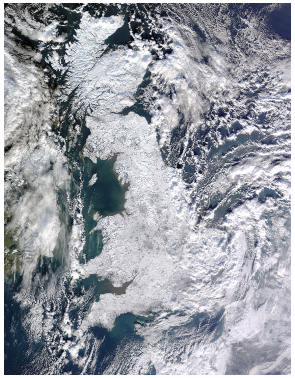
- Several recent extremes due to jet variability
- Is variability increasing?



Hanna et al (2014)

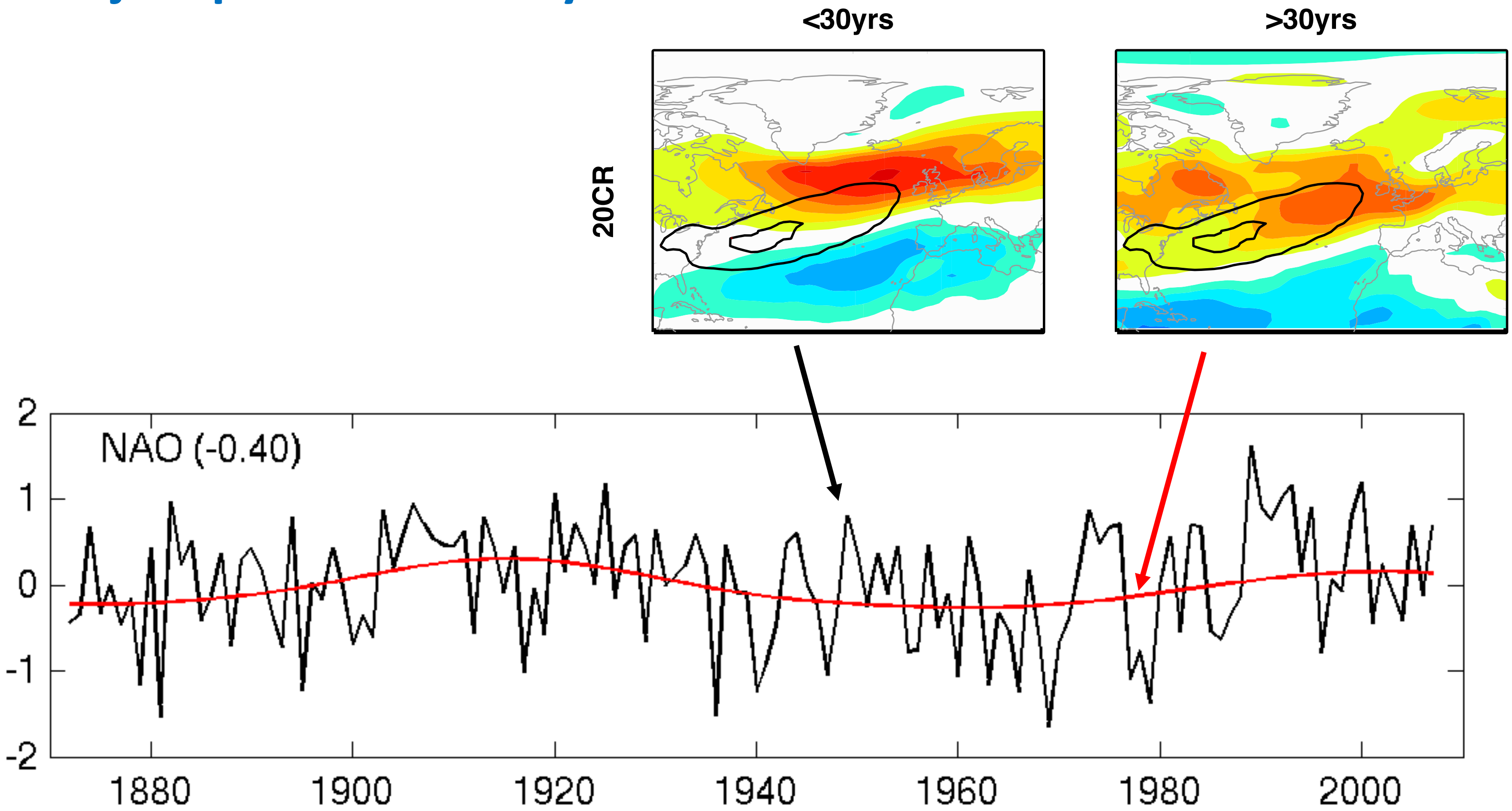


Mitchell et al (2017, CD)



Decadal jet speed variability

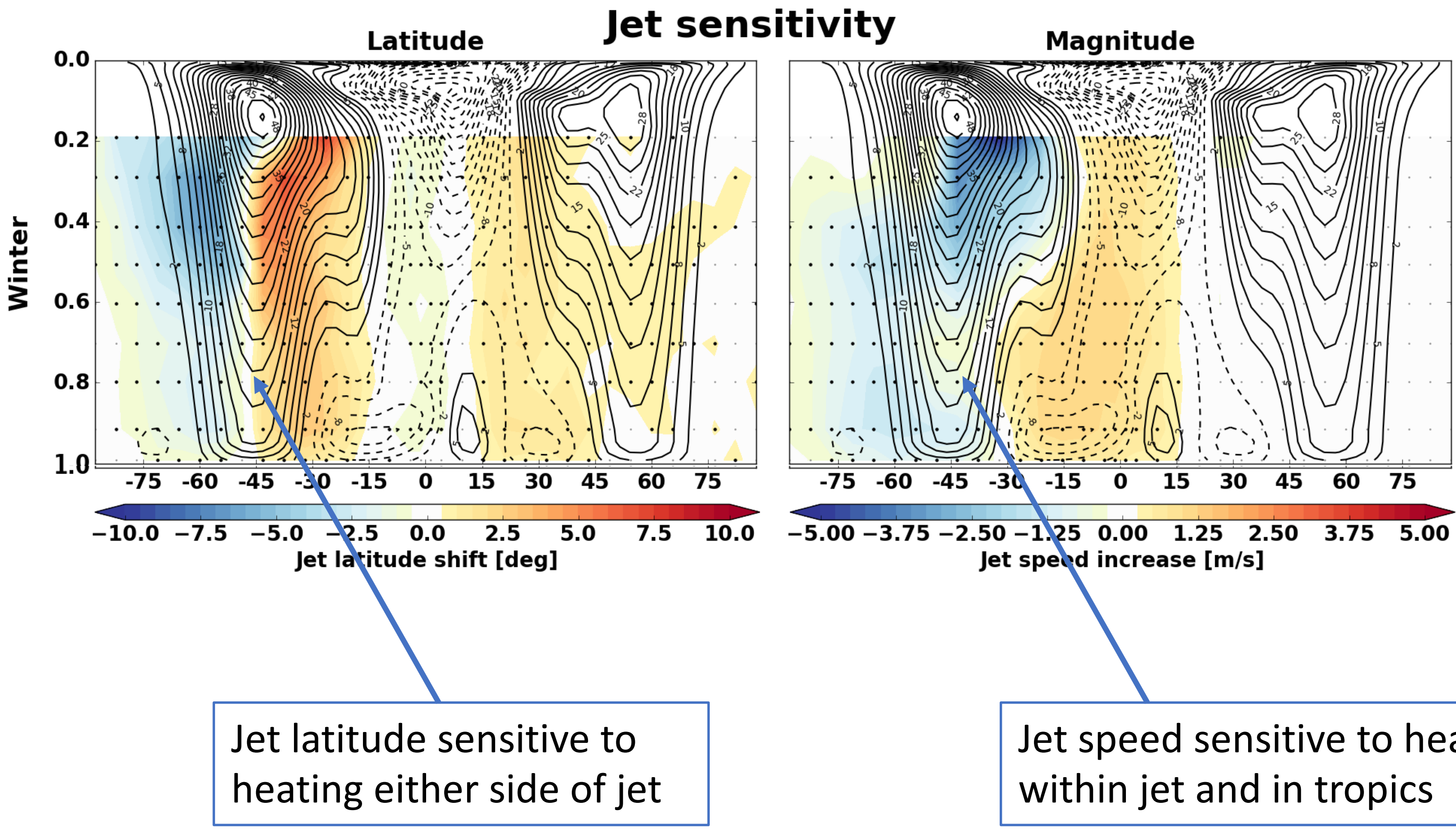
U850 regressed on NAO



Woollings et al (2015, CD)

- Decadal NAO is mostly variations in jet speed
- Interannual NAO is mostly variations in jet latitude
- **Suggests distinct mechanism (and predictability?) on decadal timescale**

Jet latitude and speed have different sensitivities



Based on idealized dry dynamical core simulations; Baker et al (2017, JClim)

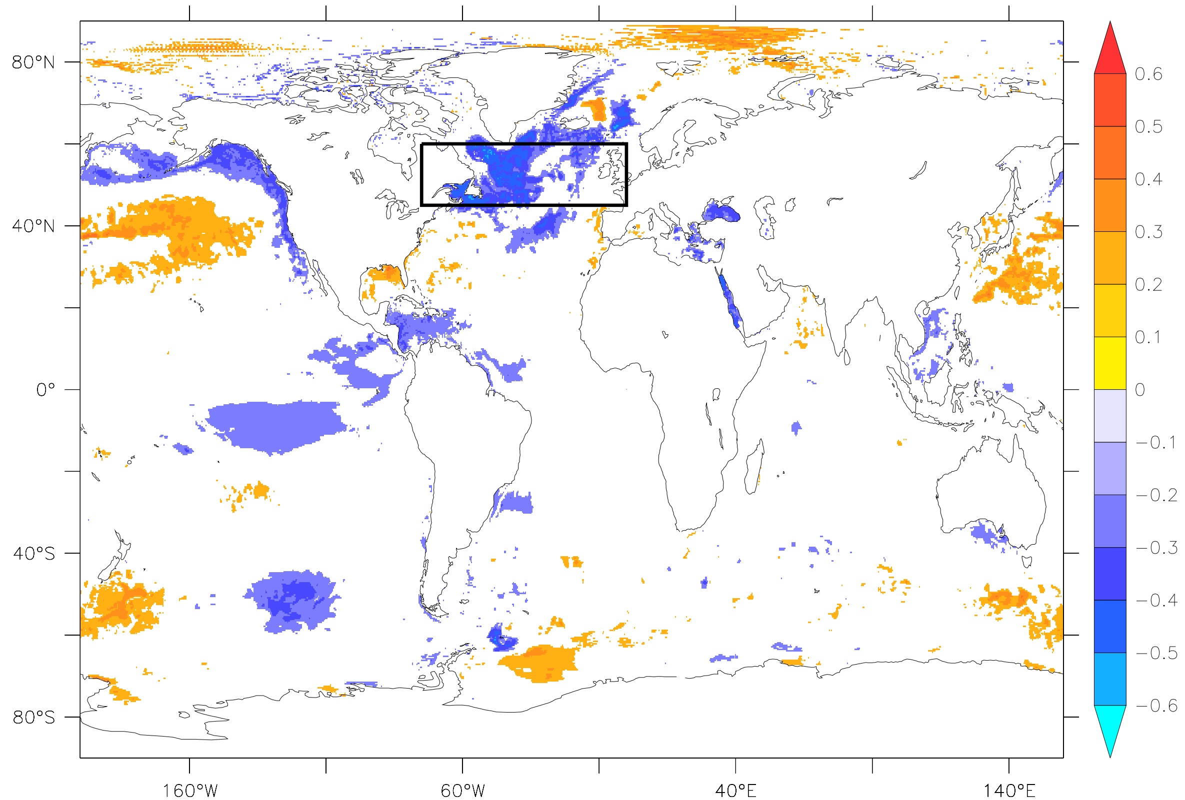
Ocean influence on decadal timescale?

Ocean-atmosphere coupling in the model:

Decrease in ocean heat flux convergence

-> Colder subpolar gyre

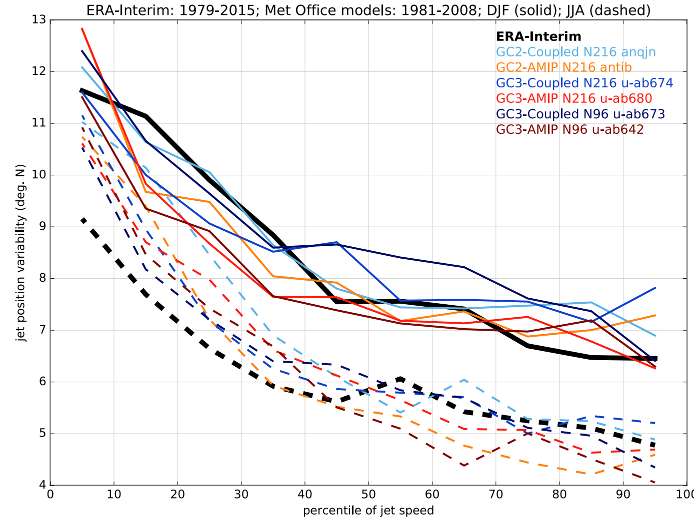
-> Stronger atmospheric jet



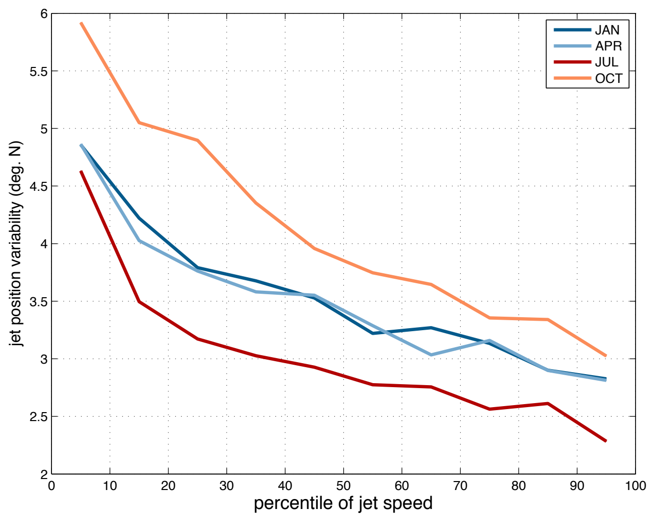
Woollings et al (2015, CD)

Linking timescales: Weaker jets are more variable

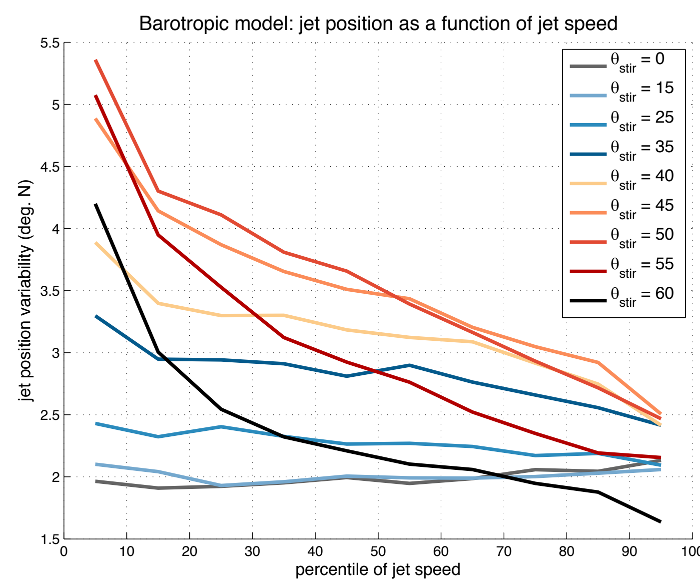
ERA-I and HadGEM3



Dry dynamical core



Barotropic vorticity model on sphere

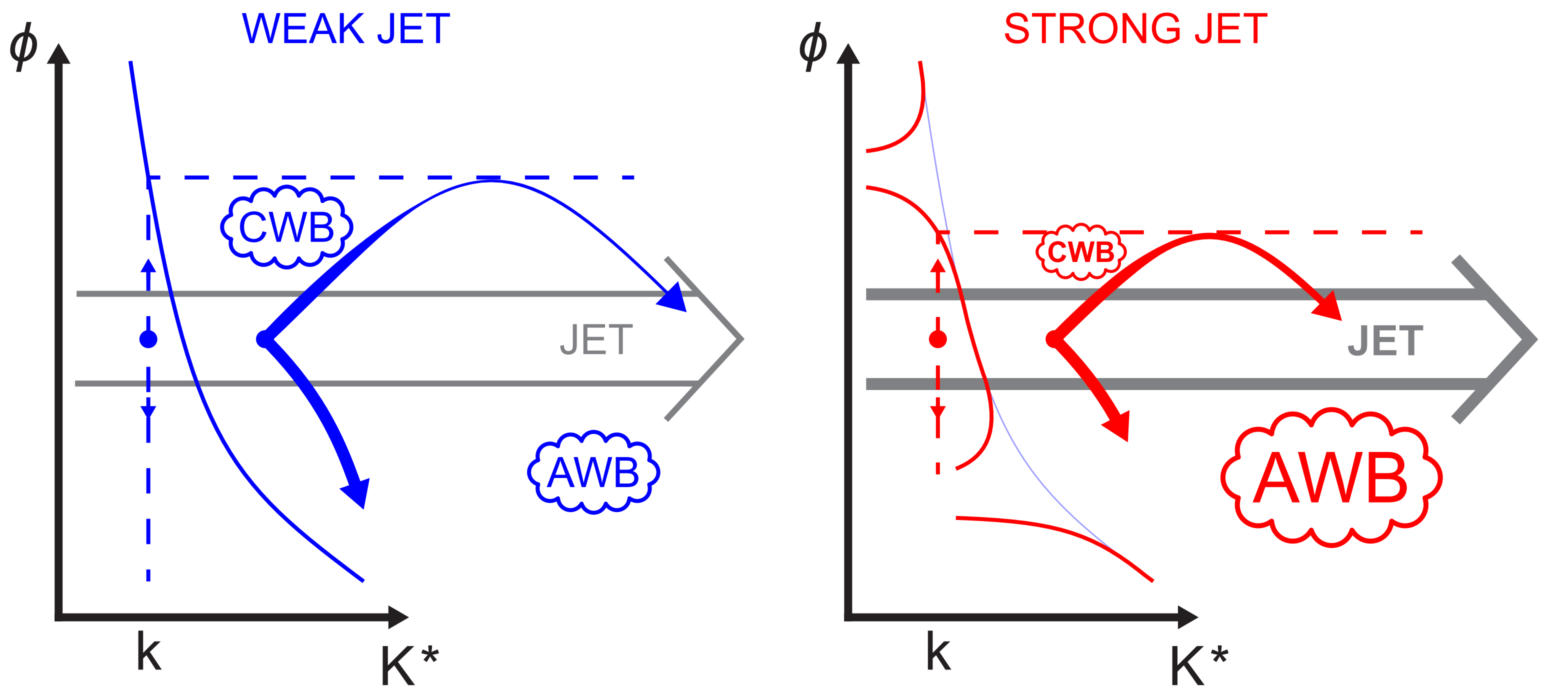


Woollings et al (2018, JClim).

Mechanism

Jet speed affects vorticity gradient and hence wave propagation

$$K^* = \cos\phi \left(\frac{\beta^*}{[u]-c}\right)^{1/2}$$

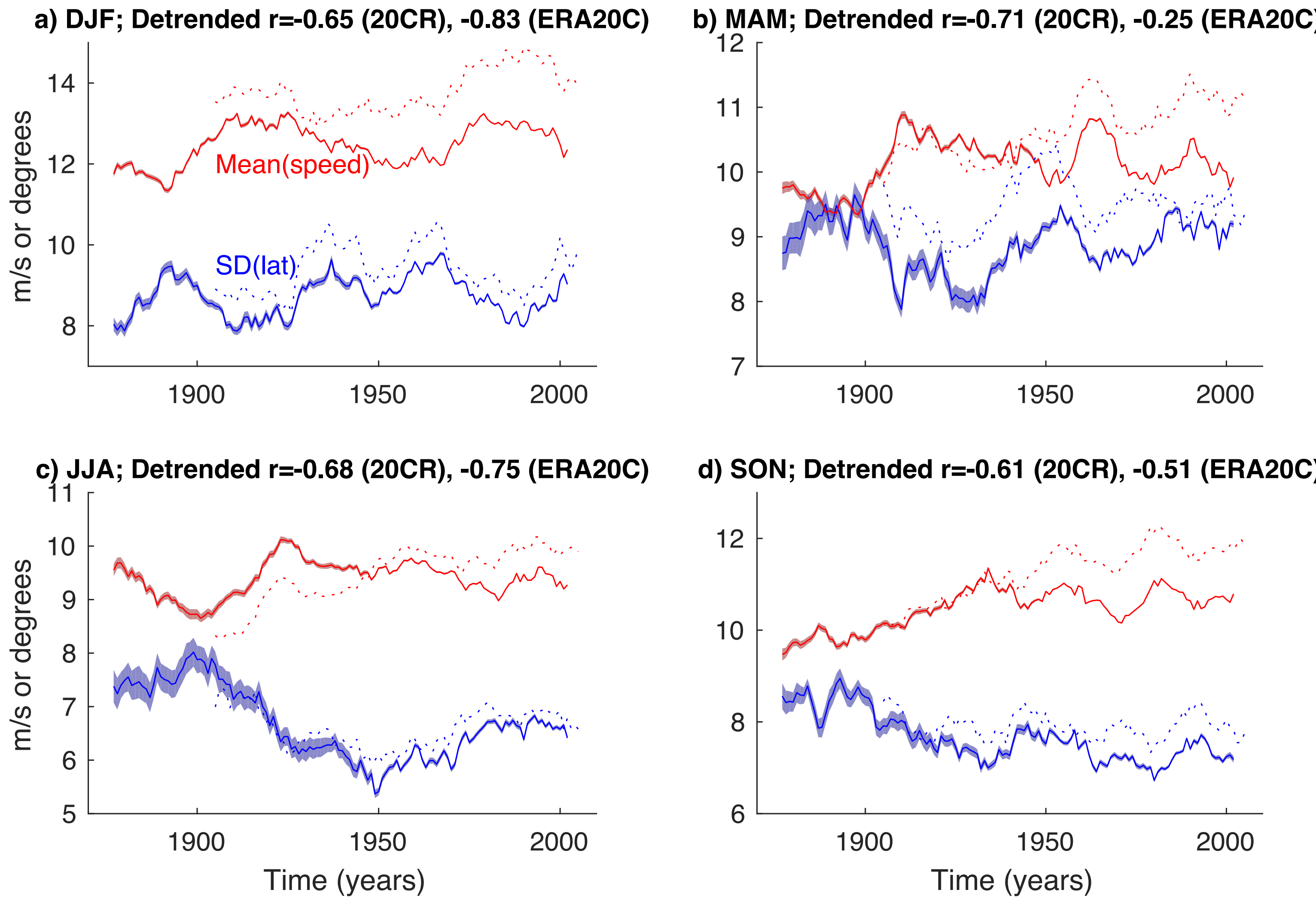


- Poleward turning latitude remote from jet
- Lots of cyclonic wave breaking
- Very variable jet latitude

- Poleward turning latitude close to jet
- Little cyclonic wave breaking
- Waves turned instead
- Increased anticyclonic wave breaking
- Less variable jet latitude

Woollings et al (2018, JClim).

Slow decadal variability modulates the faster timescales

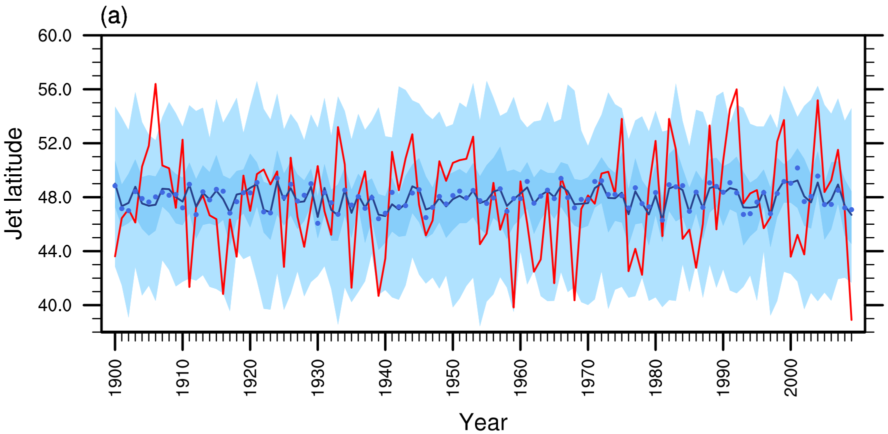


U850 jet indices from 20CR (solid) and ERA-20C (dashed). *Woollings et al (2018, JClim).*

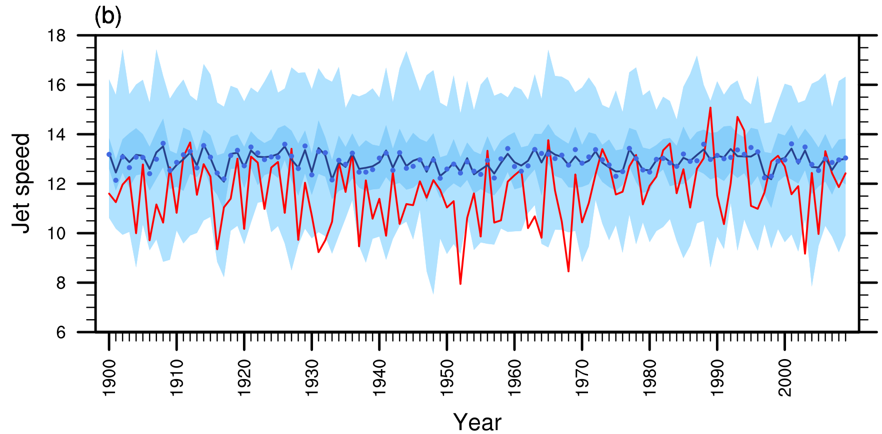
20th Century Atmospheric Seasonal Hindcast

ECMWF model, atmosphere-only, forced with observed SST and sea ice.

Jet latitude; r = 0.25

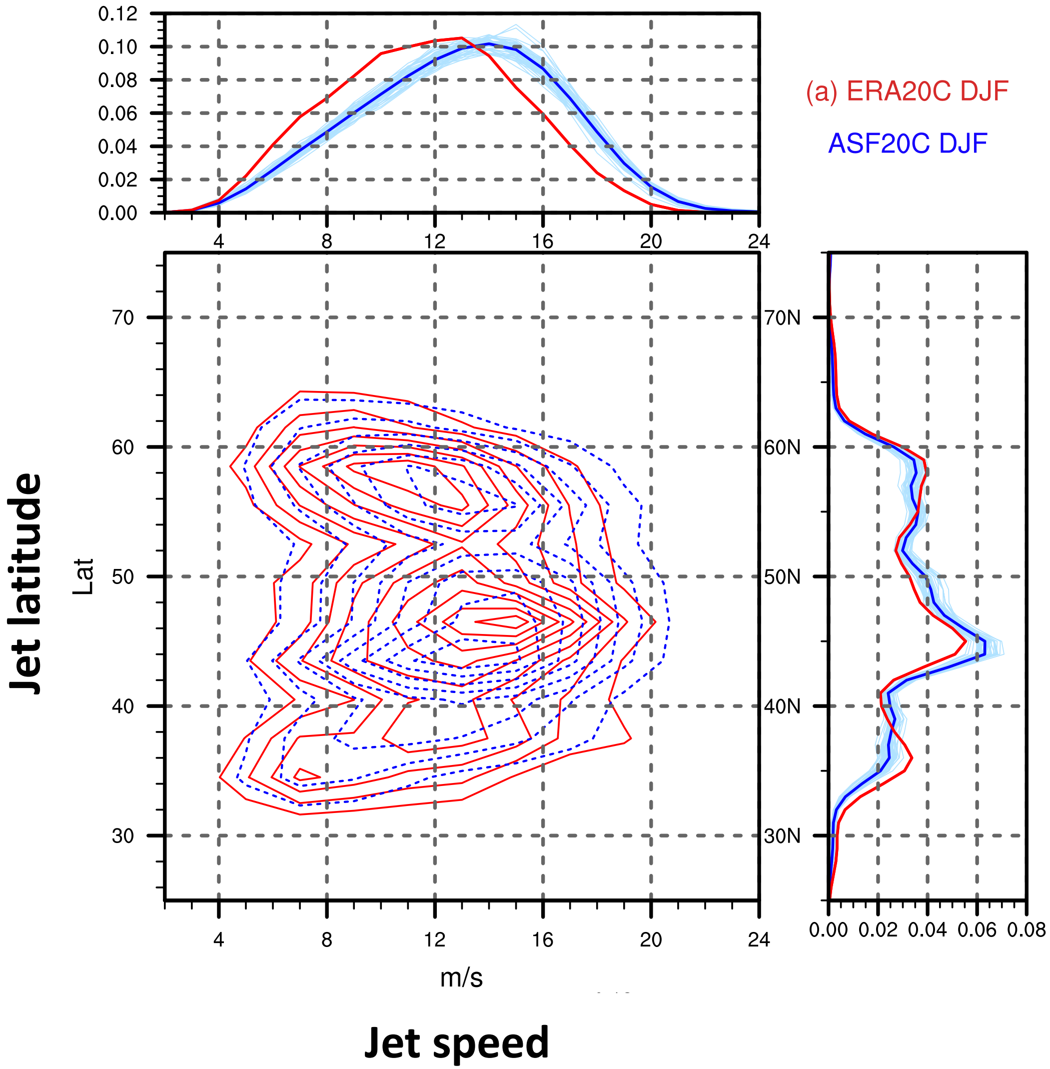


Jet speed; r = 0.21



- Skill in jet latitude and speed both very small but significant
- Both contribute to skill in NAO
- Dominant source of skill is **interannual jet latitude**

20th Century Atmospheric Seasonal Hindcast



- Model jet is too strong
- Also not enough variability in jet position
- This is consistent with the general relationship between mean jet speed and variability of jet latitude

WORK IN PROGRESS

Conclusions

- Interannual winter NAO is mostly affected by jet latitude
- Decadal winter NAO is more related to jet speed – suggests potentially distinct source of skill for S2D timescales
- NAO skill in the Atmospheric Seasonal Hindcast largely comes from interannual jet latitude
- Decadal variations in the jet speed modulate the amount of interannual shifting
- In weak-jet decades we might expect more variability on S2S timescales
- Mean biases in jet speed can affect the strength of model's shifting variability