The Abdus Salam International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization
IAEA International Atomic Energy Agency

1968-53

Conference on Teleconnections in the Atmosphere and Oceans

17 - 20 November 2008

Large-scale flow variability in glacial and greenhouse climates

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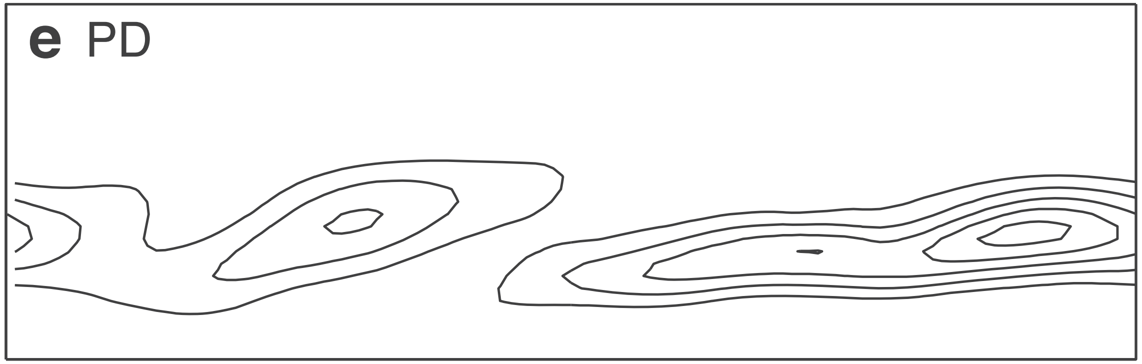
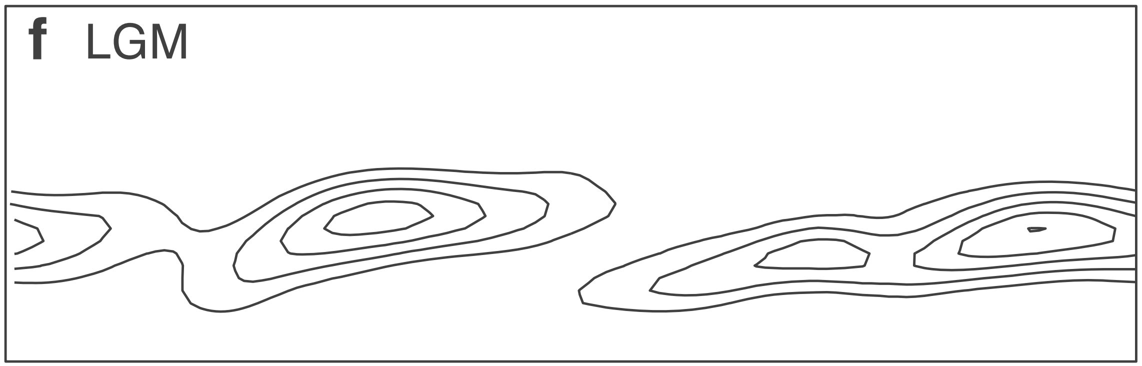
NORWAY

motivation (1)

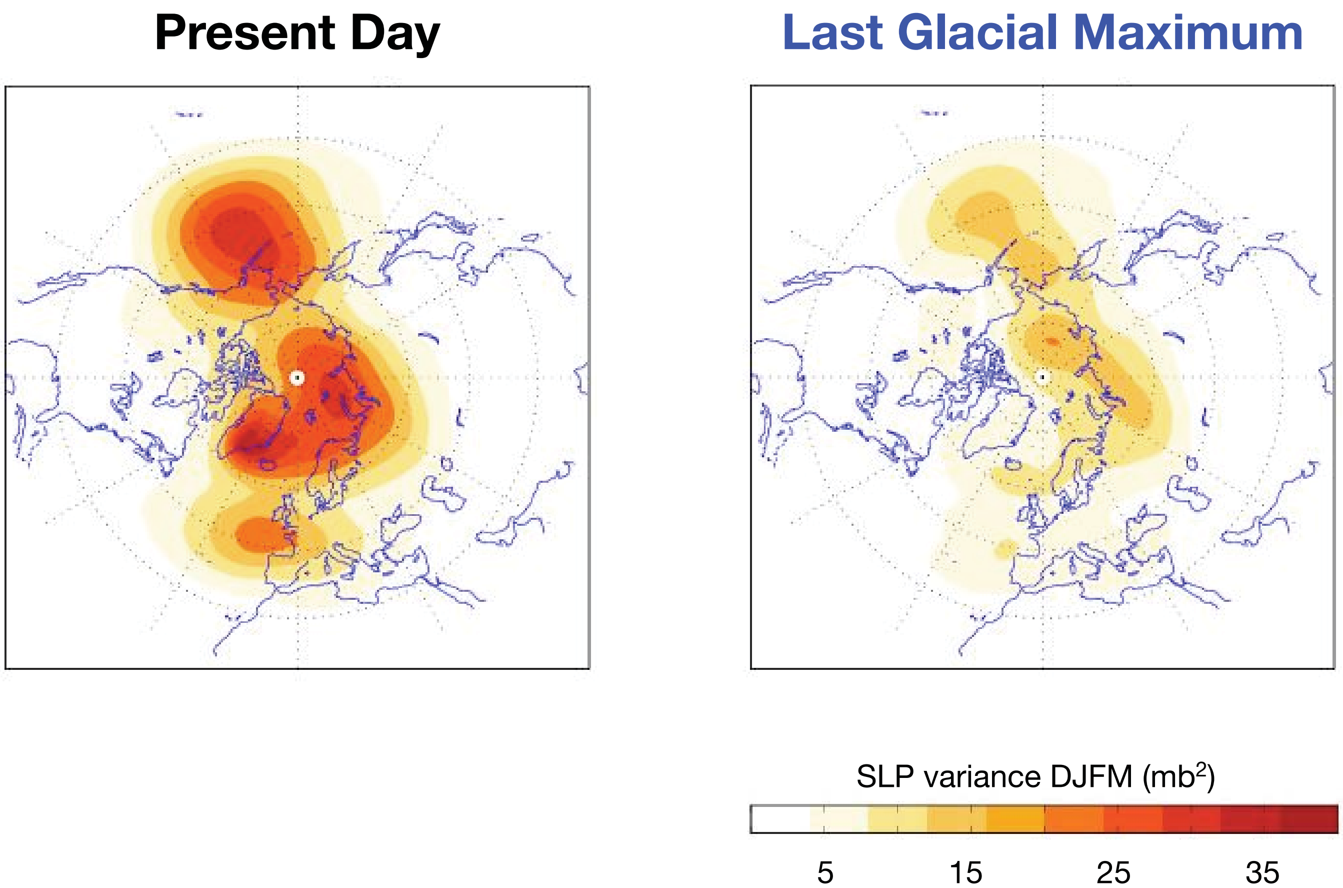
Present Day



Last Glacial Maximum



motivation (2)



eddy activity: cold to warm climates

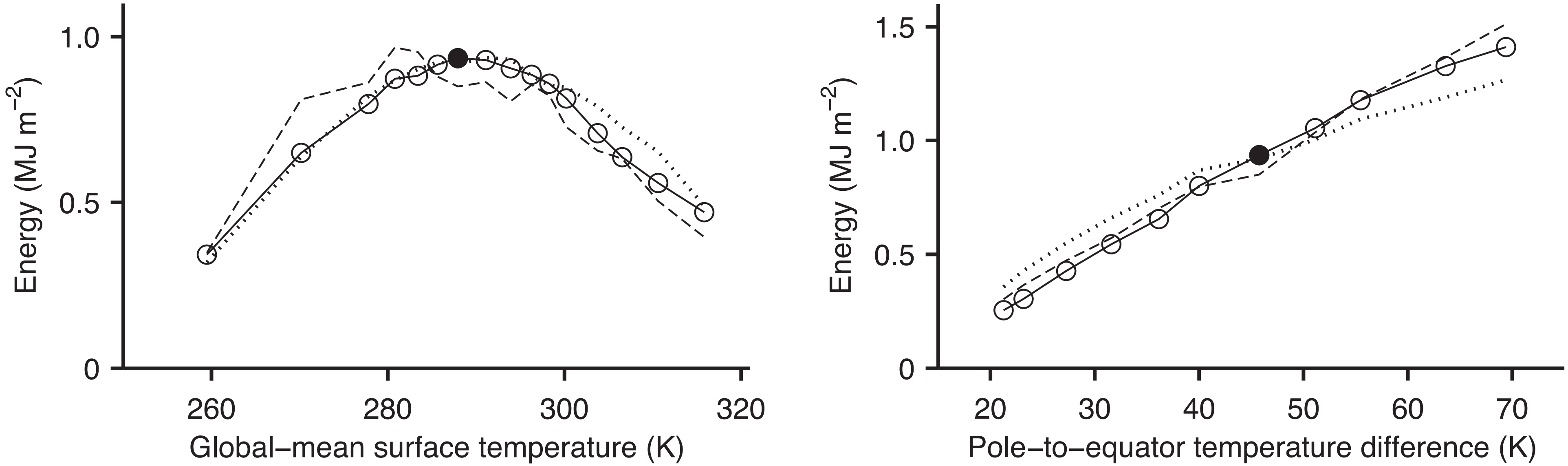
mean climate factors

- ∇T
- 1/stability
- depth of baroclinic zones
- moisture

other factors

- “governors”
- mean flow interaction
- ...

idealized cold to warm climates

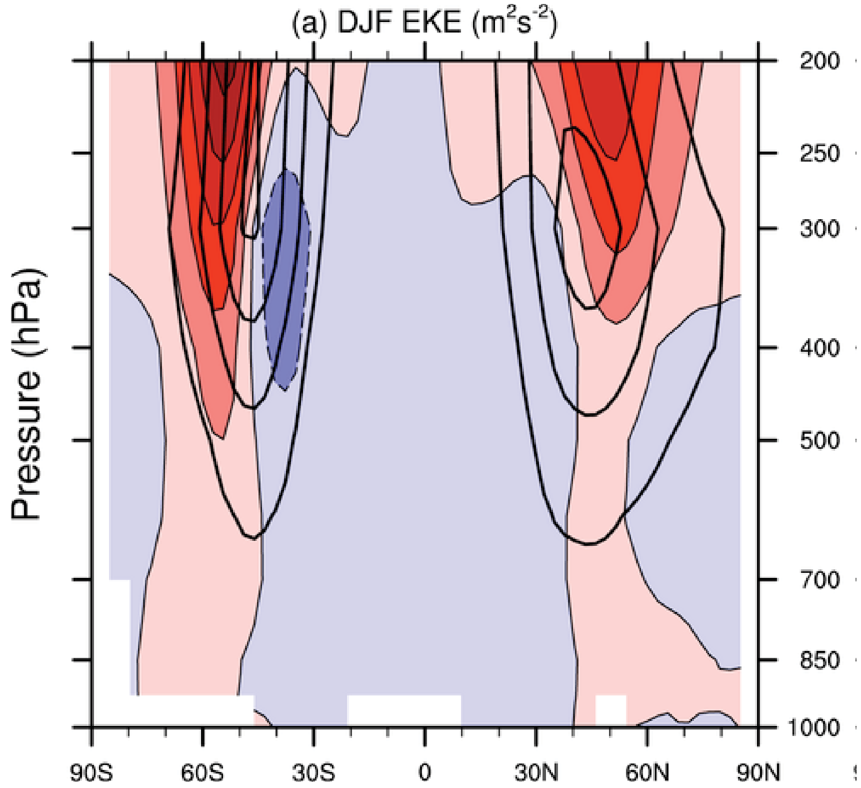


O’Gorman & Schneider 2008 JClim

warming climate

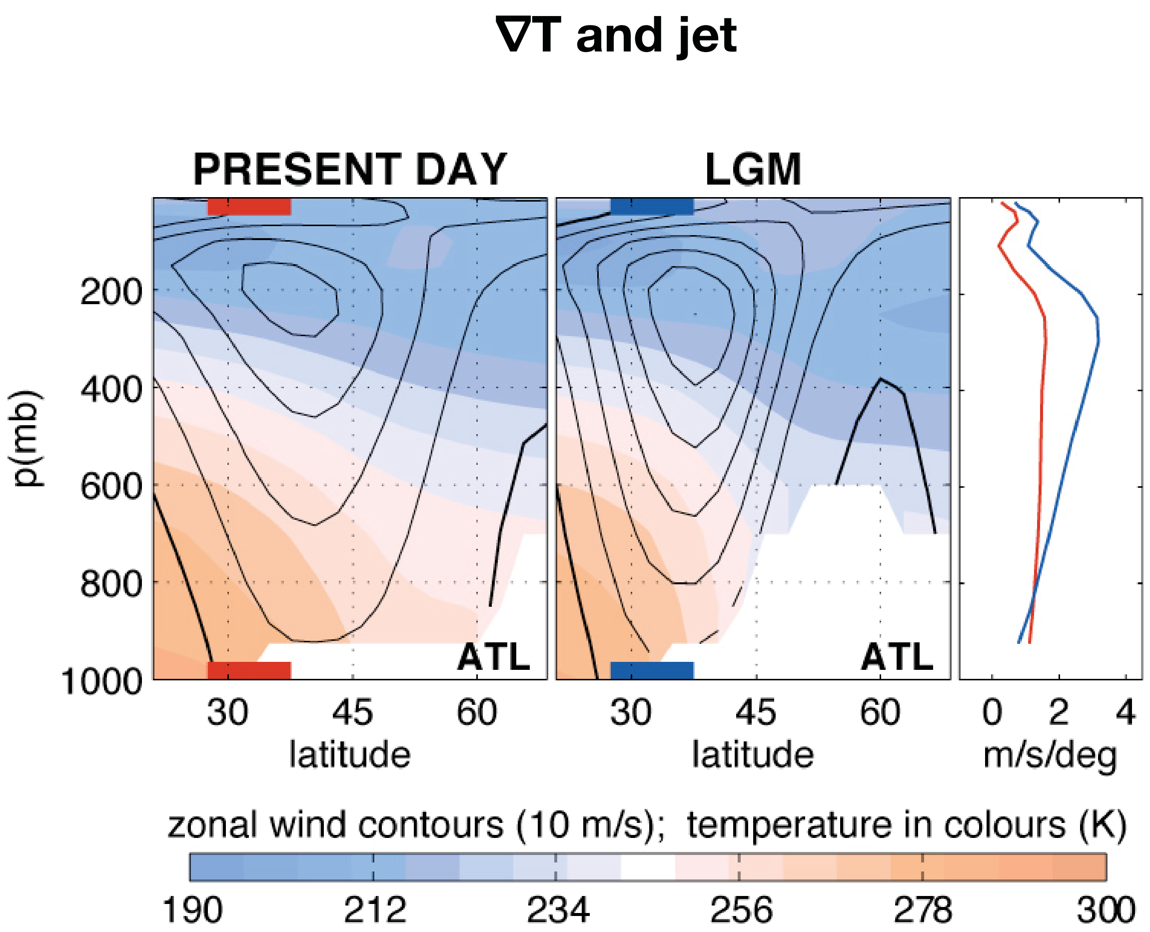
mean climate factors

- ∇T
- 1/stability
- depth of baroclinic zones
- moisture



Yin 2005 GRL

cold climate

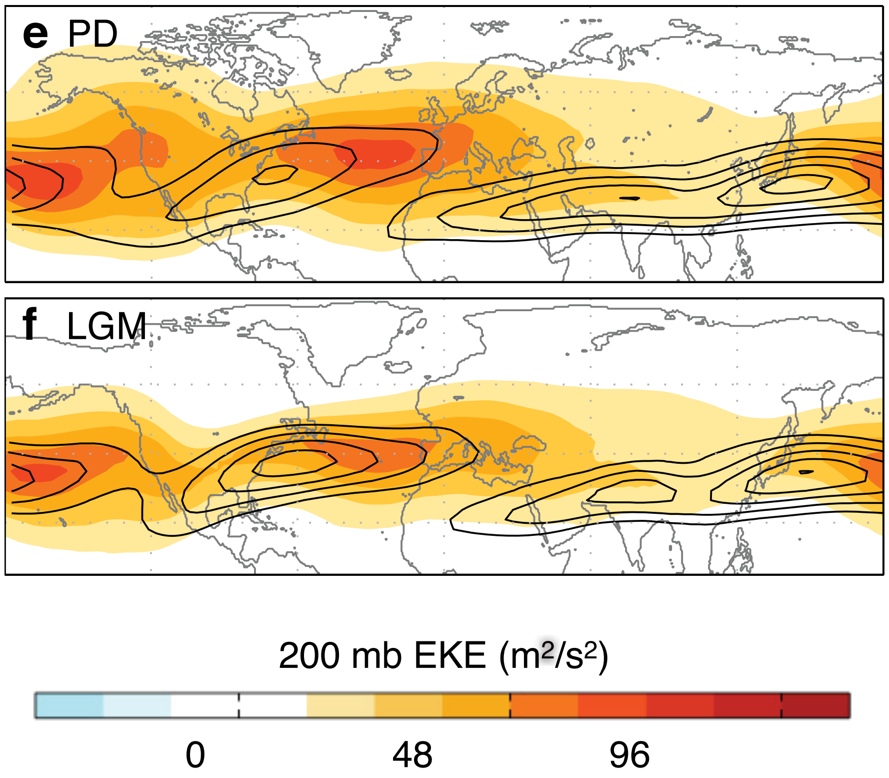


Li and Battisti 2008 JClim

cold climate

eddy activity and jet

colours: eddy kinetic energy aloft
contours: zonal wind aloft (10 m/s starting at 30 m/s)

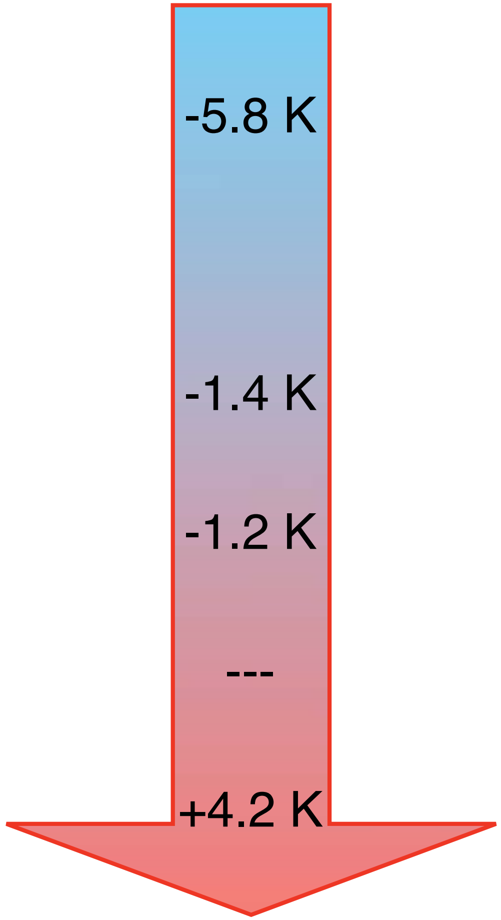


see also Laîné et al 2008 ClimDyn
Li and Battisti 2008 JClim

cold to warm: climates

Coupled simulations (CCSM3)

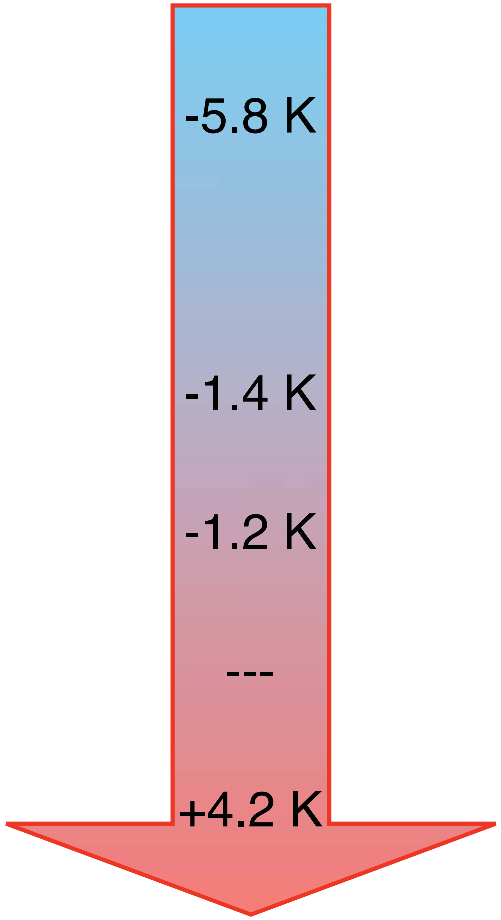
- Last Glacial Maximum (21 ka)
- deglaciation (14 ka)
- mid-Holocene (6 ka)
- pre-industrial
- present day
- 4xCO2



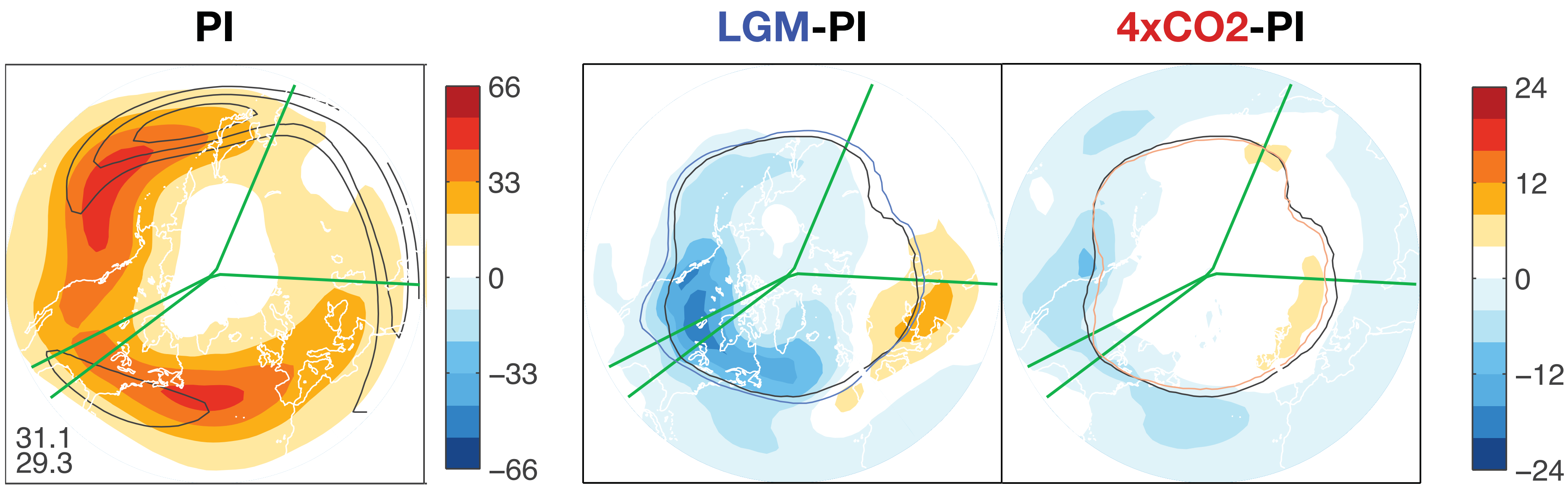
cold to warm: climates

Atmosphere simulations (CAM3)

- Last Glacial Maximum (21 ka)
- deglaciation (14 ka)
- mid-Holocene (6 ka)
- pre-industrial
- present day
- 4xCO2



cold to warm: eddy activity

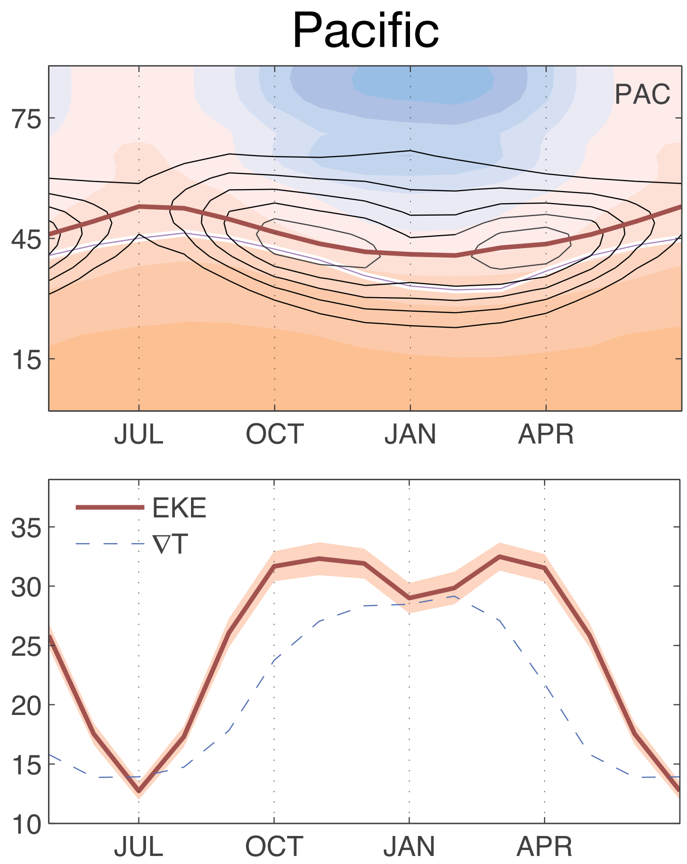


winter (NDJFM) eddy kinetic energy

colours: column eddy kinetic energy (m^2/s^2)

left: zonal wind aloft (10 m/s contours starting at 40 m/s)

cold to warm: eddy activity

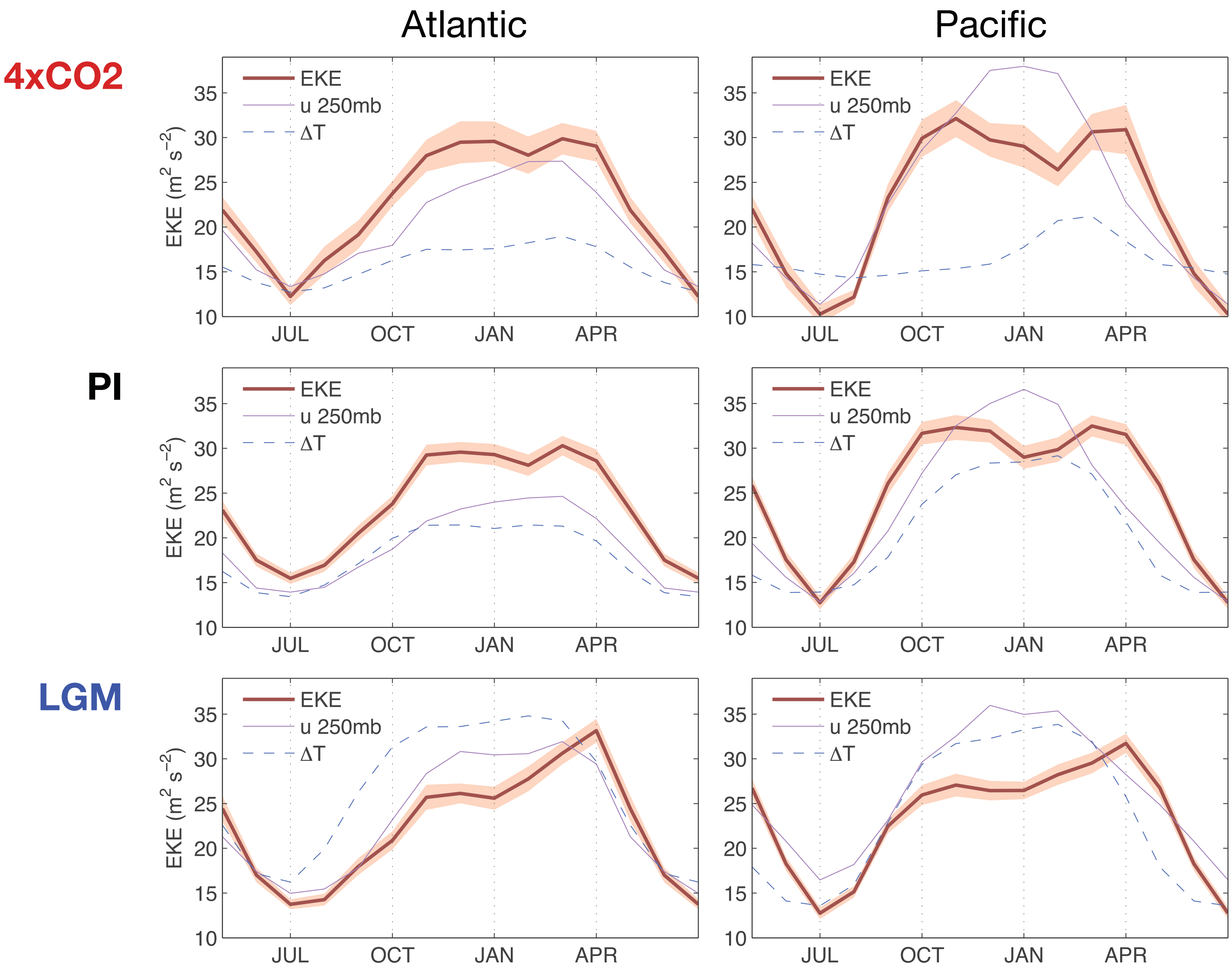


seasonal cycle of column EKE

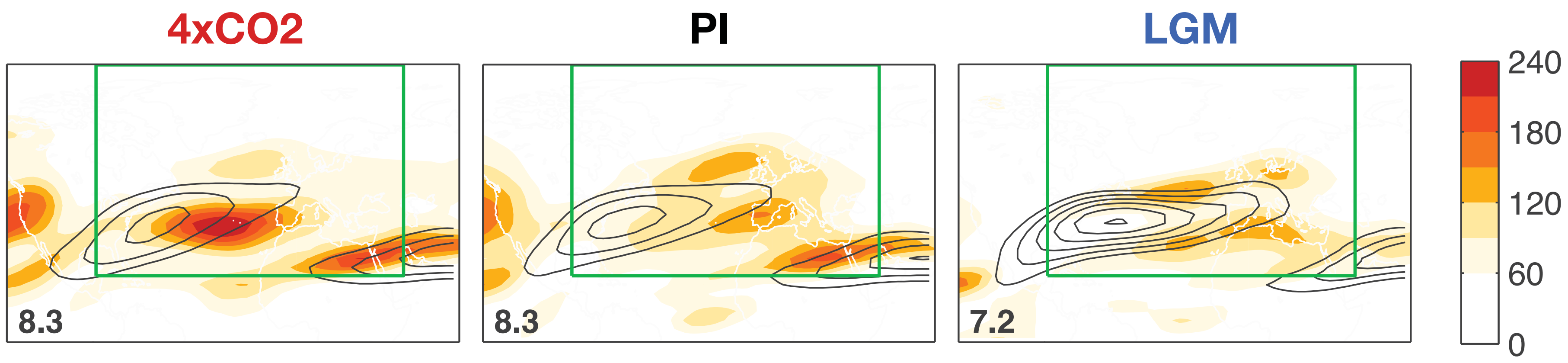
top: 6 m^2/s^2 contours starting at 15 m^2/s^2, pale colours showing Ts

bottom: baroclinic zone EKE + rescaled ∇Ts (10-80N)

cold to warm: eddy activity



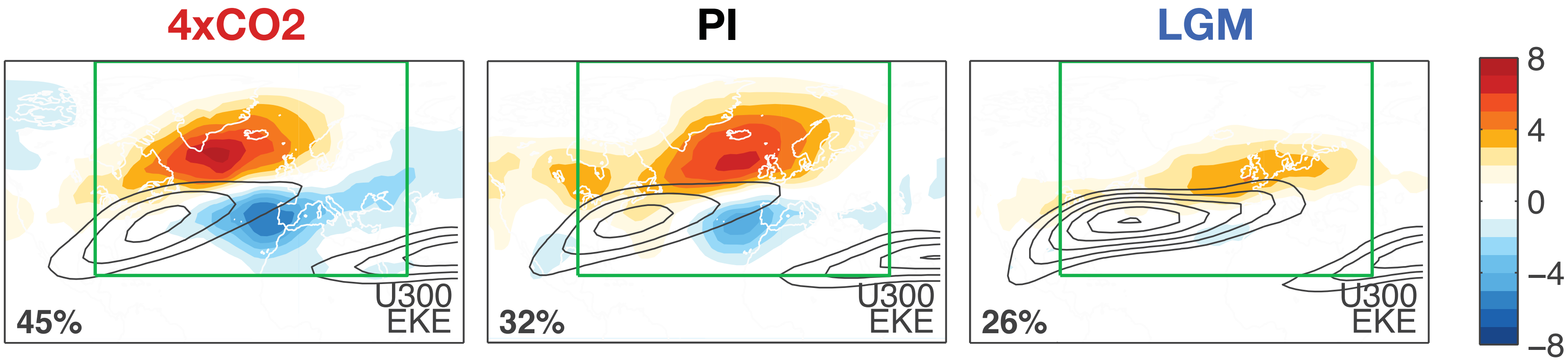
cold to warm: variability



winter (DJFM) jet variance (m/s)

contours: 300 mb wind (10 m/s starting at 40 m/s)

cold to warm: variability



winter (DJFM) jet and EKE variability

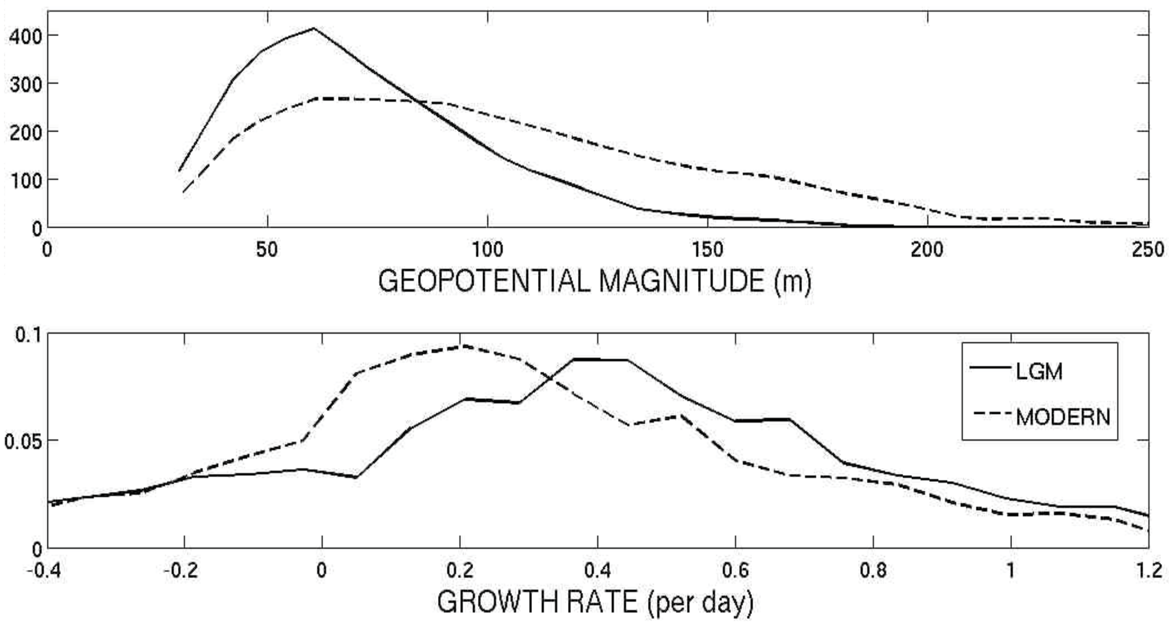
contours: U300 (10 m/s starting at 40 m/s)

colours: column EKE (m^2/s^2) on EOF1 of U300

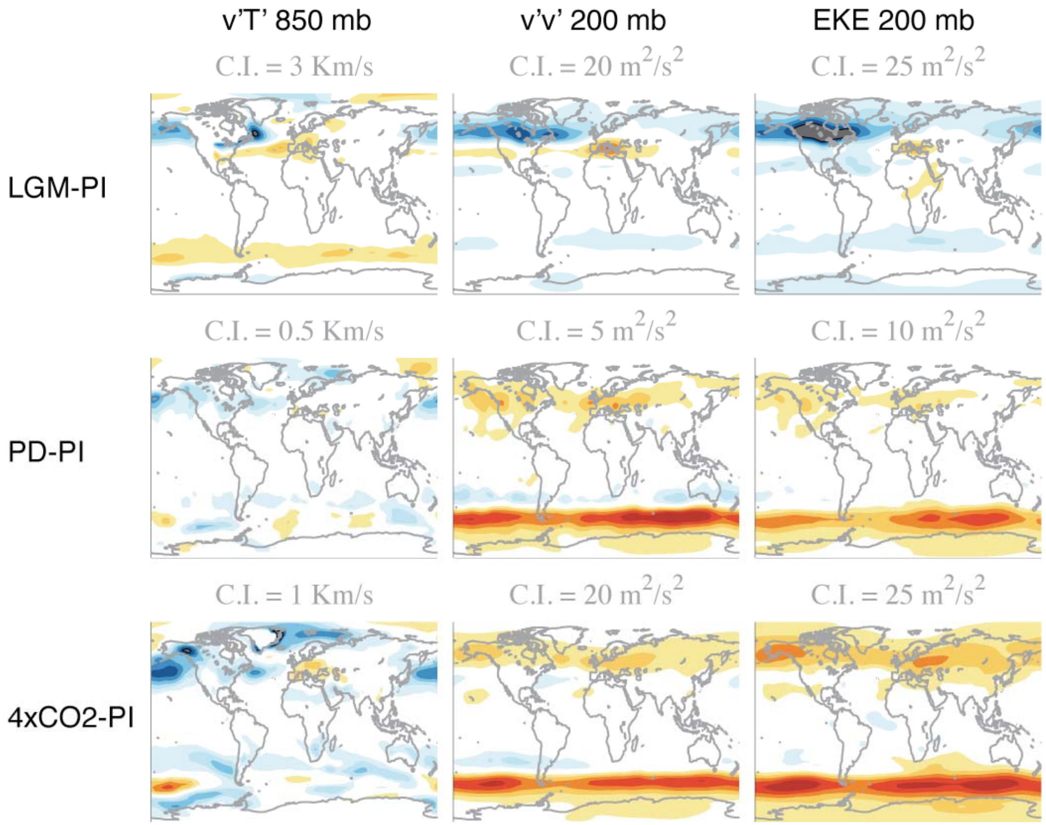
cold climate

seeding of the Atlantic storm track

top: distribution of storm magnitude
bottom: distribution of storm growth rate

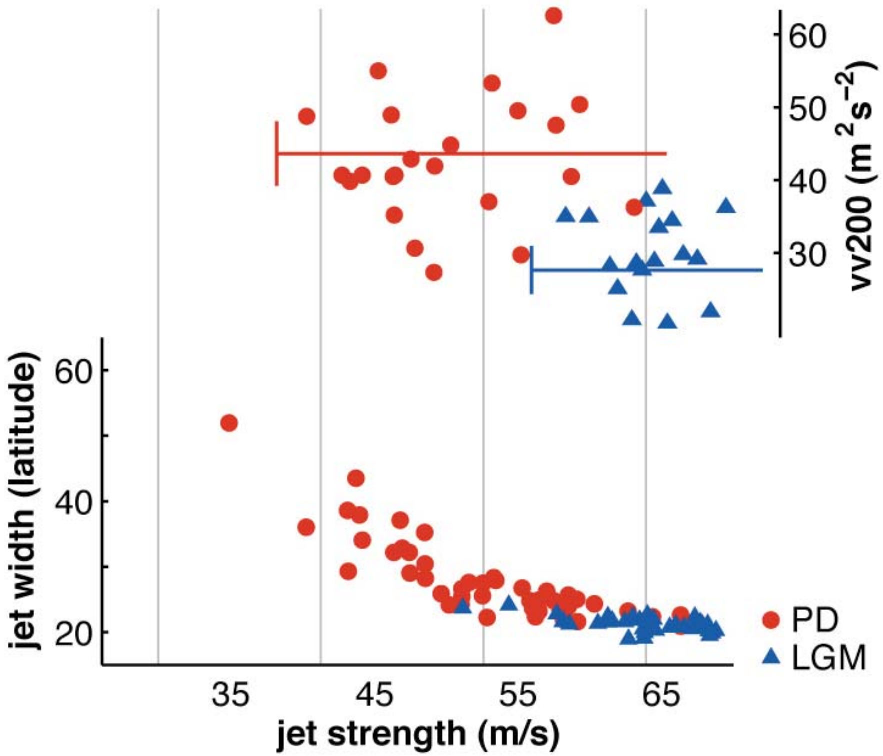


Donohoe & Battisti, submitted to JAS


v'T' 850 mb
v'v' 200 mb
EKE 200 mb
C.I. = 3 Km/s
C.I. = 20 m^2/s^2
C.I. = 25 m^2/s^2
LGM-PI
C.I. = 0.5 Km/s
C.I. = 5 m^2/s^2
C.I. = 10 m^2/s^2
PD-PI
C.I. = 1 Km/s
C.I. = 20 m^2/s^2
C.I. = 25 m^2/s^2
4xCO2-PI

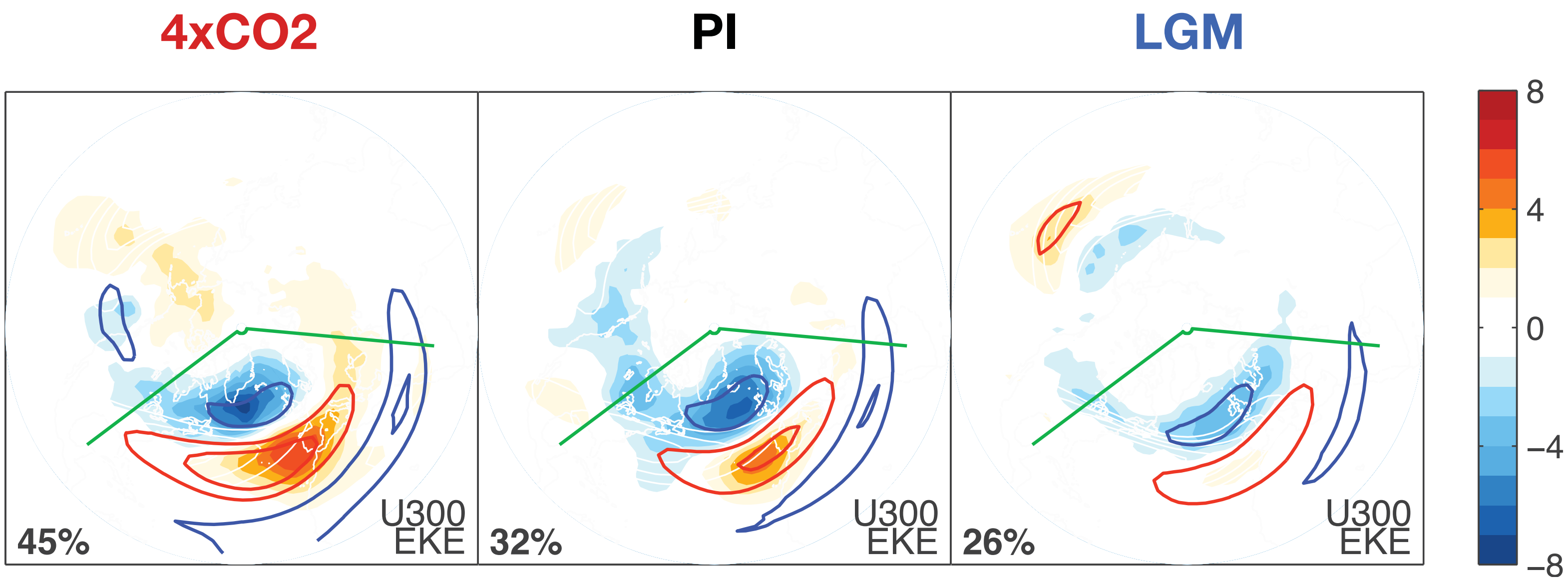
motivation

interannual variability of January Atlantic jet and storm track



Li and Battisti 2008 JClim

cold to warm: variability

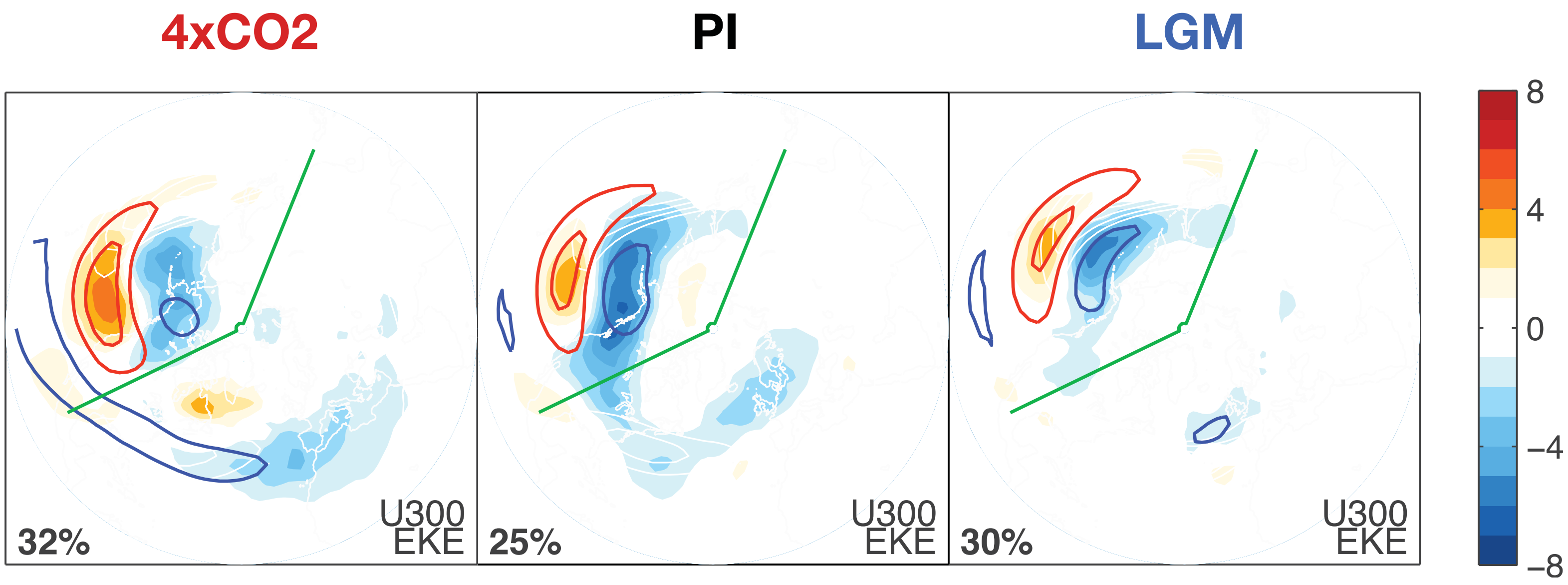


winter (DJFM) jet and EKE variability

contours: EOF1 of U300 (5 m/s contours)

colours: column eddy kinetic energy (m^2/s^2)

cold to warm: variability



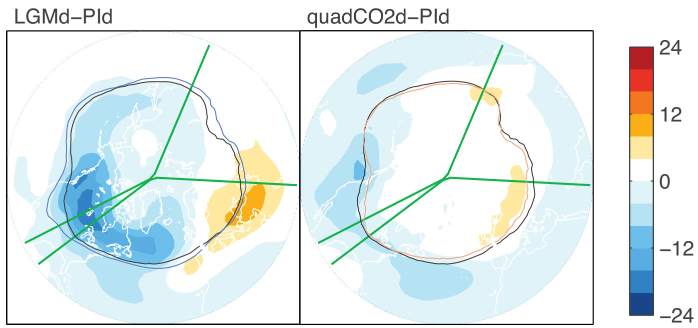
winter (DJFM) jet and EKE variability

contours: EOF1 of U300 (5 m/s contours)

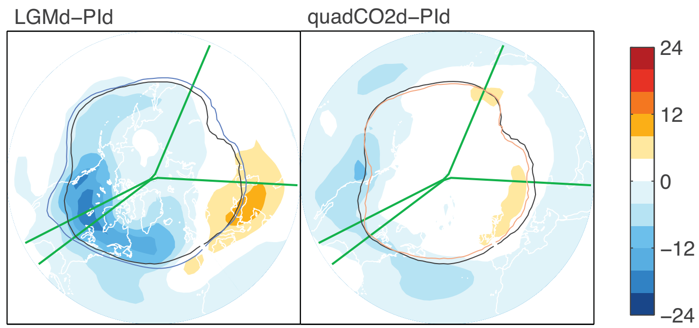
colours: column eddy kinetic energy (m^2/s^2)

NDJFM / JJA

column

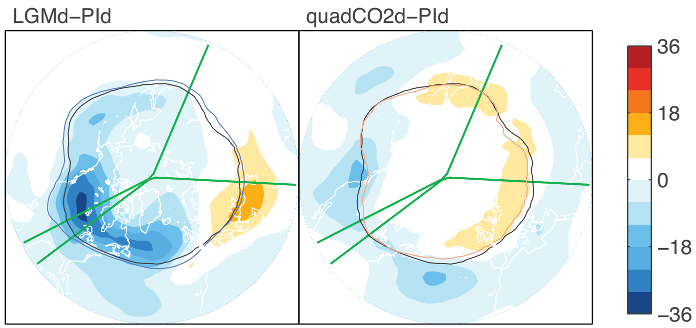


EKE (m2/s2), 0925–0200 mb, NDJFM
u200 10 m/s contours starting at 40 m/s

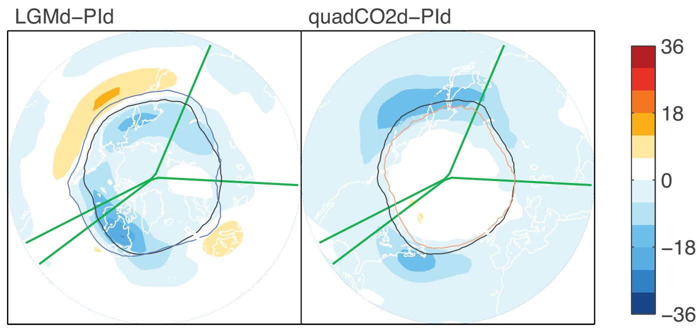


EKE (m2/s2), 0925–0200 mb, NDJFM
u200 10 m/s contours starting at 40 m/s

aloft

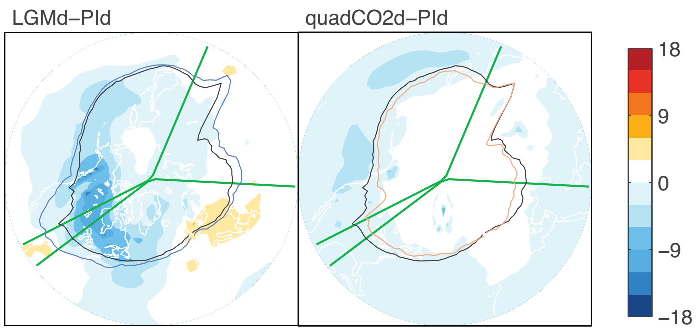


EKE (m2/s2), 0500–0200 mb, NDJFM
u200 10 m/s contours starting at 40 m/s

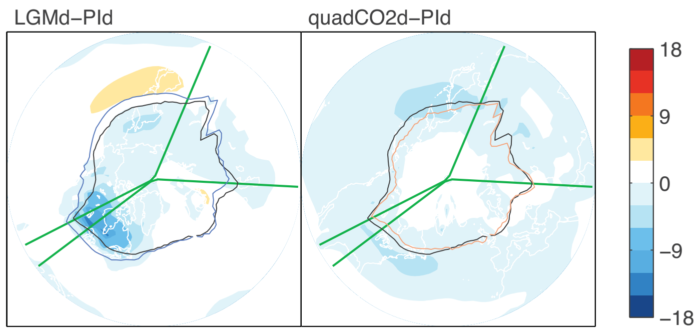


EKE (m2/s2), 0500–0200 mb, JJA
u200 10 m/s contours starting at 20 m/s

low level

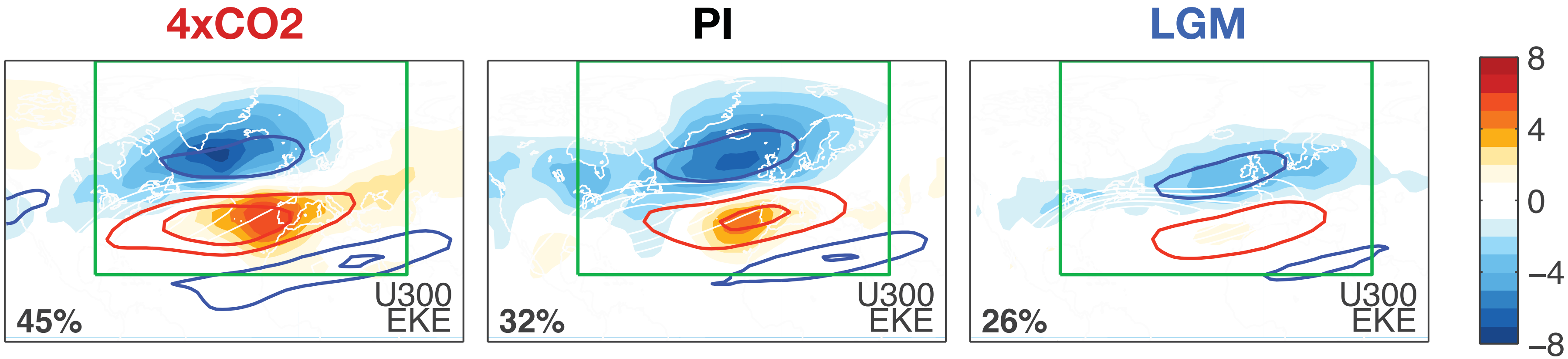


EKE (m2/s2), 0925–0700 mb, NDJFM
u200 10 m/s contours starting at 40 m/s



EKE (m2/s2), 0925–0700 mb, JJA
u200 10 m/s contours starting at 20 m/s

cold to warm: variability

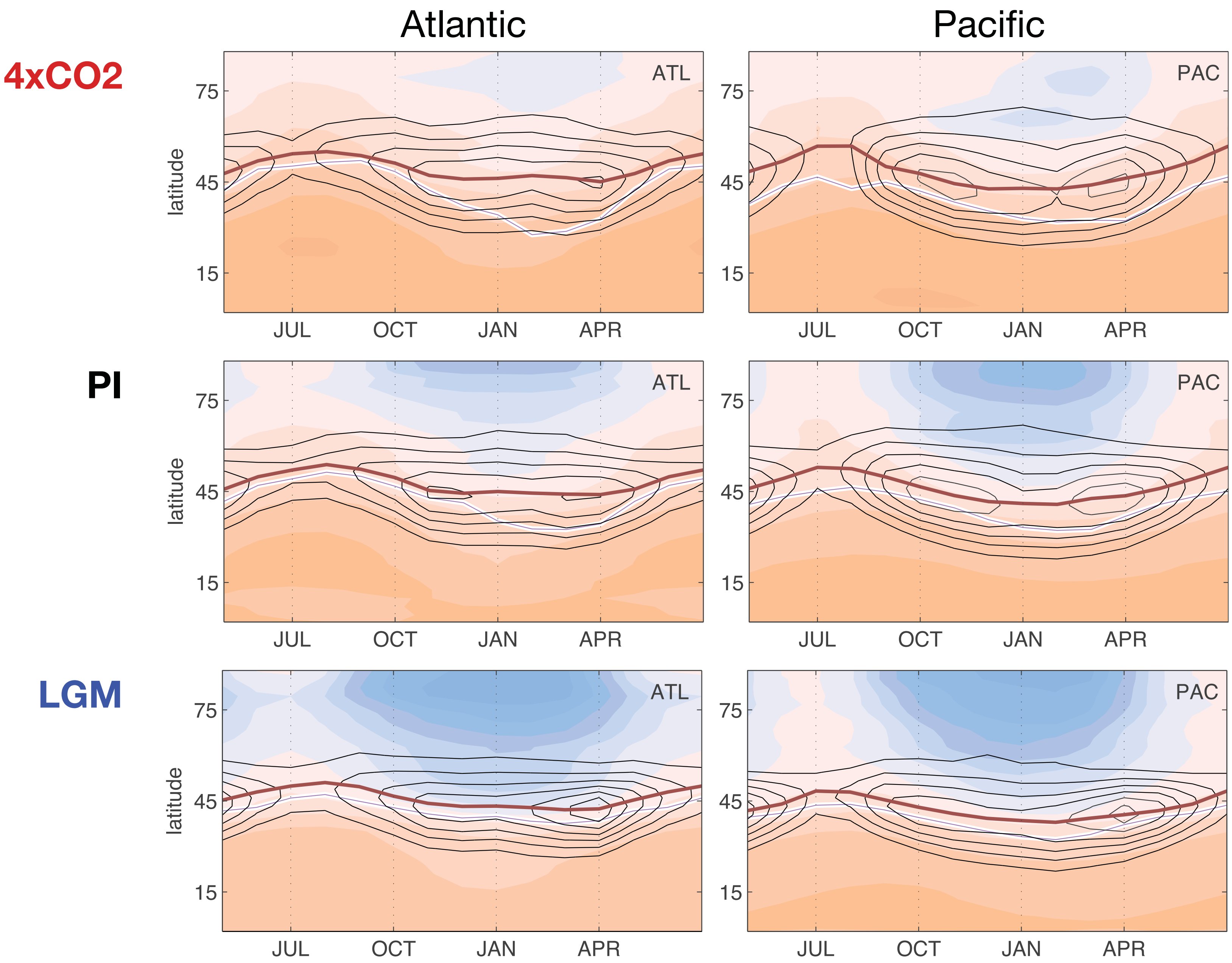


winter (DJFM) jet and EKE variability

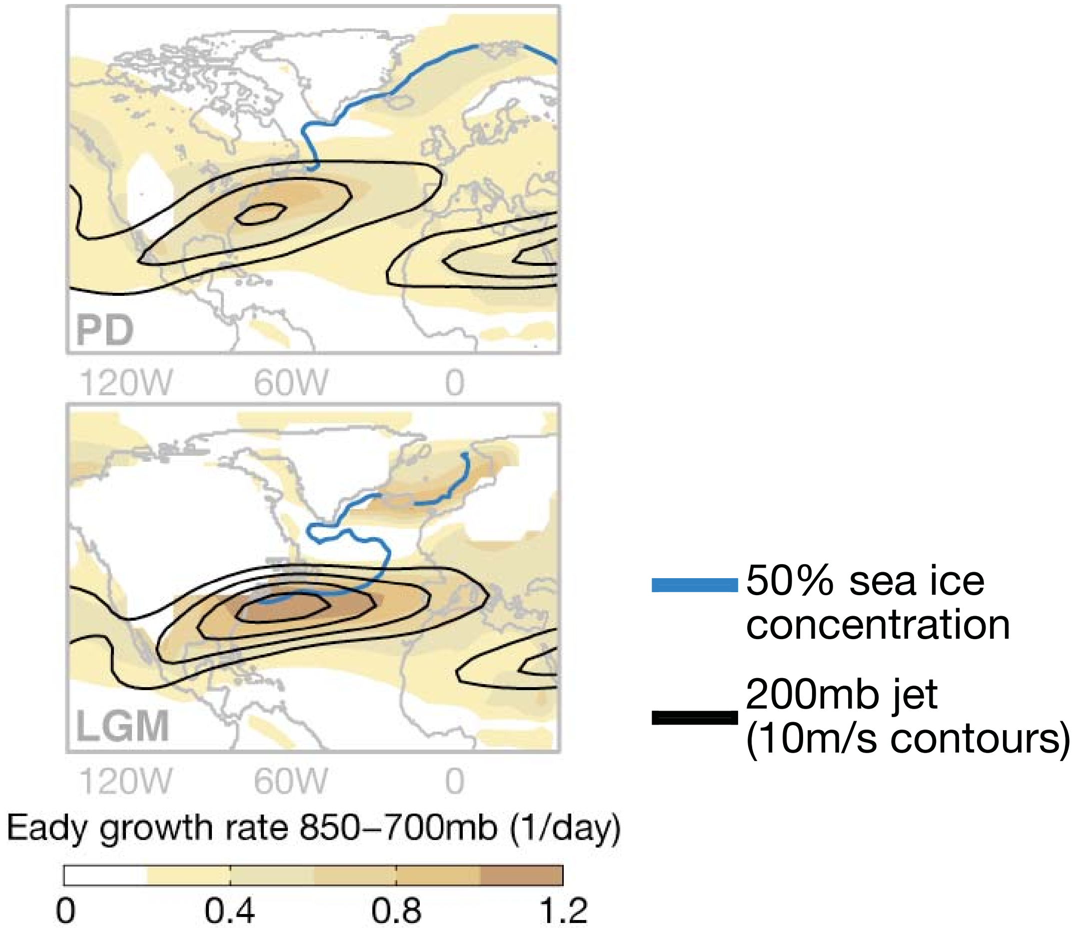
contours: EOF1 of U300 (5 m/s contours)

colours: column eddy kinetic energy (m^2/s^2)

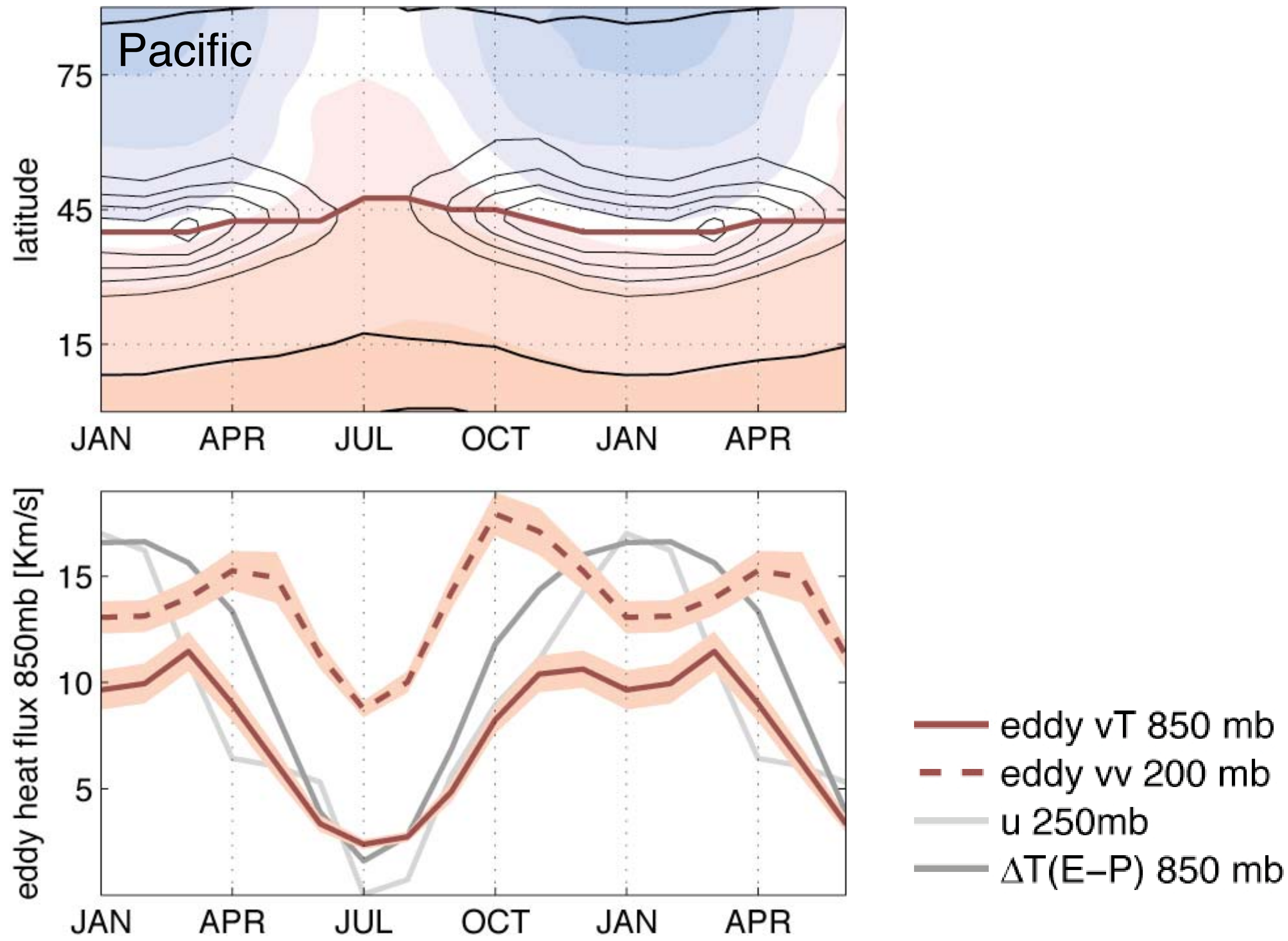
Atlantic vs Pacific

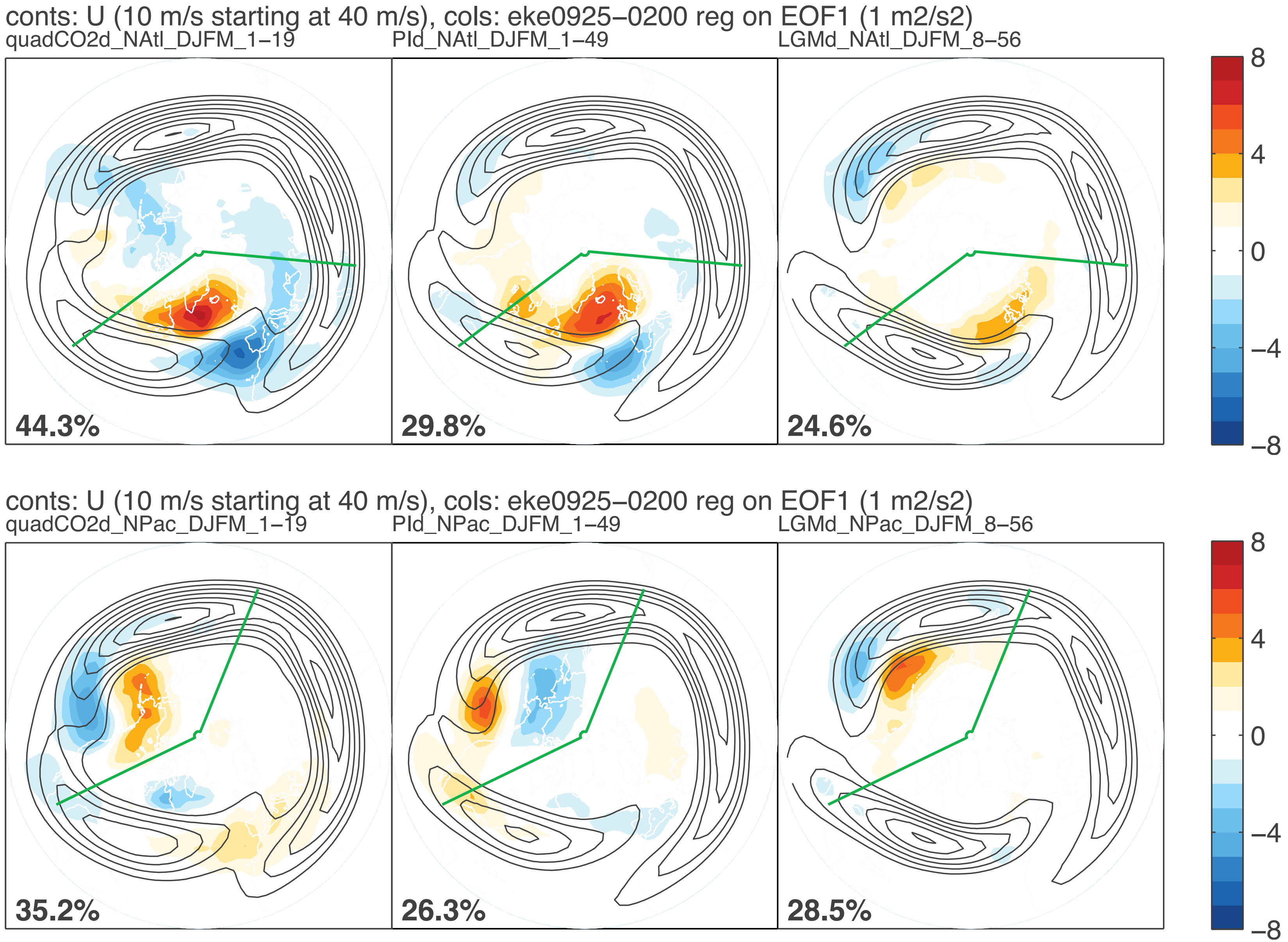


∇T and stability

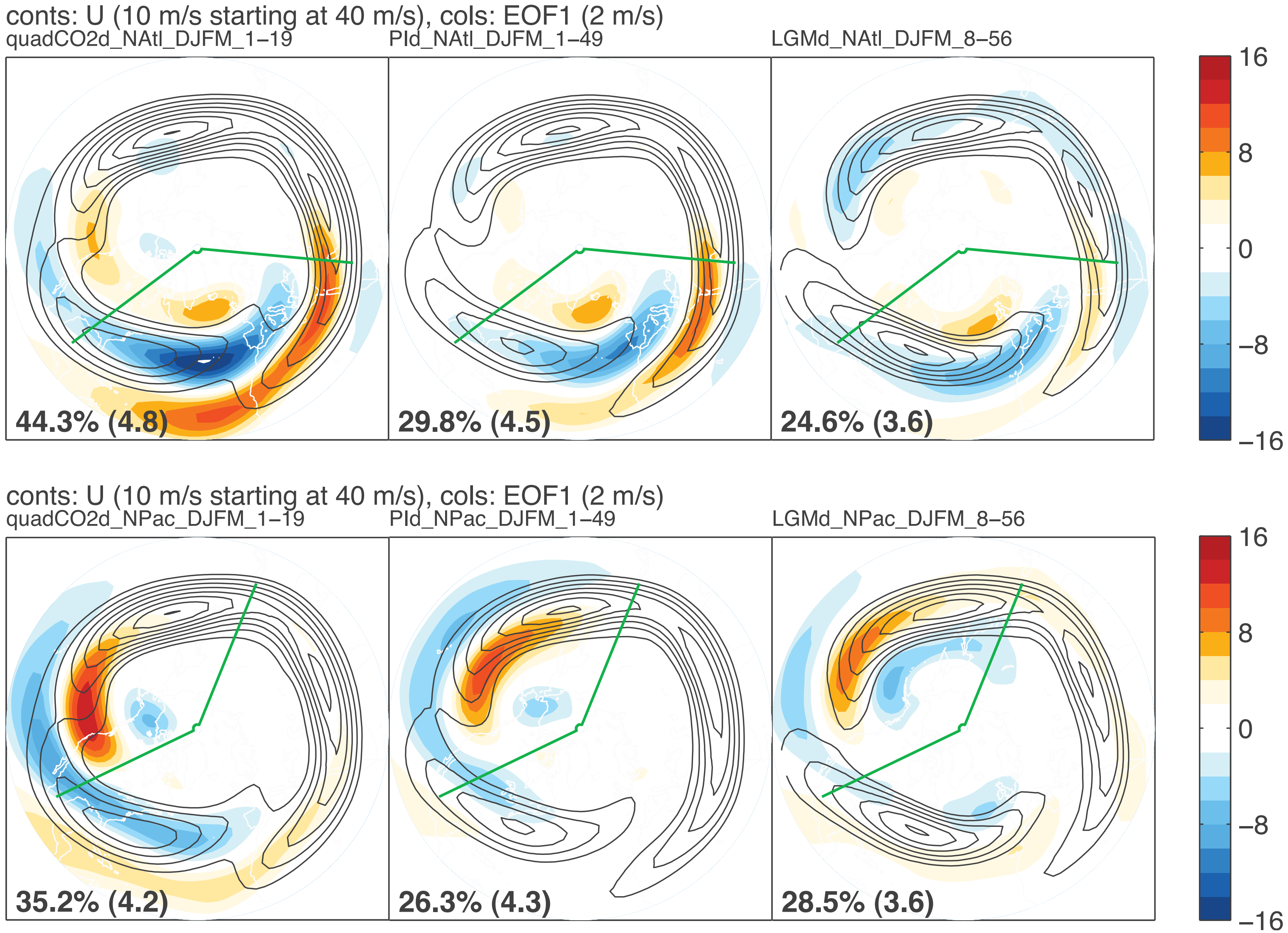


Pacific midwinter suppression



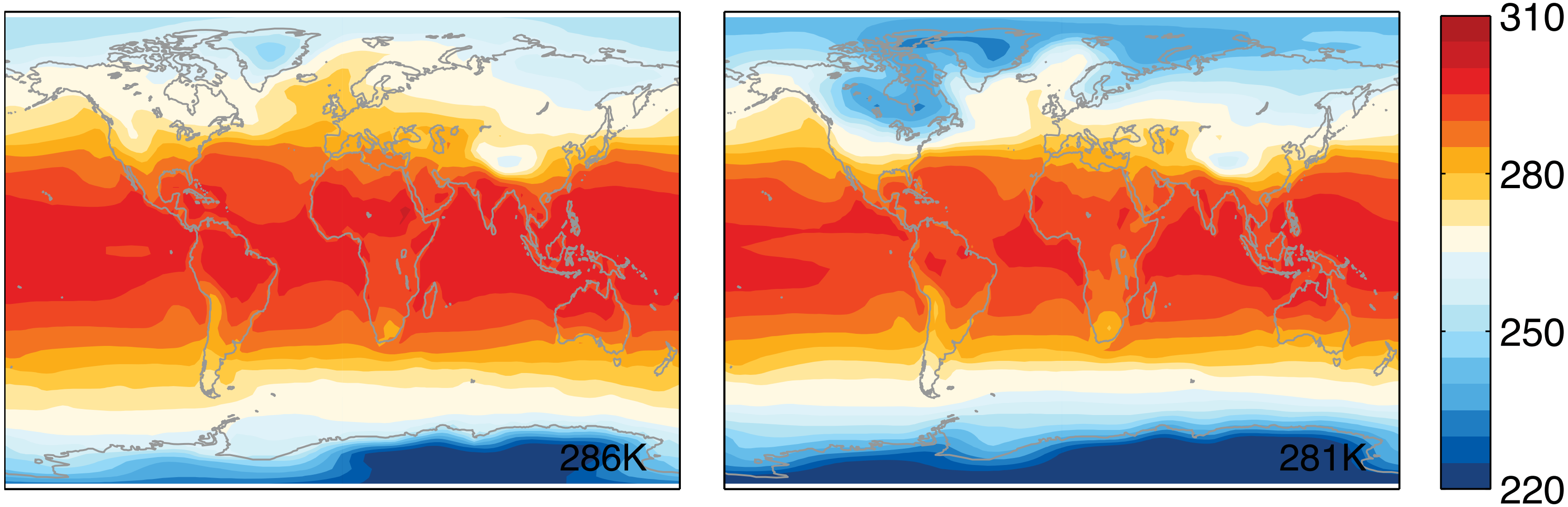


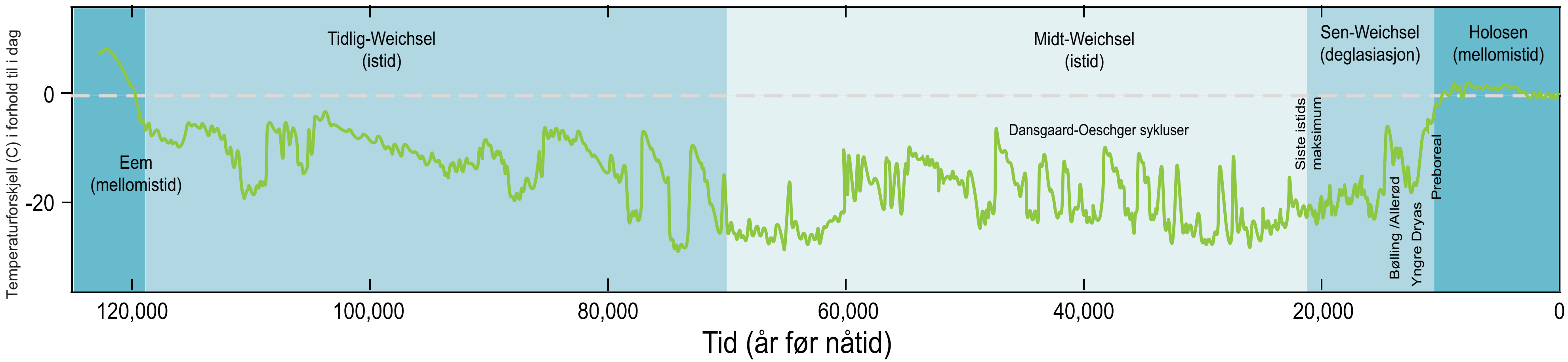
conts: U (10 m/s starting at 40 m/s), cols: eke0925–0200 reg on EOF1 (1 m2/s2)
quadCO2d_NAtl_DJFM_1–19
PId_NAtl_DJFM_1–49
LGMd_NAtl_DJFM_8–56
44.3%
29.8%
24.6%
8
4
0
−4
−8
conts: U (10 m/s starting at 40 m/s), cols: eke0925–0200 reg on EOF1 (1 m2/s2)
quadCO2d_NPac_DJFM_1–19
PId_NPac_DJFM_1–49
LGMd_NPac_DJFM_8–56
35.2%
26.3%
28.5%
8
4
0
−4
−8



conts: U (10 m/s starting at 40 m/s), cols: EOF1 (2 m/s)
quadCO2d_NAtl_DJFM_1–19
PId_NAtl_DJFM_1–49
LGMd_NAtl_DJFM_8–56
44.3% (4.8)
29.8% (4.5)
24.6% (3.6)
16
8
0
−8
−16
conts: U (10 m/s starting at 40 m/s), cols: EOF1 (2 m/s)
quadCO2d_NPac_DJFM_1–19
PId_NPac_DJFM_1–49
LGMd_NPac_DJFM_8–56
35.2% (4.2)
26.3% (4.3)
28.5% (3.6)
16
8
0
−8
−16

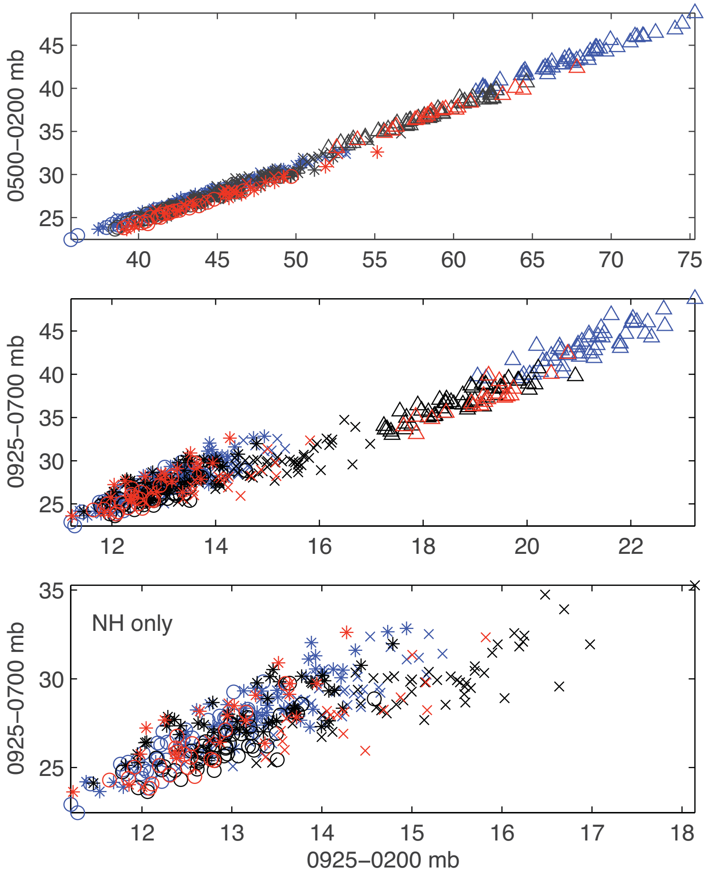
background


286K
281K
310
280
250
220


Tidlig-Weichsel
(istid)
Midt-Weichsel
(istid)
Sen-Weichsel
(deglasiasjon)
Holosen
(mellomistid)
Eem
(mellomistid)
Dansgaard-Oeschger sykluser
Siste istids maksimum
Bølling /Allerød
Yngre Dryas
Preboreal
Temperaturforskjell (C) i forhold til i dag
0
-20
120,000
100,000
80,000
60,000
40,000
20,000
0
Tid (år før nåtid)

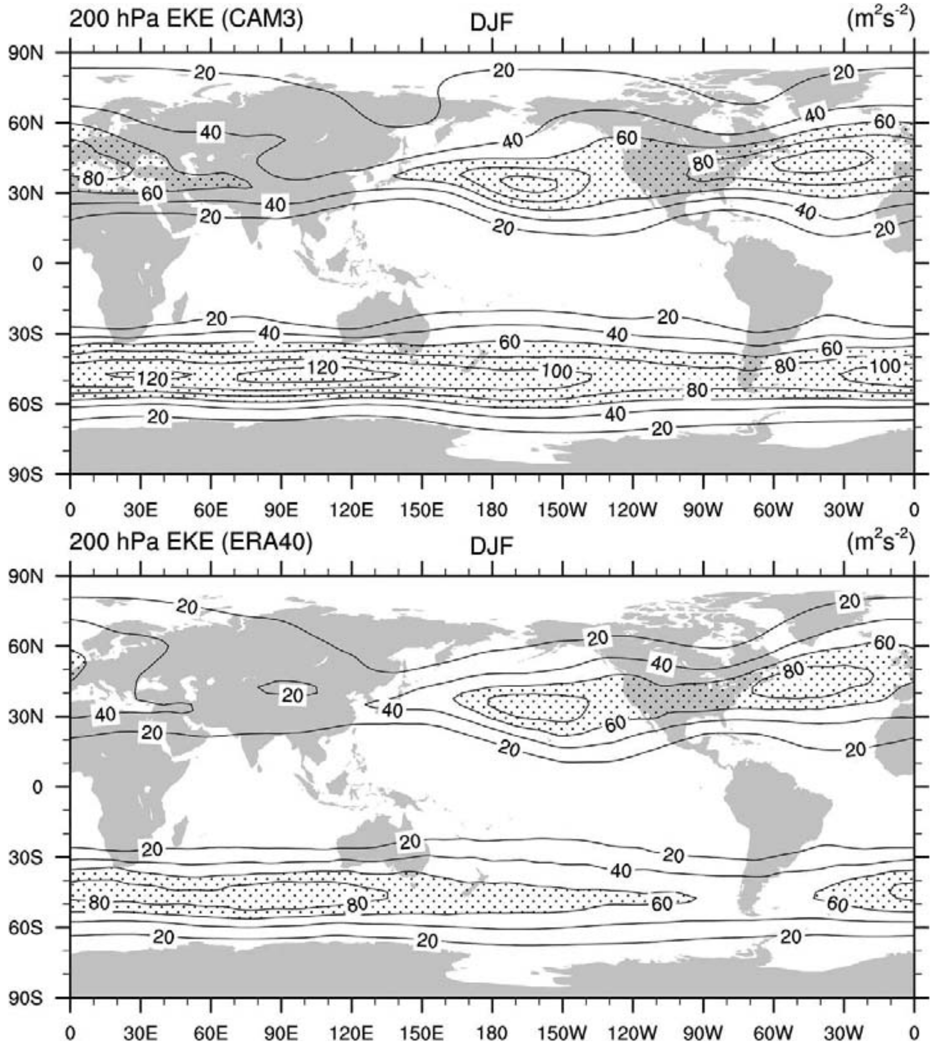
aloft, low-level, column?

NDJFM

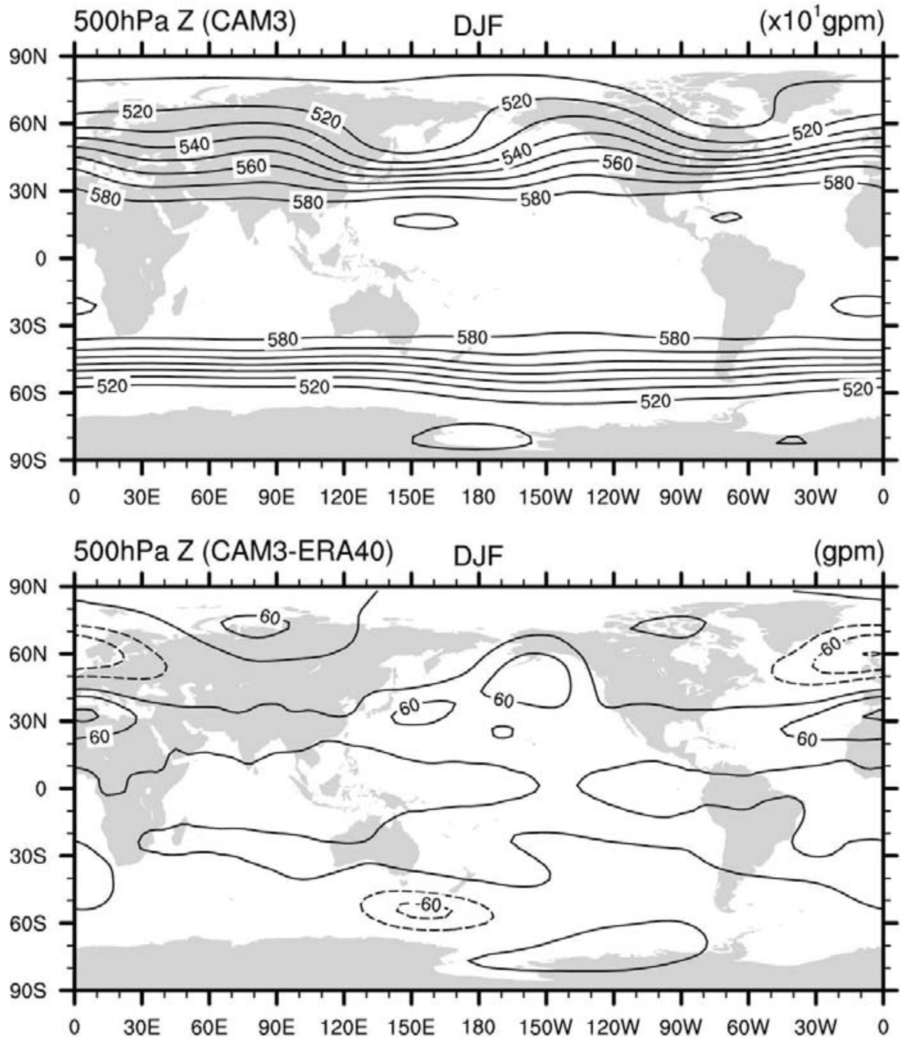


EKE (m2/s2): NDJFM (SH offset by 6 months)

In general, low-level vs column EKE shows a linear relationship. The Atlantic tends to have lower column EKE “concentrated at low levels (i.e., *’s lie above line) while the Pacific has higher column EKE concentrated at higher levels (i.e., x’s lie below the line). This is an autumn/winter thing (see next).


200 hPa EKE (CAM3)
DJF
(m^2s^{-2})
200 hPa EKE (ERA40)
DJF
(m^2s^{-2})
90N
60N
30N
0
30S
60S
90S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0

CCSM vs obs



In particular, the ridge over the west coast of North America during DJF is shifted just to the west of the observed location at 500 hPa.

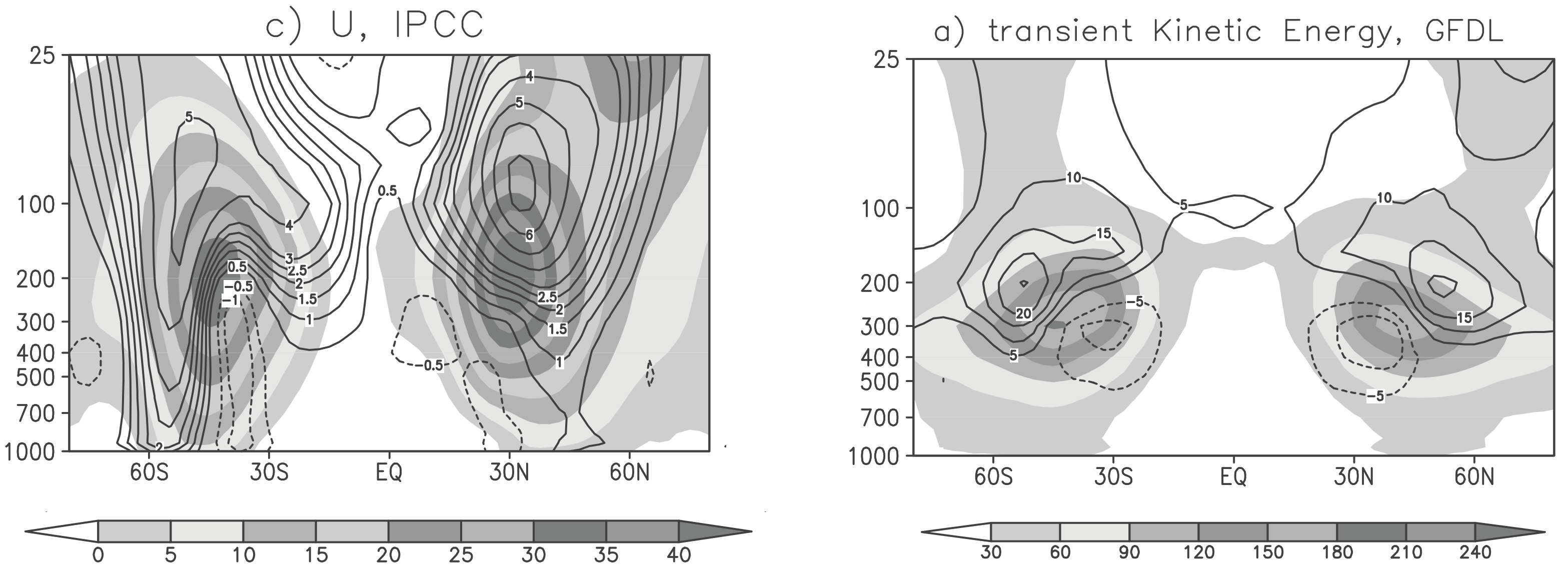
The simulation of the middle-tropospheric flow is very good in CAM3, with regional differences from observations broadly consistent with the biases evident in the simulated SLP. The model successfully reproduces the observed large-scale zonal asymmetries at 500 hPa, including the dominance of wavenumber 1 at high latitudes of the SH throughout the year, and the very large interseasonal changes in the quasi-stationary wave structure over the NH. The major shortcoming of the simulation is that CAM3 500-hPa heights are higher than observed throughout the Tropics and subtropics, consistent with a slight warm bias in the tropical troposphere (Hack et al. 2006a).

The zonal wind structure in CAM3 is close to that observed, although the middle-latitude westerlies are too strong in both hemispheres throughout the year. These westerly biases, which are consistent with errors in the pressure fields and the simulated transient momentum fluxes, are largest during northern summer and exceed 8 m s−1 in the zonal-mean upper-tropospheric flow over both the NH and the SH. An overall view of the upper-tropospheric flow, as measured

Hurrell et al. 2006 JClim

warming climate

zonal wind (left) and eddy kinetic energy (right)



Lorenz and DeWeaver 2007 JGR