The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

1968-22

Conference on Teleconnections in the Atmosphere and Oceans

17 - 20 November 2008

Global teleconnections via the tropospheric subtropical waveguide.

BRANSTATOR Grant Webster

Climate and Global Dynamics Division, Paleoclimatology
National Center For Atmospheric Research, NCAR
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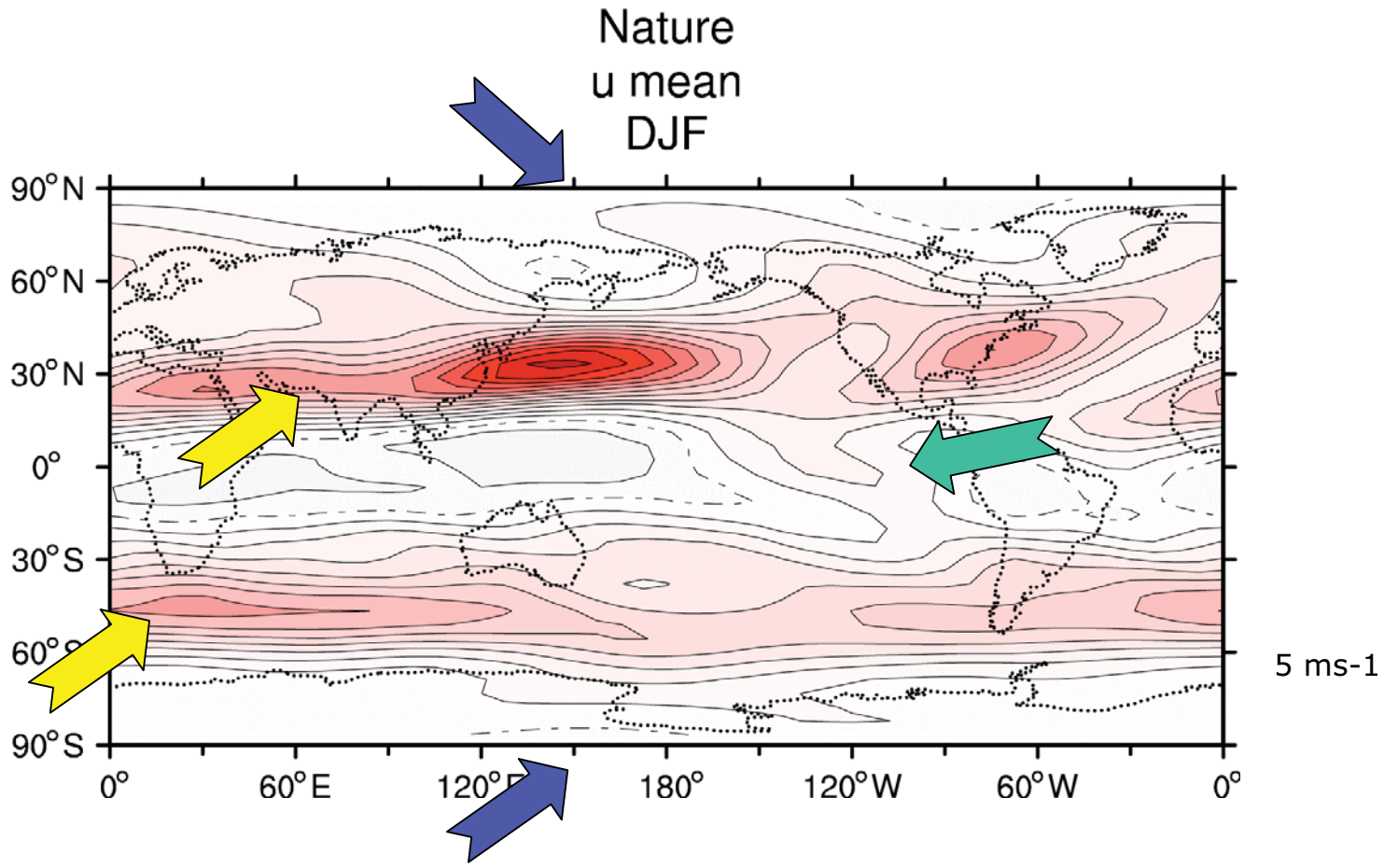
80307-3000 CO Boulder
U.S.A.

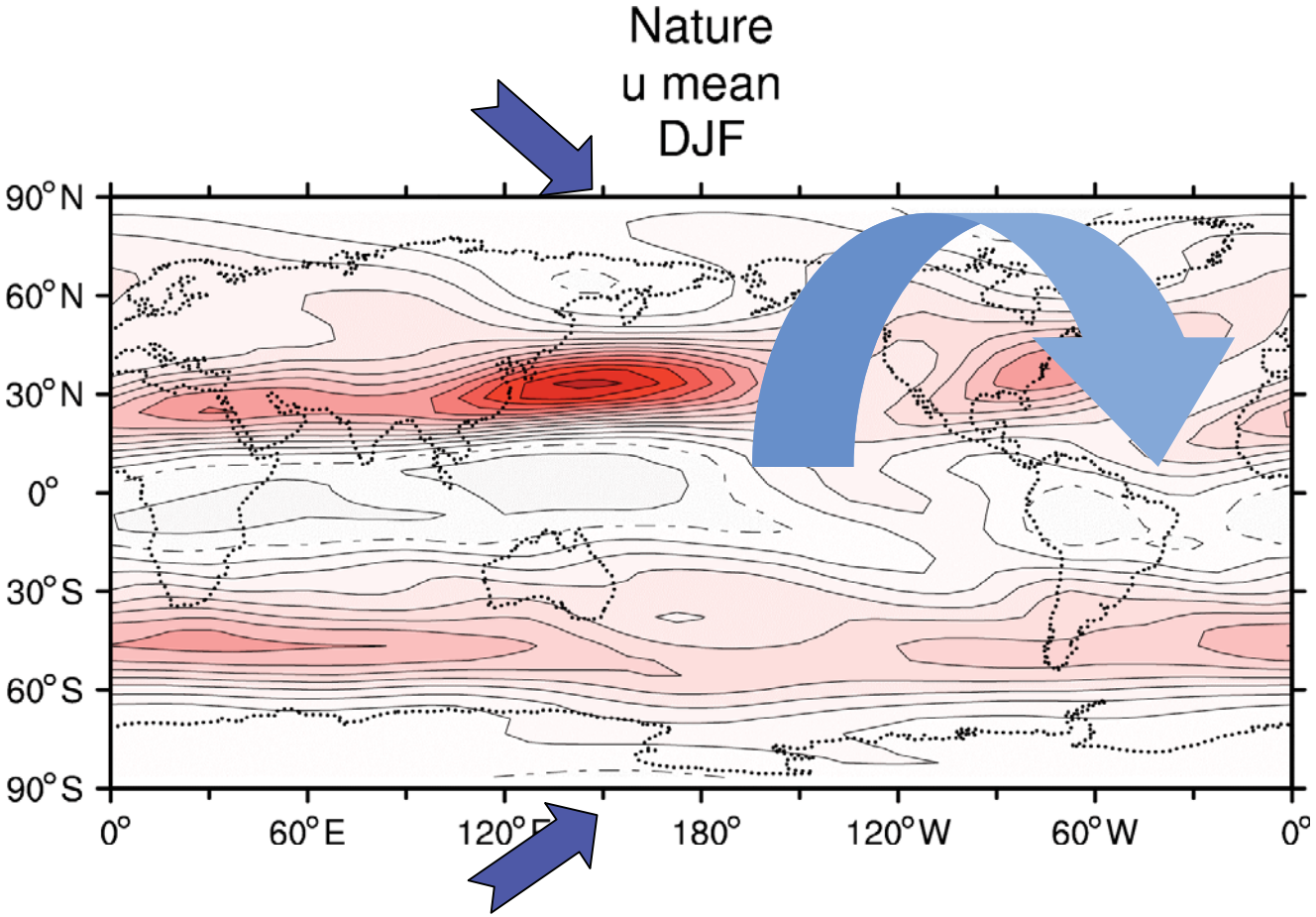
Global Teleconnections via the Tropospheric Subtropical Waveguide

Grant Branstator, NCAR

Waveguides

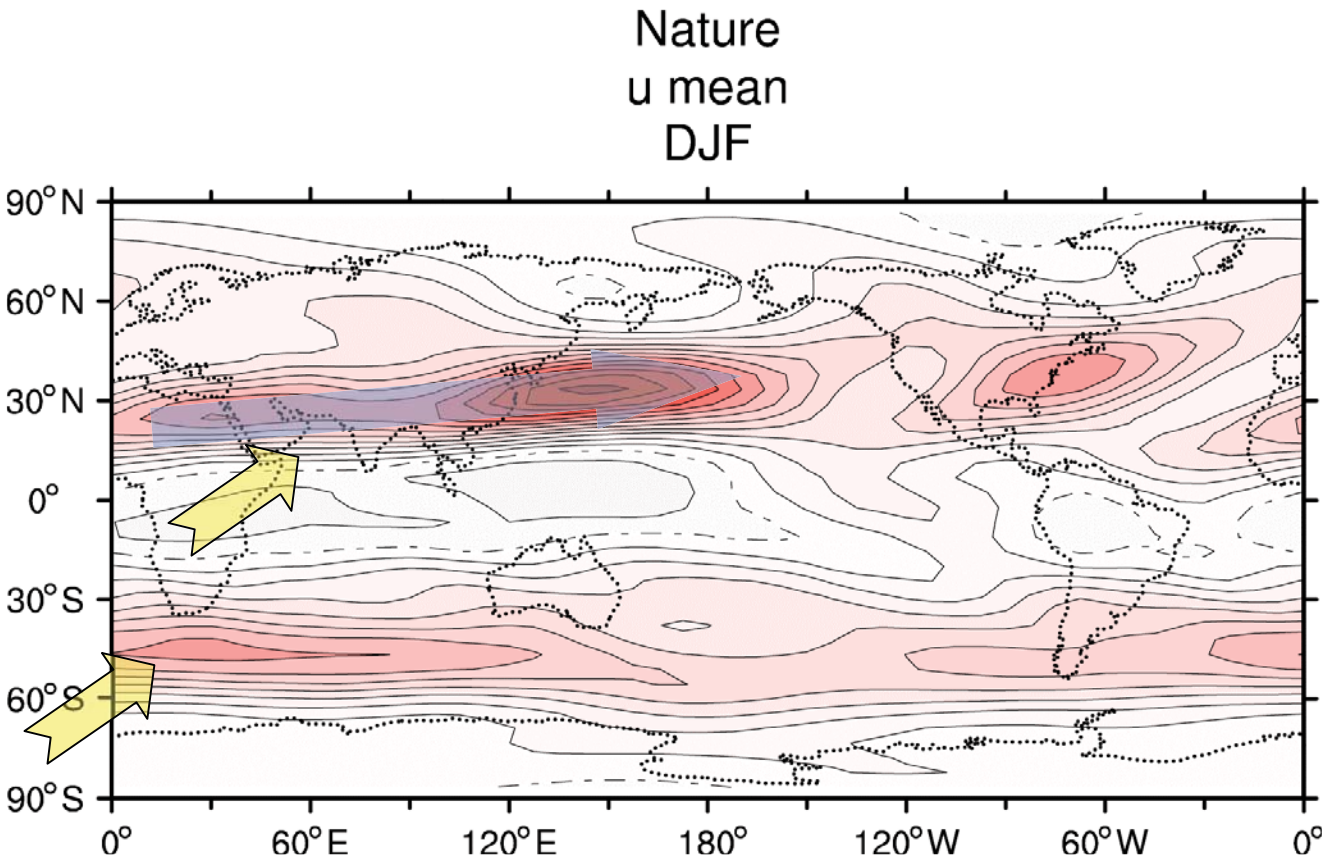

Nature
u mean
DJF
90°N
60°N
30°N
0°
30°S
60°S
90°S
0°
60°E
120°E
180°
120°W
60°W
0°
5 ms-1

Waveguides

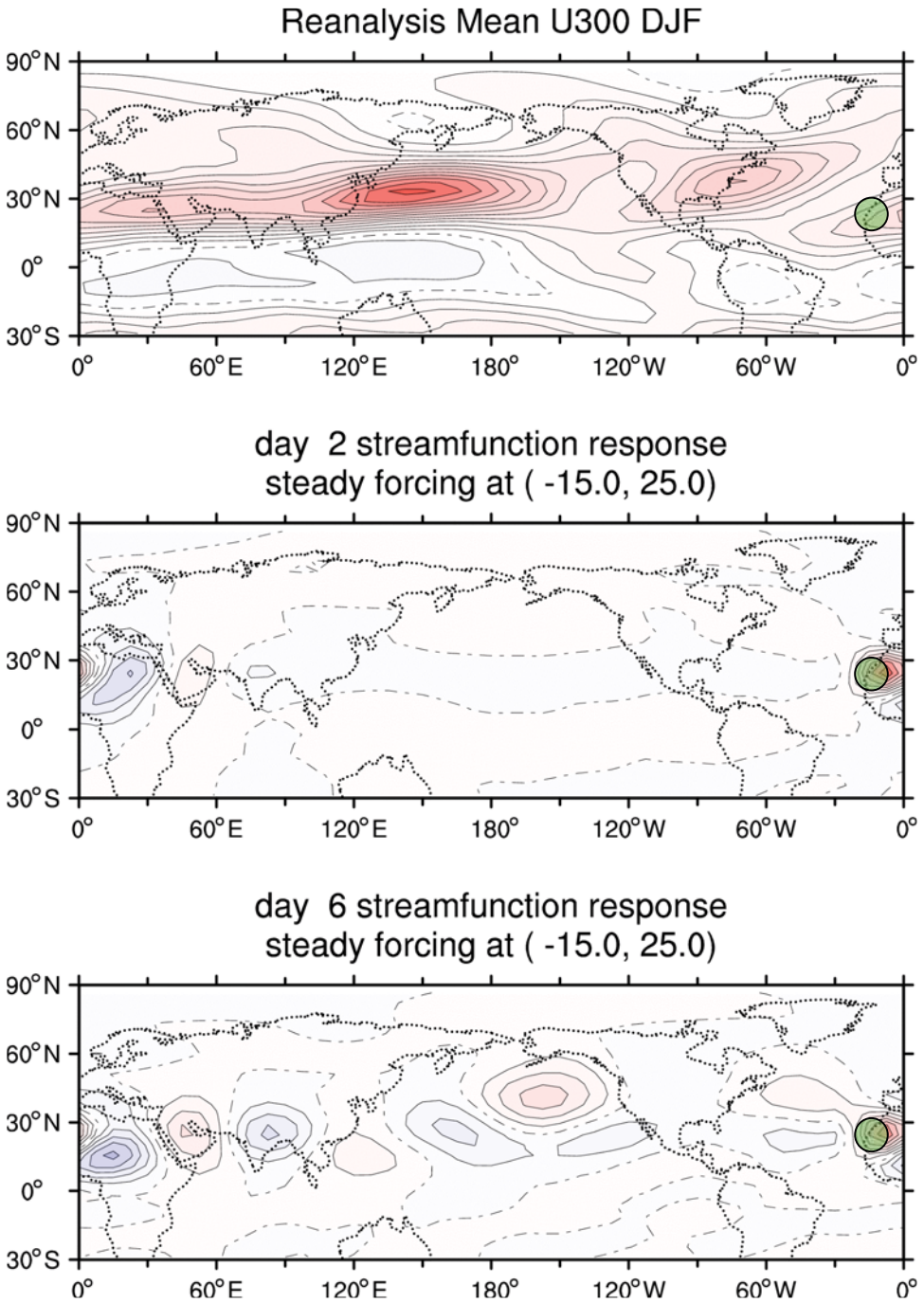


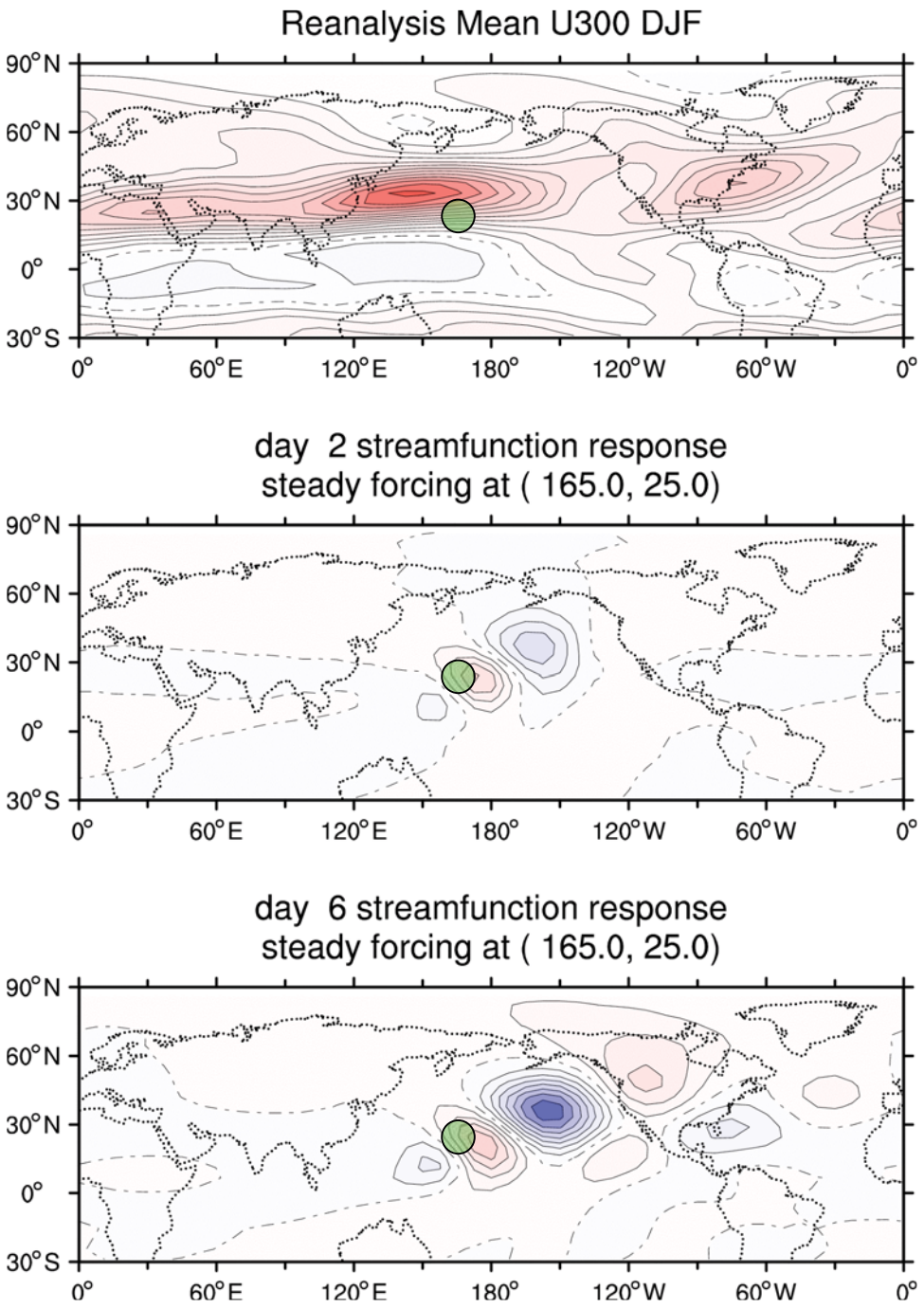
$$\frac{d^2\Psi(s)}{ds^2} + \rho^2\Psi(s) = 0, \qquad \text{for } \rho^2 = \frac{\cos\varphi}{\overline{\omega}}\frac{d\overline{q}}{d\varphi} - k^2$$

Waveguides

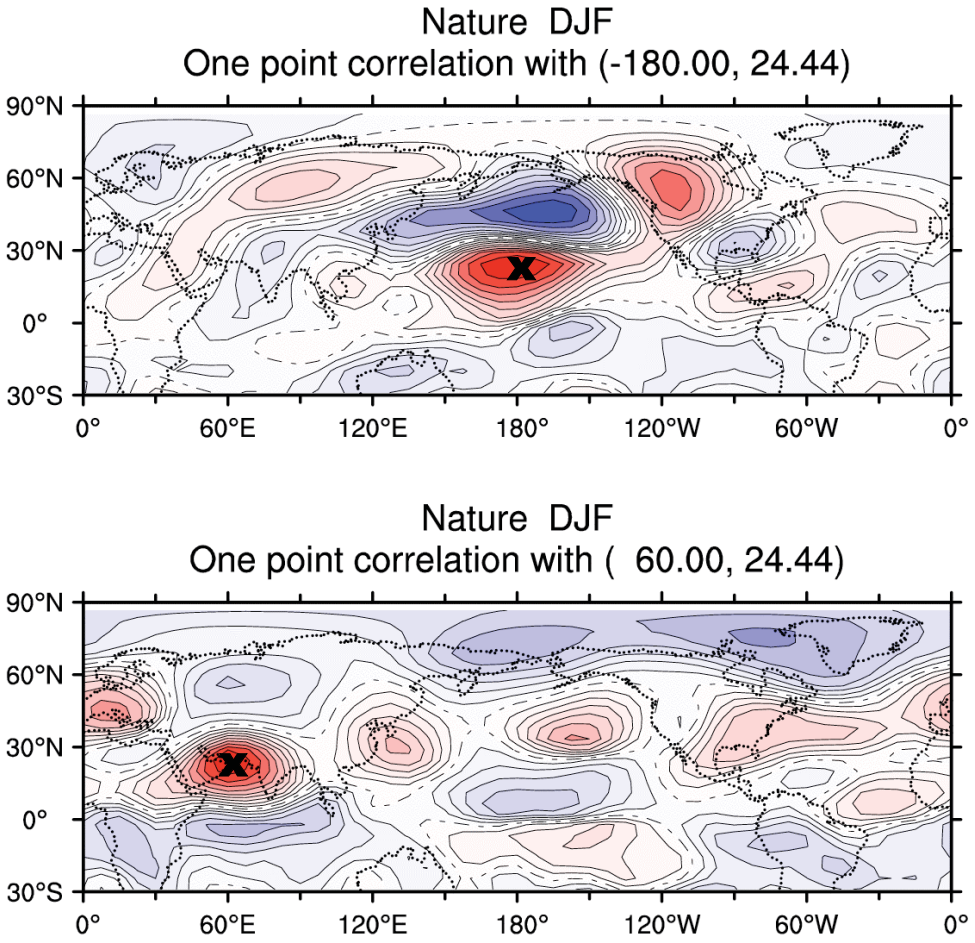


$u_g \propto \bar{u}$ *Hoskins et al*; *Held*

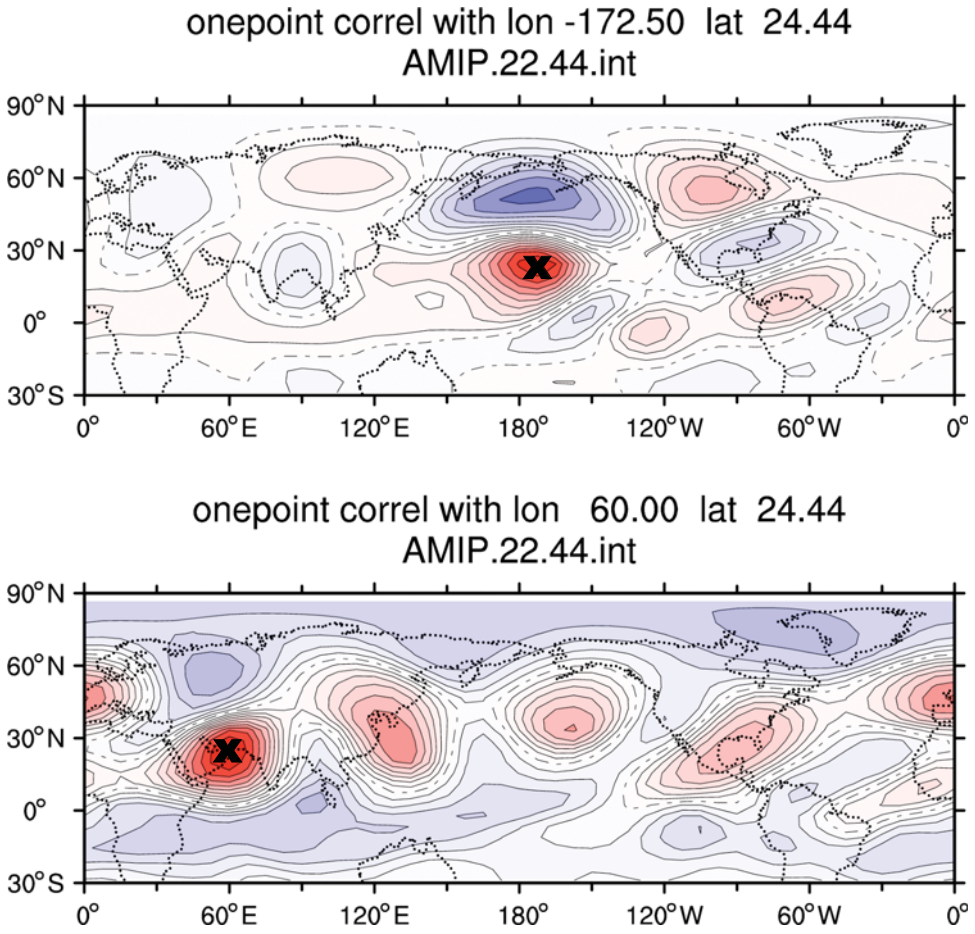

Reanalysis Mean U300 DJF
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
day 2 streamfunction response
steady forcing at (-15.0, 25.0)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
day 6 streamfunction response
steady forcing at (-15.0, 25.0)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°


Reanalysis Mean U300 DJF
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
day 2 streamfunction response
steady forcing at (165.0, 25.0)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
day 6 streamfunction response
steady forcing at (165.0, 25.0)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°

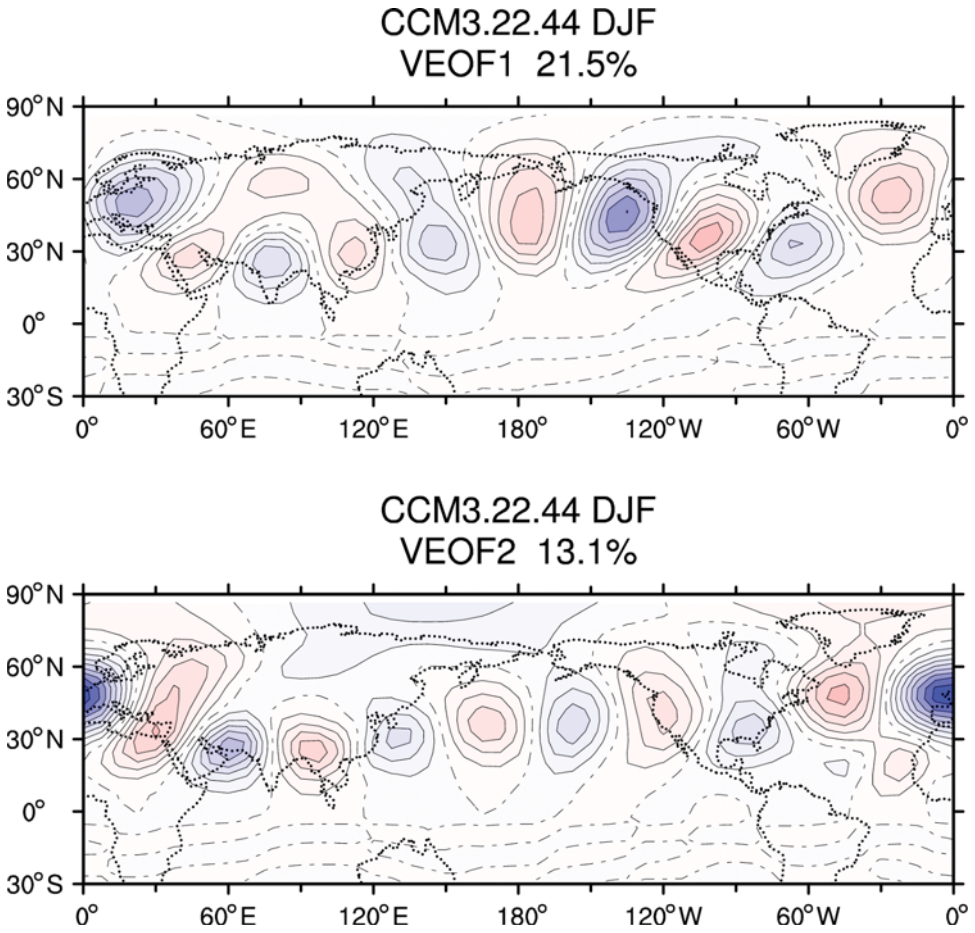
psi300


Nature DJF
One point correlation with (-180.00, 24.44)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
Nature DJF
One point correlation with (60.00, 24.44)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°

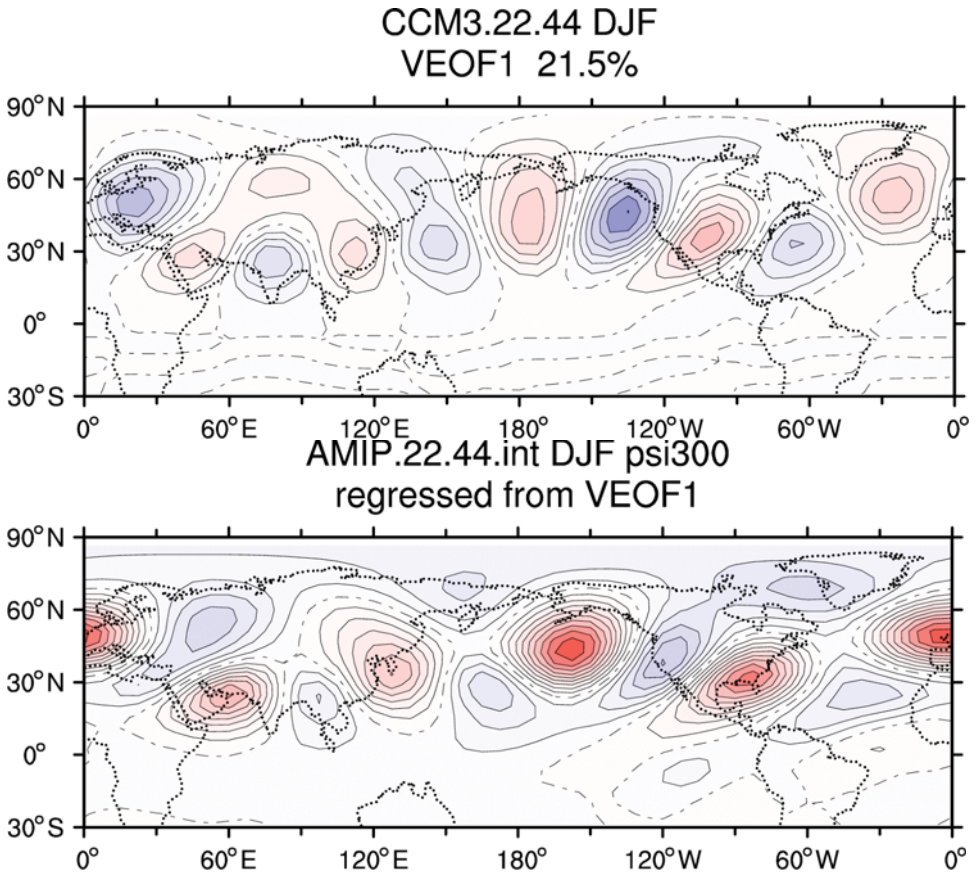
300mb streamfunction



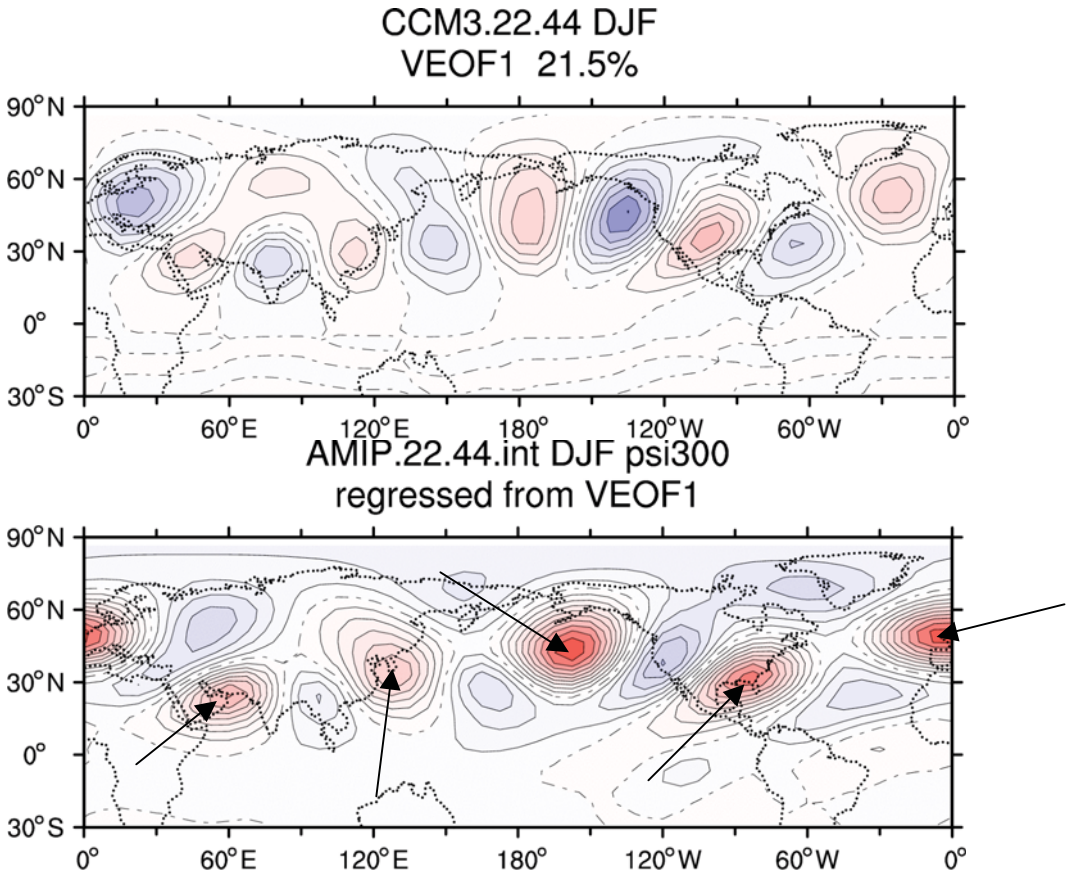
0.1


CCM3.22.44 DJF
VEOF1 21.5%
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
CCM3.22.44 DJF
VEOF2 13.1%
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°

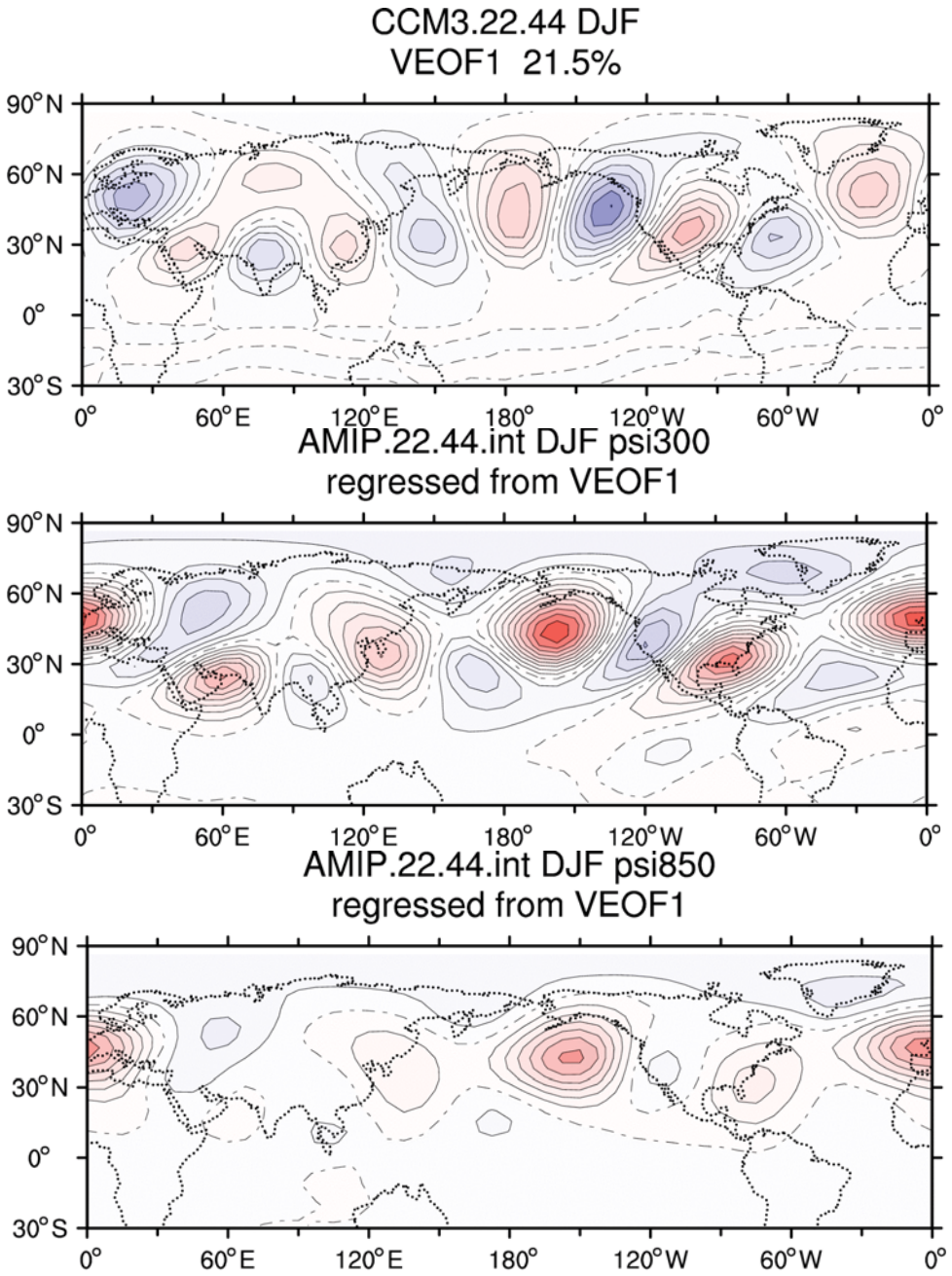
Circumglobal Waveguide Pattern

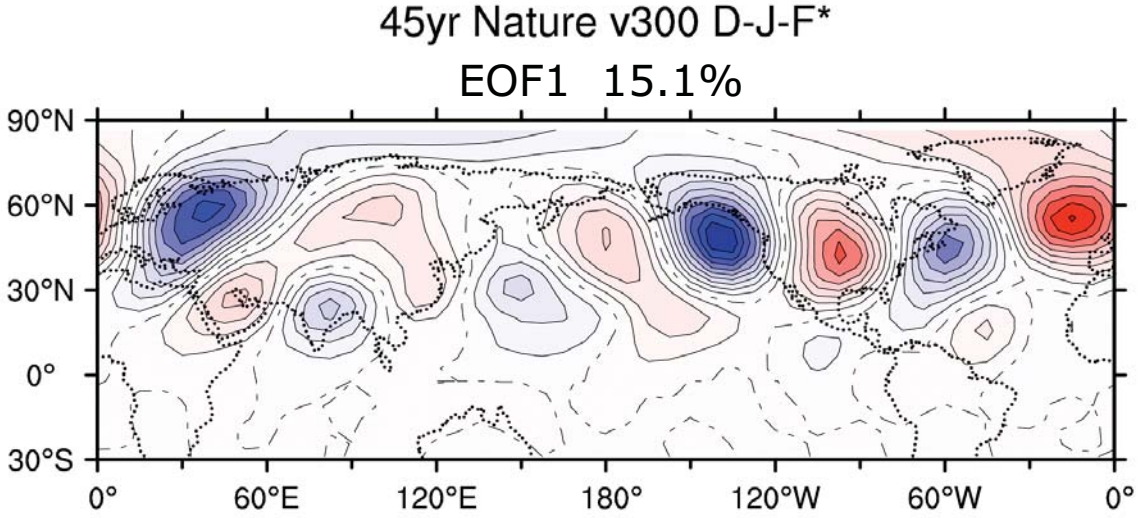


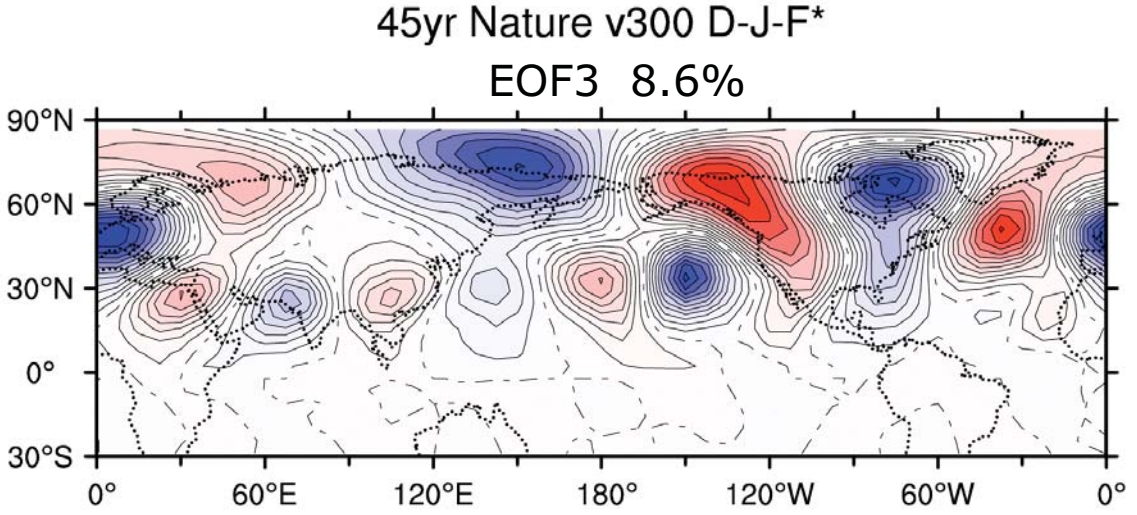
Circumglobal Waveguide Pattern

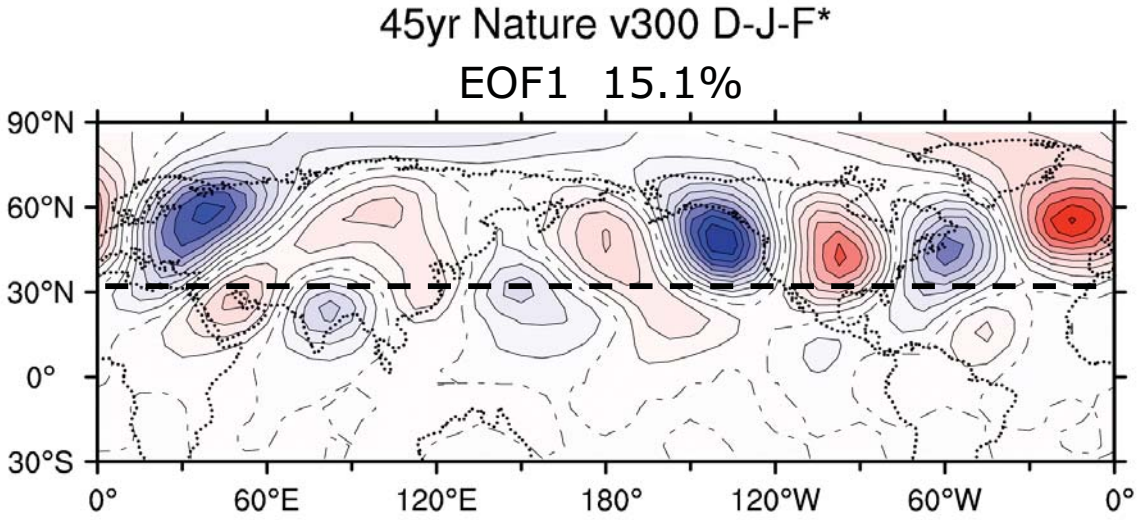


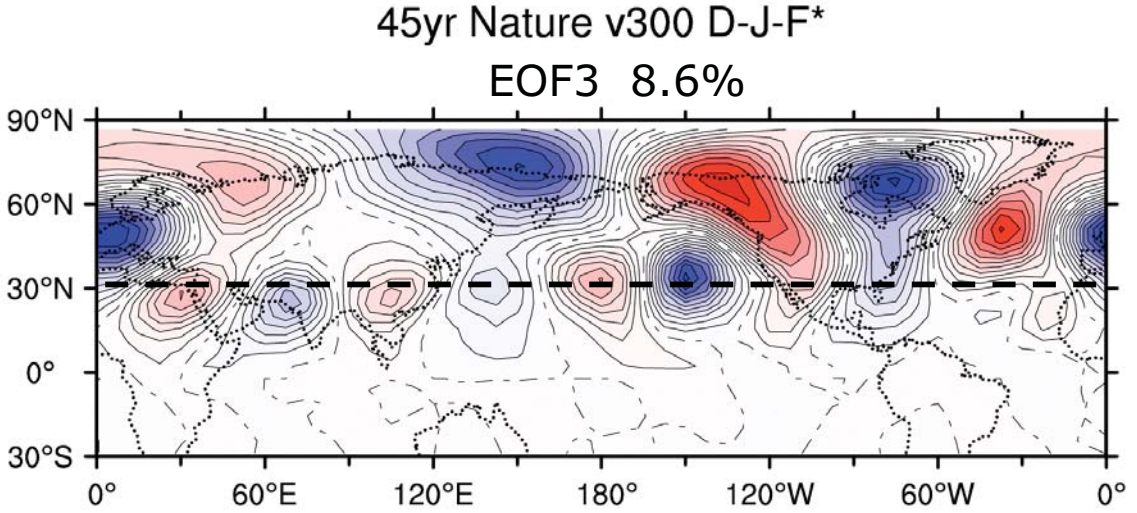
Circumglobal Waveguide Pattern

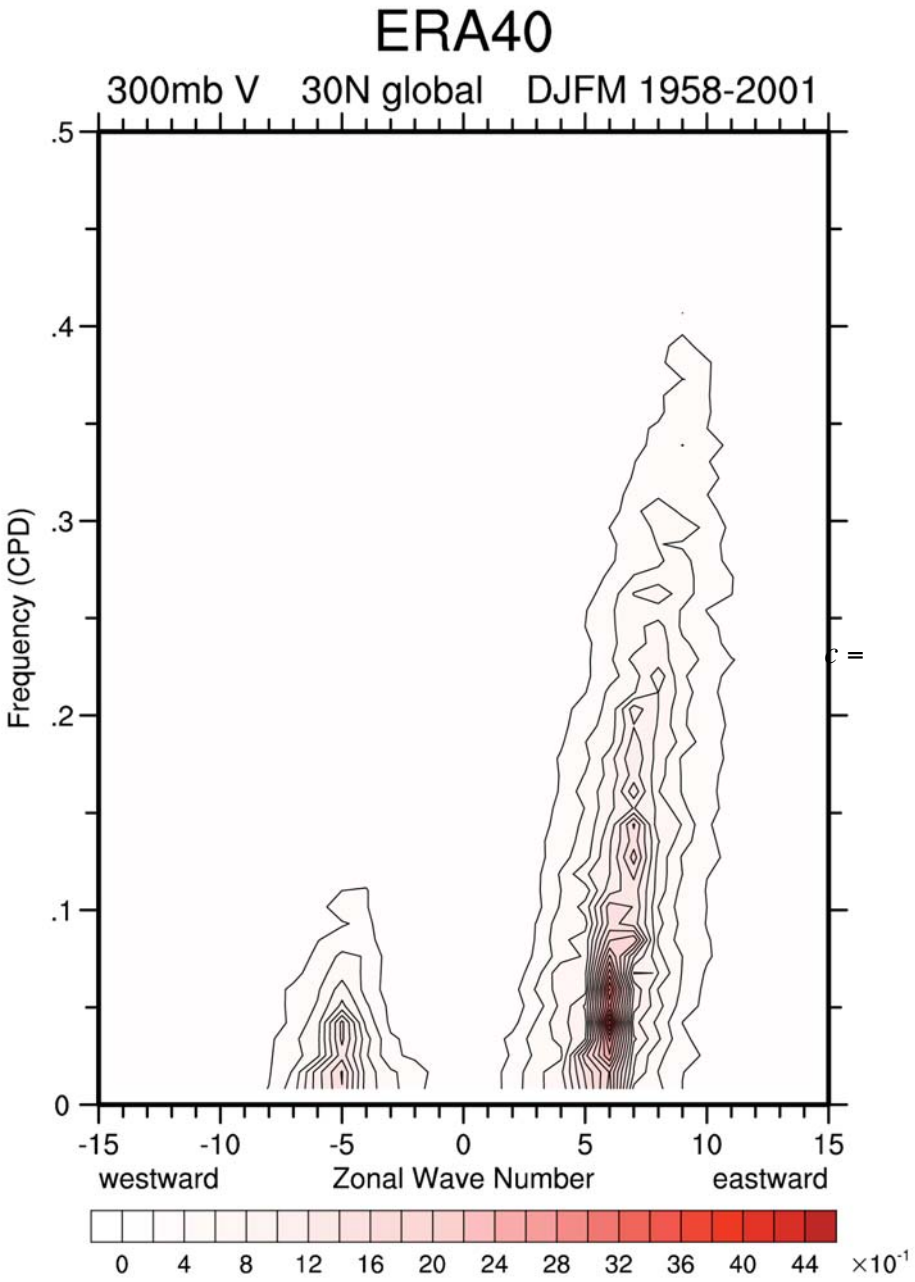



45yr Nature v300 D-J-F*
EOF1 15.1%
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°


45yr Nature v300 D-J-F*
EOF3 8.6%
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°

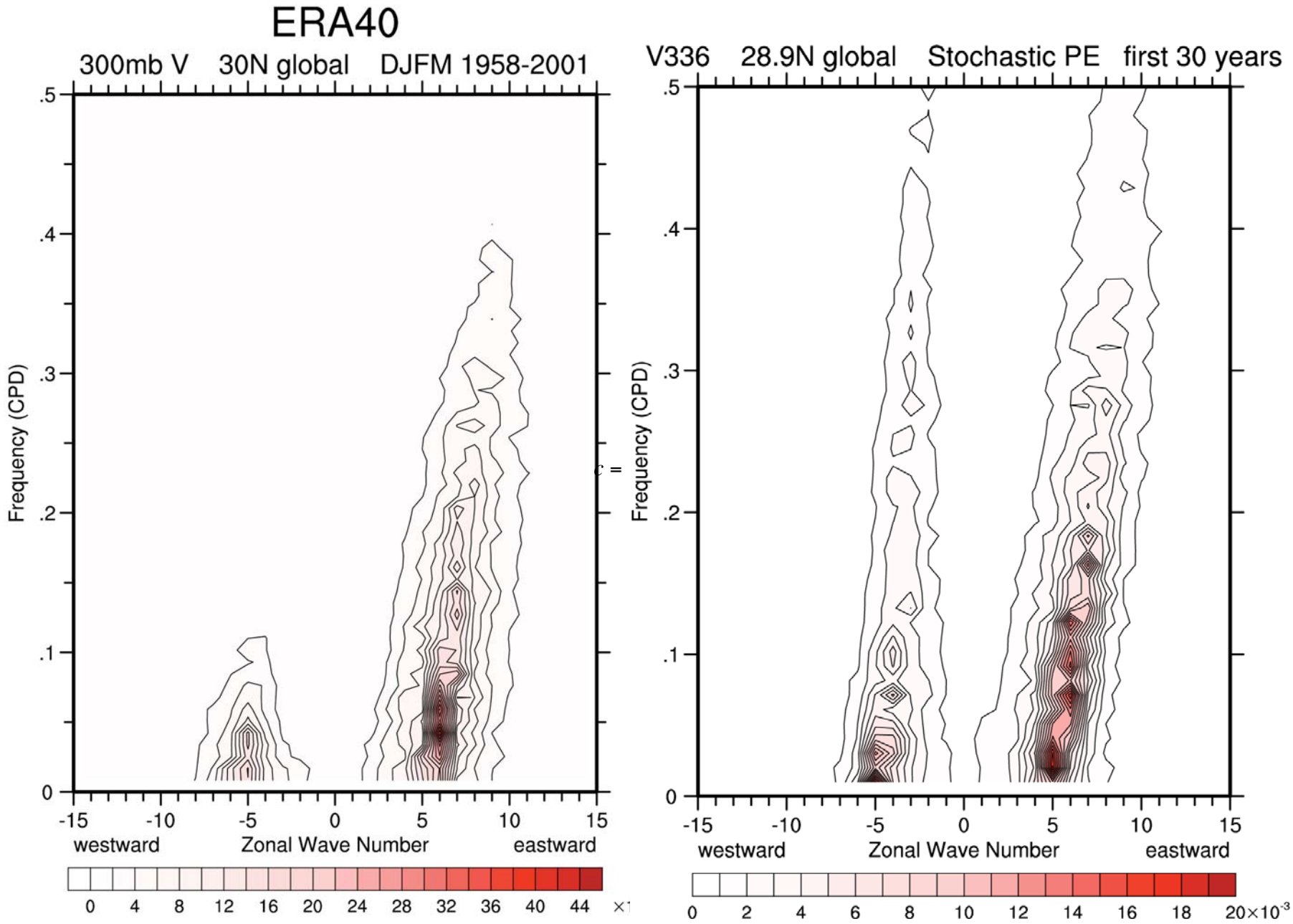

45yr Nature v300 D-J-F*
EOF1 15.1%
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°


45yr Nature v300 D-J-F*
EOF3 8.6%
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°

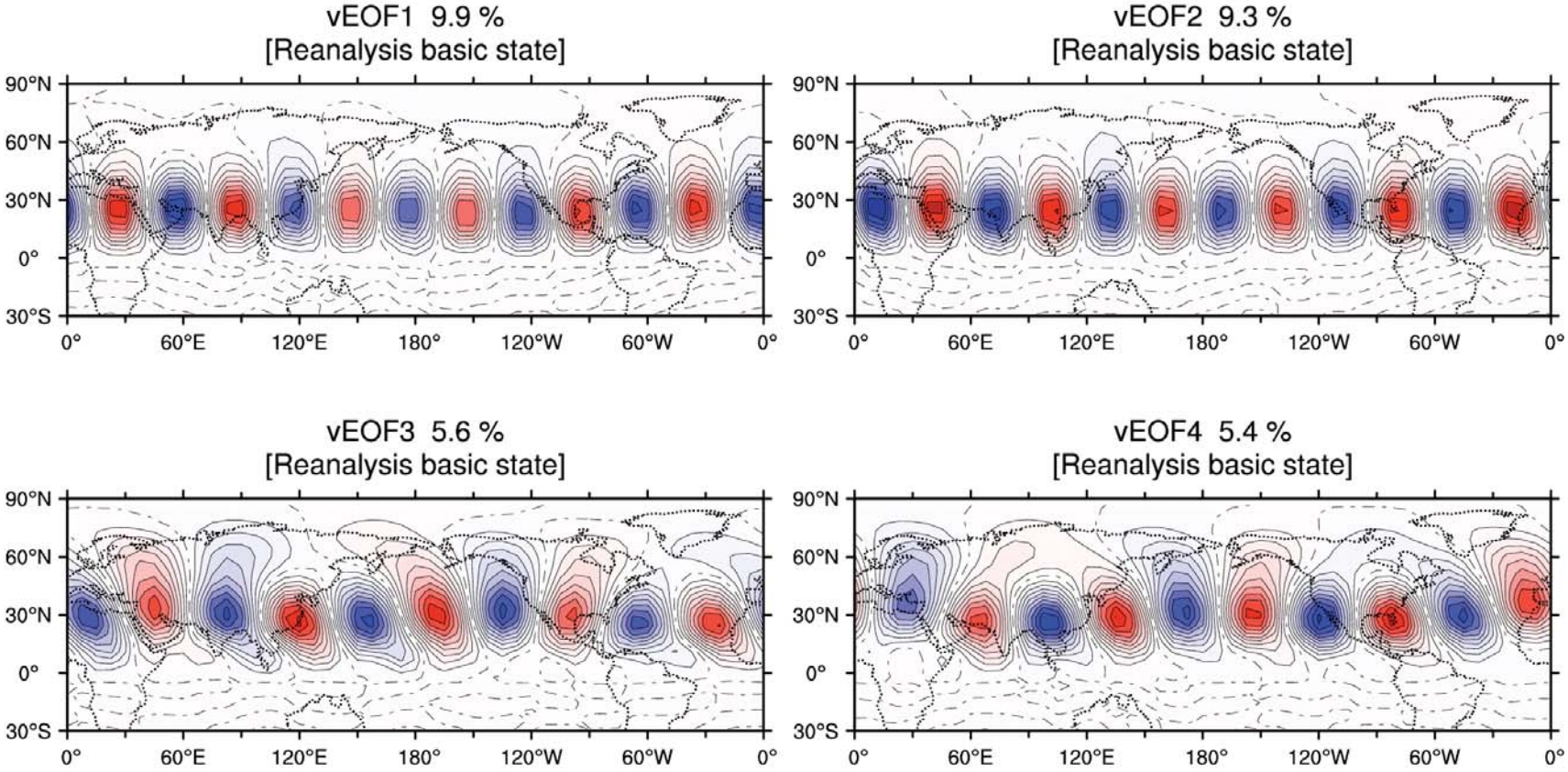


$$\sigma = \left\{ \overline{u} - \frac{\beta}{(k^2 + l^2)} \right\} k$$

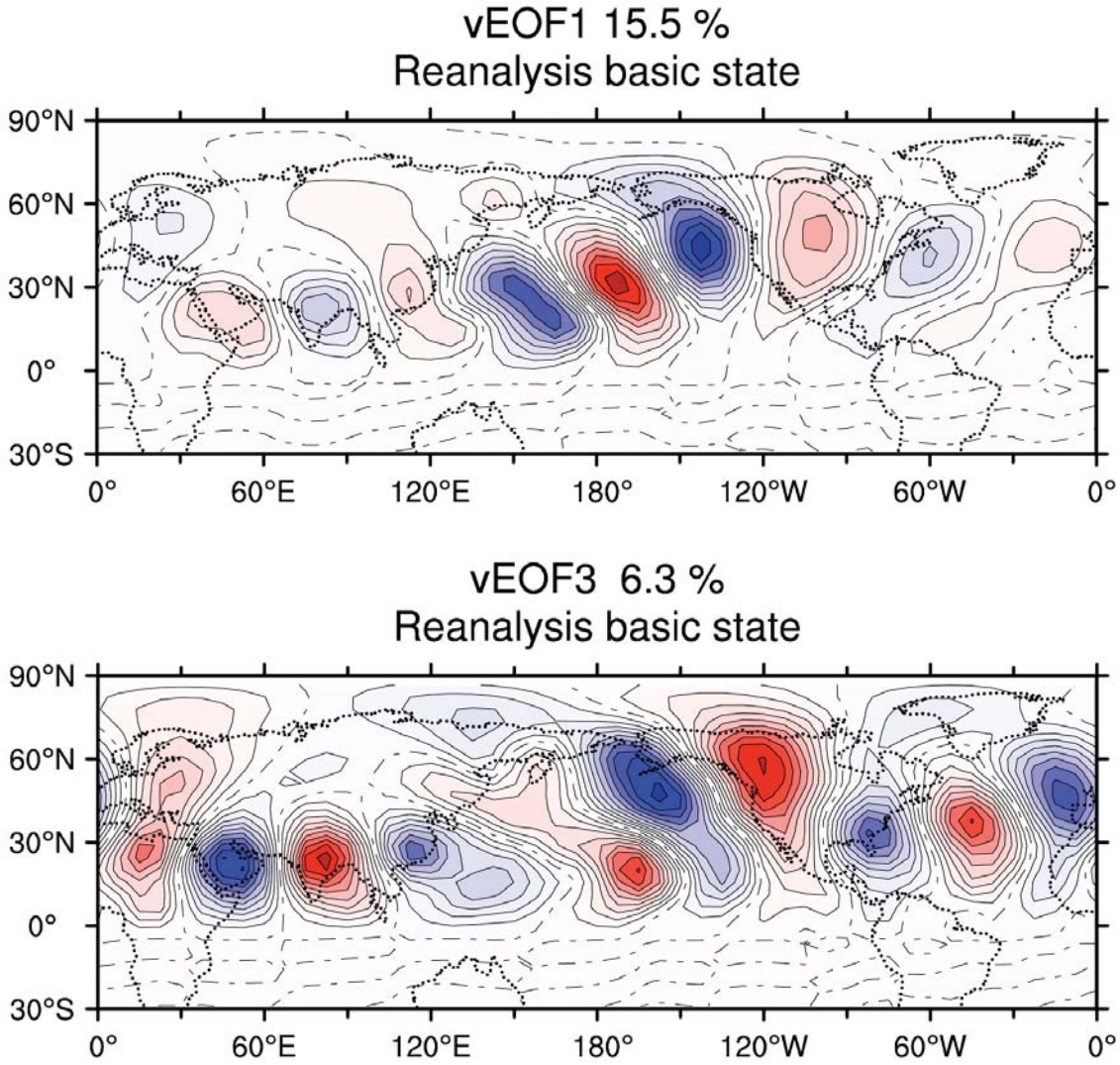
Hsu & Lin (1992)

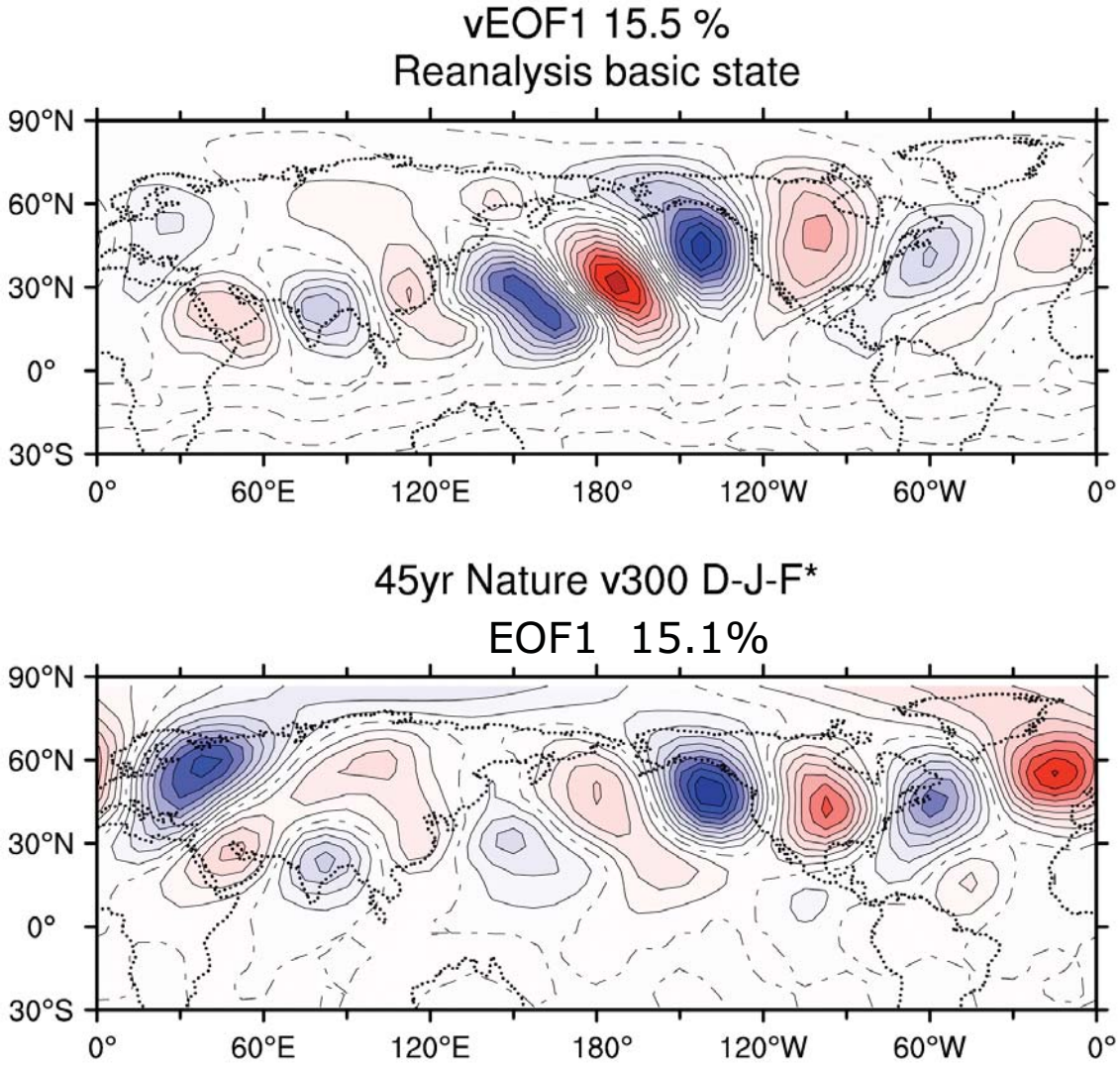

ERA40
300mb V 30N global DJFM 1958-2001
Frequency (CPD)
.5
.4
.3
.2
.1
0
-15 -10 -5 0 5 10 15
westward
Zonal Wave Number
eastward
0 4 8 12 16 20 24 28 32 36 40 44
V336 28.9N global Stochastic PE first 30 years
Frequency (CPD)
.5
.4
.3
.2
.1
0
-15 -10 -5 0 5 10 15
westward
Zonal Wave Number
eastward
0 2 4 6 8 10 12 14 16 18 20×10-3

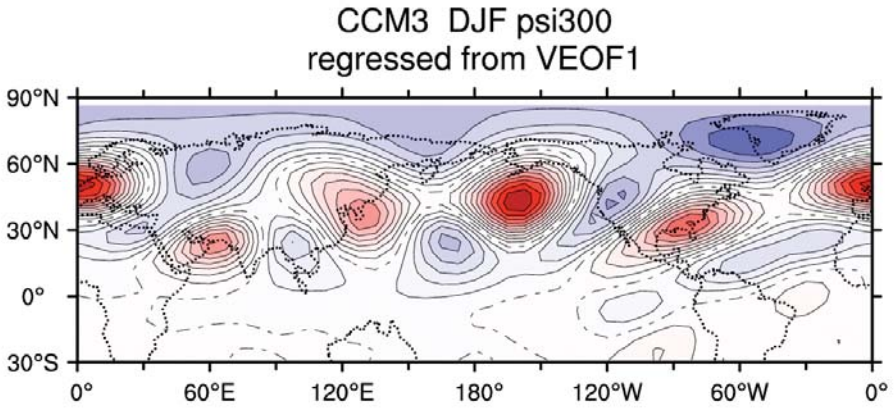
Stochastically Driven Primitive Equations

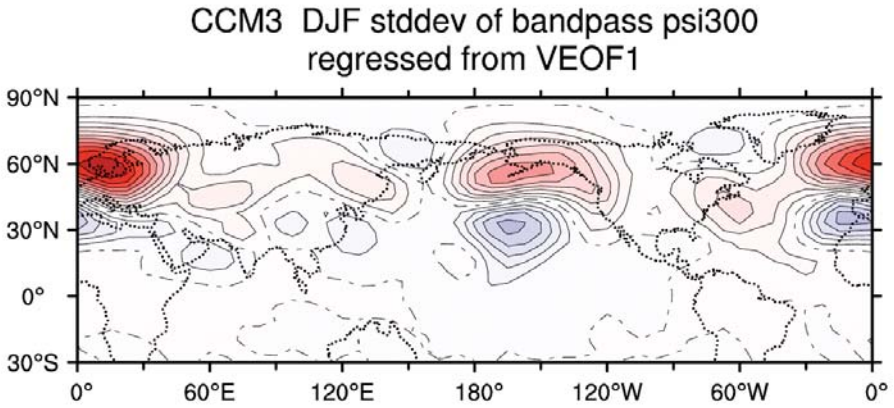


Stochastically Driven Primitive Equations

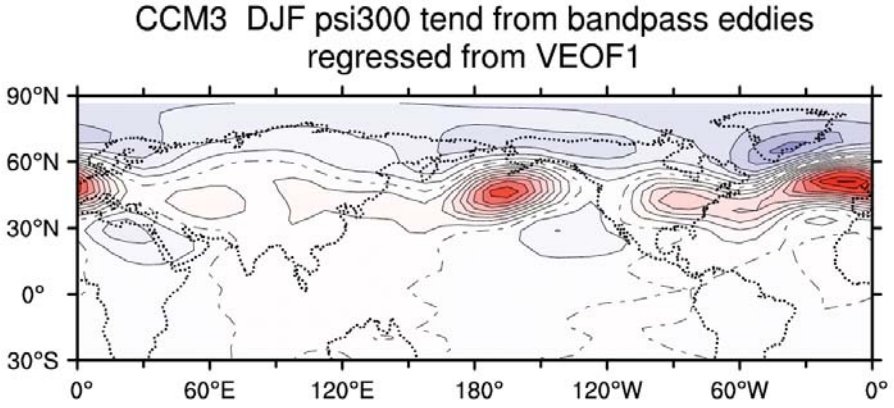



vEOF1 15.5 %
Reanalysis basic state
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
45yr Nature v300 D-J-F*
EOF1 15.1%
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°





$$\overline{(\psi')^2}$$

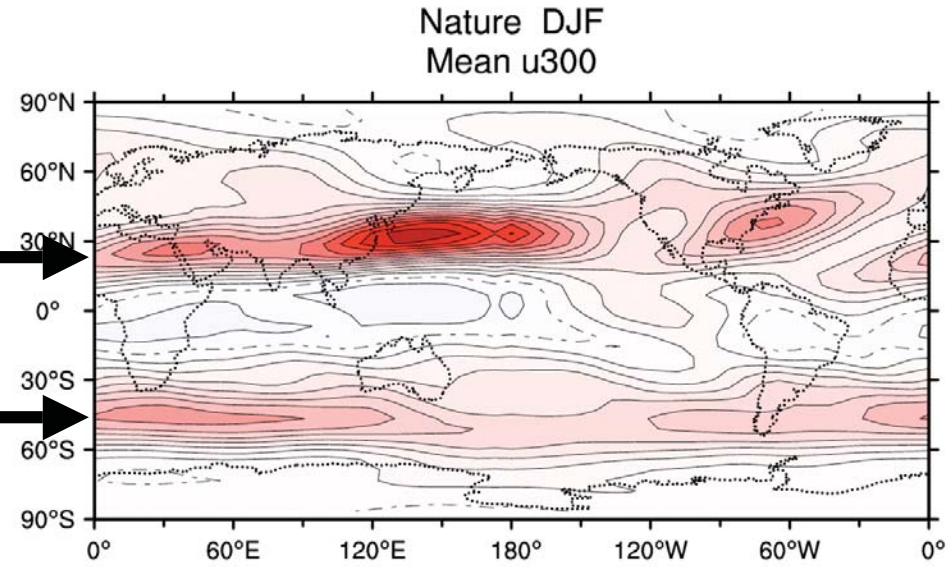


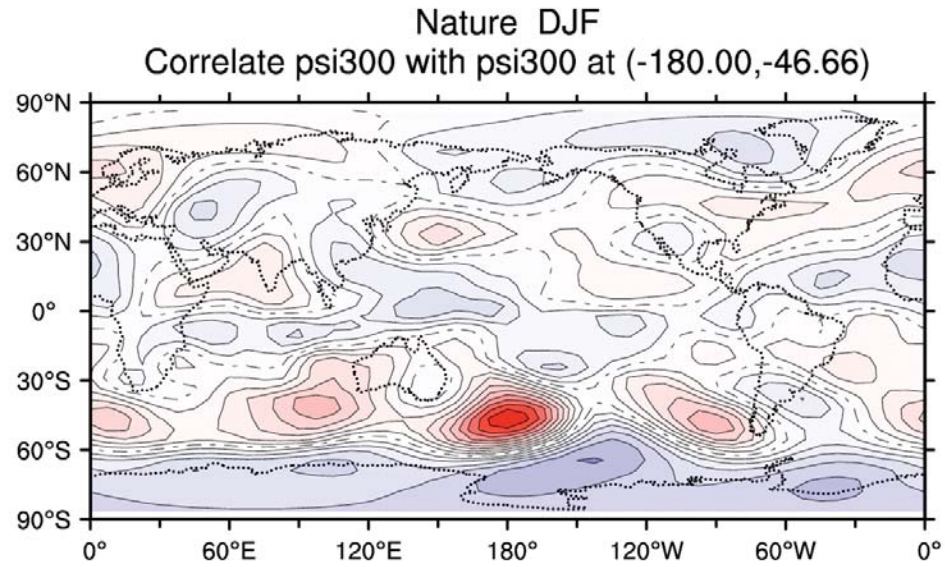
$$-\overline{\nabla^{-2}\left[\mathrm{v}' \bullet \nabla \varsigma'\right]}$$

Southern Hemisphere DJF Waveguide

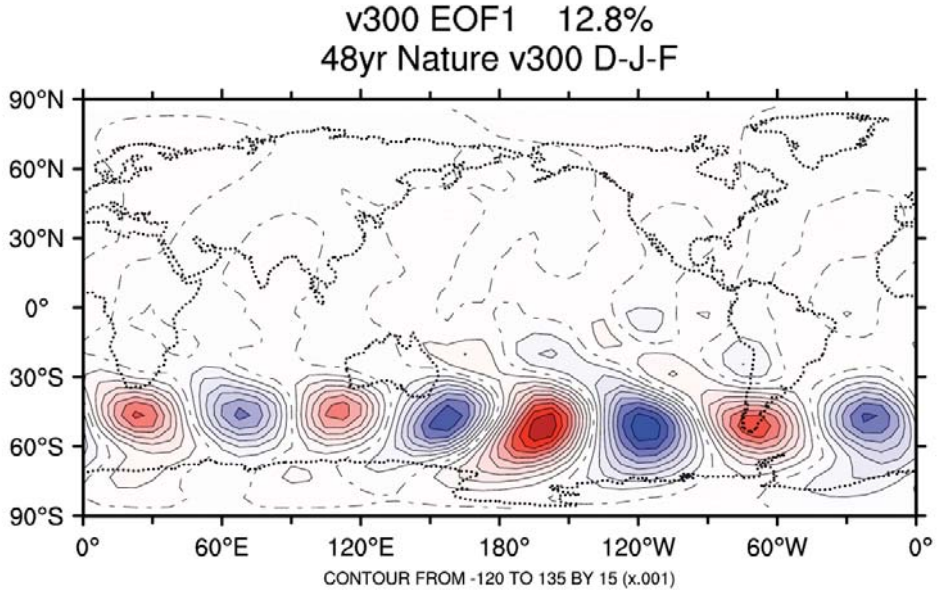
$K_s=7$

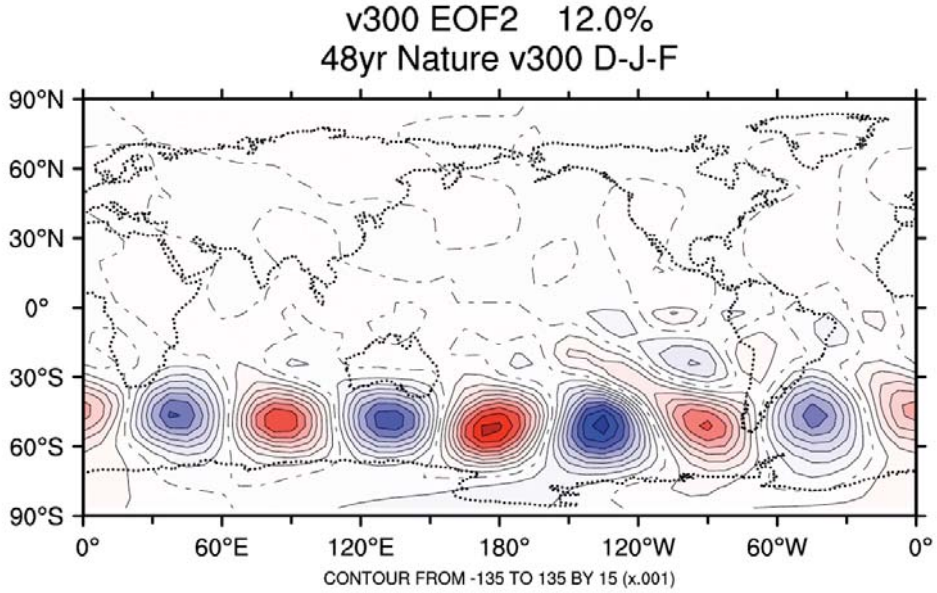
$K_s=6$



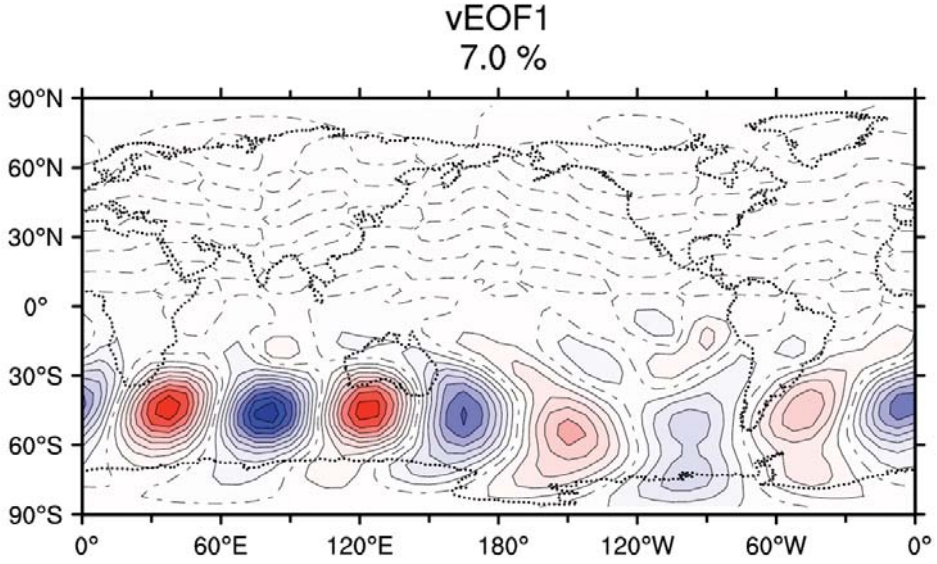


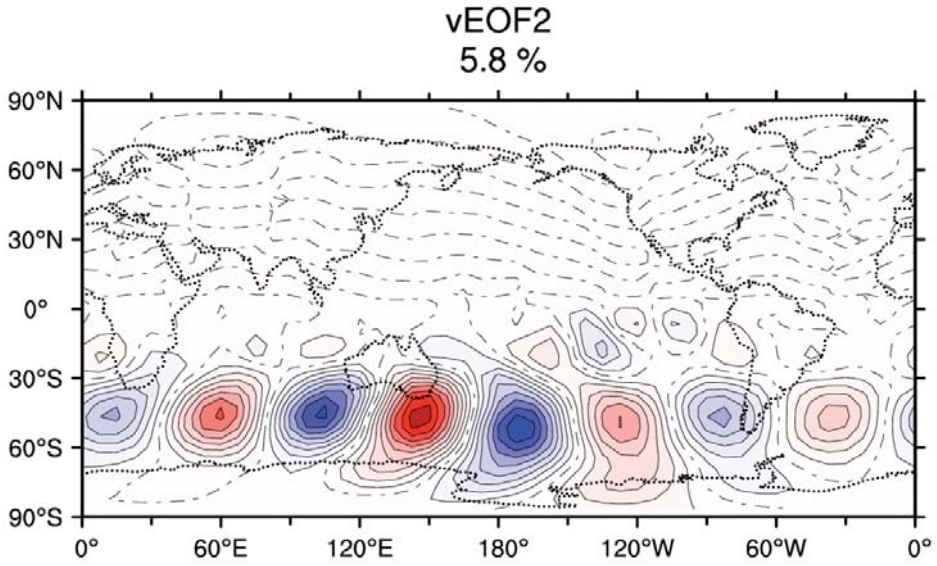
Nature
Southern Hemisphere DJF 300hPa vEOFs



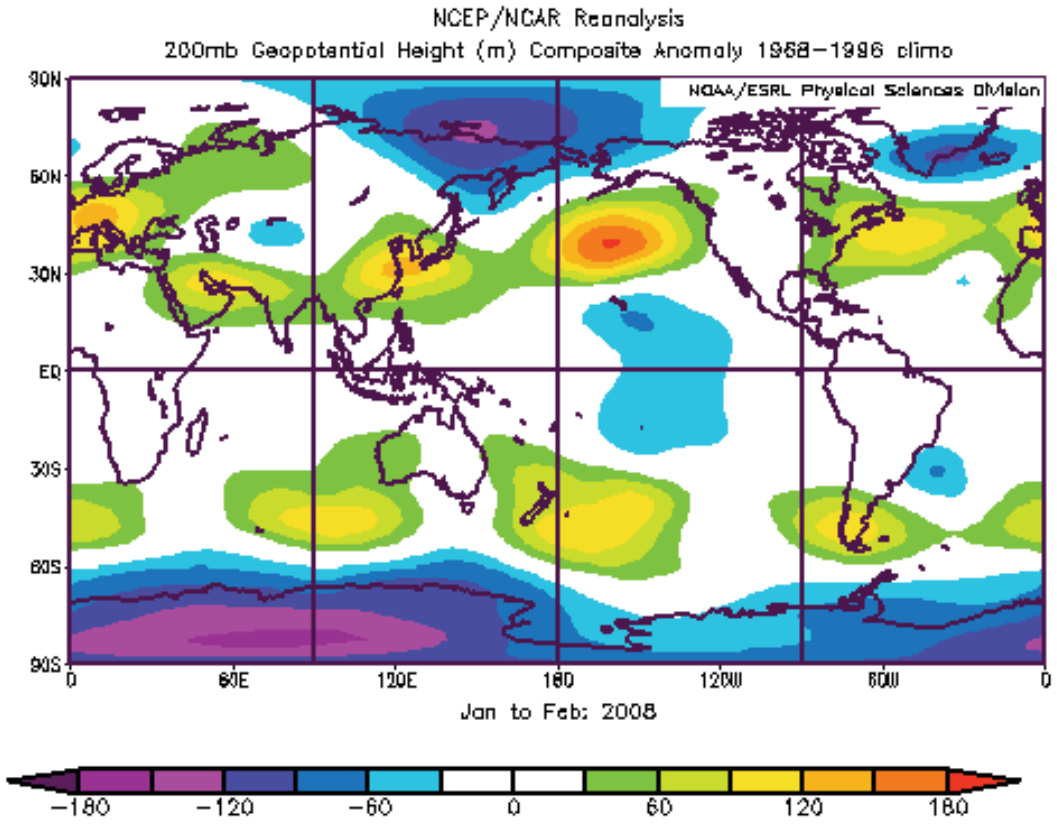


Stochastically Driven Primitive Equations
Southern Hemisphere DJF 300hPa vEOFs

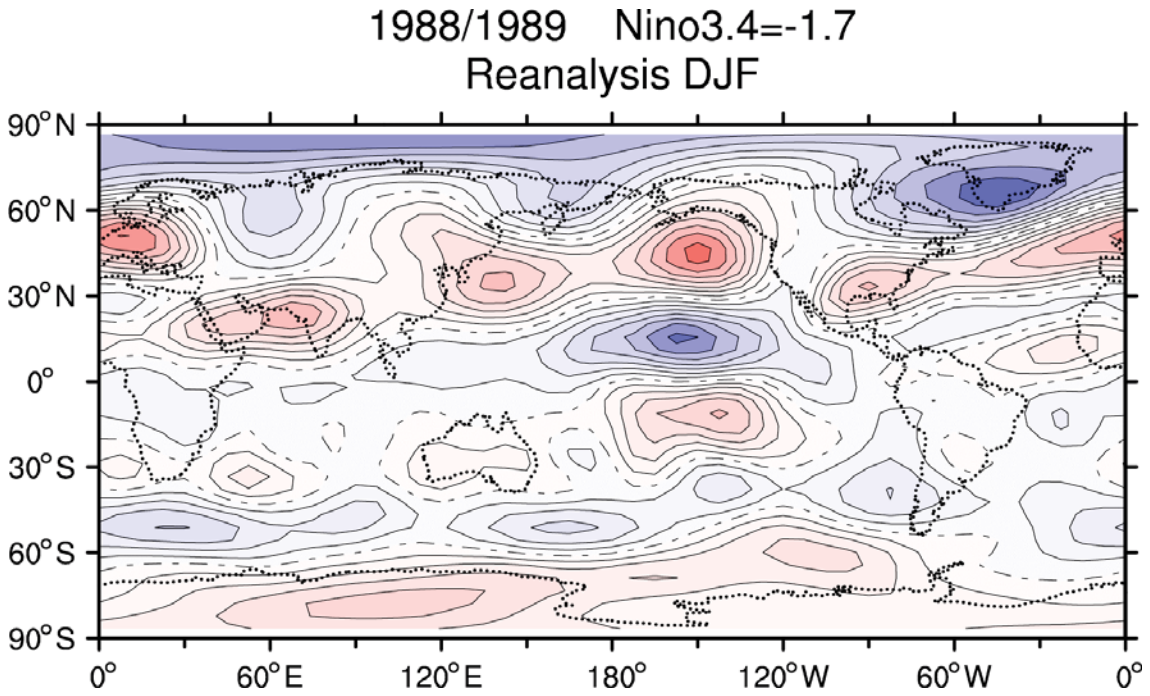


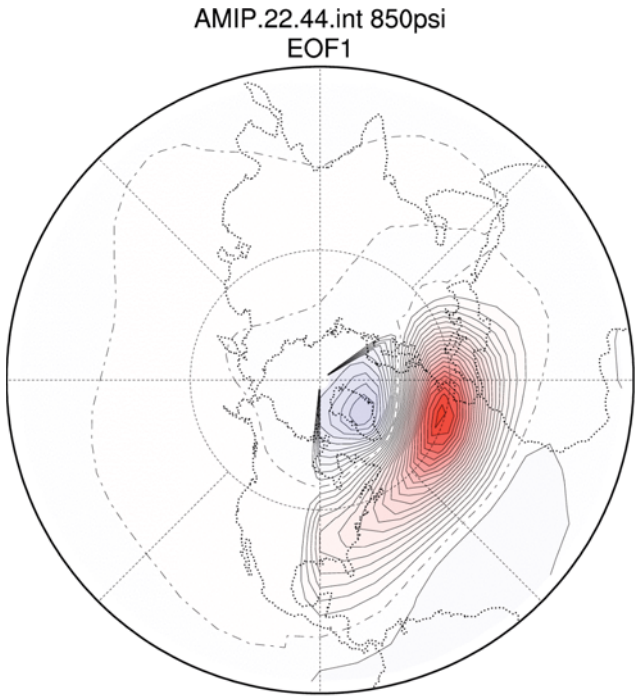


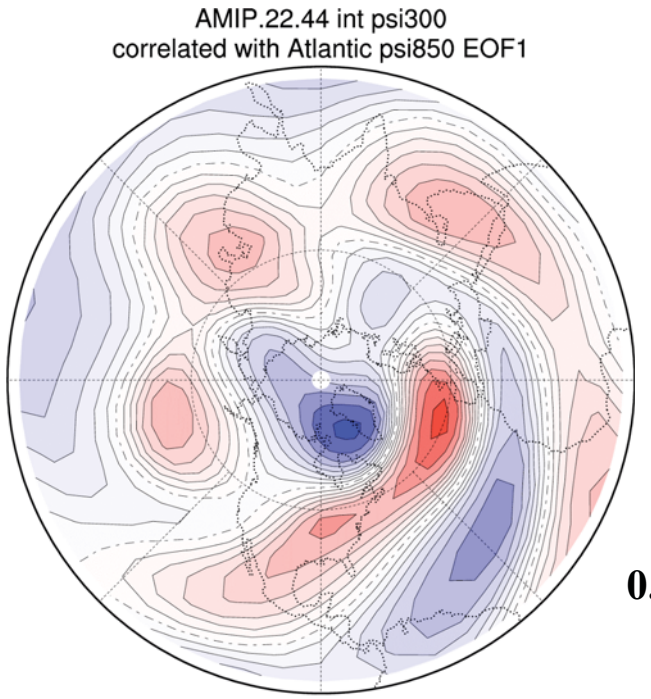
200hPa heights
Jan-Feb 2008



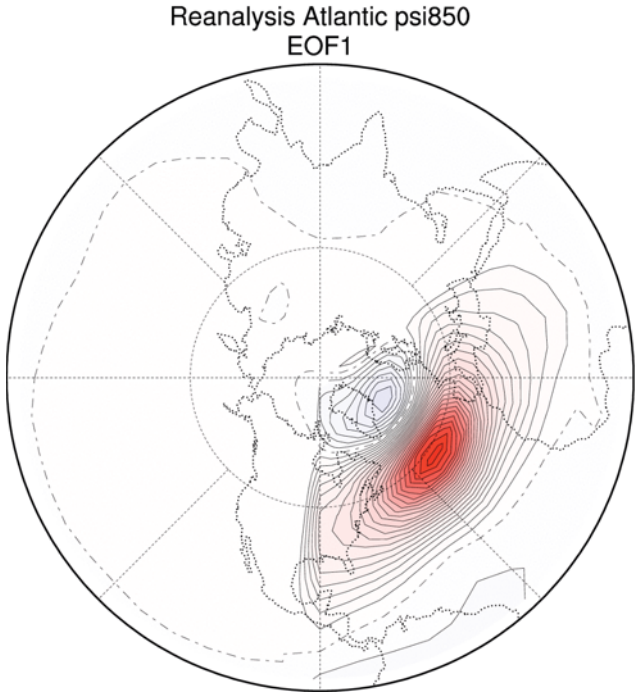
Dommenget (17Nov08)

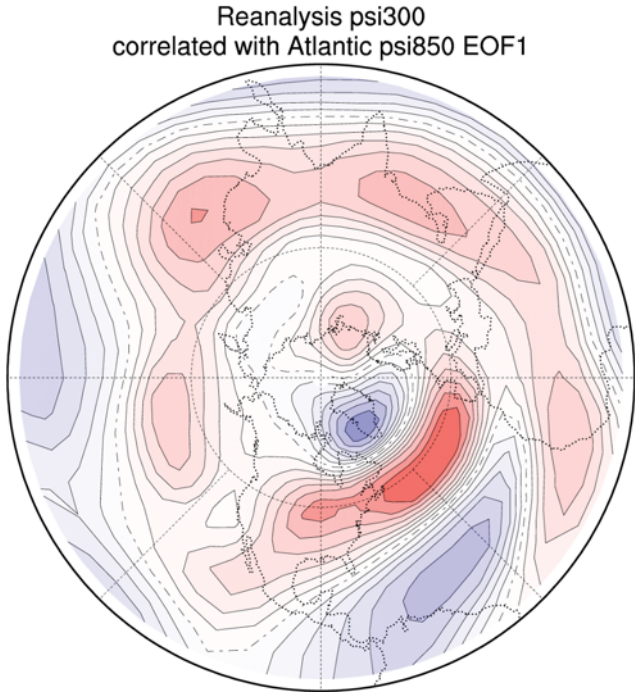

1988/1989 Nino3.4=-1.7
Reanalysis DJF
90°N
60°N
30°N
0°
30°S
60°S
90°S
0°
60°E
120°E
180°
120°W
60°W
0°

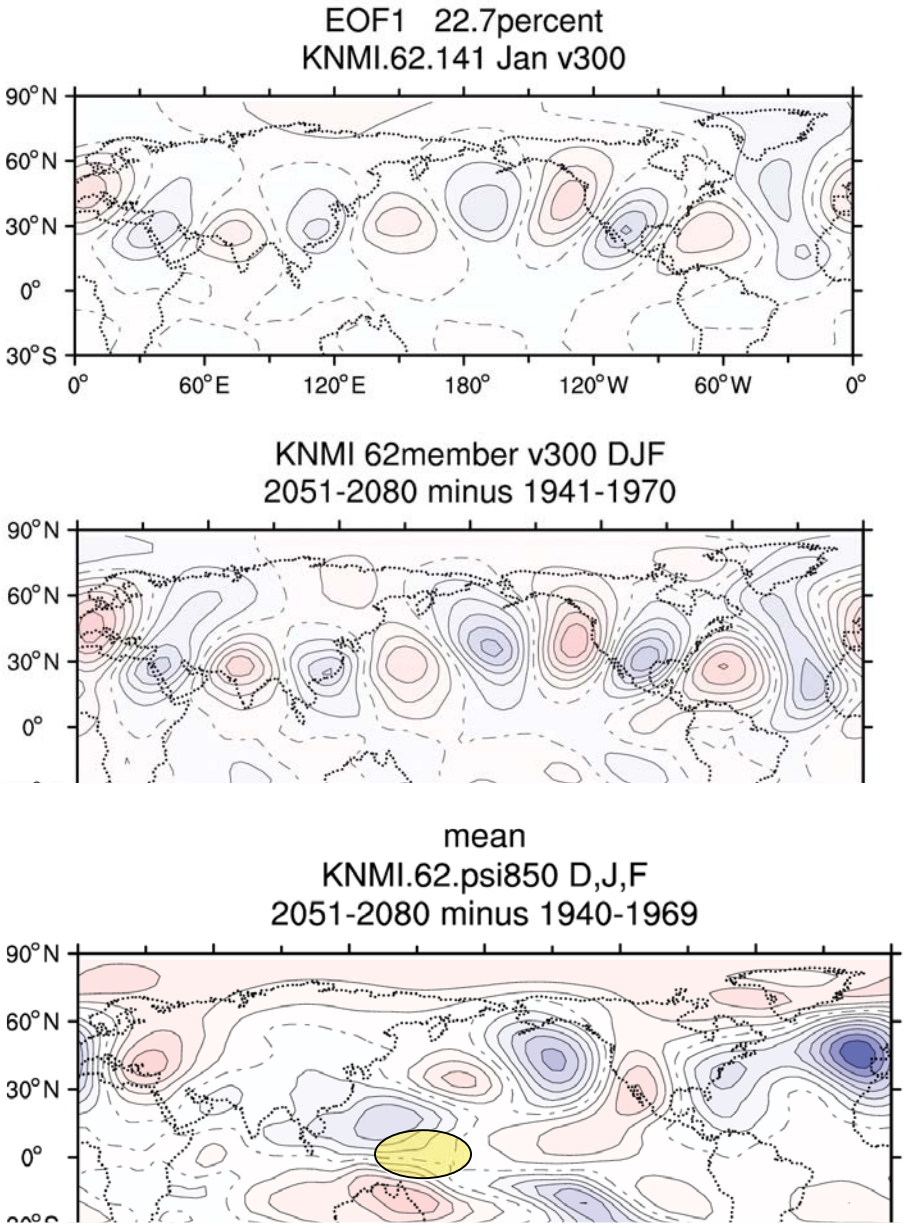

AMIP.22.44.int 850psi
EOF1


AMIP.22.44 int psi300
correlated with Atlantic psi850 EOF1

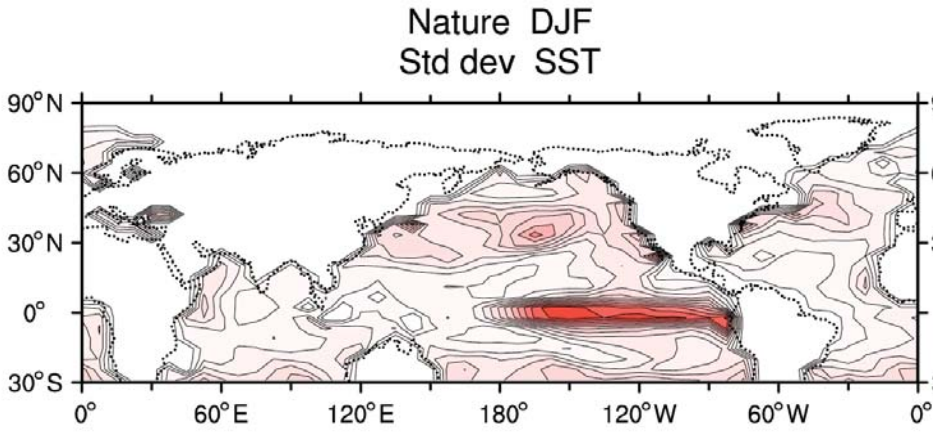
0.1

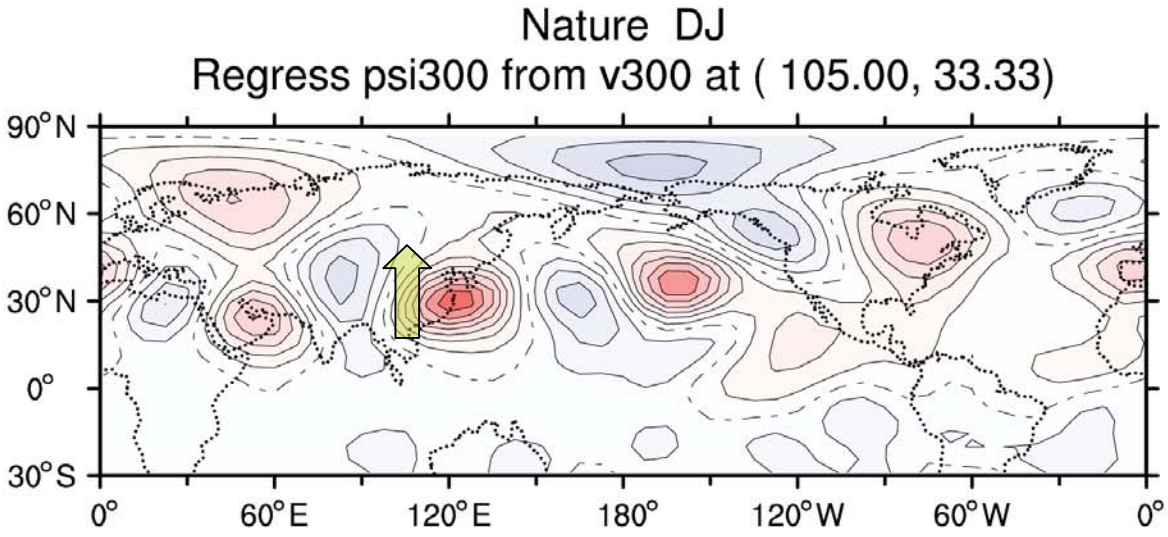

Reanalysis Atlantic psi850
EOF1


Reanalysis psi300
correlated with Atlantic psi850 EOF1

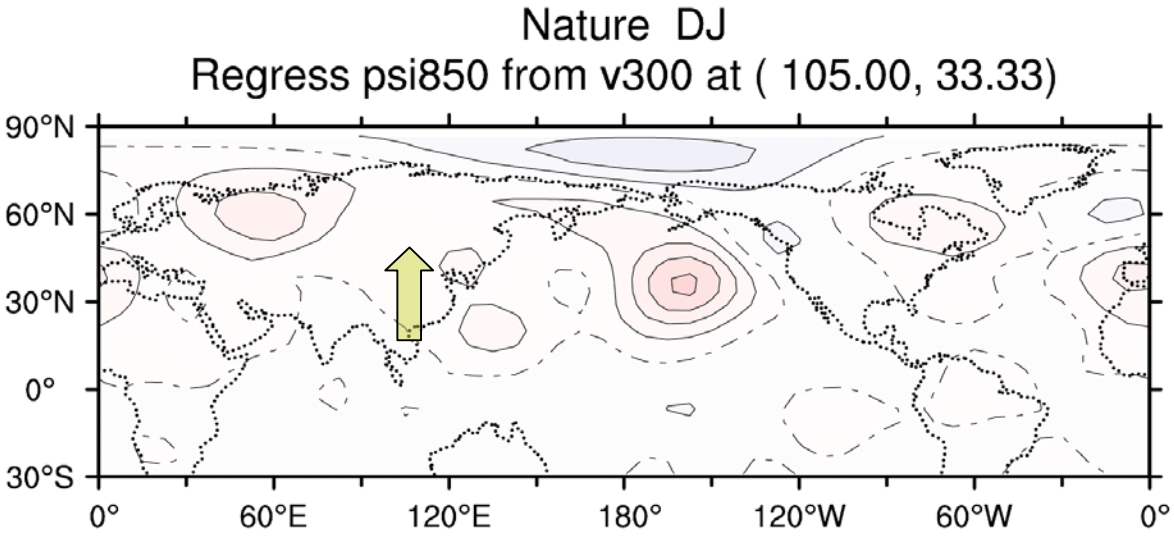


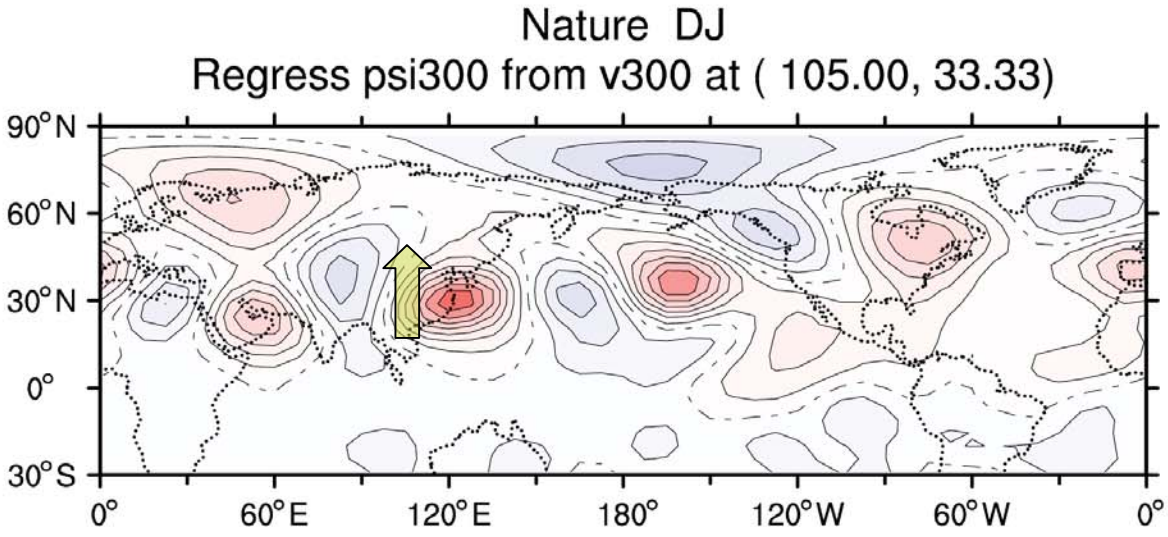
Branstator & Selten (2009)


Nature DJF
Std dev SST
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°

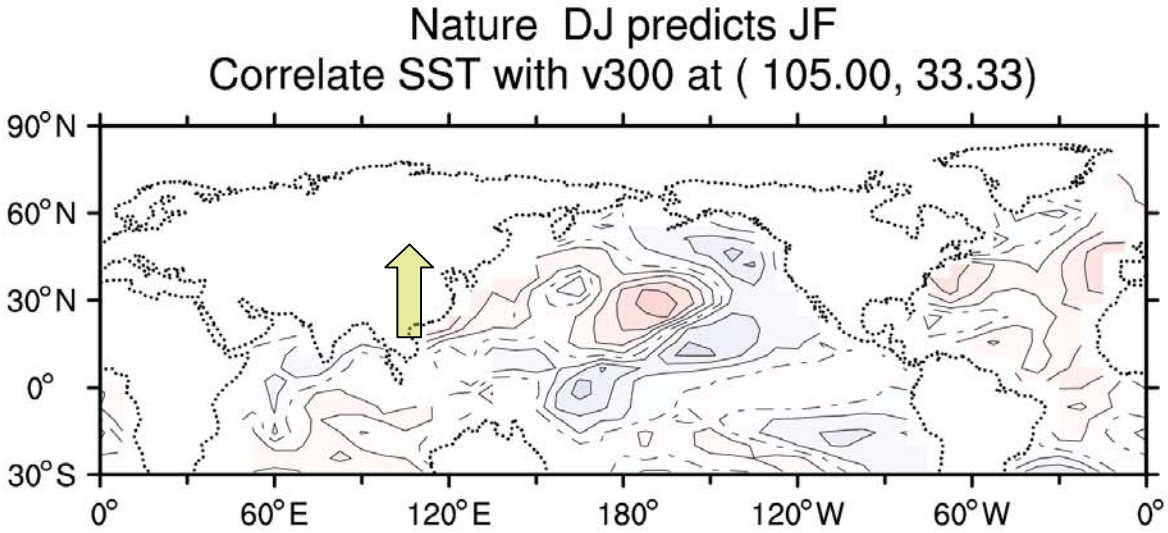

Nature DJ
Regress psi300 from v300 at (105.00, 33.33)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°

$5x10^5\,m^2s^{-1}$

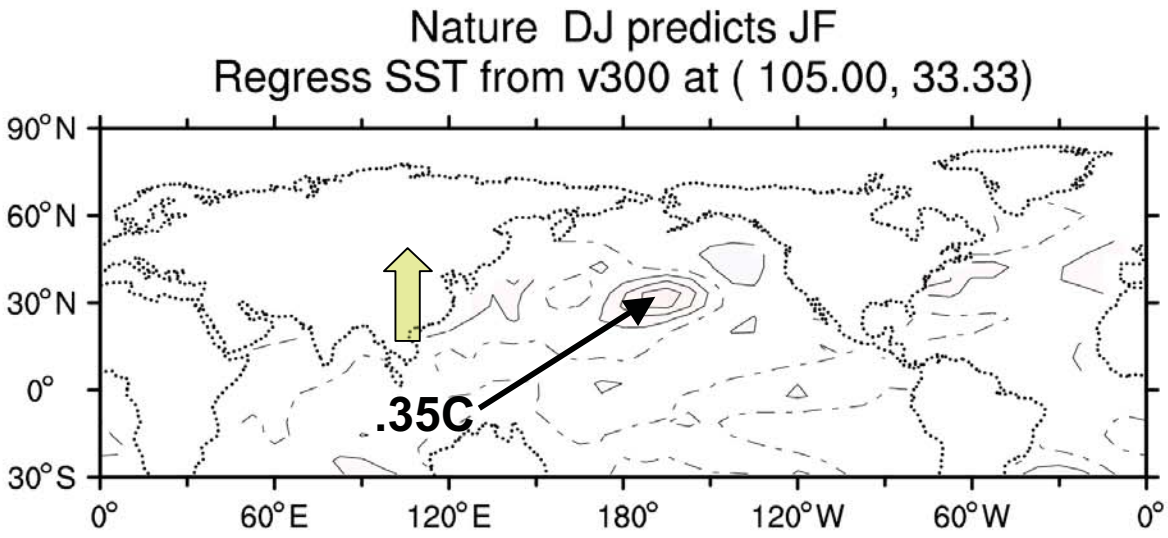

Nature DJ
Regress psi850 from v300 at (105.00, 33.33)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°



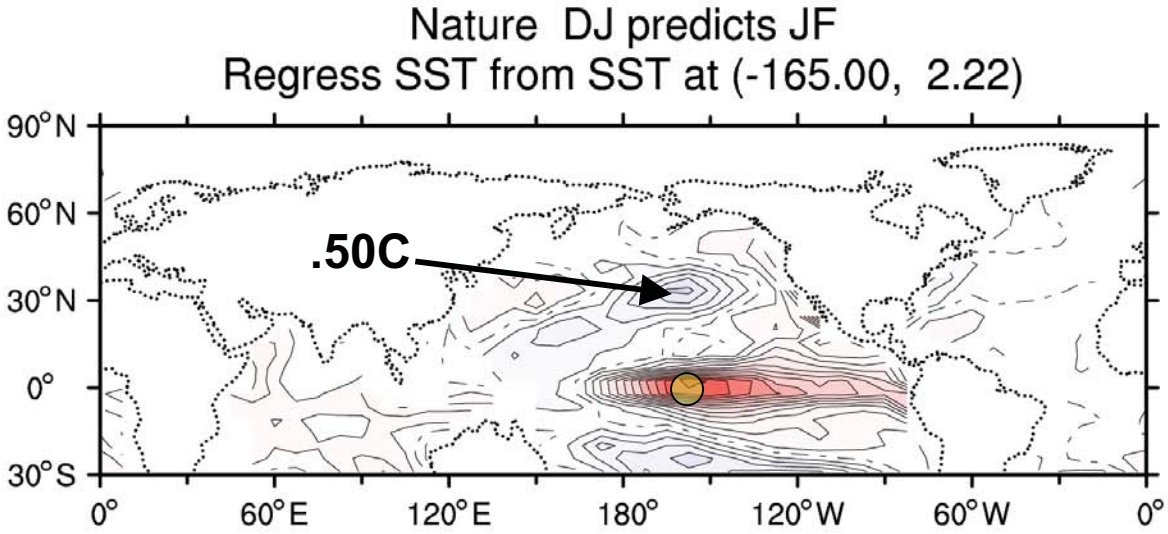
$5x10^5\, m^2 s^{-1}$



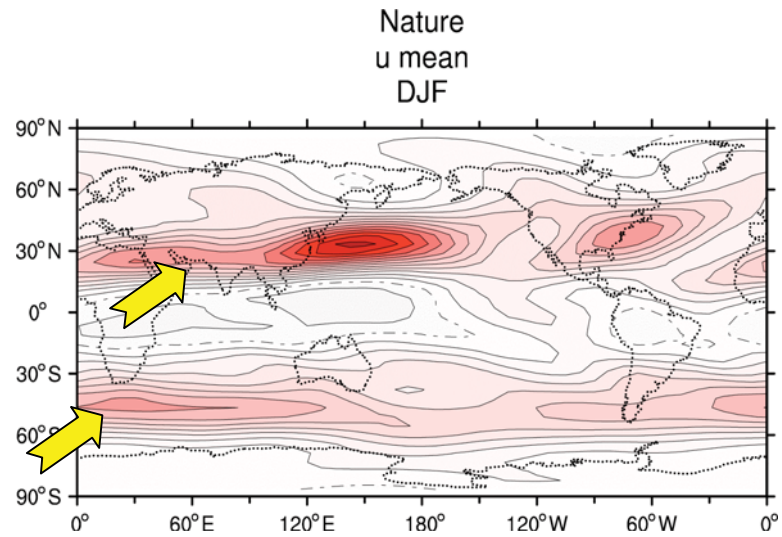
0.1

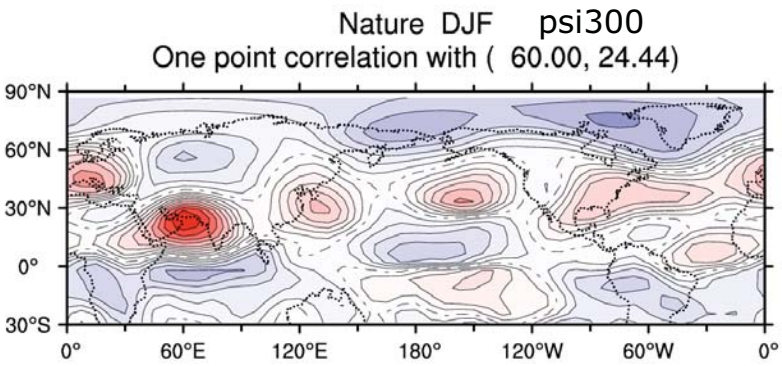

Nature DJ predicts JF
Regress SST from v300 at (105.00, 33.33)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
.35C

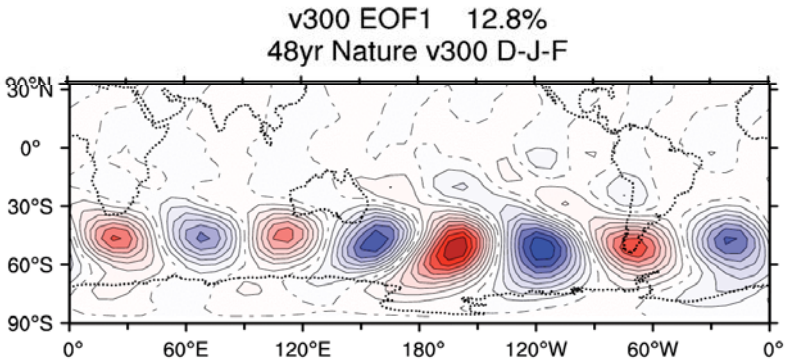
0.1C


Nature DJ predicts JF
Regress SST from SST at (-165.00, 2.22)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°
.50C

0.1C


Nature
u mean
DJF
90°N
60°N
30°N
0°
30°S
60°S
90°S
0°
60°E
120°E
180°
120°W
60°W
0°


Nature DJF psi300
One point correlation with (60.00, 24.44)
90°N
60°N
30°N
0°
30°S
0°
60°E
120°E
180°
120°W
60°W
0°


v300 EOF1 12.8%
48yr Nature v300 D-J-F
30°N
0°
30°S
60°S
90°S
0°
60°E
120°E
180°
120°W
60°W
0°