ENSO modulation of MJO teleconnection to the North Atlantic & Europe and implications for subseasonal predictability

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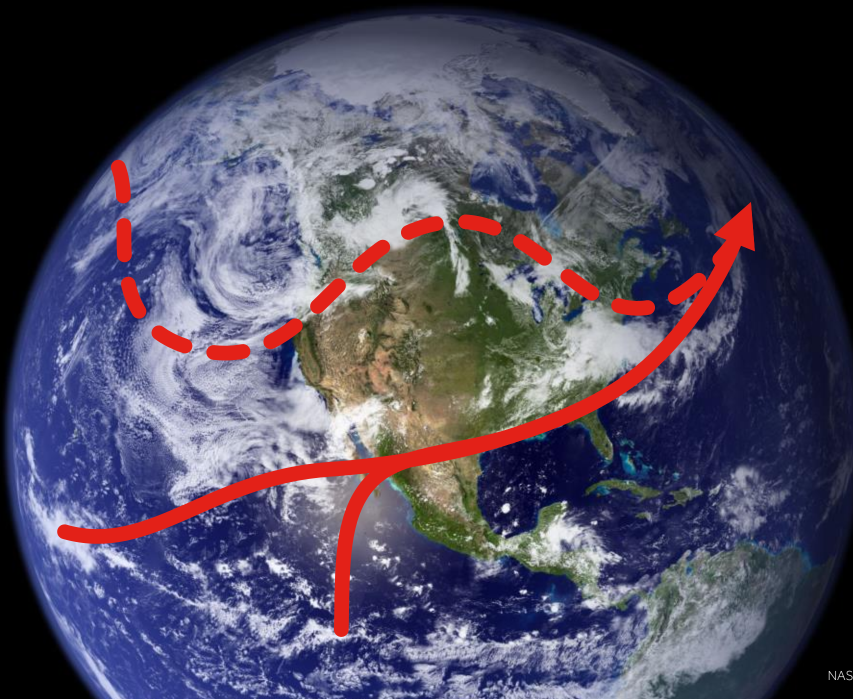

NASA Goddard Space Flight Center Image using MODIS

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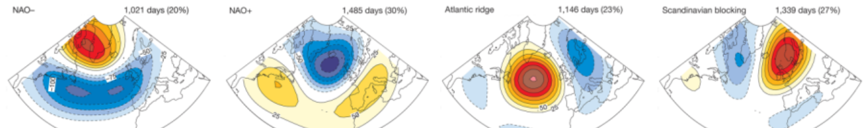
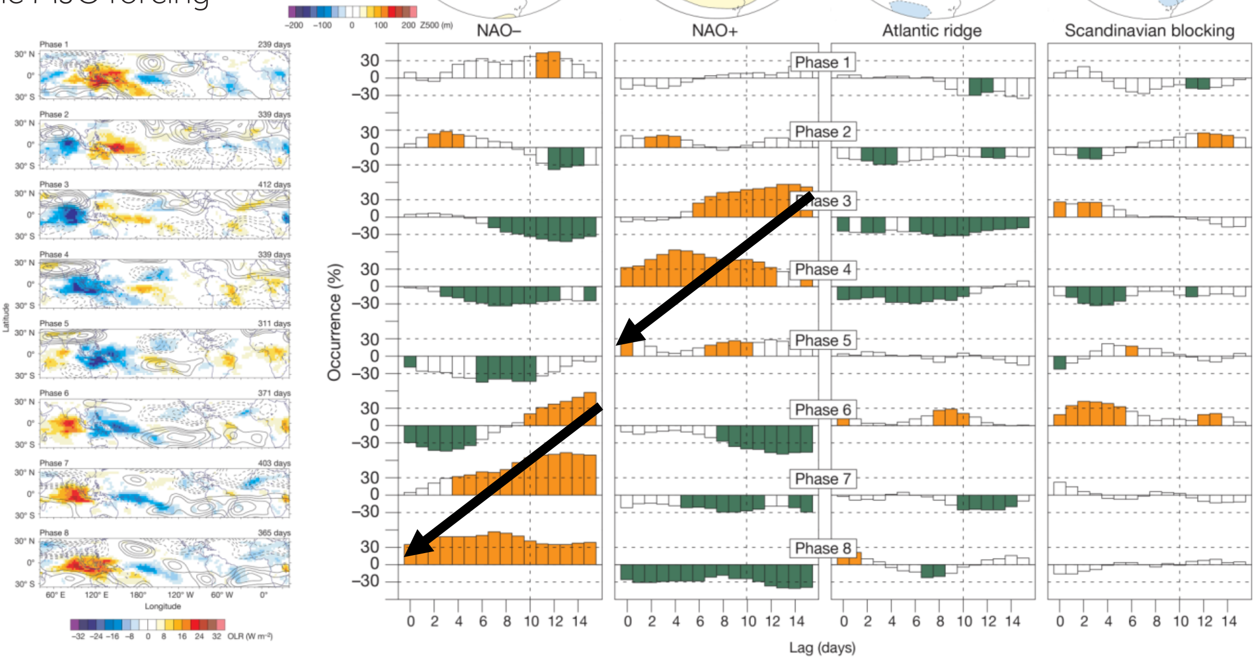
Introduction – MJO teleconnections to N. Atlantic

- **Cassou, (2008):** anomalous percentage occurrence of a given regime as a function of lag in days (with regimes lagging MJO phases).

"The presence of a slope as a function of lag is suggestive of the MJO forcing"





Statistical tests: χ^2 statistics at the 99% significance level, and 95% using a Gaussian distribution

Introduction – seasonal teleconnections to NAE

- Via the stratosphere in late winter:
  - El Niño associated with NAO−
  - La Niña associated with NAO+
  - However opposite during strong El Nino: associated with NAO+
    (Toniazzo and Scaife 2006, *G.R.L.*)
- SSW associations:
  - SSW events appear independent source of variability to ENSO for NAE region
    (Polvani et al. 2017, *J.Cli.*)
  - El Niño leads to NAO− only in winters when SSW events occur
    (Butler et al. 2014, *E.R.L.*; Richter et al. 2015, *E.R.L.*; Domeisen et al. 2015, *J.Cli.*; Butler et al. 2016, *Q.J.R.M.S.*)
- Via the troposphere :
  - El Niño conditions associated with NAO−
  - La Niña conditions associated with NAO+
  - Stratosphere strongly modulates - the stratosphere and troposphere working in tandem
    (Jiménez-Esteve and Domeisen, 2018, *J. Cli.*)

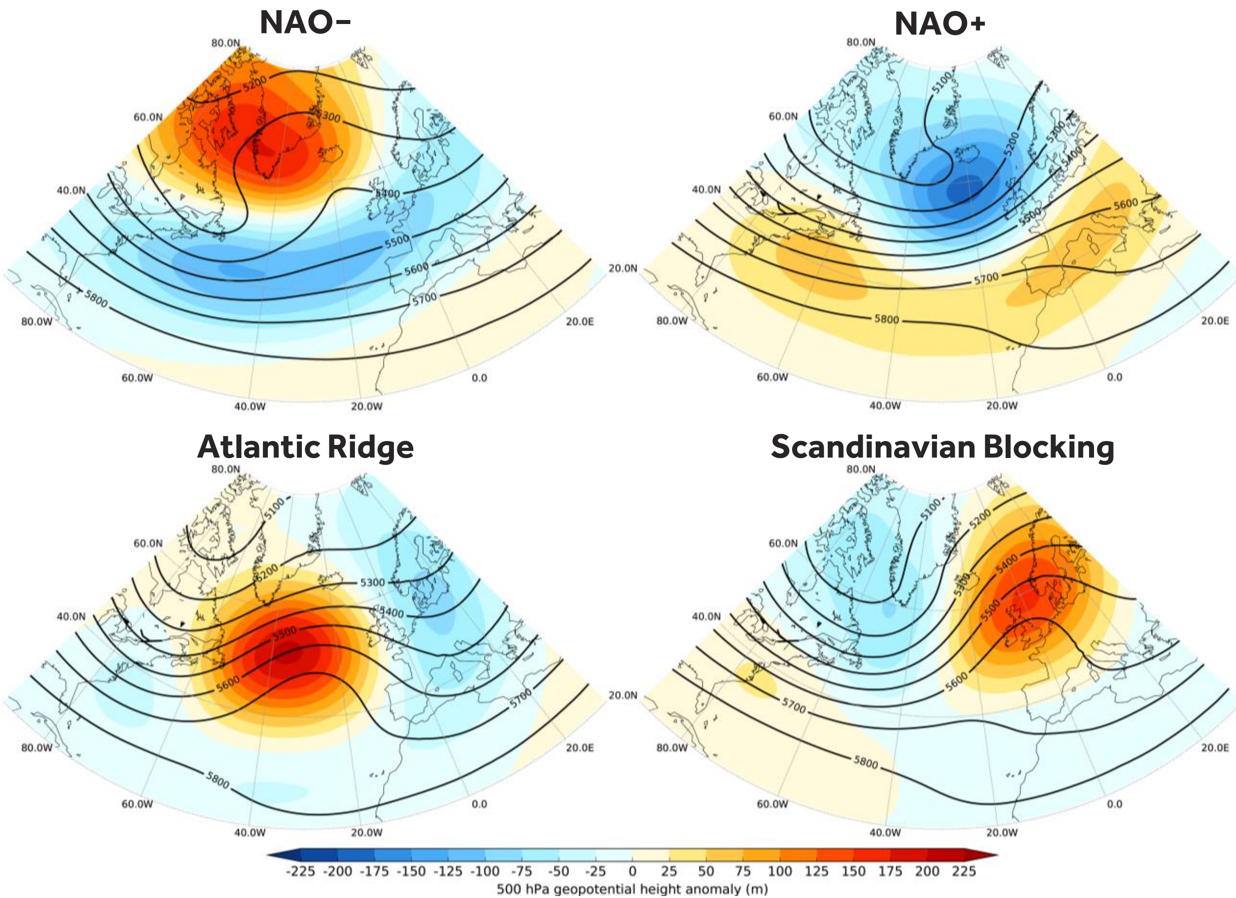
Comparison of methods

Cassou, 2008	Present study
NCEP/NCAR reanalysis	ERA-Interim reanalysis
1974-2007 (33 years)	1979-2018 (39 years)
RMM index from BoM for when amplitude > 1	RMM index from BoM for when amplitude > 1, also for MJO 'phase 0' (amplitude < 1)

NDJFM extended boreal winter season

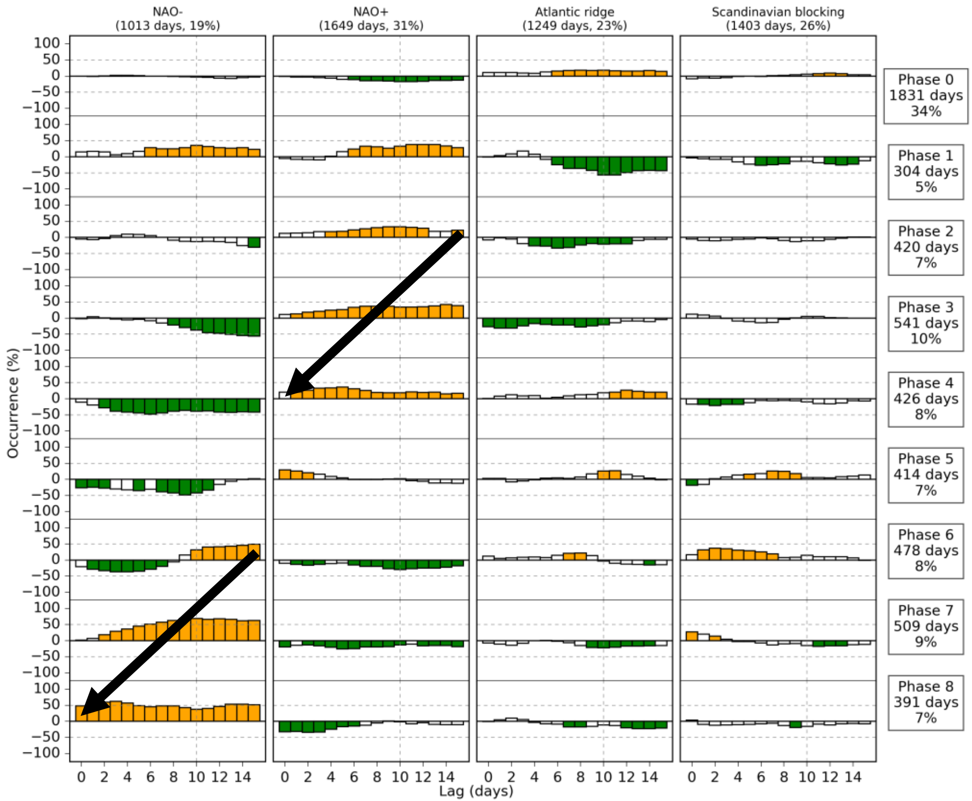
k-mean clustering algorithm (4 clusters) from 14 EOFs of anomalous daily geopotential height at 500hPa

The NAE weather regimes



MJO – NAE teleconnections during all 39 years

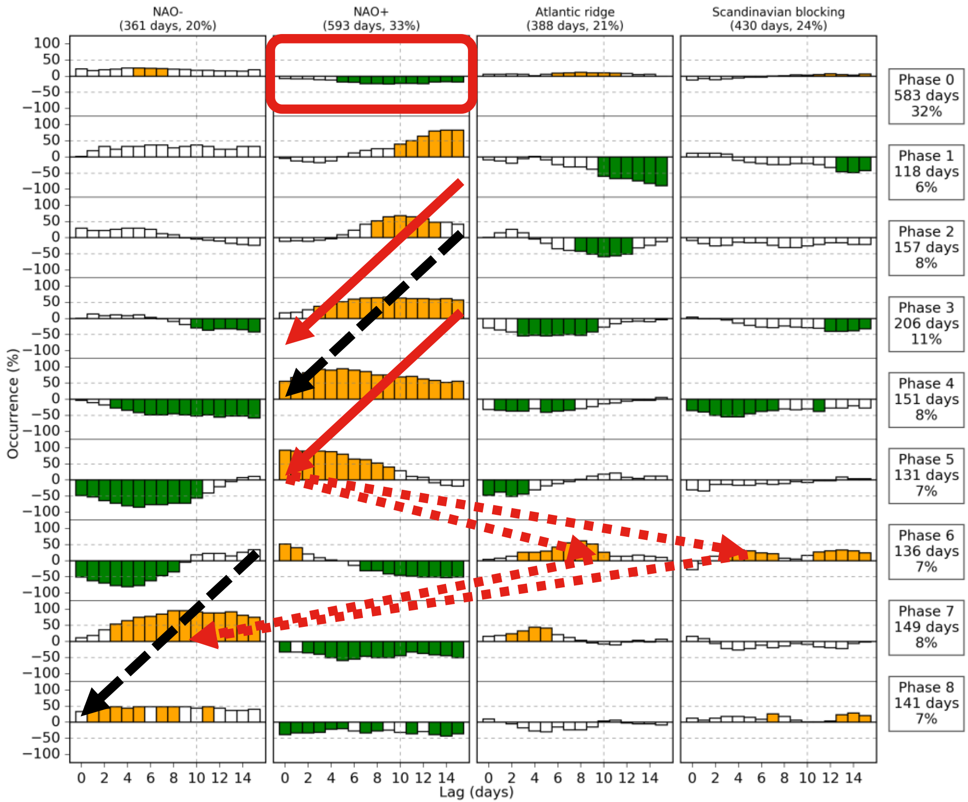
With the new dataset and analysis applied the main teleconnections are still seen, with more years included there are also more days which are statistically significant:



MJO – NAE teleconnections during El Niño

Using ENSO3.4 DJF mean temperature anomaly to split 39 years into 3 terciles (each compositing 13 years):

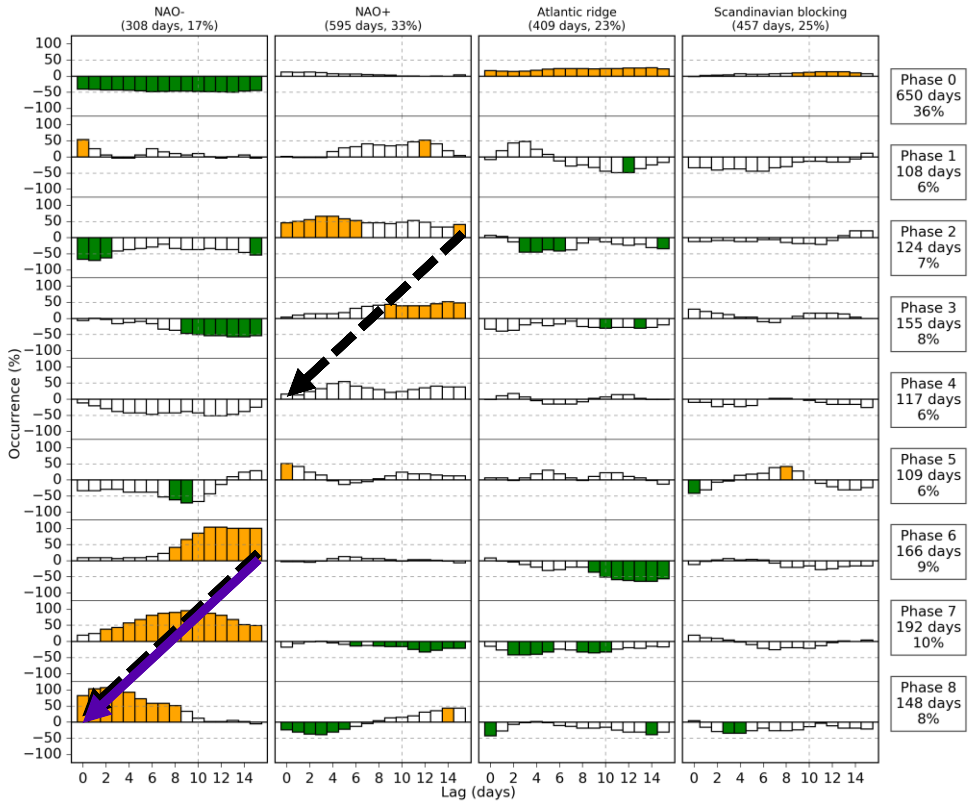
- Phase 0 shows reduced NAO+, despite higher climatology
- Due to MJO phase 1-4 to NAO+ teleconnection: extended; increased amplitude
- *In situ* development
- No clear NAO– teleconnection



MJO – NAE teleconnections during ENSO Neutral

Using ENSO3.4 DJF mean temperature anomaly to split 39 years into 3 terciles (each compositing 13 years):

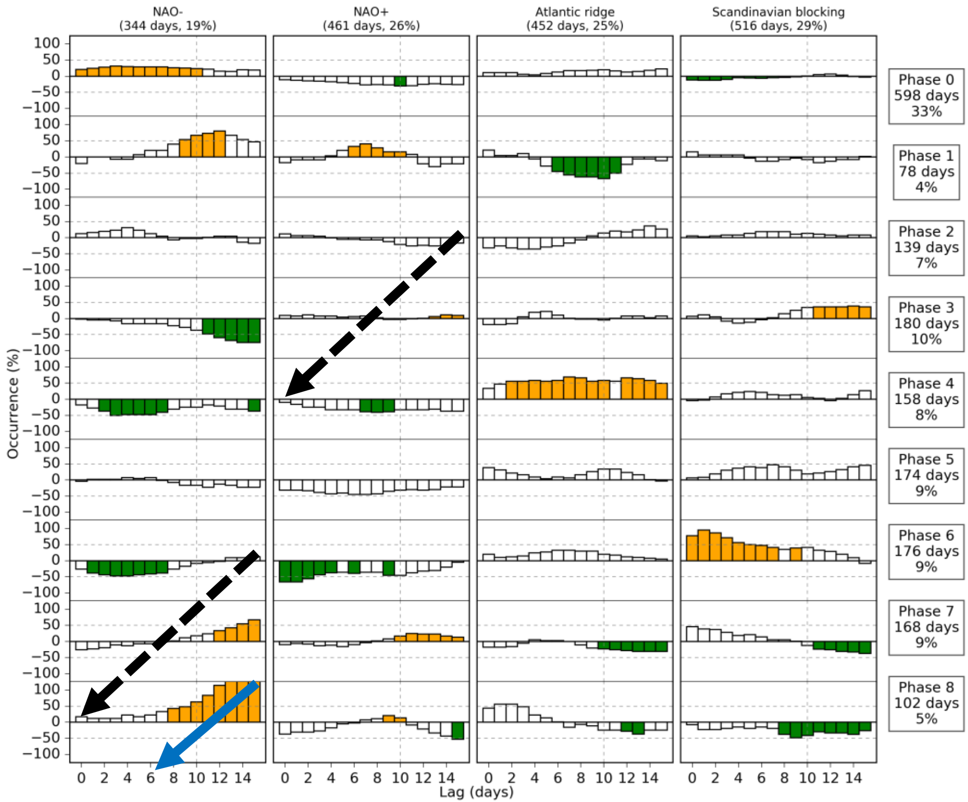
- No apparent NAO+ teleconnection
- NAO− teleconnection very active



MJO – NAE teleconnections during La Niña

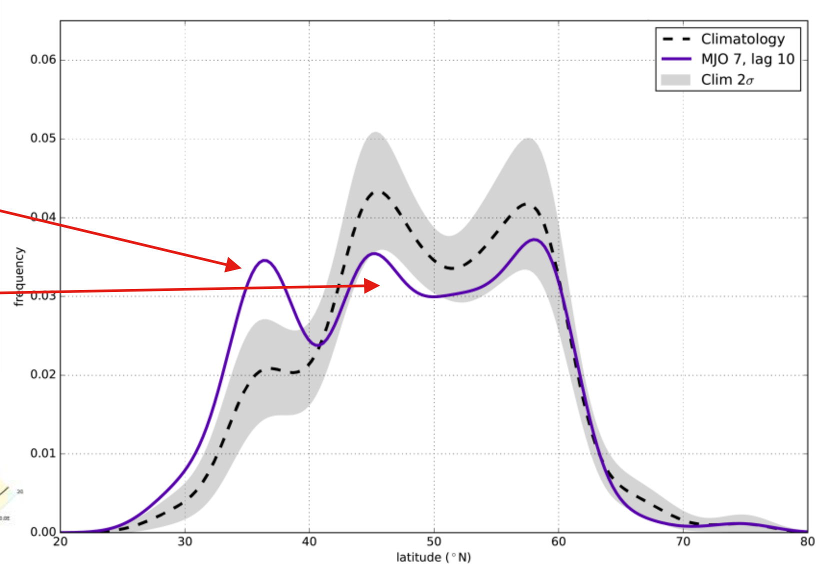
Using ENSO3.4 DJF mean temperature anomaly to split 39 years into 3 terciles (each compositing 13 years):

- No NAO+ teleconnection
- Possible late NAO– teleconnection, but never makes it to 0-lag days

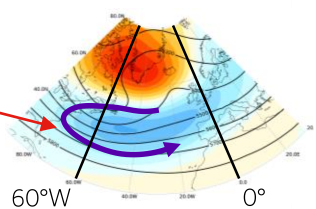


North Atlantic eddy driven jet

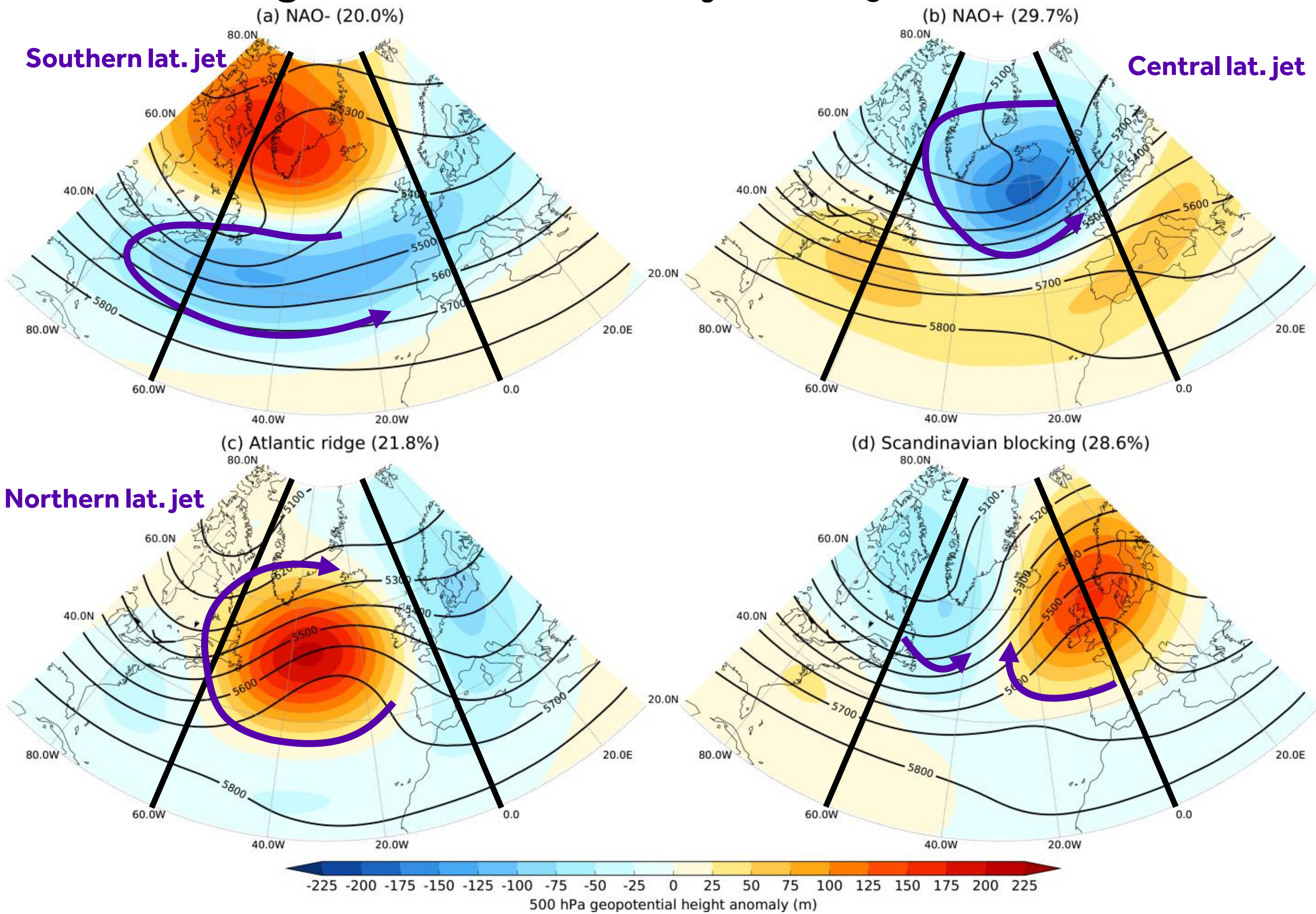
- Using methodology of Woollings et al. (2010):
  - low-pass filtered u850 wind **0-60°W** to cover the North Atlantic
  - daily data
  - 3 'regimes': southern, central, northern
  - bootstrap 10000 times by year over the 39 years, calculate 2σ spread (grey shading)
- Calculate jet latitude distribution for lagged days after an MJO phase
- For example:
  - 10 days after MJO phase 7 (purple line)
  - significantly more frequently in southern regime
  - significantly less frequently in central regime
  - in agreement with increased occurrence of NAO−



Anomalous wind circulation as a result of regime flow



Regimes into N.Atl. eddy driven jet latitude



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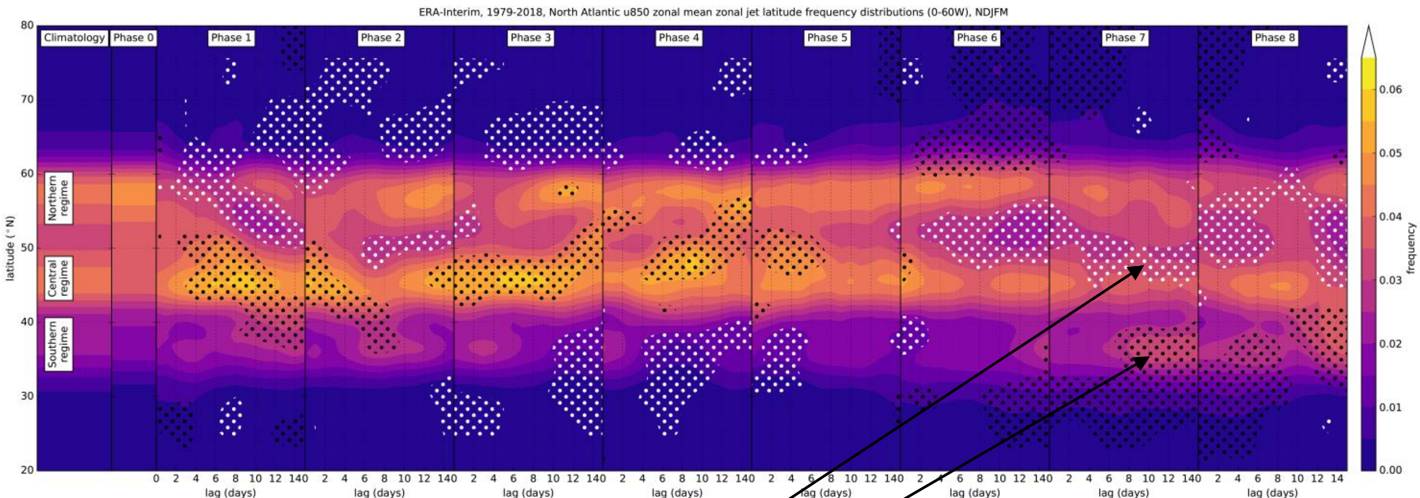
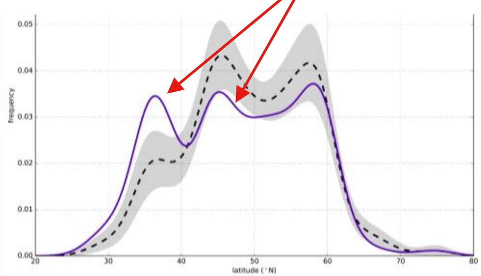
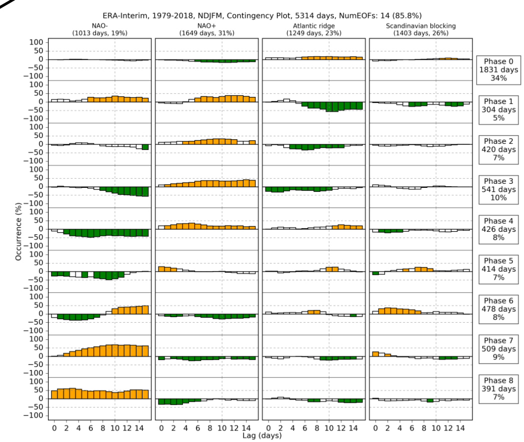
Eddy driven jet as Hovmöller: all 39 years



- White dots where distribution < 2σ
- Black dots where distribution > 2σ





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Eddy driven jet as Hovmöller: all 39 years

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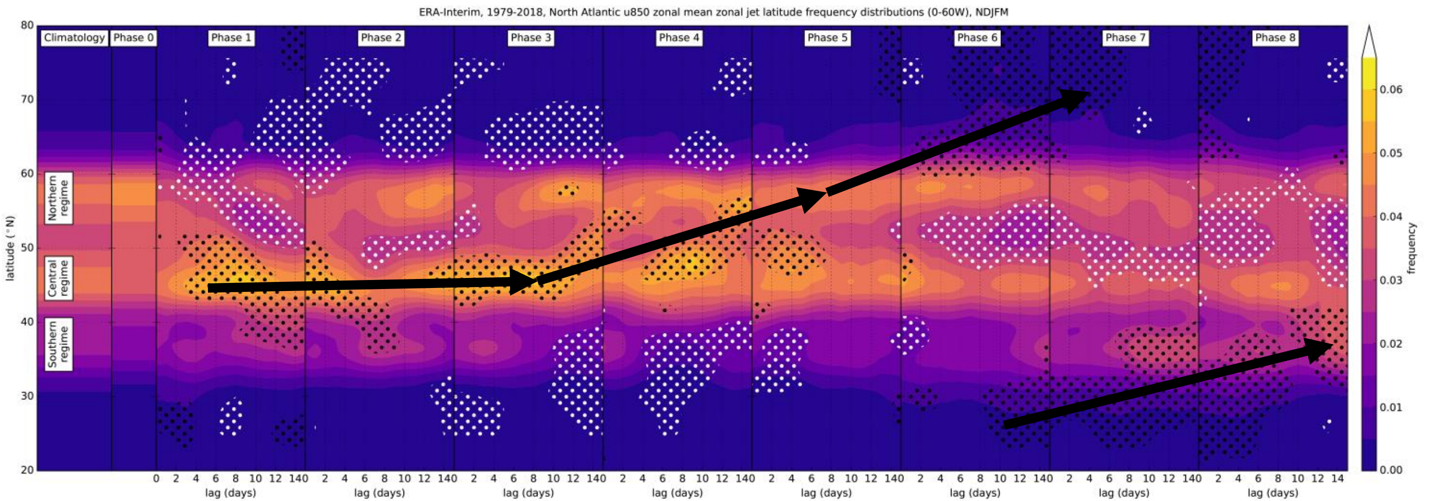
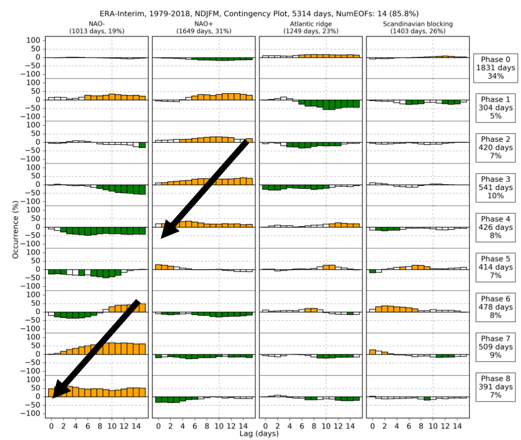
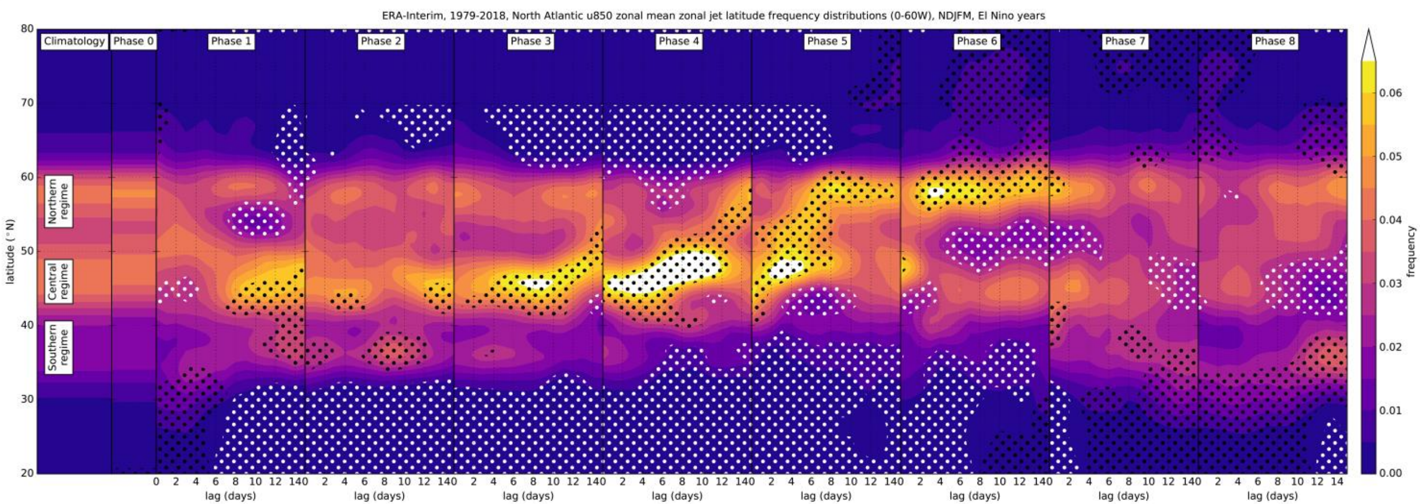


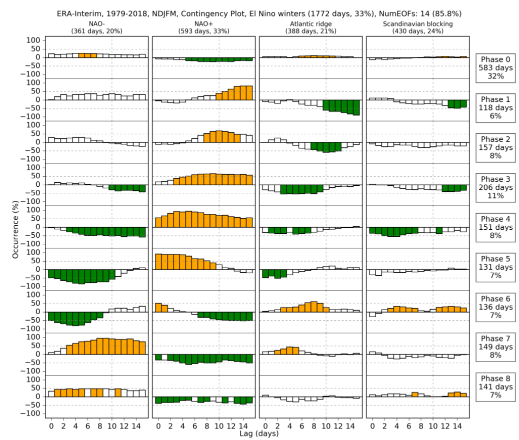
- Central regime phases 1-4 (NAO+)
- Some shift to northern regime (possible Atlantic ridge)
- Shifts to southern regime from phases 6-8
- In keeping with research on jet latitude evolution as a loop: S -> C -> N -> S…



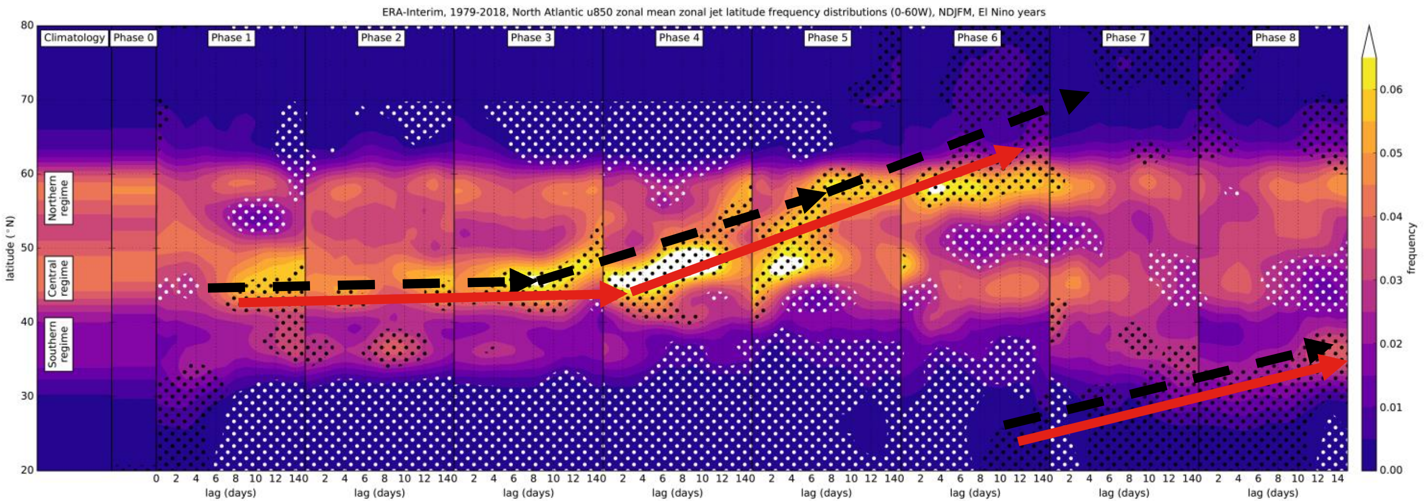
Eddy driven jet as Hovmöller: El Niño years



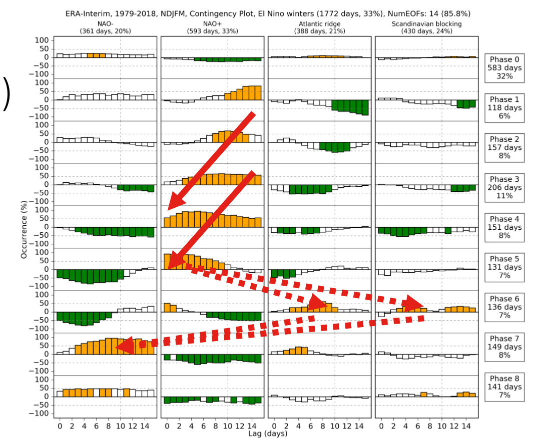
- Now subsetting by the ENSO state terciles by year
- (same colourbar extent)



Eddy driven jet as Hovmöller: El Niño years



- During El Niño, frequency distributions are even more extreme (particularly phases 3-5)
- Slightly later shift from Central to Northern regime
- Shift to southern regime during phases 7 and 8



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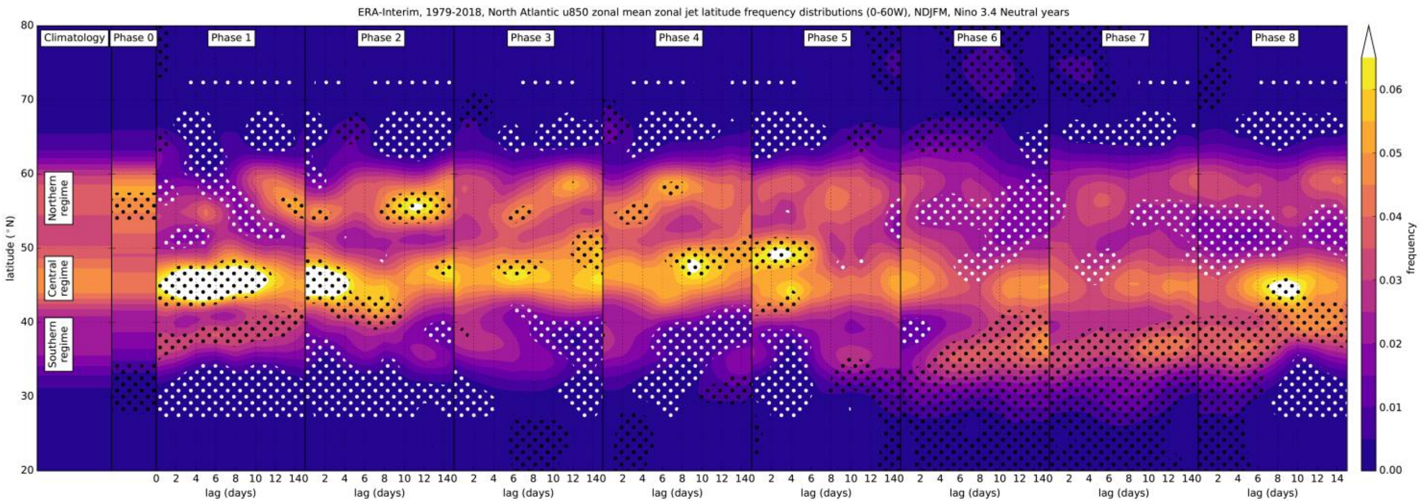
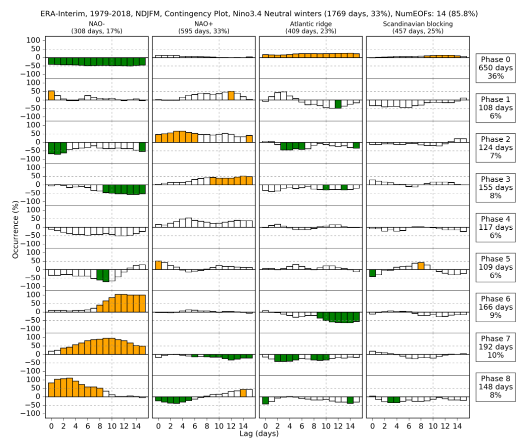
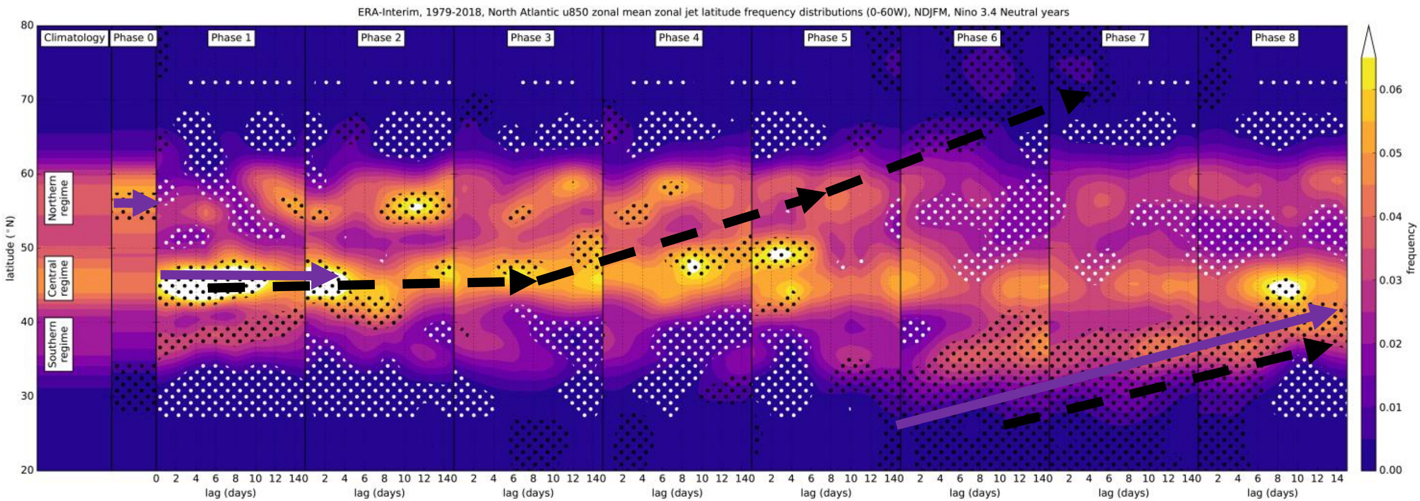
Eddy driven jet as Hovmöller: Neutral years

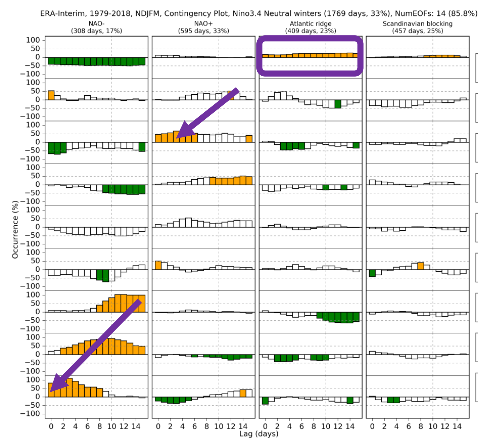




Eddy driven jet as Hovmöller: Neutral years



- During Neutral years increased significant time in southern regime at phases 6-8
- Moving to central regime by Phase 1



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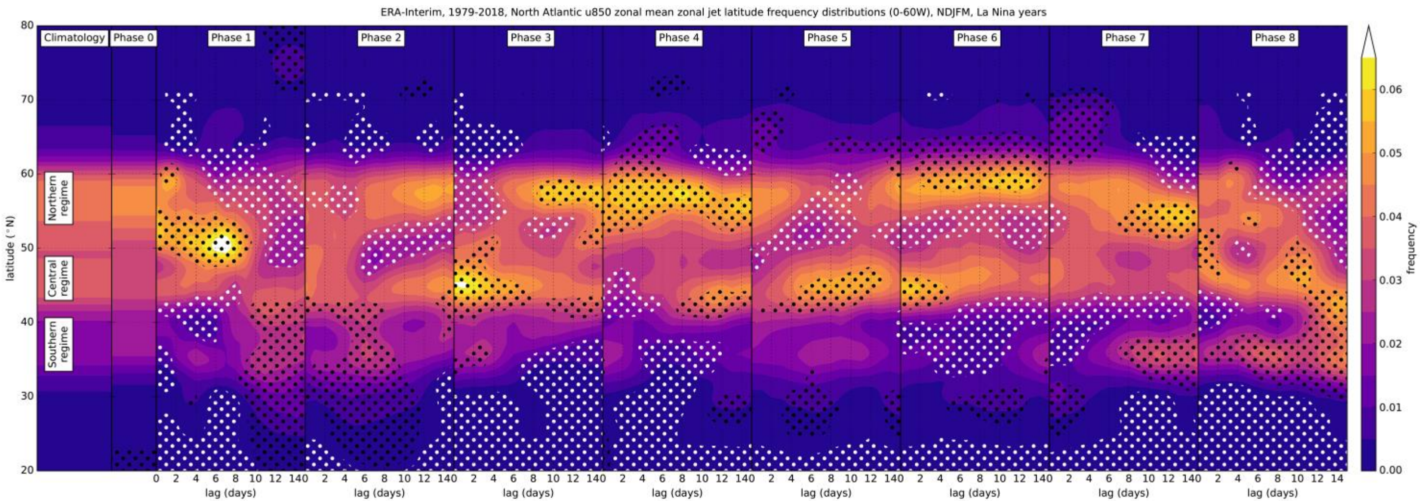
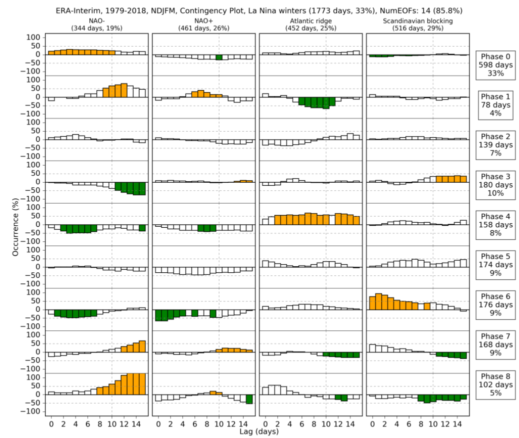
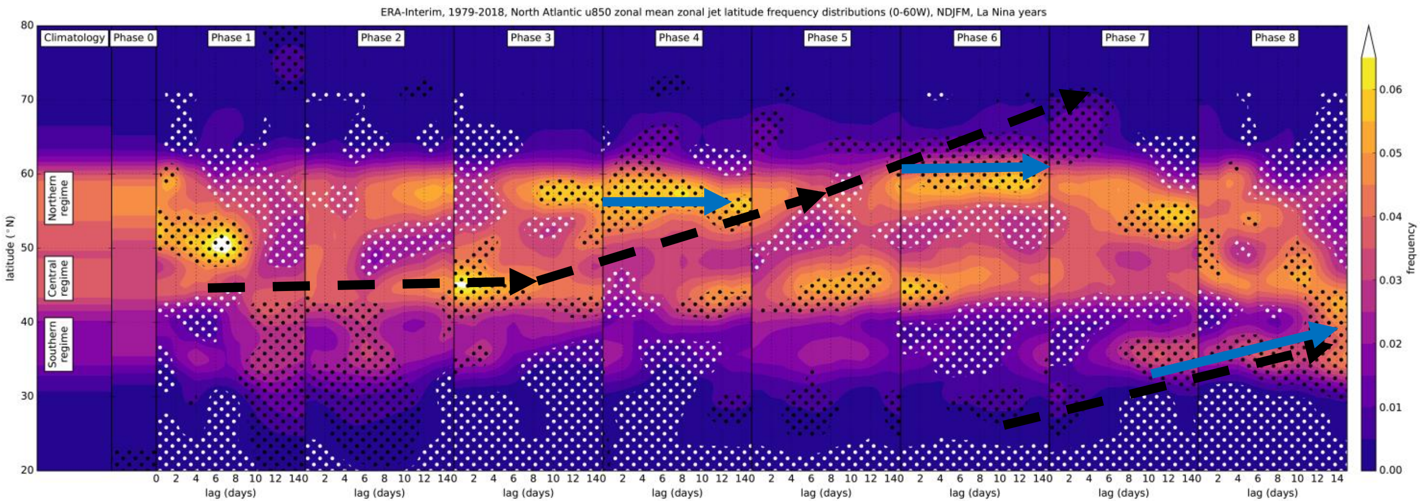
Eddy driven jet as Hovmöller: La Niña years

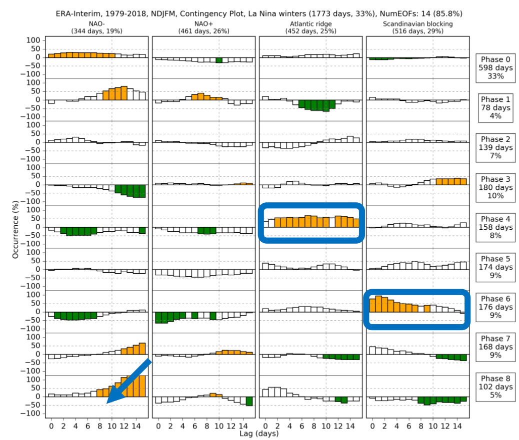




Eddy driven jet as Hovmöller: La Niña years



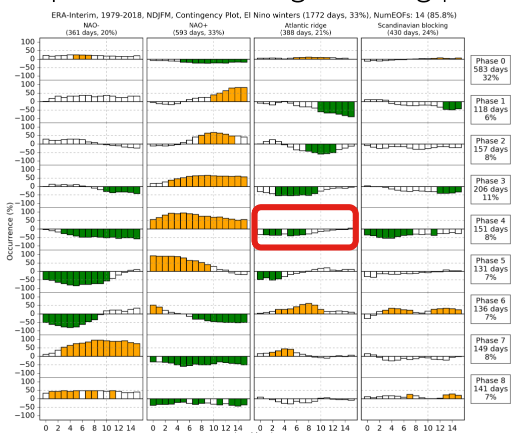
- Few clear teleconnections

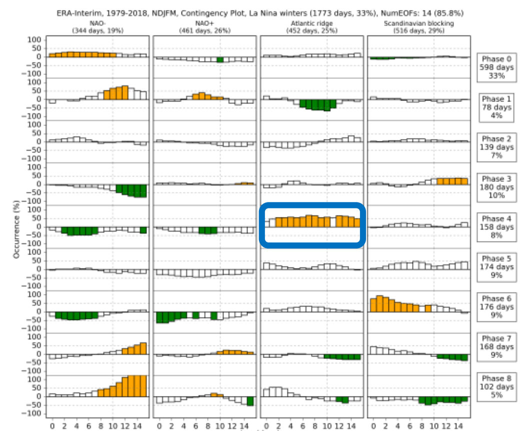


Conclusions

Clear dependence of the MJO teleconnection to the North Atlantic/European regimes (and North Atlantic eddy-driven jet) on the ENSO background state.

- NAO+ teleconnection stronger during El Niño
- NAO− teleconnection stronger during ENSO Neutral
- ENSO state also shift timing of regime transitions and persistence as a function of MJO phase and current North Atlantic regime
  - For example: increased persistence of NAO+ into phase 5 during El Niño
  - Some phases can have opposite sign of anomalous regime occurrence (for example: Atlantic Ridge during phase 4).





Implications for subseasonal predictability

Clear dependence of the MJO teleconnections on the ENSO background state.

Implications for subseasonal predictability

Models need to get the background state correct to represent these teleconnections

- May be that errors in the teleconnection of MJO – NAE region are related to errors in the background state
- Consistent with models having too much of a La Niña like state

Implications for interannual predictive skill

- Predictability associated with MJO likely to be larger in El Niño and Neutral years than La Niña years since teleconnections are stronger (current work in progress)
- In both good models and the real world

Next: apply analysis of the MJO – NAE region teleconnections and their dependence on the background state (e.g. ENSO) to the subseasonal models in the S2S forecast database

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