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Zonal asymmetries in NAO

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Zonal asymmetries in the NAO

(and in the Southern Annular Mode)

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Motivation:

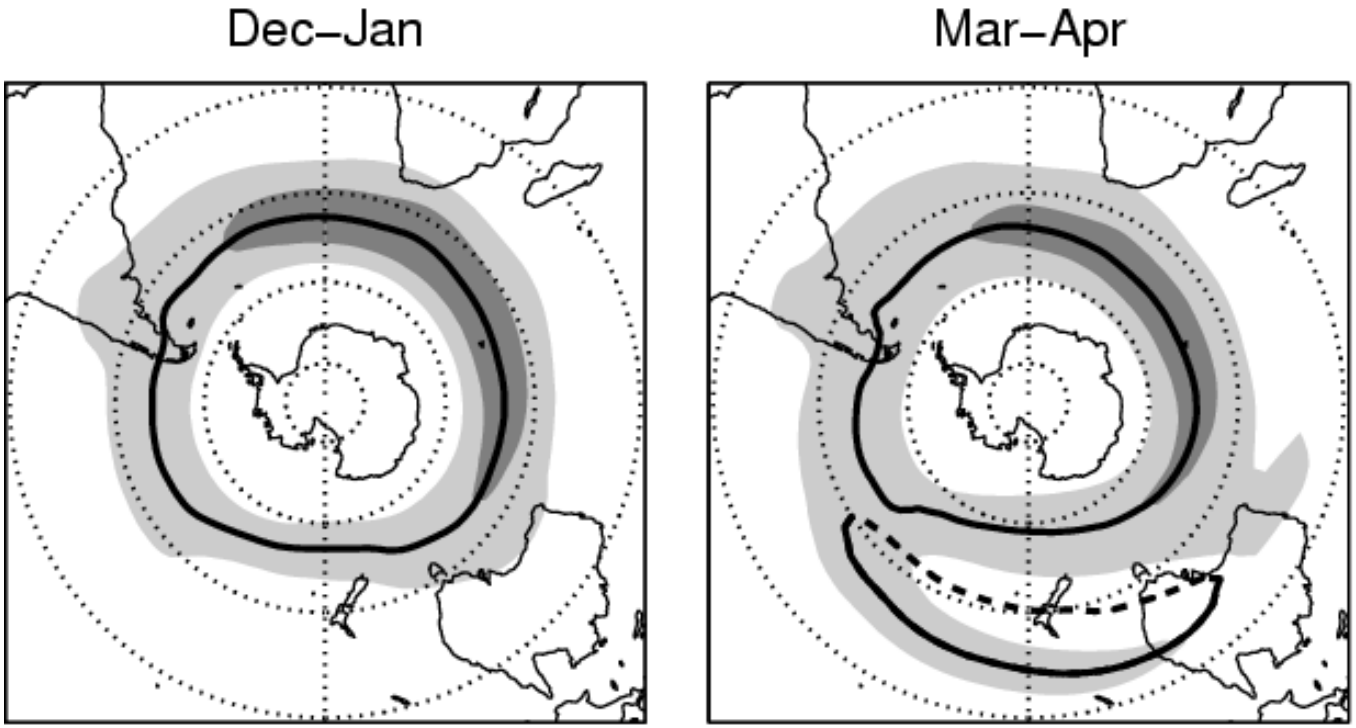
- Teleconnection patterns at low frequency tend to have a zonally-elongated shape.
- Theory of « annular » dynamics in zonally-averaged case: jet shifts in latitude are selected by positive feedback with high-frequency (HF) eddies.

Goals:

- Check what happens in the non-zonally symmetric case: Relation with the mean state, dynamics.
- Look at longitudal changes.

1. Southern Hemisphere summer: almost symmetric basic state

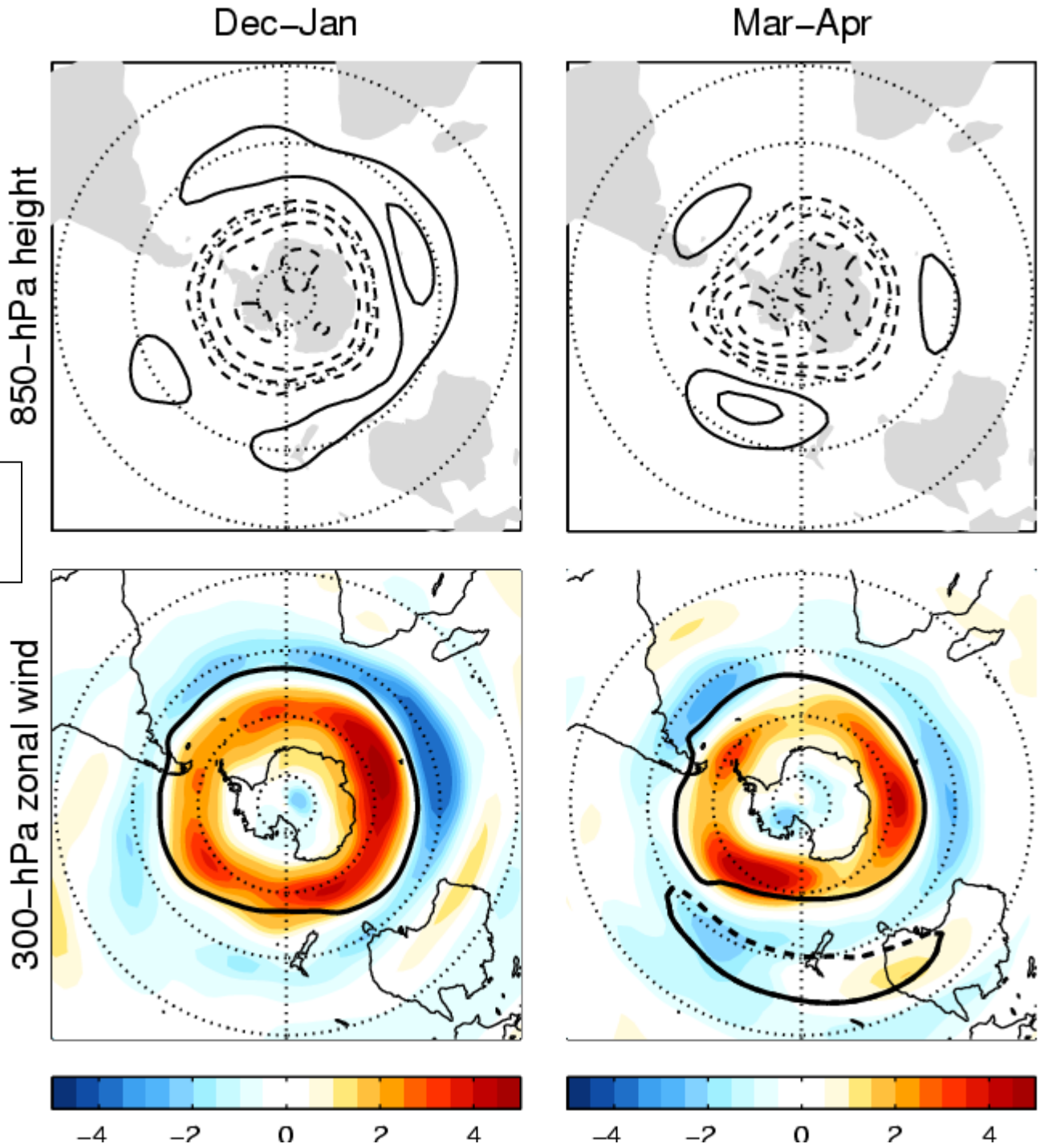
300-hPa zonal wind



(but the jet is located equatorward in Dec-Jan)

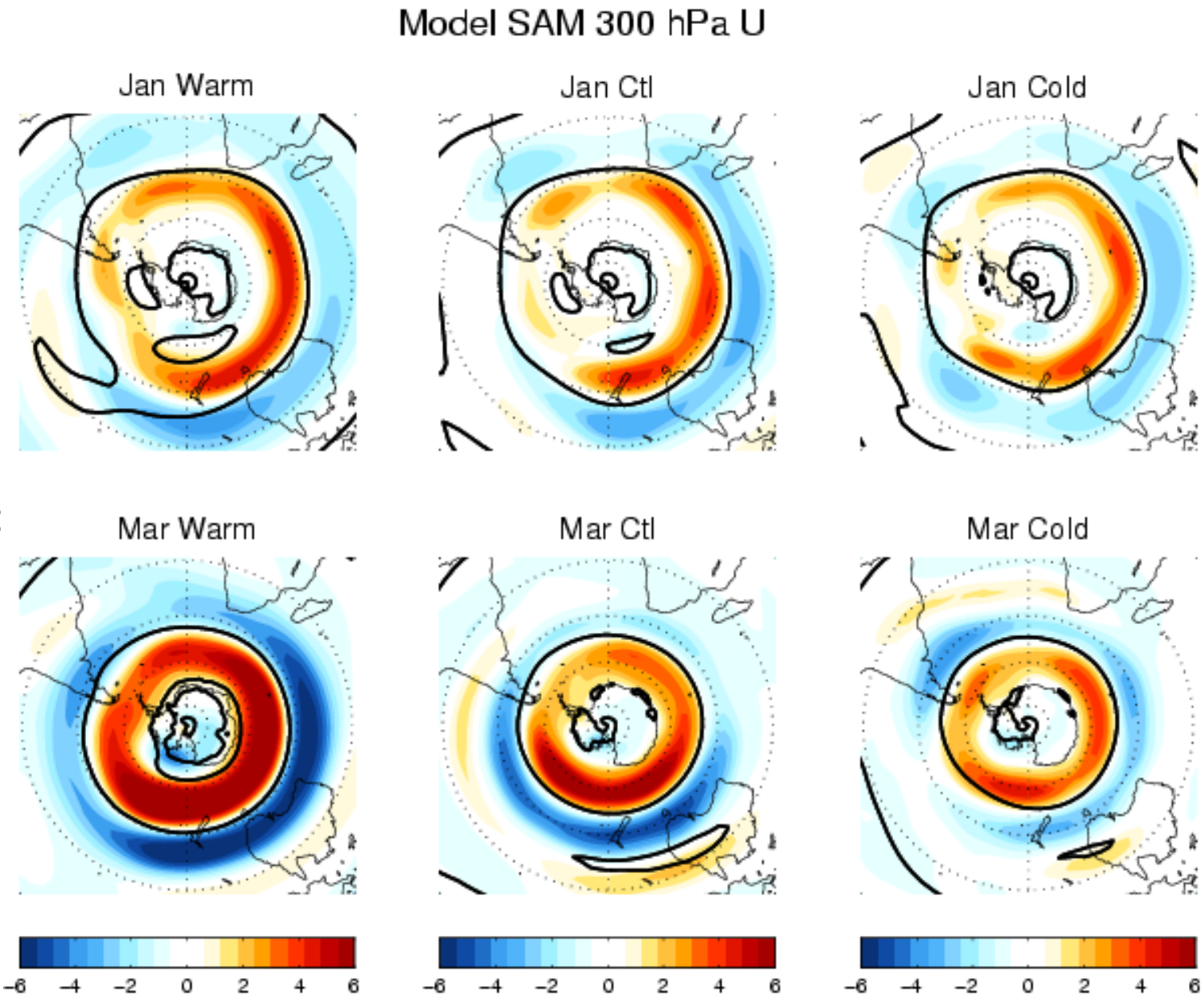
Summer SAM regressions:

➢**The SAM is a latitude shift of the jet**



Codron, *JClim* 2005

Perpetual state: change in season and ENSO phase

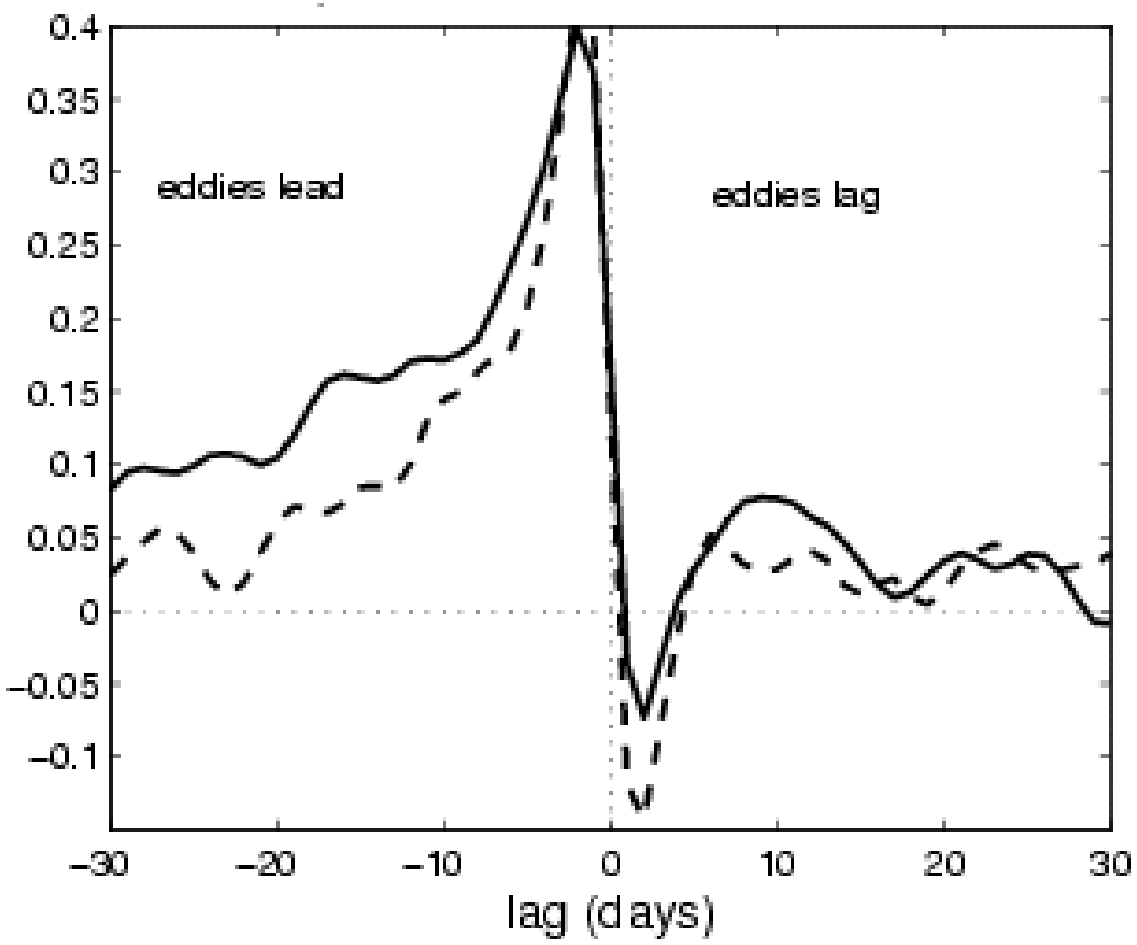


➢ **still a jet shift for many other zonally-symmetric basic states**

Eddy forcing of the SAM:

(u'v'$_y$ projected on 300-hPa zonal wind anomaly pattern)

Lagged-correlation with daily SAM index



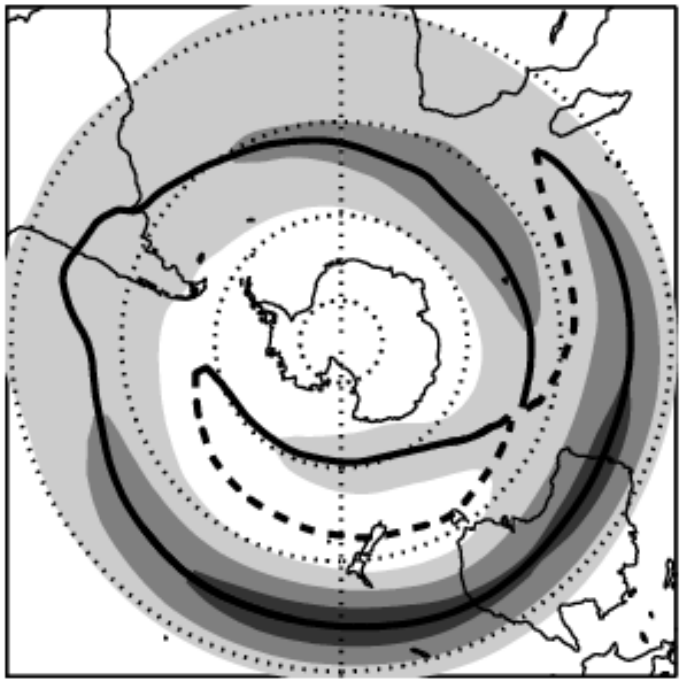
- **Peak at negative lags: eddies force the SAM**
- **Corr. >0 at long lags: feedback by eddies**

2. Southern Hemisphere winter (JJA): more zonally asymmetric basic state

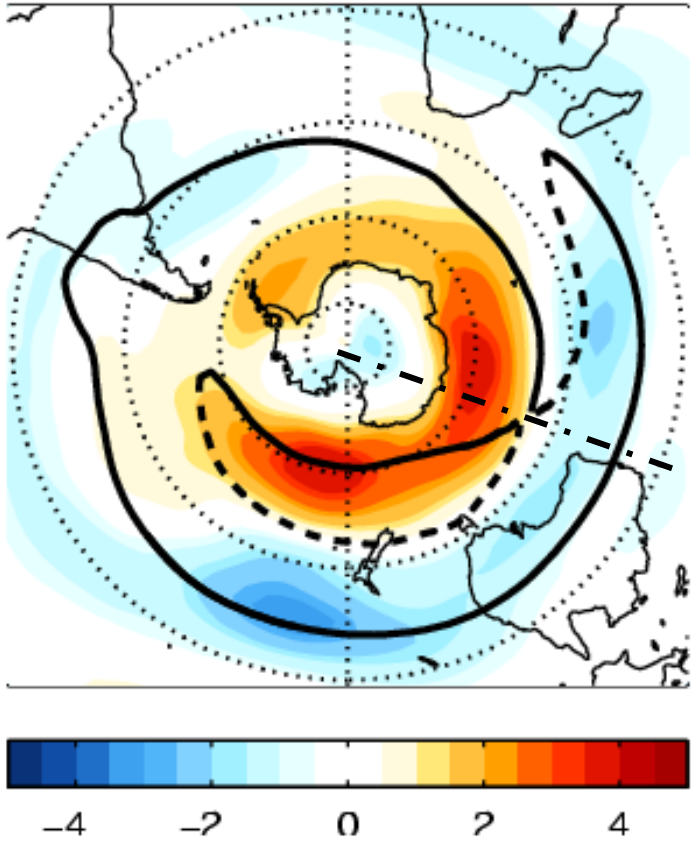
(strong subtropical jet over the Indian-Pacific)

300-hPa zonal wind:

Mean State



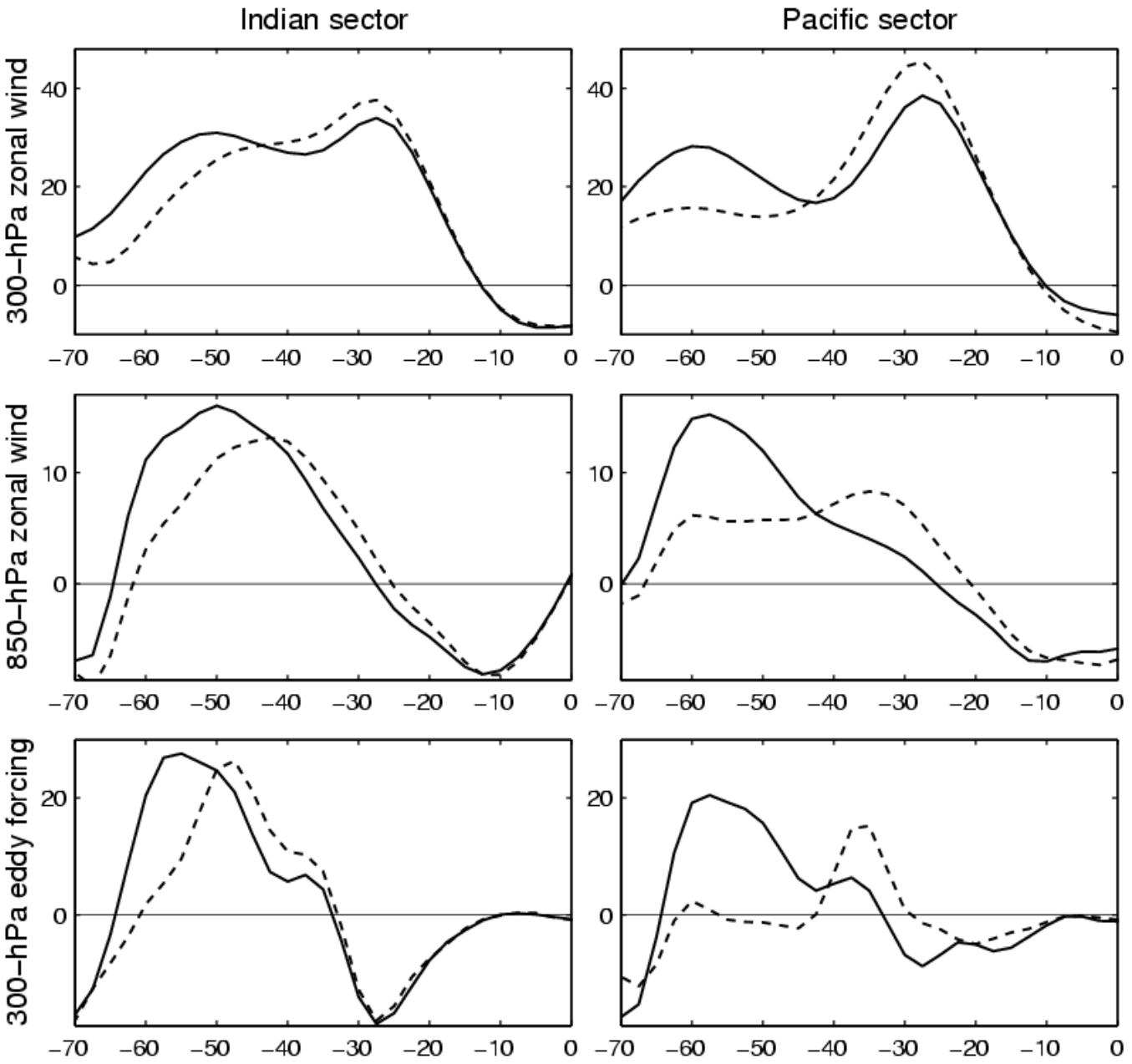
SAM regression



Codron, *JAS* 2007

➢ **Change of behavior between Indian and Pacific sectors**

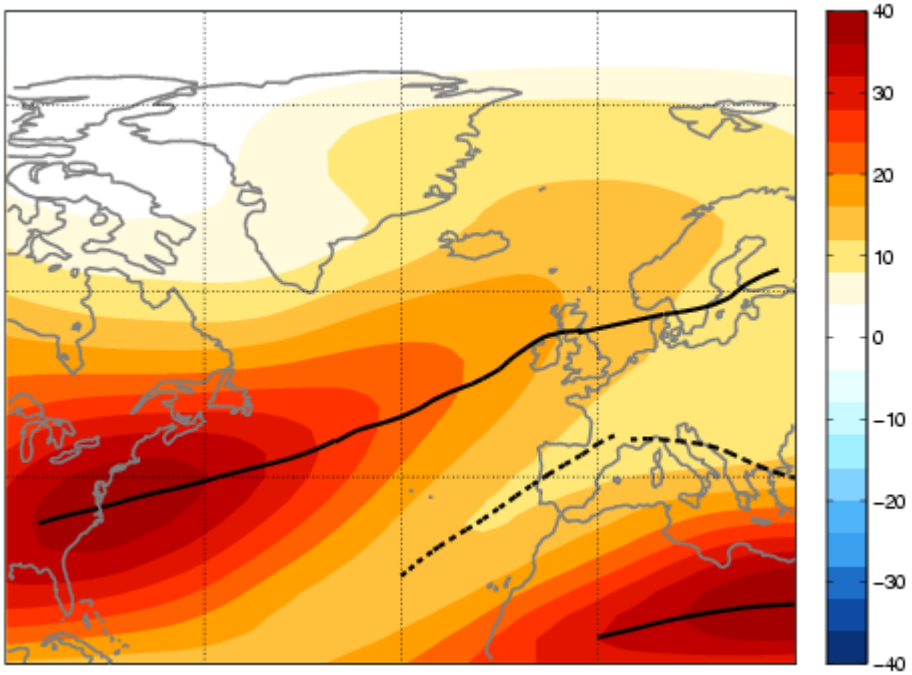
JJA SAM composites



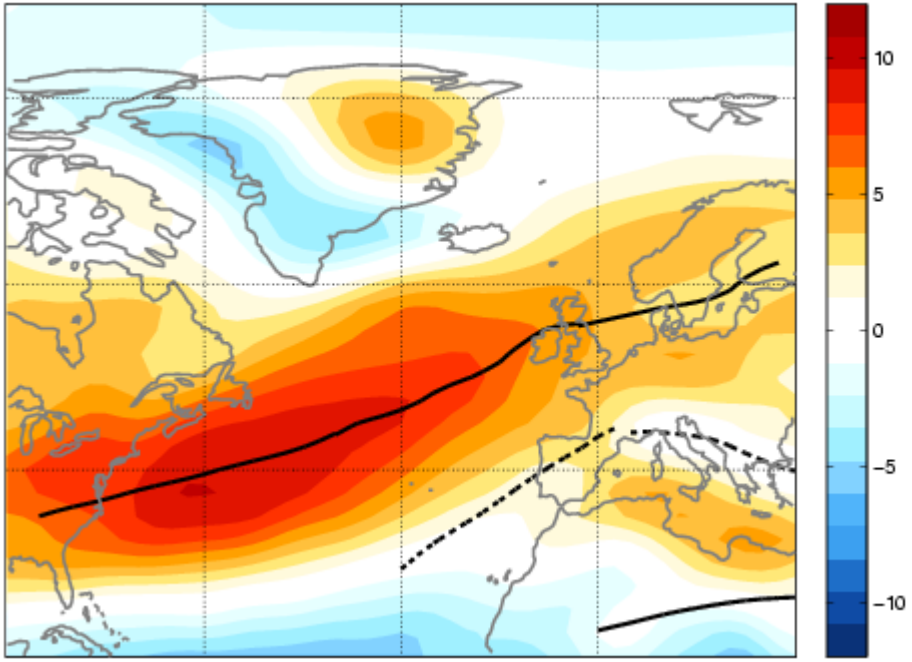
➢ **Shift of eddy-driven jet in the Indian, see-saw in the Pacific**

3. North Atlantic (DJFM): even more complex basic state

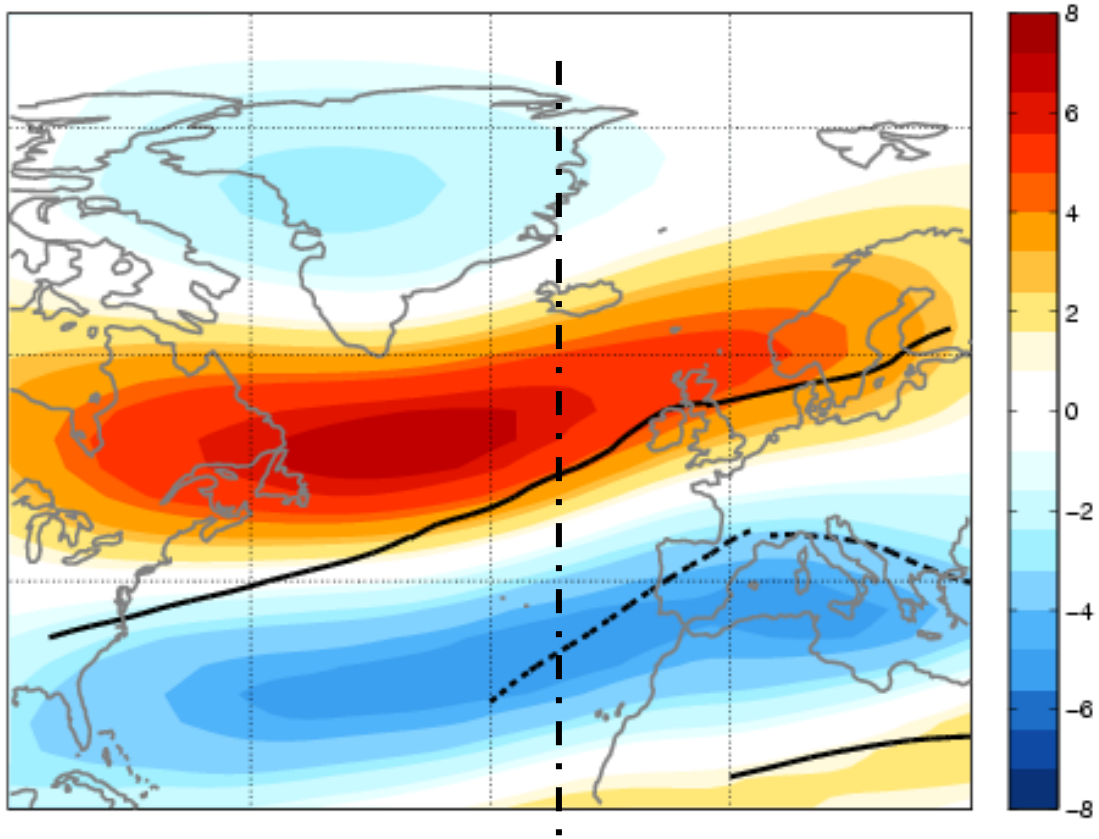
300-hPa
zonal wind



850-hPa
zonal wind



Regression on NAO:
300-hPa Zonal Wind

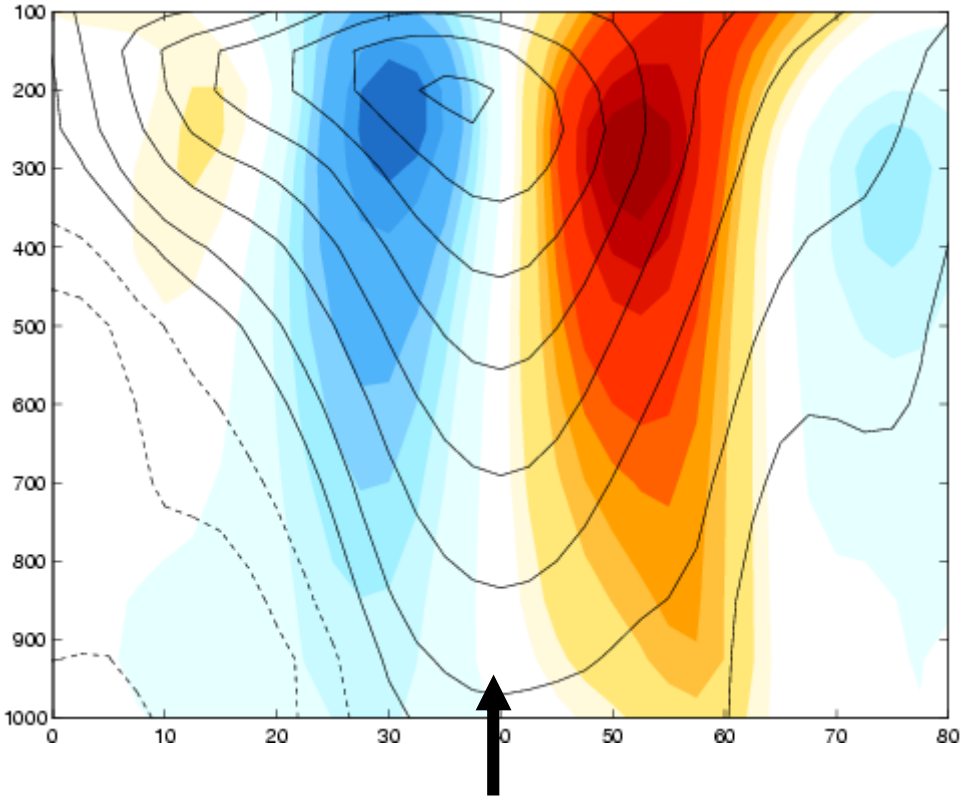


Anomalies less tilted than the mean state: different behavior West vs. East!

Zonal Wind latitude-height cross-sections:

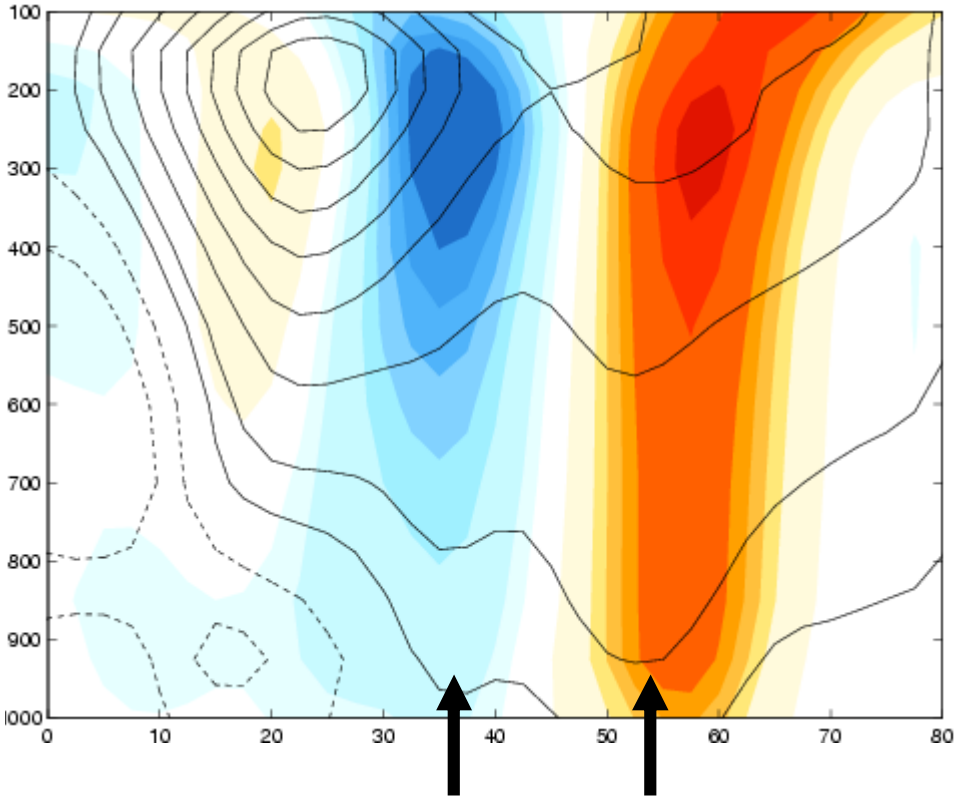
Mean (contours)
NAO regression (color)

Western Sector



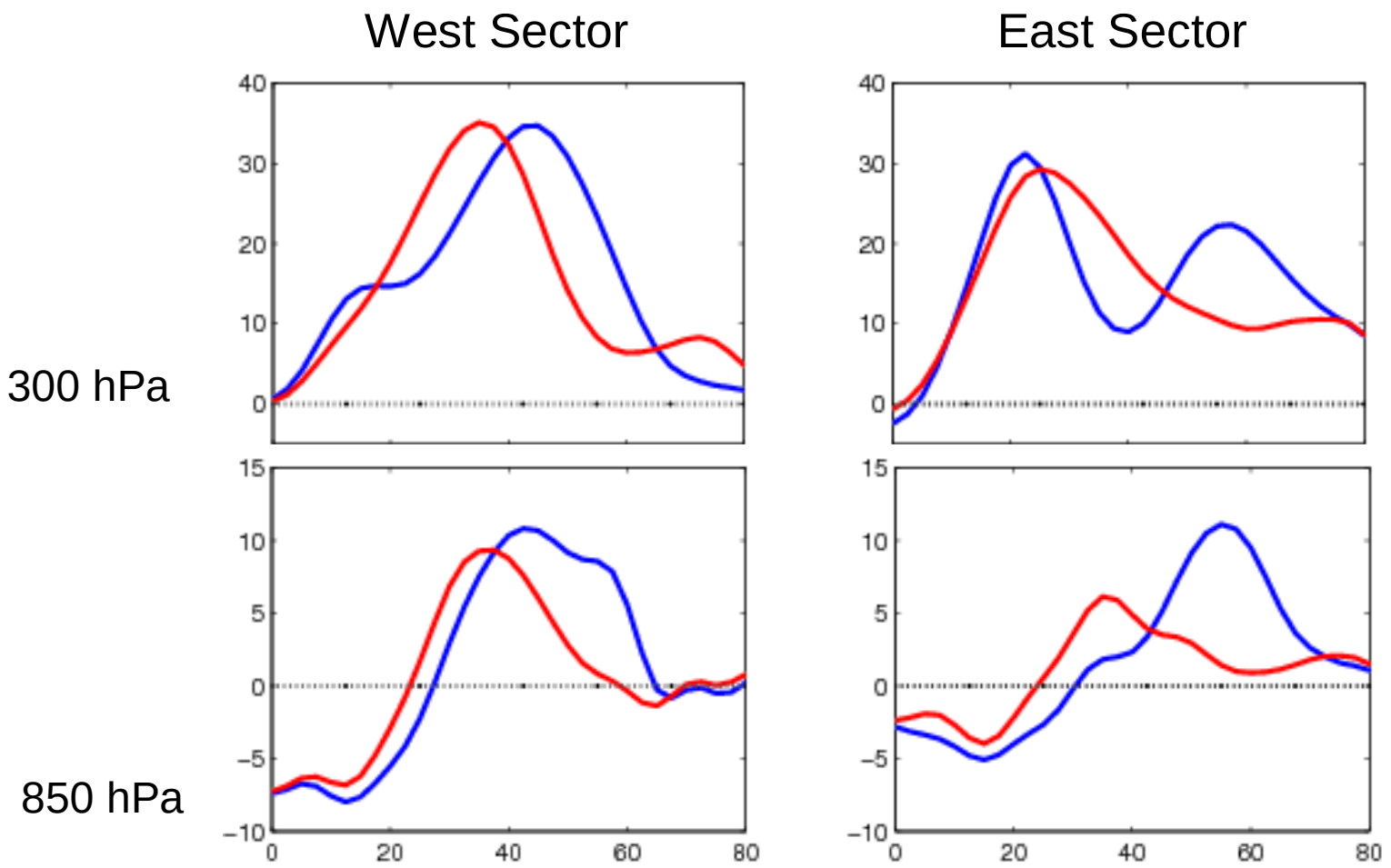
➢ **Shift of eddy-driven jet**

Eastern Sector



➢ **See-saw between two latitudes**

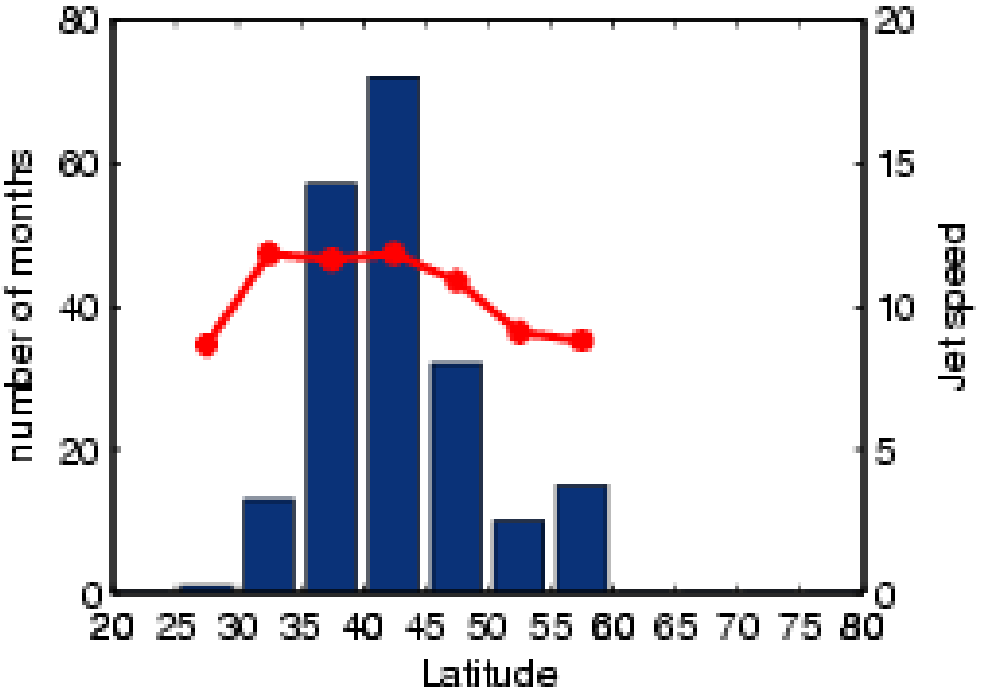
NAO composites of zonally-averaged zonal wind



- **Shift of eddy-driven jet**
- **See-saw between two latitudes**

Distribution of Jet latitude and speed: Western sector

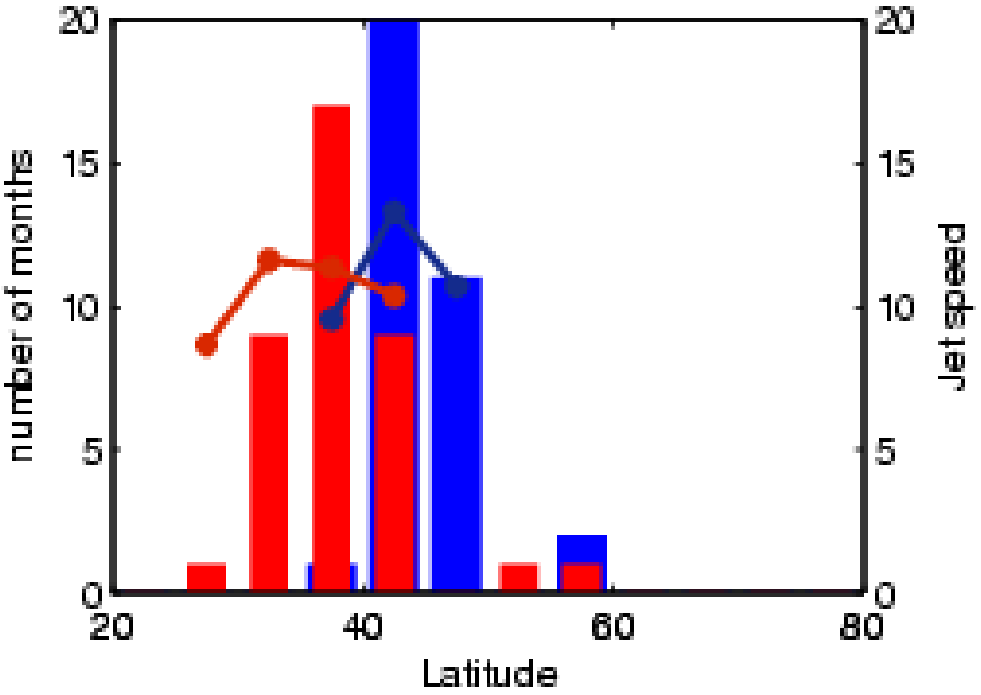
All winter months



NAO composites:

Positive

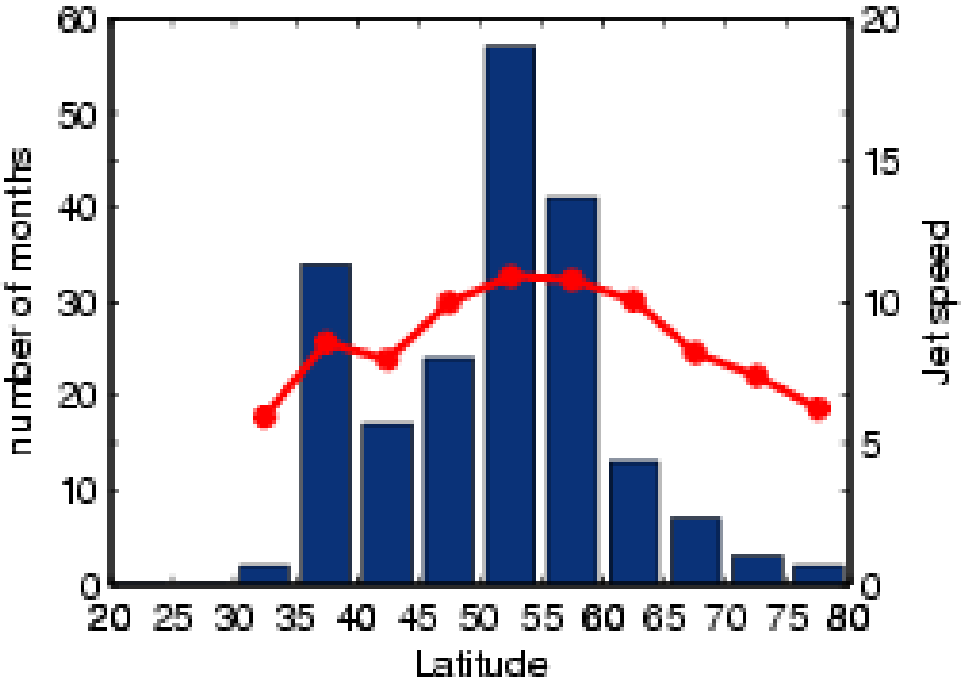
Negative



- **Latitude shift of distribution**
- **No change of speed**

Distribution of Jet Latitude and speed: Eastern Sector

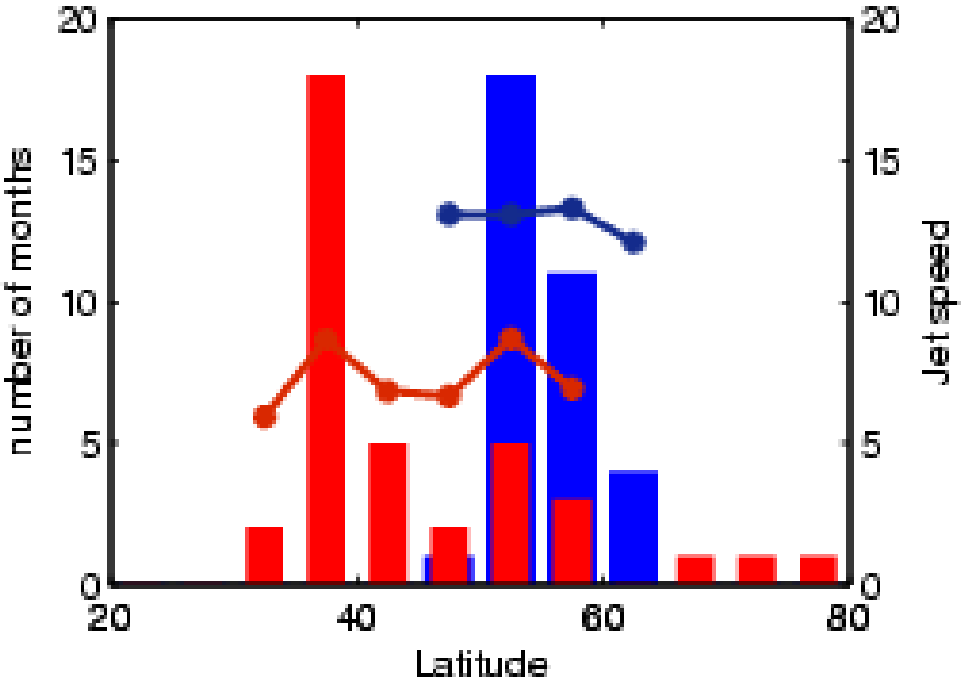
All winter months



NAO composites:

Positive

Negative

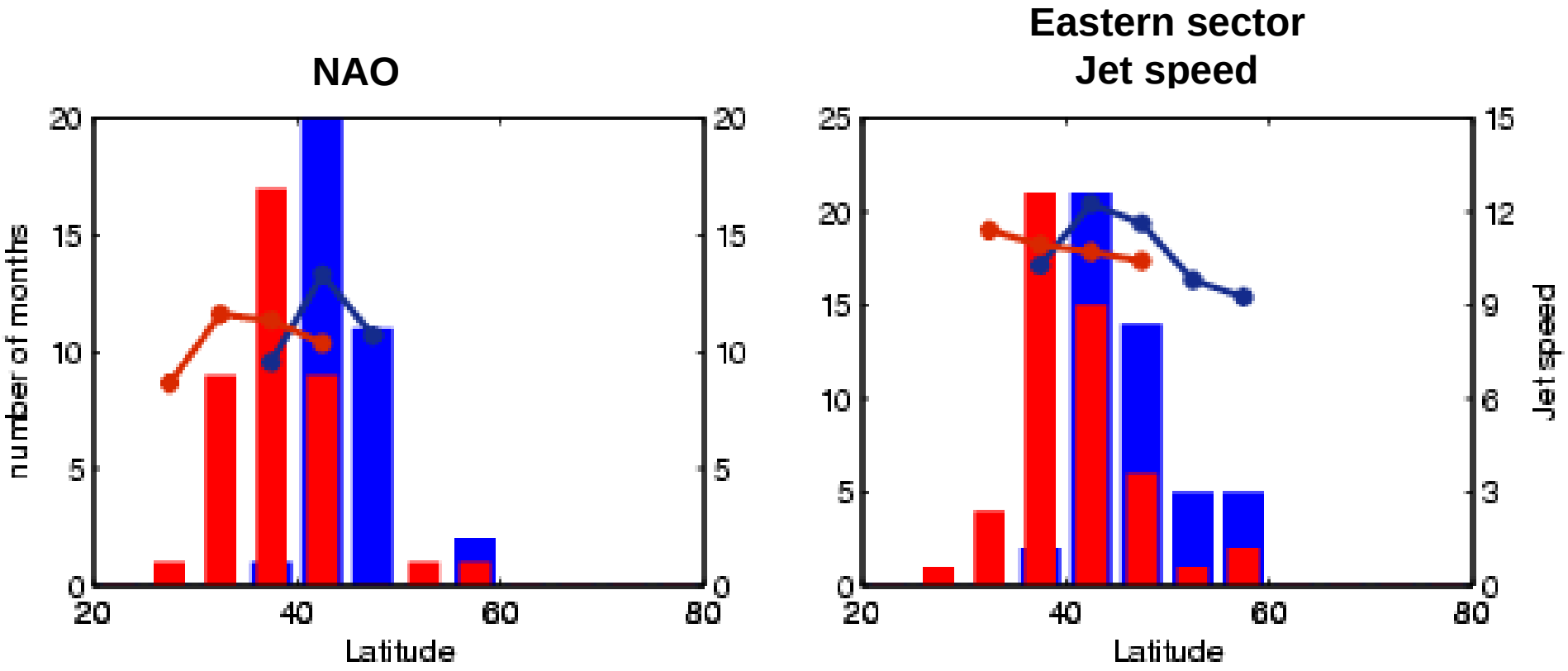


- **Bimodal latitude distribution**
- **Change of track and speed**

Consistent results if compositing by:

- Jet latitude in the west
- Jet speed in the east

e.g. Distribution of jet latitude and speed in Western sector based on index of:

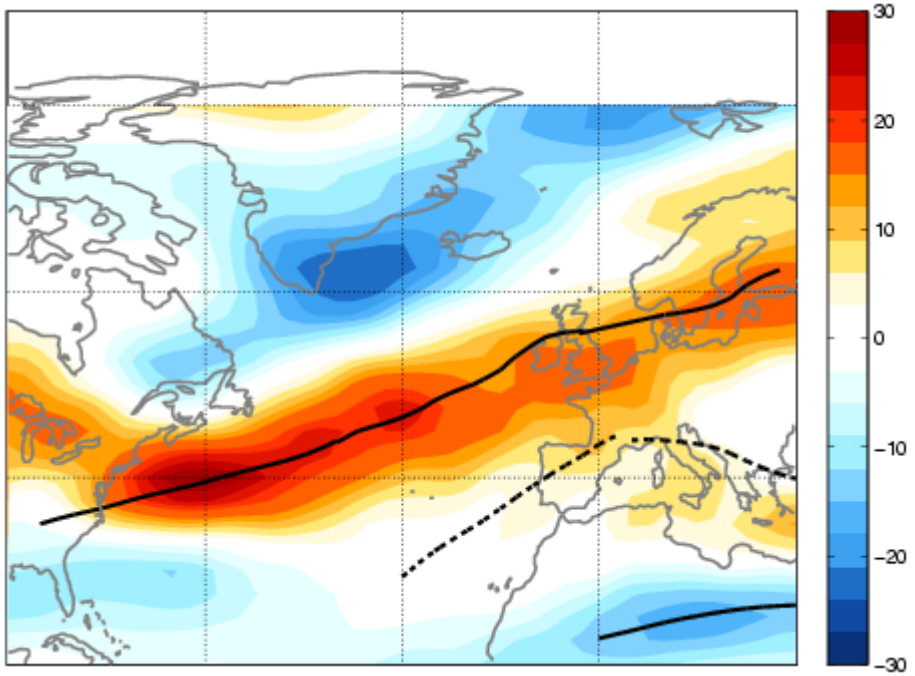


➢ **West/East relation independent of NAO index**

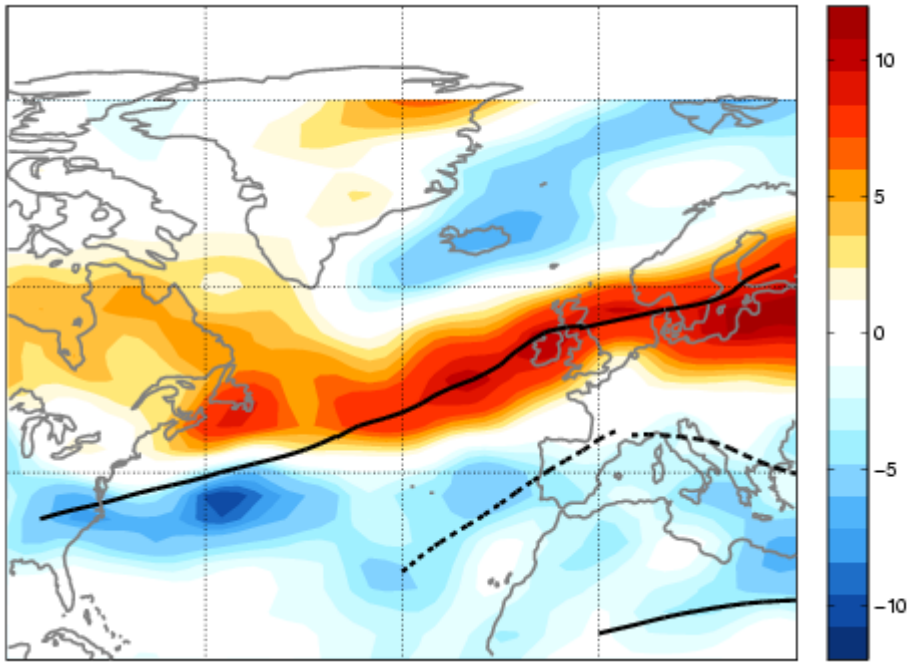
Forcing of flow anomalies:

HF Transients mom. flux convergence $U'V'_y$ 300 hPa

DJFM Mean



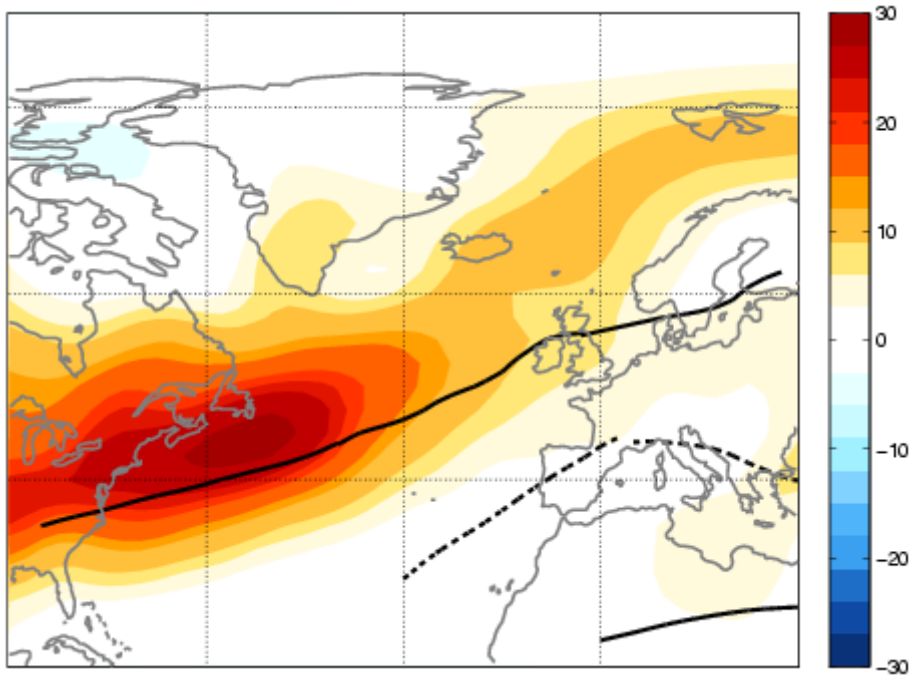
NAO regression



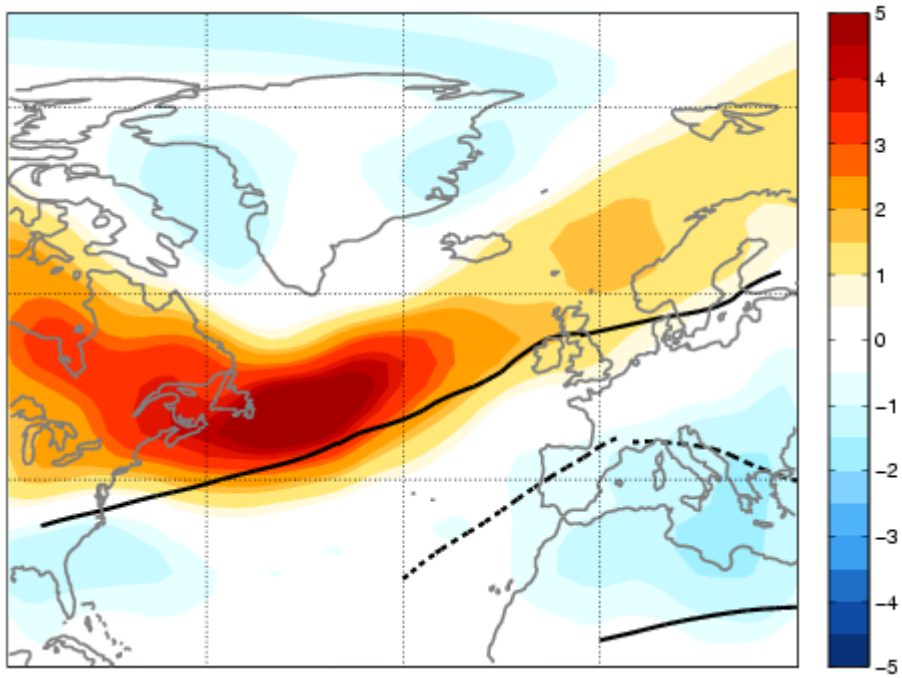
- **West: dipole about mean maximum (change in wave breaking?)**
- **East: reinforcement of mean-state pattern (more waves?)**

Low-level waves:
HF Transients v'T' 850-hPa

DJFM mean



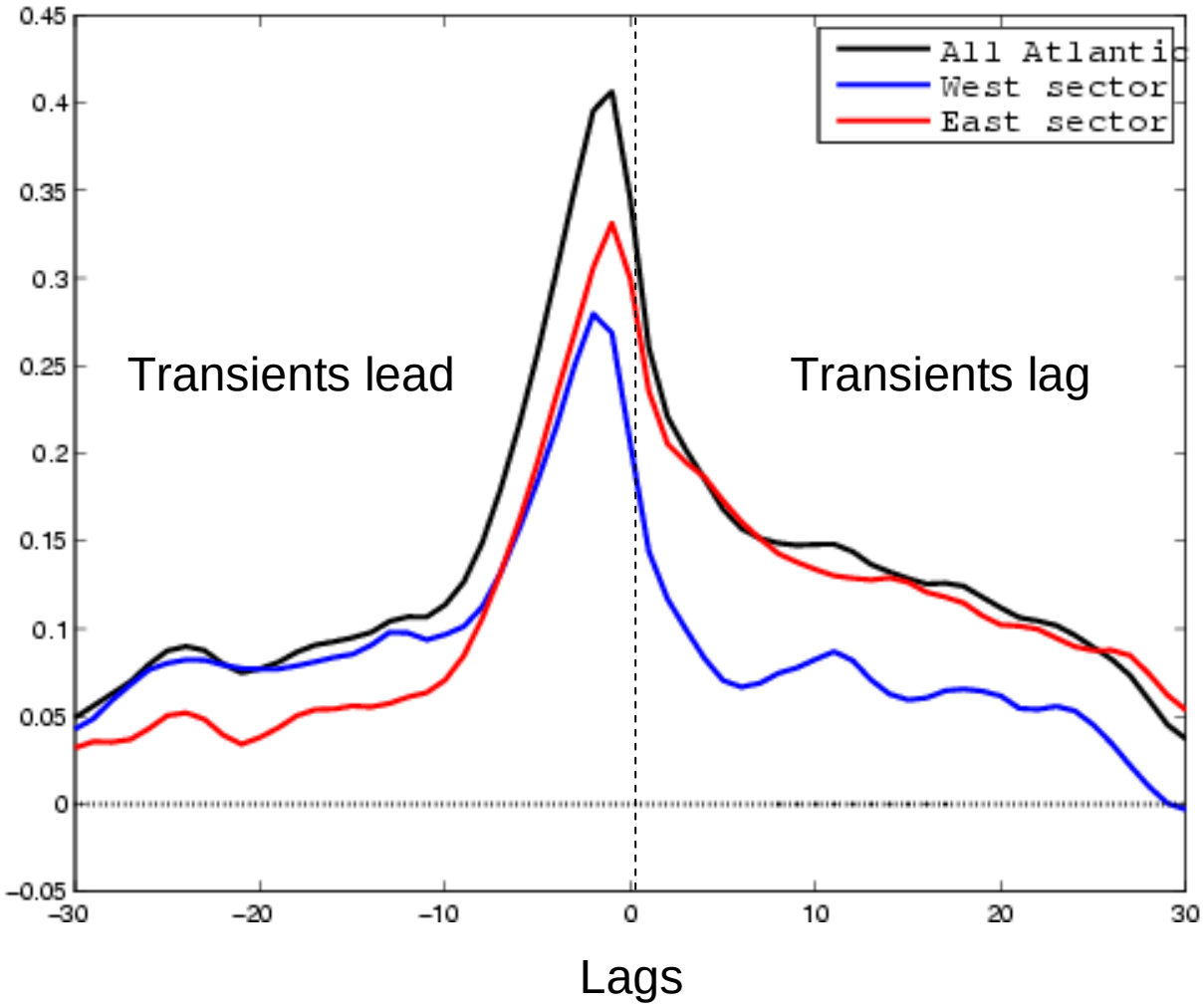
NAO regression



➢ **Increase of HF transients heat flux in the *West.***

Feedback by HF transients?

Lagged correlation:
daily NAO /
HFT forcing



➢ **Feedback stronger in the *East***

… In conclusion

1. In **zonally-symmetric** basic states, the variability follows « annular mode » theory: **shift of the jet** around its mean position, positive eddy feedback.

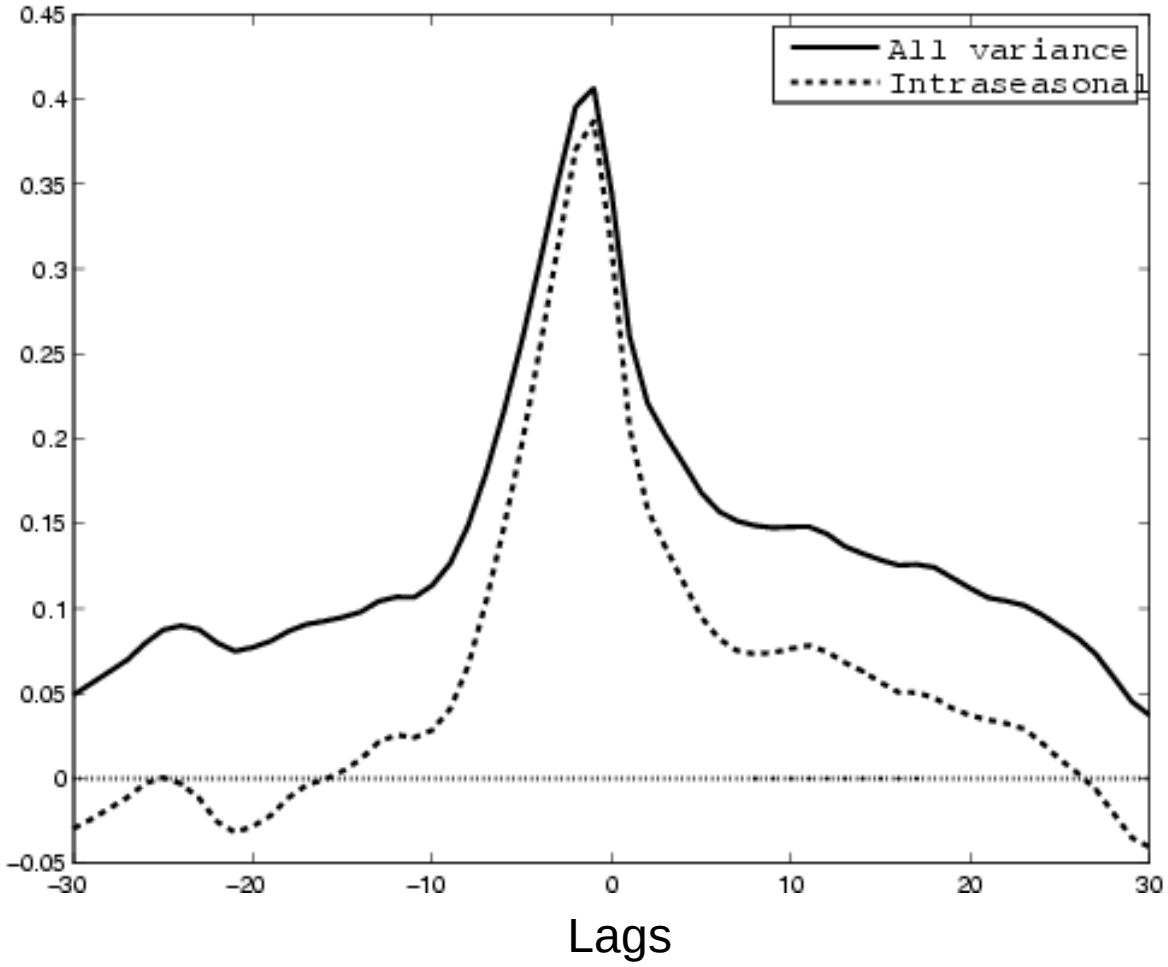
2. In the presence of zonal **asymmetries**, the patterns of variability remain zonally-extended (and more symmetric than the basic state), but the relationship with the basic state can be more complex than a jet shift: **change of speed**, **see-saw** between subtropical and mid-latitude jets.

3. **Eddy-feedback** is still important, but it is **not local**:

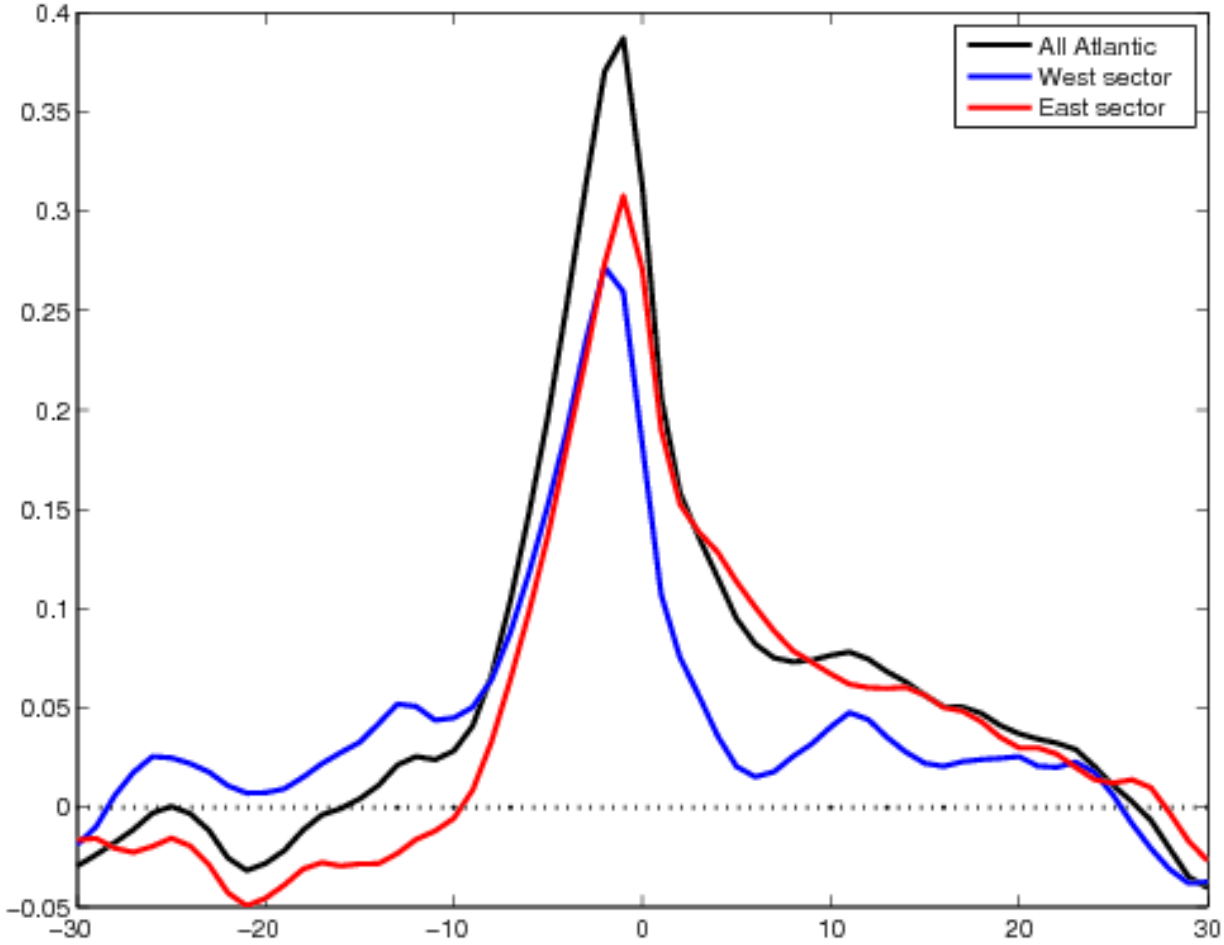
   wind anomalies influence the amount and behavior of waves further downstream.

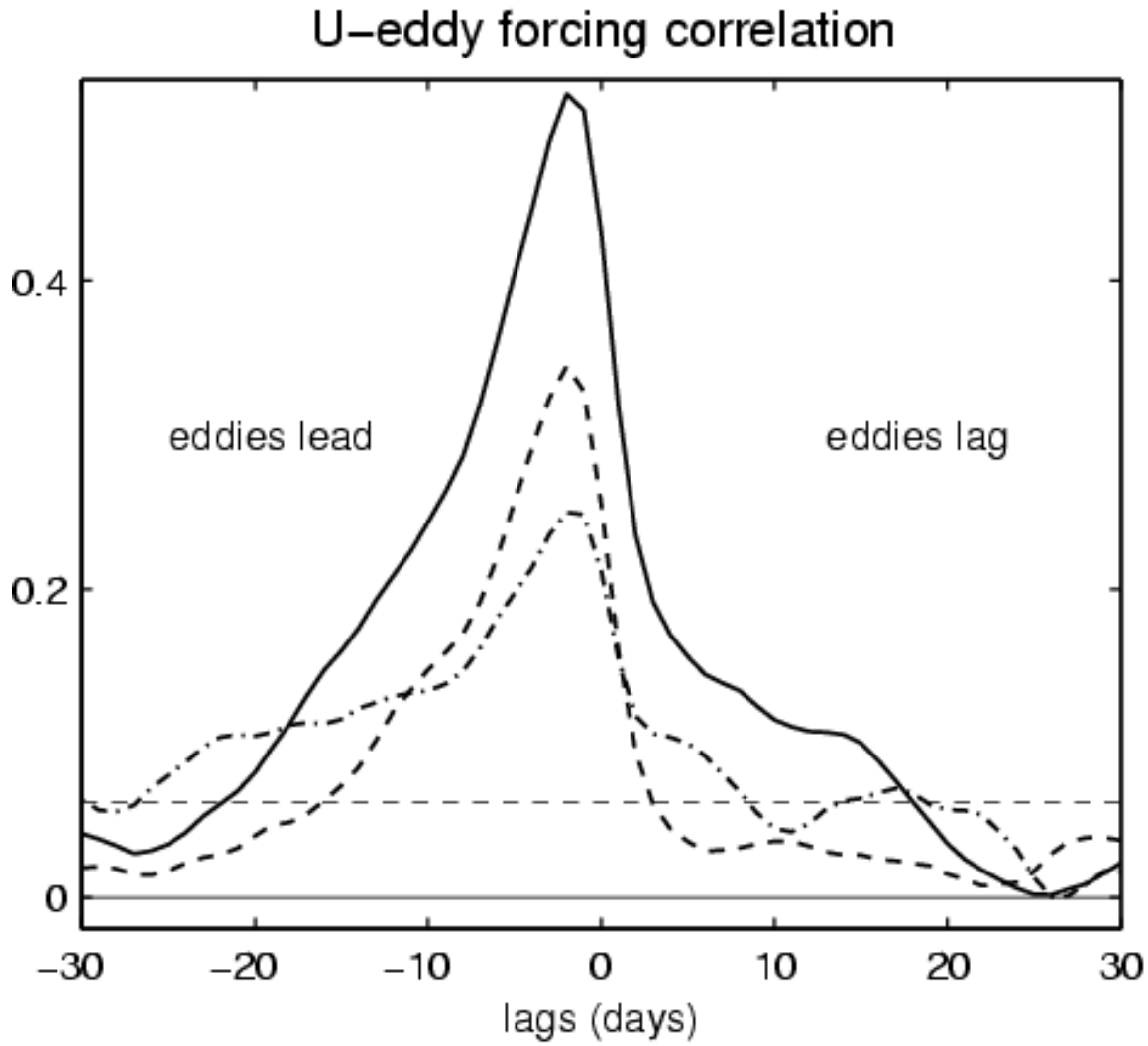
Winter-mean versus intraseasonal events

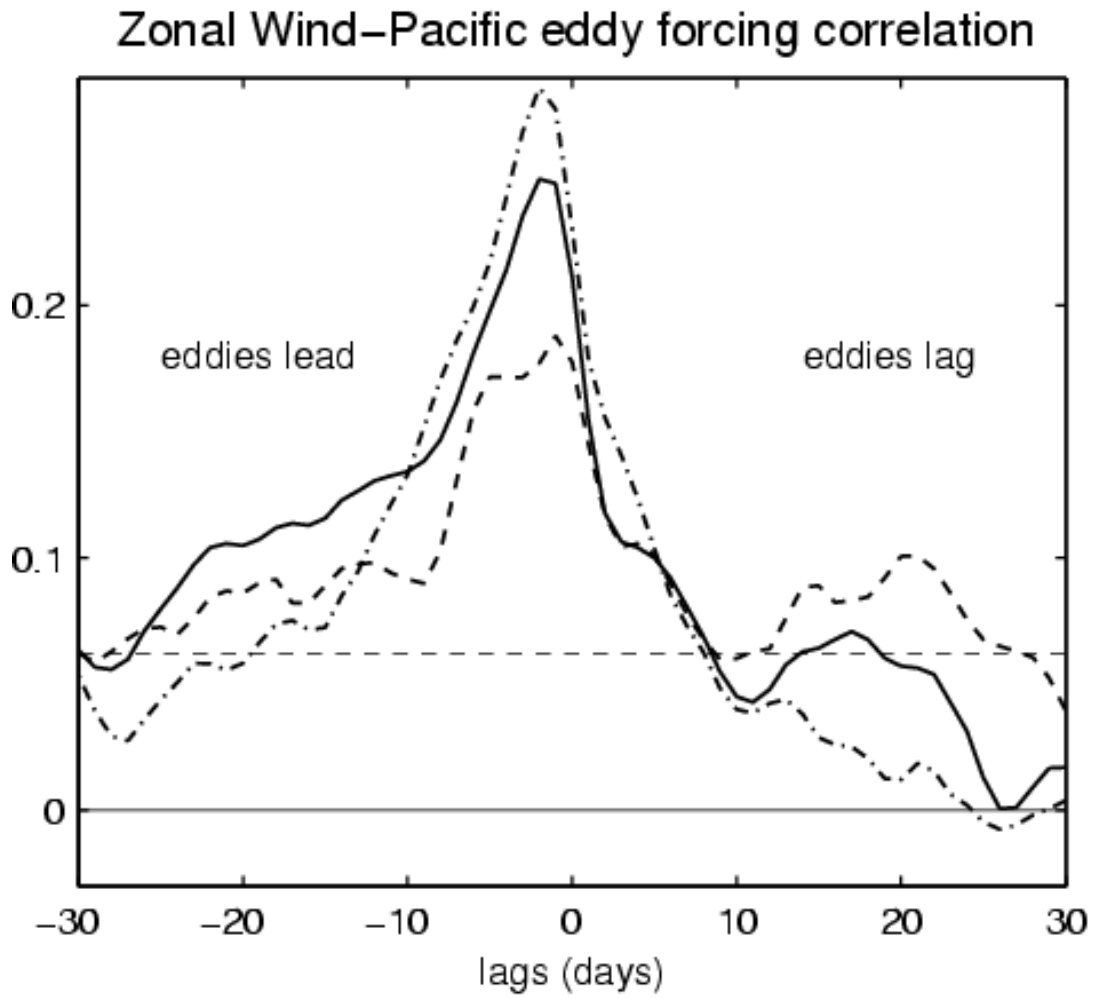
Dashed line:
Winter means removed



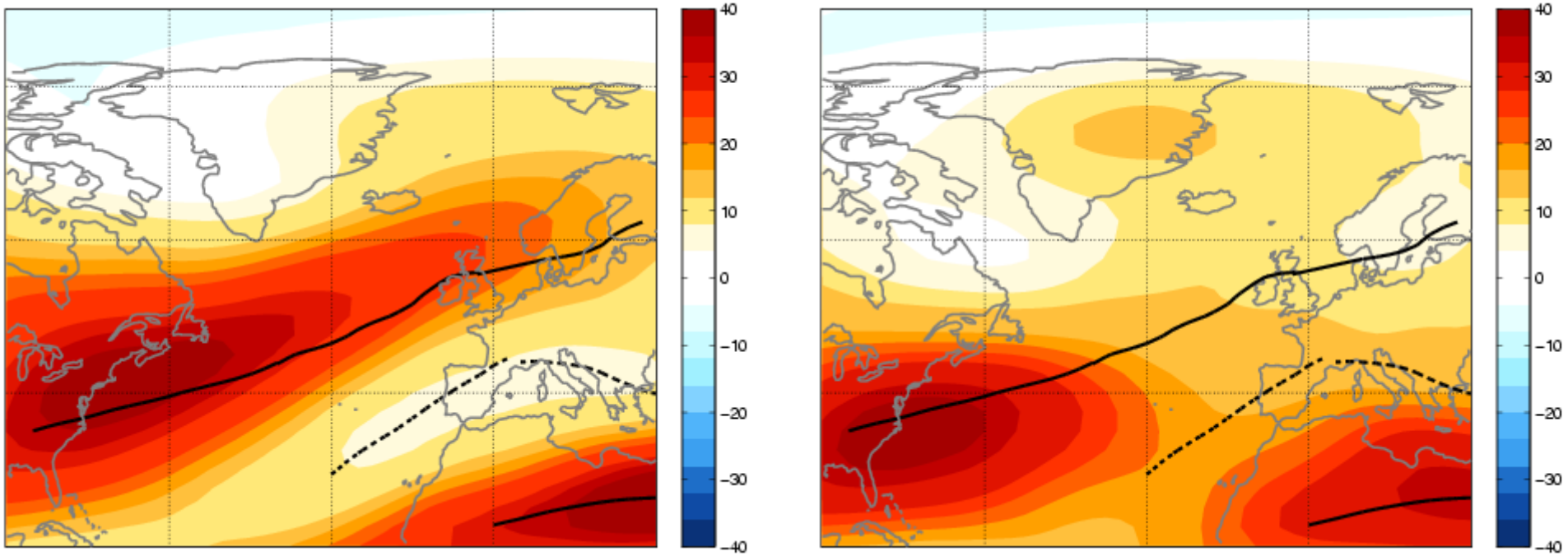
➢ **Positive feedback is dominated by interannual anomalies (but remains significant at intraseasonal timescale)**


All Atlantic
West sector
East sector
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
−0.05
−30
−20
−10
0
10
20
30

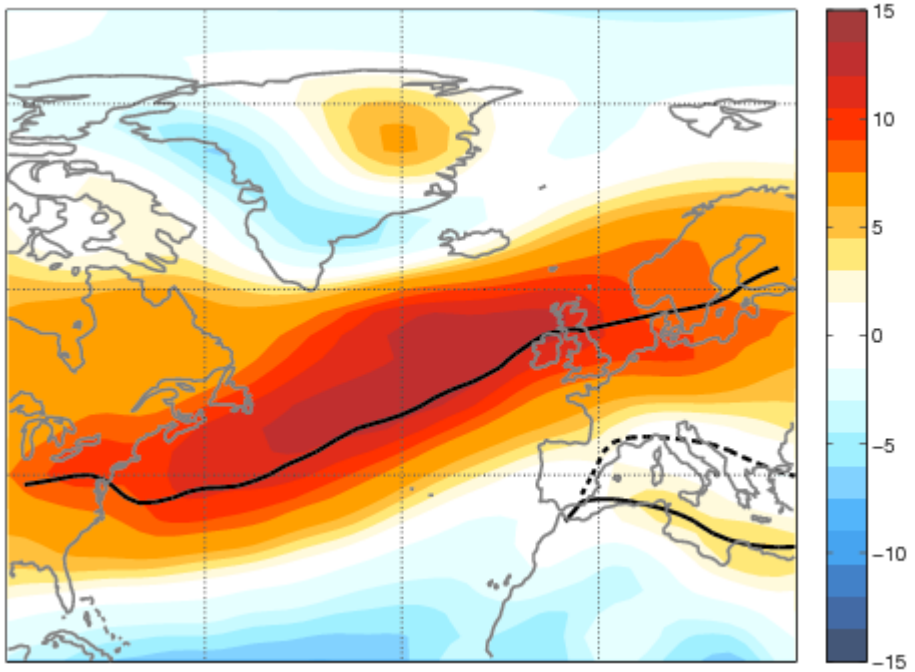

U–eddy forcing correlation
0.4
0.2
0
eddies lead
eddies lag
–30
–20
–10
0
10
20
30
lags (days)

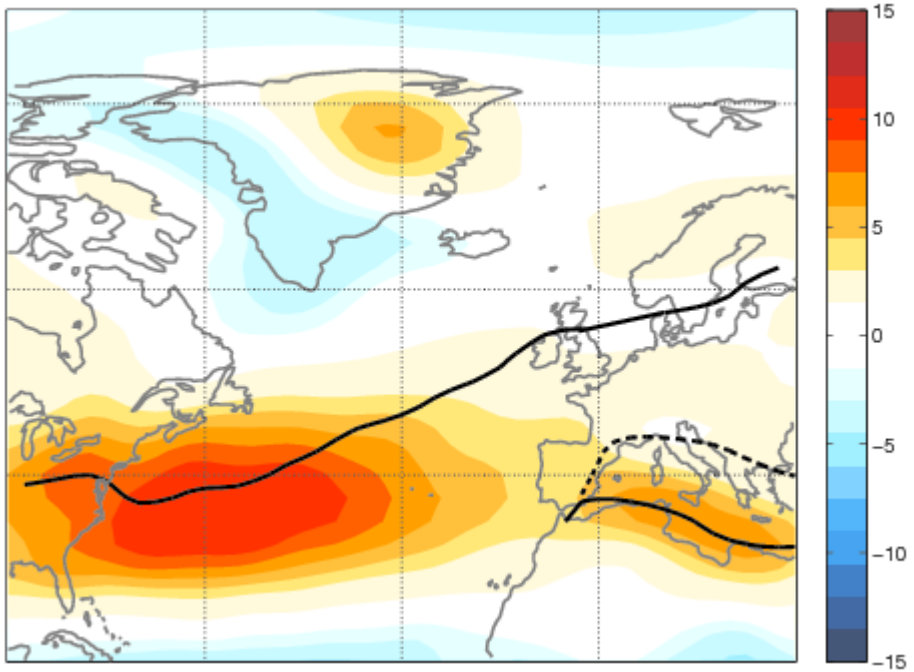

Zonal Wind–Pacific eddy forcing correlation
0.2
0.1
0
eddies lead
eddies lag
−30
−20
−10
0
10
20
30
lags (days)

U 300 hPa Composites

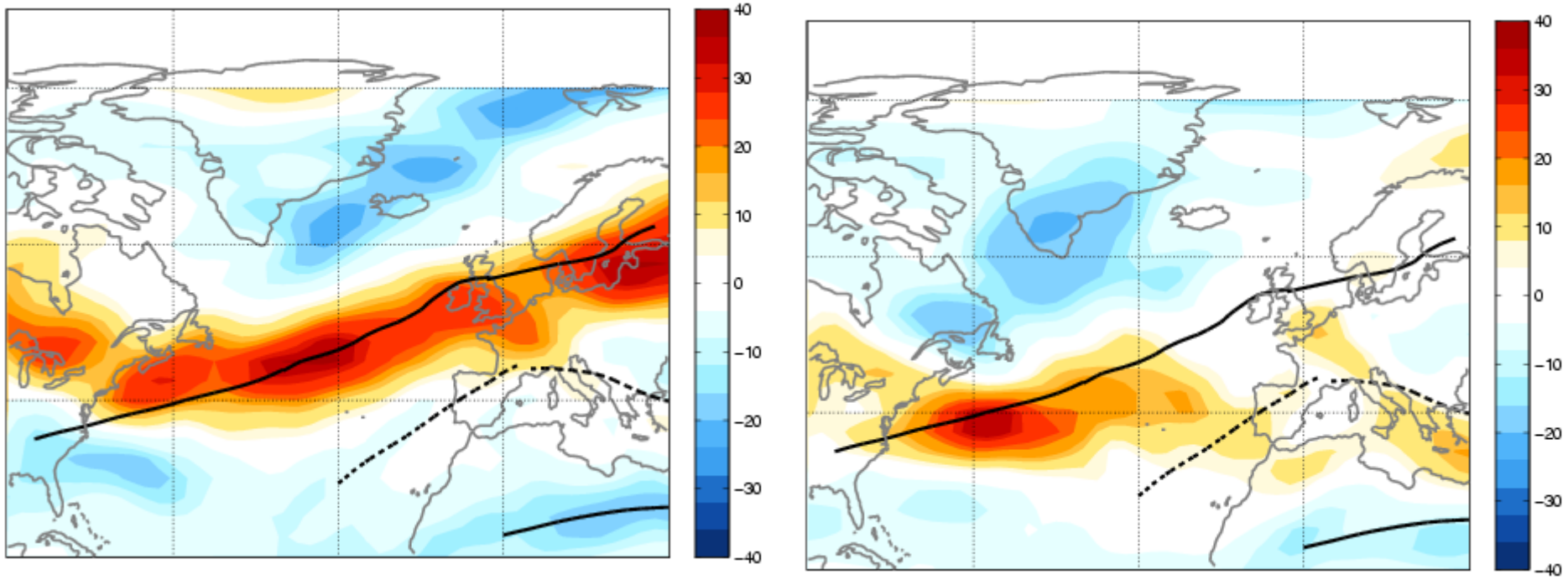


U 850 hPa Composites

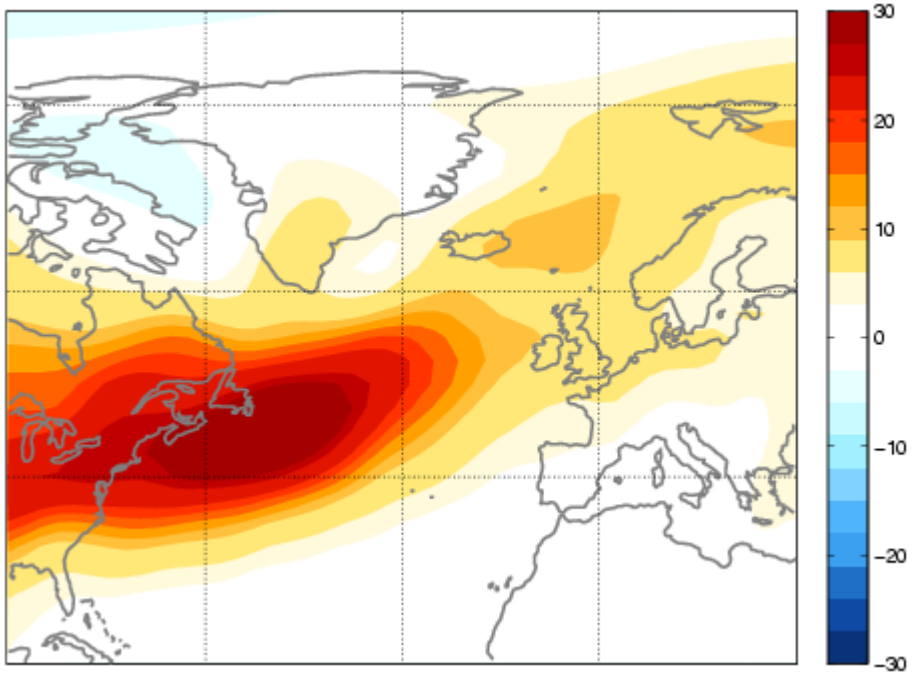


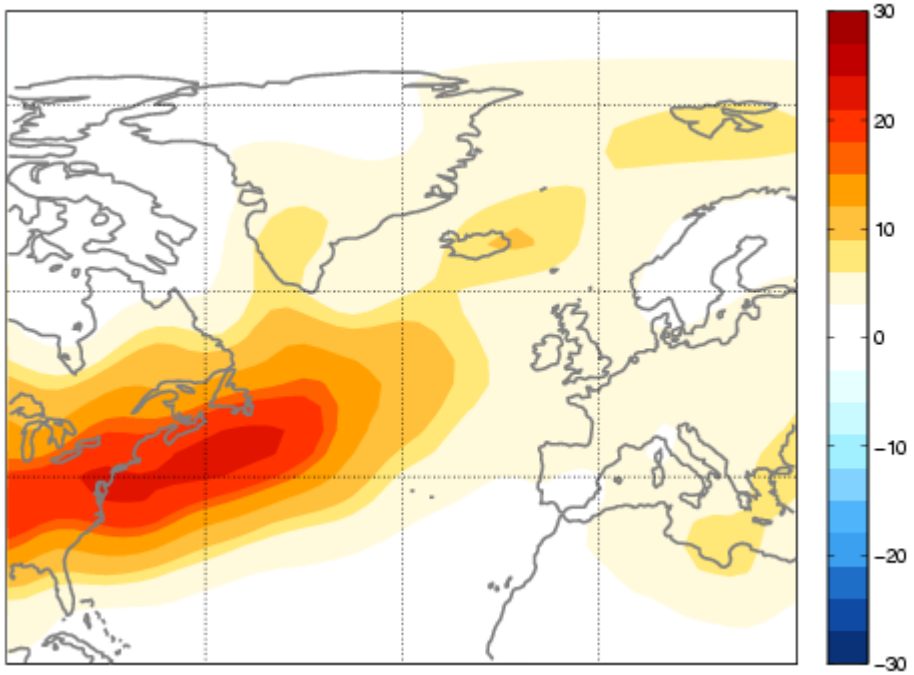


U'V'$_y$ 300 hPa Composites



V’T’ 850 hPa Composites

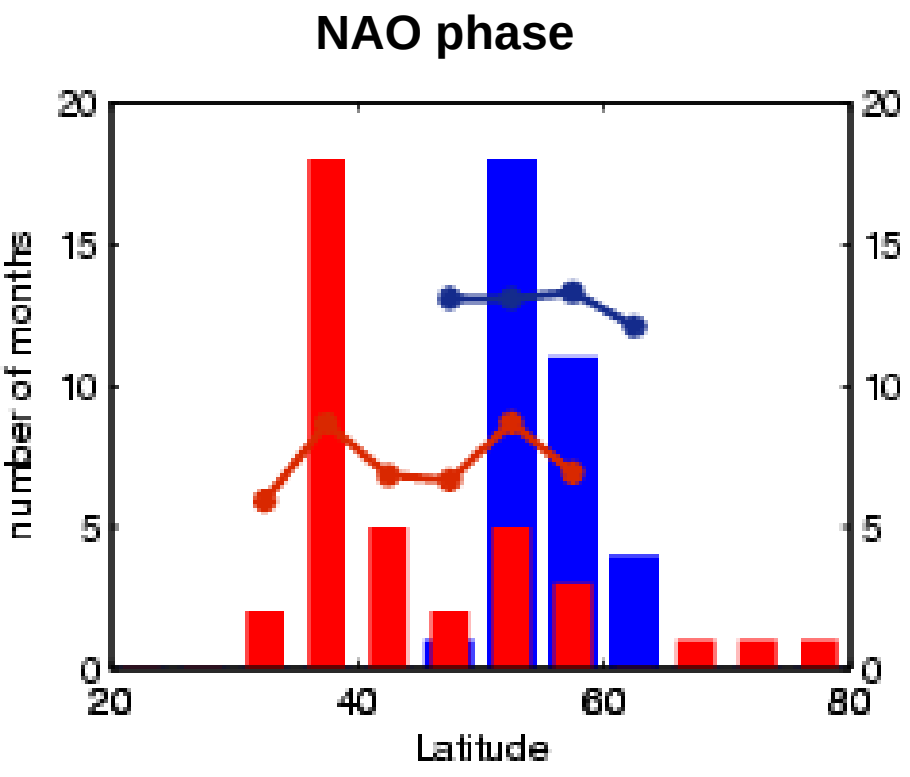


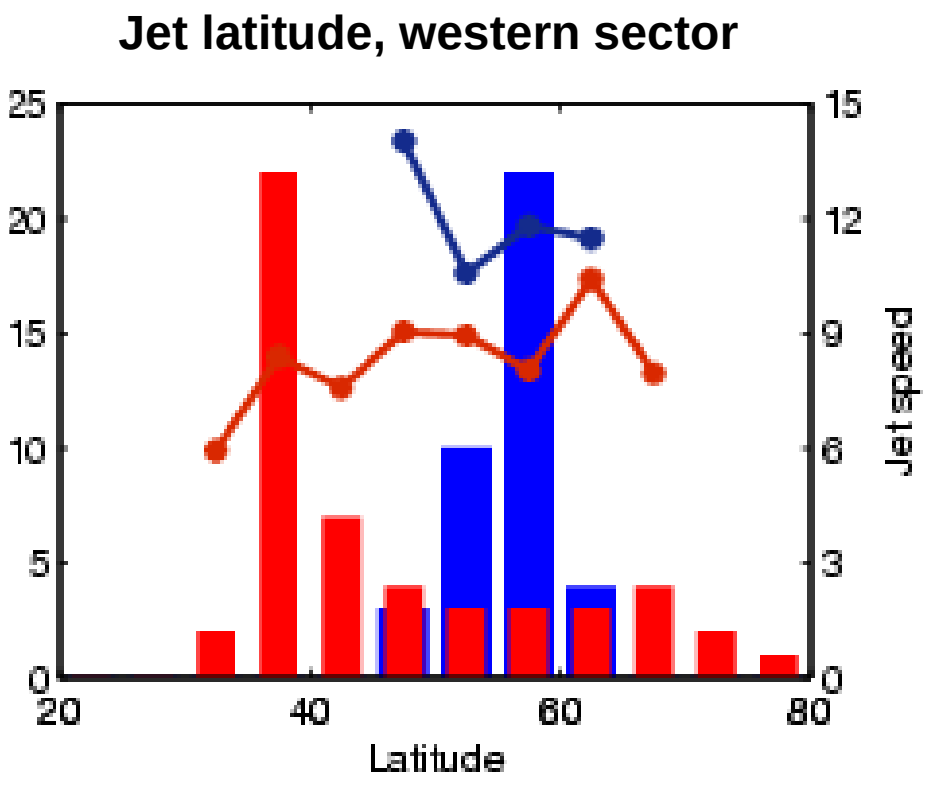


Same results if compositing by:

- Jet latitude in the west
- Jet speed in the west

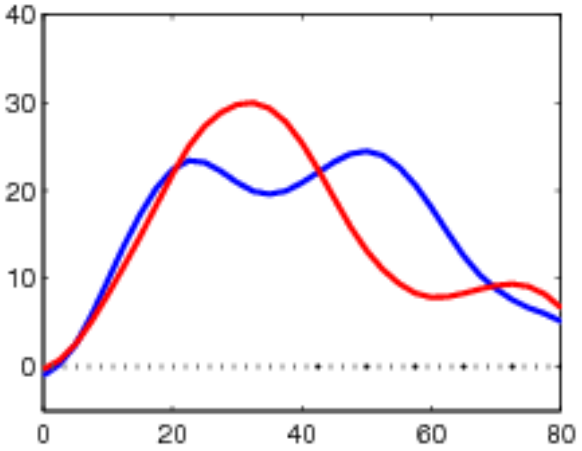
Distribution of Jet latitude and speed, *Eastern* Sector

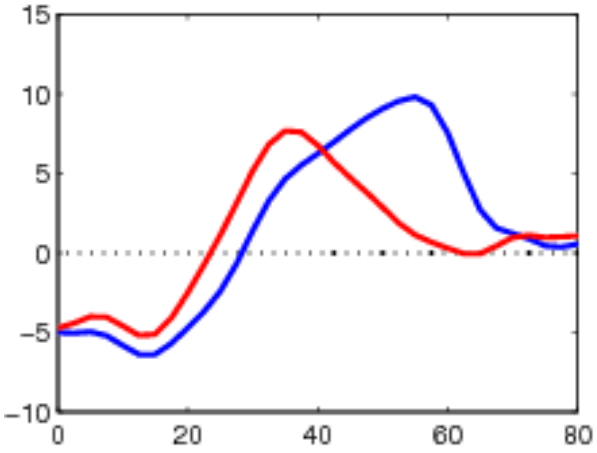




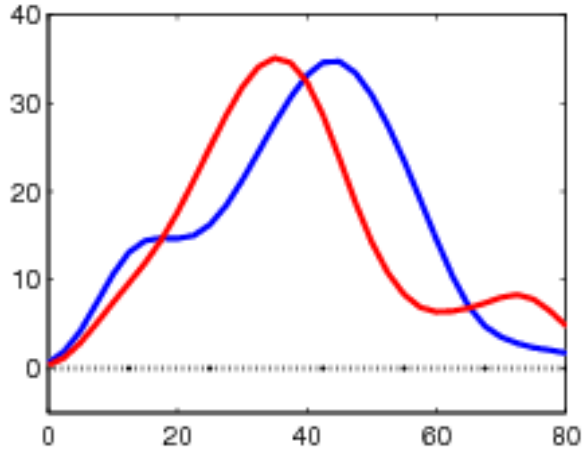
Composites of zonally-averaged zonal wind

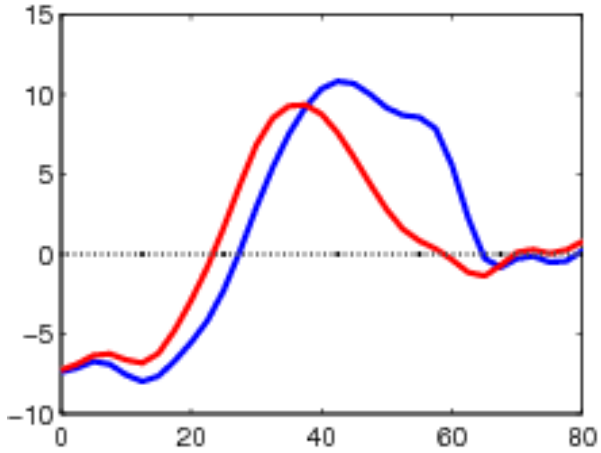
All Atlantic





West Sector





East Sector