Requirements for monitoring and detecting climate variability and change: Atmospheric Circulation

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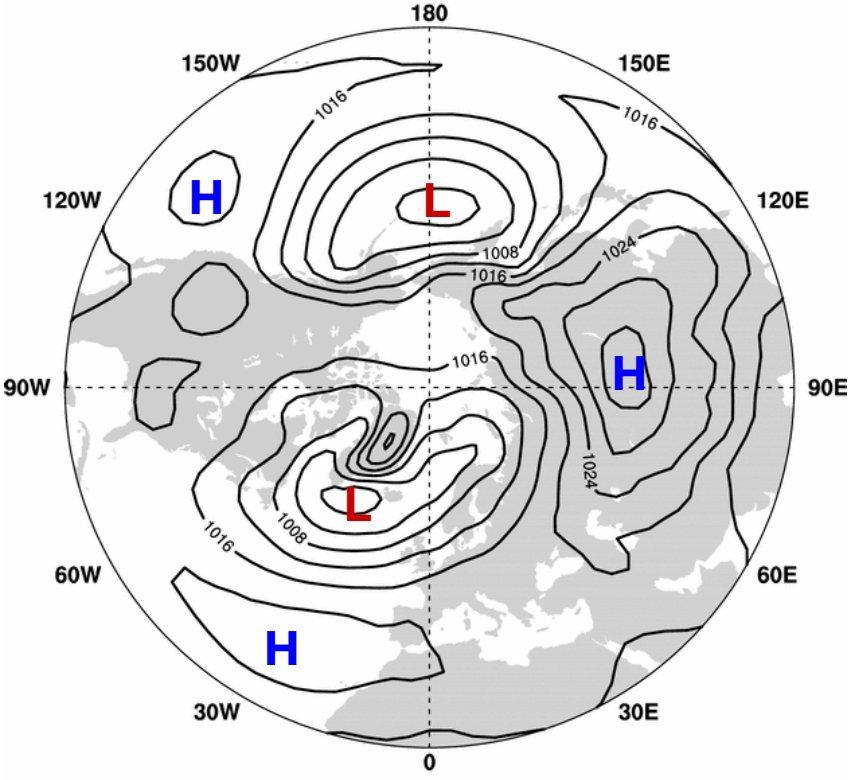
NOAA/GCOS Workshop
Climate Requirements for Upper-Air Observations
8-11 February 2005

Boulder, Colorado

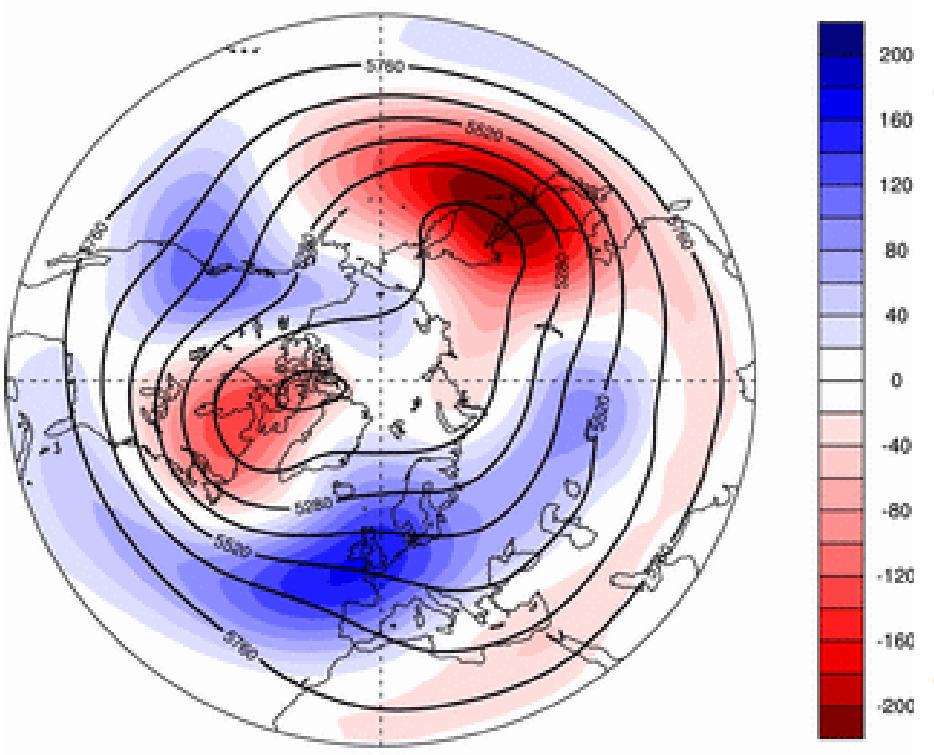
NCAR

The Mean State and Stationary Waves (DJF)

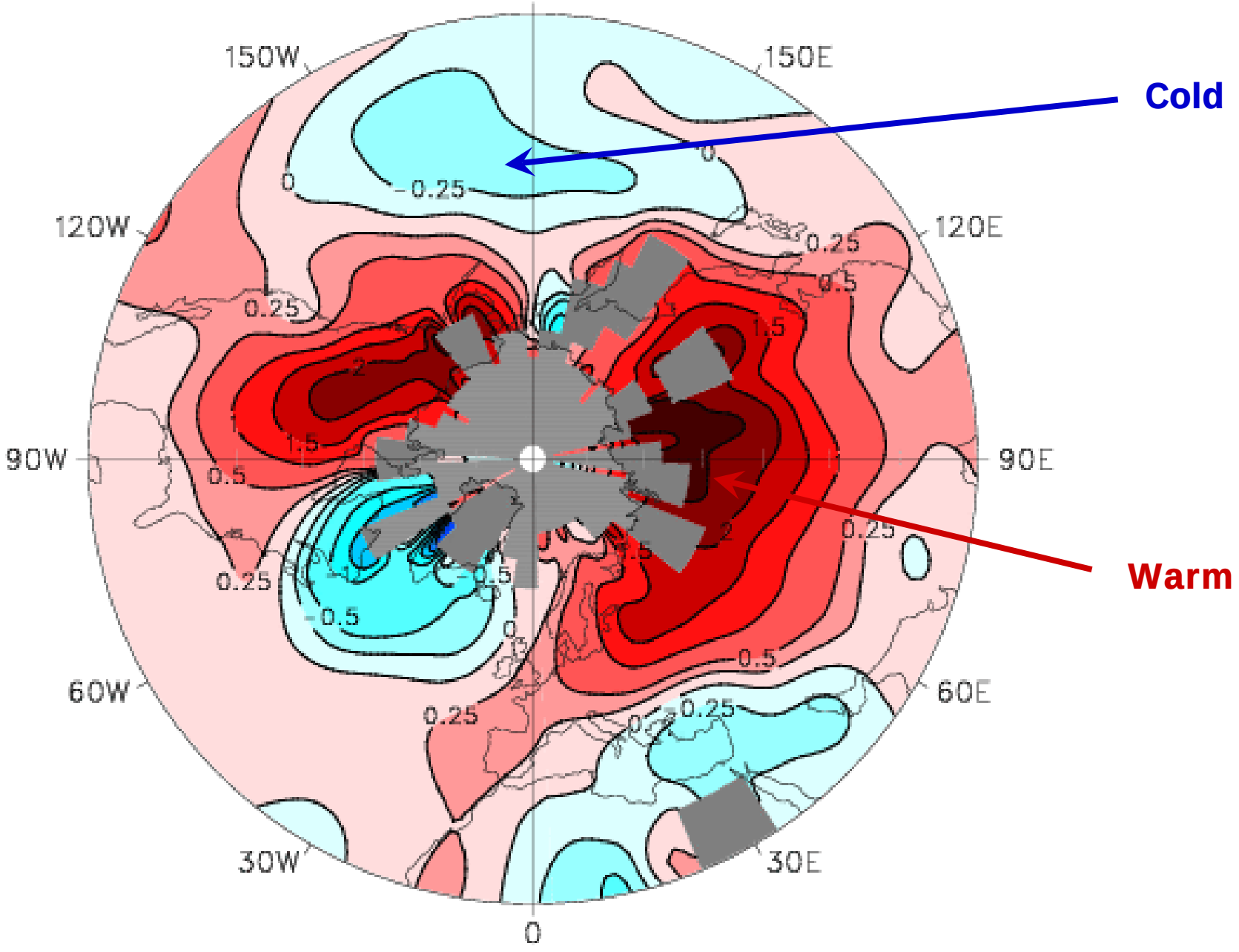
Sea Level Pressure



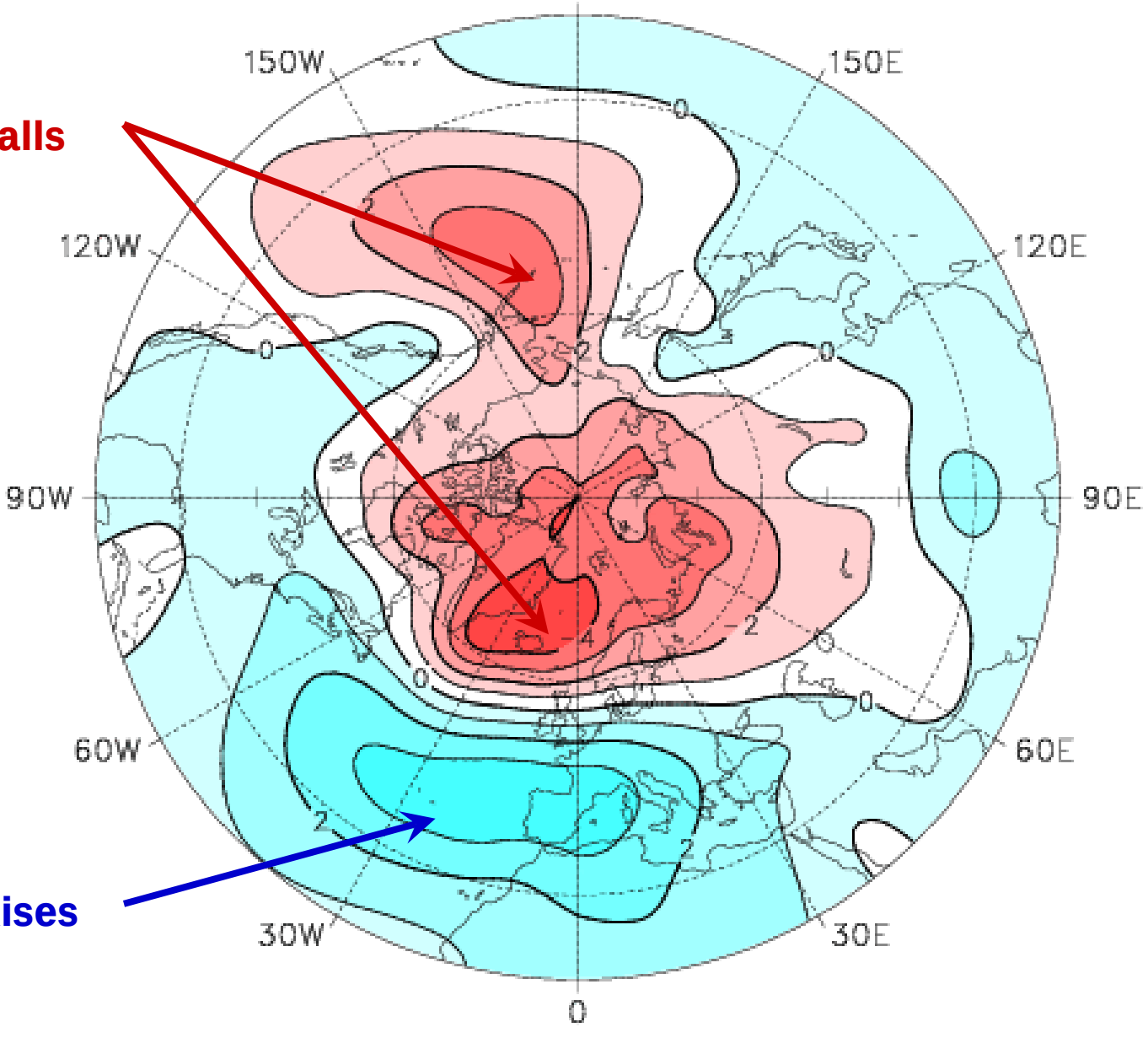
Mid Tropospheric Height



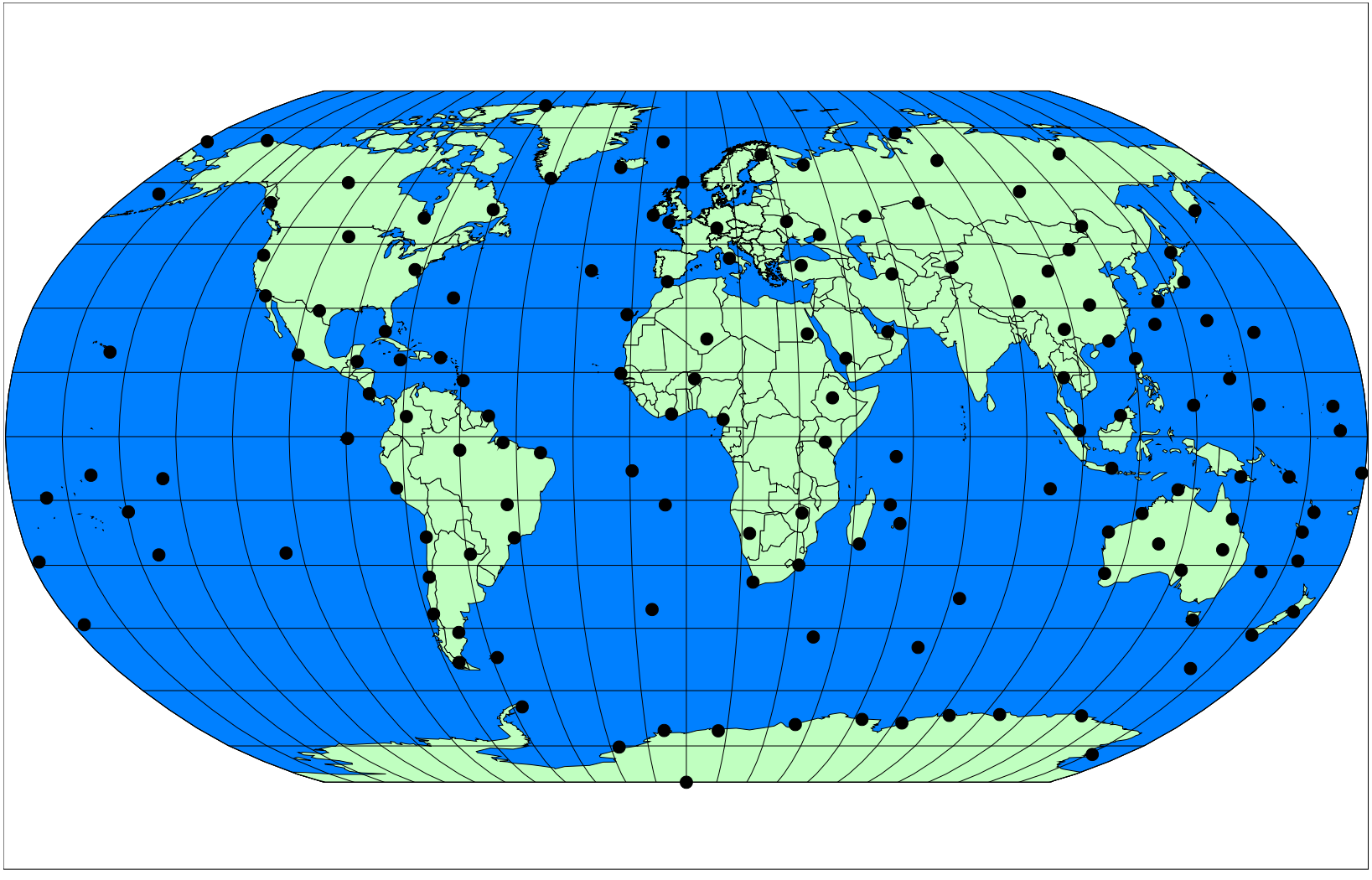
Change in Winter Surface Temperature since 1980



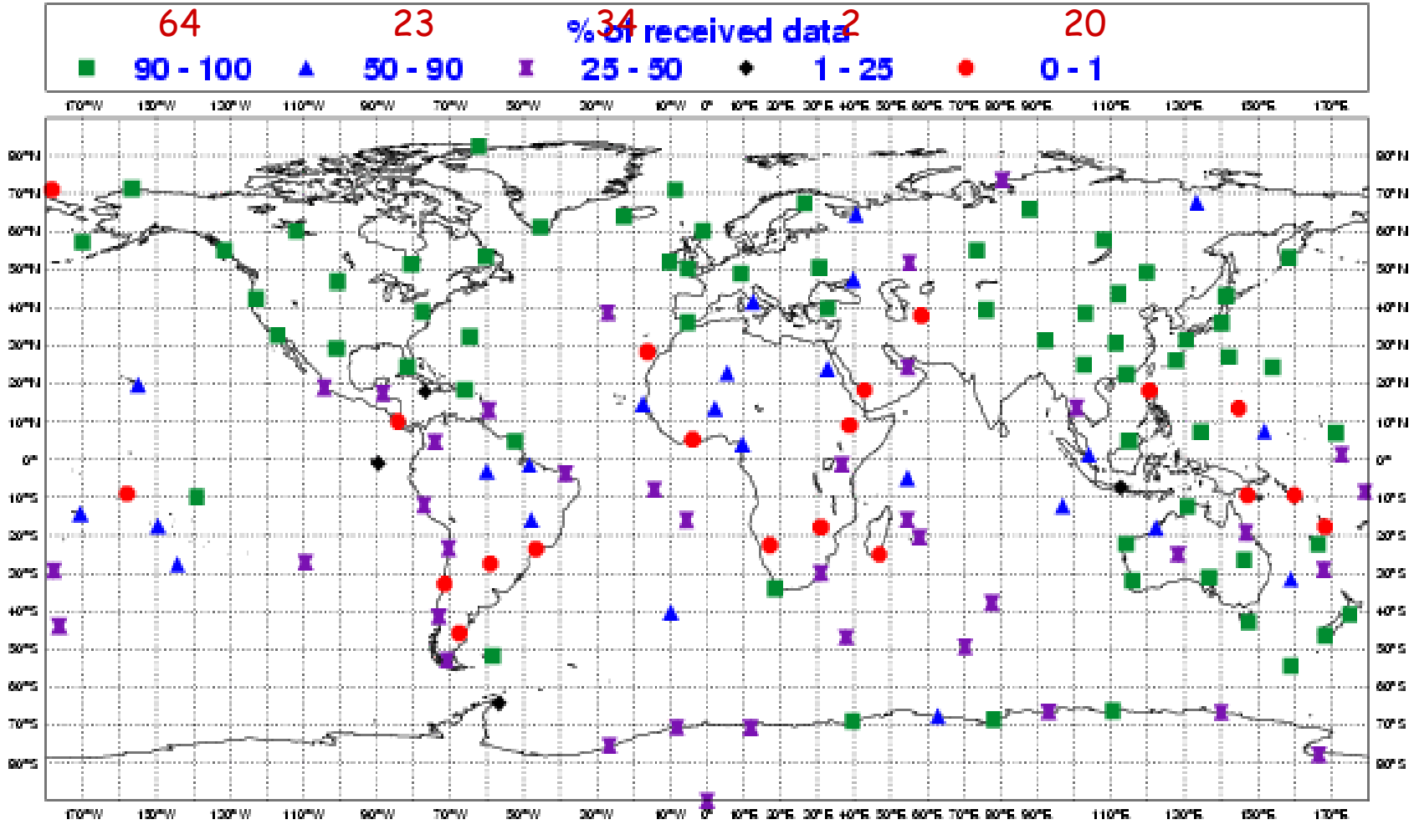
Change in Winter Sea Level Pressure since 1980

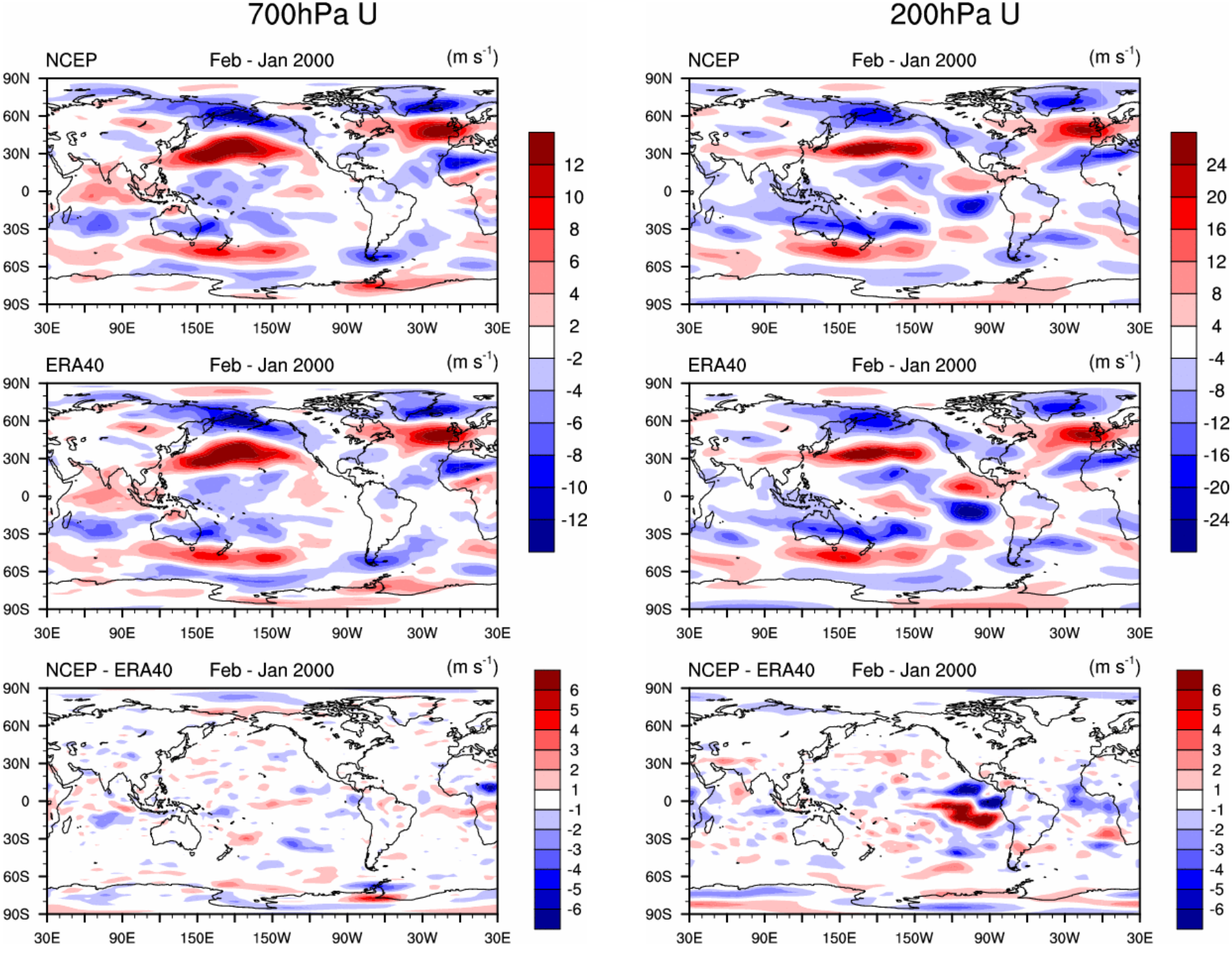


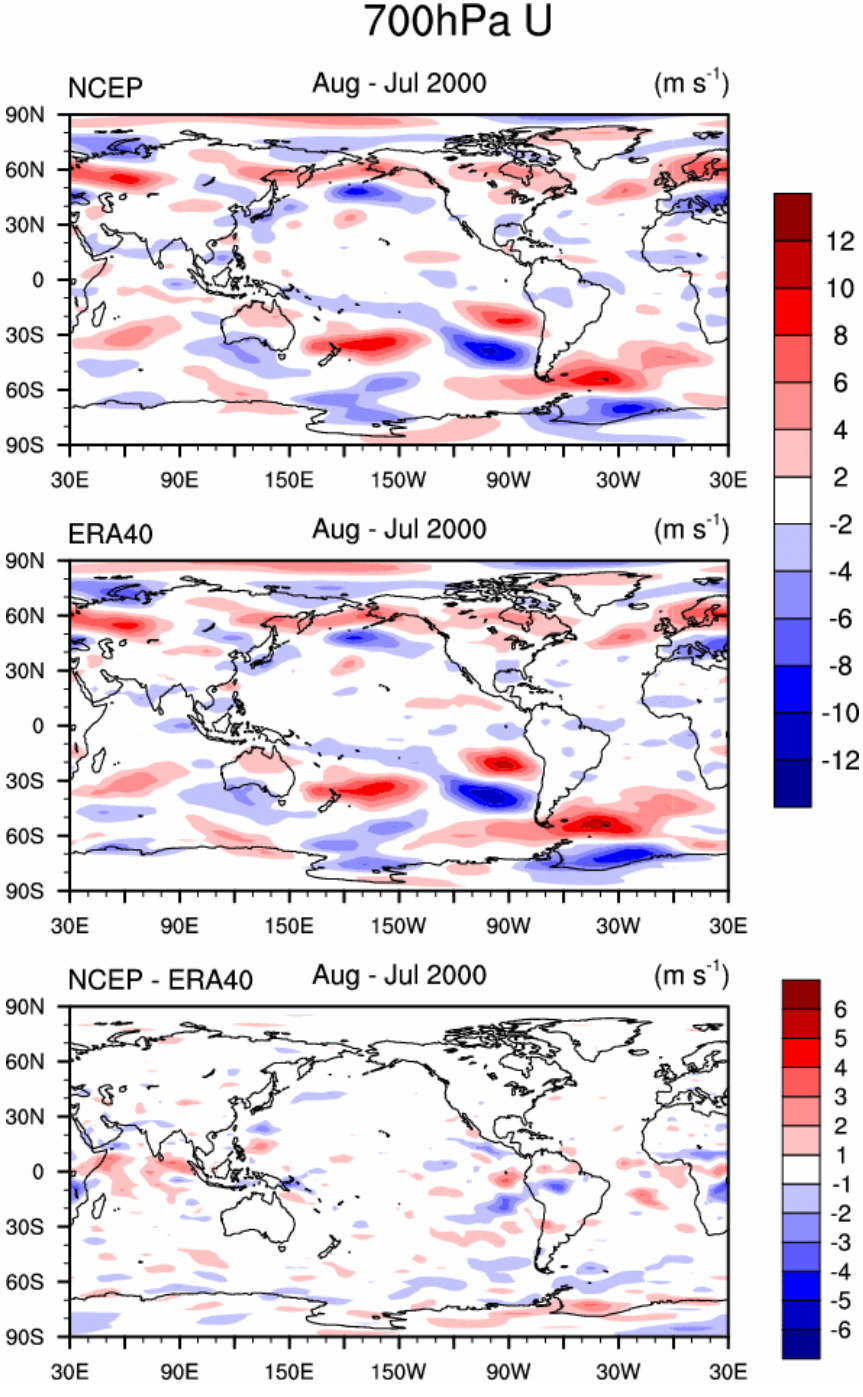
Global Upper Air Network (GUAN)

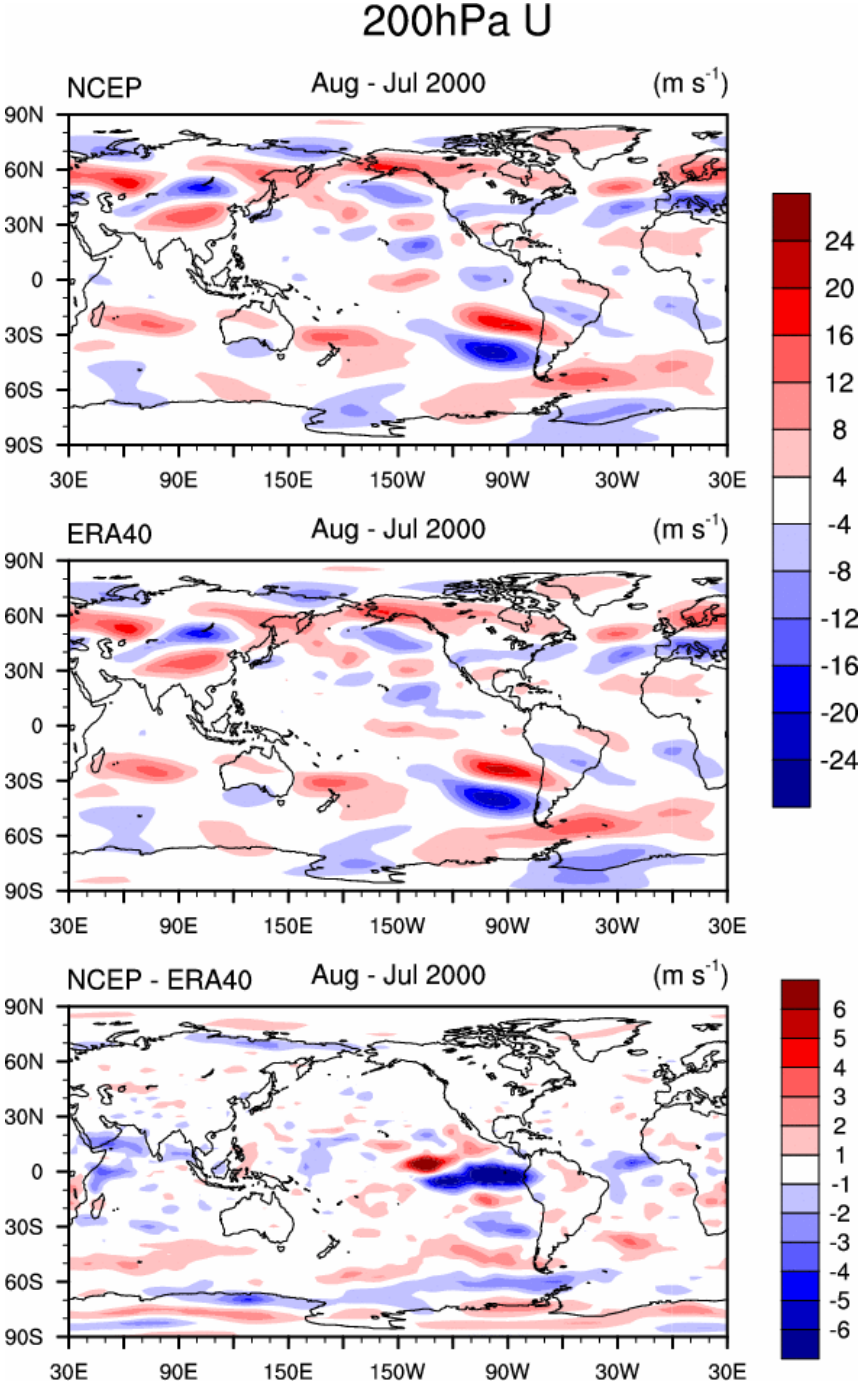


GUAN STATIONS APR 2003
Frequency of RECEPTION data at ECMWF
Level: 300 hPa Temperature SUMMARY 00/12 UTC

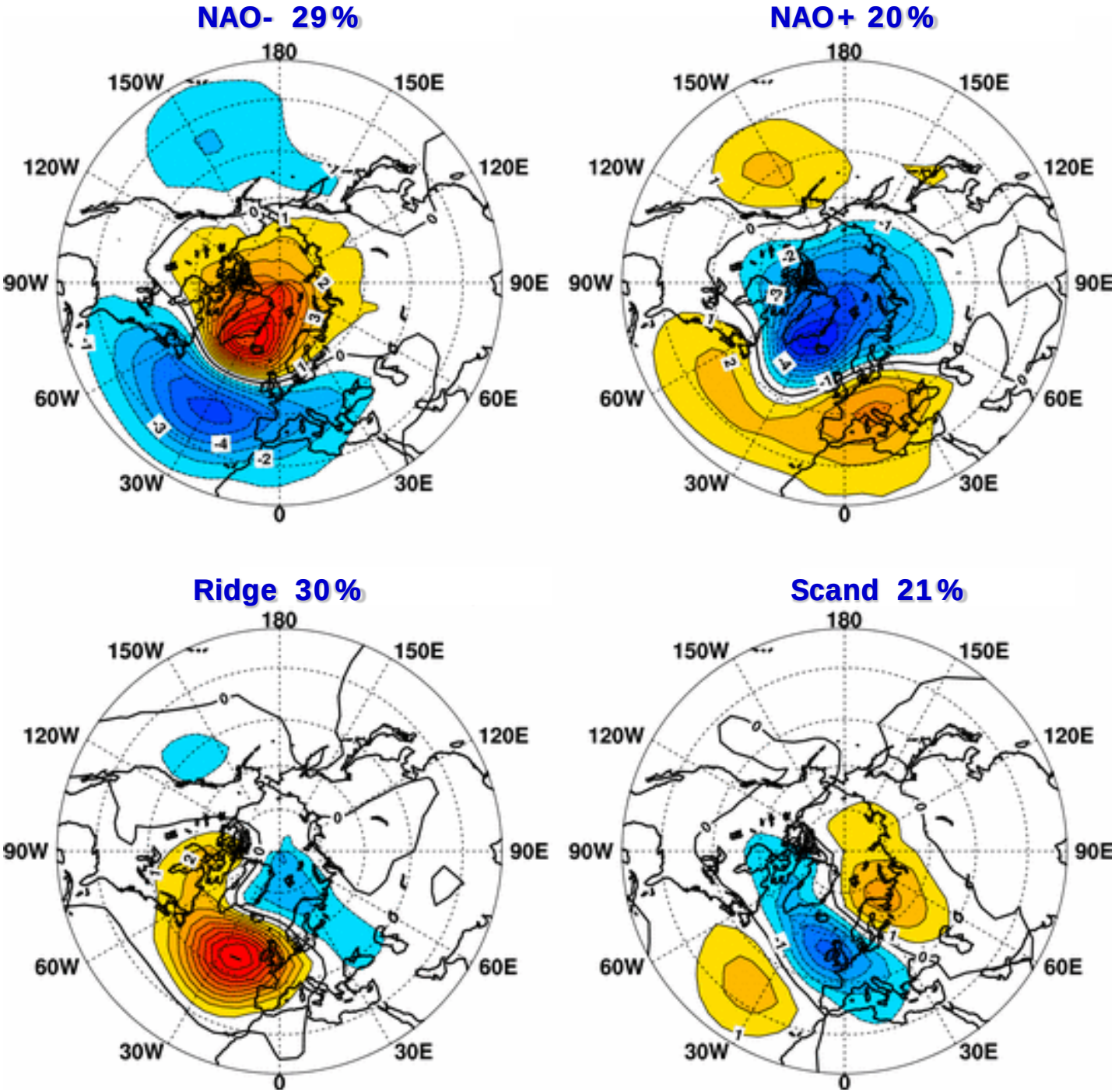



700hPa U
NCEP
Feb - Jan 2000
(m s-1)
90N
60N
30N
0
30S
60S
90S
30E
90E
150E
150W
90W
30W
30E
12
10
8
6
4
2
-2
-4
-6
-8
-10
-12
ERA40
Feb - Jan 2000
(m s-1)
NCEP - ERA40
Feb - Jan 2000
(m s-1)
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6
200hPa U
NCEP
Feb - Jan 2000
(m s-1)
24
20
16
12
8
4
-4
-8
-12
-16
-20
-24
ERA40
Feb - Jan 2000
(m s-1)
NCEP - ERA40
Feb - Jan 2000
(m s-1)

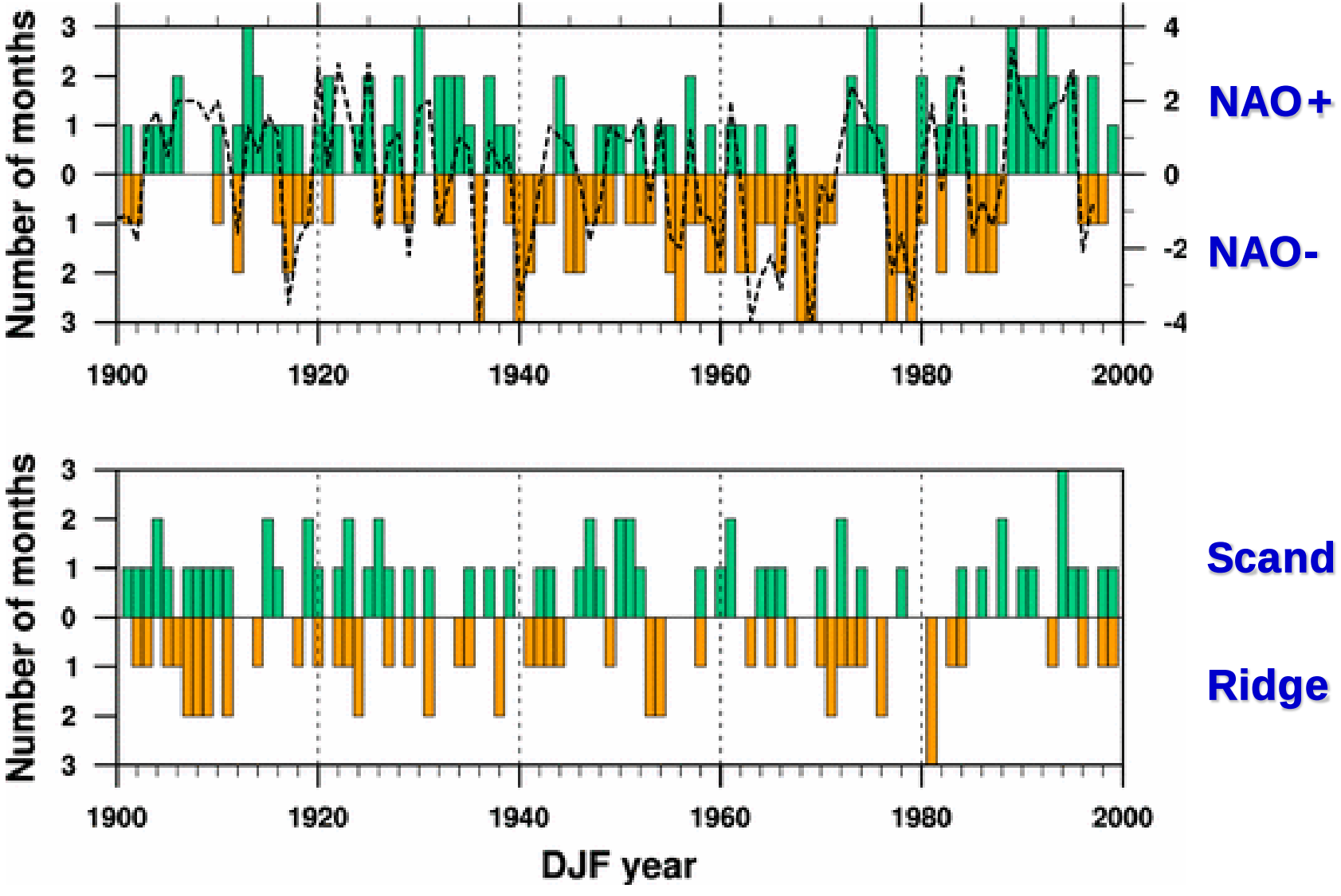

700hPa U
NCEP
Aug - Jul 2000
(m s-1)
90N
60N
30N
0
30S
60S
90S
30E
90E
150E
150W
90W
30W
30E
12
10
8
6
4
2
-2
-4
-6
-8
-10
-12
ERA40
Aug - Jul 2000
(m s-1)
NCEP - ERA40
Aug - Jul 2000
(m s-1)
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6


200hPa U
NCEP
Aug - Jul 2000
(m s-1)
90N
60N
30N
0
30S
60S
90S
30E
90E
150E
150W
90W
30W
30E
24
20
16
12
8
4
-4
-8
-12
-16
-20
-24
ERA40
Aug - Jul 2000
(m s-1)
NCEP - ERA40
Aug - Jul 2000
(m s-1)
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6

Cluster Analysis



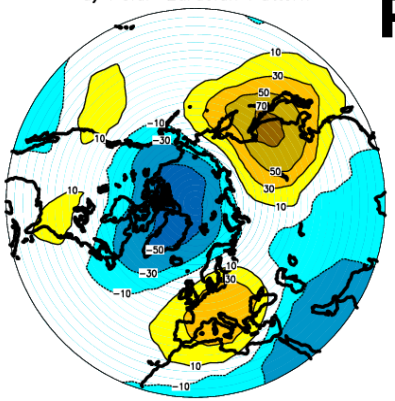
Time History of Occurrence



Northern Hemisphere wintertime teleconnection patterns

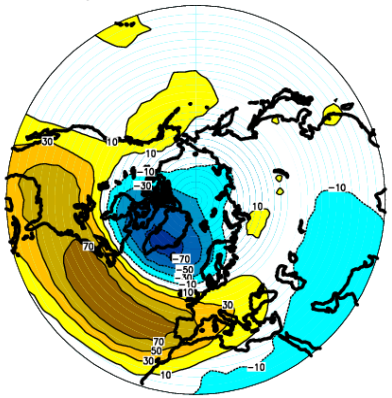
a) Polar–Eurasian Pattern

PEU



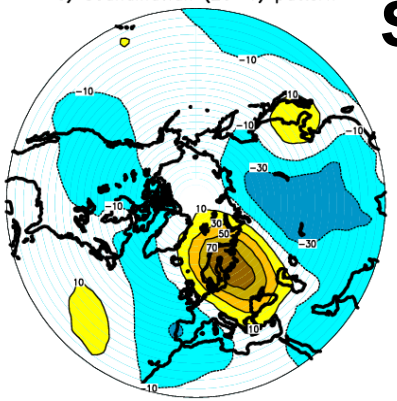
b) North Atlantic Oscillation

NAO



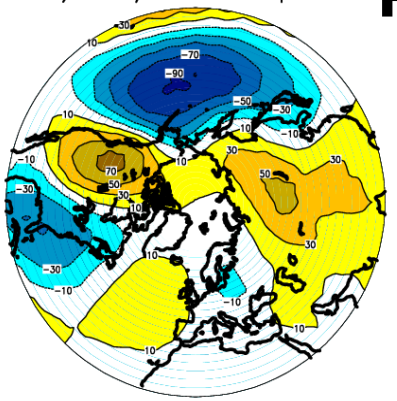
c) Scandinavian (EU–1) pattern

SCA



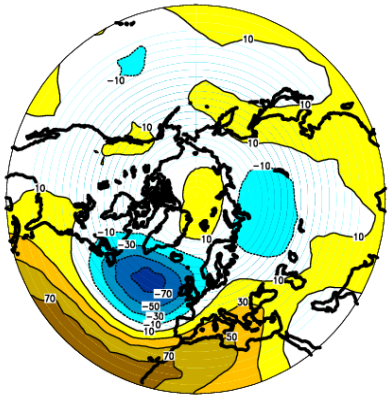
d) Pacific/North America pattern

PNA



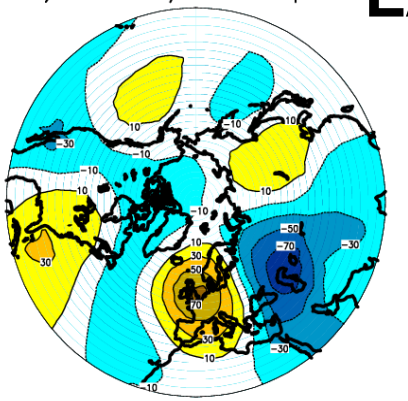
e) East Atlantic Oscillation

EA



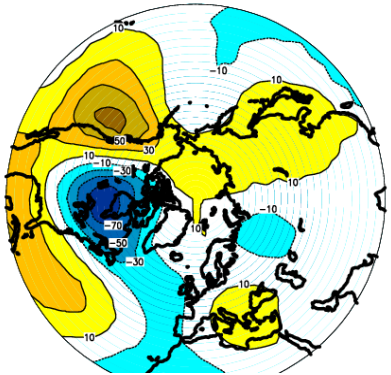
f) East Atlantic/West Russia pattern

EA / WR



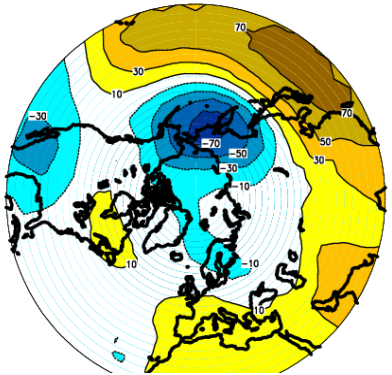
g) Tropical/N. Hemisphere pattern

TNH



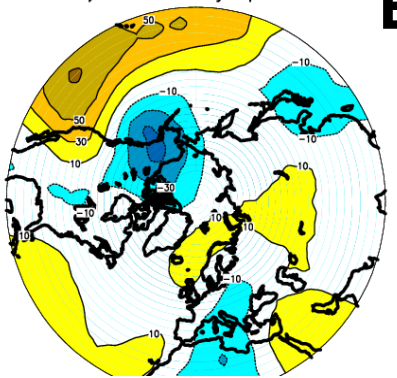
h) West Pacific Pattern

WP



i) East Pacific jet pattern

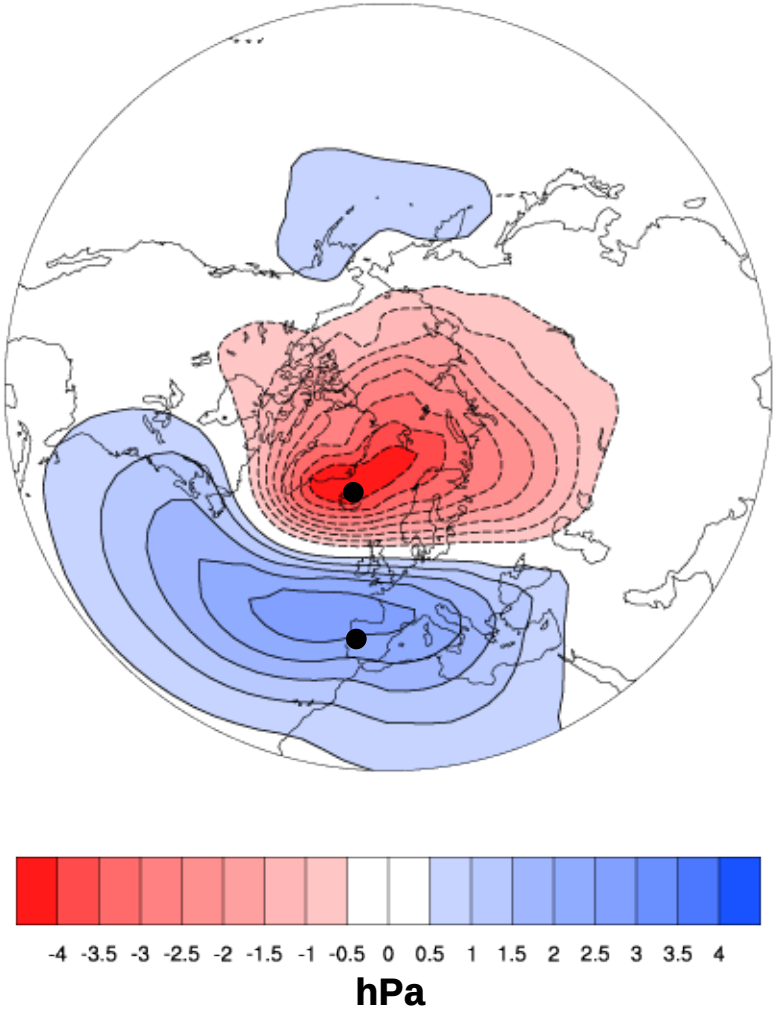
EPJ



The North Atlantic Oscillation

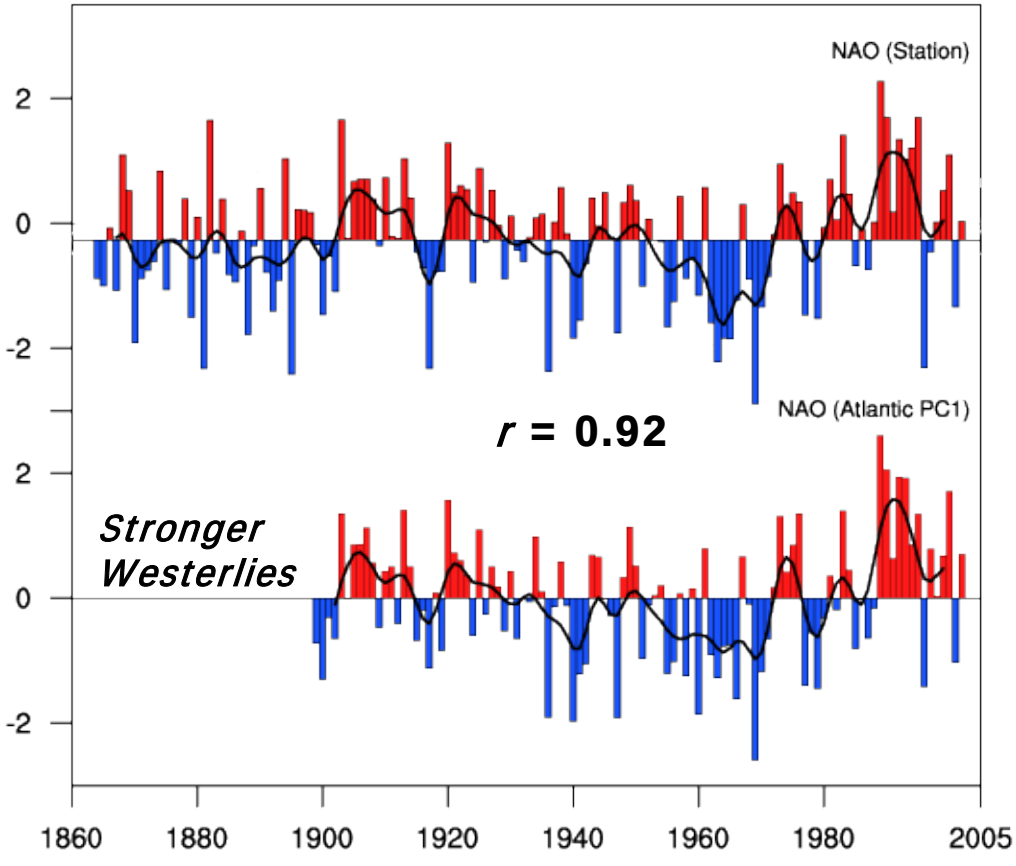
Spatial Structure

Dec-Mar 39% SLP (hPa)

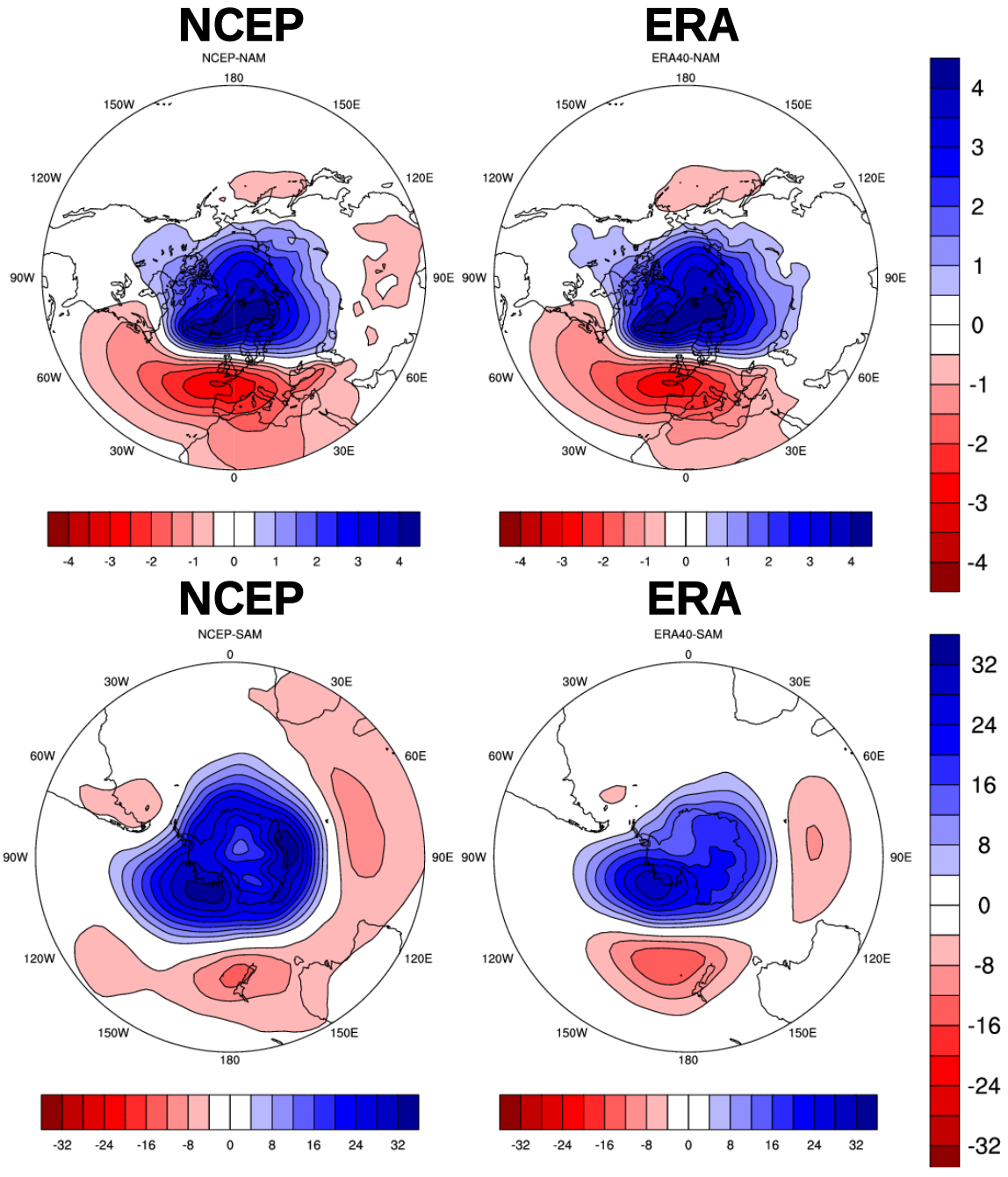


Temporal Evolution

Dec-Mar



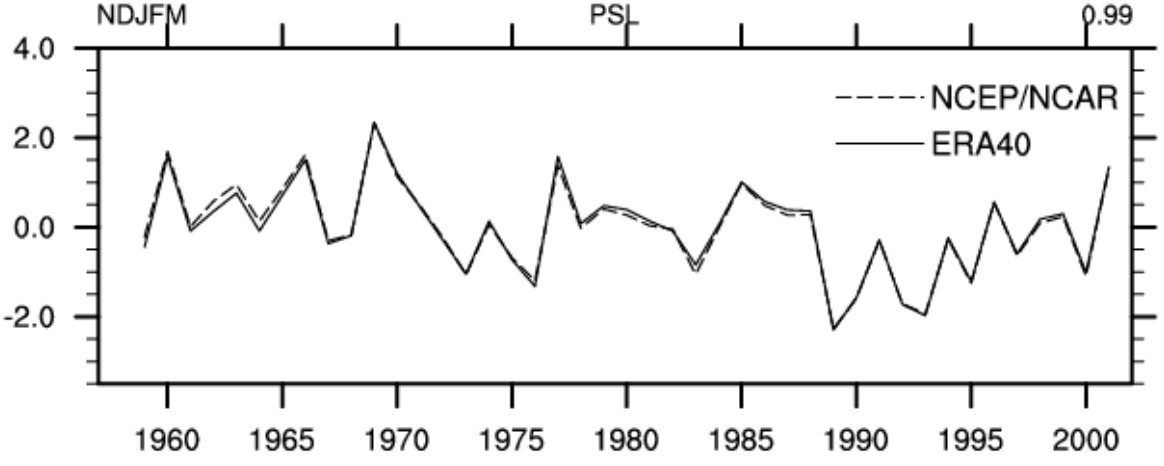
Quadrelli and Wallace (2004)



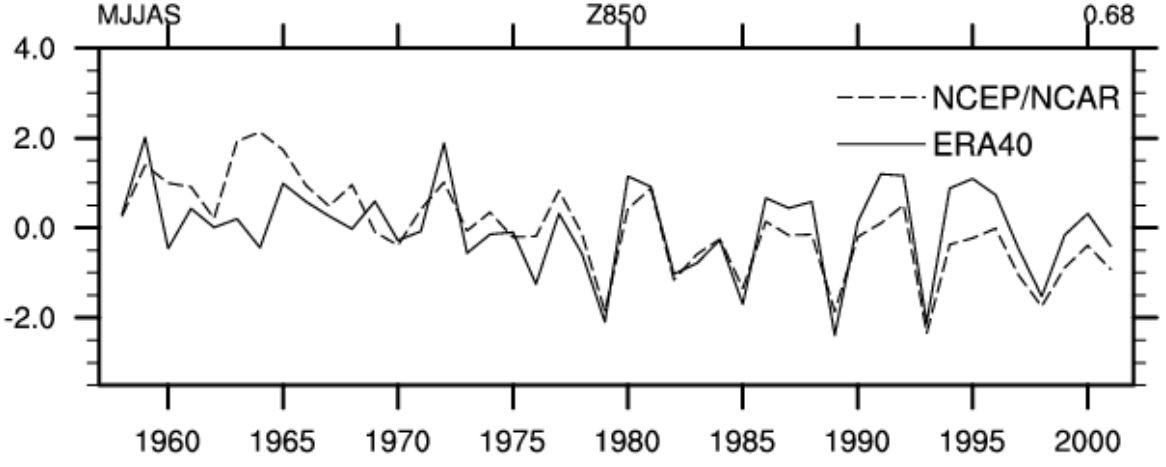
NAM (NDJFM)

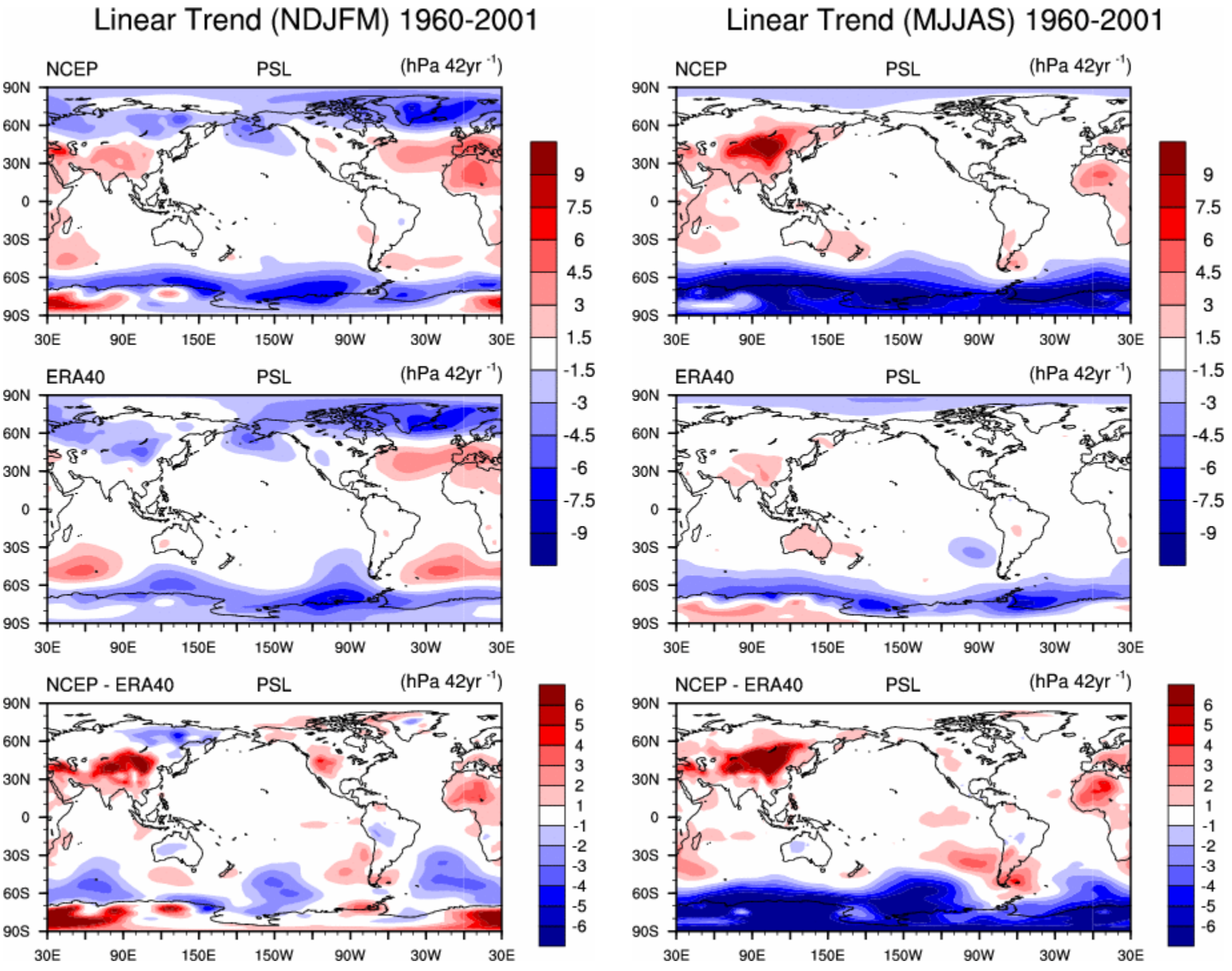
SAM (MJJAS)

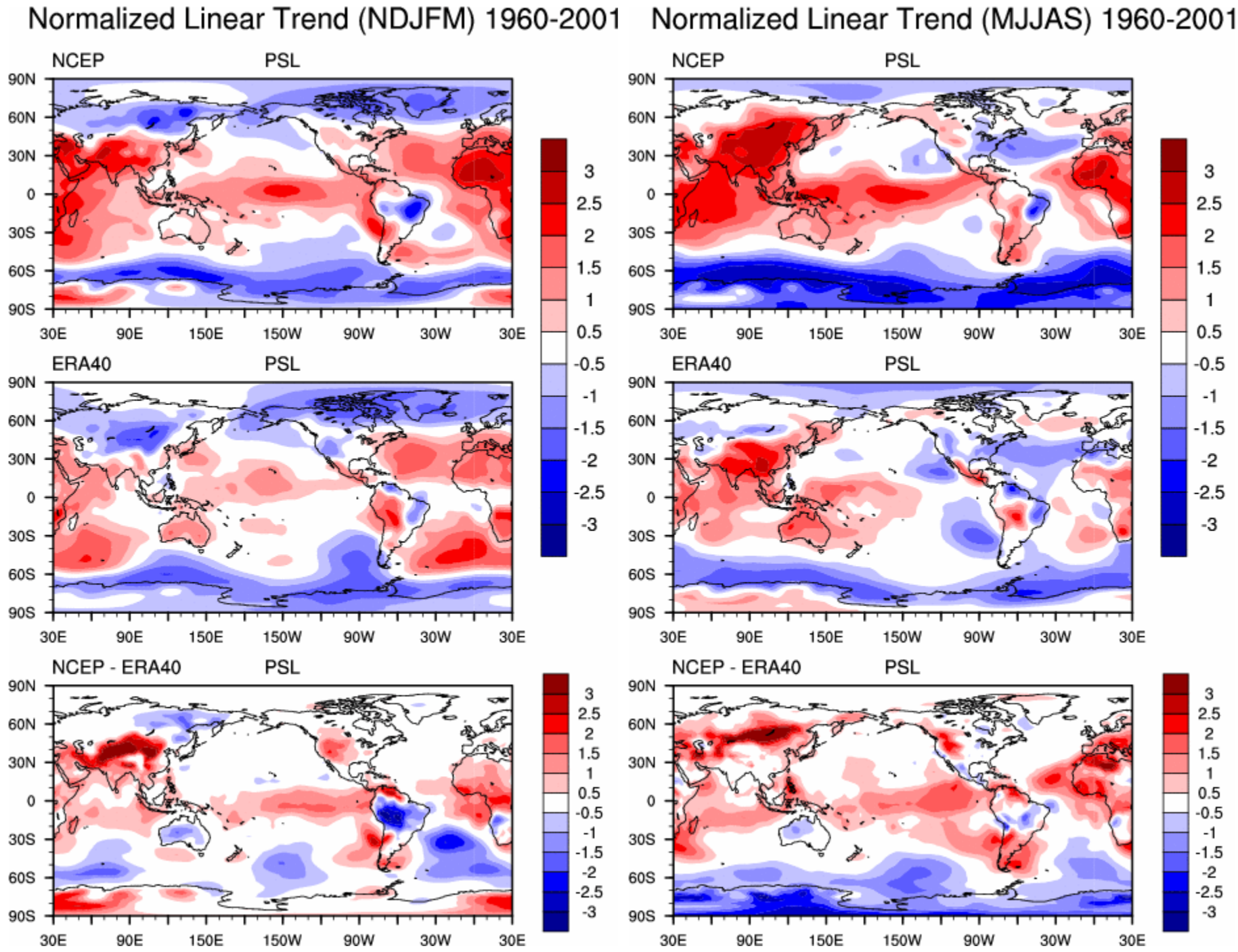
NAM (NDJFM)



SAM (MJJAS)




Linear Trend (NDJFM) 1960-2001
Linear Trend (MJJAS) 1960-2001
NCEP PSL (hPa 42yr -1)
ERA40 PSL (hPa 42yr -1)
NCEP - ERA40 PSL (hPa 42yr -1)
90N
60N
30N
0
30S
60S
90S
30E
90E
150E
150W
90W
30W
30E
9
7.5
6
4.5
3
1.5
-1.5
-3
-4.5
-6
-7.5
-9
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6

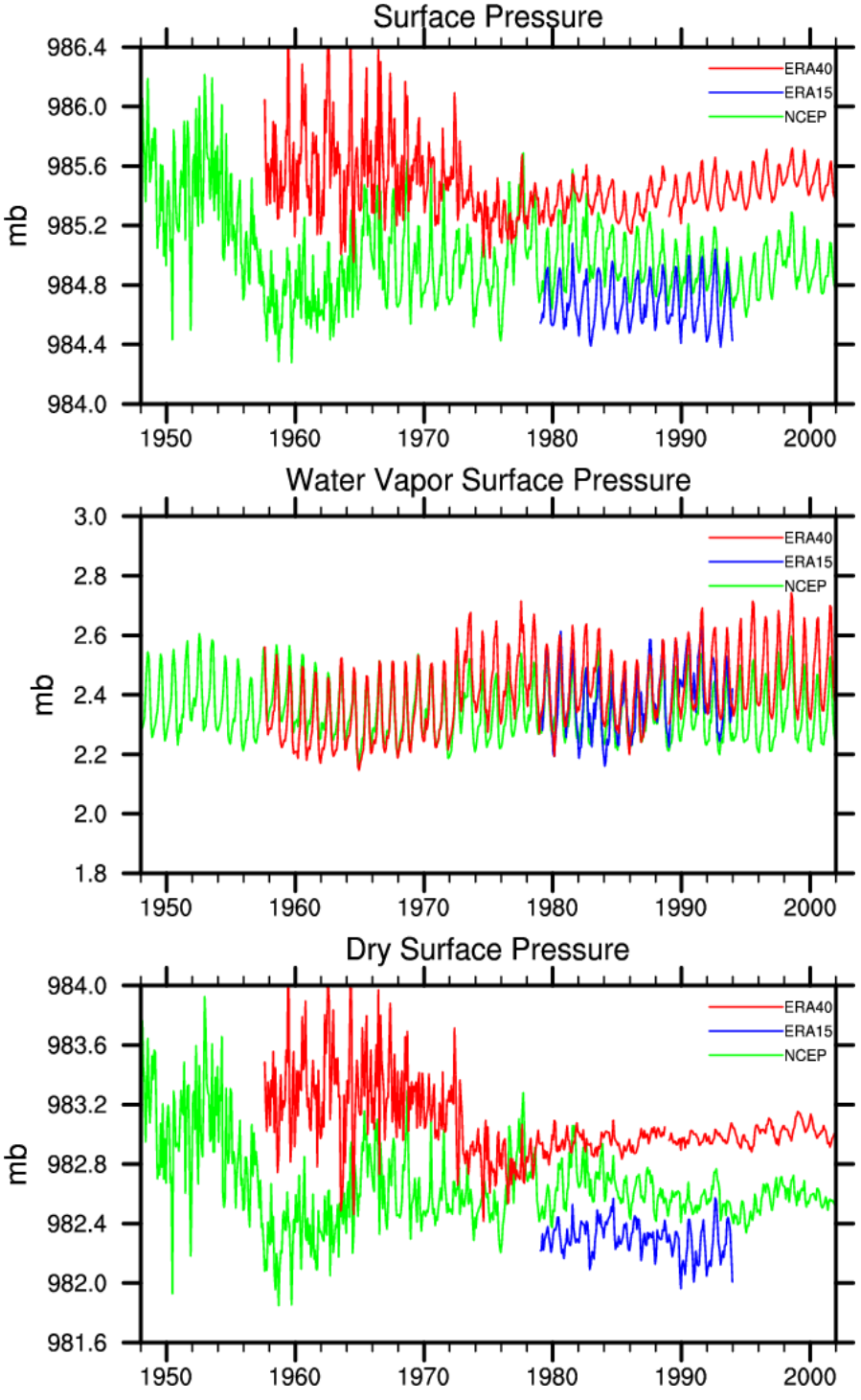

Normalized Linear Trend (NDJFM) 1960-2001
Normalized Linear Trend (MJJAS) 1960-2001
NCEP PSL
ERA40 PSL
NCEP - ERA40 PSL
90N
60N
30N
0
30S
60S
90S
30E
90E
150E
150W
90W
30W
30E
3
2.5
2
1.5
1
0.5
-0.5
-1
-1.5
-2
-2.5
-3

Conservation of mass of dry air.

Both total surface pressure p_s and that due to moisture p_w are independent measures of the water vapor contribution. Their difference p_d should be constant.

Mean annual cycle is similar for p_s and p_w, except NCEP before 1966 and ERA-15 after 1989.

ERA40 offset from global topography 5.5 m lower, mostly Antarctica.

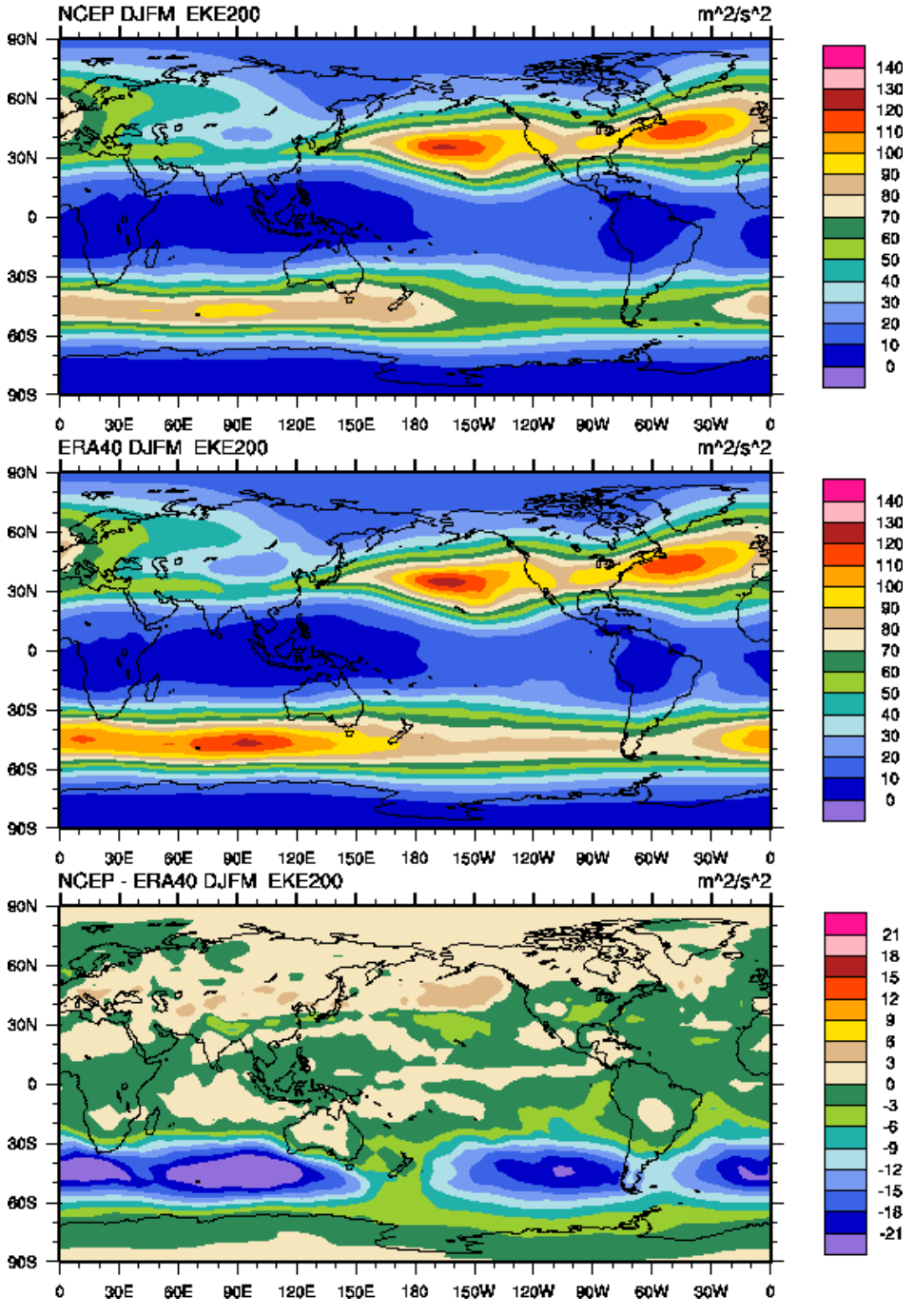


200 hPa mean EKE

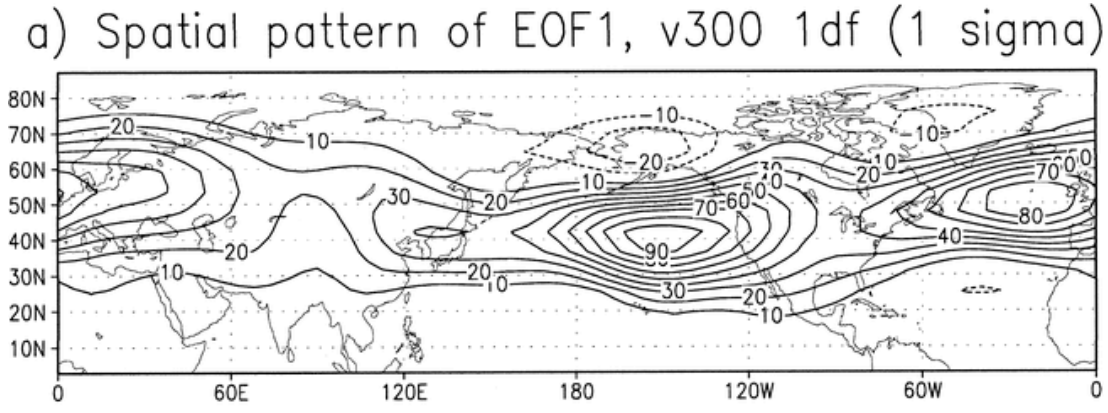
NCEP

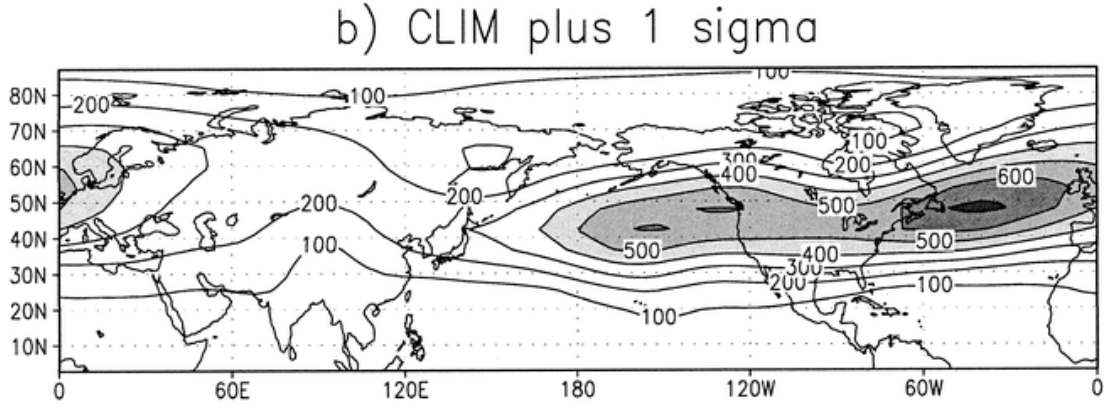
ERA-40

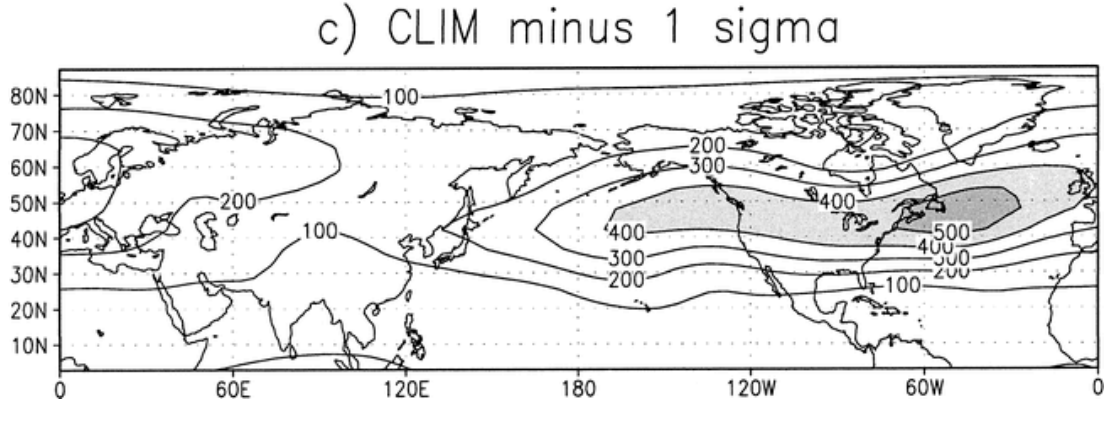
Difference

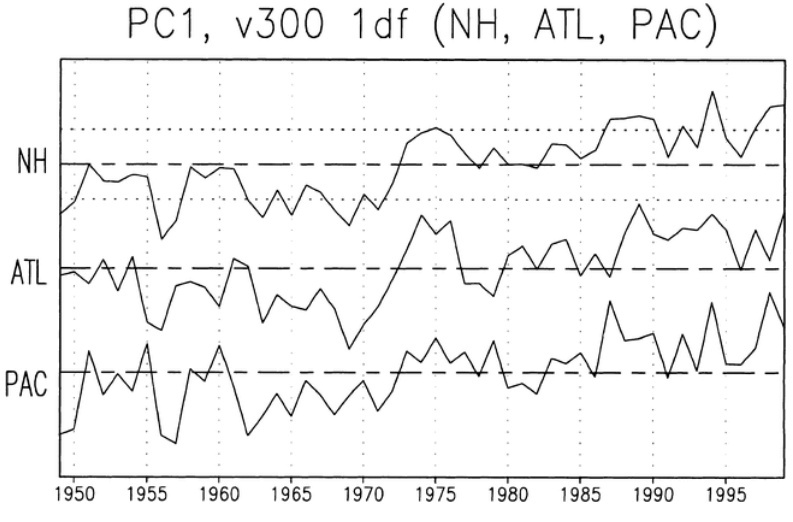


Chang and Fu (2002)



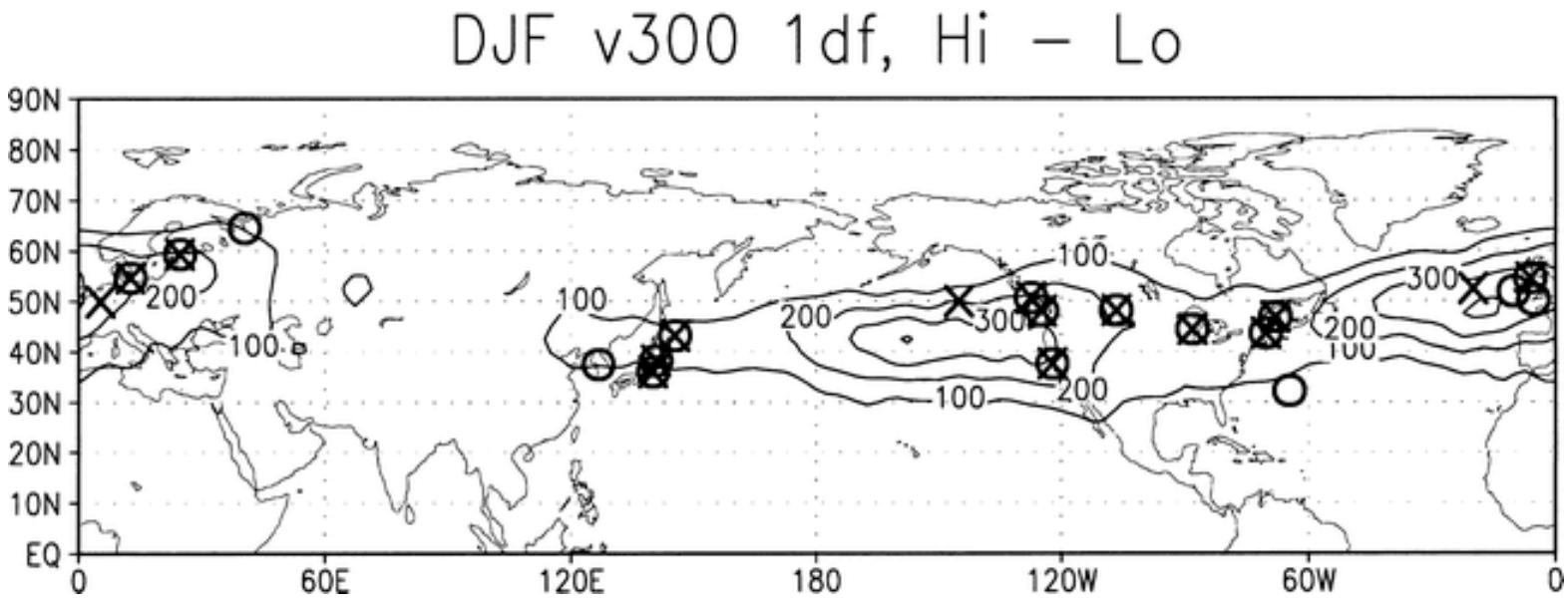


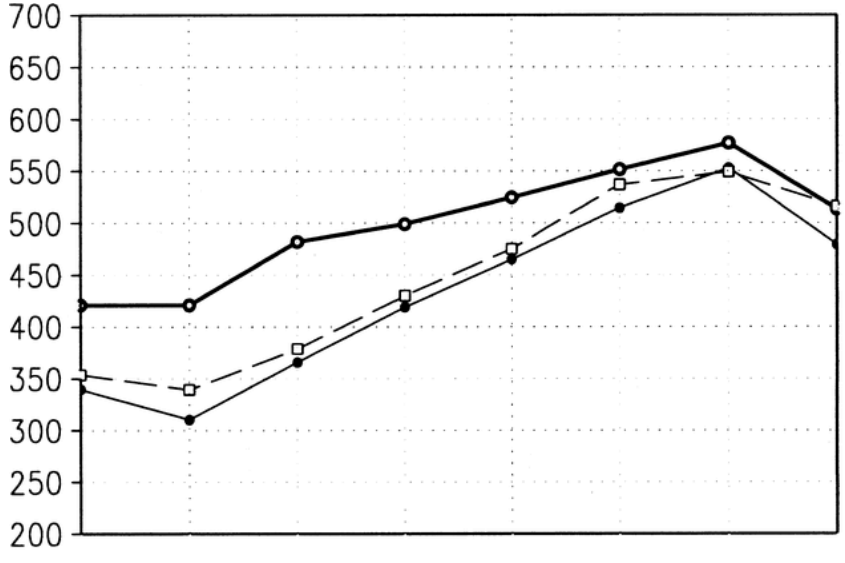




Is this trend real?

Chang and Fu (2002)





Dark Line: Radiosondes (v'2)

Dotted: NCEP/NCAR when station data available

Thin Solid: NCEP/NCAR at all times

Conclusion: Perhaps slight over-estimation in analysis, although no stations over oceans to truly verify

Trenberth et al. (2003)

ECMWF Reanalyses

Objective: To replicate full model level diagnostics with the pressure level archive

Test bed:

- EC model level data (31 levels)
- EC p-level data (17 levels)
- p-level data (17 levels) NCAR post-processor
- p-level data (30 levels) NCAR post-processor

Primary Diagnostics:

- **Vertically-integrated**
  Mass, moisture and energy budgets

Trenberth et al. (2003)

Recommend that future pressure archives should contain higher vertical resolution of the following 31 levels (in addition to any other levels above 10 mb):

p = 1025, **1000**, 975, 950, **925**, 900, 875, **850**, 825, 800, 775, 750, 725, **700**, 650, **600**, 550, **500**, 450, **400**, 350, **300**, **250**, **200**, **150**, **100**, **70, 50, 30**, 20 and **10** mb.

(Current in bold).

This increases the resolution to 25 mb below 700 mb, 50 mb through the main troposphere, and includes the 20 mb level in the stratosphere.

Should apply also to **radiosonde data** standard levels.

From: Executive Summary of
"The Second Report on the Adequacy of The Global Observing Systems for Climate in Support of the UNFCCC".

Reanalysis has been applied to atmospheric data covering the past five decades. Although the resulting products have proven very useful, considerable effort is needed to ensure that reanalysis products are suitable for climate monitoring applications.

Issues for trends and low frequency variability:

- Model bias
  - Analysis tends to revert to model climate in absence of data
- Real trends
  - SSTs and radiative gases;
  - But not total solar irradiance, aerosols, land use change
- Changes in observing systems
- Perturbations (like Pinatubo)

While some trends may be captured by the observing system and can be reflected in other quantities through the dynamics, in general the null hypothesis should be that **trends and low frequency variability are more likely to be spurious unless proven otherwise.**