Some Associations between Arctic Sea Level Pressure and Remote Phenomena Seen in Daily Data

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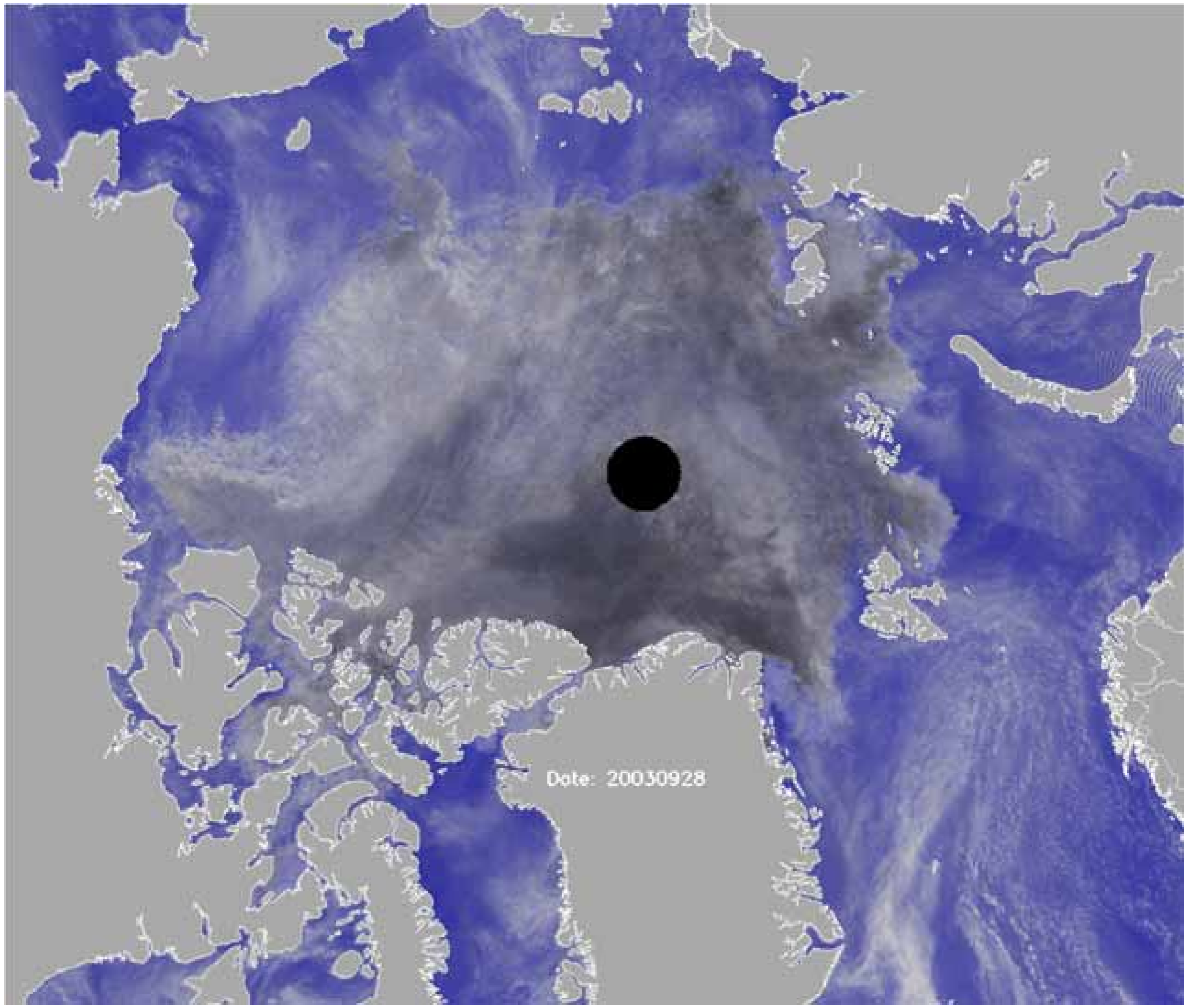
AMSR two-channel reconstruction of Arctic sea ice cover,
28 Sept. 2003 – 10 May 2004
by Tom Agnew, (Meteorological Service of Canada, Toronto; CRB)

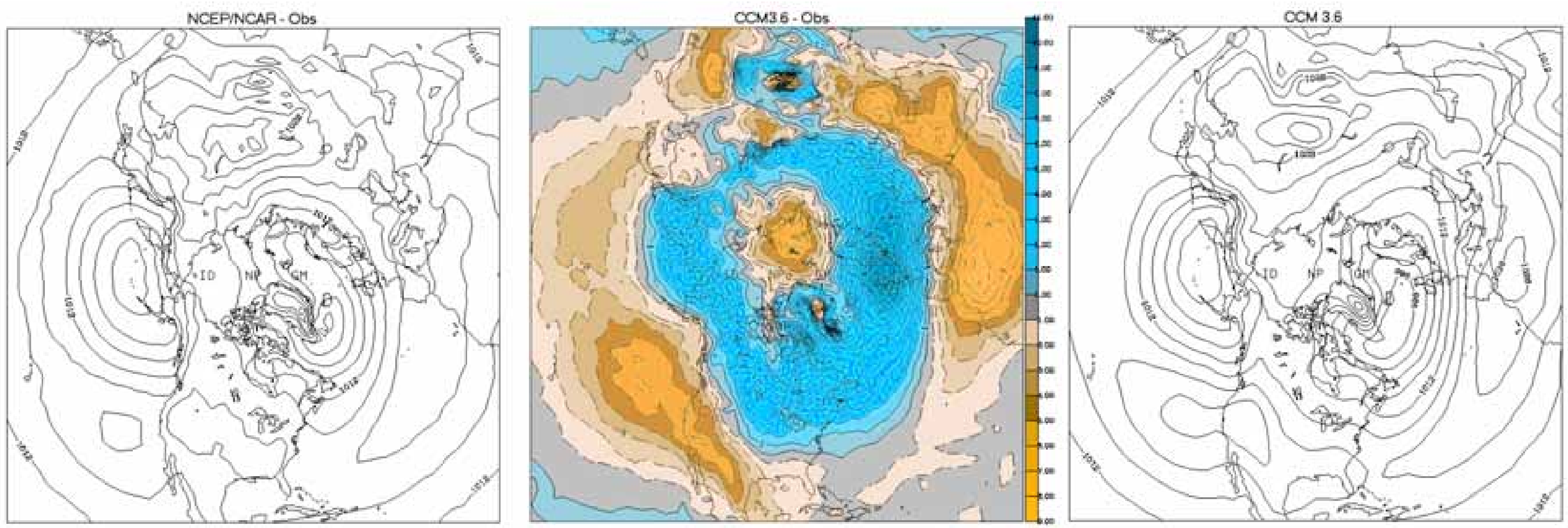


Review: SLP – CCM 3.6

General pattern similar to observations

Error pattern has rings of higher and lower SLP

error has effect on wind



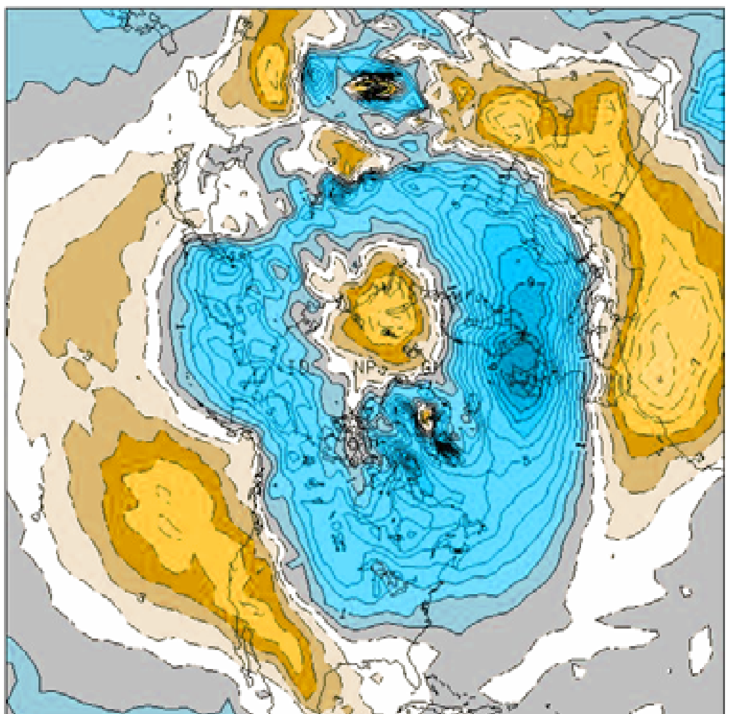
SLP – similar error as before

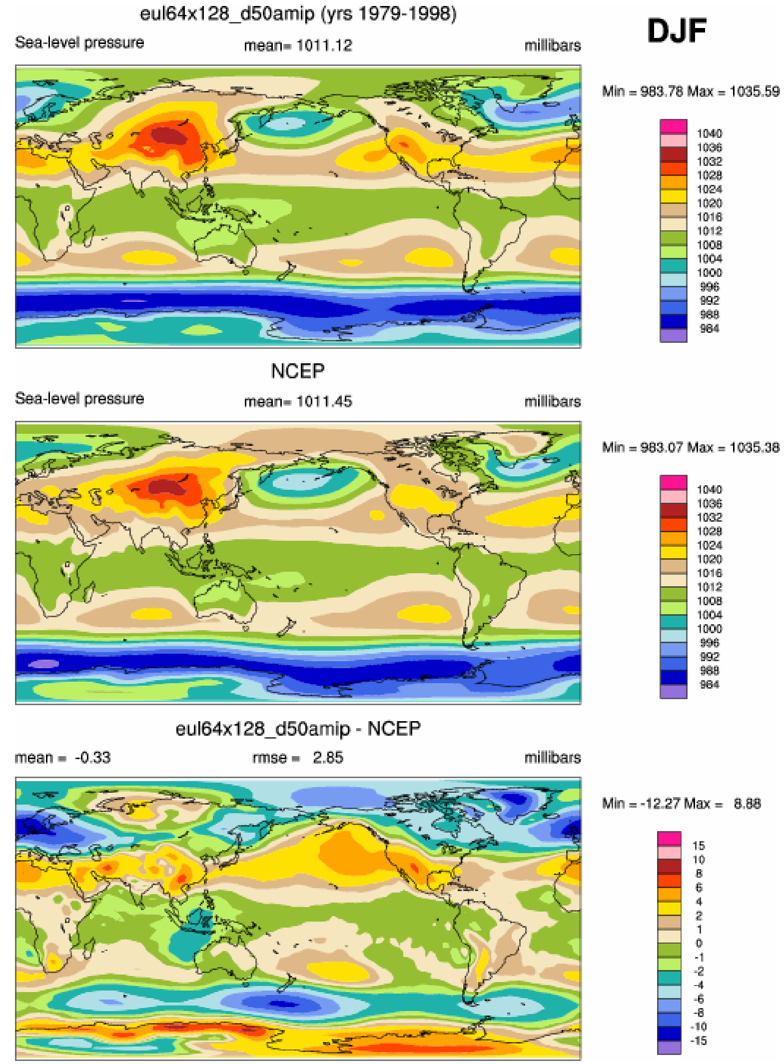
CCM 3.6 vs eul_d50amip (T42) 1979-1999 OBS

Ring pattern similar

Shift of loc over Arctic.

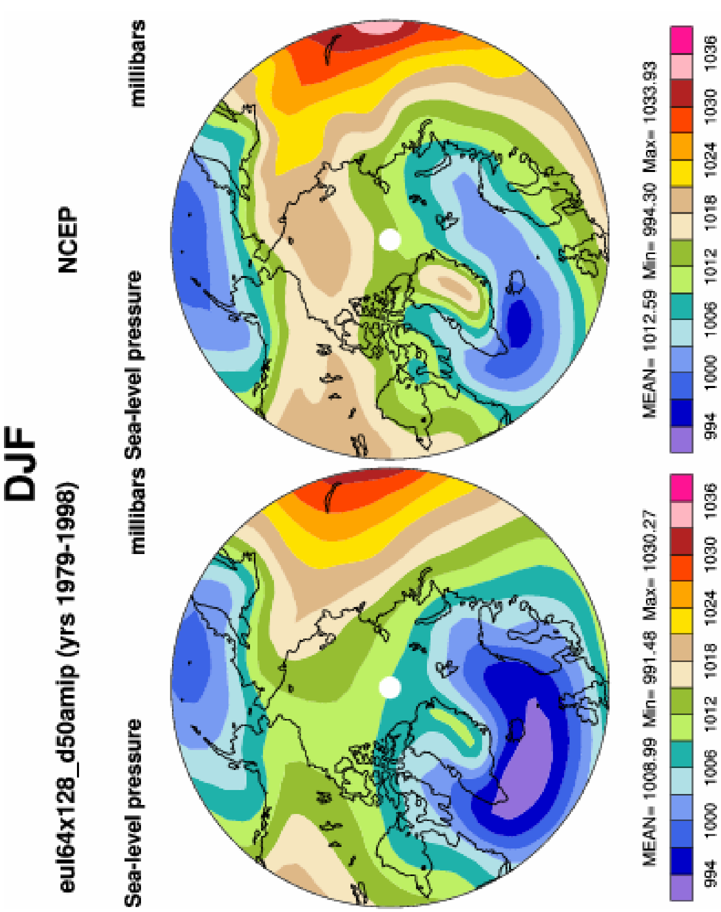
1 mb interval

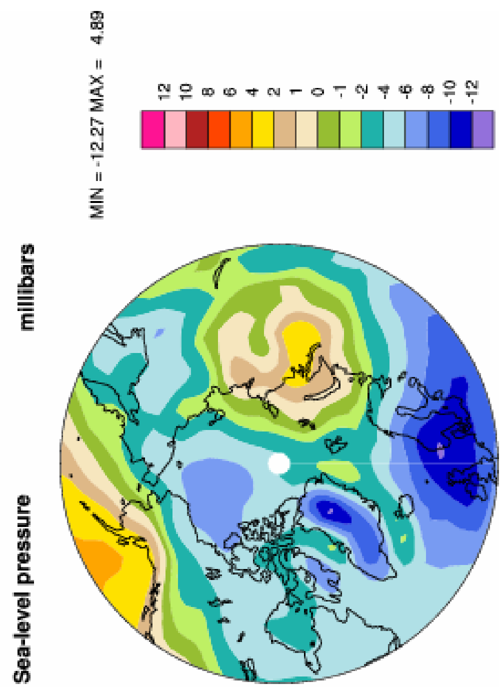




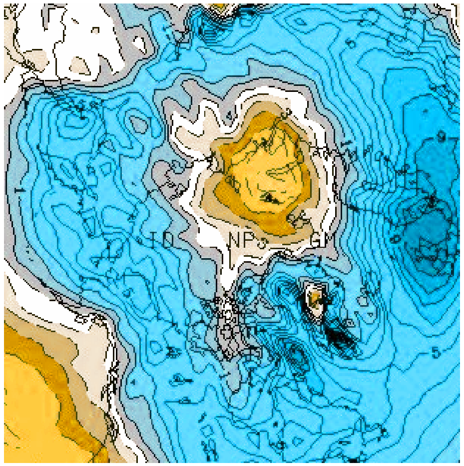
SLP eul_d50amip (T42) 1979-1999 OBS

(similar error still present)



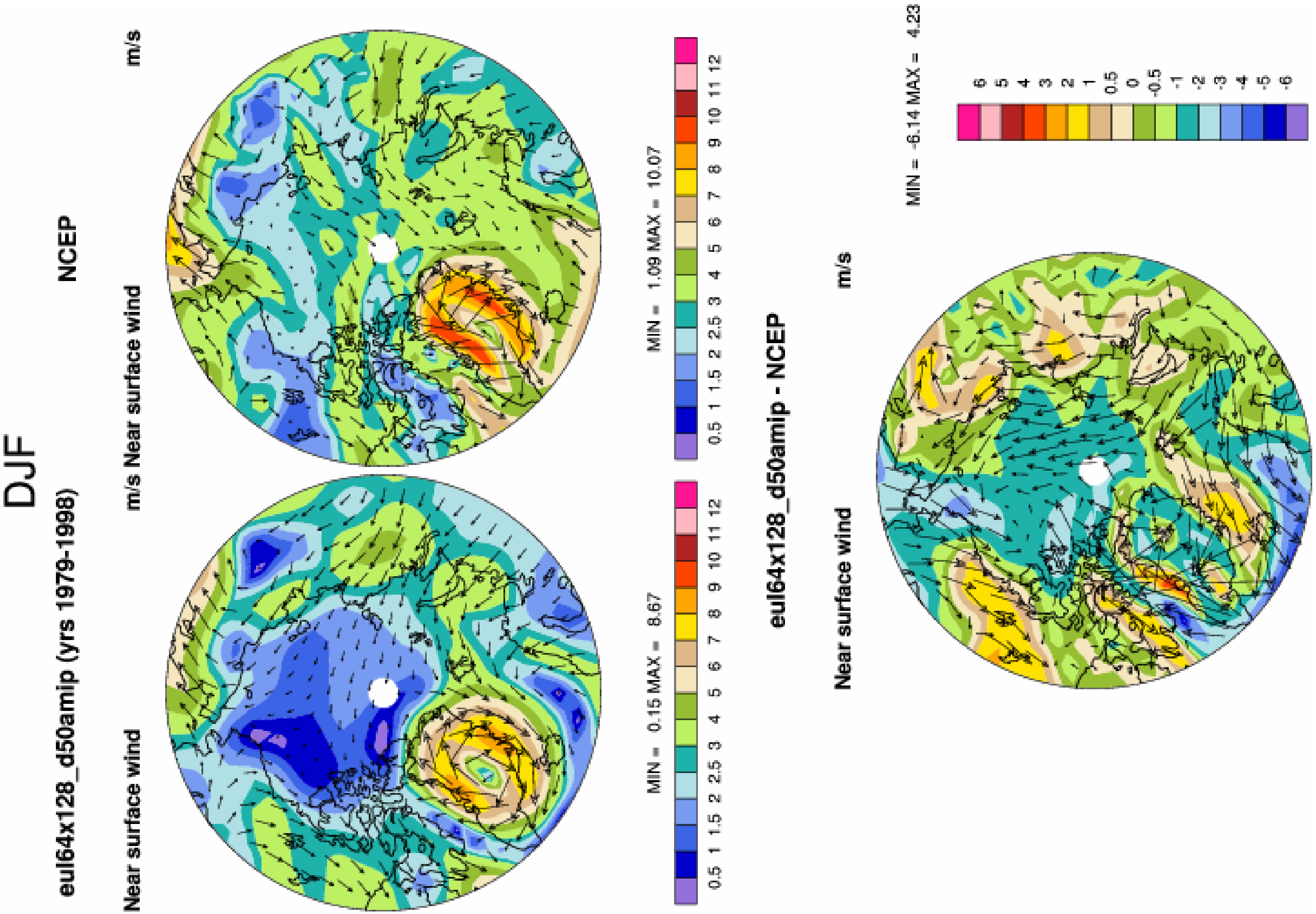


CAM 3.x



CCM 3.6

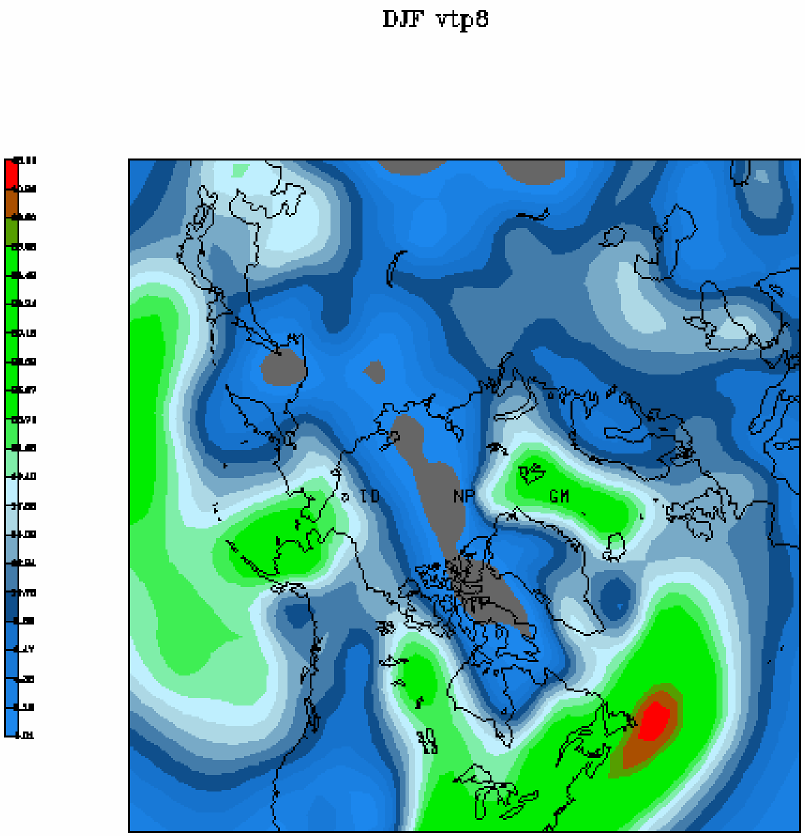
Srfc Winds eul_d50amip (T42) 1979-1999 OBS

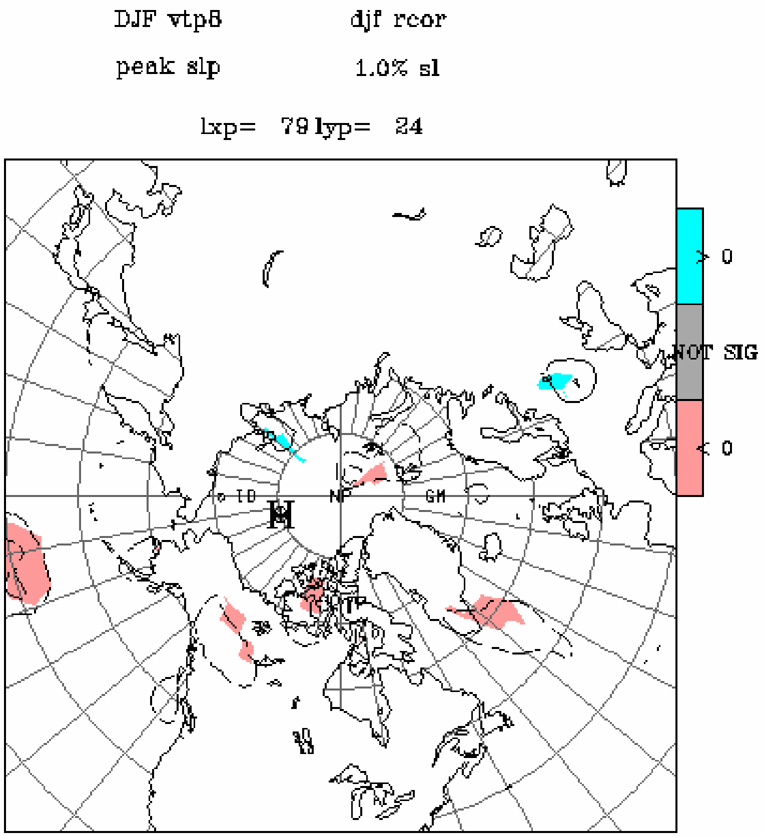


Review: 850mb meridional heat flux

Monthly Data – Correlations with Max SLP

Higher SLP w/ less at Pacific storm track end





high pass eddy heat fluxes

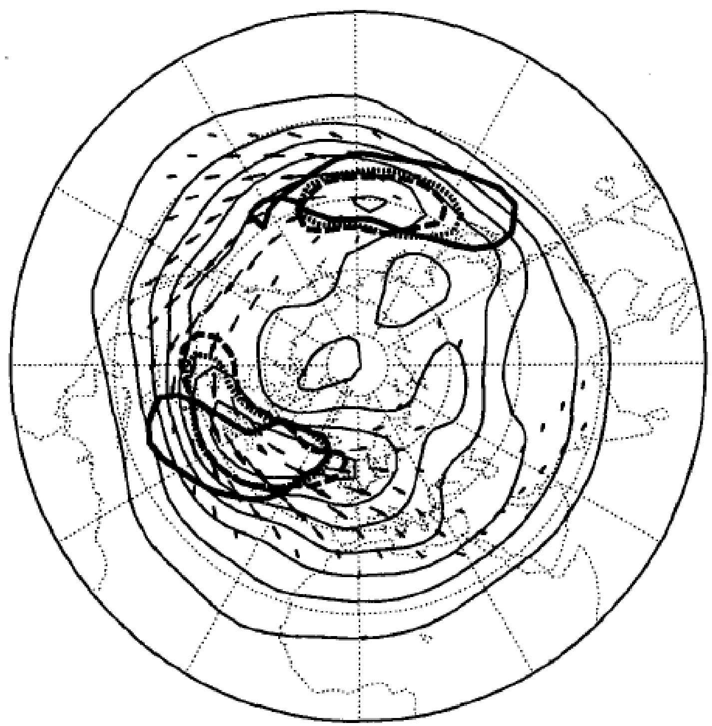
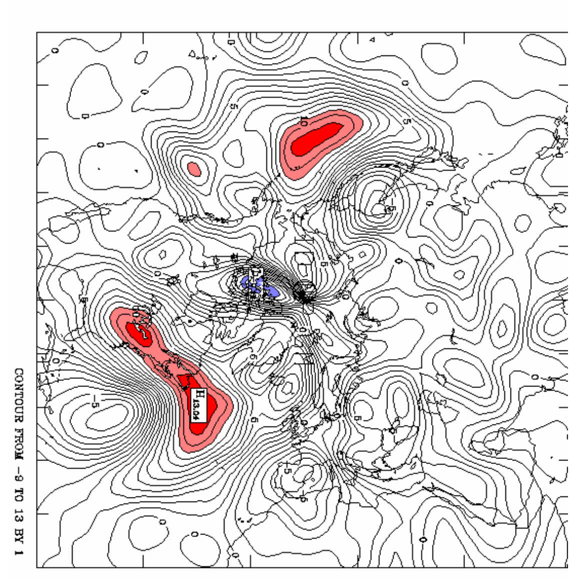


FIG. 1. A summary of the Northern Hemisphere winter storm-track structure based on high-pass time-filtered transients in ECMWF data for the December–February season in the years 1979–84. The thin contours are of height variance ($\overline{\phi'^2}$) (contour interval 15 m^2) and arrows indicate E = ($\overline{v'^2 - u'^2}$, $\overline{-u'v'}$), both at 250 mb. Also shown are single contours of the 700 mb horizontal temperature flux ($\overline{v'T'}$) (thick dashed contour at 10 K m s^{-1}), 700 mb vertical temperature flux ($\overline{-\omega' T'}$) (thick dotted contour at 0.2 K Pa s^{-1}), and the column mean diabatic heating (thick solid contour at 50 W m^{-2}).



High pass eddy fluxes used by Hoskins and Valdes are similar in location and strength

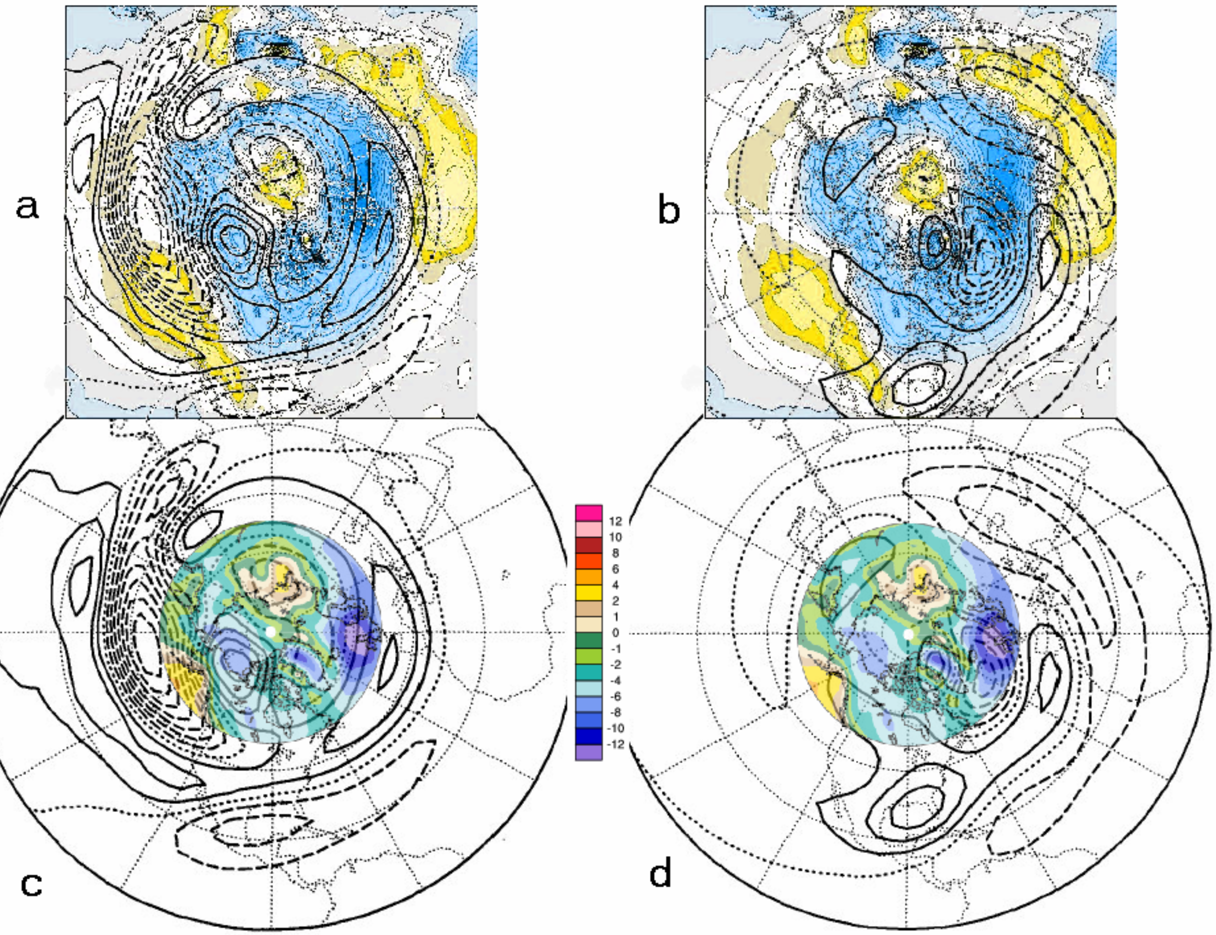
Compare >10 mK/s regions:

(L) thick dashed line (1979-84)

(R) pink (1979-2004)

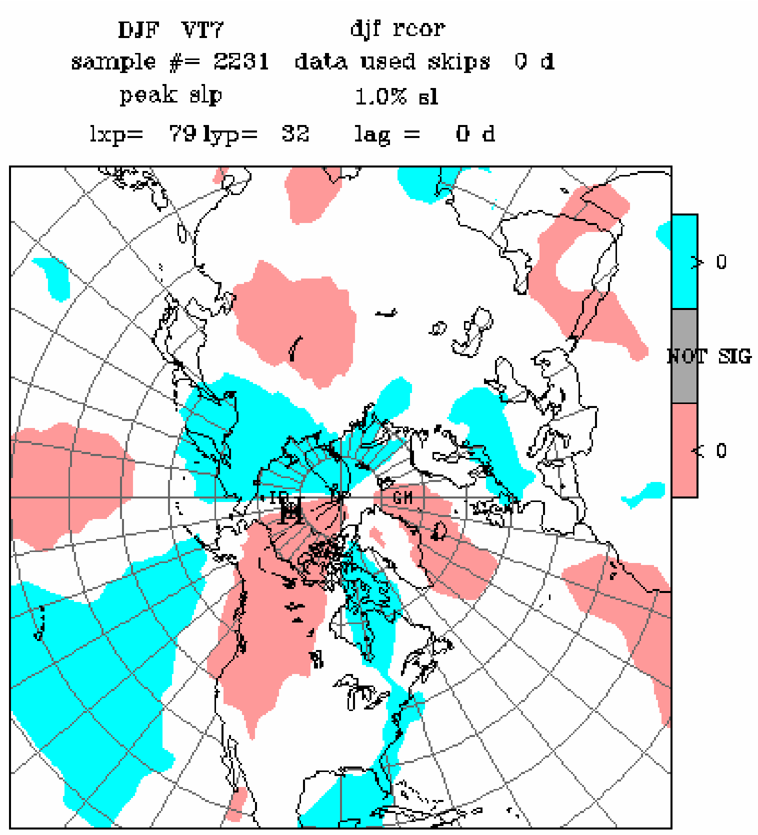
Review: Hoskins & Valdez results overlaid on model SLP error fields

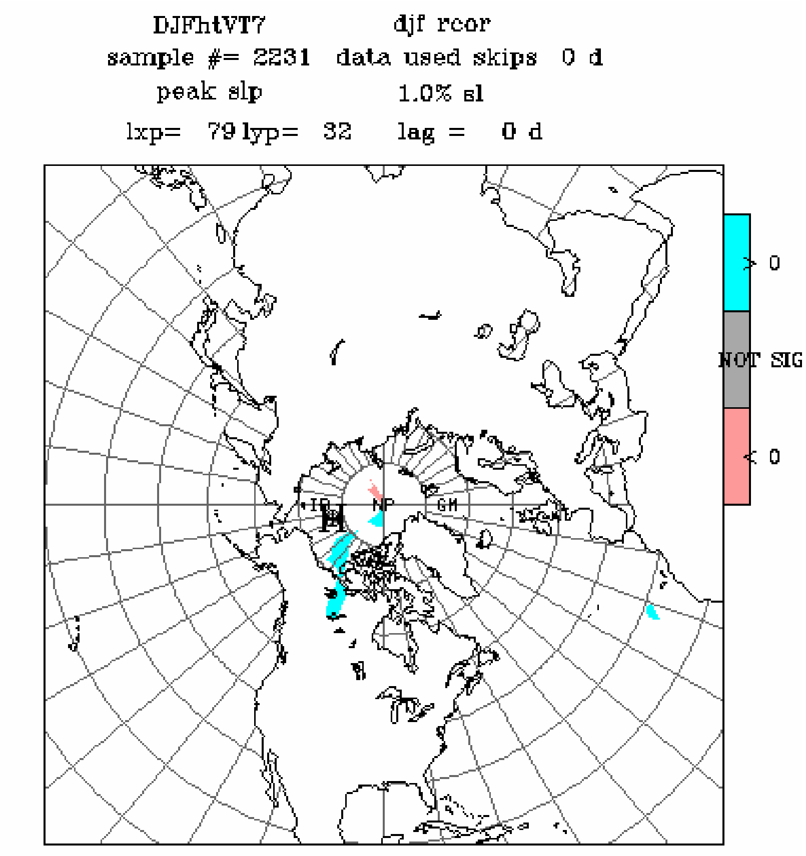
qualitatively similar to N. Pacific linear response



1-pt correlations SLP v transient heat fluxes

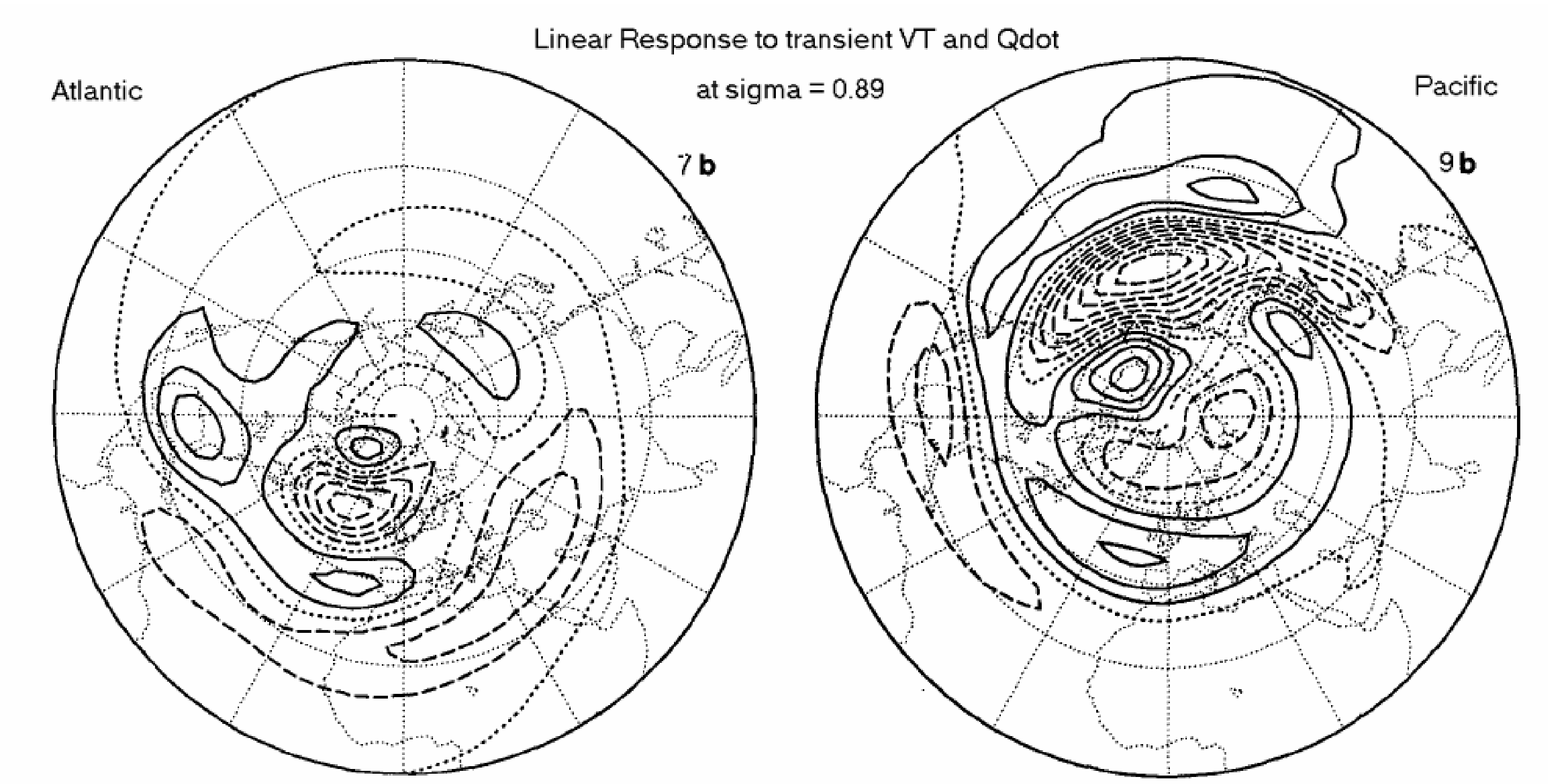
not compelling for high pass. When longer frequencies allowed longwave T trough pattern





Hoskins & Valdes 1990
high pass eddy heat flux & response fields

Atlantic Pacific



Stream function at 0.889 sigma level

Monthly data eofs

Ambaum et al. 2001, J. Climate

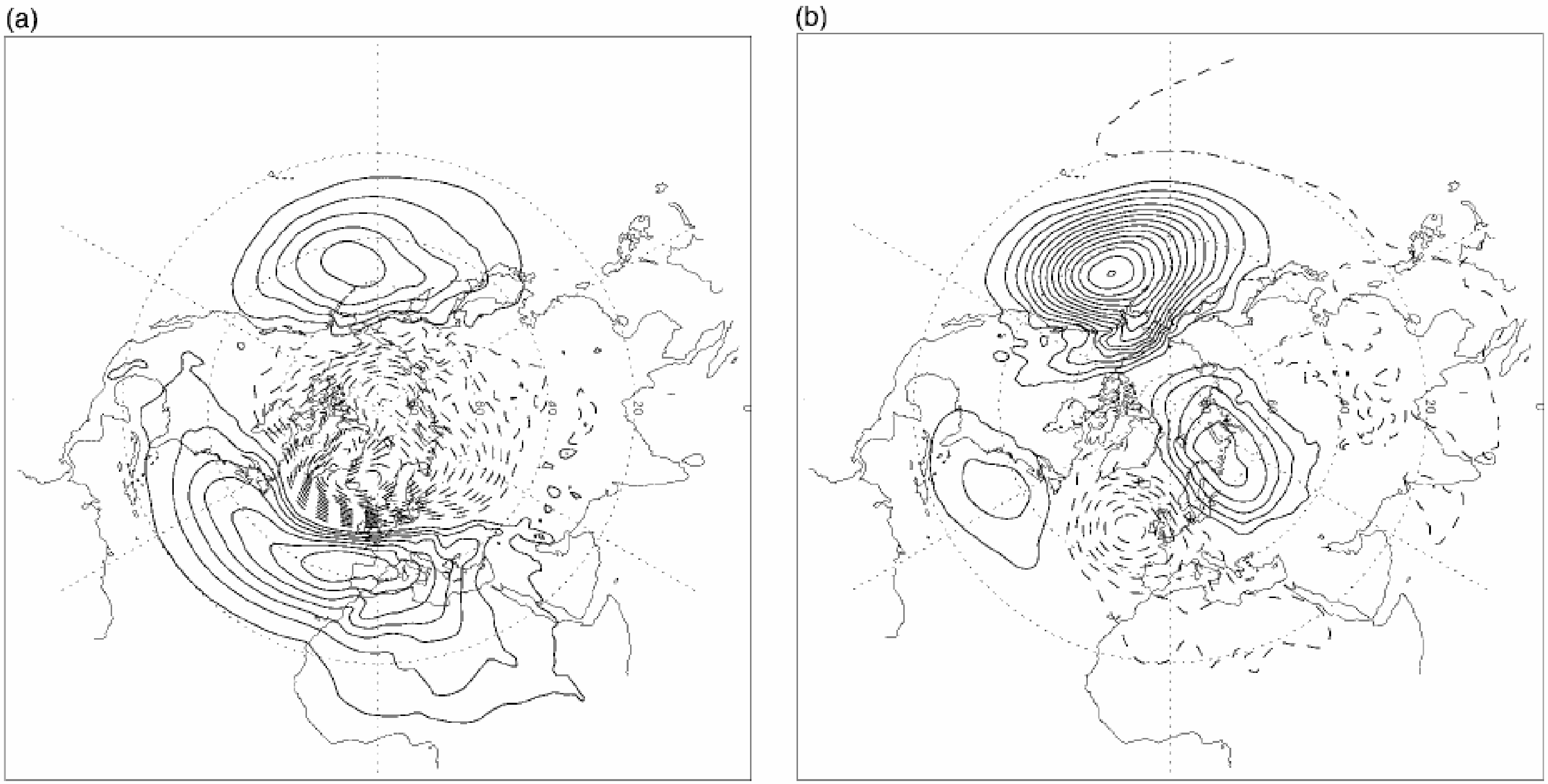
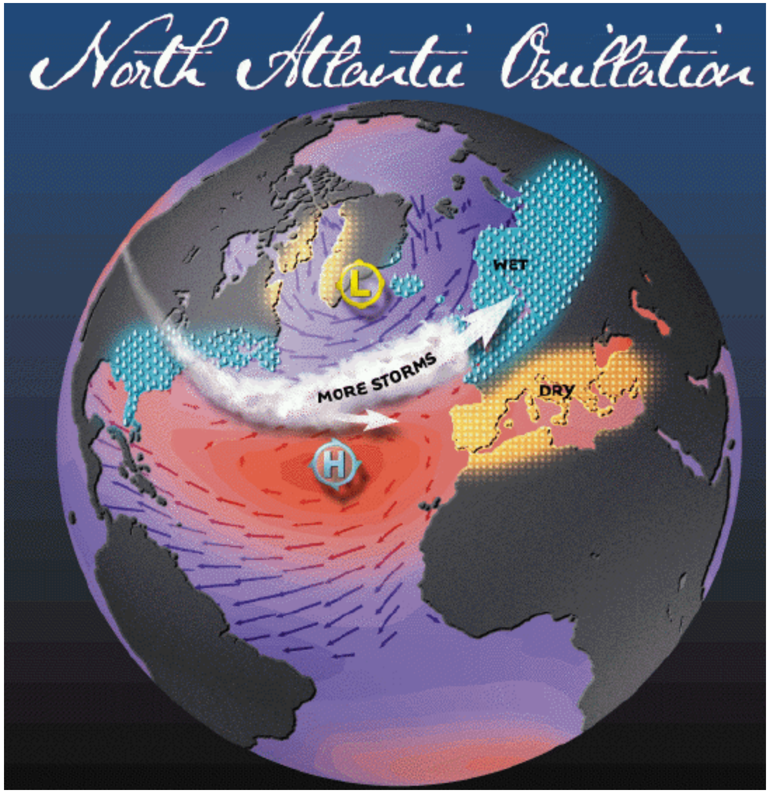


FIG. 1. First two EOFs [(a) EOF1 and (b) EOF2] for the DJFM mean sea level pressure. These EOFs explain 25% and 14% of the variance, respectively. The contour interval is 0.5 hPa.

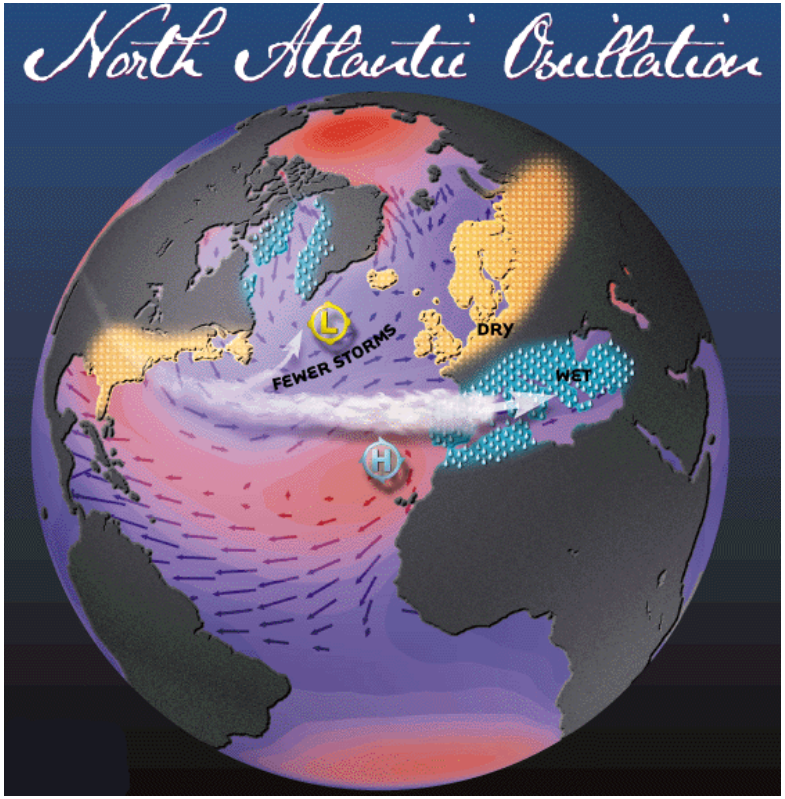
NAO + and –

http://www.ldeo.columbia.edu/NAO/

Positive



Negative



Ambaum & Hoskins (2002) mechanism

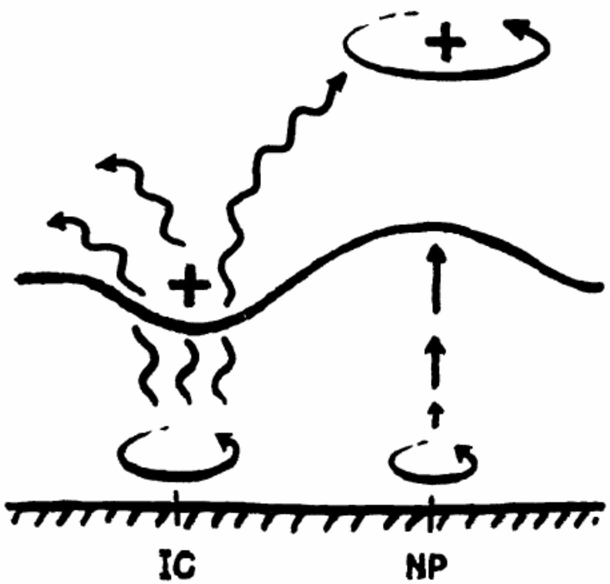


FIG. 1. Schematic of the connections between modulations in the NAO, the height of the tropopause, and the strength of the stratospheric jet. If the NAO index increases, associated with it the cyclonic circulation over Iceland (IC) enhances (circular arrow at IC) and the tropopause (thick solid line) lowers with associated positive potential vorticity anomaly (+); upward-propagating Rossby waves (wavy lines) refract more toward the equator and break less in the stratospheric jet; the stratospheric jet enhances (large circular arrow) with associated positive potential vorticity anomaly (+); the tropopause below this anomaly rises and stretches (vertical arrows) the tropospheric column leading to an enhanced cyclonic circulation over the North Pole (circular arrow at NP).

links midlatitude storm tracks and polar pressure fields through the stratosphere

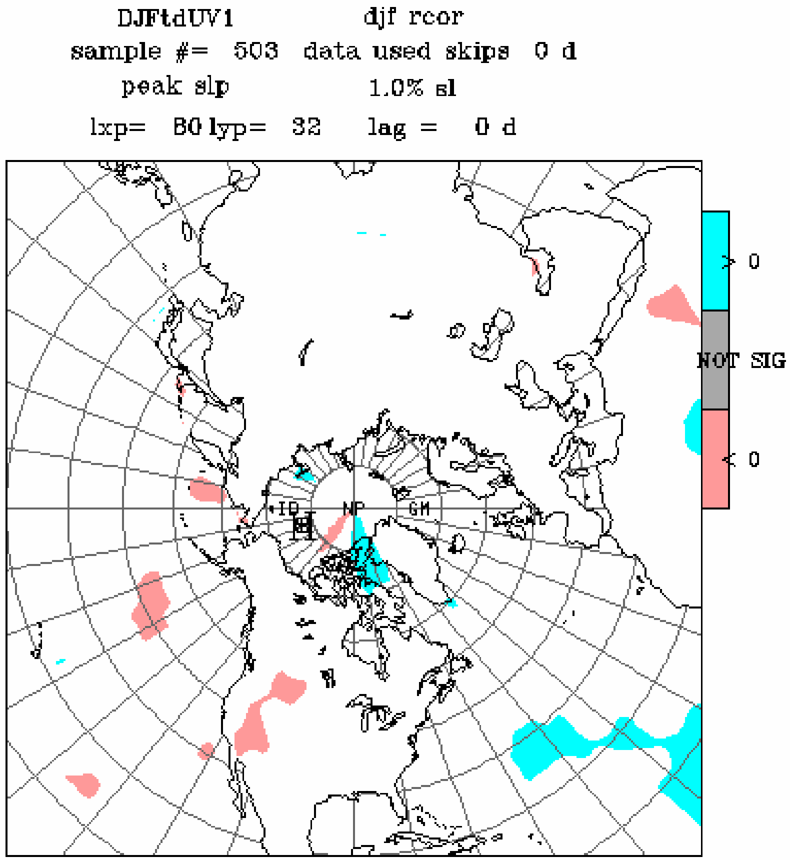
EP flux = (F^y , F^p)

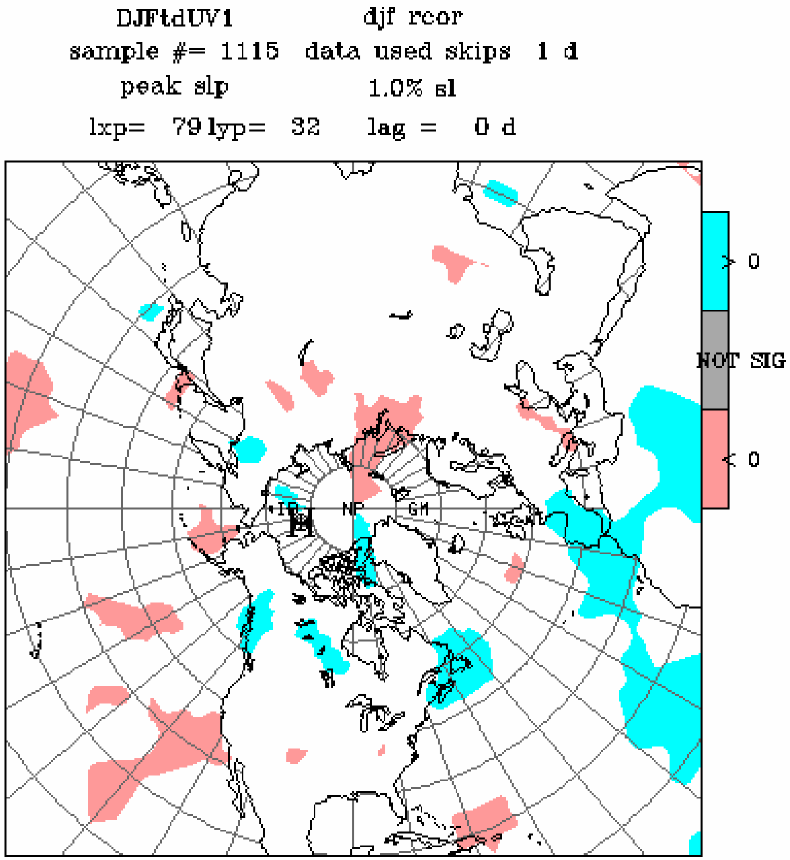
$F^y = -[u'v']$

$F^p = f\ [v'\theta']/(d[\theta]/dp)$

Transient eddy momentum flux

weak correlations even after low-pass filtering





ZI = $U_{35} - U_{55}$ @200 hPa opposite variation from mean as AO

"Low index" "High index"

15 August 2001 AMBAUM ET AL. 3503

AO <0 => U_{35}-U_{55} >0

AO >0 => U_{35}-U_{55} <0

Atlantic sector

AO>0: Jet Strengthened In Atlantic (high index)

AO <0 => U_{35}-U_{55} >>0

AO >0 => U_{35}-U_{55} >0

Pacific sector

AO>0 Jet Weakened In Pacific (high index)

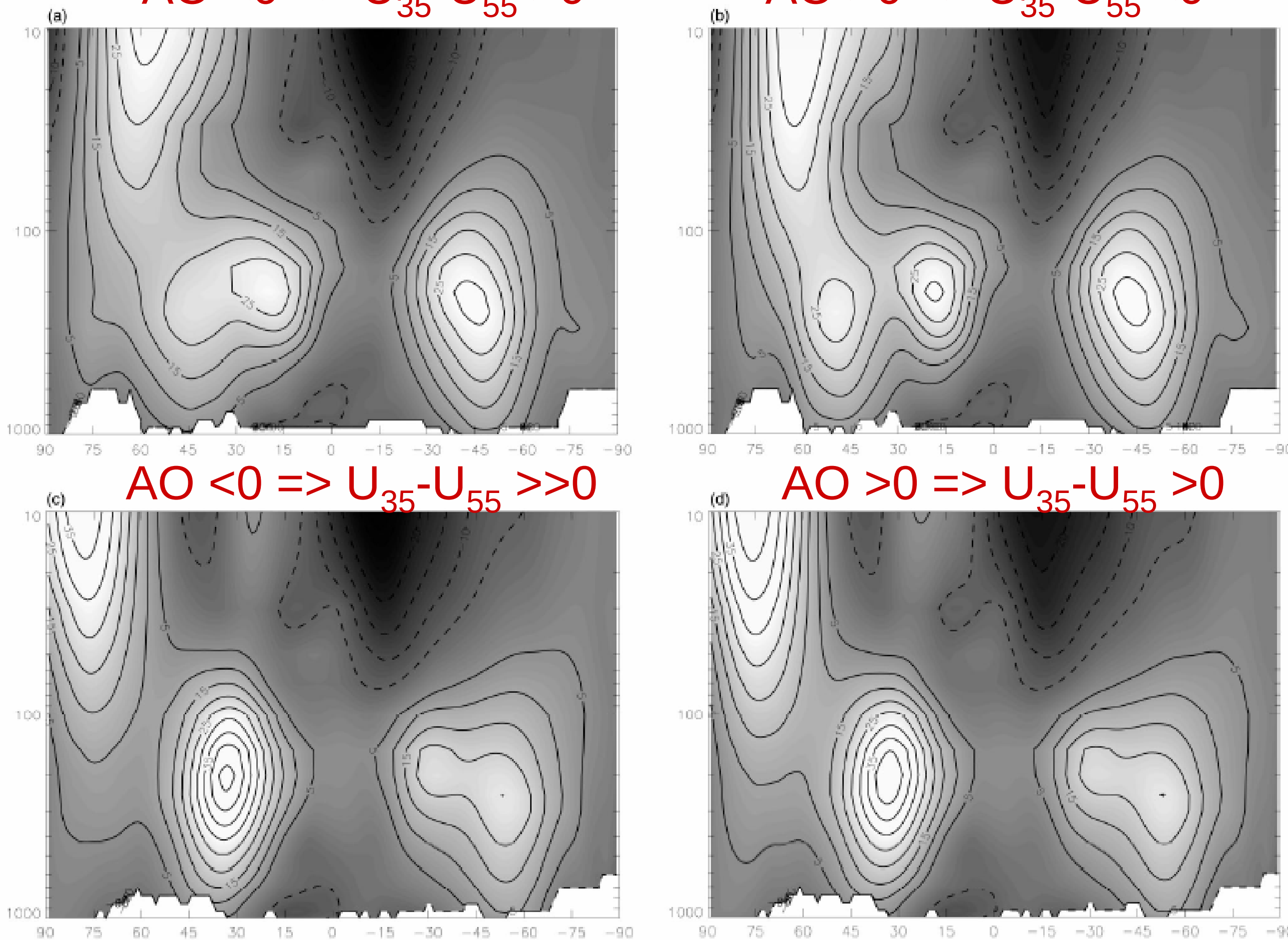
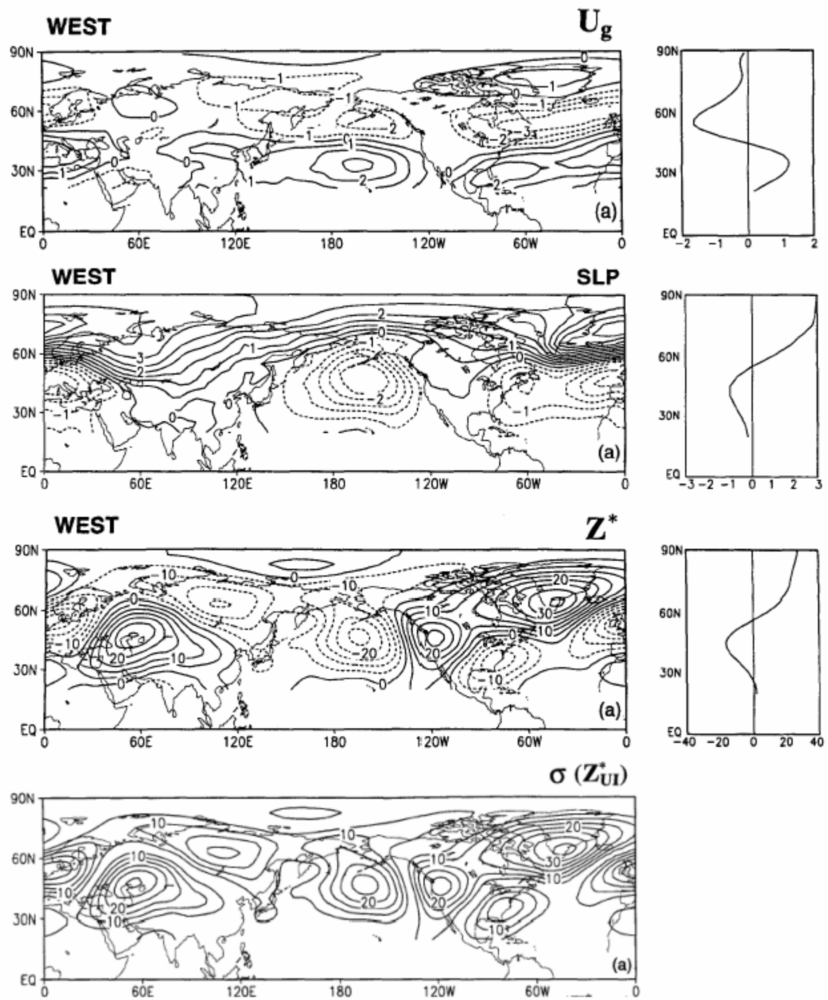


FIG. 6. Climatological mean of zonal winds in the Atlantic sector (60°W–0°) for an AO index of (a) −1 std dev and (b) +1 std dev. (c) and (d) The same as (a) and (b), but for the Pacific sector zonal winds (150°E–120°W).

Zonal Index

$U_{35} - U_{55}$



Panel "a)" selected from each of these figures whose captions are below.

FIG. 5. Regressions of the December–February geostrophic zonal wind upon (a) the zonal wind index (b) the equatorial SST index. Anomaly amplitudes are derived by multiplying the regression coefficients at each grid point by the appropriate index standard deviation: 2.7 m s^{-1} for the UI and 0.69°C for the SSTI. The indicated phase is that associated with a westerly phase of UI in (a), and a positive phase of ENSO in (b). The corresponding zonal mean is shown in the right side panels. The contour interval is 1 m s^{-1}, and negative contours are dashed.

FIG. 9. Same as in Fig. 5 except for the sea level pressure. The corresponding zonal-mean surface temperature is shown in the right side panels. The contour interval is 0.5 mb, and negative contours are dashed.

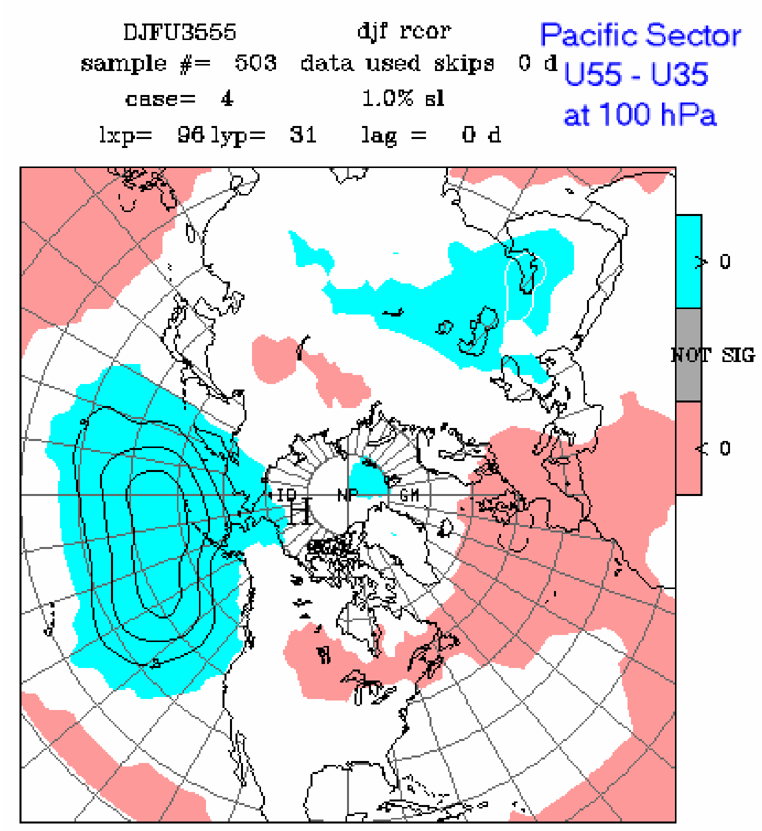
FIG. 6. Same as in Fig. 5 except for the 500-mb stationary wave geopotential heights. The corresponding zonal-mean 500-mb height anomaly is shown in the right side panels. The contour interval is 5 gpm, and negative contours are dashed.

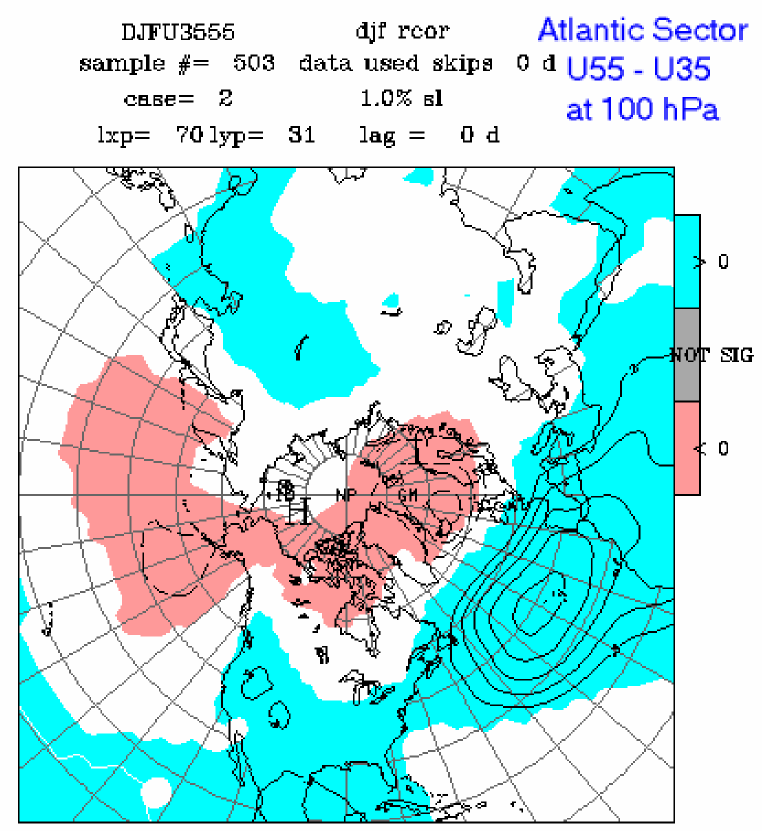
FIG. 7. Standard deviation of 500-mb NH stationary wave geopotential heights that is linearly related to (a) the zonal-mean zonal wind index, (b) the equatorial SST index, and (c) the combination of the UI and the SST index. The contour interval is 5 gpm.

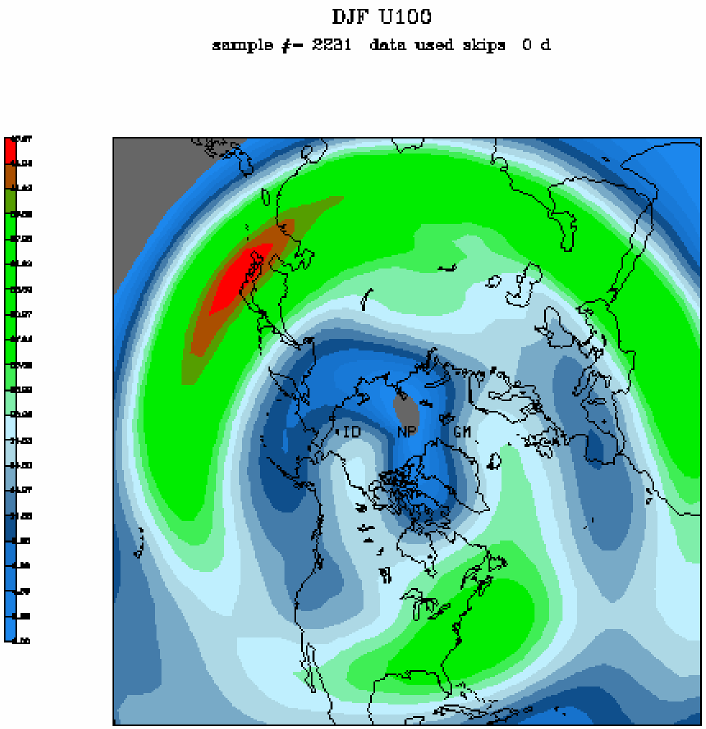
Source: Ting et al 1996.

-Zonal index: $U_{55} - U_{35}$ Sectors

Pacific sector: -ZI>0 w/ weaker Aleutian low (as expect)
Atlantic sector: -ZI>0 w/ deeper Icelandic low (as expect)
Neither has much signal for Arctic SLP

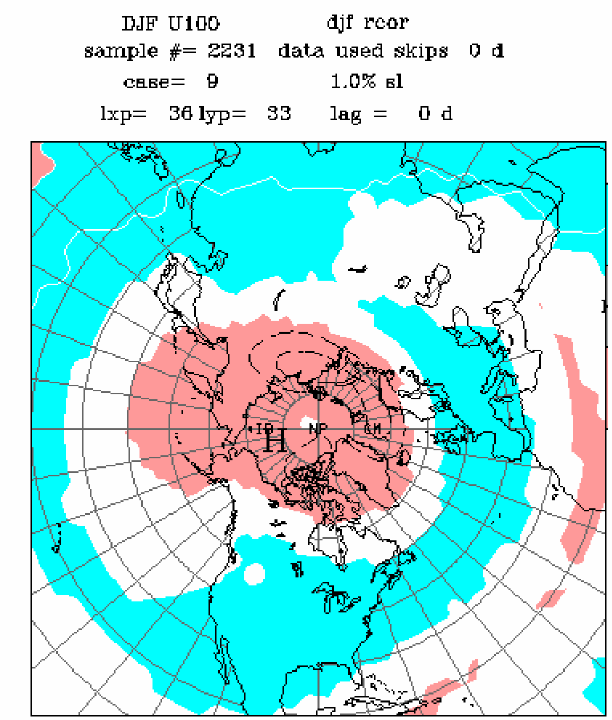


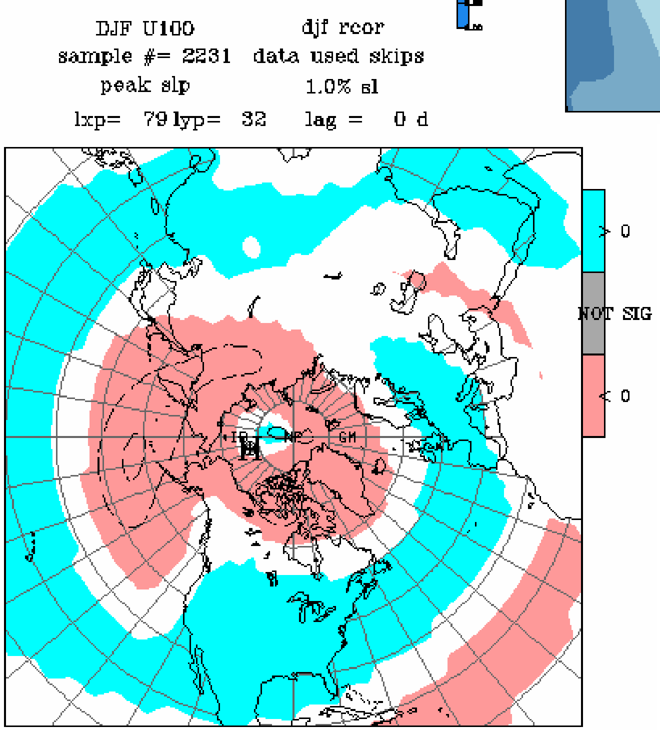




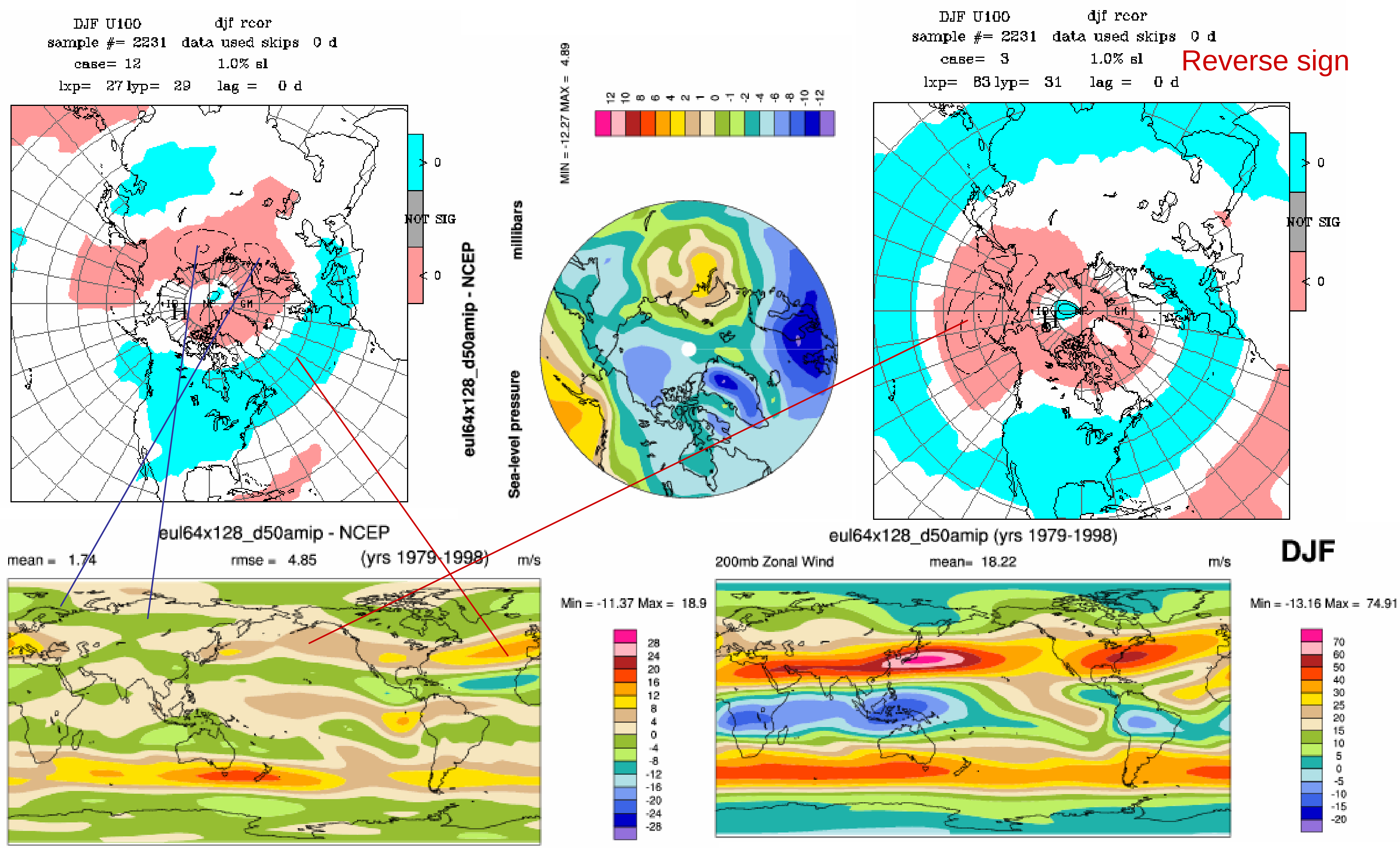
Back to Basics: U100 vs SLP

Stronger SLP with weaker, broader Stratospheric vortex



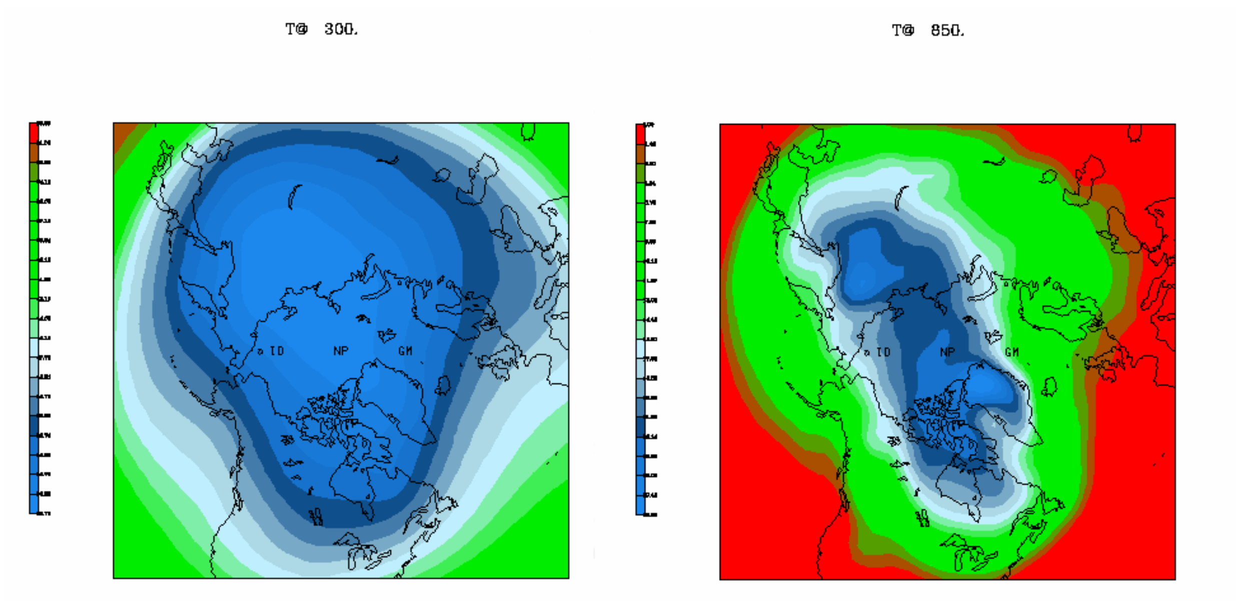


CAM3.x U_{200} bias vs observed U_{100} correlations



Review: Temperature @ 300, 850

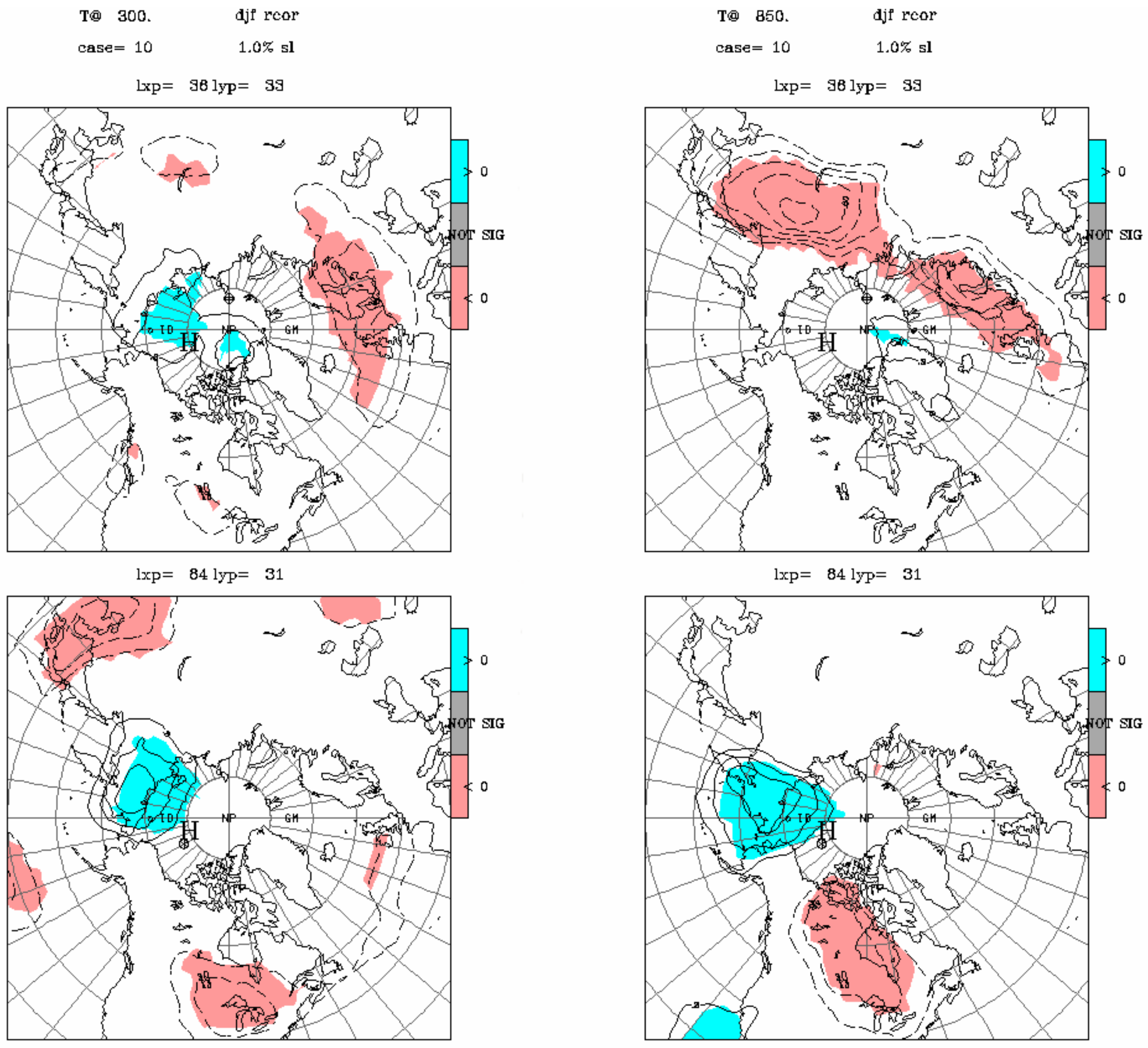
Monthly Means for DJF



Review: Temperature @ 300, 850

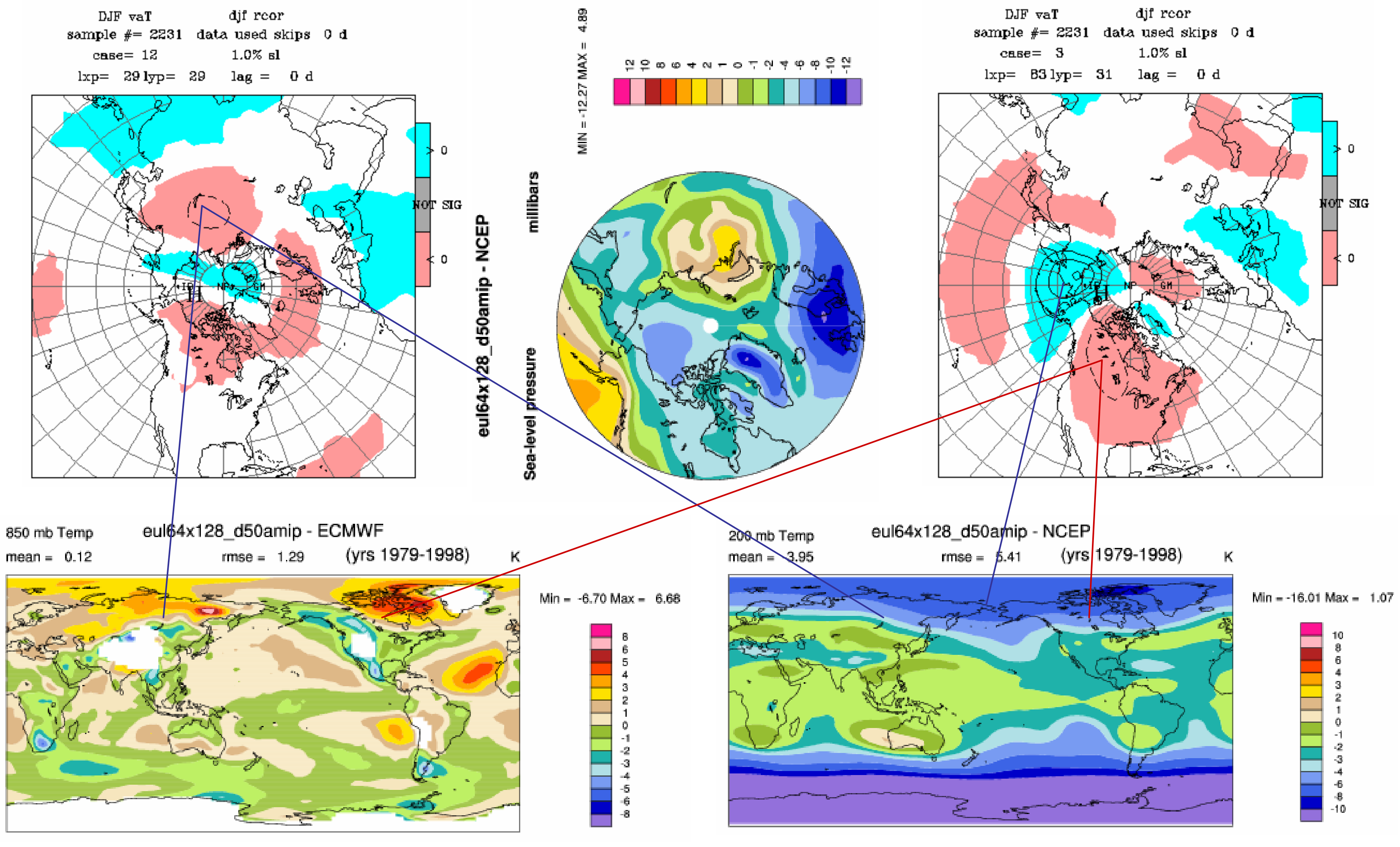
SLP pt where Model bias >0

SLP pt where Model bias <0. (reverse Sign shown)



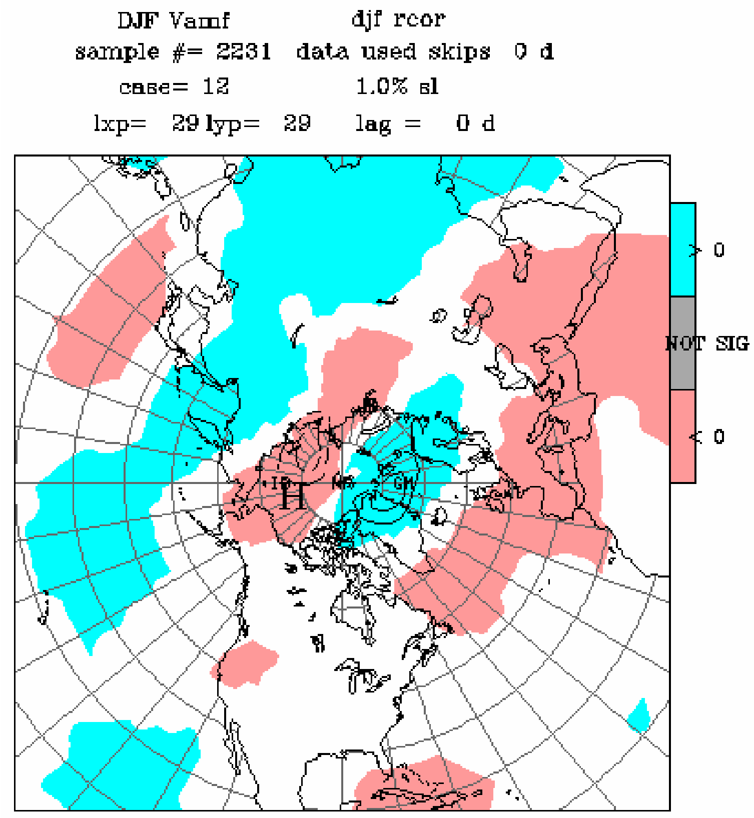
CAM3.x bias vs 1-pt observed correlations: T

vert. ave. daily T correl. More like T_{200} bias than T_{850}

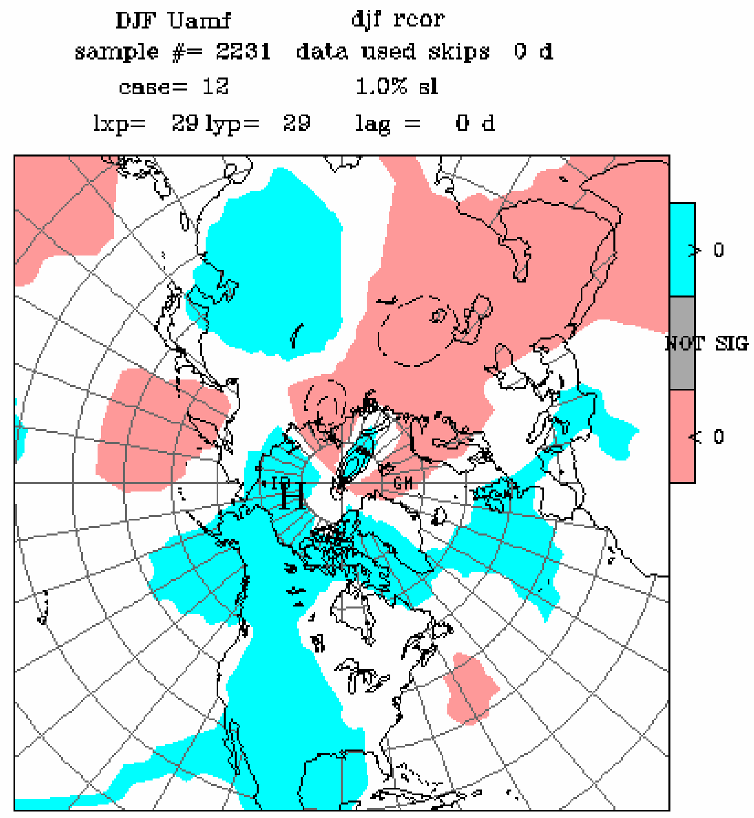


Net mass flux

mass flowing from Beaufort into the Kara Sea when SLP higher at mouth of Ob river



Meridional component



Zonal component

Early Conclusions (after 1 month)

- AMIP run with CAM3.x at T42 has similar SLP error as CCM 3.6
- Sea ice responds to daily changes
- Attempts to link Arctic SLP to midlatitude cyclone activity in 3 ways:
- 1. high pass transient VT based on linear stationary wave solutions
- 2. transient daily UV based on EP flux argument
- 3. zonal wind index ZI based on connection to AO
- None of these three quantities showed convincing link to Arctic SLP
- Attempts were made to compare the model biases in T and zonal wind to observed links between those variables and SLP.
- 1. Model biases were consistent with the observed correlations
- 2. Seems to alter the long wave pattern, amplify wave# 1; reduce wave# 2
- Daily “mass fluxes” (pressure integral of divergent wind):
- 1. Possible mass flow from W. Beaufort towards Kara sea consistent with model bias
- 2. Max SLP looks like flow around a high

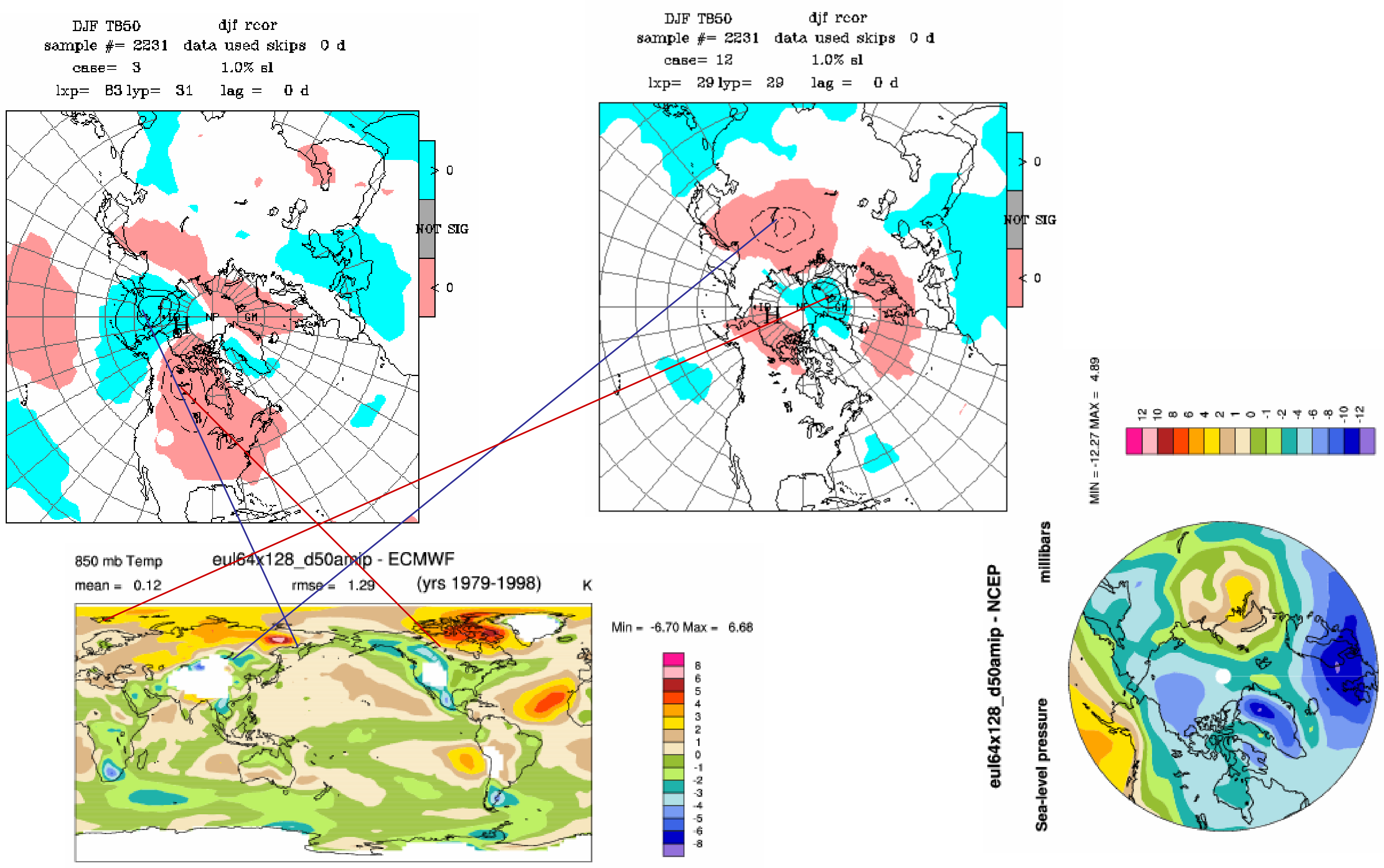
Future Work

- Consult with collaborators
- Additional observational work: diabatic heating, composites
- Better eddy flux information, possibly with filtering
- Further comparison of model fields to parallel the observational work
- Test stationary wave model response to prescribed anomalous: eddy fluxes, diabatic heating (“stationary wave model”)
- Test what anomalous eddy fluxes arise from an anomalous stationary wave pattern (“storm track model”)
- Model variations (topography, surface stress, etc.)

Storage

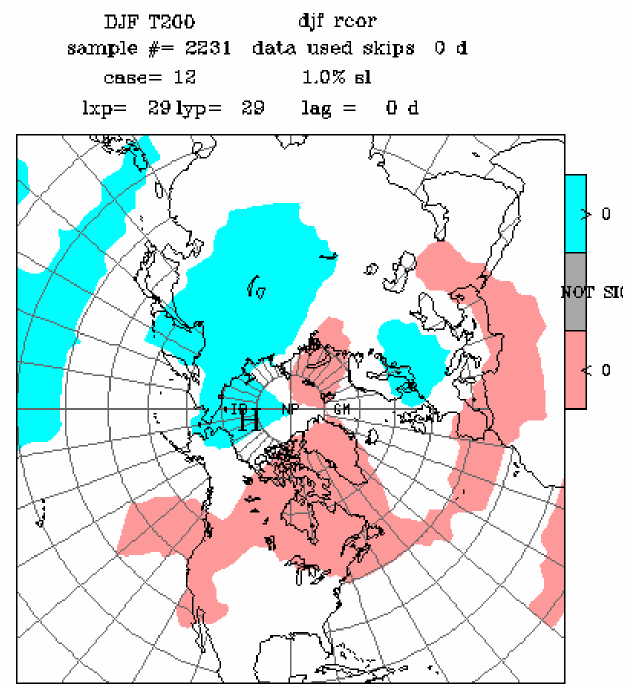
CAM3.x bias vs 1-pt observed correlations: T_{850}

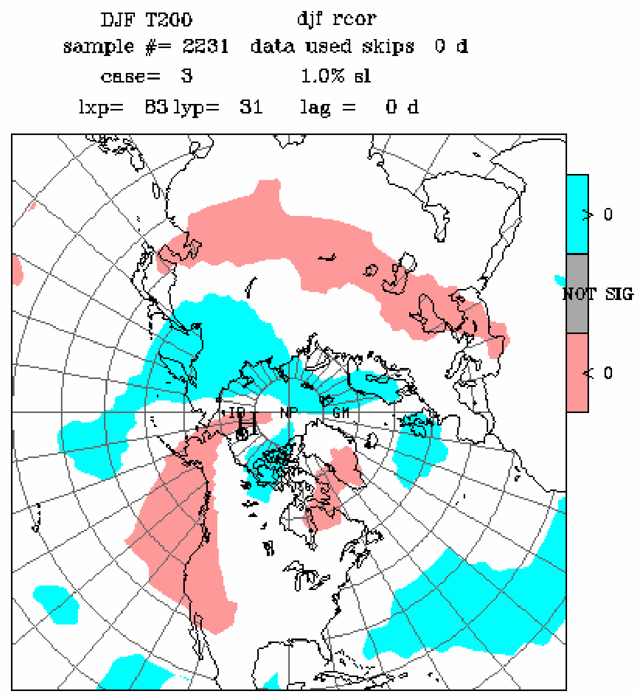
daily T_{850} correl. vs model bias T_{850} – poor match

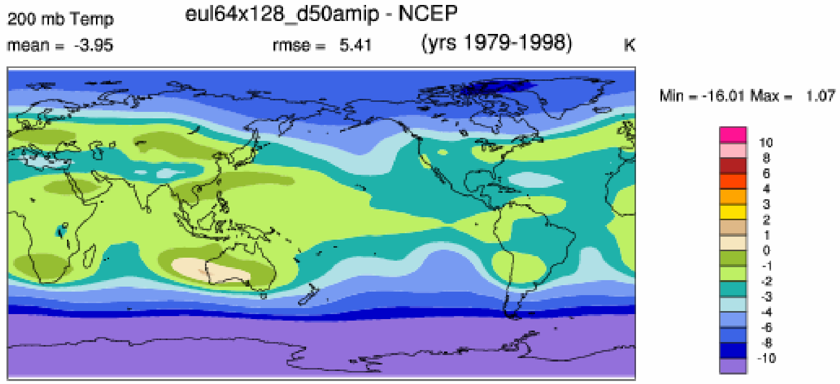


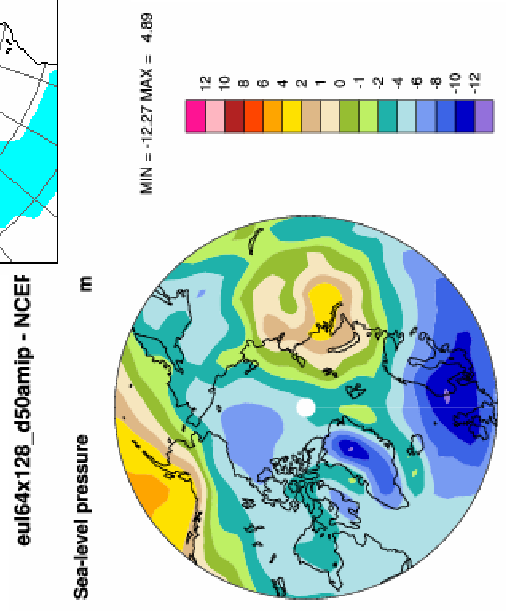
CAM3.x bias vs 1-pt observed correlations: T_{200}

daily T_{200} correl. vs model bias





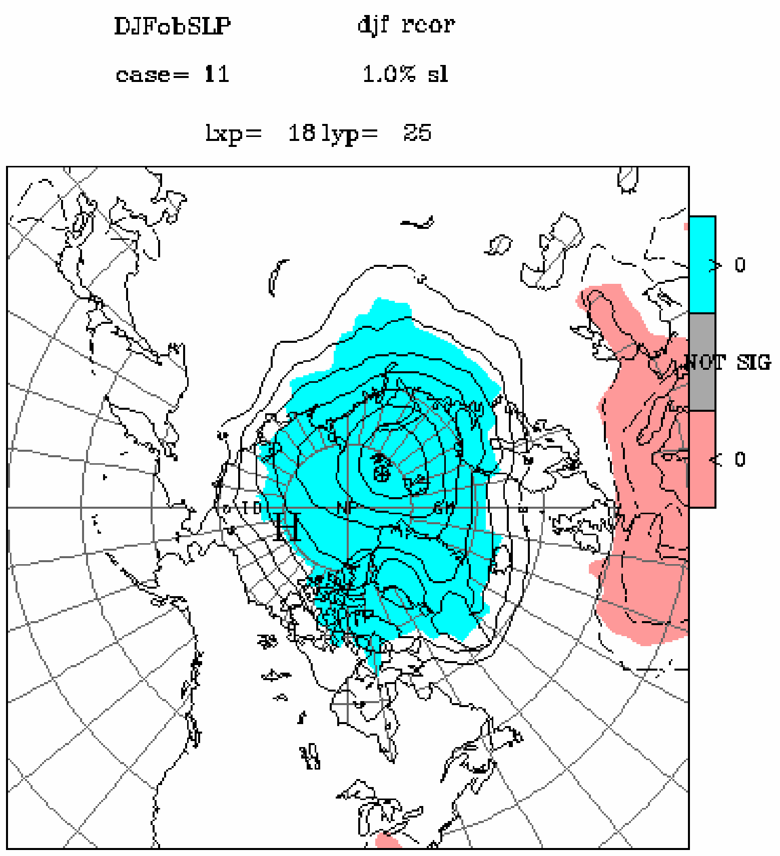




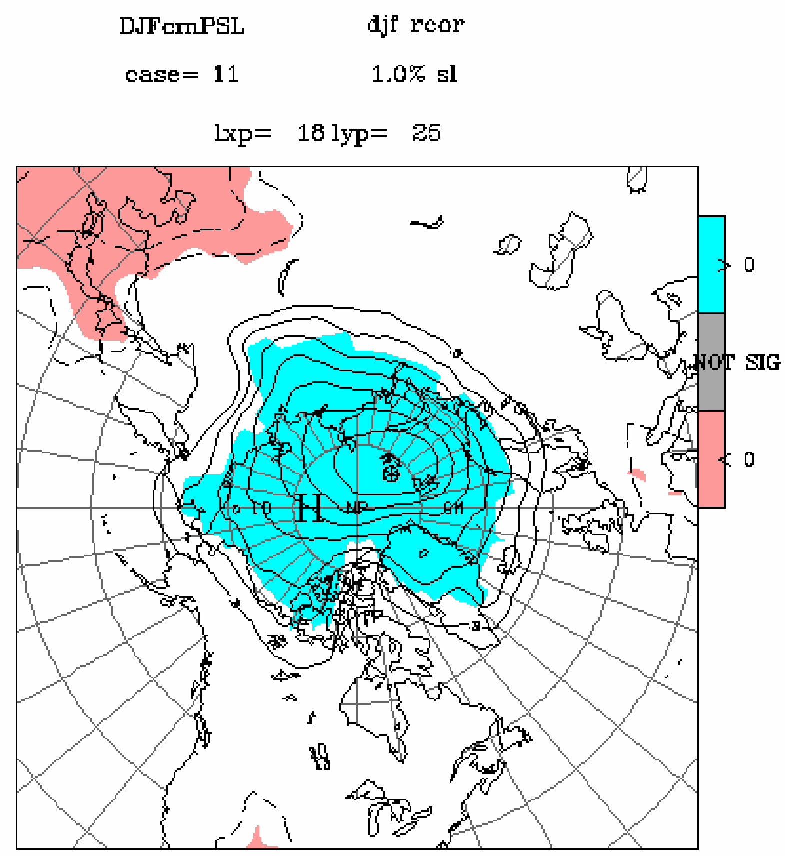
Review: SLP autocorrelation

Monthly Data – obs on left, ccm3.6 on right

CCM3.6 sees Pacific more strongly than the obs



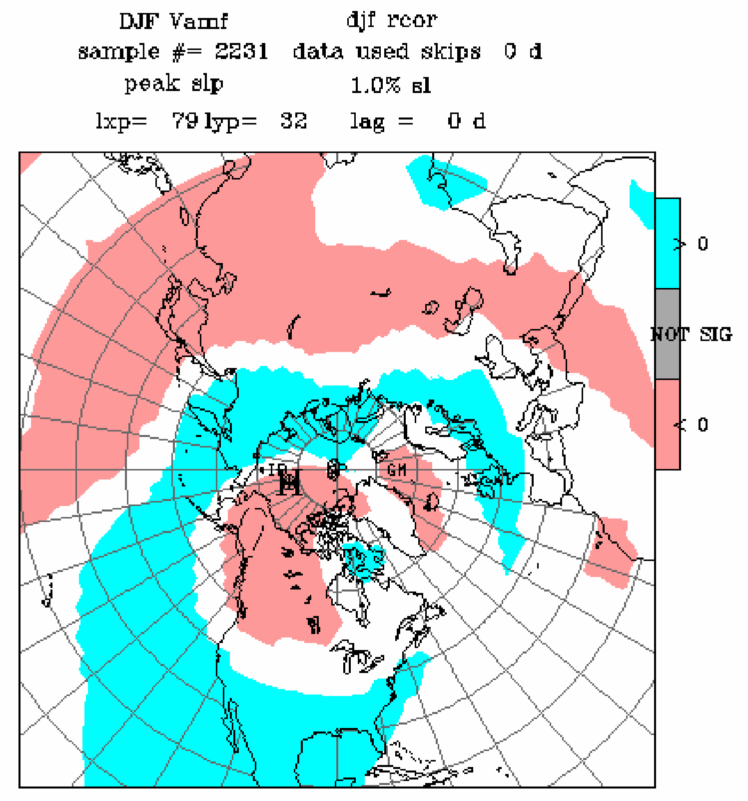
Observed



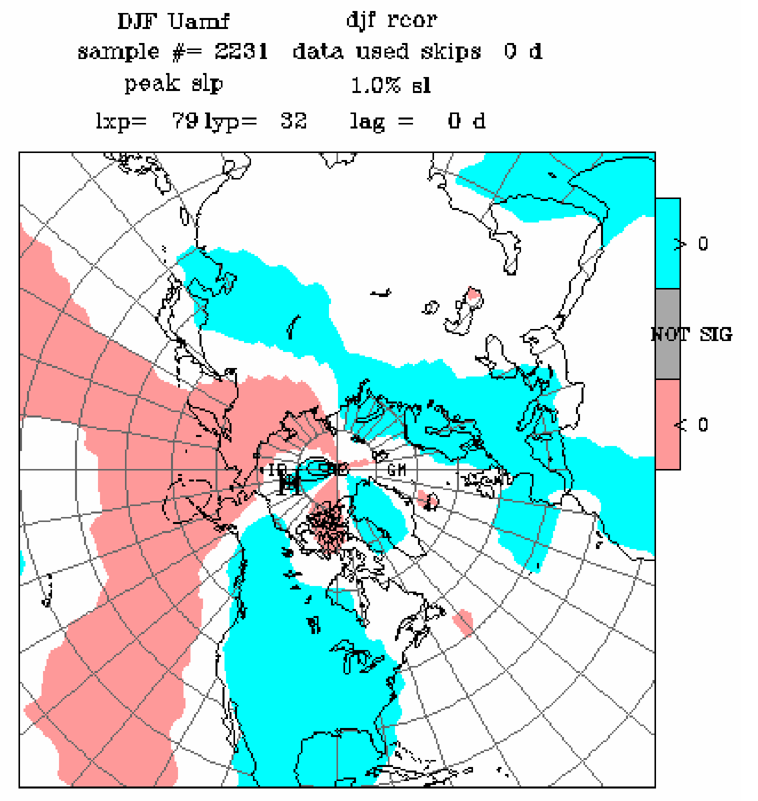
CCM 3.6

Net mass flux

mass flowing around the mean location of the high



Meridional component

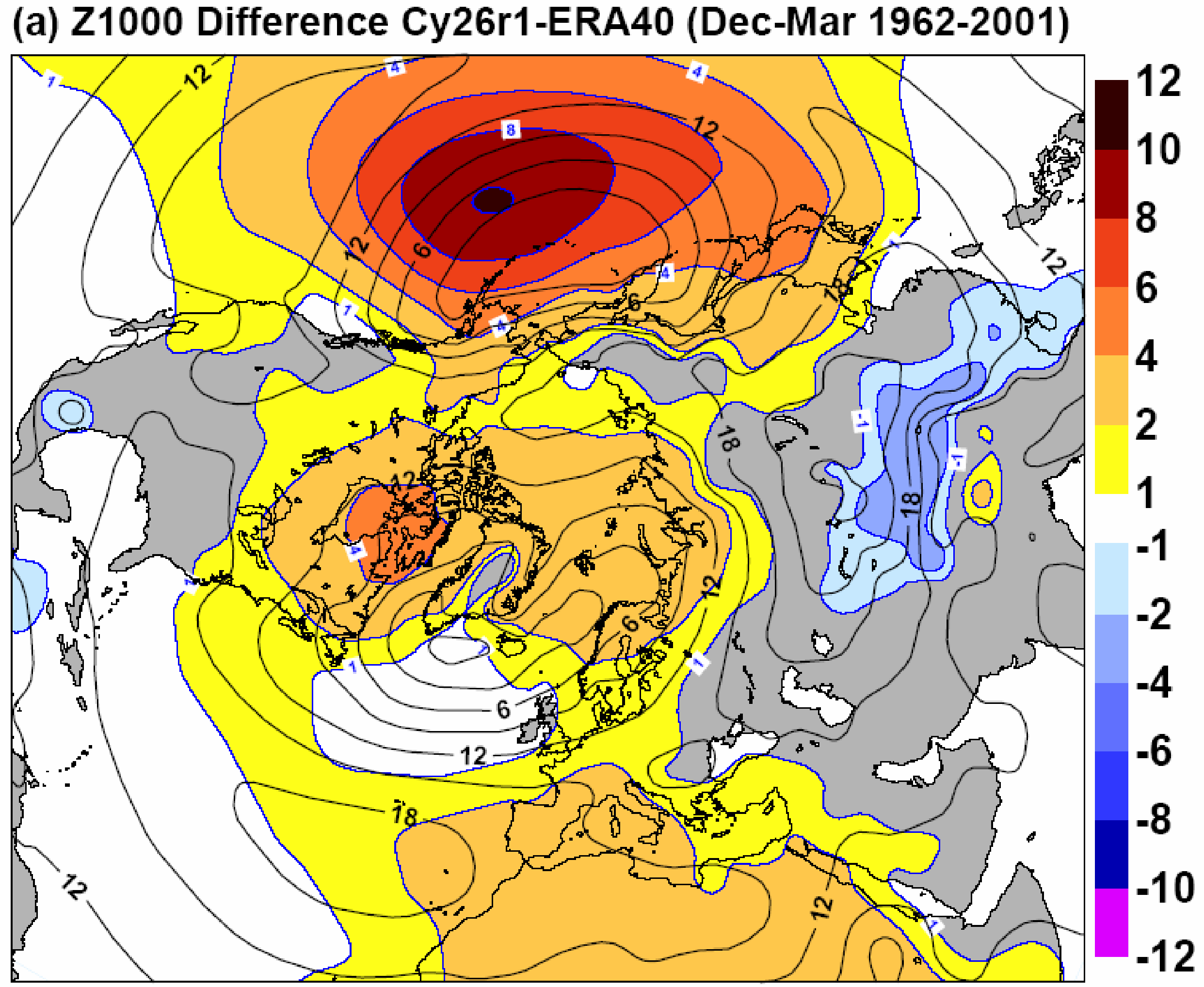


Zonal component

ECMWF model performance

cy26r1 T_L95L60 – Jung & Tompkins, 2003

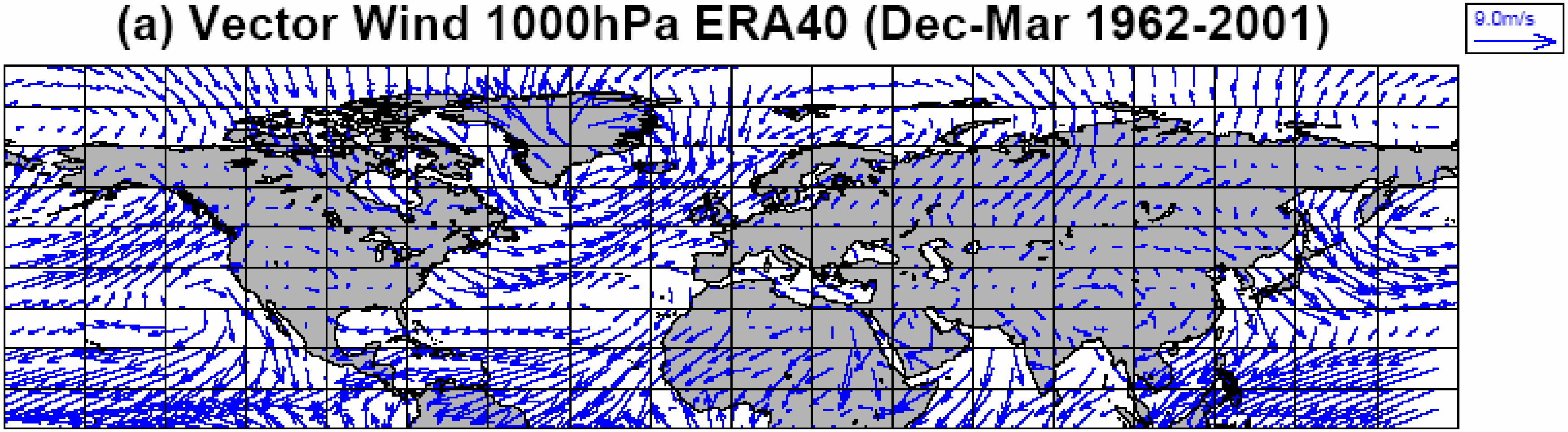
Mean: thin contours in dam
Difference: is shaded in dam



ECMWF model performance

cy26r1 T_L95L60 – Jung & Tompkins, 2003

(a) Vector Wind 1000hPa ERA40 (Dec-Mar 1962-2001)



(b) Vector Wind Error 1000hPa Cy26r1-ERA40 (Dec-Mar 1962-2001)