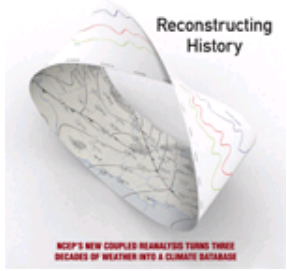
An assessment of the Tropospheric Variability in NCEP's Climate Forecast System Reanalysis (CFSR)

Muthuvel Chelliah
Climate Prediction Center, NCEP

Saha et al, 2010 (BAMS): The NCEP Climate Forecast System Reanalysis.



New features of the CFSR (1979 – current) include :

1) coupling of the atmosphere and ocean during the generation of the 6-h guess field,

2) an interactive sea ice model,

3) assimilation of satellite radiances by the Gridpoint Statistical Interpolation (GSI) scheme over the entire period.

4) The global land surface model has four soil levels and the global sea ice model has three layers.

5) The CFSR atmospheric model has observed variations in carbon dioxide (CO_2), together with changes in aerosols and other trace gases and solar variations.

The CFSR global atmosphere resolution is ~38 km (T382) with 64 levels extending from the surface to 0.26 hPa.

- **EMC ran the Reanalysis simultaneously in 5 streams with 1-year overlap.**
- **During production phase, EMC ran CPC's automatic monitoring (for ocean, troposphere, surface and stratosphere) scripts – evaluating 1 month's worth of individual analyses at a time.**
- **Now CFSR is run in real-time CDAS mode that began in … 2011.**

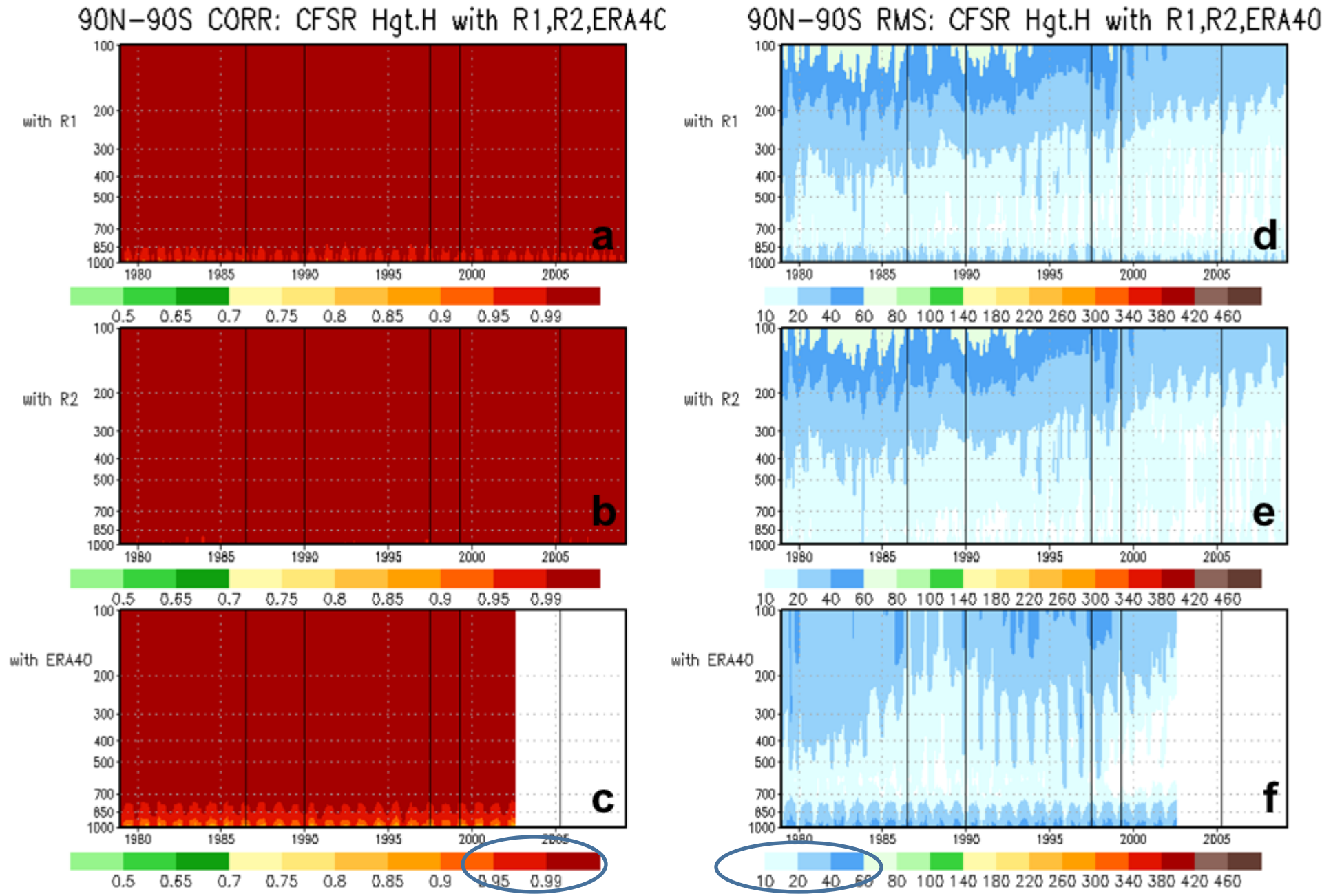
Wang, Xie, Yoo, Xue, Kumar, and Wu , 2011 (Clim. Dyn): An assessment of the surface climate in the NCEP climate forecast system reanalysis.

Xue, Huang, Hu, Kumar, Wen, Behringer and Nadiga, 2010 (Clim. Dyn): An assessment of oceanic variability in the NCEP climate forecast system reanalysis.

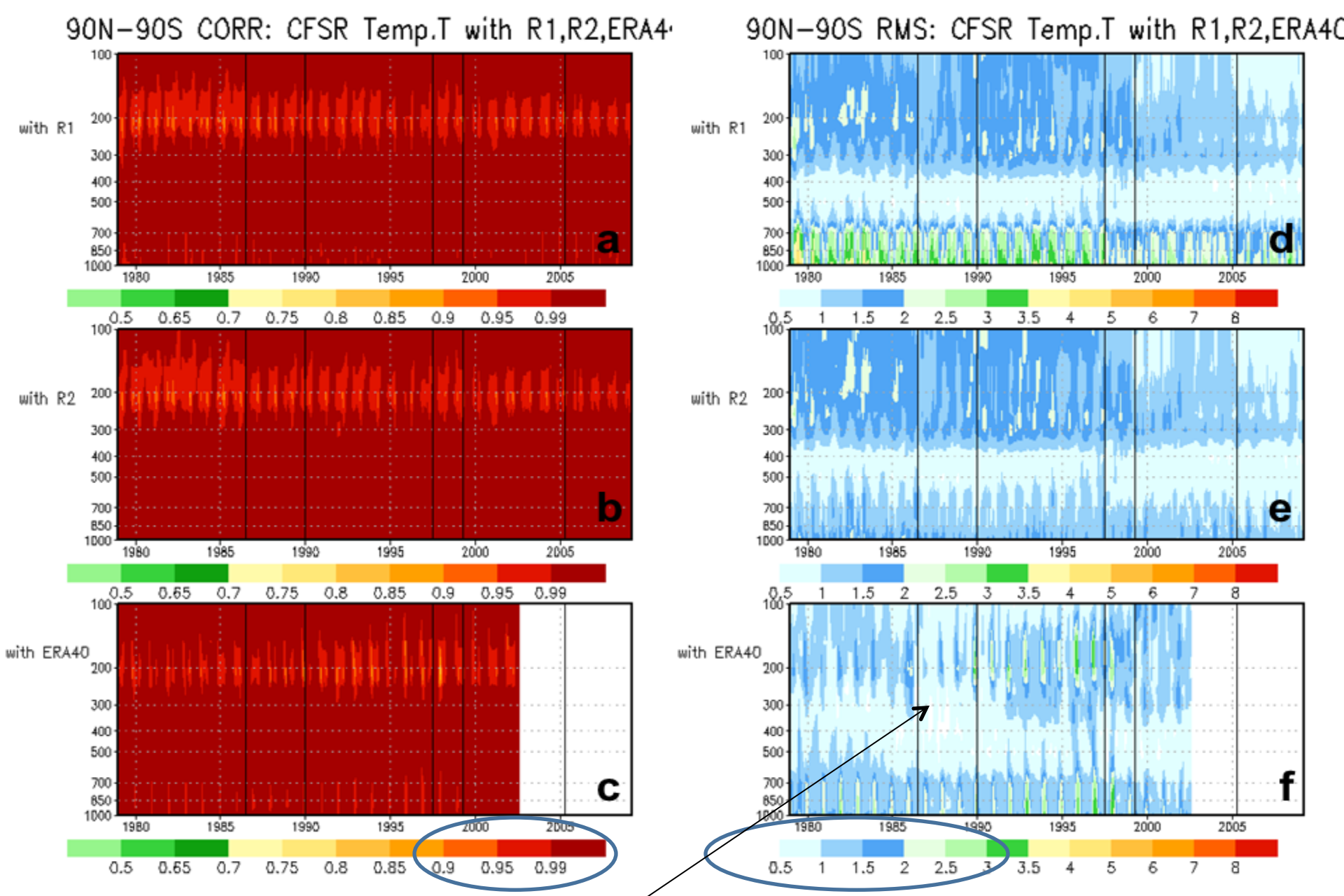
Ebisuzaki, and Zhang , 2011 (Clim. Dyn): Assessing the Performance of the CFSR by an Ensemble of Analyses.

Chelliah, Ebisuzaki, Weaver, and Kumar, 2011 (JGR): Evaluating the tropospheric variability in NCEP's Climate Forecast System Reanalysis .

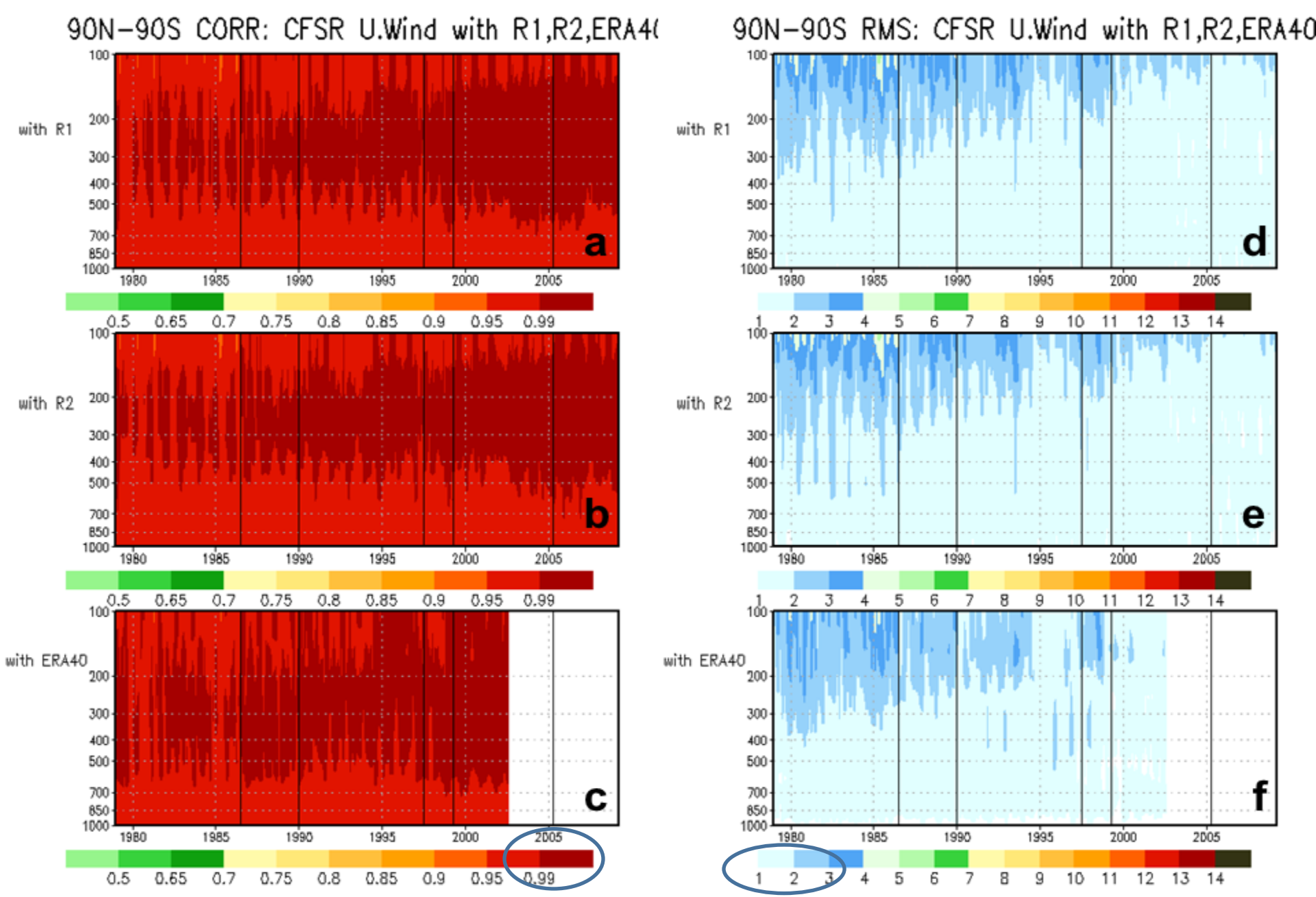
- **This talk is based mostly on this last study.**
- **Relatively simple analyses, means, rms, time series, trade wind/wind shear indices, trends, etc.**



With time, in general, the CORR increase and RMS diffs. decrease. Relatively low CORR at low levels.



With time, in general, the correlations increase and rms differences decrease. Impact of running CFSR is many streams is seen slightly obvious.



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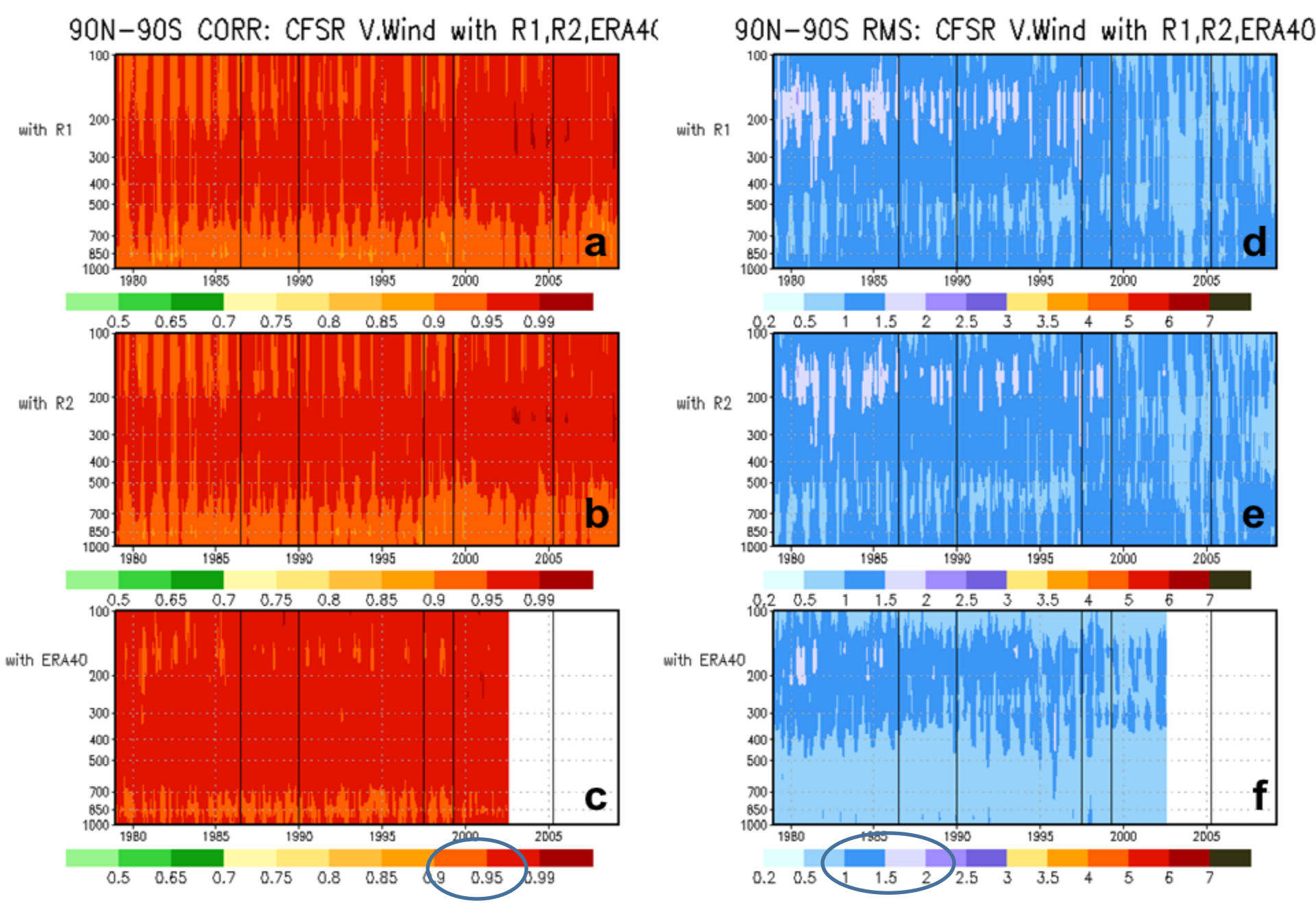
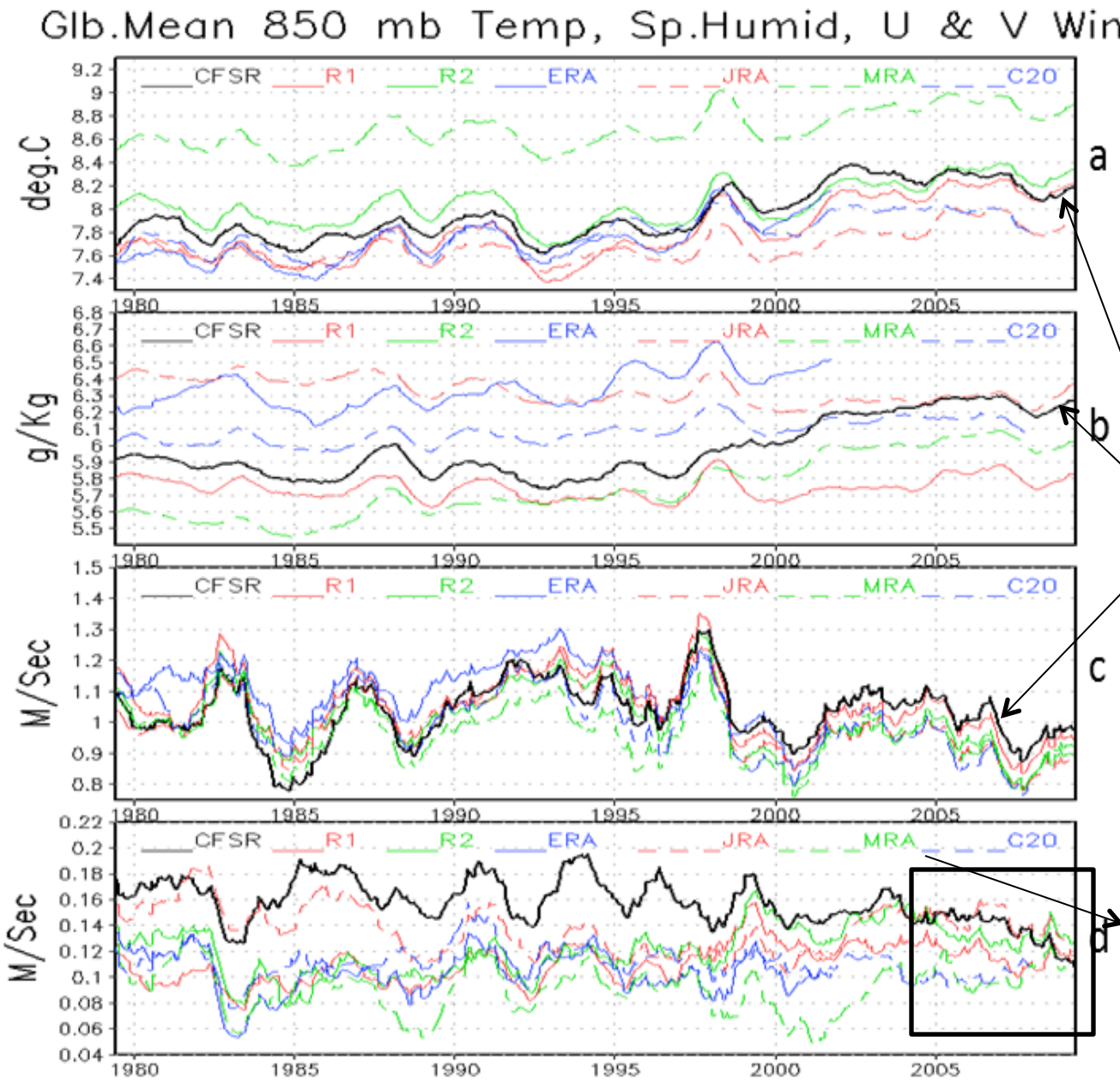
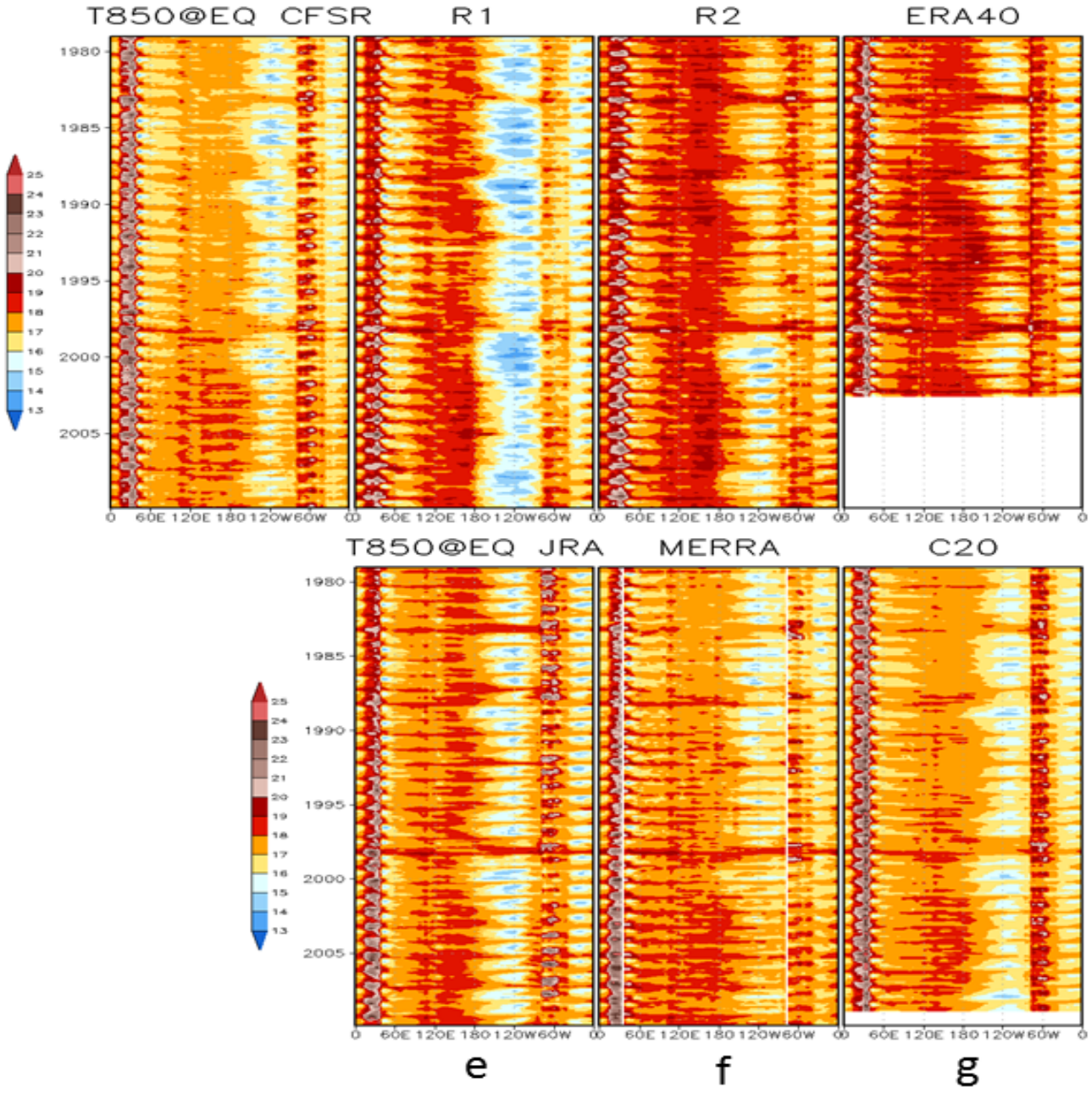


With time, in general, the correlations increase and rms differences decrease. Relatively low corr overall.



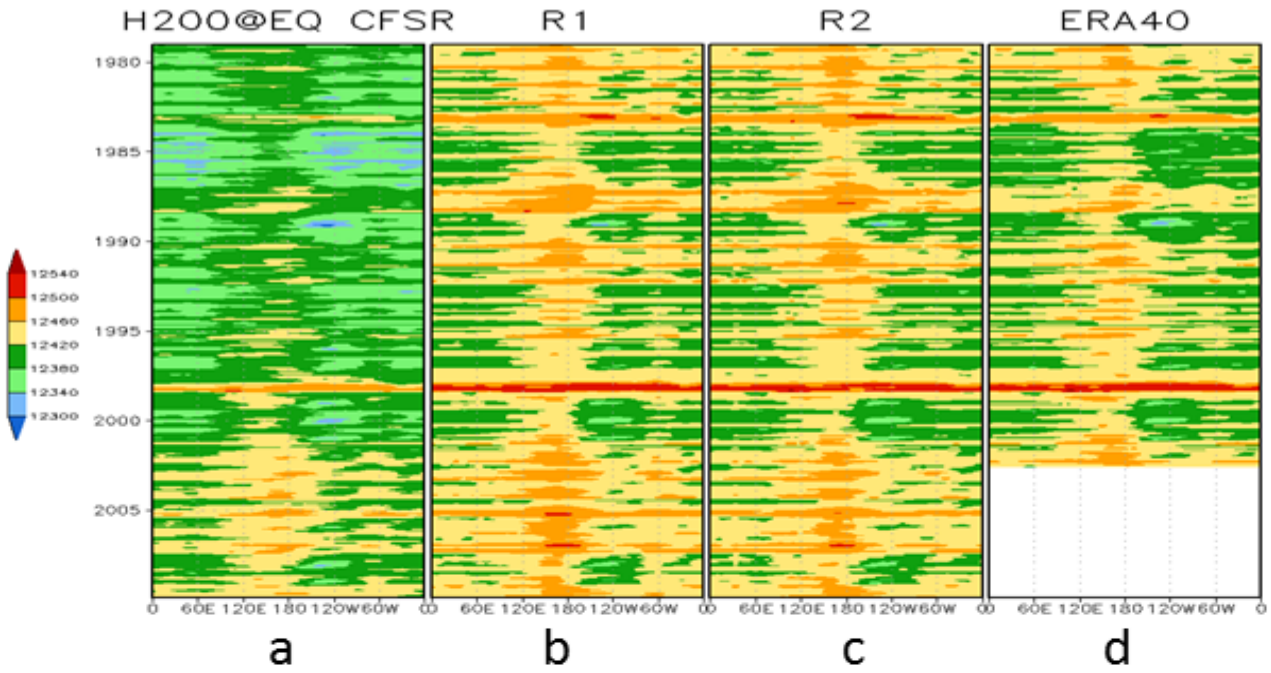
CFSR has the most trend of all reanalyses (old and relatively new) in the global mean 850 mb temp. T, specific humidity q, zonal wind U and meridional wind V.

? This trending is strange or is it that the long term global mean meridional wind V trending to zero correct? There is also less variability in all reanalyses.

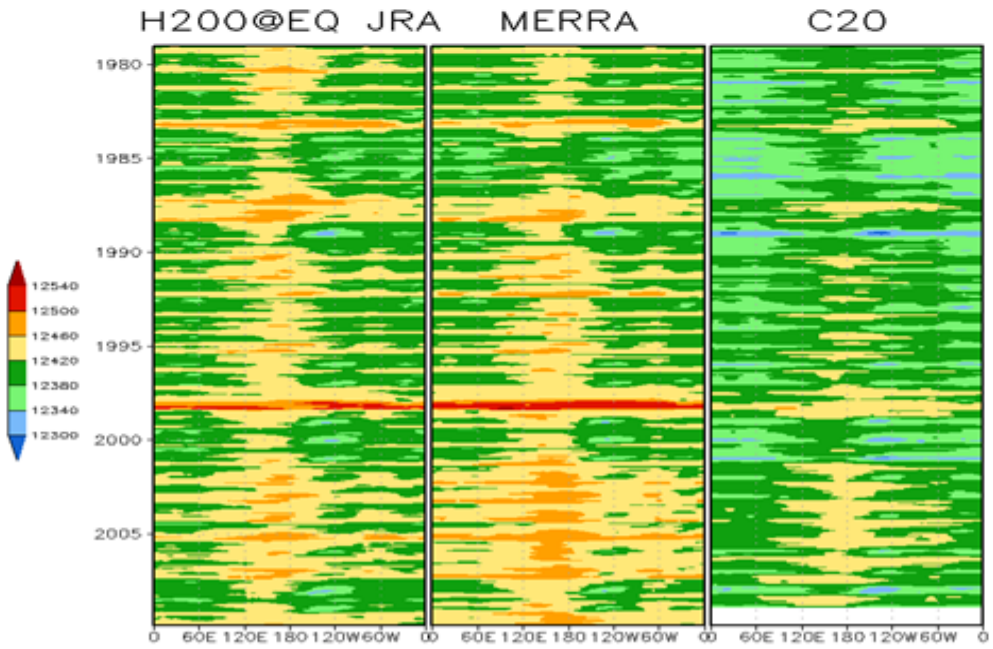


Hovmöller cross section of temperature along equator at 850 mb in °C.

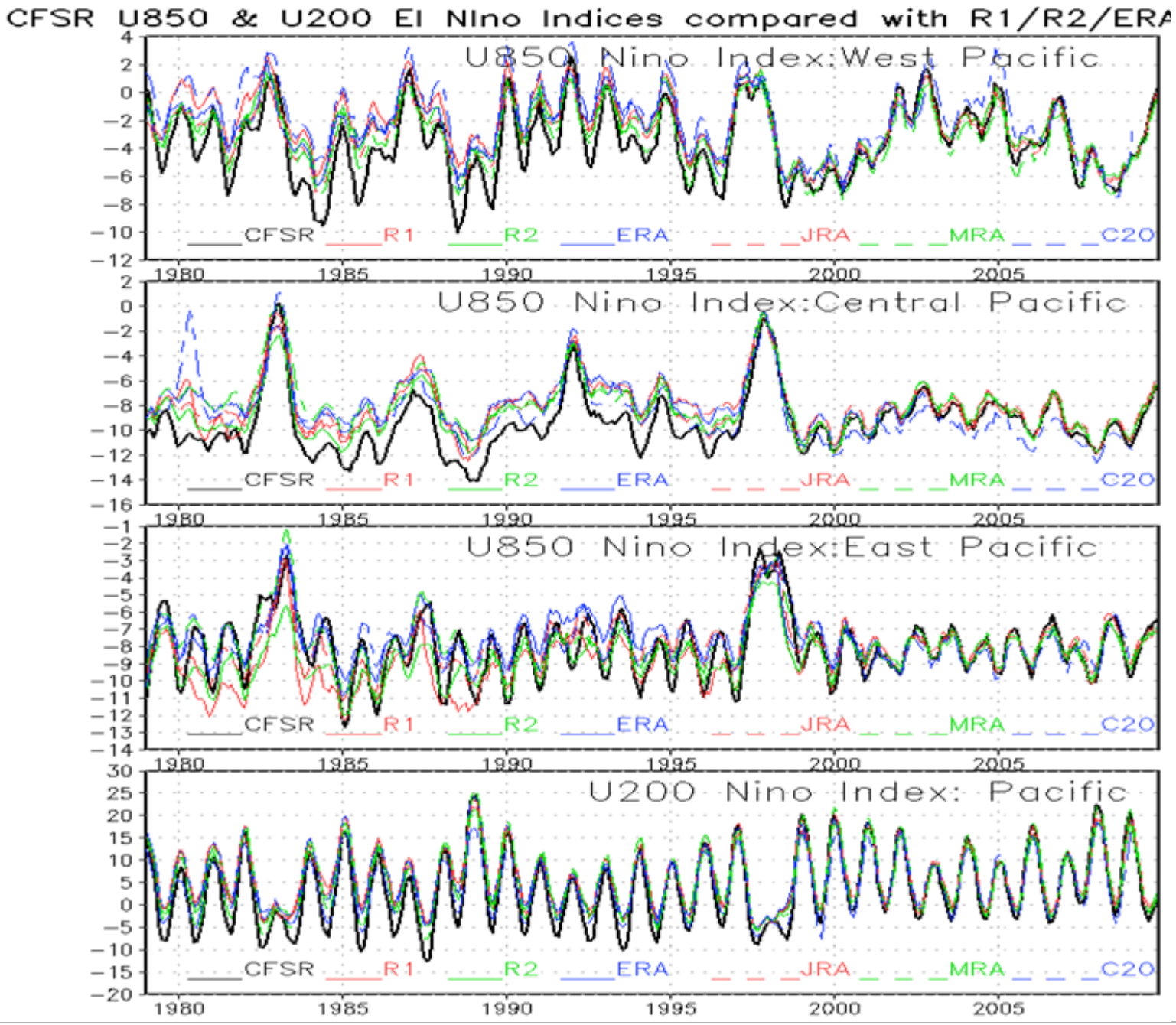
In the tropics, before the introduction of ATOVS data in 1998, CFSR's T is cooler than most other reanalyses.



Hovmöller cross section along equator of geopotential height H at 200 mb in M.

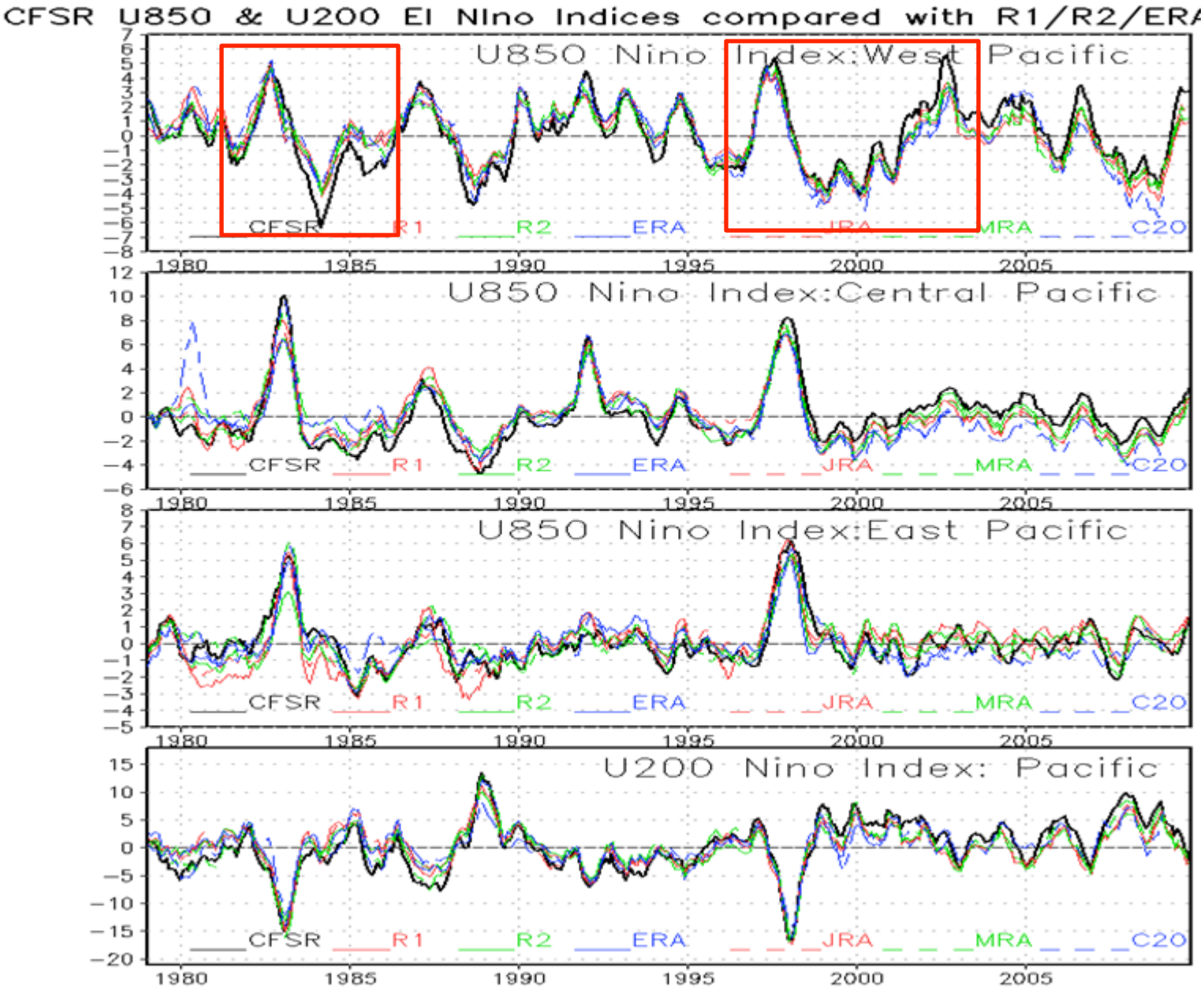


CFSR's upper level heights are also lower than most other reanalyses.



With increasing observed data types of all kinds, the analyses tend to converge with time and are more in agreement.

In the tropical equatorial Pacific, in the various Nino regions, CFSR trade winds are more easterly, particularly in the western and central Eq. Pacific before the use of ATOVS data in 1998.



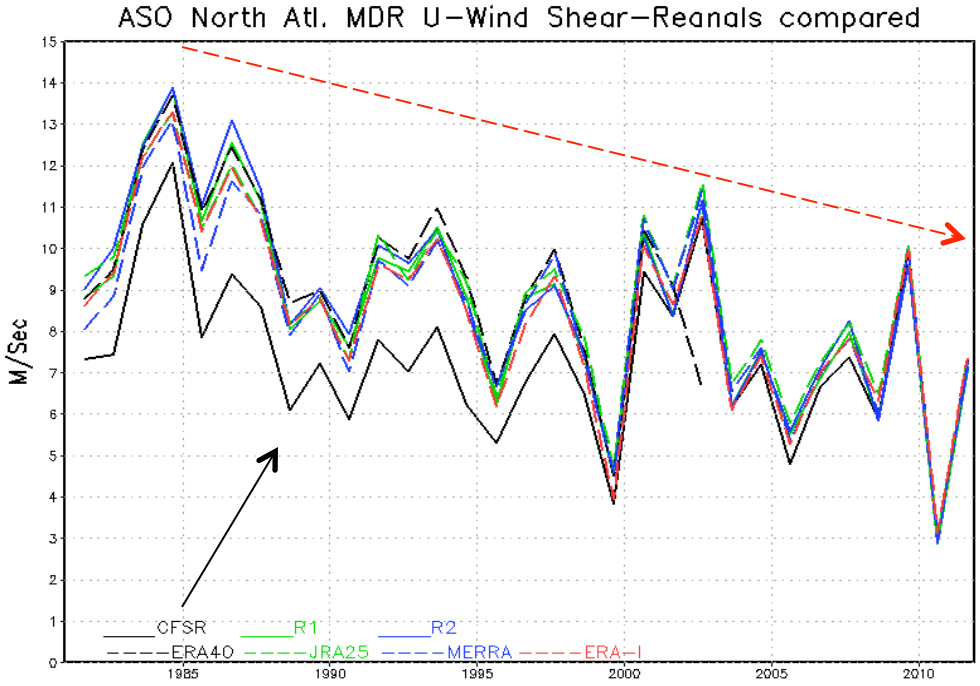
Based on ANOMALIES.

Comparison of relative strengths of El/Ninos & La Ninas based on CFSR anomalies from long term means, foe eg. In the eq. W.Pacific need to be analyzed carefully.

Compare:

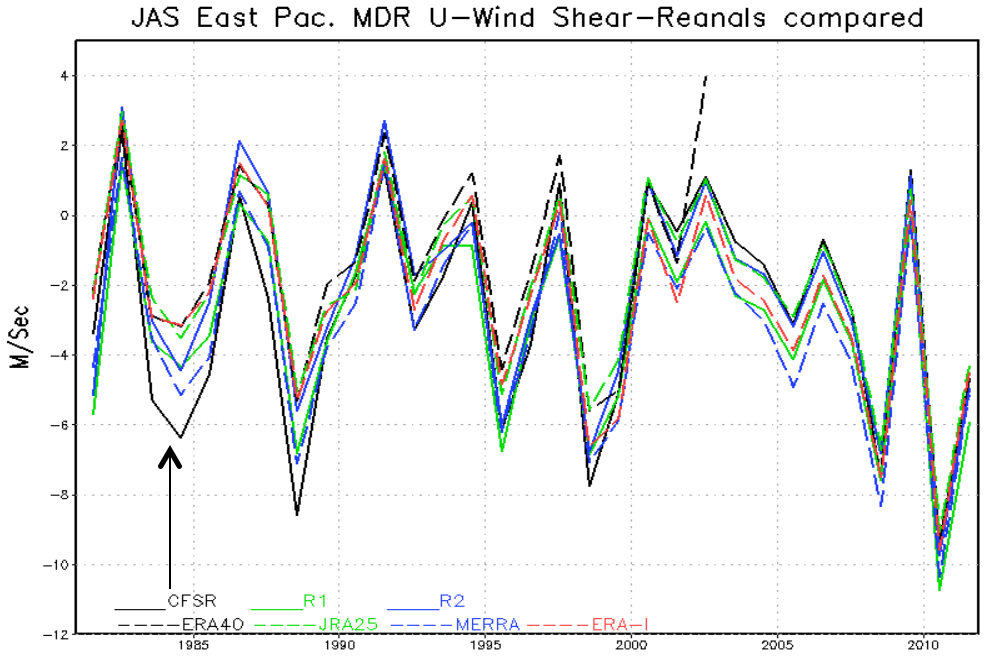
1) 1982/83 El nIno VS 1984 Lanina(?)

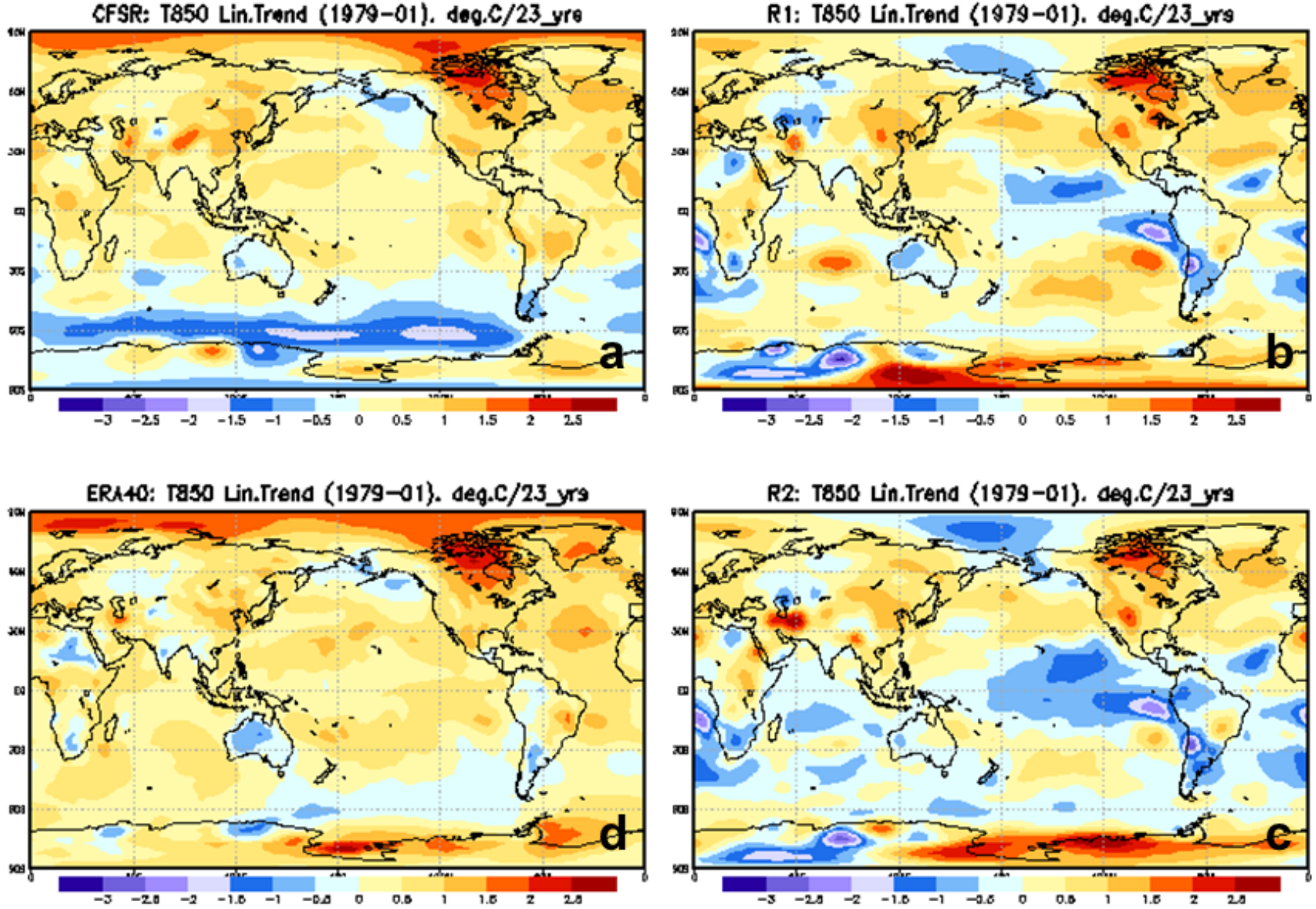
2) 1997 El Nino VS 2002 El Nino.



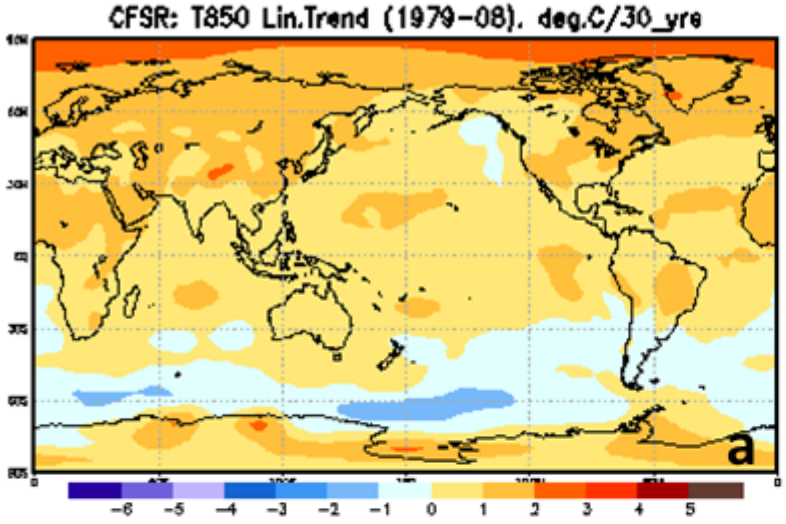
Aug-Sep-Oct mean vertical 'zonal wind(U)' shear over the Main Development Region for the North Atlantic Hurricane activity

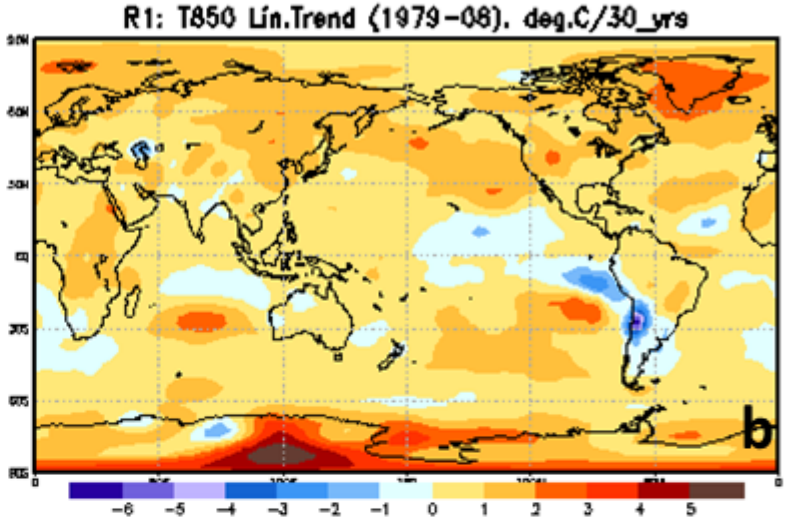
and for the Jul-Aug-Sep season in the tropical East Pacific Ocean.



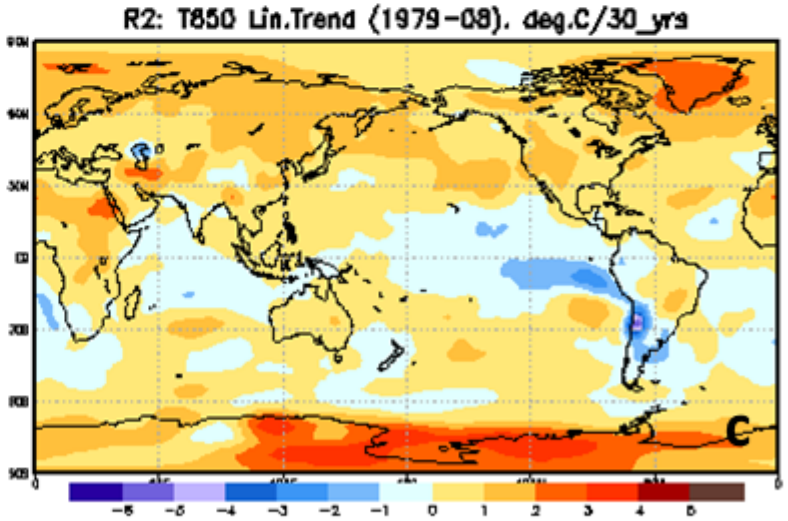


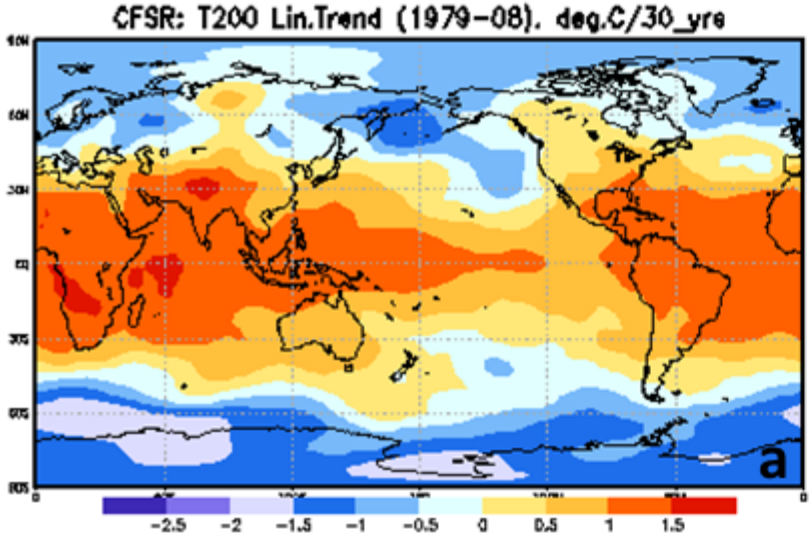
Simple linear trend in **°C/23 years (1979–2001**) of the annual mean temperature at 850 mb. Notable differences in CFSR in tropics and near the polar latitudes.

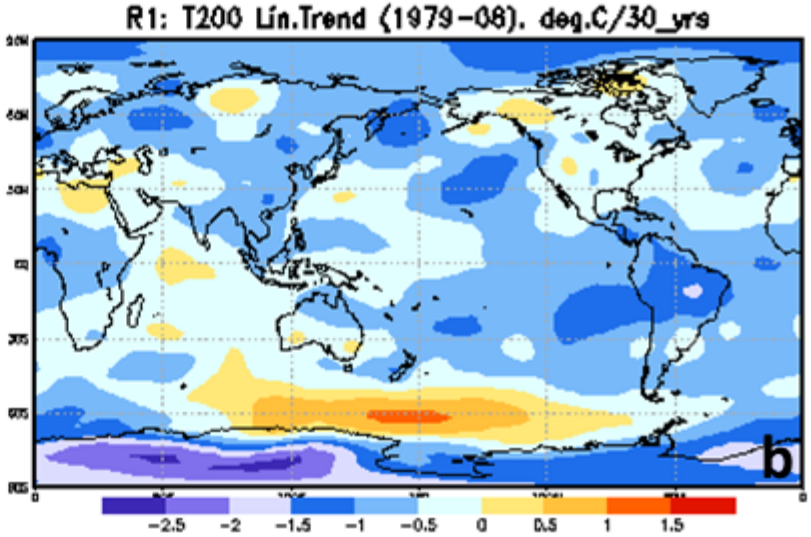




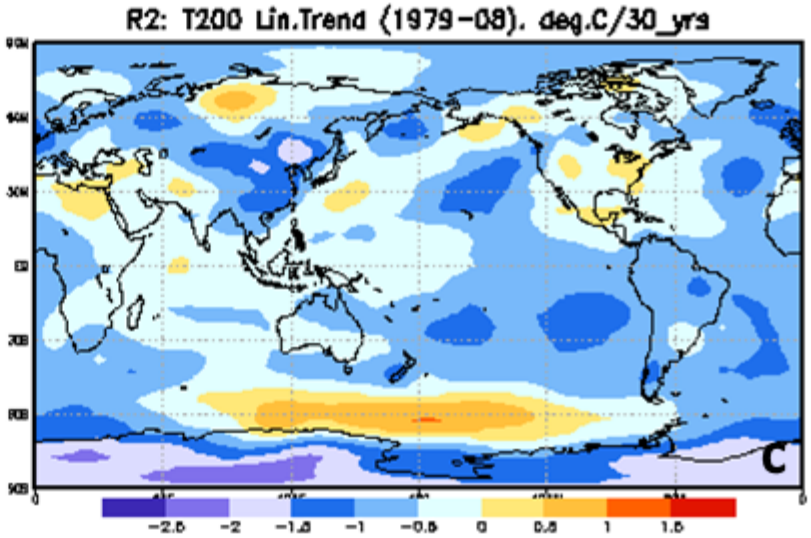
Linear trend in **°C/30 years (1979–2008)** of the **annual mean temperature at 850 mb**. Differences in the trend relatively less (as compared to the shorter period).







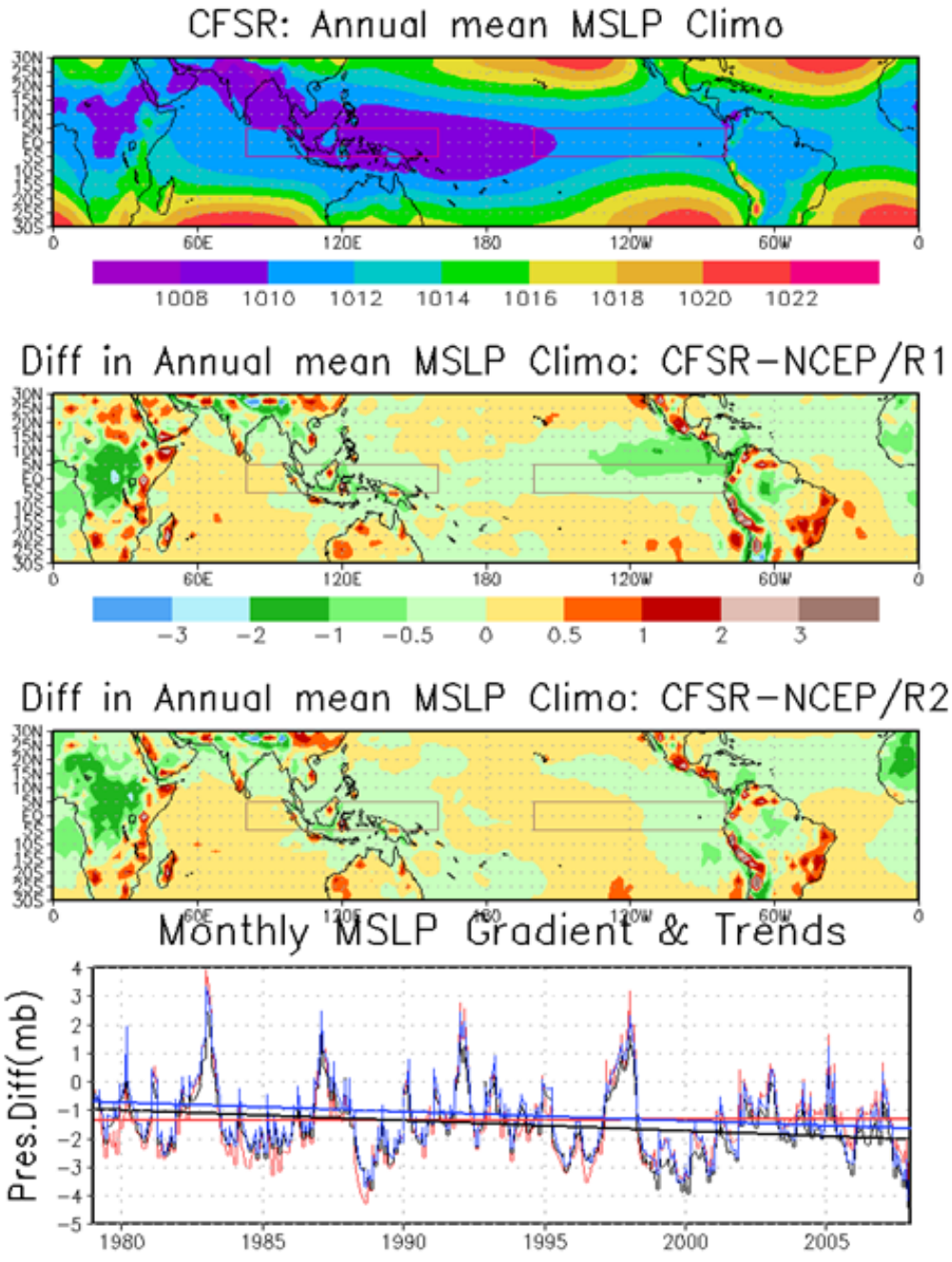
Linear trend in **°C/30 years (1979–2008)** of the **annual mean temperature at 200 mb. -** Large differences**.**

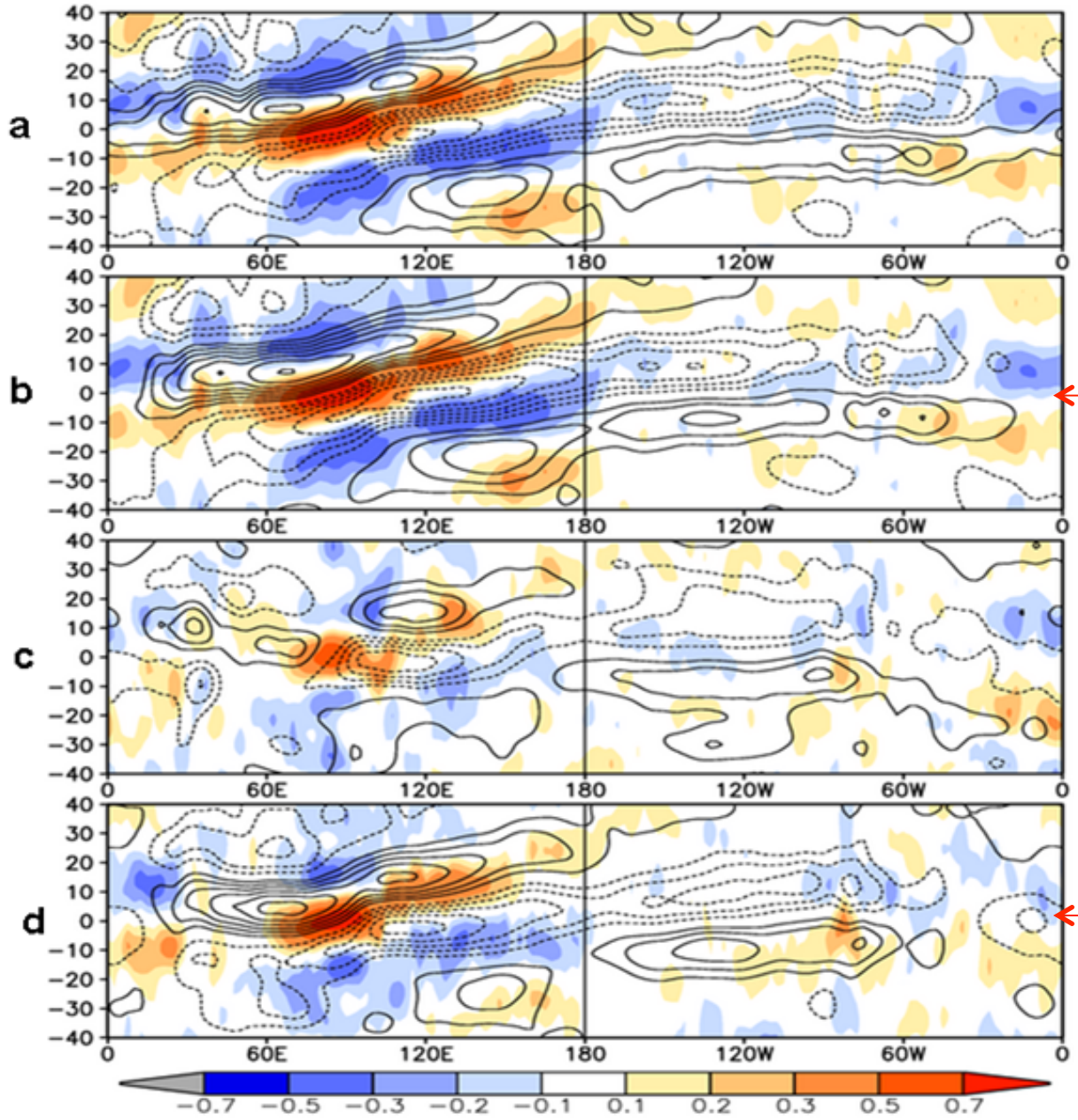


Walker Circulation:

(a) Annual mean climatology of mean sea level pressure (MSLP) in mb from CFSR.
(b) Difference in MSLP climatology for CFSR – NCEP/R1.
(c) Difference in MSLP climatology for CFSR – NCEP/R2.
(d) Time series for CFSR (red), NCEP/R1 (black), and NCEP/R2 (blue) of MSLP differences averaged over the two tropical equatorial boxes shown. (Indian Ocean box minus the east Pacific box.)

The linear trend lines are also shown.





Lag correlations of 20–100 day filtered 10°S–10°N averaged <u>precipitation (shaded) and 850 hPa zonal winds</u> (contoured) with respect to the Indian Ocean precipitation index.

(a) R2 850 hPa zonal winds and GPCP precipitation.
(b) CFSR 850 hPa zonal winds and GPCP precipitation.
(c) (c) R2 850 hPa zonal winds and R2 precipitation.
(d) CFSR 850 hPa zonal winds and CFSR precipitation.

Warm (cold) colors indicate positive (negative) correlations for precipitation, while solid (dashed) lines indicate positive (negative) correlations for 850 hPa zonal winds and are contoured at 0.1 intervals

(d) <u>CFSR 850 hPa zonal winds and CFSR precipitation</u> **is as good as**
b) <u>CFSR 850 hPa zonal winds and GPCP precipitation</u>.

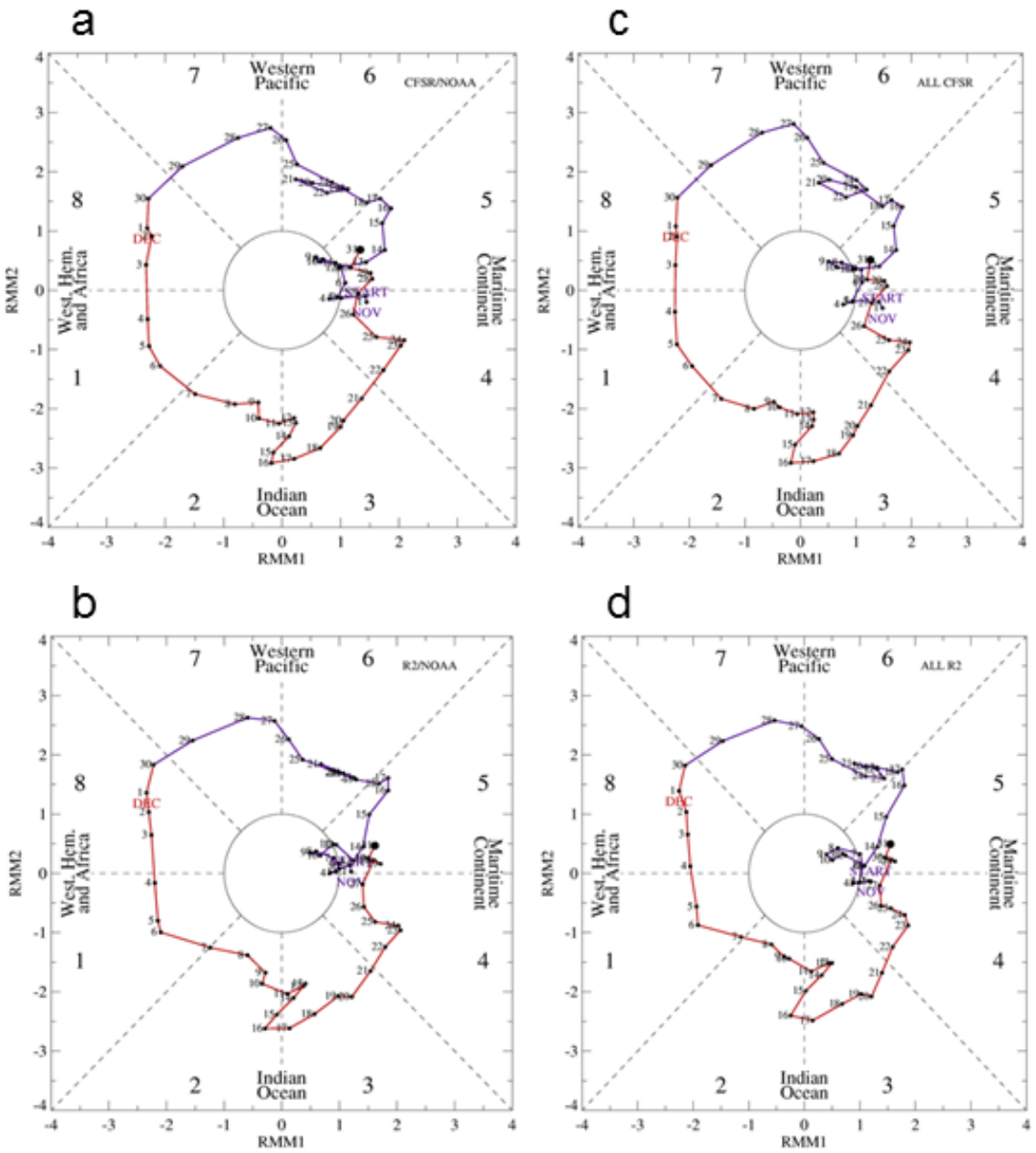
WH index for the MJO event of November–December 2007.

(a) CFSR winds and NOAA OLR,

(b) R2 winds and NOAA OLR,

(c) CFSR winds and CFSR OLR,

(d) R2 winds and R2 OLR.



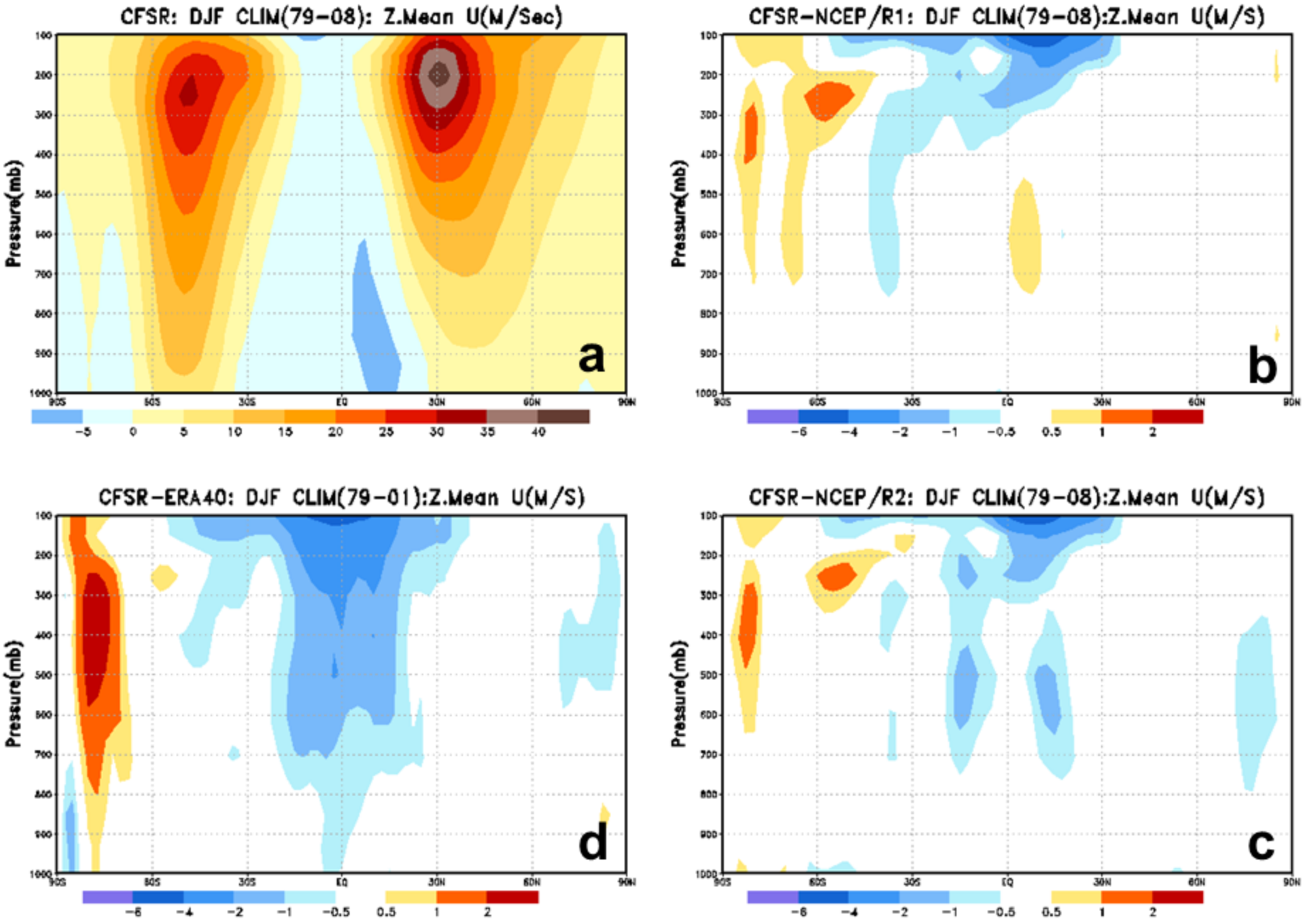
Summary:

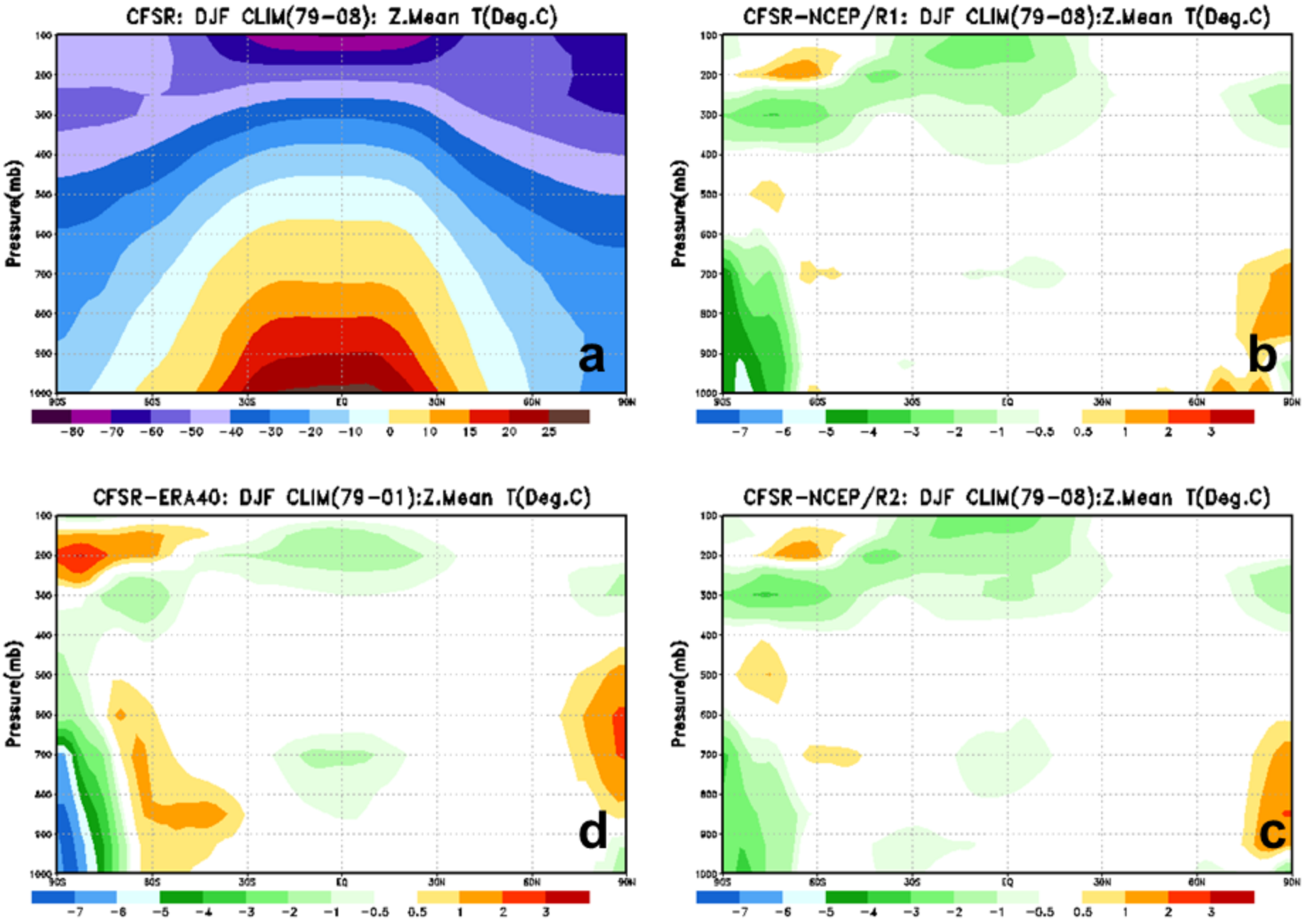
- **CFSR analyses agree and correlate well with the other reanalyses for any given analysis time or day or month.** Given this, and considering the fact that **the 5 day forecast skill scores with the CFSR as initial conditions have considerably improved as compared with such forecasts made with previous models and reanalyses** [Saha et al., 2006], and that the modern CFSR model and data assimilation systems at NCEP reflect the recent advances in the field, **the new CFSR is most likely an improved data set for synoptic studies, such as MJO and other calculations**. ---------- Other CFSR evaluation studies [Xue et al., 2011; Wang et al., 2011] report CFSR reanalyses are an improvement over previous NCEP and ERA40 reanalyses in quantities such as precipitation, surface temperature and oceanic variables.

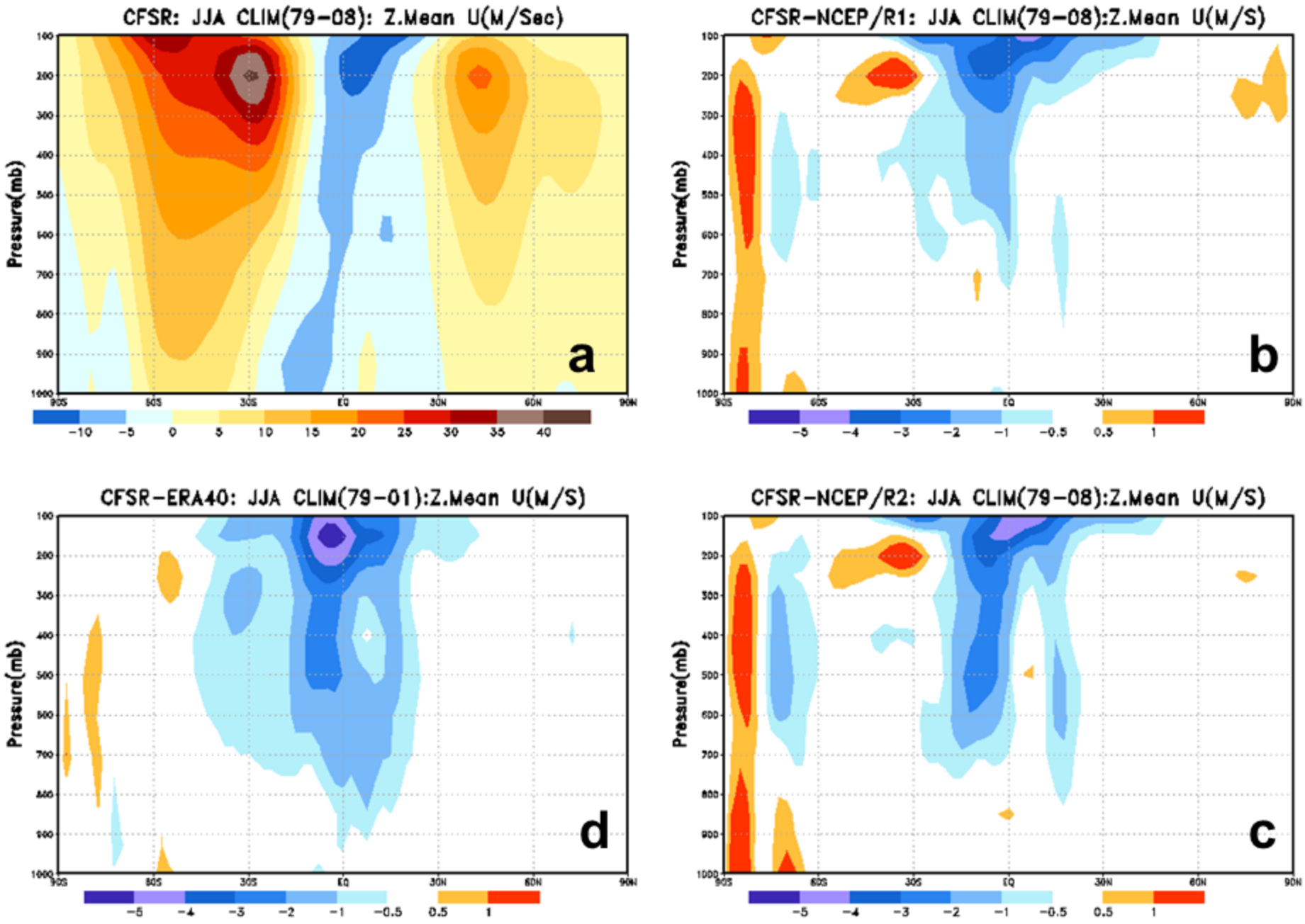
- When we compared the long-term temporal variability such as ENSO relevant regional mean indices and wind shear indices**, while the other reanalyses tended to group together, the CFSR often tends to stand apart, particularly in the period before the assimilation of ATOVS radiance data in 1998. Before this period, in the tropics, CFSR low level Pacific easterly trade winds were relatively much stronger, 850 mb temperatures were colder, and the 200 mb geopotential heights were lower as compared to the other reanalyses, which implies stronger tropospheric warming trend in CFSR.**

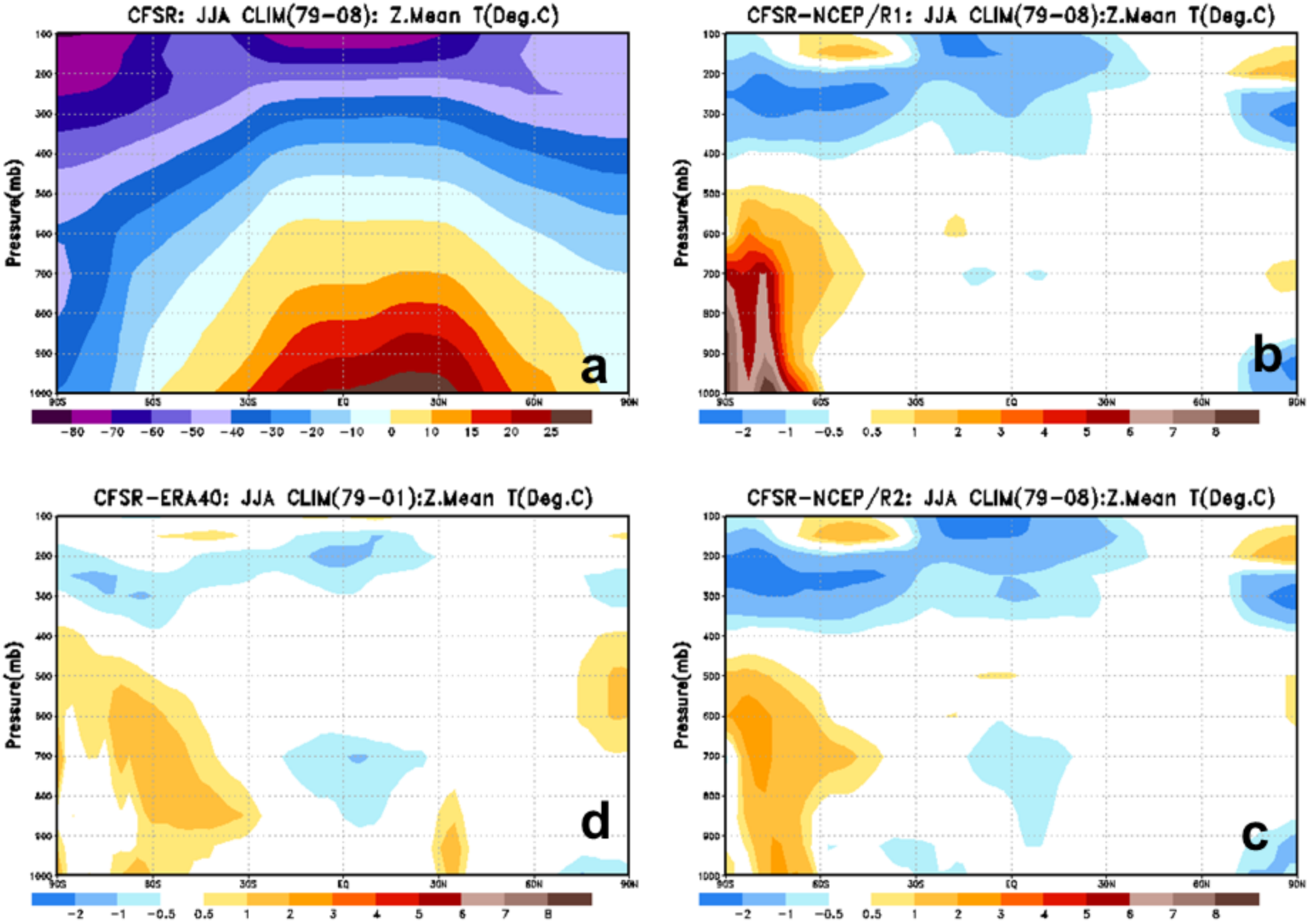
- Hence **the use of CFSR data in operational ENSO and climate monitoring using anomalies as departures from long-term climate means, needs to be undertaken with some caution**, until further accurate validation studies using the sparsely available radiosonde network particularly over the tropical oceans, are carried out, it is possible that the other reanalyses have greater errors. For tropical climate studies, the CFSR may actually represent an improved reanalysis, since it is the first reanalysis now that is based on a coupled (partly) atmosphere-ocean–sea ice model and assimilation system.

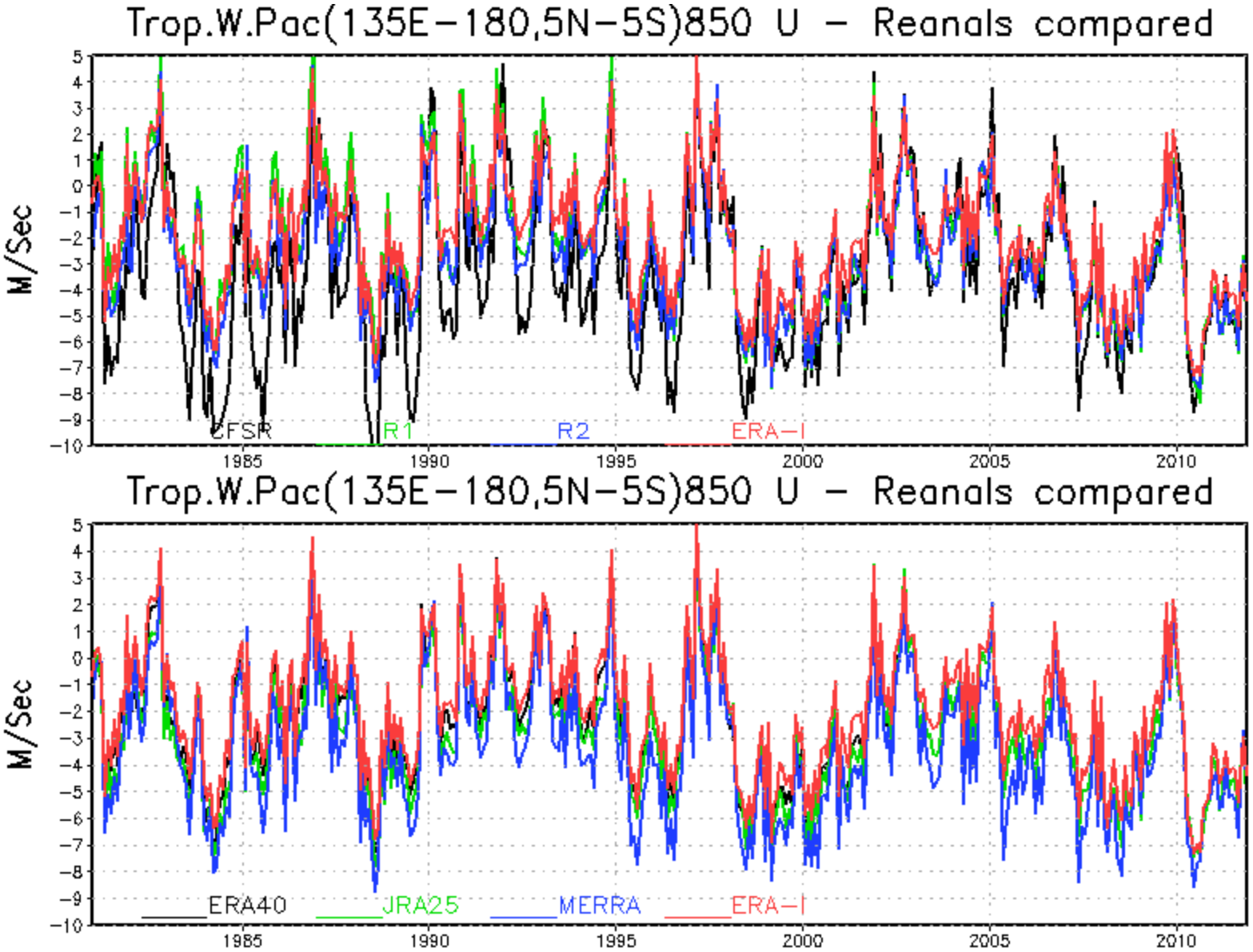
Thanks for listening..

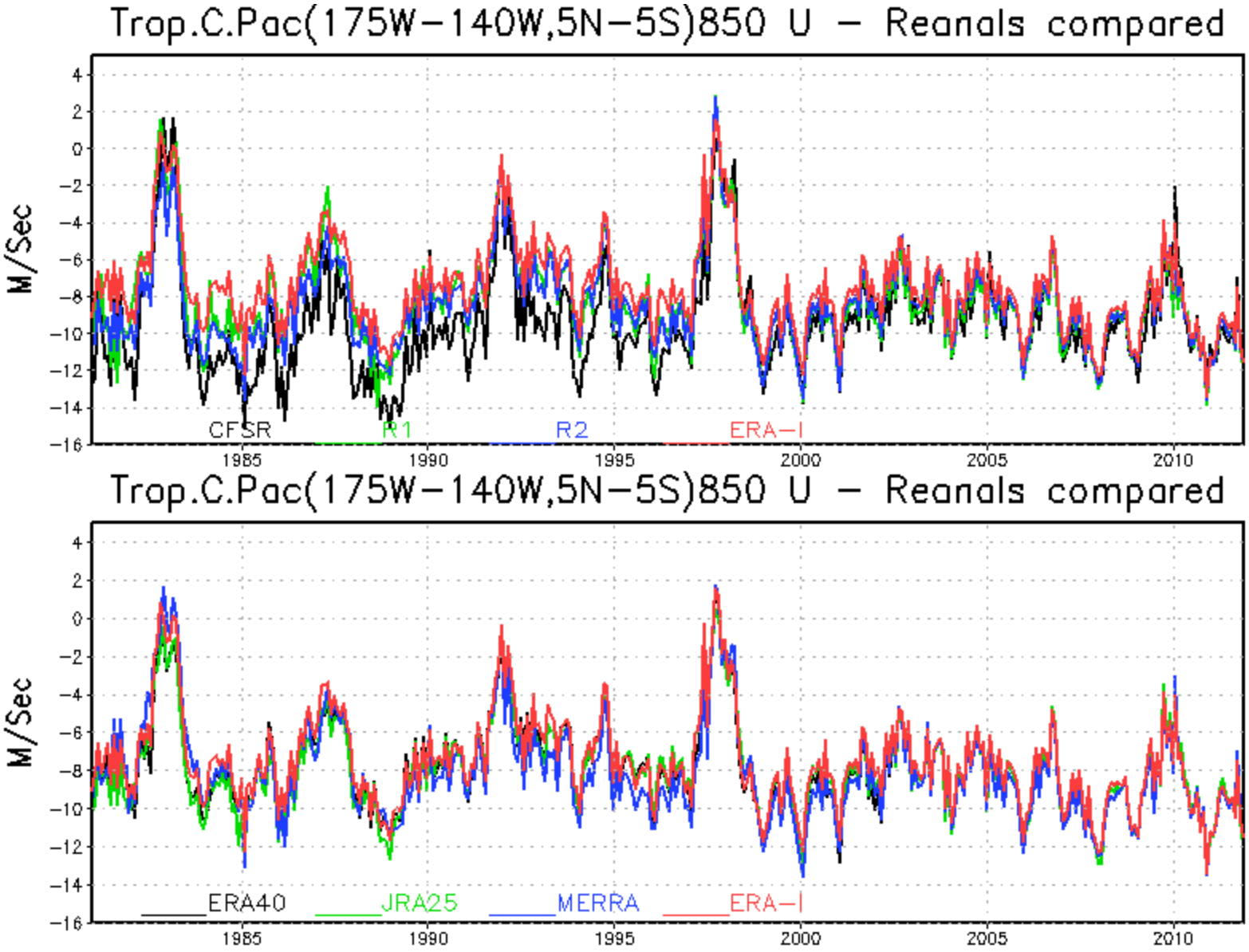

CFSR: DJF CLIM(79-08): Z.Mean U(M/Sec)
Pressure(mb)
100
200
300
400
500
600
700
800
900
1000
90S
60S
30S
EQ
30N
60N
90N
-5
0
5
10
15
20
25
30
35
40
a
CFSR-NCEP/R1: DJF CLIM(79-08):Z.Mean U(M/S)
-6
-4
-2
-1
-0.5
0.5
1
2
b
CFSR-ERA40: DJF CLIM(79-01):Z.Mean U(M/S)
d
CFSR-NCEP/R2: DJF CLIM(79-08):Z.Mean U(M/S)
c

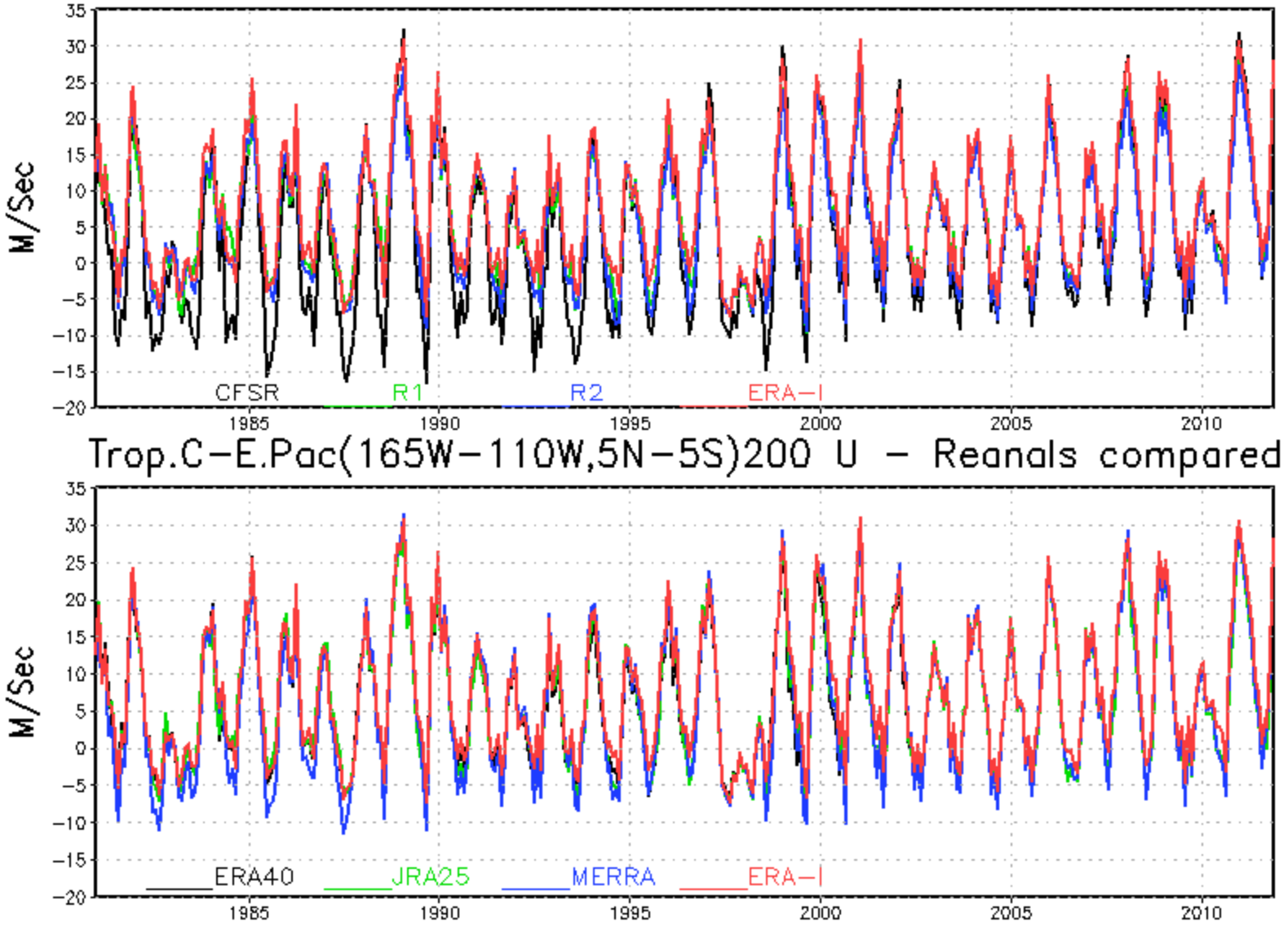

CFSR: DJF CLIM(79-08): Z.Mean T(Deg.C)
CFSR-NCEP/R1: DJF CLIM(79-08):Z.Mean T(Deg.C)
CFSR-ERA40: DJF CLIM(79-01):Z.Mean T(Deg.C)
CFSR-NCEP/R2: DJF CLIM(79-08):Z.Mean T(Deg.C)
Pressure(mb)
100
200
300
400
500
600
700
800
900
1000
90S
60S
30S
EQ
30N
60N
90N
a
b
c
d
-80 -70 -60 -50 -40 -30 -20 -10 0 10 15 20 25
-7 -6 -5 -4 -3 -2 -1 -0.5 0.5 1 2 3

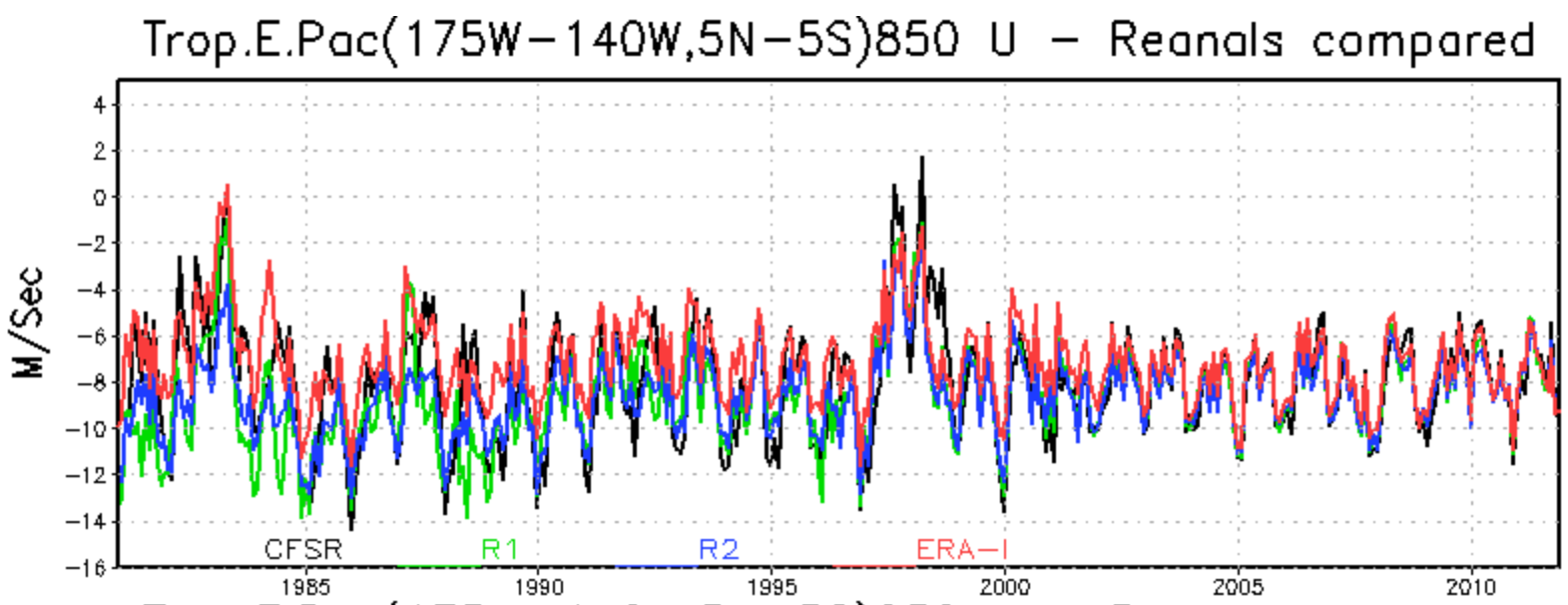

CFSR: JJA CLIM(79-08): Z.Mean U(M/Sec)
Pressure(mb)
100
200
300
400
500
600
700
800
900
1000
90S
60S
30S
EQ
30N
60N
90N
-10
-5
0
5
10
15
20
25
30
35
40
a
CFSR-NCEP/R1: JJA CLIM(79-08):Z.Mean U(M/S)
-5
-4
-3
-2
-1
-0.5
0.5
1
b
CFSR-ERA40: JJA CLIM(79-01):Z.Mean U(M/S)
d
CFSR-NCEP/R2: JJA CLIM(79-08):Z.Mean U(M/S)
c

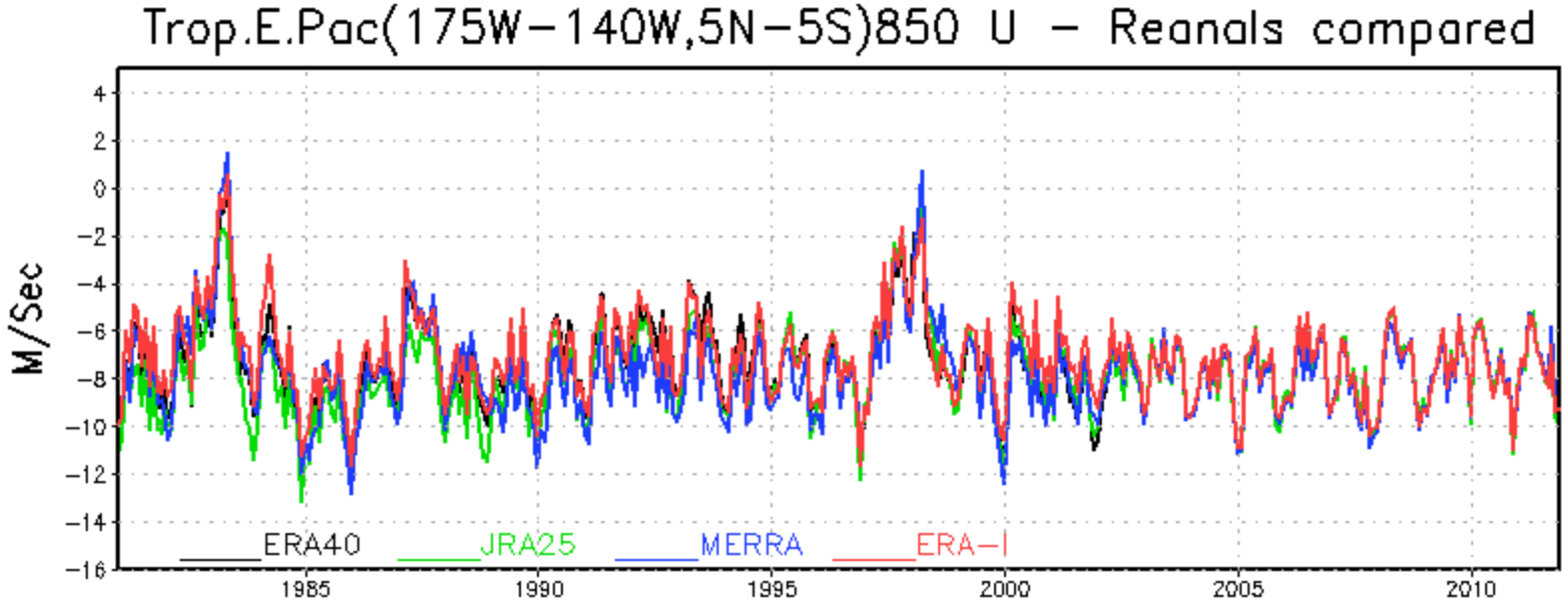

CFSR: JJA CLIM(79-08): Z.Mean T(Deg.C)
CFSR-NCEP/R1: JJA CLIM(79-08):Z.Mean T(Deg.C)
CFSR-ERA40: JJA CLIM(79-01):Z.Mean T(Deg.C)
CFSR-NCEP/R2: JJA CLIM(79-08):Z.Mean T(Deg.C)
Pressure(mb)
100
200
300
400
500
600
700
800
900
1000
90S
60S
30S
EQ
30N
60N
90N
-80 -70 -60 -50 -40 -30 -20 -10 0 10 15 20 25
-2 -1 -0.5 0.5 1 2 3 4 5 6 7 8
a
b
c
d

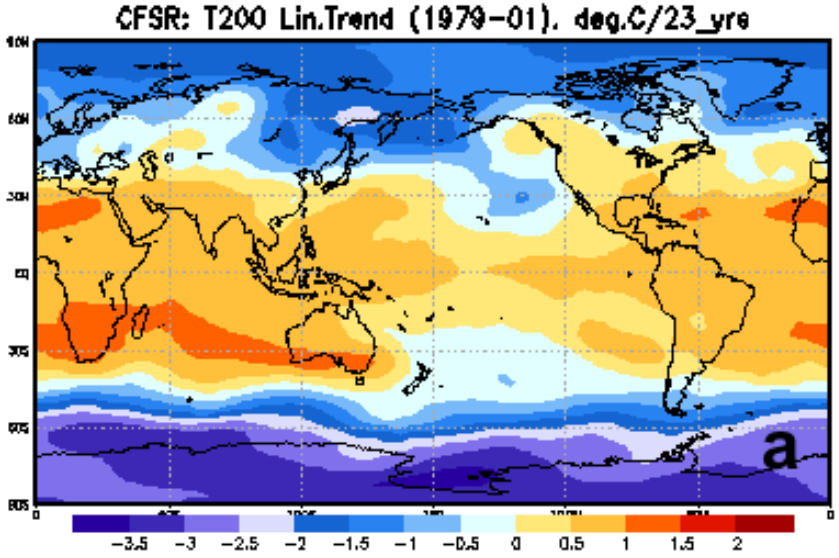

Trop.W.Pac(135E-180,5N-5S)850 U - Reanals compared
M/Sec
CFSR
R1
R2
ERA-I
Trop.W.Pac(135E-180,5N-5S)850 U - Reanals compared
M/Sec
ERA40
JRA25
MERRA
ERA-I

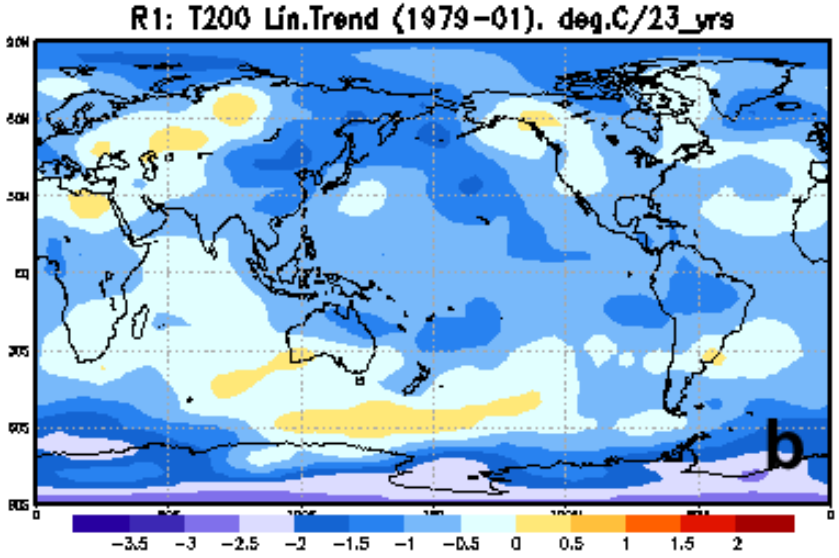

Trop.C.Pac(175W−140W,5N−5S)850 U − Reanals compared
M/Sec
4
2
0
−2
−4
−6
−8
−10
−12
−14
−16
1985
1990
1995
2000
2005
2010
CFSR
R1
R2
ERA−I
Trop.C.Pac(175W−140W,5N−5S)850 U − Reanals compared
M/Sec
ERA40
JRA25
MERRA
ERA−I

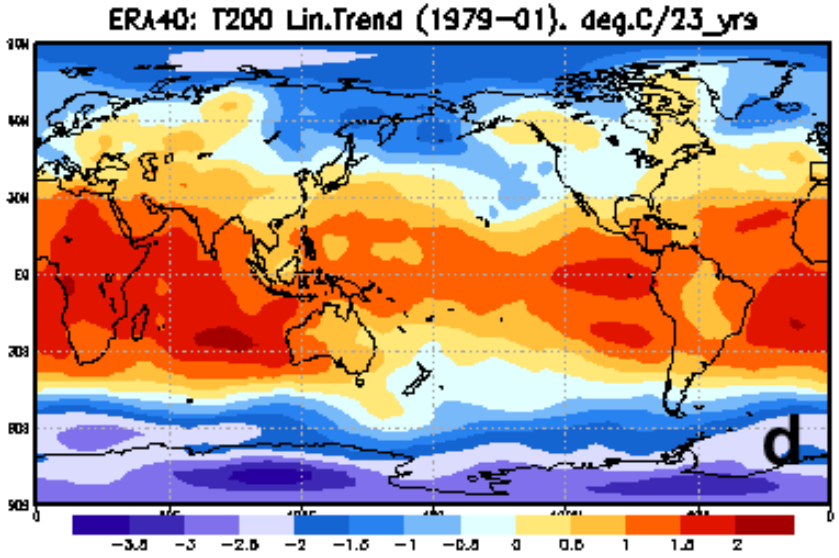

M/Sec
35
30
25
20
15
10
5
0
−5
−10
−15
−20
1985
1990
1995
2000
2005
2010
CFSR
R1
R2
ERA−I
Trop.C−E.Pac(165W−110W,5N−5S)200 U − Reanals compared
M/Sec
ERA40
JRA25
MERRA
ERA−I

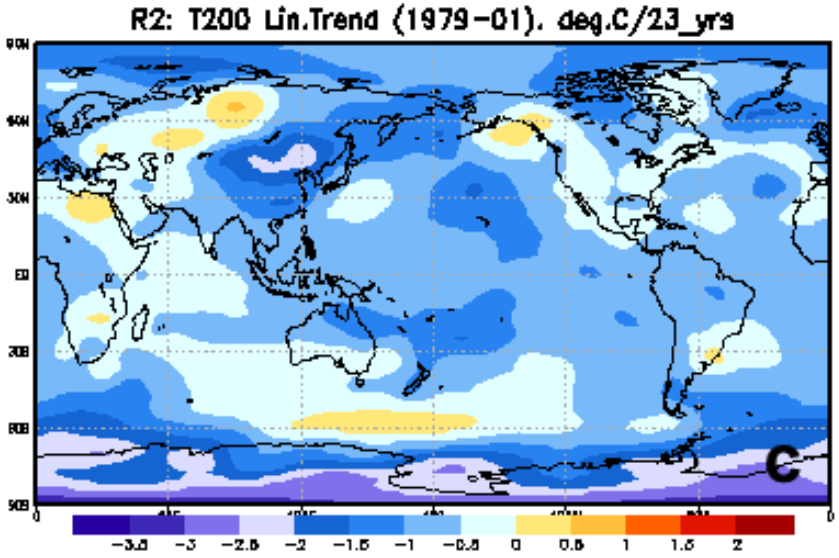

Trop.E.Pac(175W-140W,5N-5S)850 U - Reanals compared
M/Sec
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
1985
1990
1995
2000
2005
2010
CFSR
R1
R2
ERA-I


Trop.E.Pac(175W-140W,5N-5S)850 U - Reanals compared
M/Sec
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
1985
1990
1995
2000
2005
2010
ERA40
JRA25
MERRA
ERA-I


CFSR: T200 Lin.Trend (1979-01). deg.C/23_yrs
a
−3.5 −3 −2.5 −2 −1.5 −1 −0.5 0 0.5 1 1.5 2


R1: T200 Lin.Trend (1979-01). deg.C/23_yrs
b
−3.5 −3 −2.5 −2 −1.5 −1 −0.5 0 0.5 1 1.5 2


ERA40: T200 Lin.Trend (1979-01). deg.C/23_yrs
d


R2: T200 Lin.Trend (1979-01). deg.C/23_yrs
c