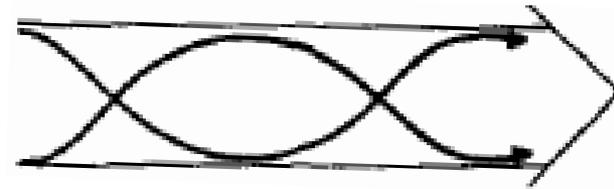
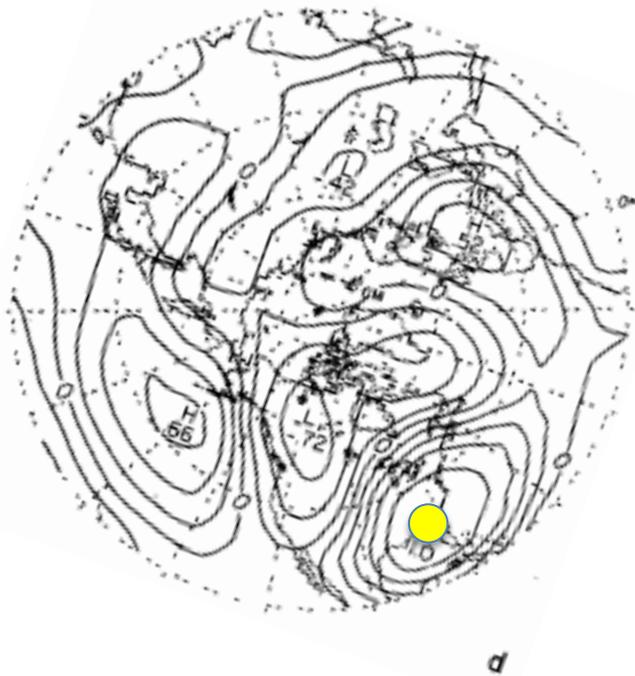


Tropospheric Waveguide Teleconnections in Winter and Summer

Branstator & Teng
NCAR



1 point correlations



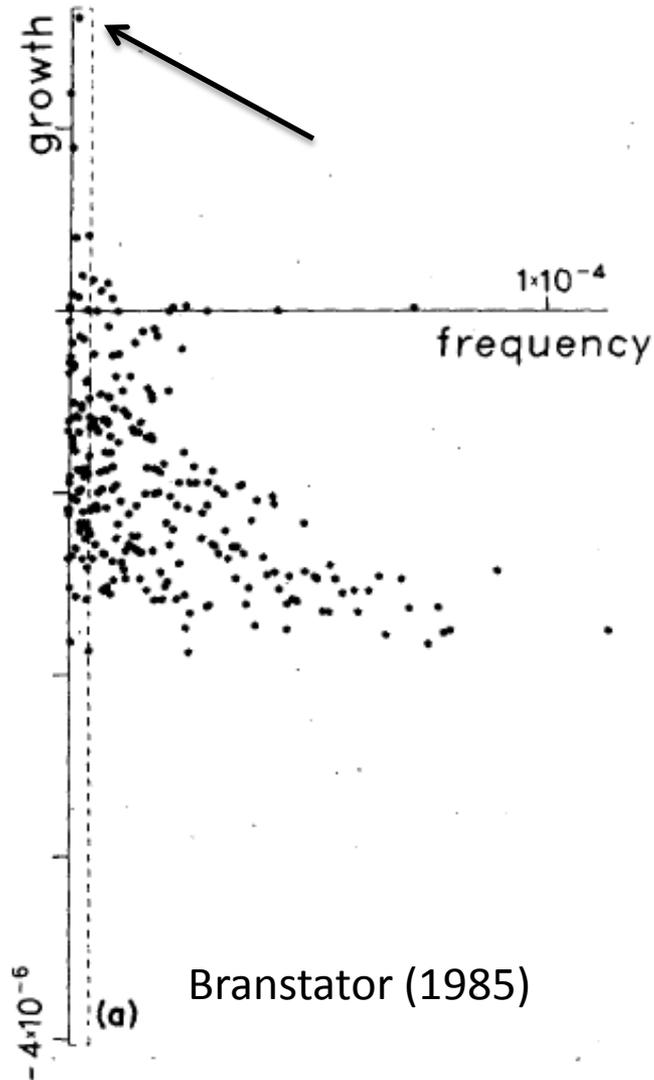
DJF Monthly mean 500hPa heights

Wallace & Gutzler (1981)

Eigenspectrum

Linear Nondivergent Barotropic Vorticity Eqn

Jan Mean 300hPa Basic State

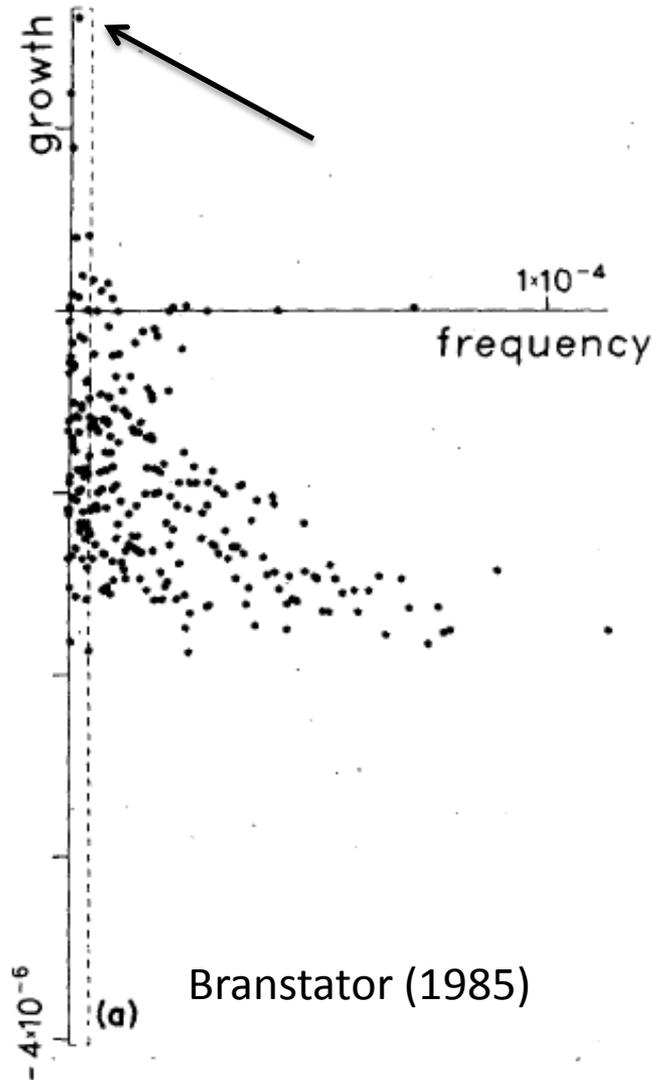


Branstator (1985)

Eigenspectrum

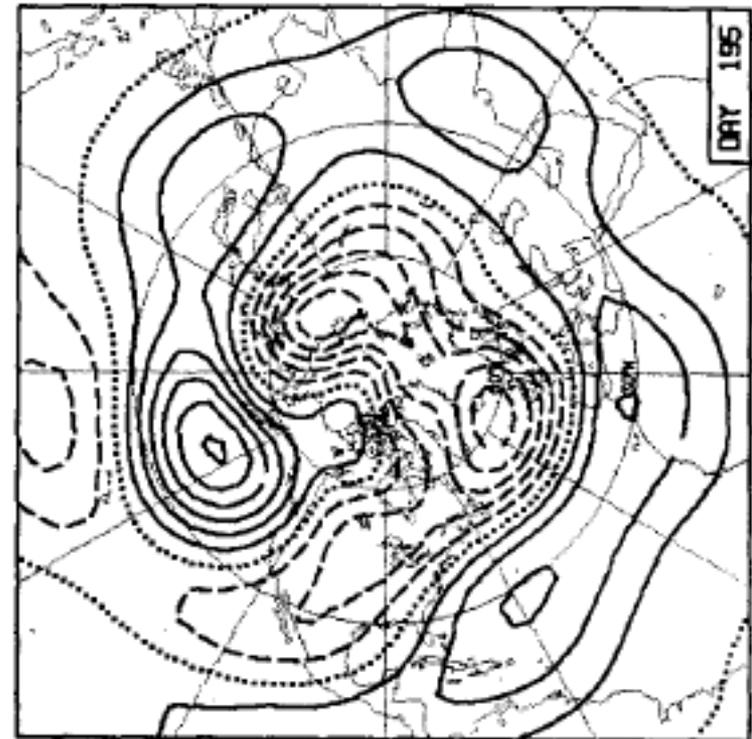
Linear Nondivergent Barotropic Vorticity Eqn

Jan Mean 300hPa Basic State



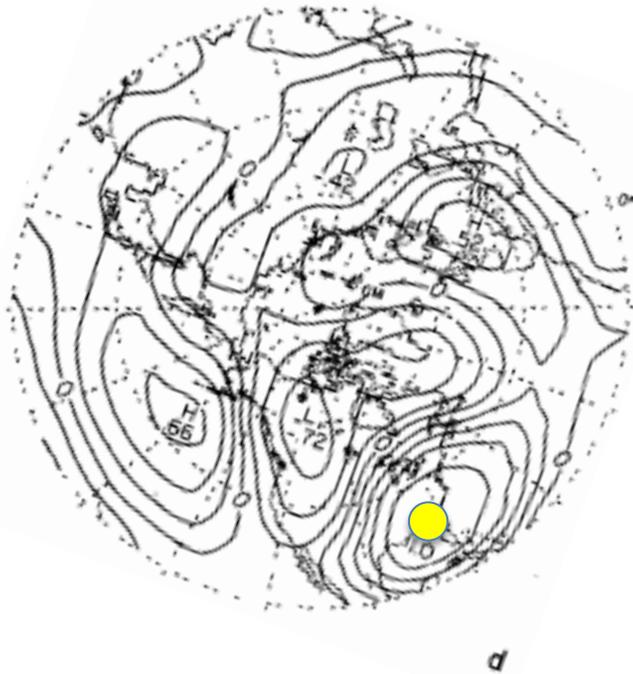
Branstator (1985)

Leading normal mode



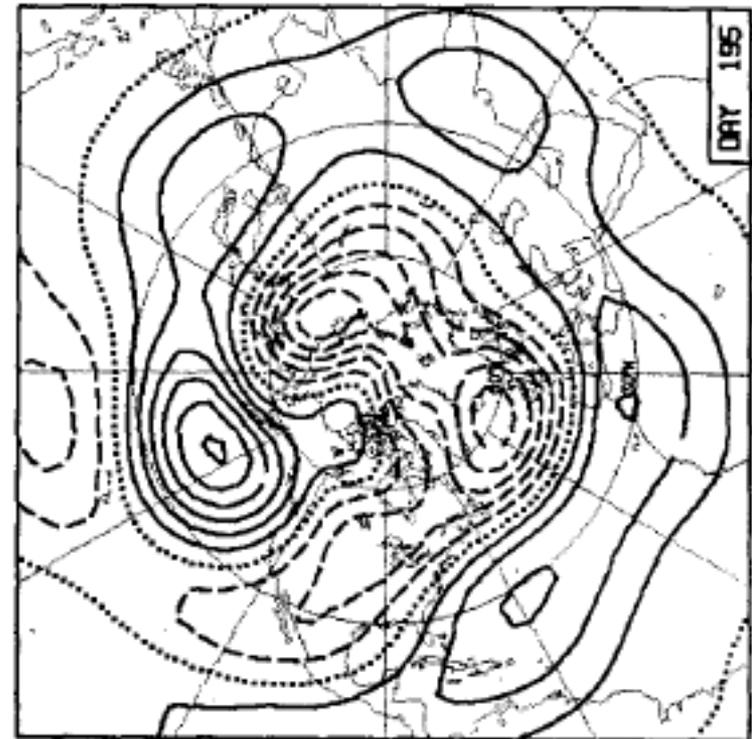
Simmons et al. (1983)

1 point correlations



DJF Monthly mean 500hPa heights
Wallace & Gutzler (1981)

Leading normal mode

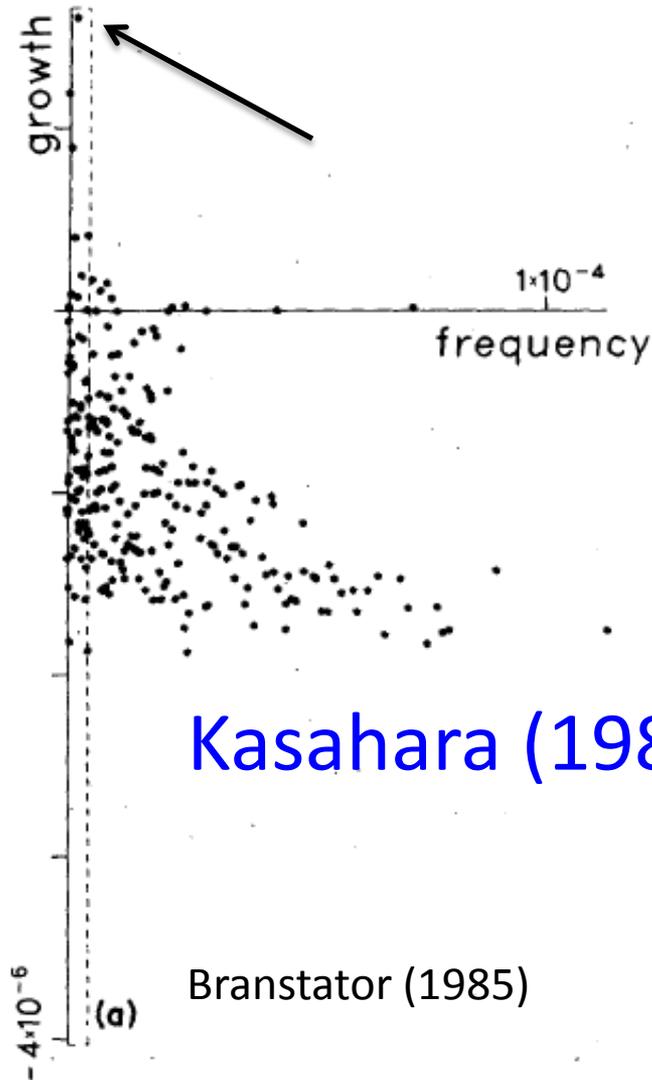


Simmons et al. (1983)

Eigenspectrum

Linear Nondivergent Barotropic Vorticity Eqn

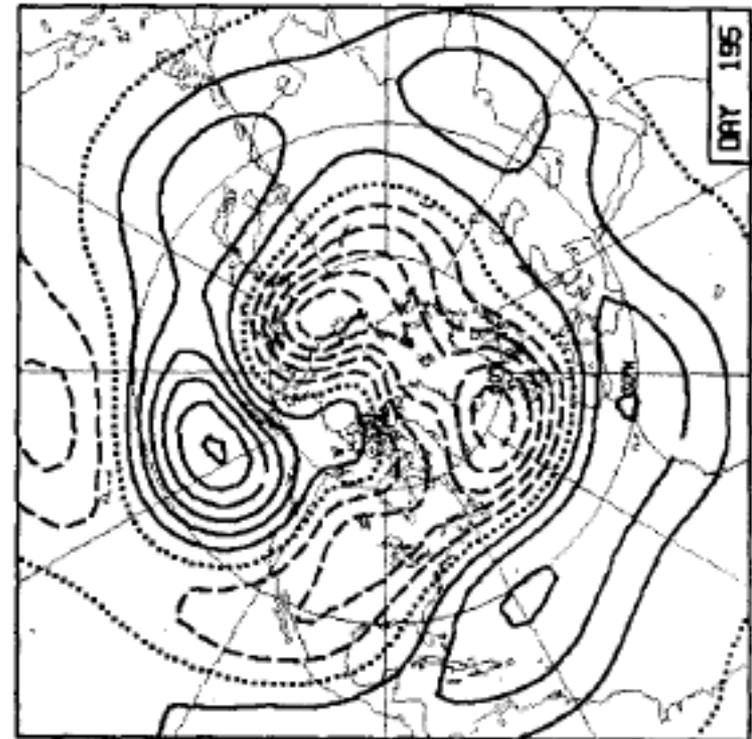
Jan Mean 300hPa Basic State



Kasahara (1980)

Branstator (1985)

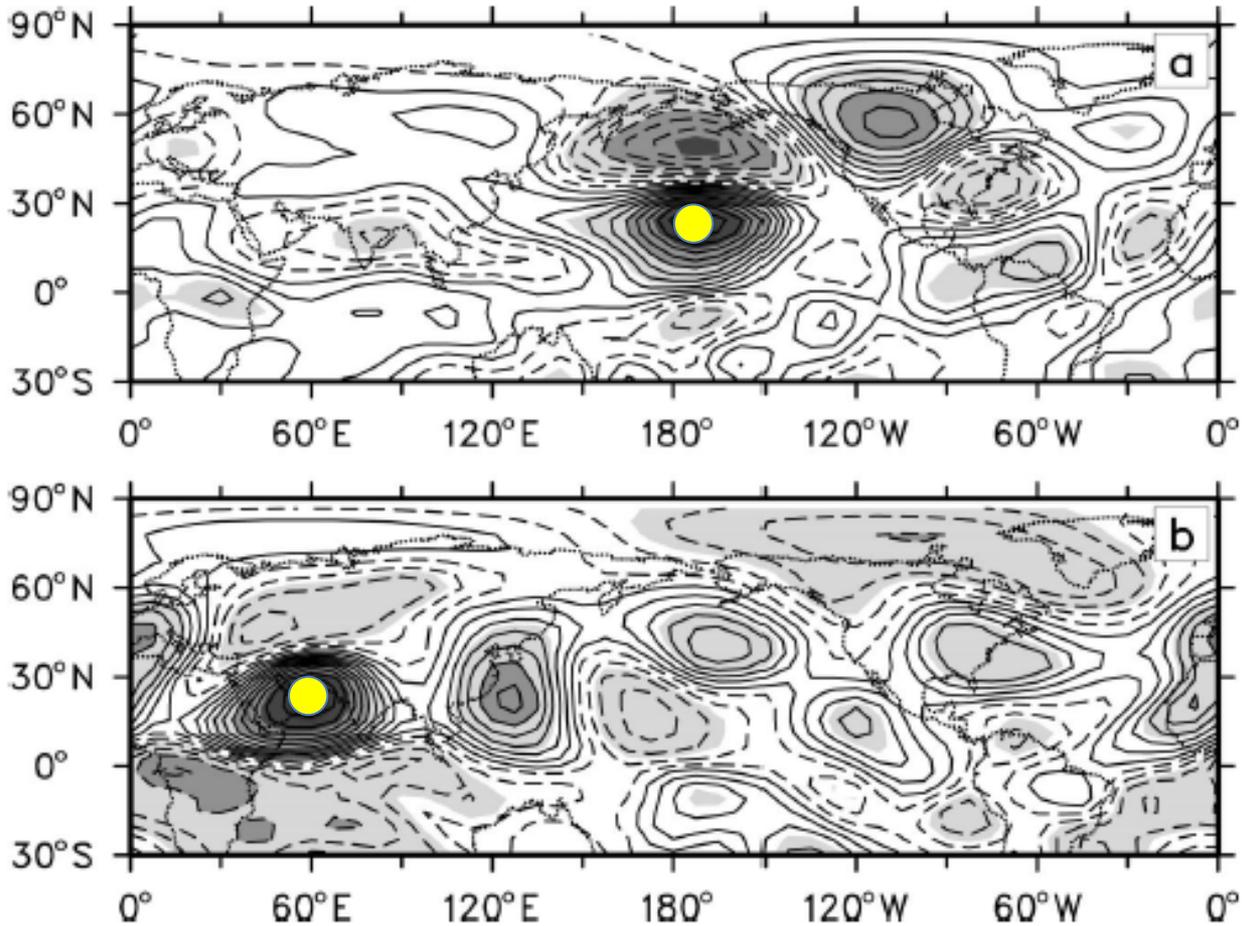
Leading normal mode



Simmons et al. (1983)

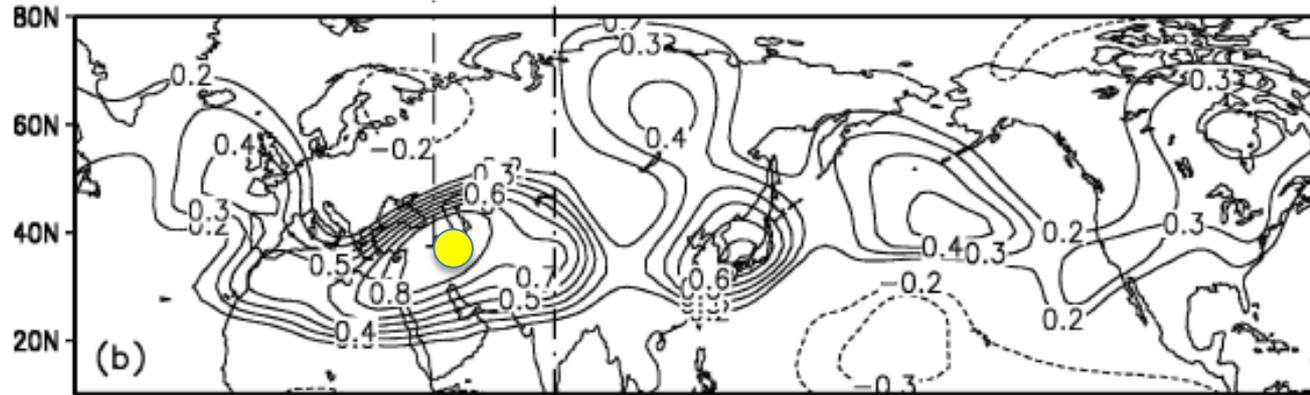
DJF 300hPa Streamfunction

1 point correlations



Branstator 2002

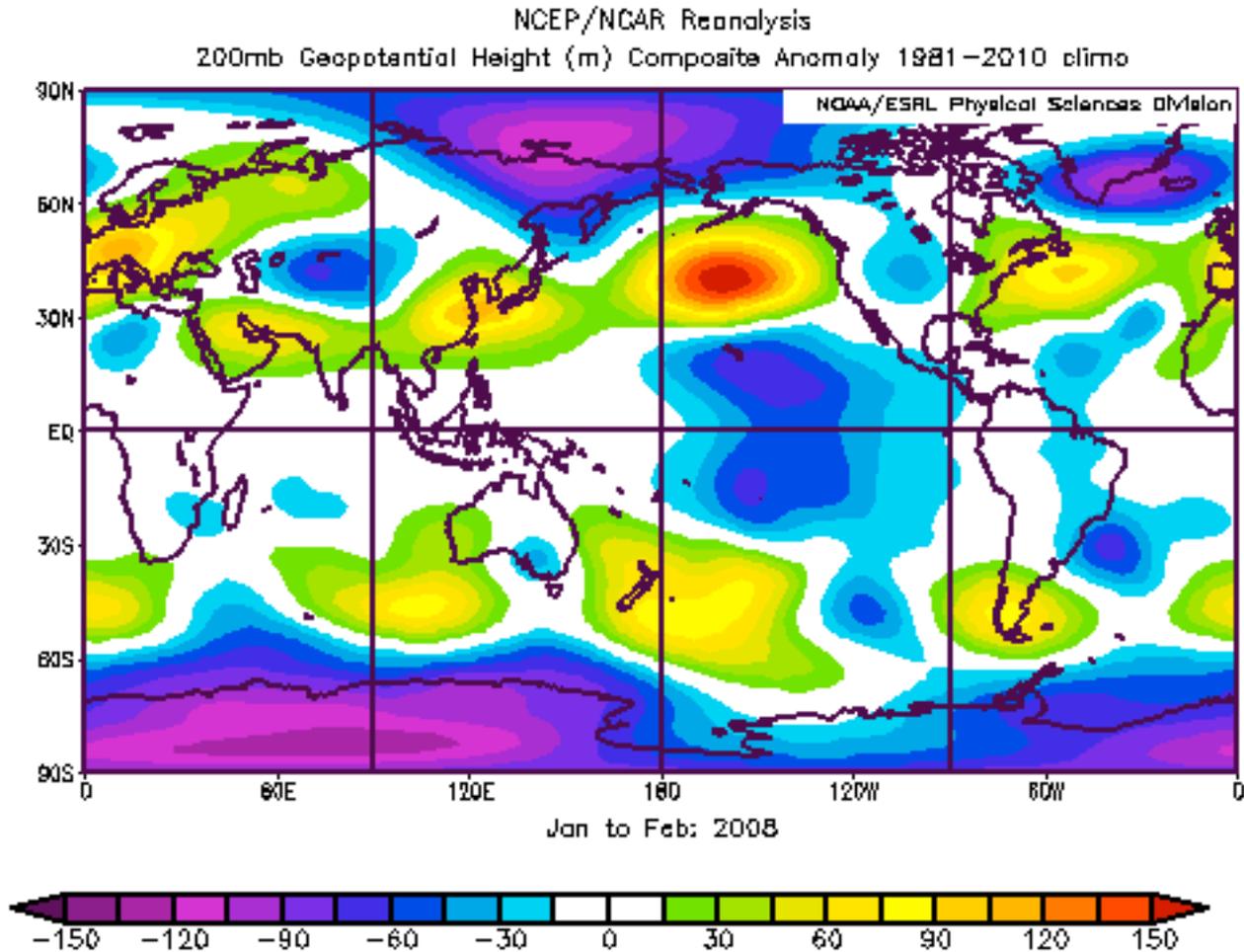
JJAS mean 200hPa heights 1 point correlations



Ding & Wang 2005

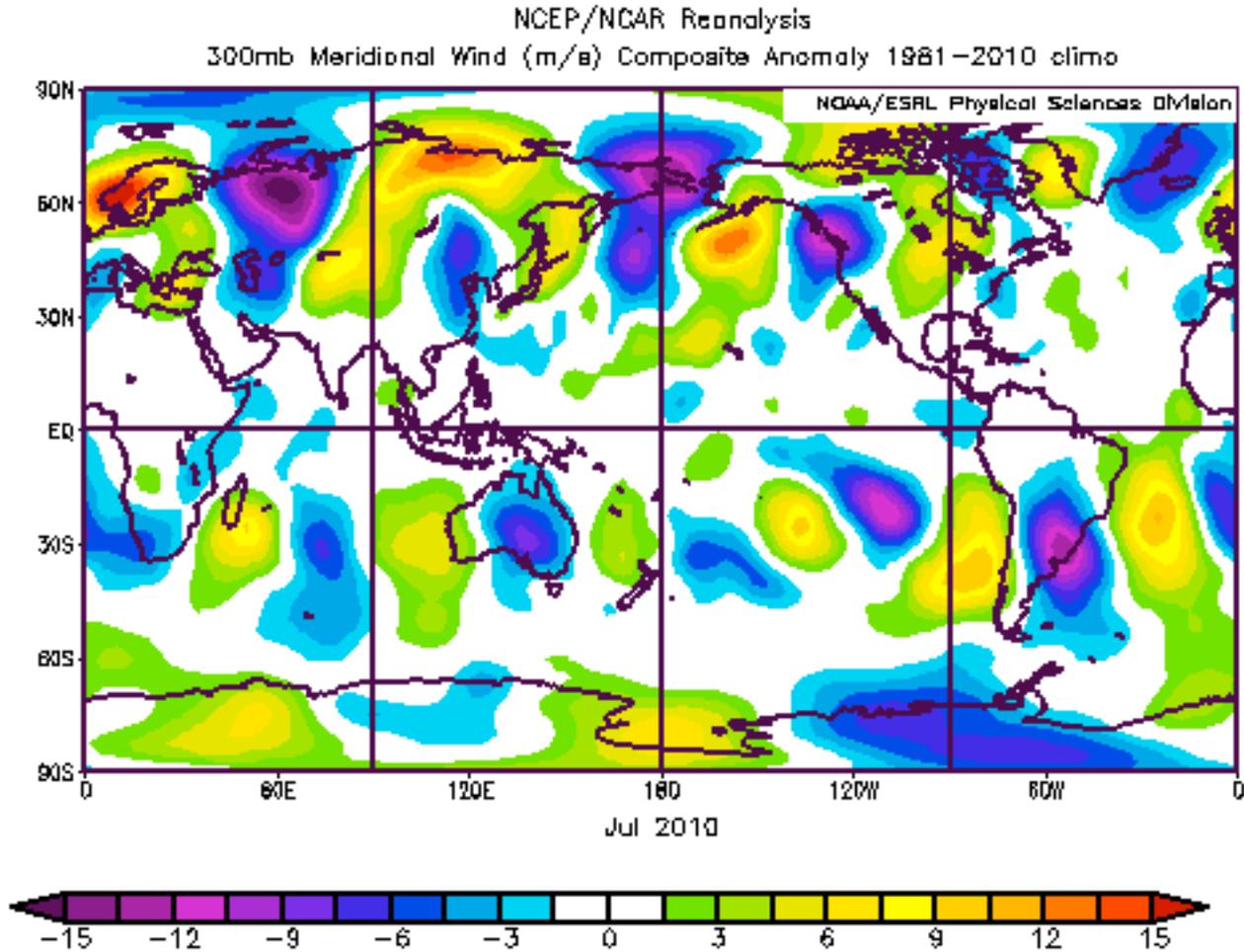
Jan-Feb 2008

200hPa height anomalies

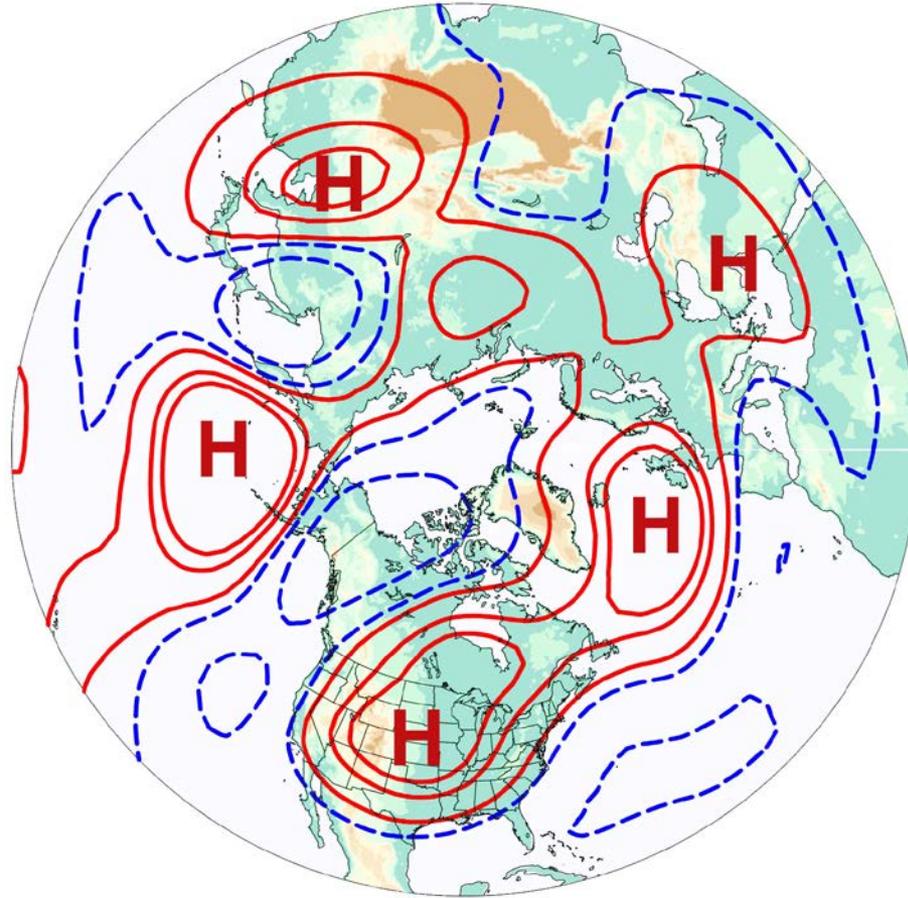


Jul 2010

300hPa meridional wind anomalies

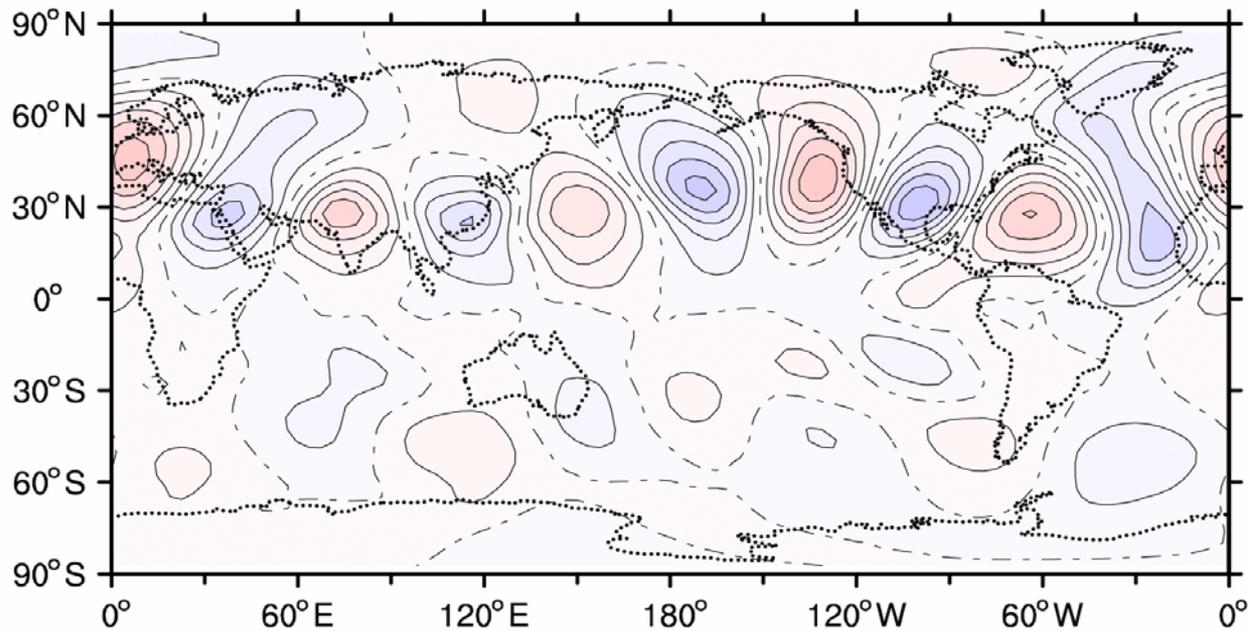


300hPa JJA anomalies
5 days before US Great Plains heat waves
CAM3



Teng et al. (2013)

CCSM1.4
KNMI 62member v300 DJF
2051-2080 minus 1941-1970

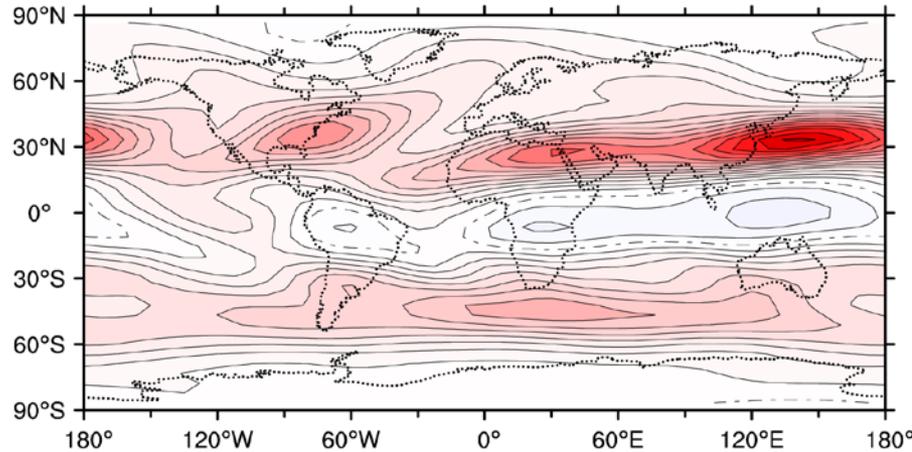


Branstator & Selten (2009)

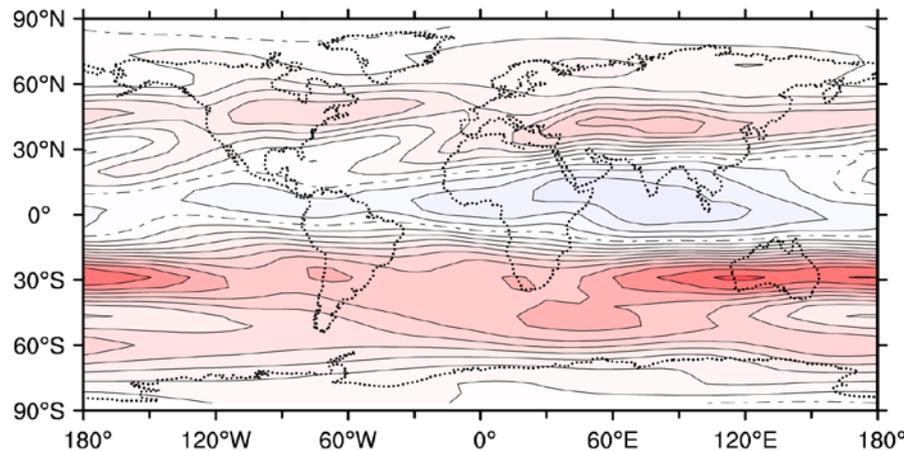
Nature

mean u200

DJF



JJA



5 m/s

Refractive index

$$K_s = \left(\frac{\beta_*}{\bar{U}} \right)^{1/2}$$

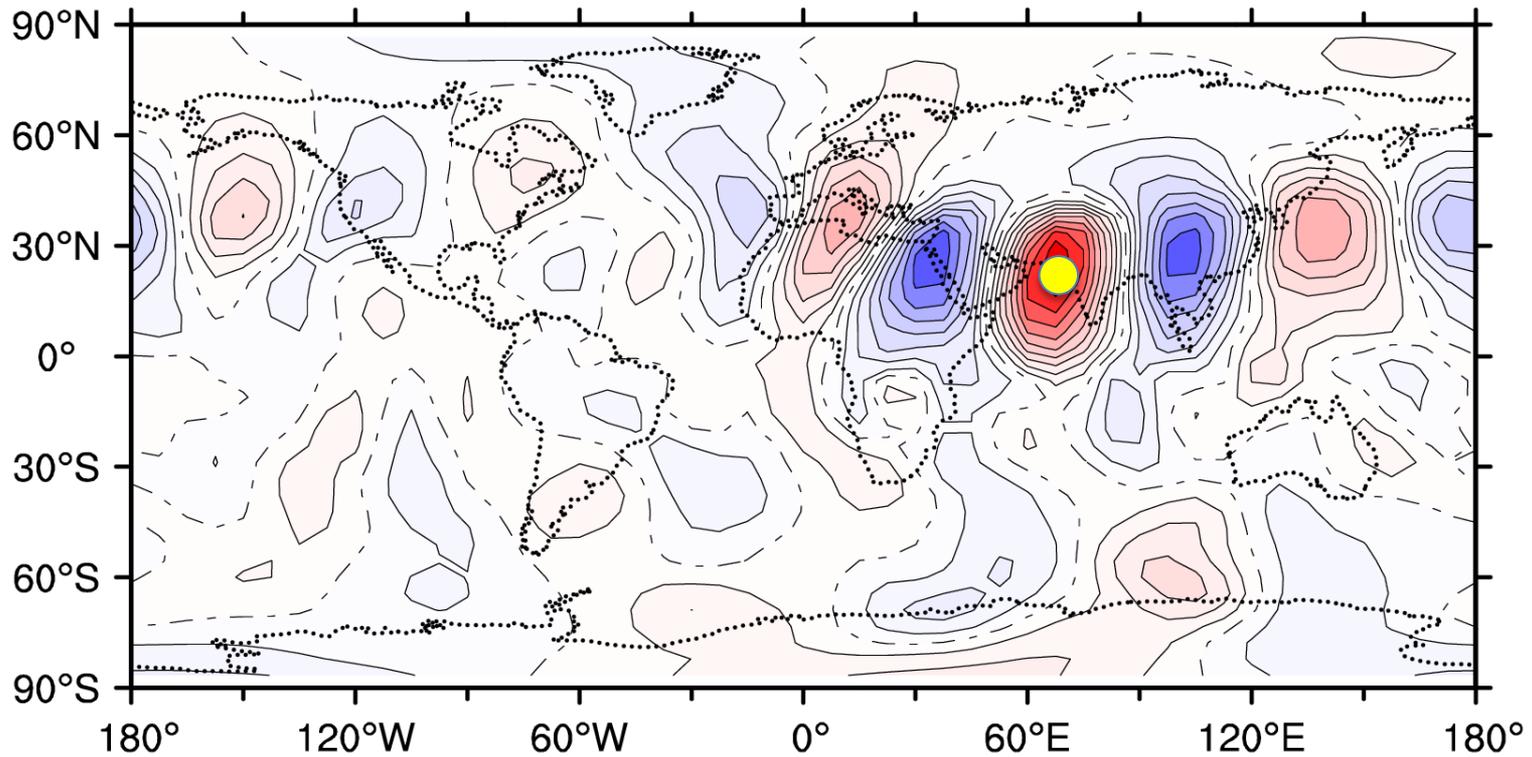
Group velocity

$$c_g = 2\bar{U} \cos \alpha.$$

Hoskins & Ambrizzi (1993)

Nature

v200 1 pt correlation
(1958-2014 DJF 3x30d_subseason)

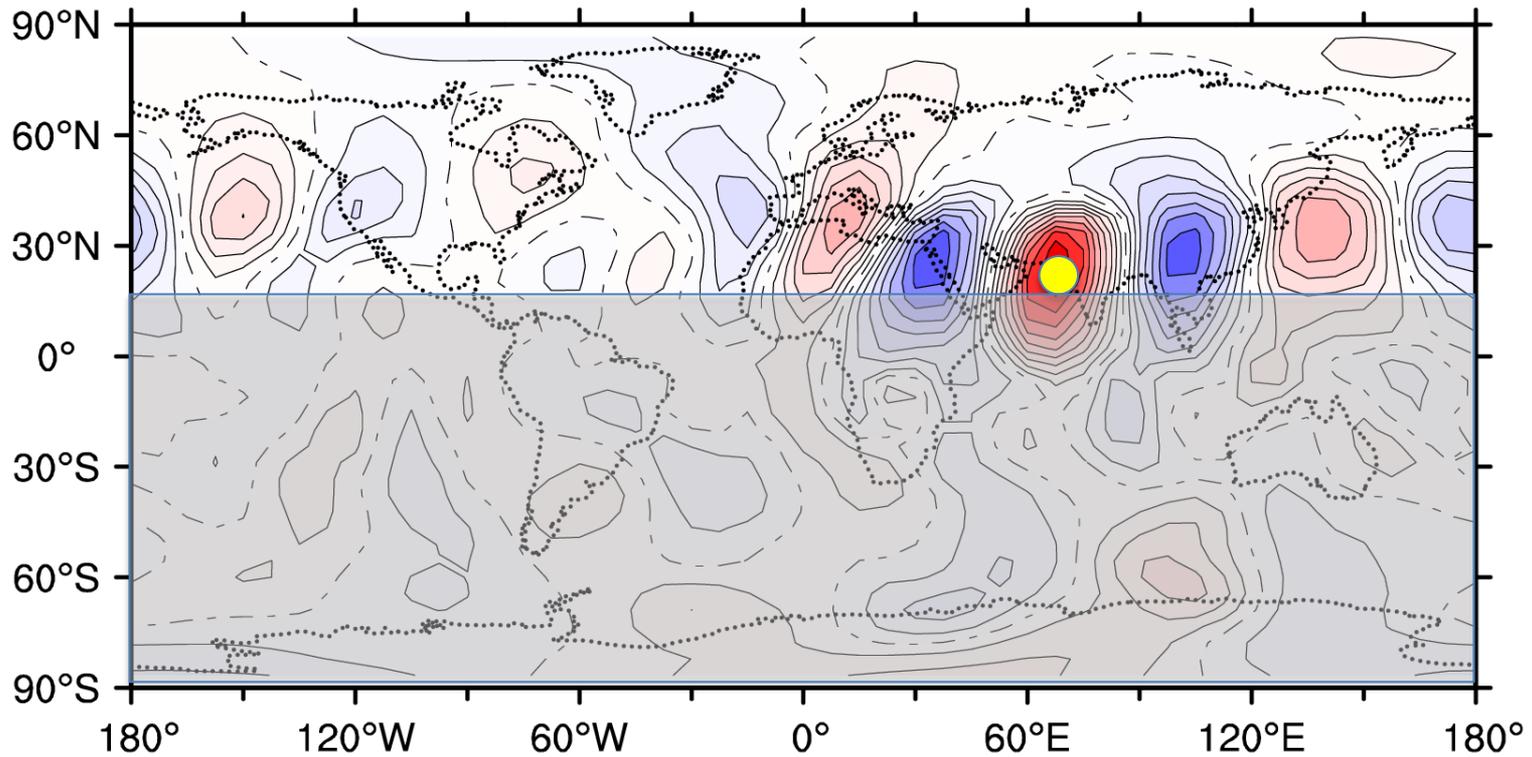


contour=0.1

Nature

v200 1 pt correlation
(1958-2014 DJF 3x30d_subseason)

“Extratropical Teleconnectivity” -- “RMScor_{extra}”

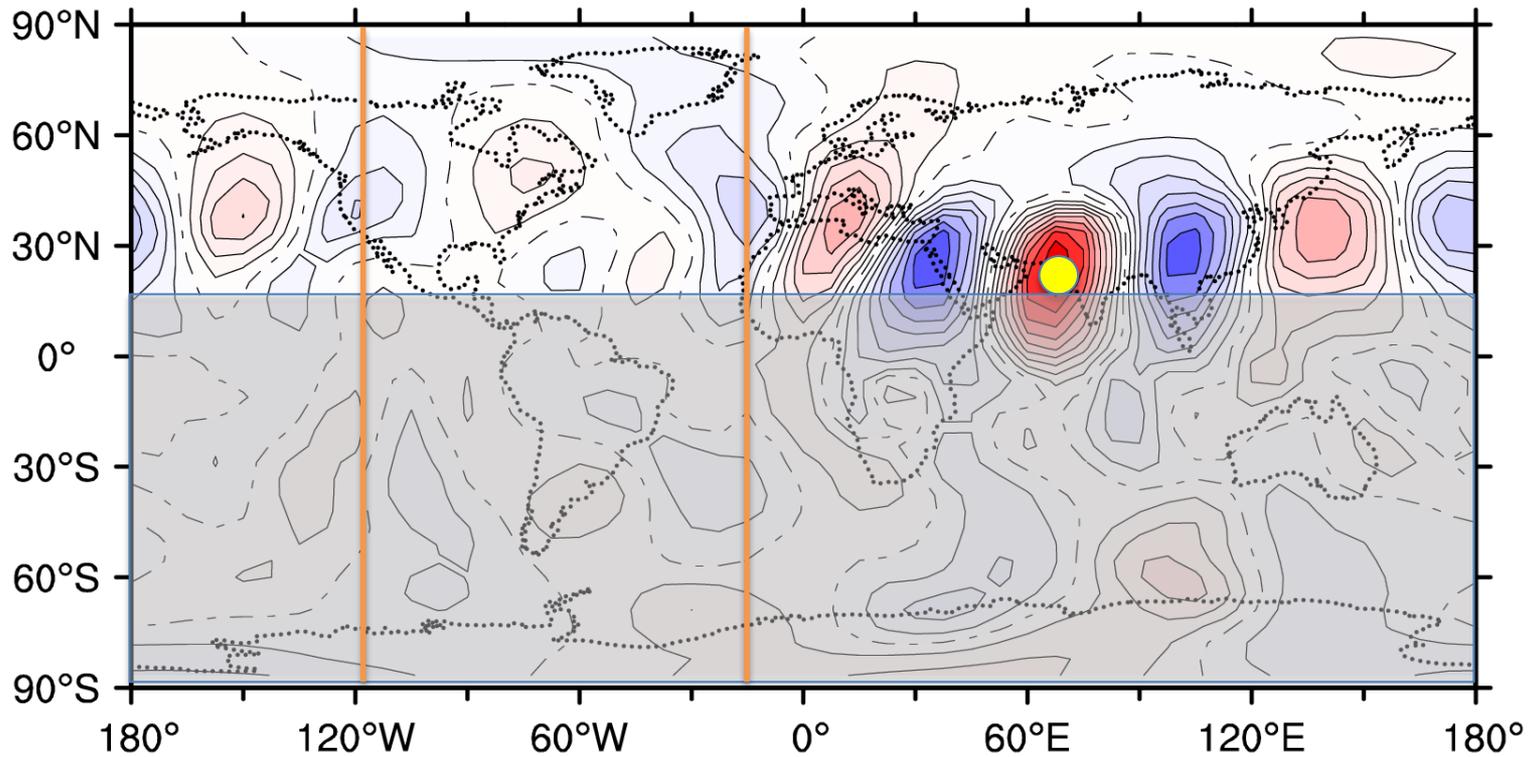


contour=0.1

Nature

v200 1 pt correlation
(1958-2014 DJF 3x30d_subseason)

“Span”

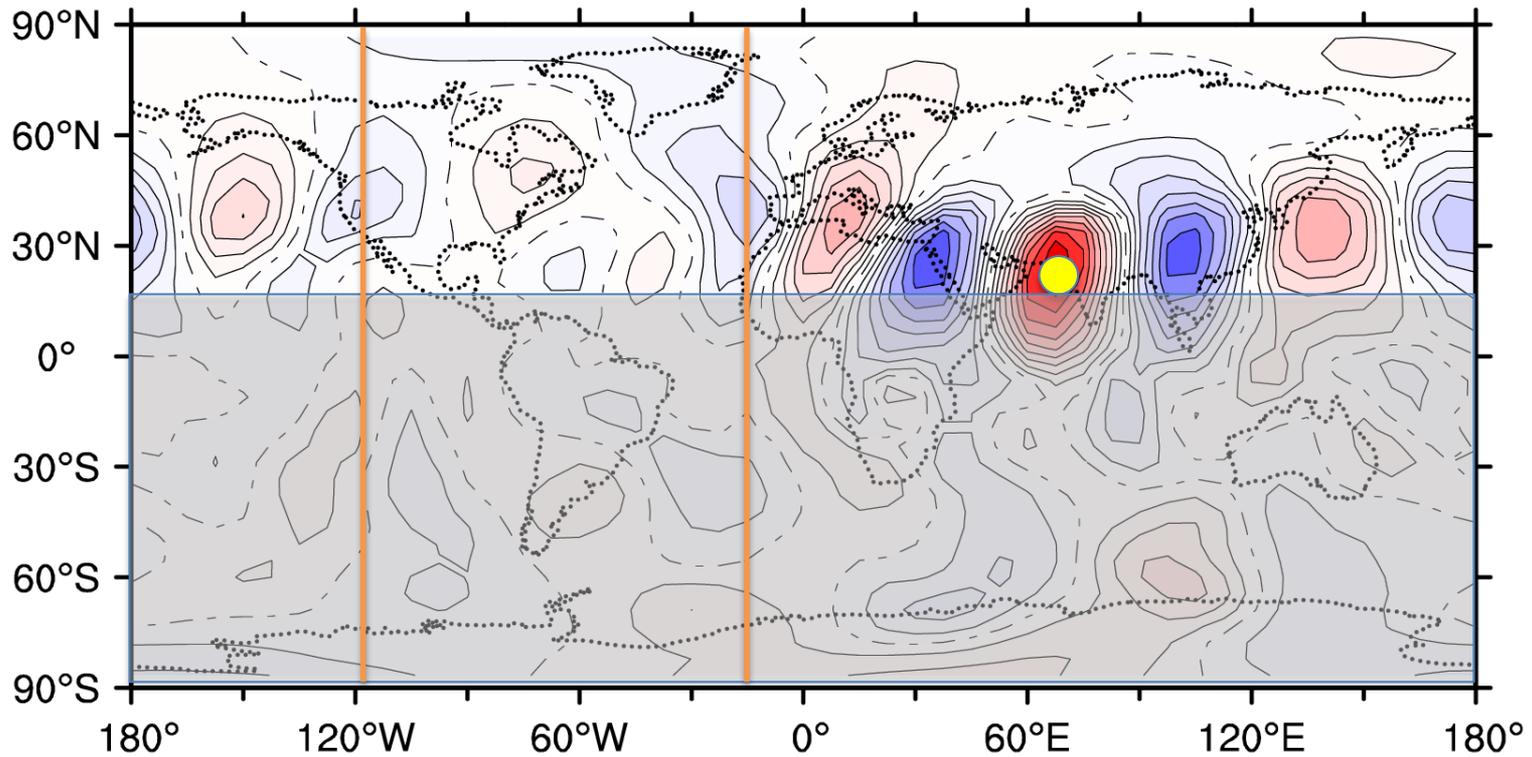


contour=0.1

Nature

v200 1 pt correlation
(1958-2014 DJF 3x30d_subseason)

“Span”

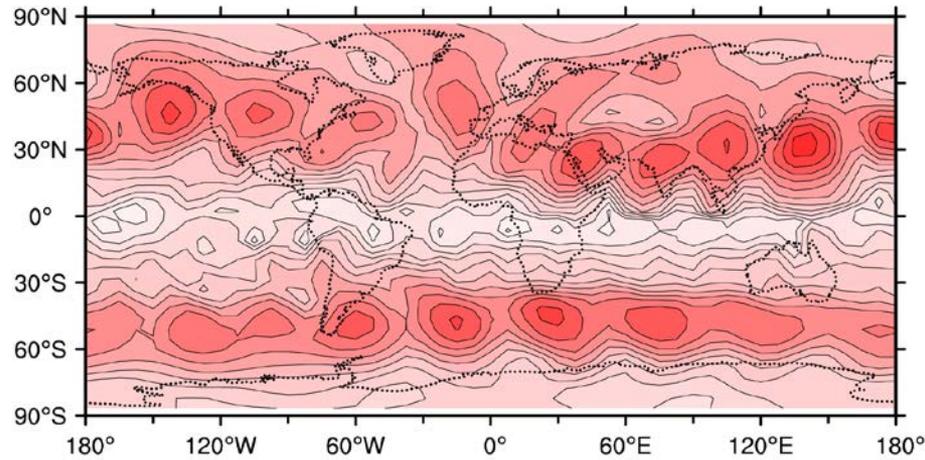


“Circumglobal”?

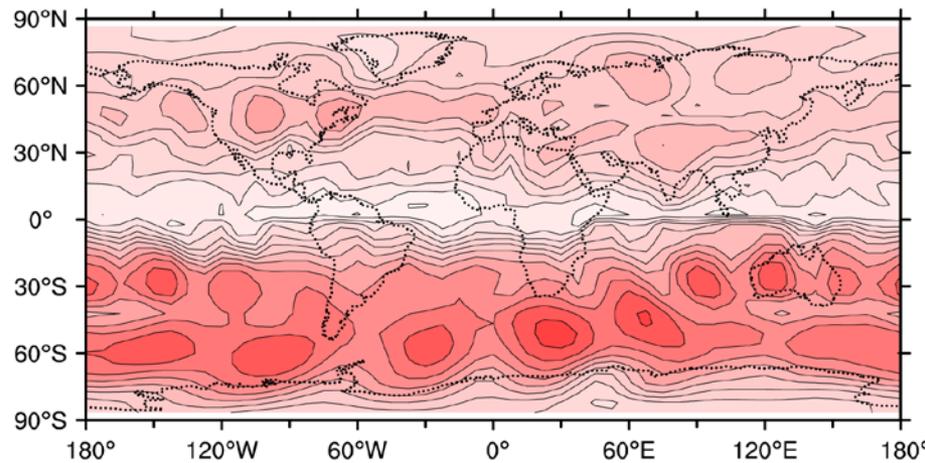
contour=0.1

Nature

Extratropical teleconnectivity
(v200 $\text{RMScor}_{\text{extra}}$) (1958-2014 3x30d_subseason)



DJF



JJA

contour=0.02

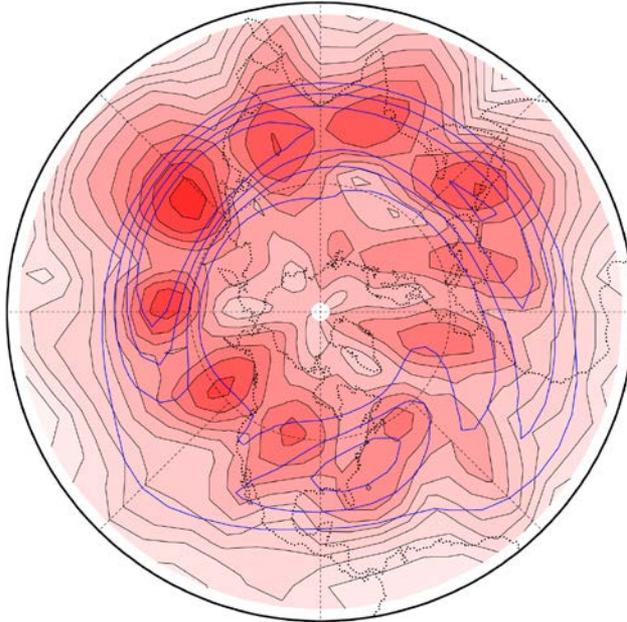
Nature

Extratropical teleconnectivity

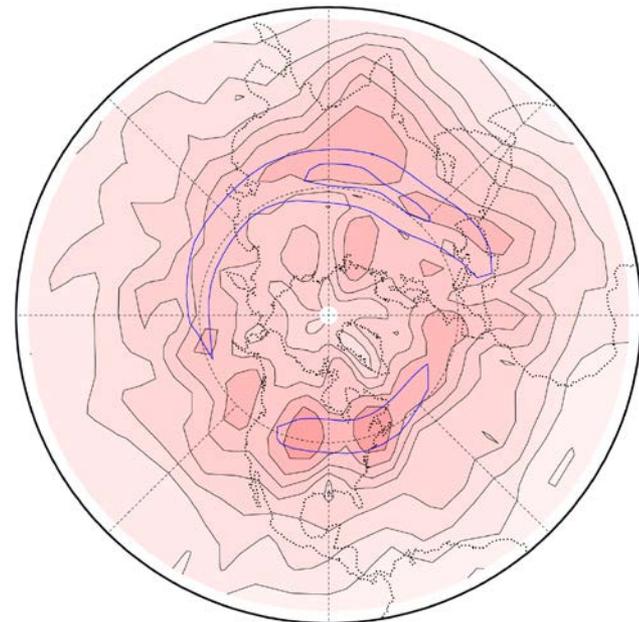
(v200 RMScor_{extra}) (1958-2014 3x30dmeans_sub)

blue contour=mean u200

DJF



JJA

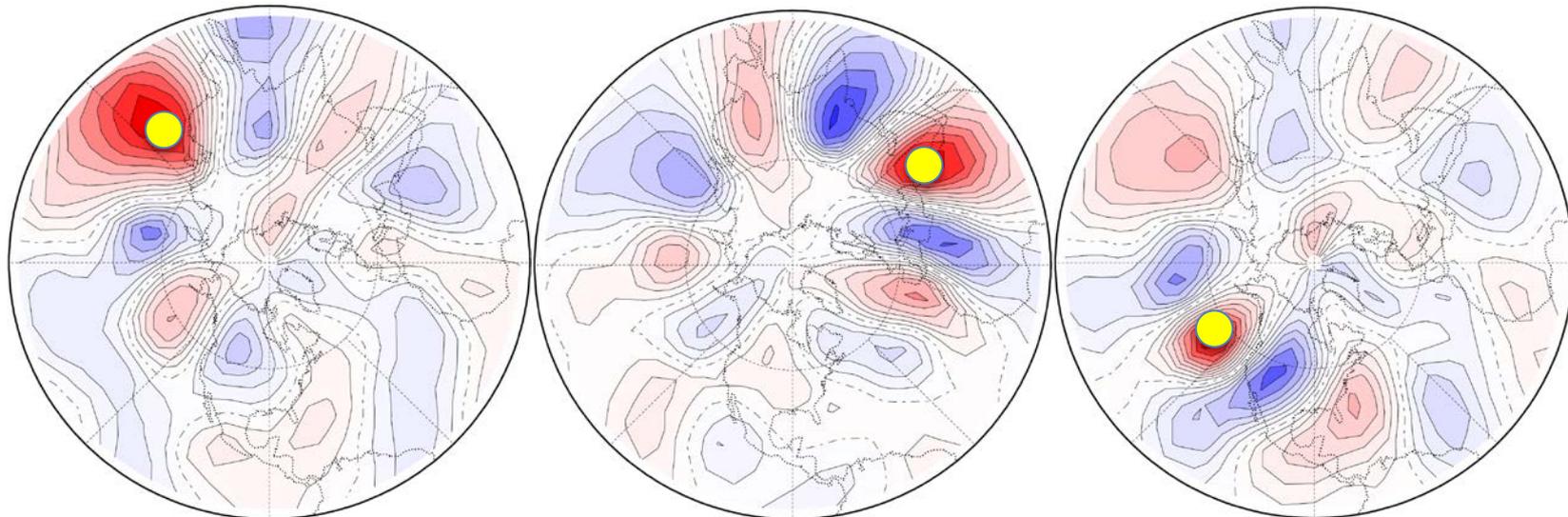


contour=0.02

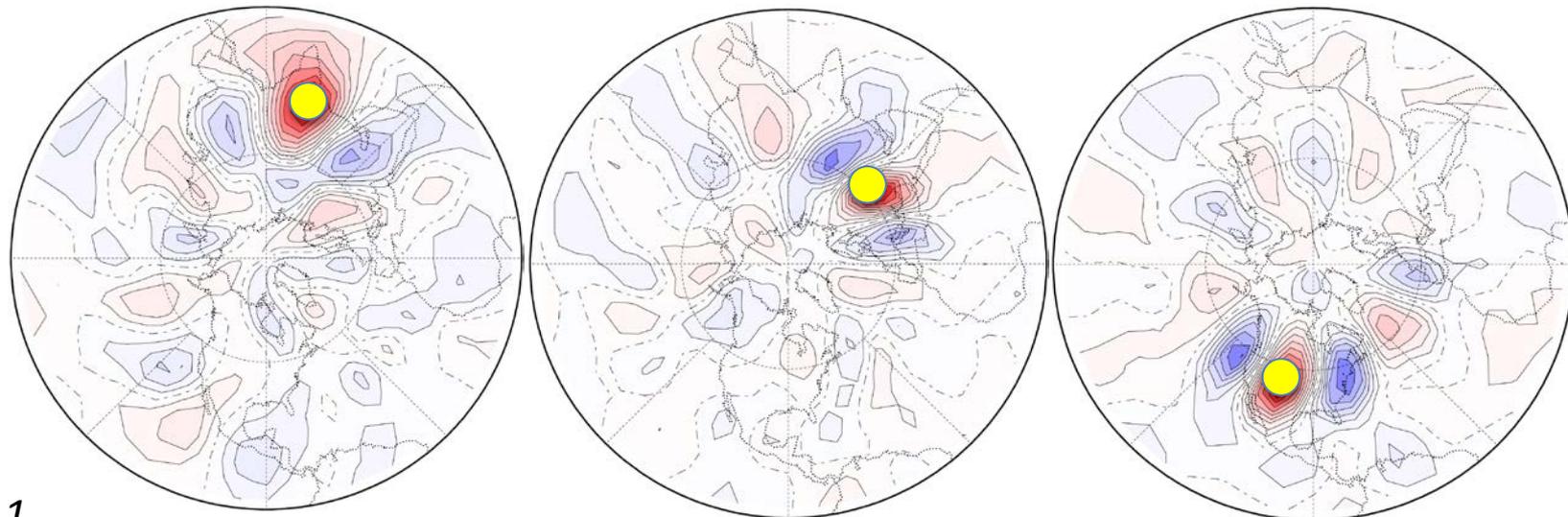
Nature

Examples of Large East/West Span of v200
(1958-2014 3x30dmeans_subseason)

DJF



JJA



contour=0.1

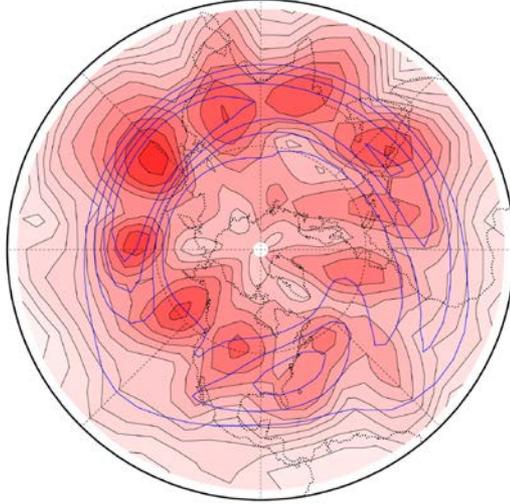
Nature vs CAM5

Extratropical teleconnectivity (v200 RMScor_{extra})

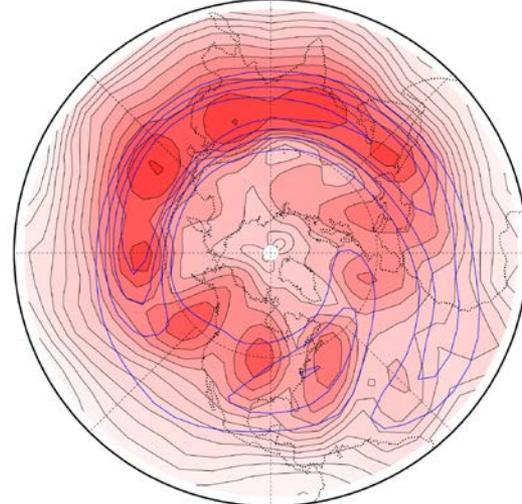
1958-2014 3x30dmeans_subseason

1000yrs 3x30dmeans_subseason

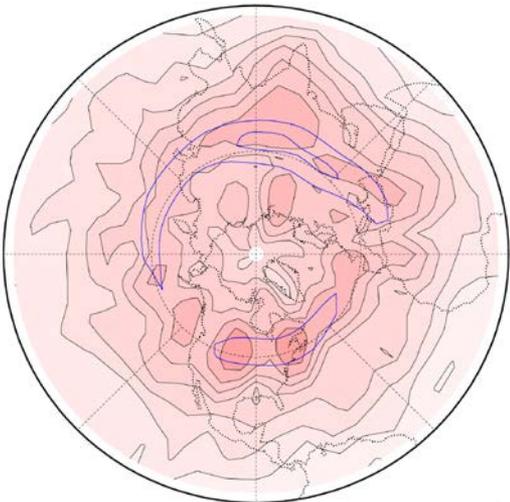
DJF



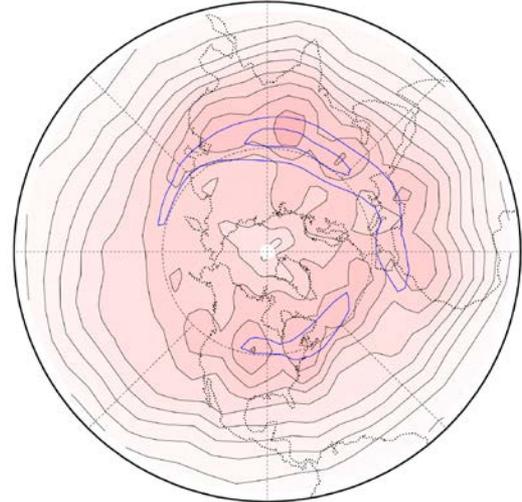
DJF



JJA



JJA



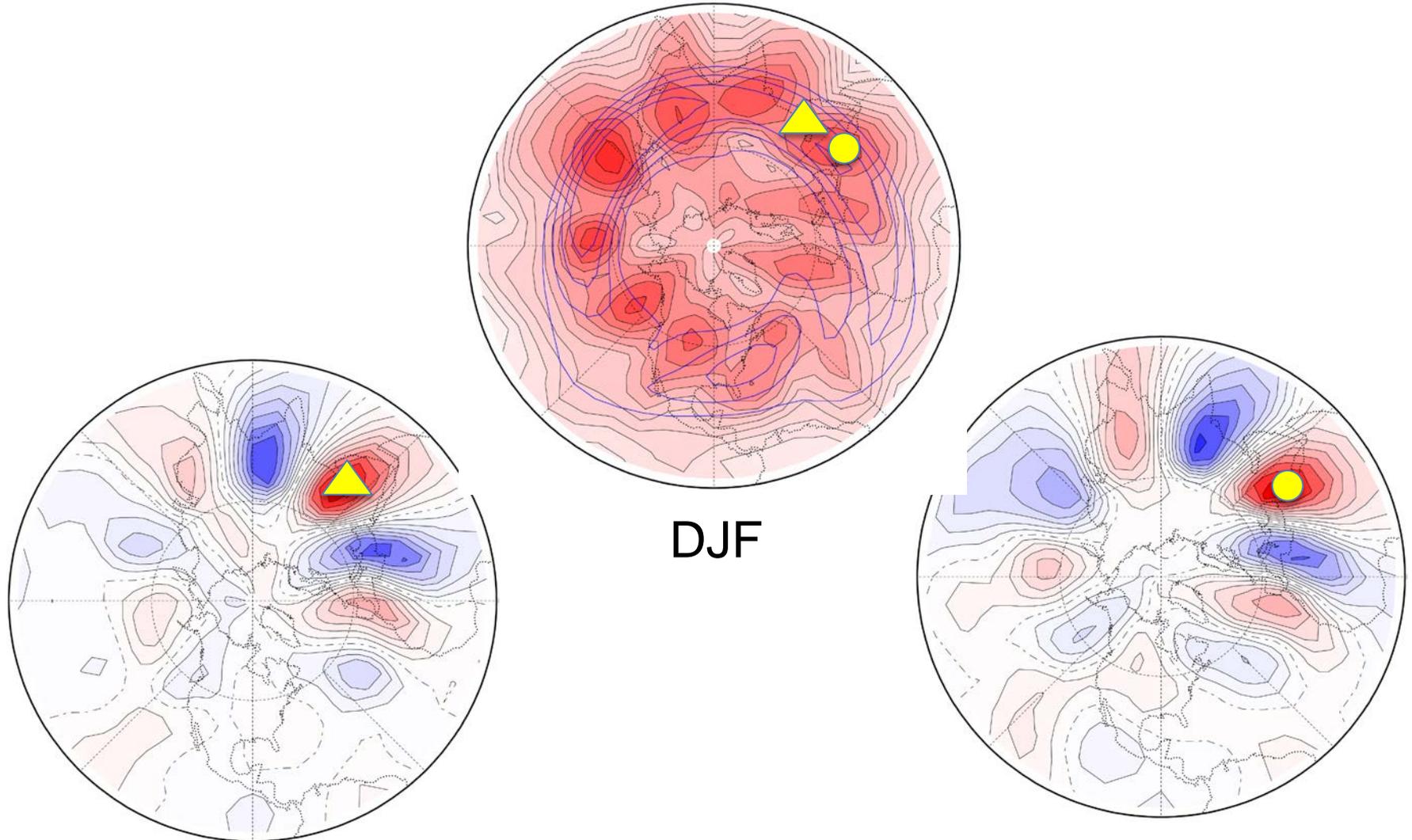
contour=0.02

Nature

Extratropical teleconnectivity

(v200 $\text{RMScor}_{\text{extra}}$)

1958-2014 3x30dmeans_subseason



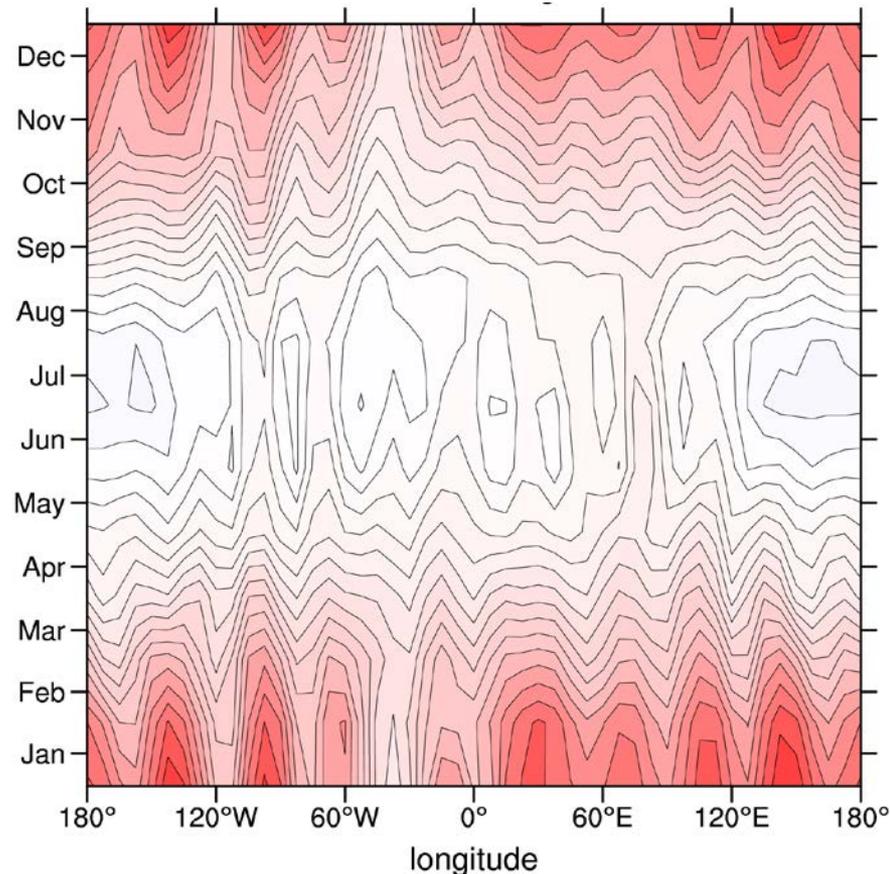
DJF

contour=0.02

CAM5

Seasonality of v200 $\text{RMScor}_{\text{extra}}$
(1000yrs 1x30dmean_subseason)

20N-60N



contour=0.008

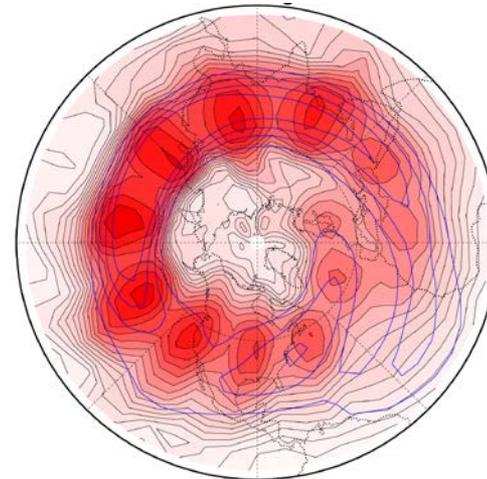
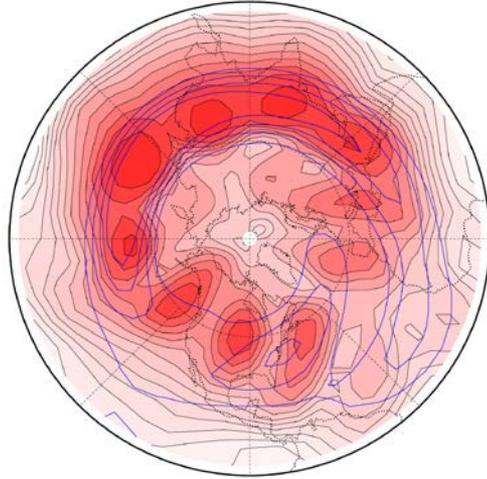
CAM5 vs Linear Planetary Wave Model

Extratropical teleconnectivity
(v200 $\text{RMScor}_{\text{extra}}$)

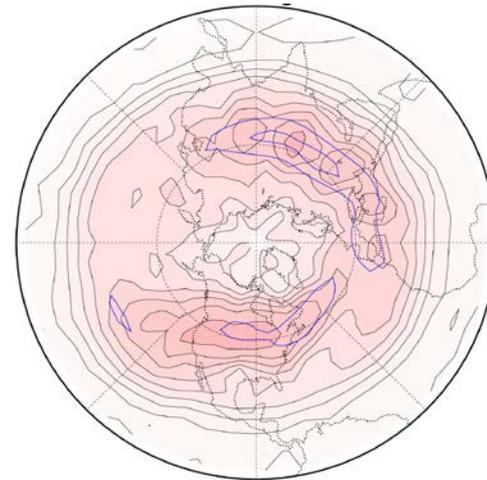
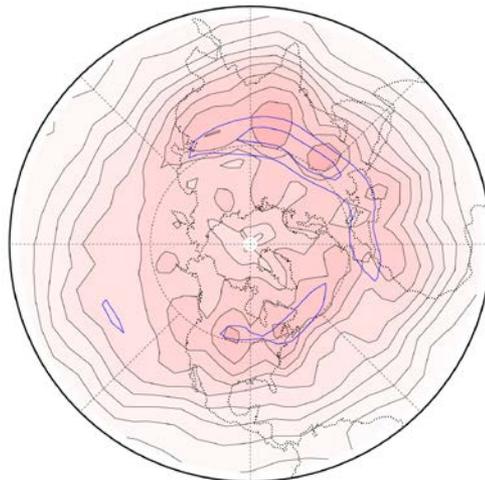
30dmeans_subseason

1000 solutions per month

Jan



Jul



contour=0.02

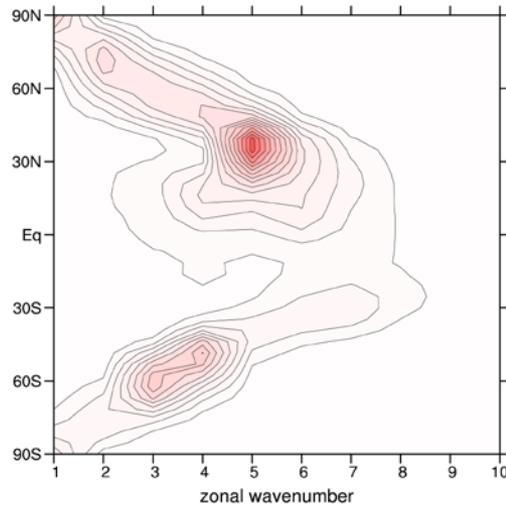
CAM5 vs Linear Planetary Wave Model

Zonal wavenumber spectra of v200 1pt correlations

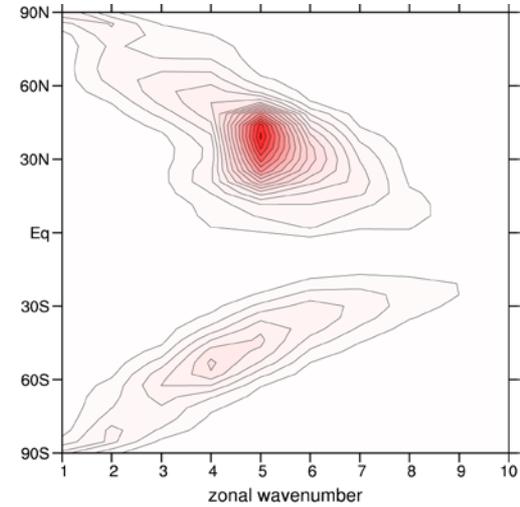
1000yrs 30dmeans_subseason

1000 solutions per month

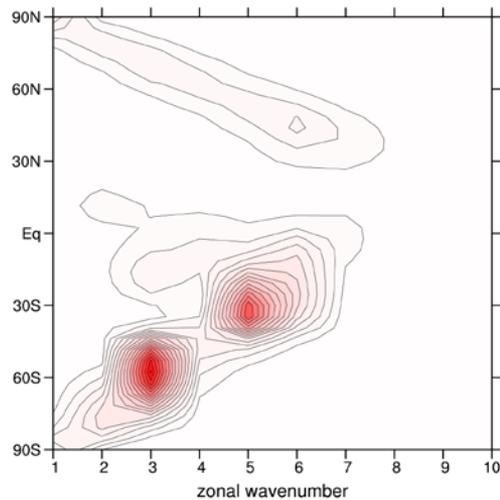
Jan



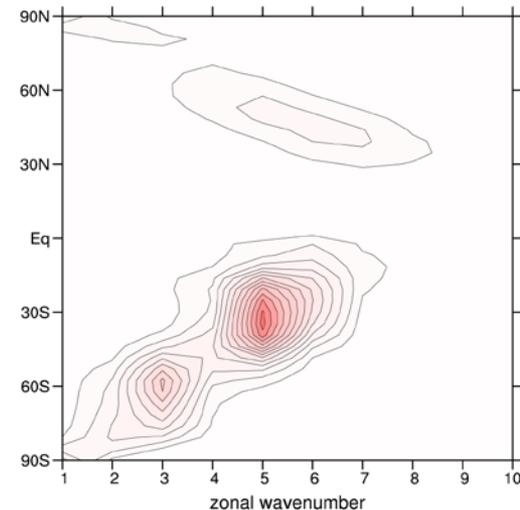
Jan



Jul



Jul



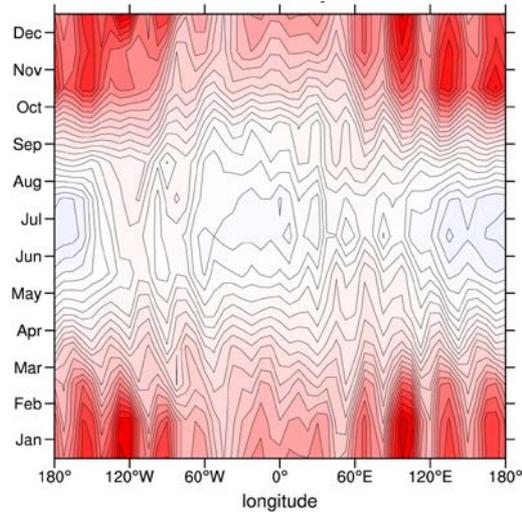
contour=0.15

Dependence on Basic State Truncation

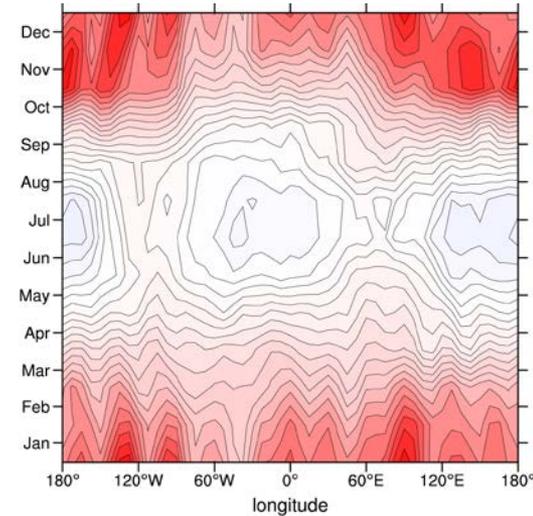
Seasonality of $v_{200} \text{RMScor}_{\text{extra}}$
(1000 steady solns per month)

20N-60N

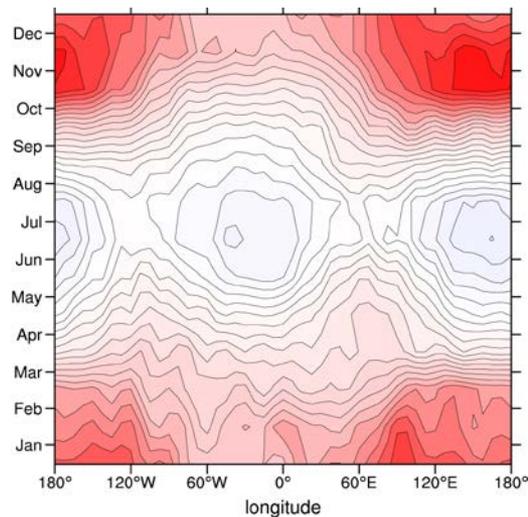
Wave 15



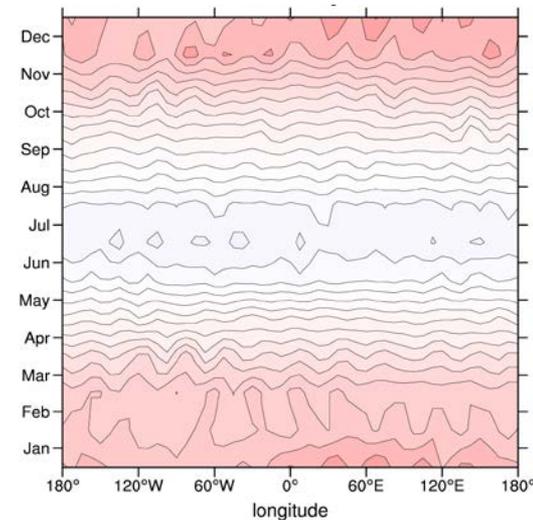
Wave 5



Wave 2



Wave 0



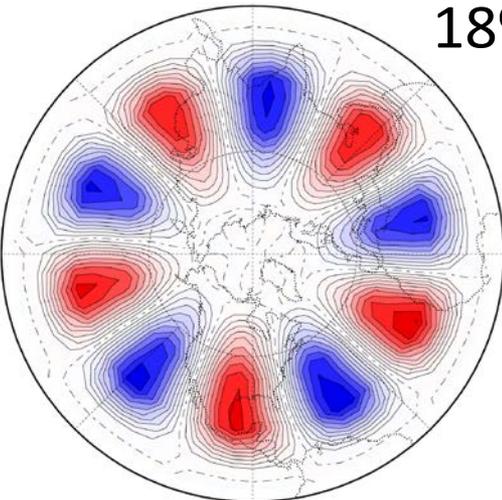
contour=0.008

Stochastically Driven Linear Nondivergent Barotropic Vorticity Eqn

Zonal Mean Jan Mean 300hPa Basic State

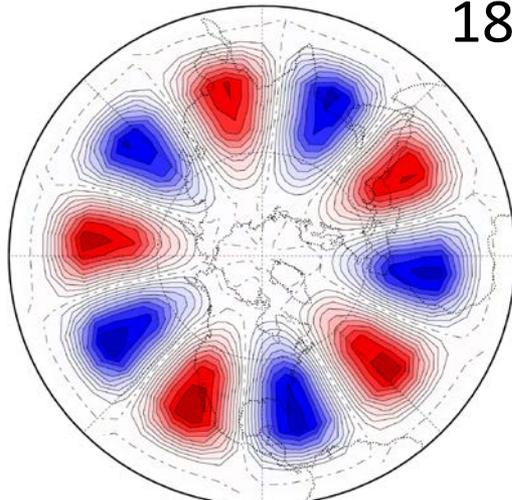
correlation vEOF1

18%

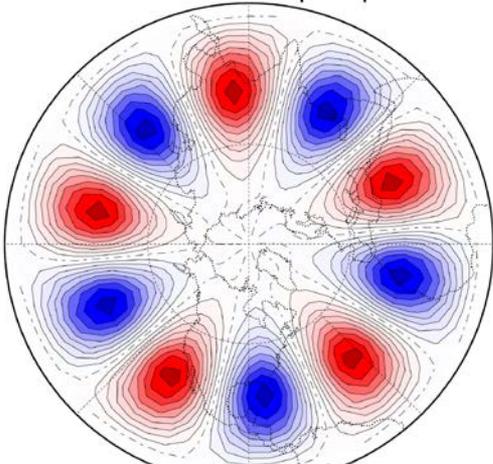
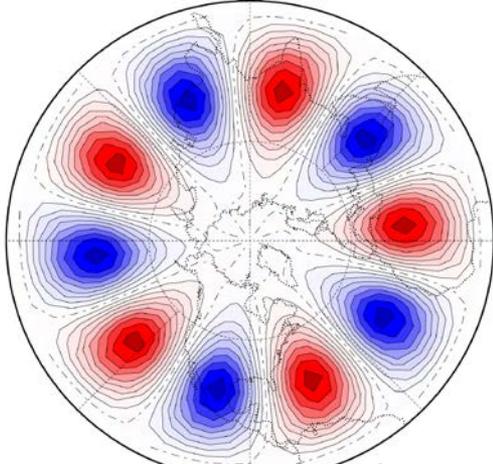


correlation vEOF2

18%



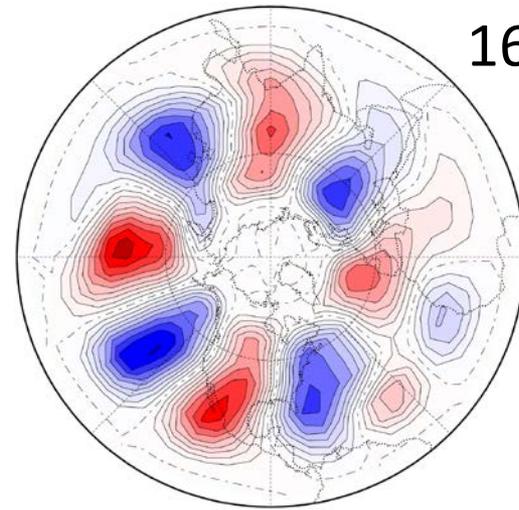
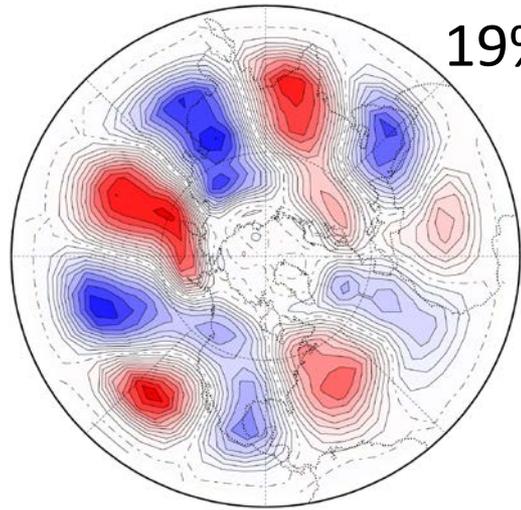
Near resonant mode



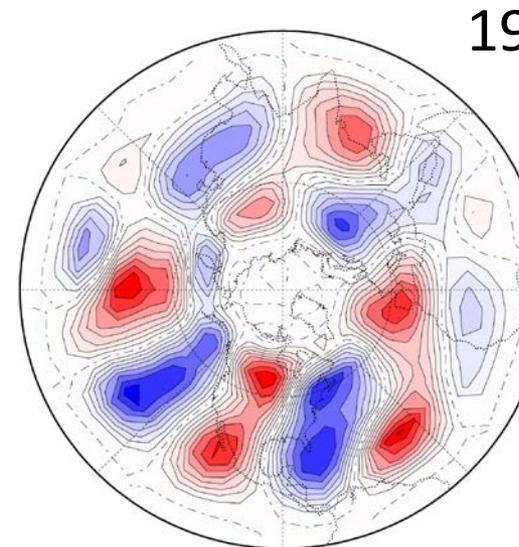
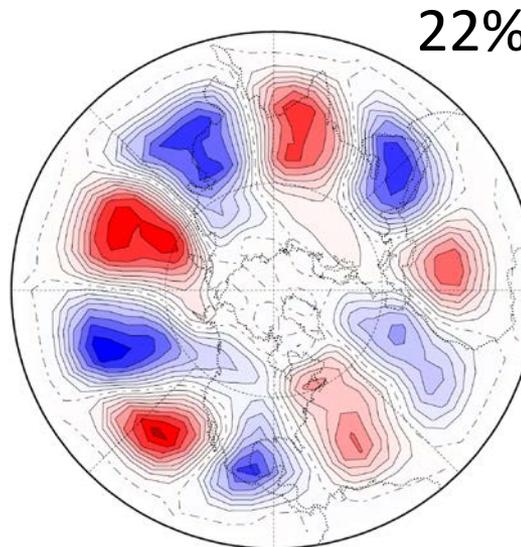
Period=81days Damping=-22days

correlation vEOF 1&2

Stochastically Driven Linear Nondivergent Barotropic Vorticity Eqn Jan Mean 300hPa Basic State



Full
Truncation



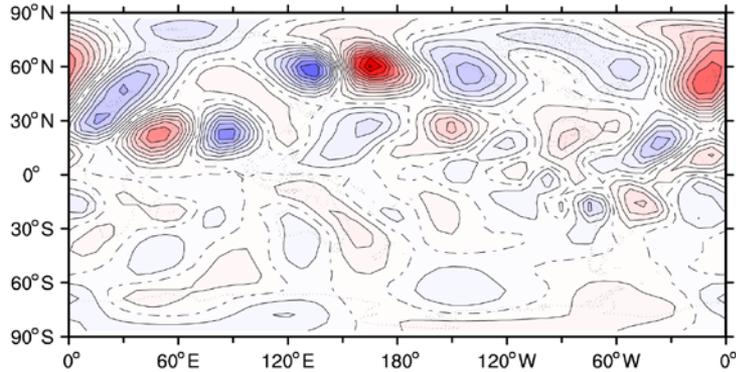
Leading 30
Modal
Patterns

Leading Linear Planetary Wave Model Normal Modes

Nature's DJF Basic State

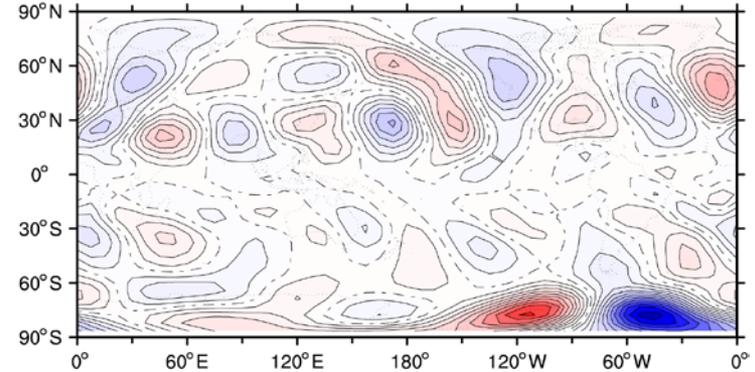
Magnitude Mode 1

e-folding time -13.92 period Infdays



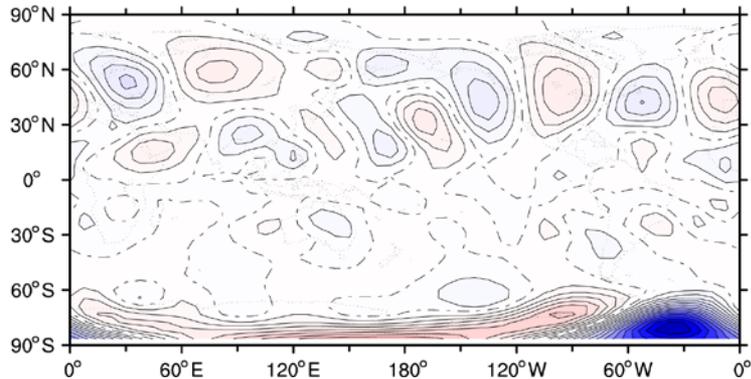
Magnitude Mode 4

e-folding time -10.17 period Infdays



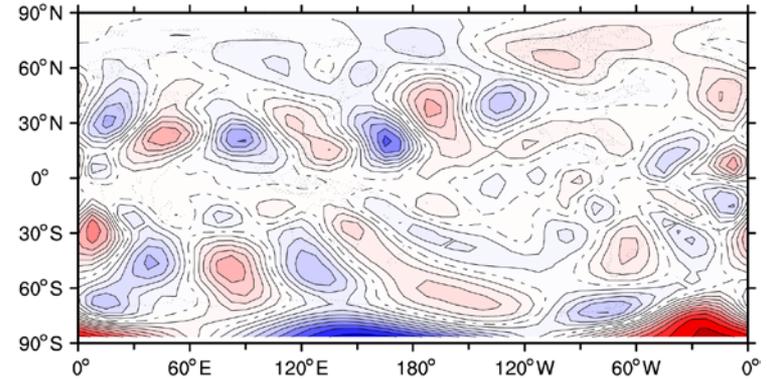
Magnitude Mode 14real

e-folding time -6.34 period 232.60days



Magnitude Mode 17imag

e-folding time -6.10 period-136.08days



Summary

There is a class of zonally oriented teleconnections which connect widely separated regions

Their structure is largely produced by the mean jet acting as a waveguide

They exist in all seasons but are much stronger in winter than summer

Details of the background jet affect the strength, span and structure of the teleconnections

The associated patterns of variability do not correspond to one or two normal modes but waveguide behavior tends to be concentrated in modes with small eigenvalues