Some Problems in CFSRR Investigated and Solutions Tested for CFSRL

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Introduction

Following an intense effort to complete the CFSRR reanalysis for 1979-2010, which contained many new features, and had to be conducted in a very strict timeframe, problems became evident in the results. Several were serious enough that a lower resolution rerun of the CFSRR (named the CFSRL), was proposed to address and correct them, and to run through the period 1948 to the present as a replacement for the R1 product. The presentation describes our experience addressing four problems affecting the atmospheric part of the CFSRR, pre-1998, and how they are to resolved in the CFSRL system.

We looked at 4 issues:

- *SSU bias correction*
- *Asian radiosonde radiation corrections*
- *Tropical tropospheric cold bias*
- *QBO wind analysis*

We accomplished 3 objectives:

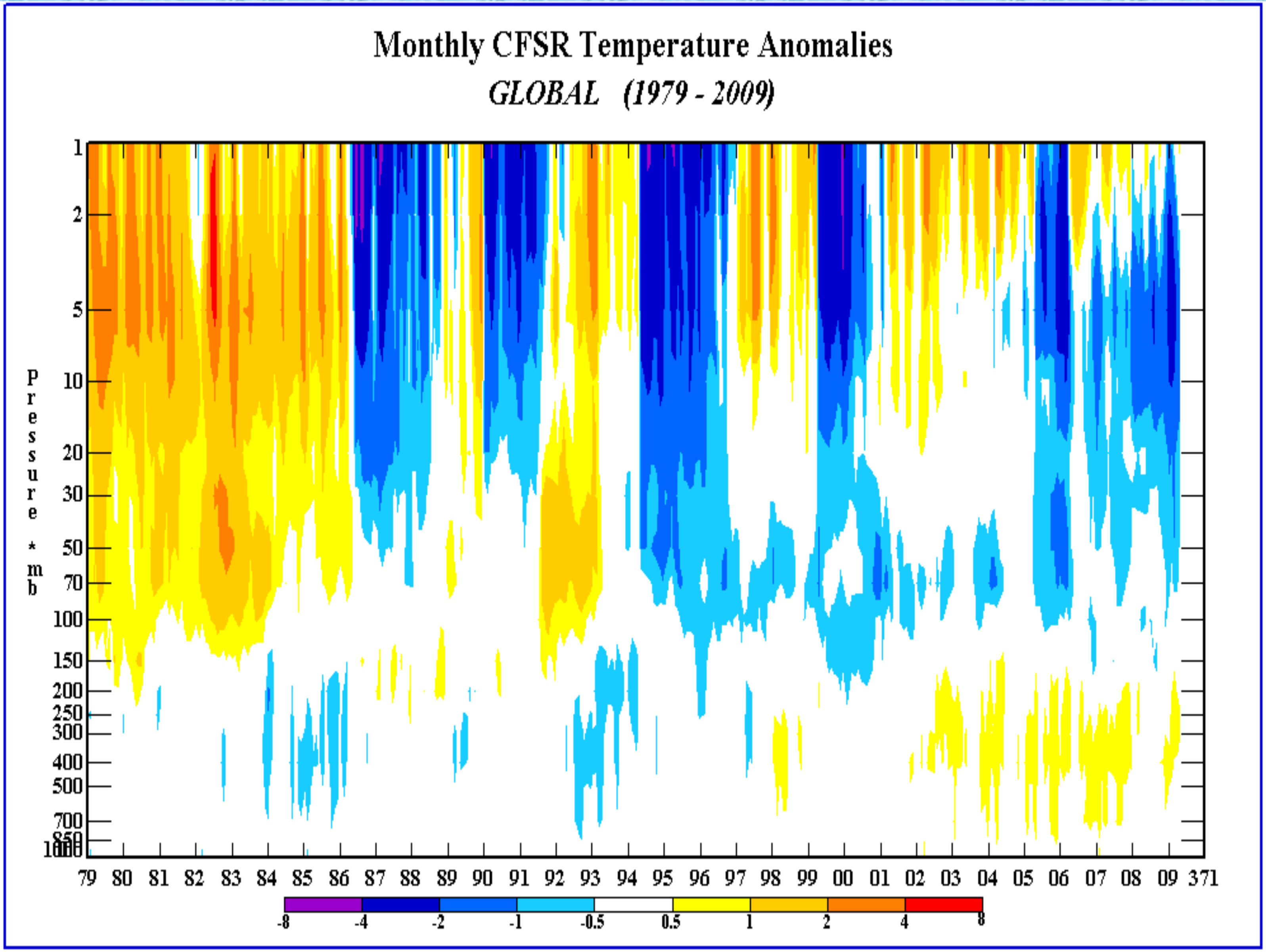
- *Devise and/or install a solution for each issue*

- *Run 8 years of "CFSRL" testing (1979-1986) for validation*

- *Run 2 additional 2-year experiments to further develop the QBO analysis (82-83, 98-99)*

Issue #1

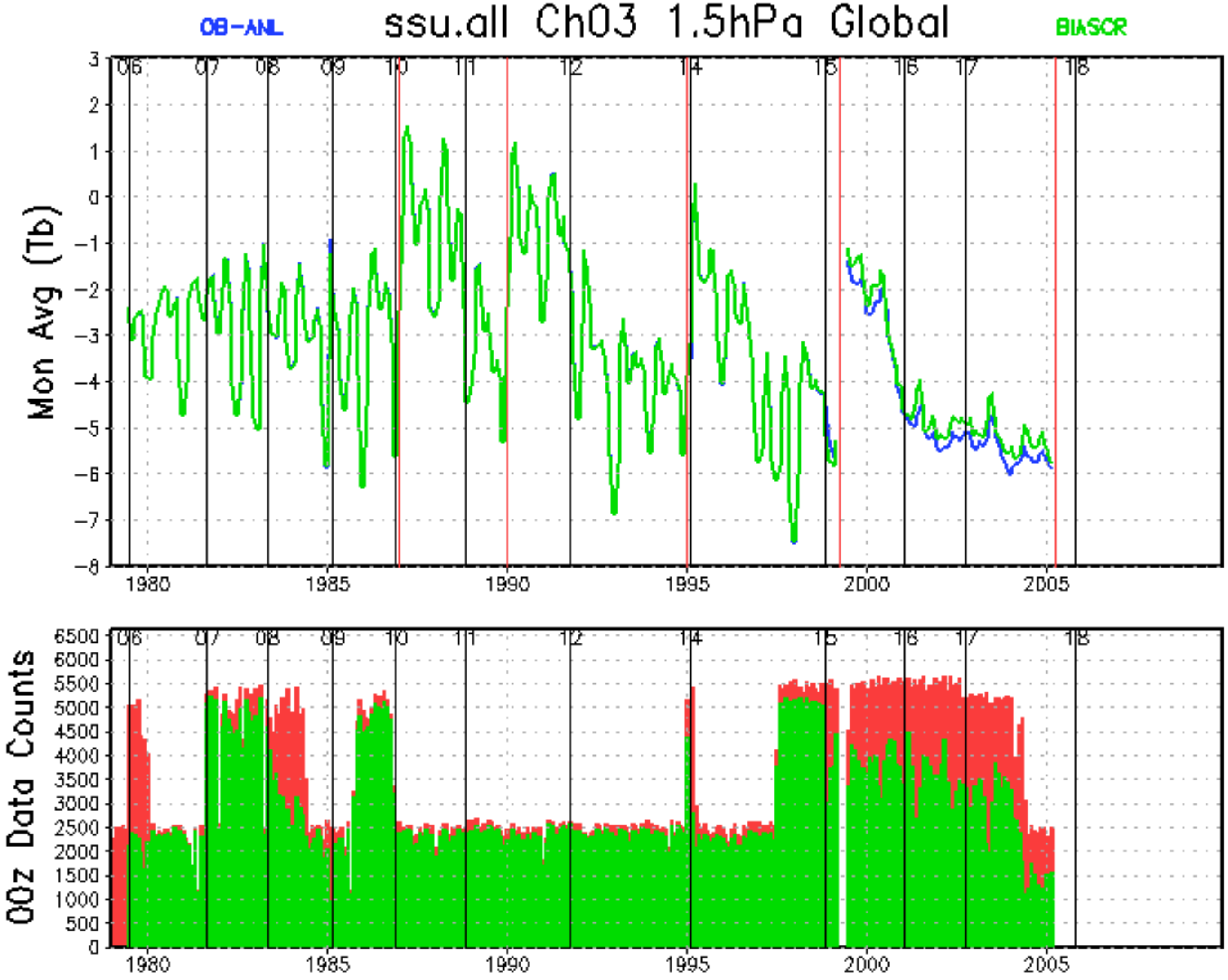
Extreme Stratospheric Temperature Variations With Jumps At Processing Stream Boundaries



Monthly CFSR Temperature Anomalies
GLOBAL (1979 - 2009)
Pressure * mb
1
2
5
10
20
30
50
70
100
150
200
250
300
400
500
700
850
1000
79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 371
-8 -4 -2 -1 -0.5 0.5 1 2 4 8

Prior to 1998 the SSU assimilation is implicated, especially bias correction of channel 3

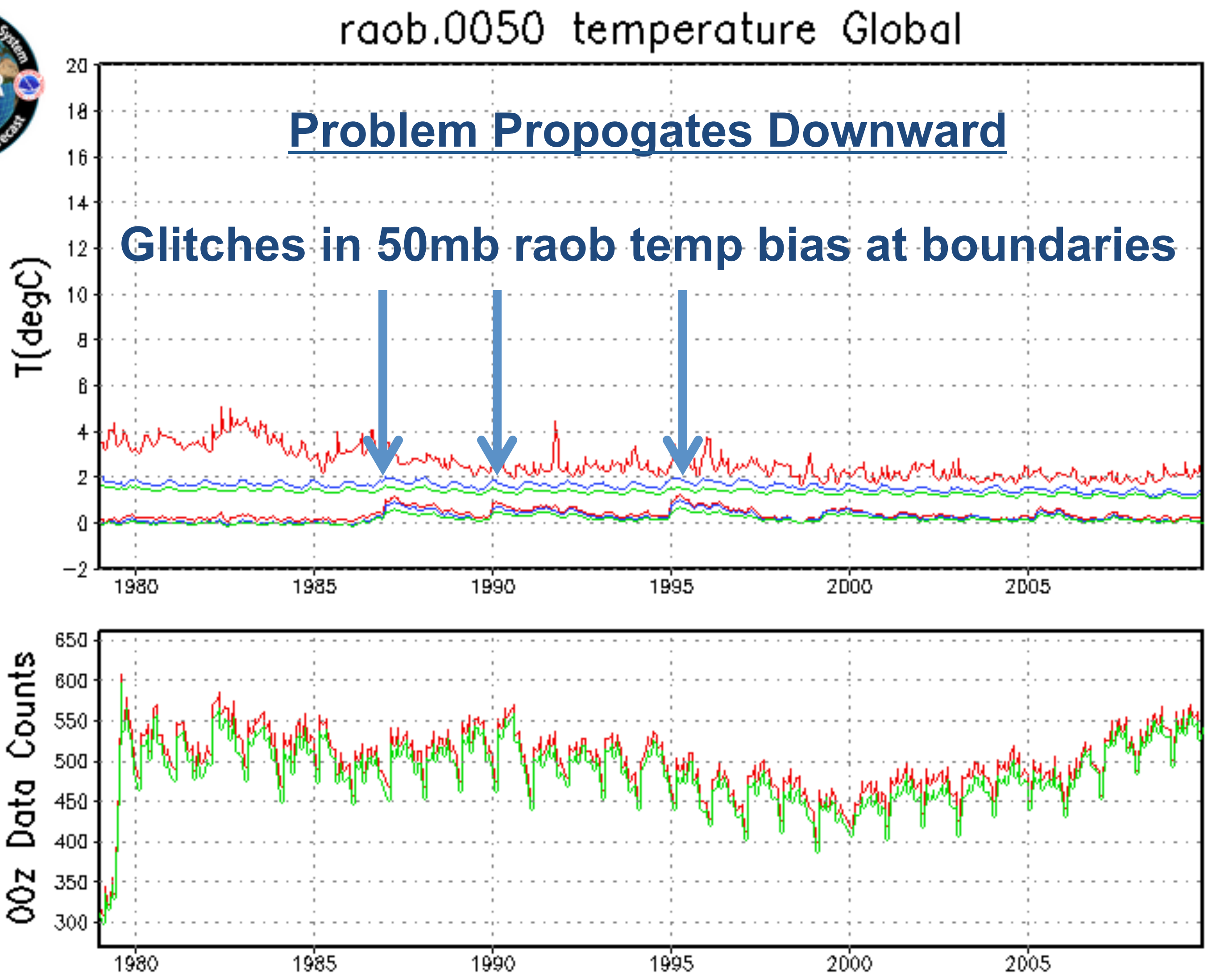
Model warm bias feeds into SSU bias correction and heats up the stratosphere until a stream (or satellite) boundary occurs when the bias correction resets…



OB-ANL
ssu.all Ch03 1.5hPa Global
BIASCR
Mon Avg (Tb)
00z Data Counts
06
07
08
09
10
11
12
14
15
16
17
18
1980
1985
1990
1995
2000
2005

Problem Propogates Downward

Glitches in 50mb raob temp bias at boundaries



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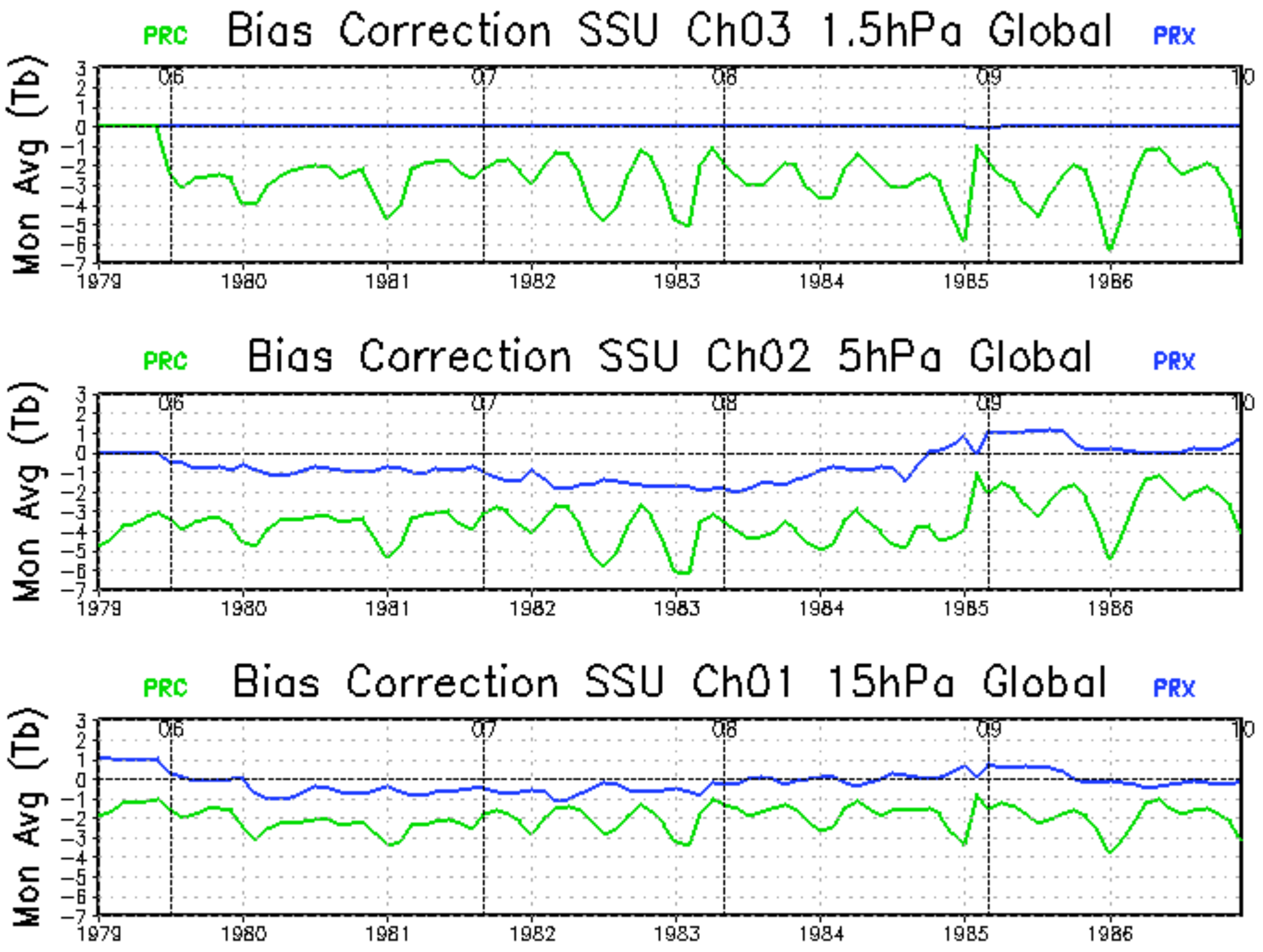
So turn off the SSU channel 3 bias correction



With Ch3 bias correction off Ch1&2 look better too

Dee et al, “Importance Of Satellites For Stratospheric Data Assimilation”, 2007

Issue #2

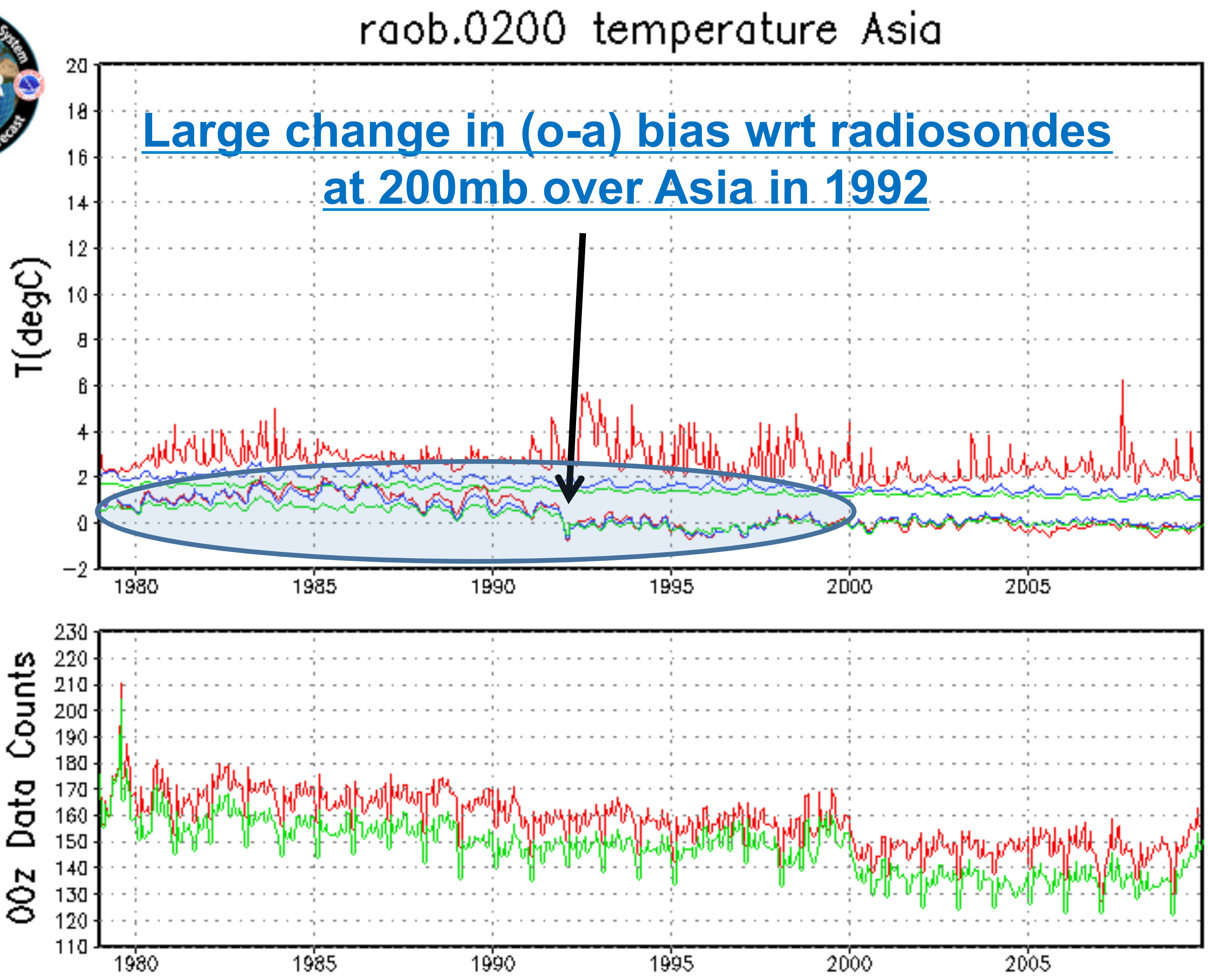
CFSRR Radiosonde Radiation Correction (RC)

Four separate operational tables used

Creates discontinuities in temp analysis

Interact with variational satellite bias corrections

Highlights the need to use a continuous radiosonde correction in CFSRL, as in ERA, JRA, MERRA, etc.



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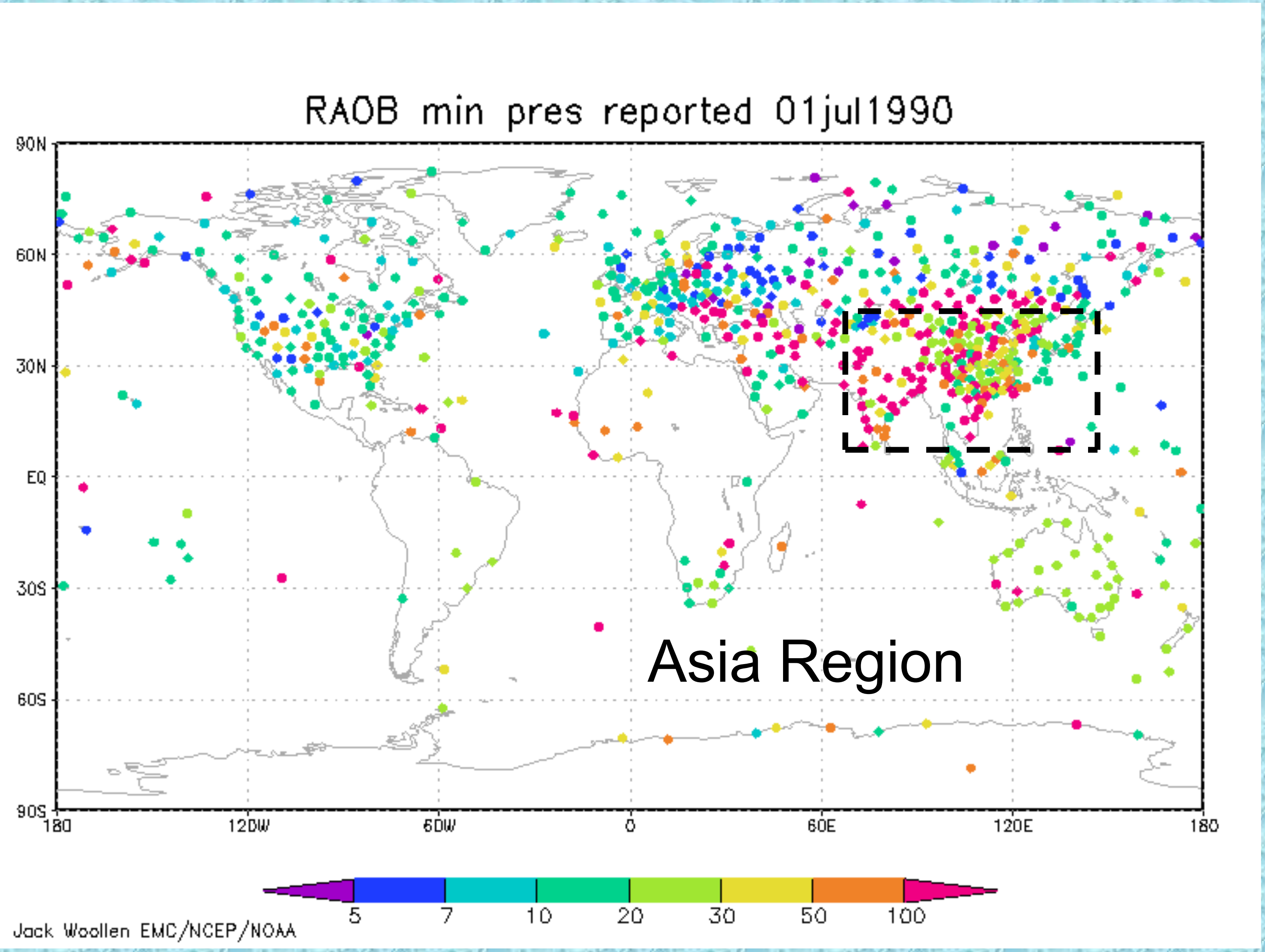

RAOB min pres reported 01jul1990
90N
60N
30N
EQ
30S
60S
90S
180
120W
60W
0
60E
120E
180
Asia Region
5
7
10
20
30
50
100
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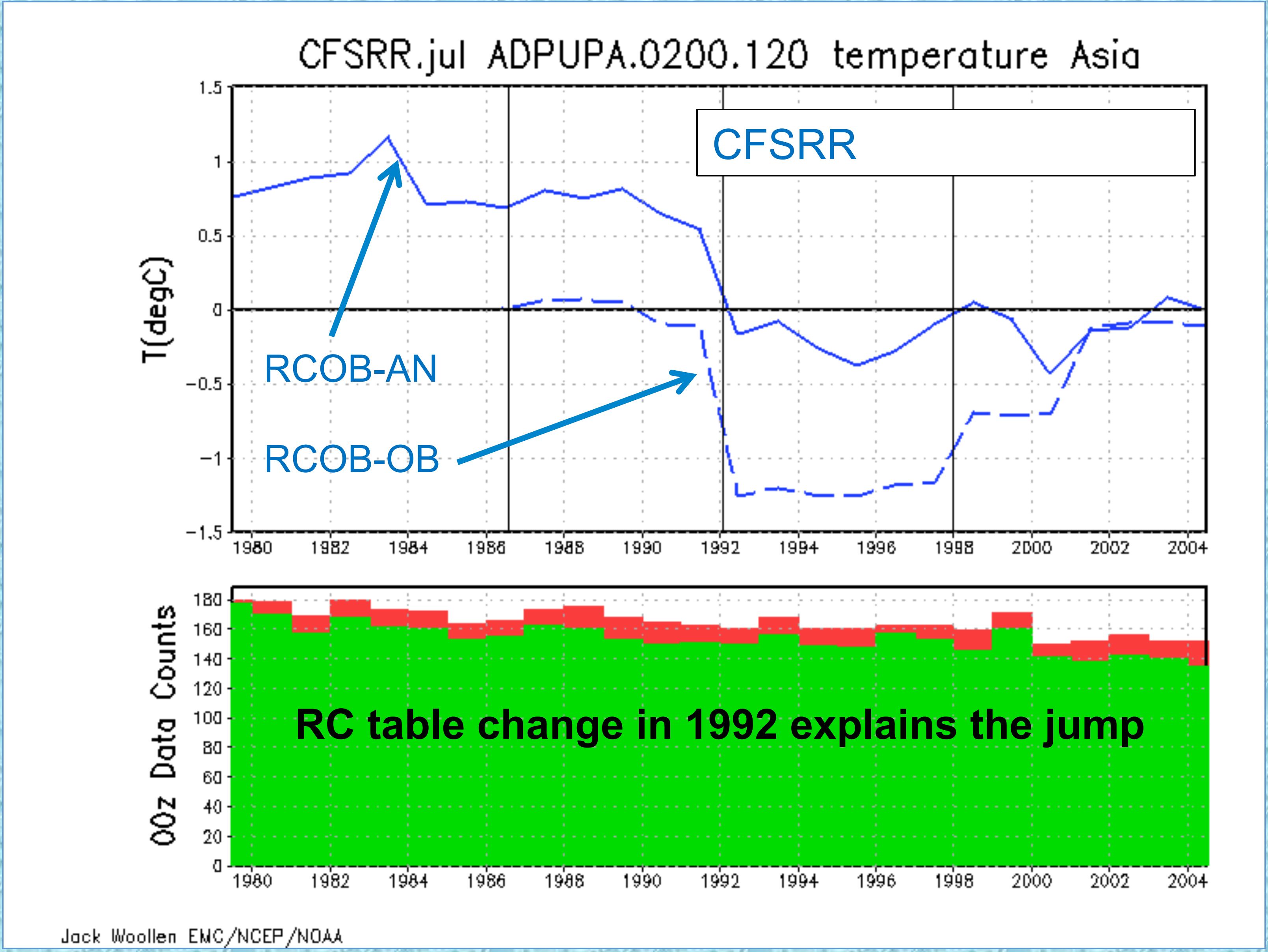
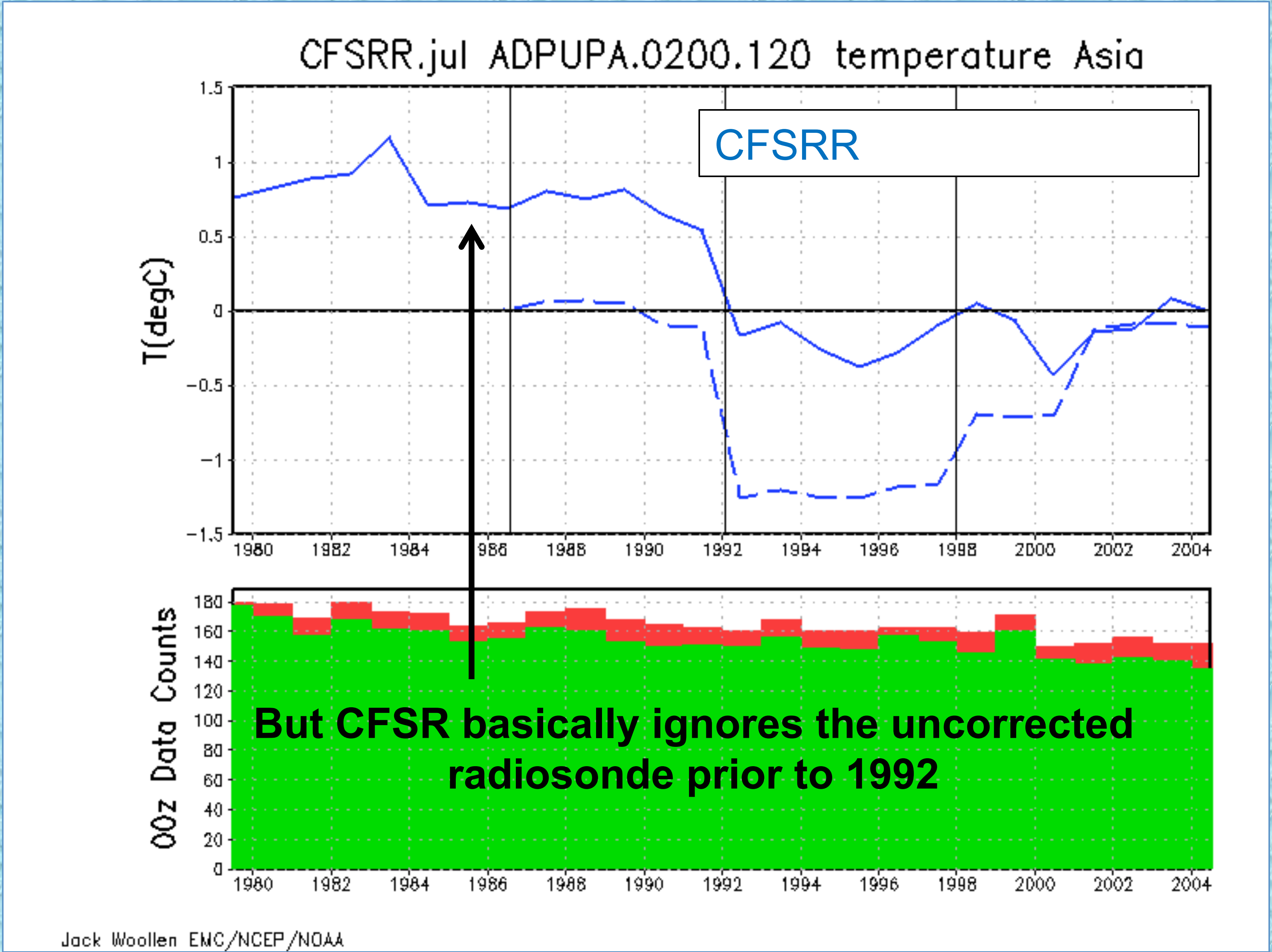

CFSRR.jul ADPUPA.0200.120 temperature Asia
CFSRR
RCOB-AN
RCOB-OB
T(degC)
1.5
1
0.5
0
−0.5
−1
−1.5
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
00z Data Counts
180
160
140
120
100
80
60
40
20
0
RC table change in 1992 explains the jump
Jack Woollen EMC/NCEP/NOAA



CFSRR.jul ADPUPA.0200.120 temperature Asia
CFSRR
T(degC)
1.5
1
0.5
0
-0.5
-1
-1.5
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
00z Data Counts
180
160
140
120
100
80
60
40
20
0
But CFSR basically ignores the uncorrected radiosonde prior to 1992
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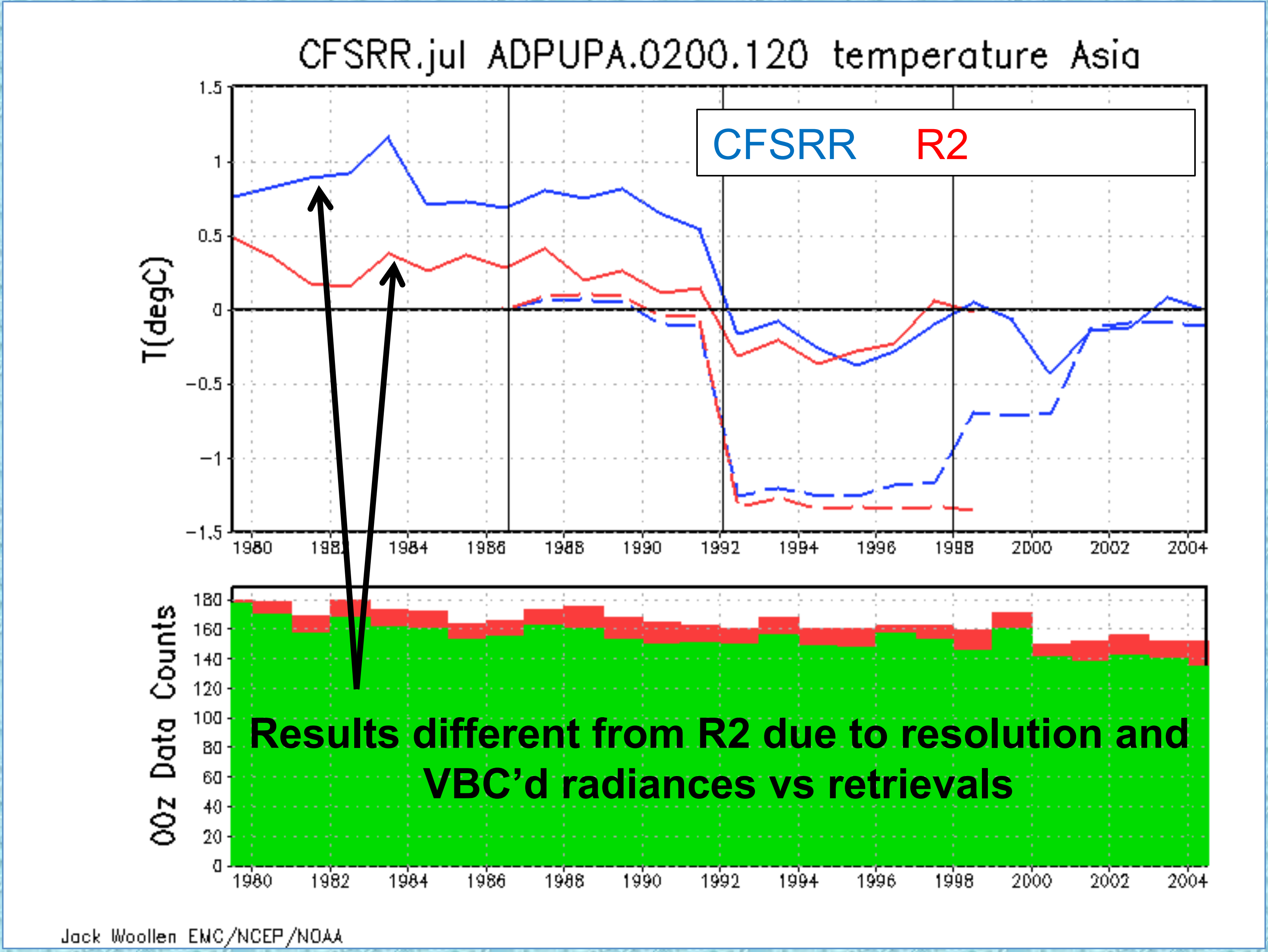
CFSRR.jul ADPUPA.0200.120 temperature Asia
CFSRR
R2
T(degC)
00z Data Counts
Results different from R2 due to resolution and VBC'd radiances vs retrievals
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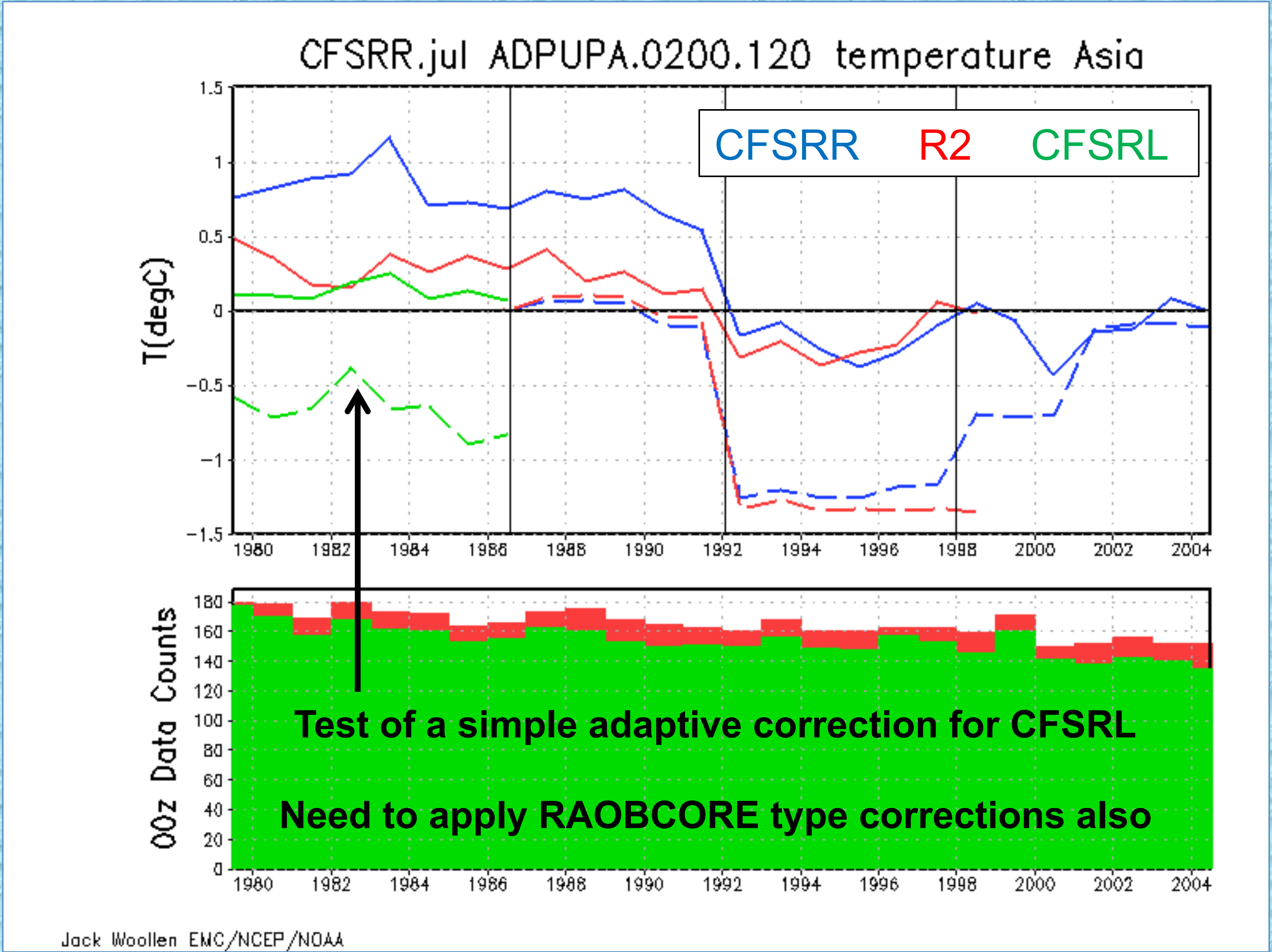
CFSRR.jul ADPUPA.0200.120 temperature Asia
CFSRR
R2
CFSRL
T(degC)
00z Data Counts
Test of a simple adaptive correction for CFSRL
Need to apply RAOBCORE type corrections also
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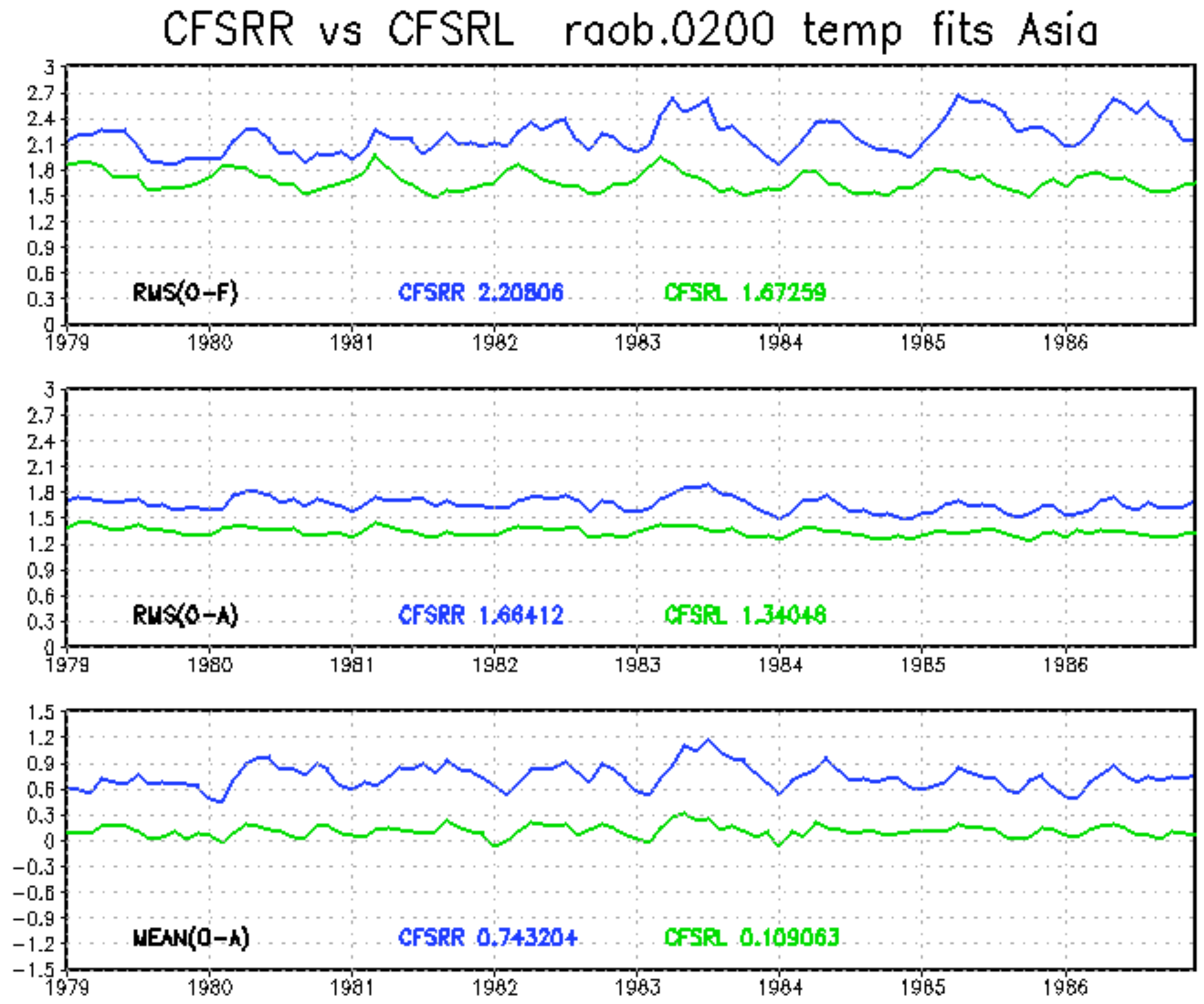
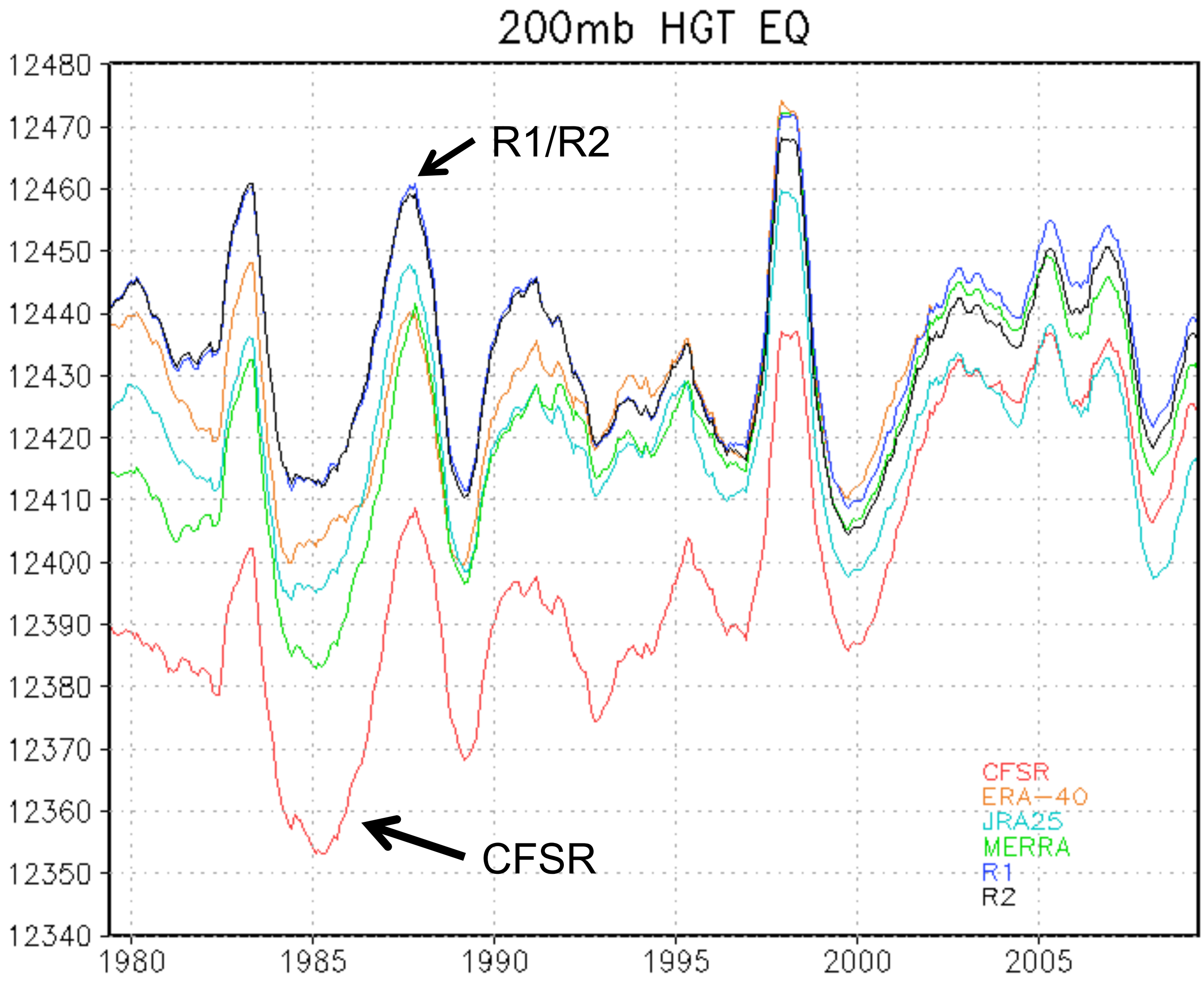
Improved Fits To Analysis And Forecast

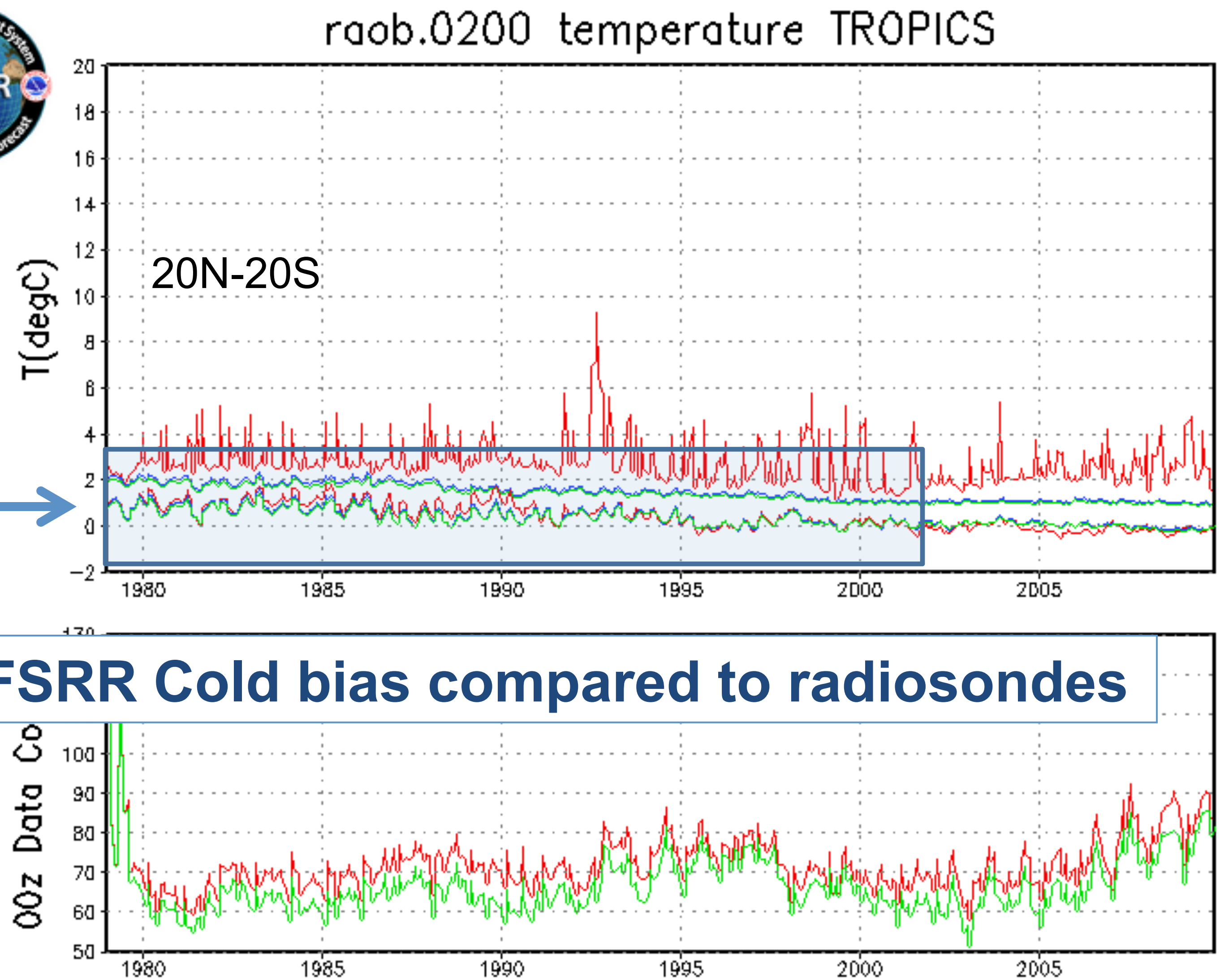


Issue #3

Significant differences from other reanalyses

In tropical tropospheric temperature


200mb HGT EQ
R1/R2
CFSR
12480
12470
12460
12450
12440
12430
12420
12410
12400
12390
12380
12370
12360
12350
12340
1980
1985
1990
1995
2000
2005
CFSR
ERA-40
JRA25
MERRA
R1
R2



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CFSRR didn't draw for the radiosonde temperature data in the tropics

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Solution: adjust the GSI structure functions to increase the forecast variance in the tropical region, top to bottom

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Analysis fits improved and large biases disappeared

CFSRL (solid lines) versus CFSRR (dotted lines)

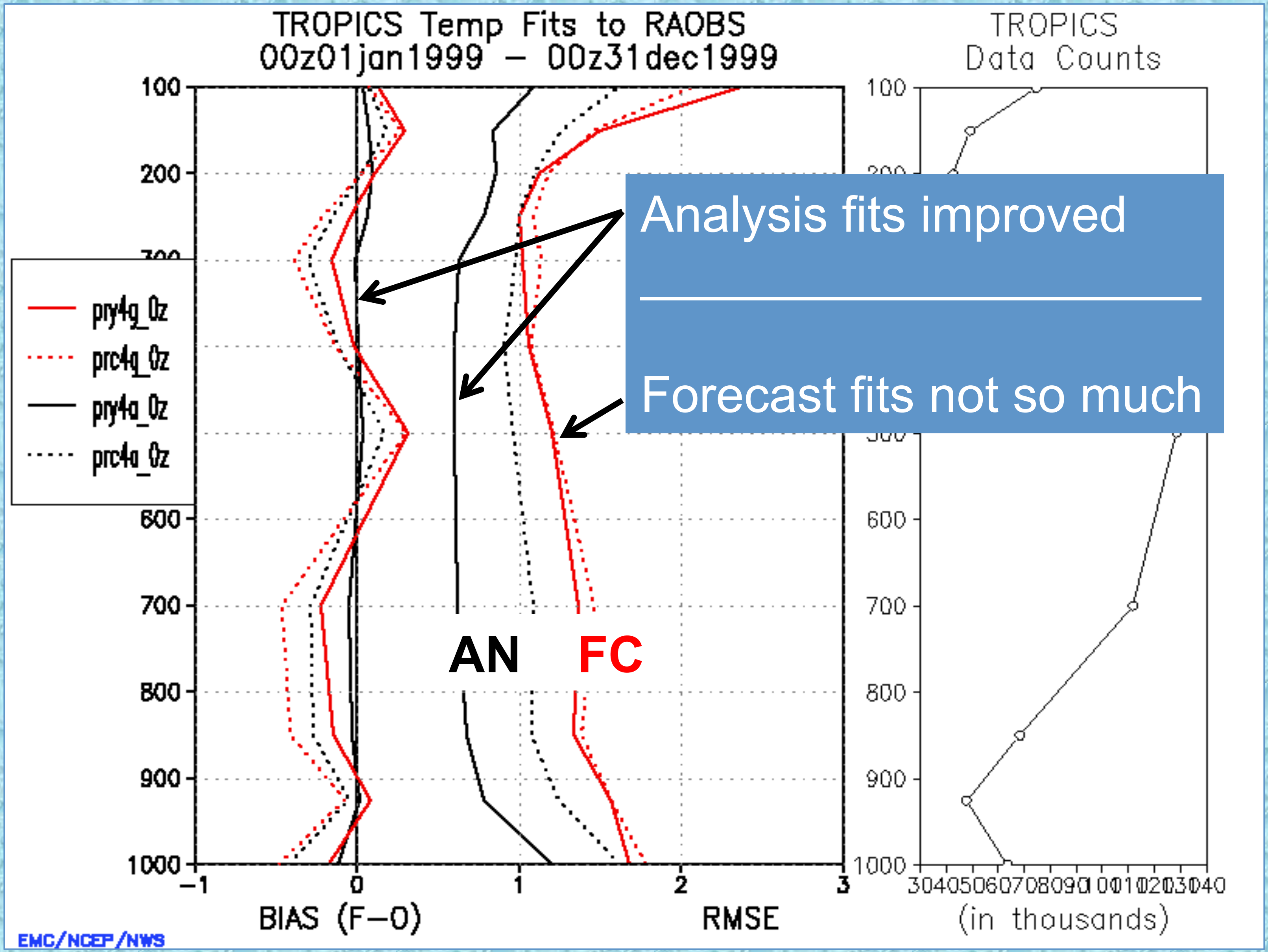
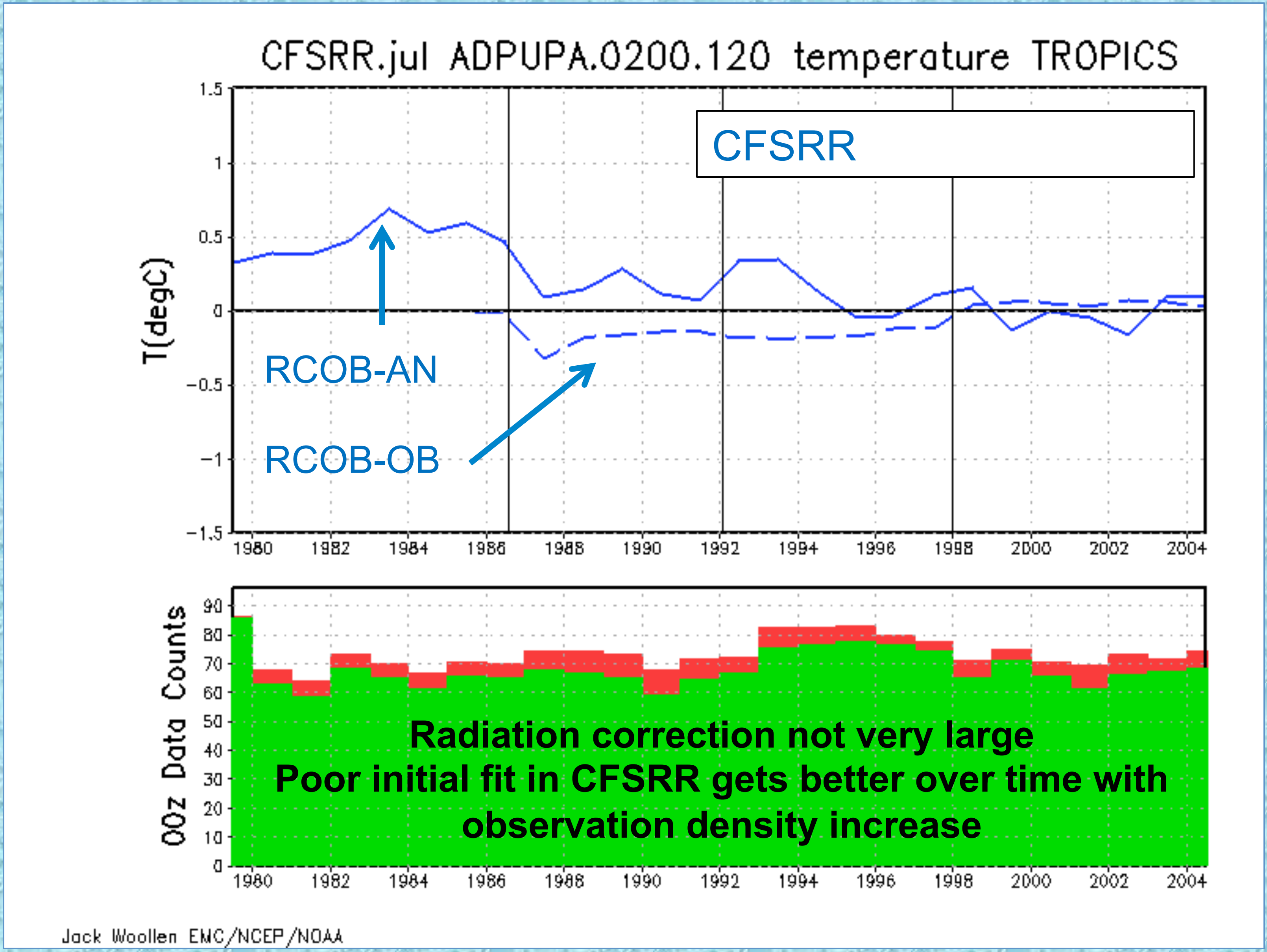


Diagram from Fanglin Yang


CFSRR.jul ADPUPA.0200.120 temperature TROPICS
CFSRR
RCOB-AN
RCOB-OB
T(degC)
00z Data Counts
Radiation correction not very large
Poor initial fit in CFSRR gets better over time with observation density increase
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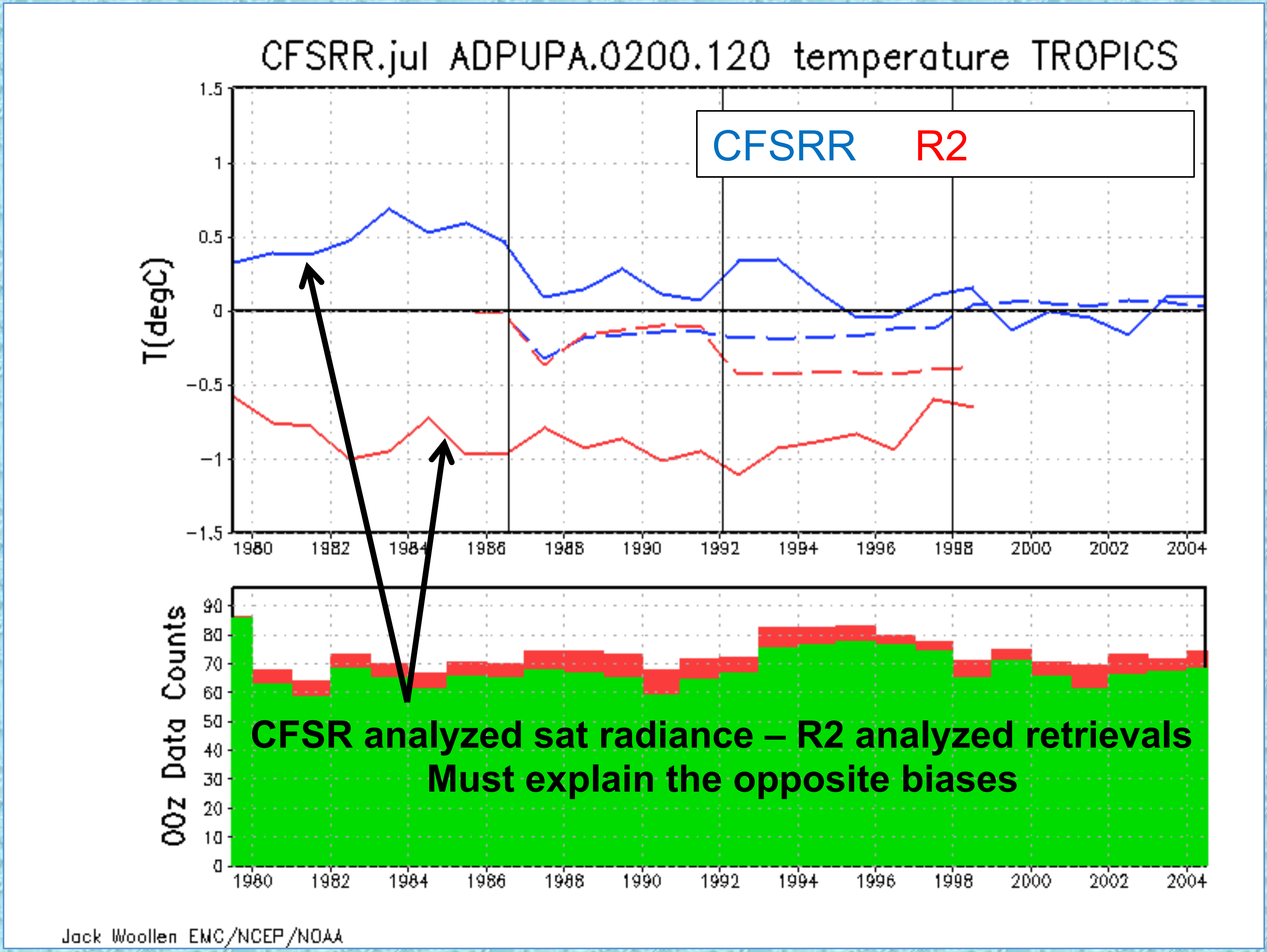
CFSRR.jul ADPUPA.0200.120 temperature TROPICS
CFSRR
R2
T(degC)
1.5
1
0.5
0
−0.5
−1
−1.5
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
00z Data Counts
90
80
70
60
50
40
30
20
10
0
CFSR analyzed sat radiance – R2 analyzed retrievals
Must explain the opposite biases
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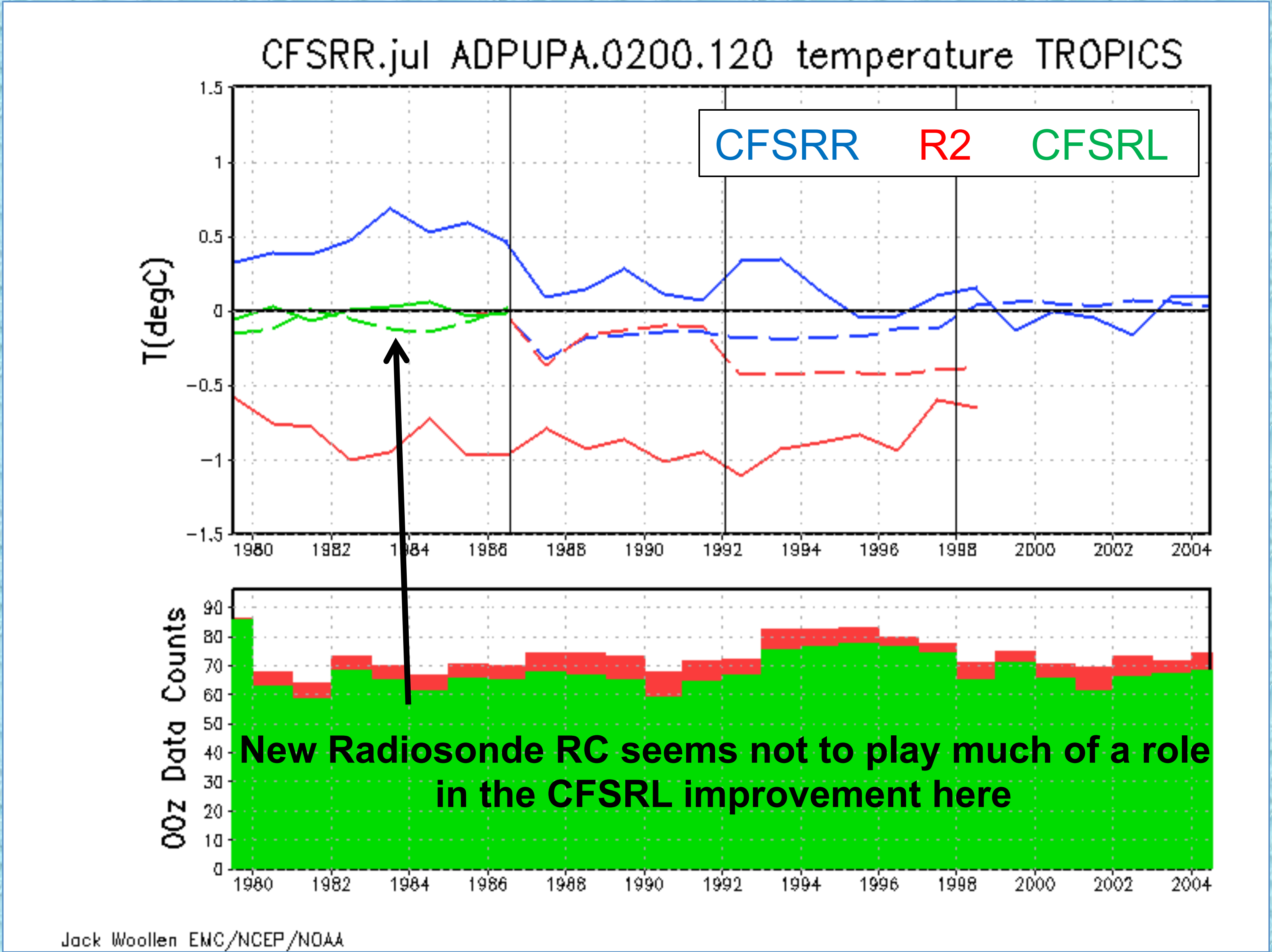

CFSRR.jul ADPUPA.0200.120 temperature TROPICS
CFSRR
R2
CFSRL
T(degC)
1.5
1
0.5
0
−0.5
−1
−1.5
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
00z Data Counts
90
80
70
60
50
40
30
20
10
0
New Radiosonde RC seems not to play much of a role in the CFSRL improvement here
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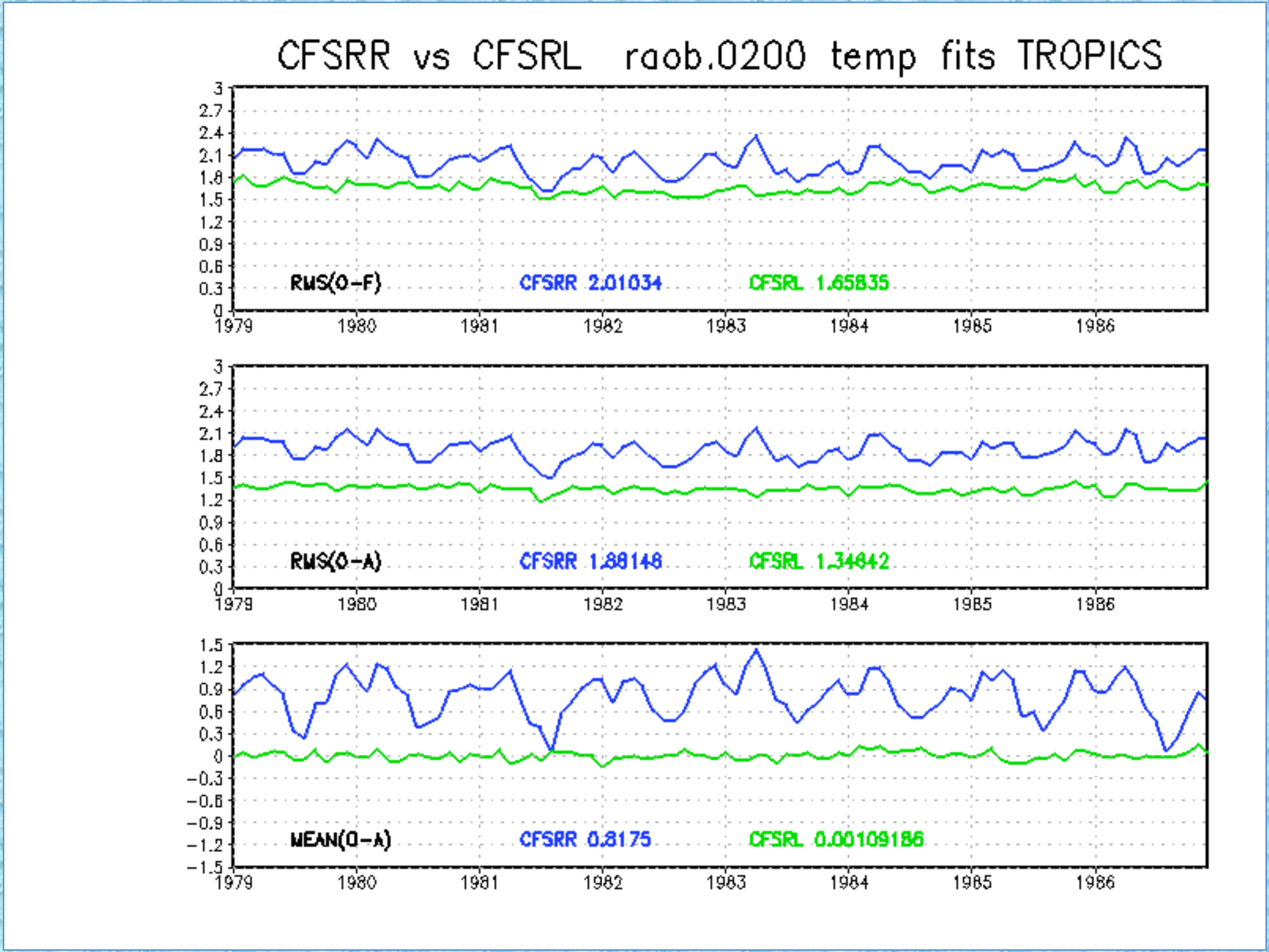
Improvements From Tropical Structure Function Changes



Issue #4

QBO Wind Reversals Not Captured Well

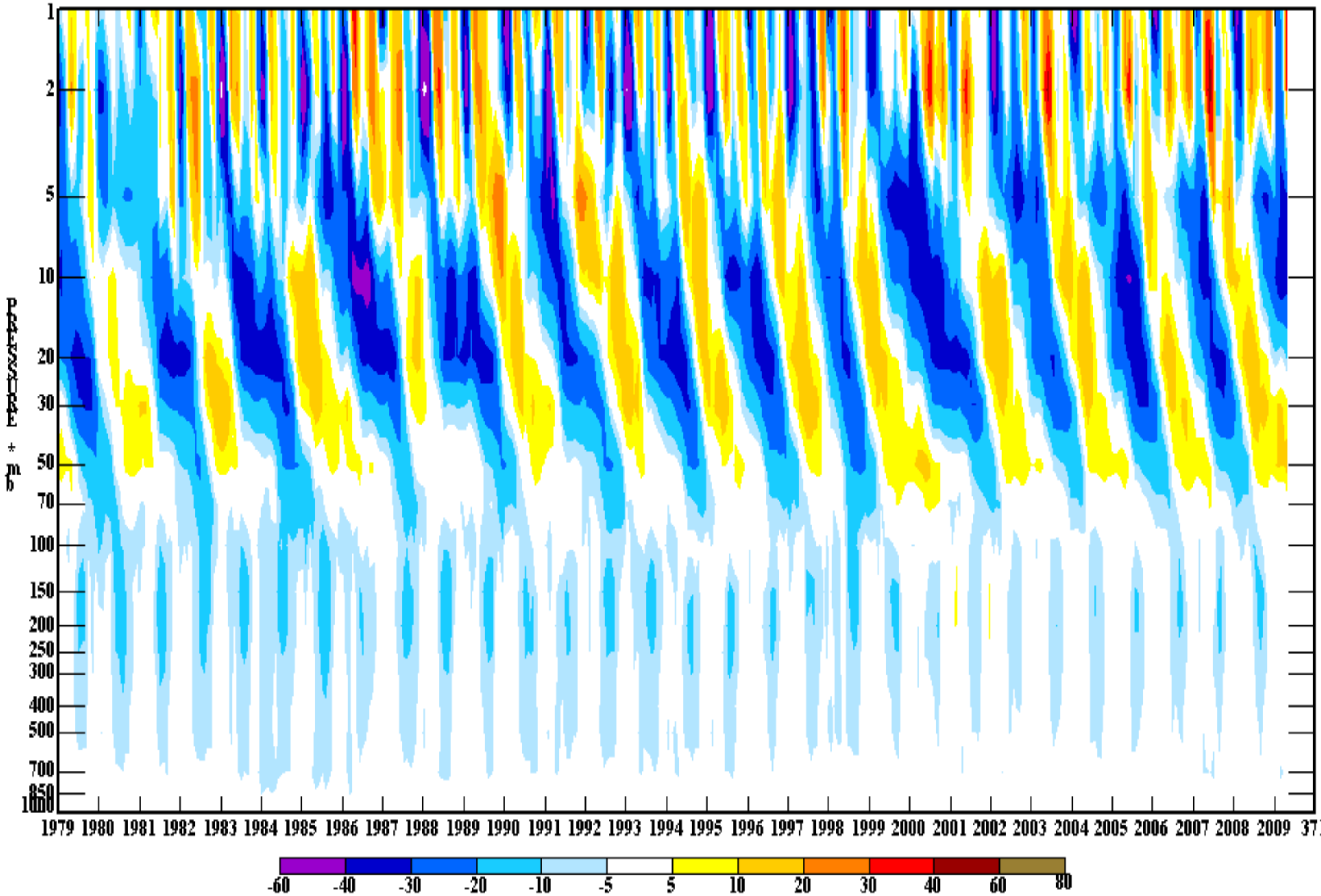
Discovered too late to fix in CFSRR

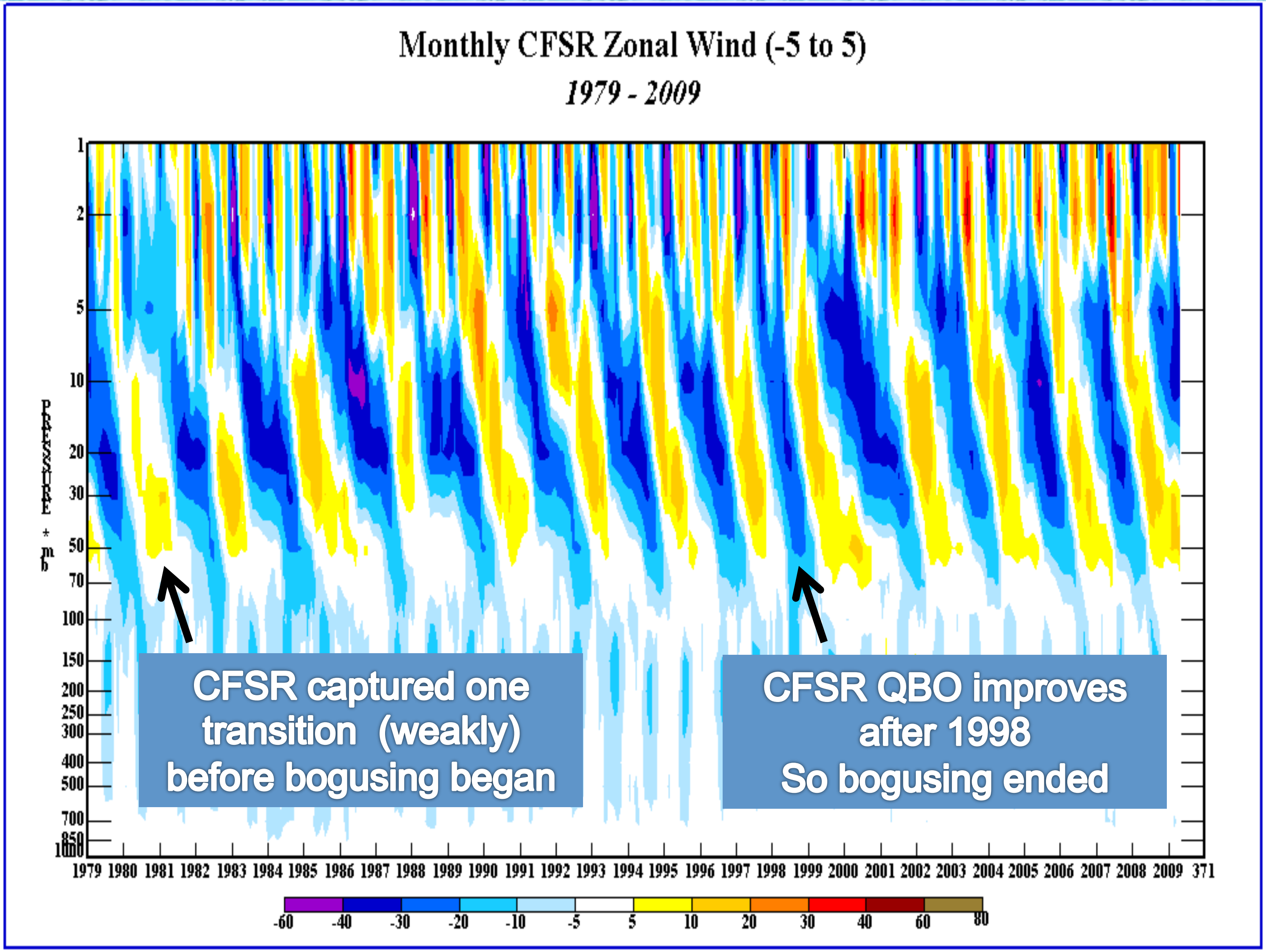
Caught by surprise – not a problem in R1 or R2

Bogus ERA40 winds into CFSR QBO region Jul1981 - Dec1998

Monthly CFSR Zonal Wind (-5 to 5)

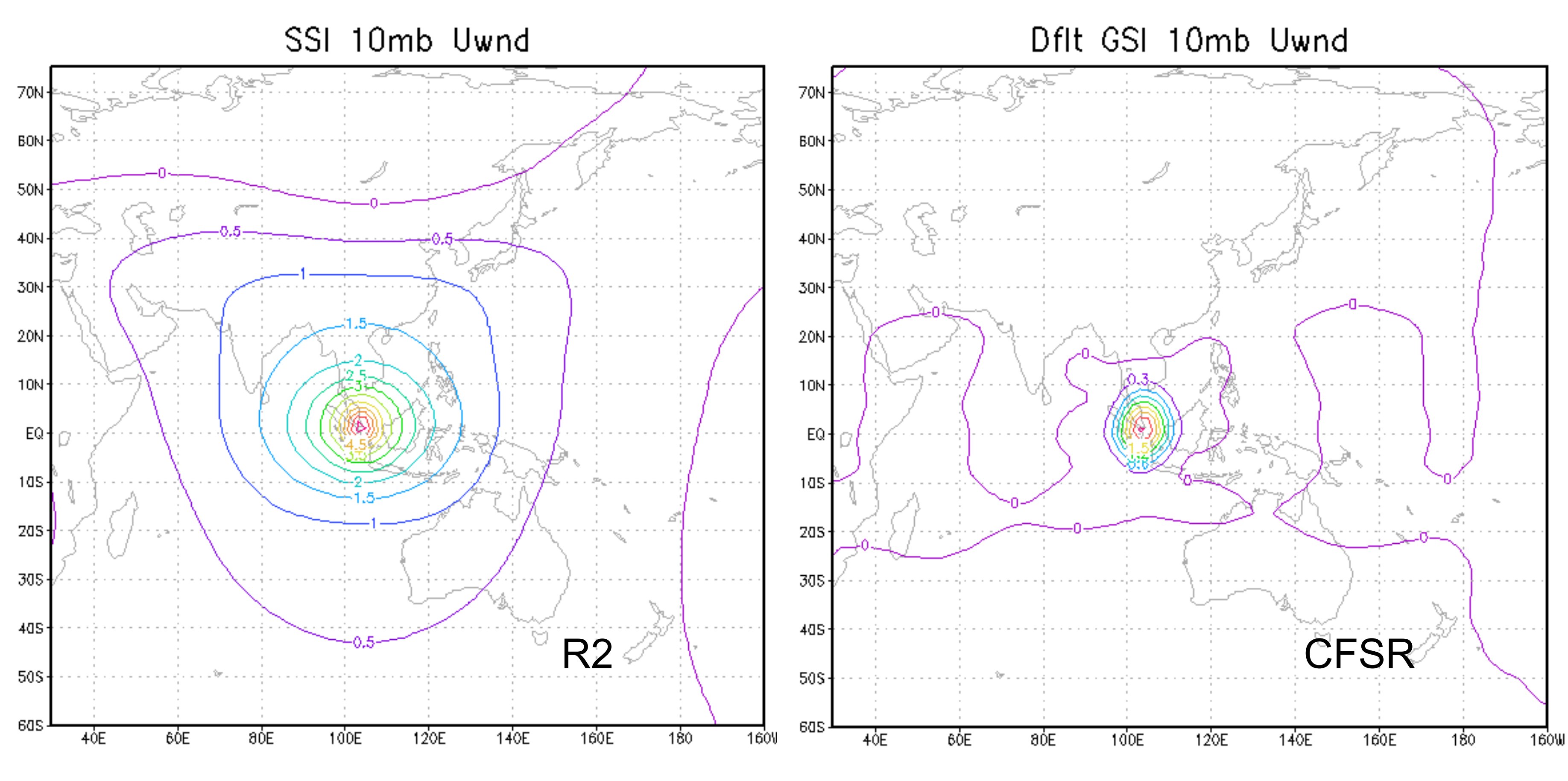
1979 - 2009




Monthly CFSR Zonal Wind (-5 to 5)
1979 - 2009
PRESSURE * mb
1
2
5
10
20
30
50
70
100
150
200
250
300
400
500
700
850
1000
1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 371
-60 -40 -30 -20 -10 -5 5 10 20 30 40 60 80
CFSR captured one transition (weakly) before bogusing began
CFSR QBO improves after 1998 So bogusing ended

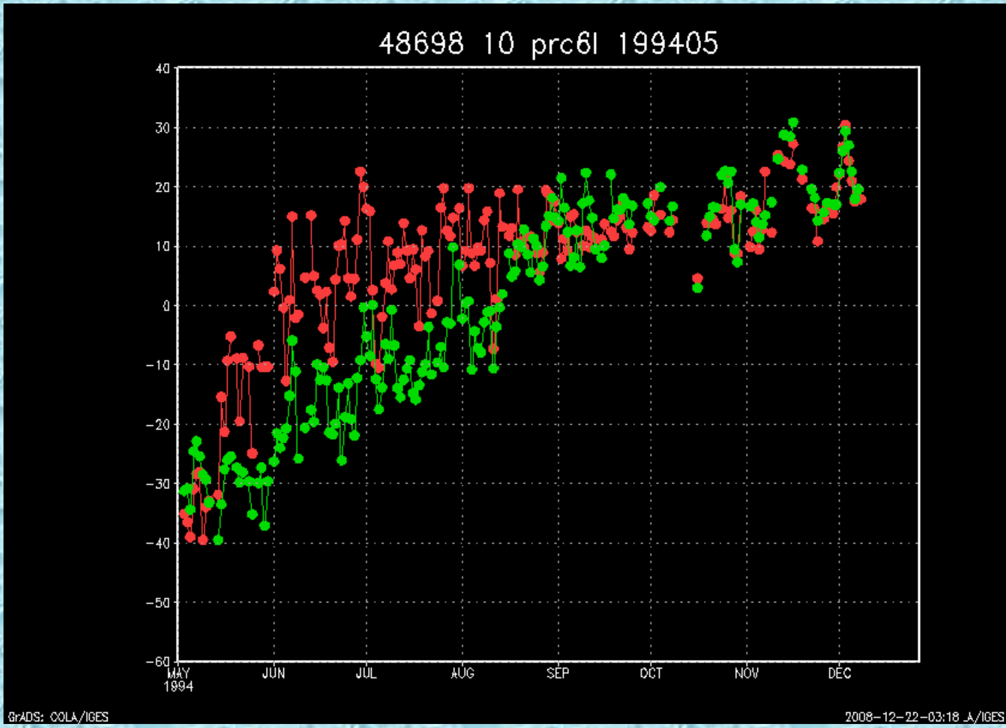
Problem seems to be due to overly narrow tropical FE structure function pre-1998

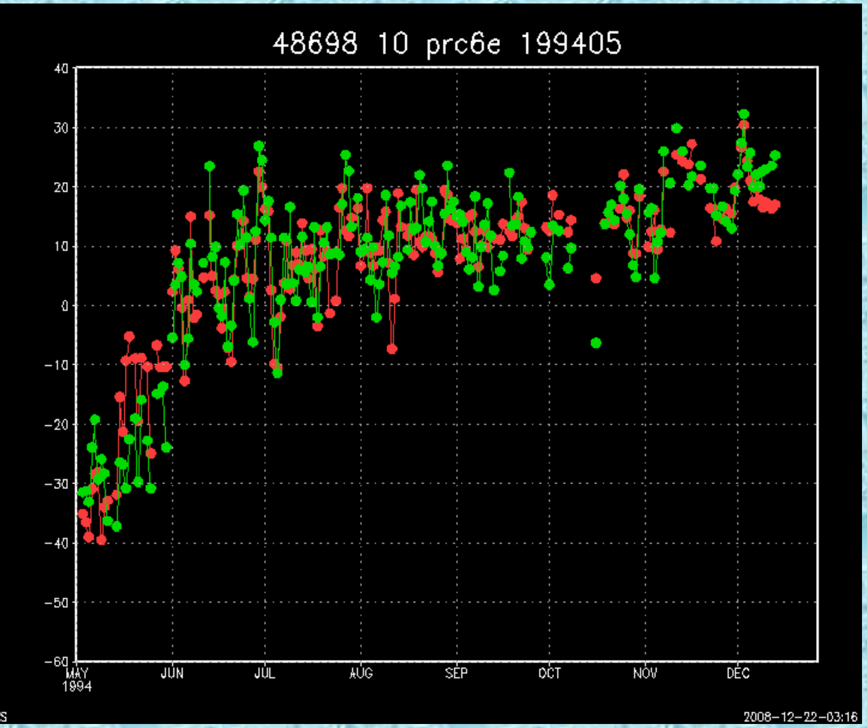
Single u component impact



Inflated variance appears to solve problem in test run starting in May1994

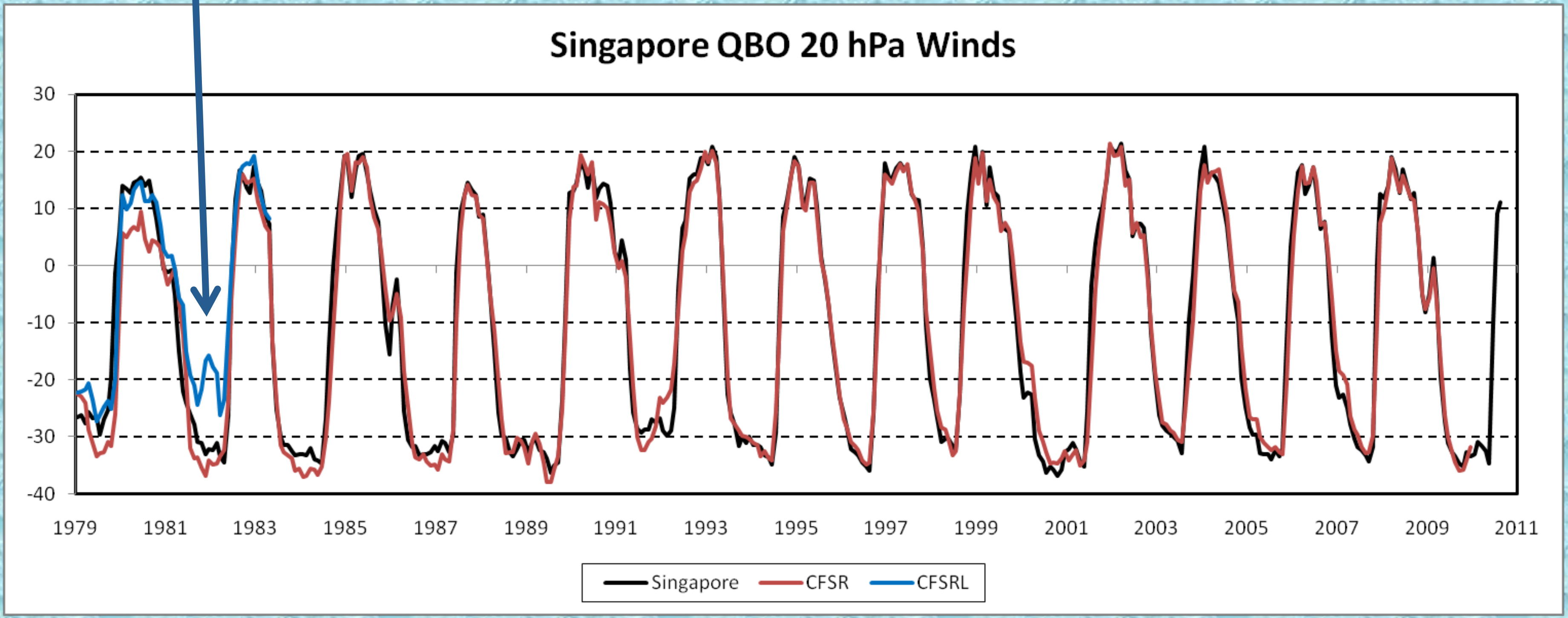
U-comp wind Singapore raob vs reanalysis 10mb





*However, zonal wind compared to Singapore ob shows the prx (SF*4) system still not capturing the wind phase shifts sufficiently in early 1980's*

Large bias in 1982 easterly phase shift



Need additional work to fix the QBO

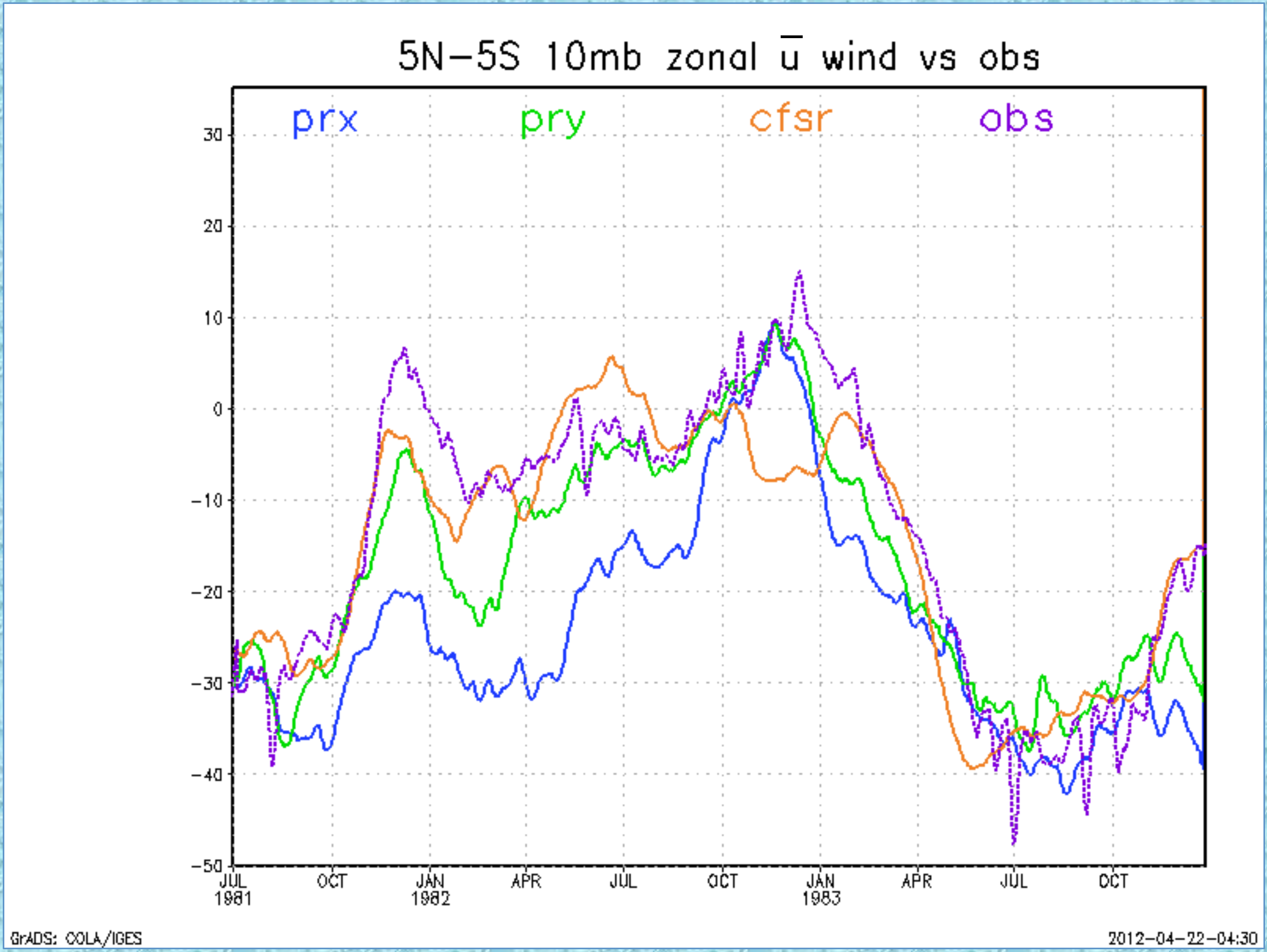
Is the SSU data interfering with the QBO wind analysis?

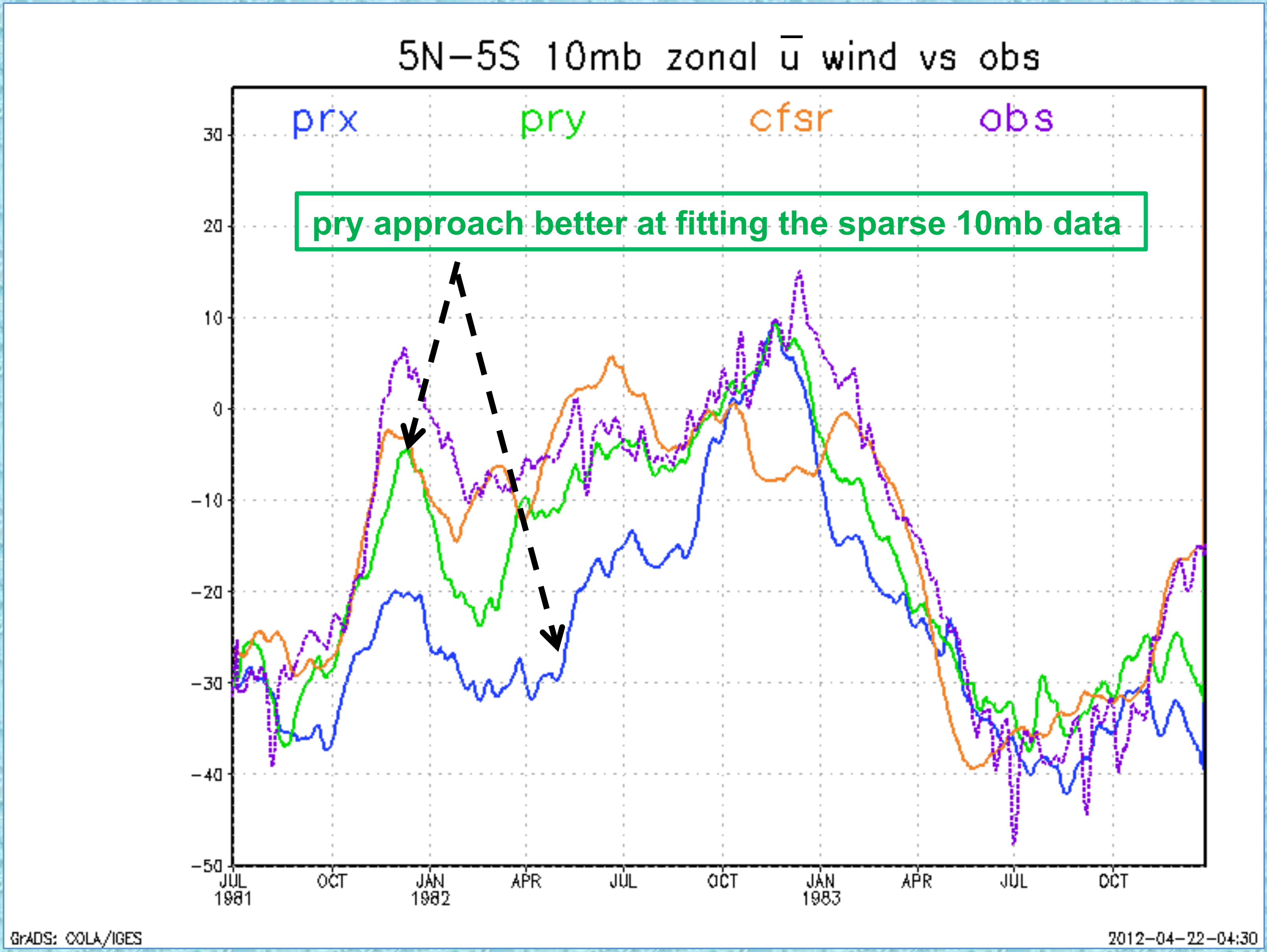
- ***Damp the effect of SSU channels by raising ob errors.***

How else can the impact of the data be increased?

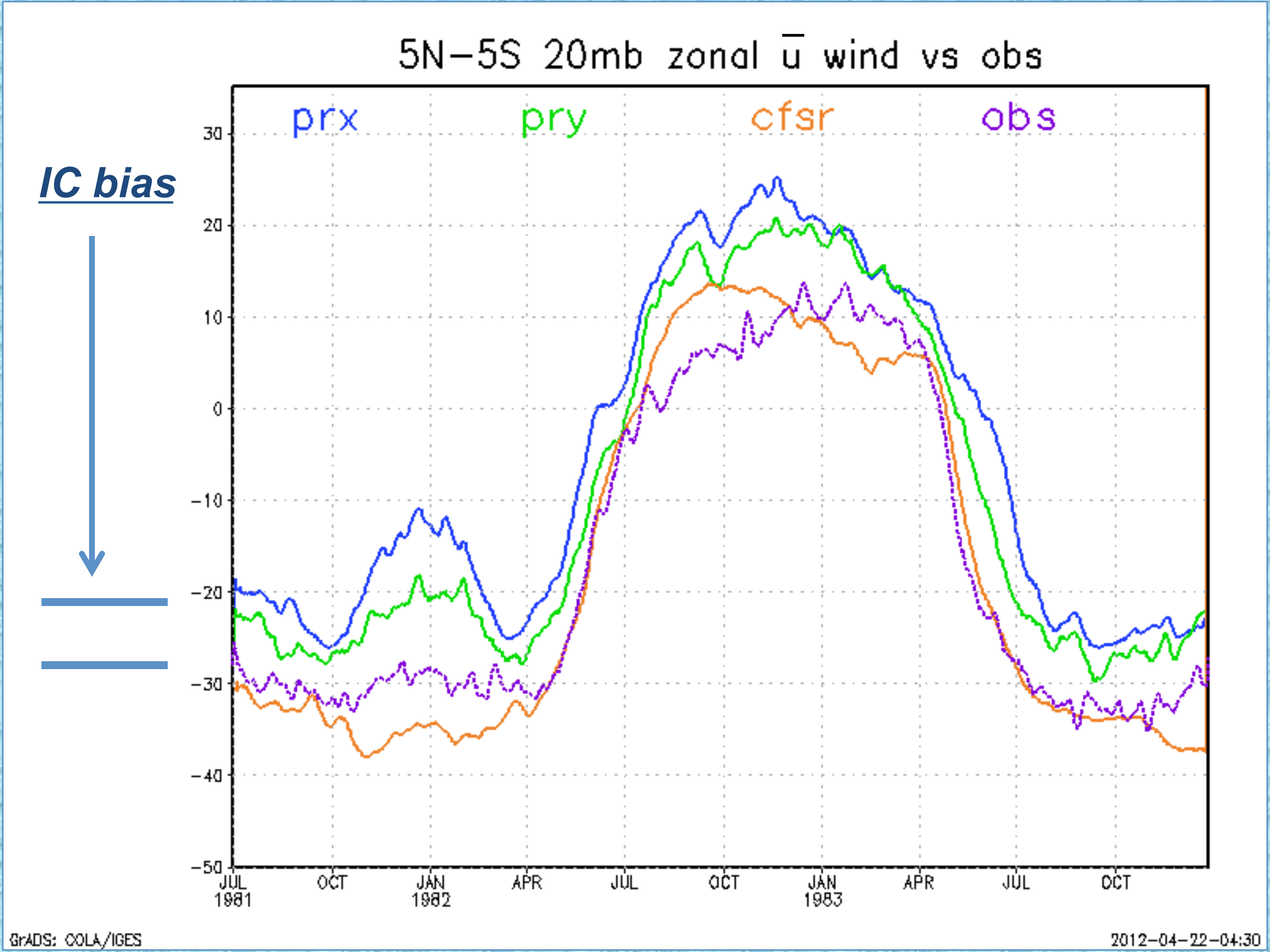
- ***Assimilate synoptic observations all day.***

It turned out both of these measures had a similar positive effect on the QBO analysis, but each at different levels

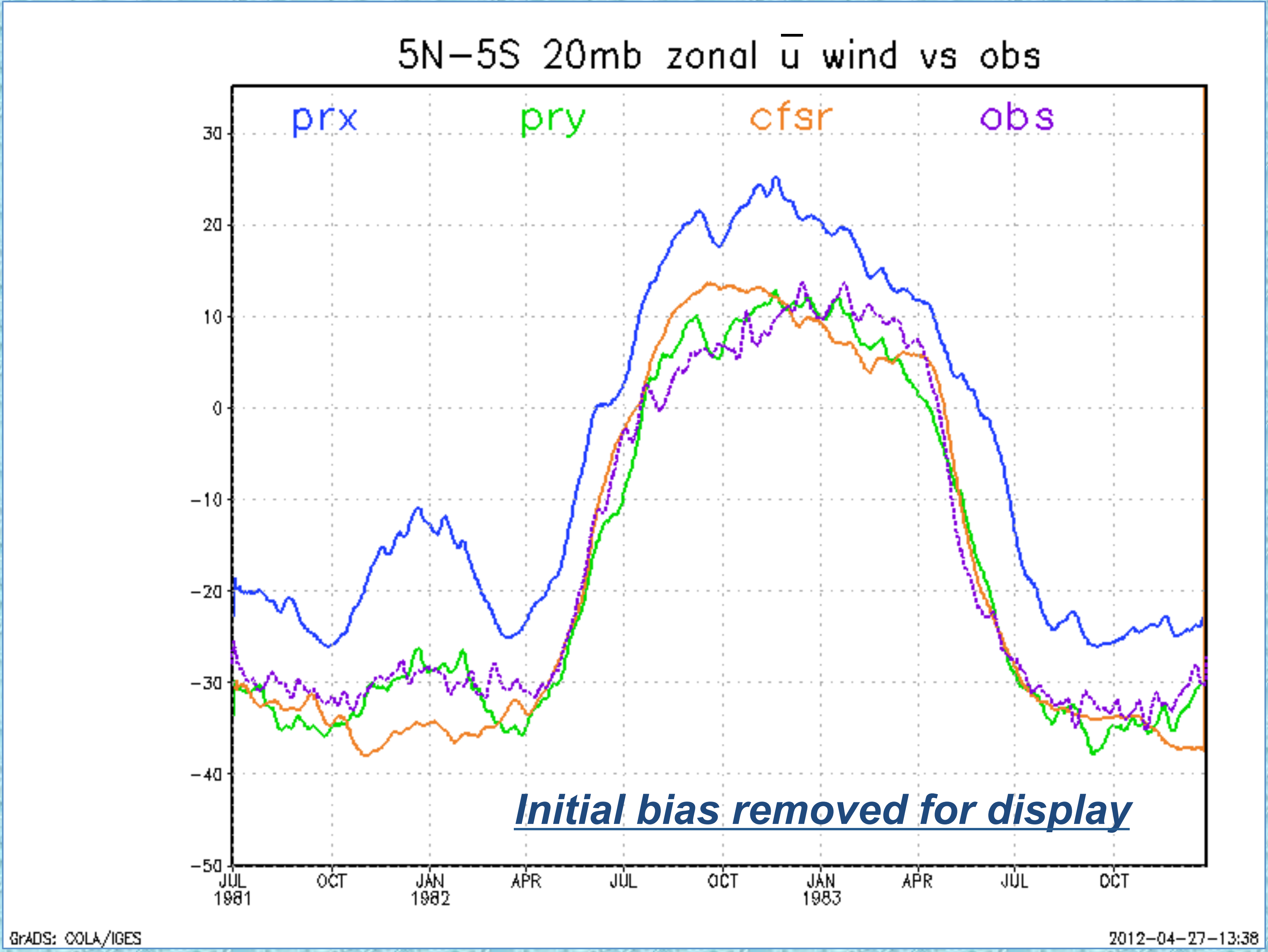

5N–5S 10mb zonal ū wind vs obs
prx
pry
cfsr
obs
30
20
10
0
–10
–20
–30
–40
–50
JUL
1981
OCT
JAN
1982
APR
JUL
OCT
JAN
1983
APR
JUL
OCT
GrADS: COLA/IGES
2012–04–22–04:30



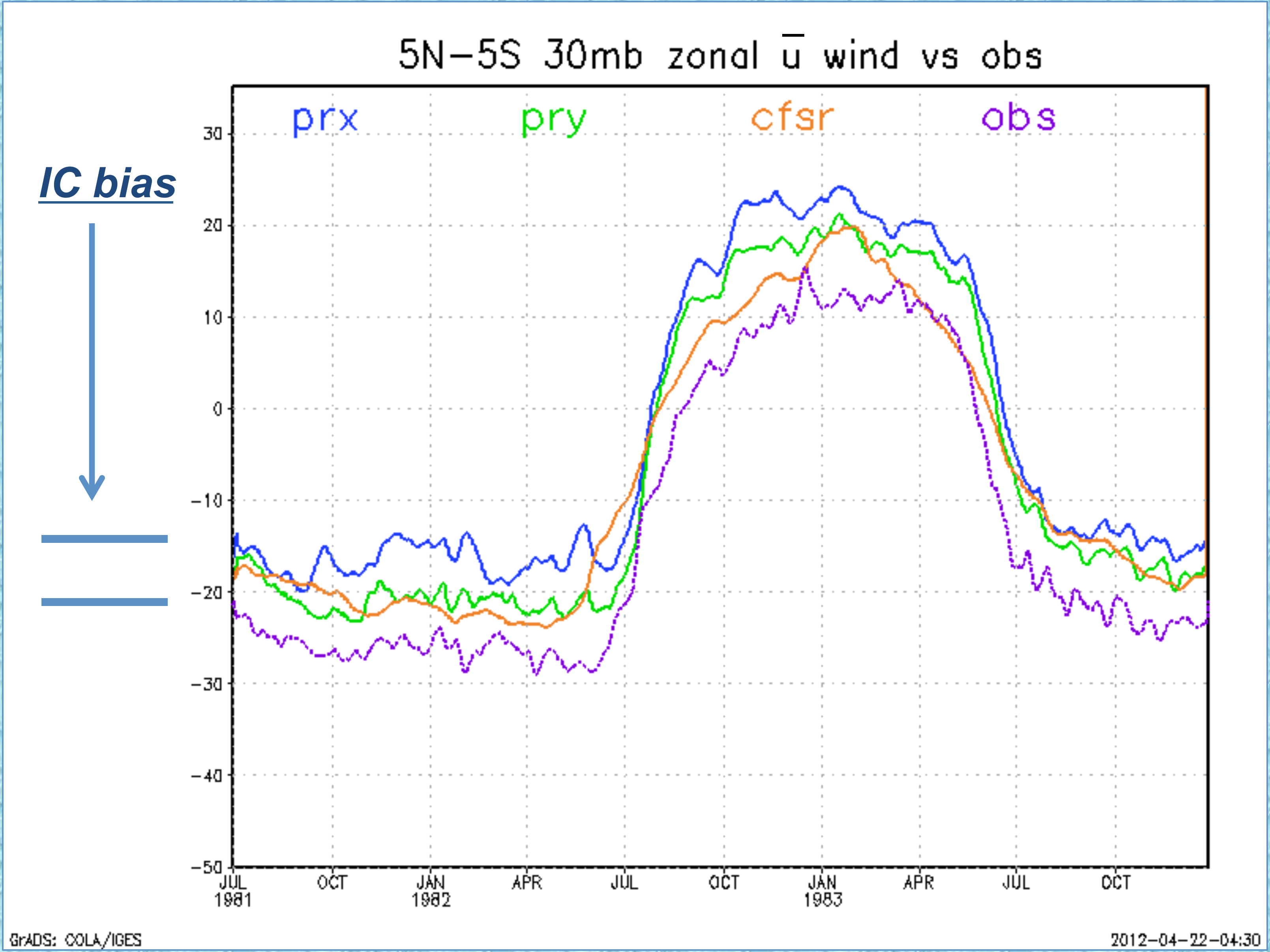
5N–5S 10mb zonal ū wind vs obs
prx
pry
cfsr
obs
pry approach better at fitting the sparse 10mb data
30
20
10
0
–10
–20
–30
–40
–50
JUL 1981
OCT
JAN 1982
APR
JUL
OCT
JAN 1983
APR
JUL
OCT
GrADS: COLA/IGES
2012–04–22–04:30



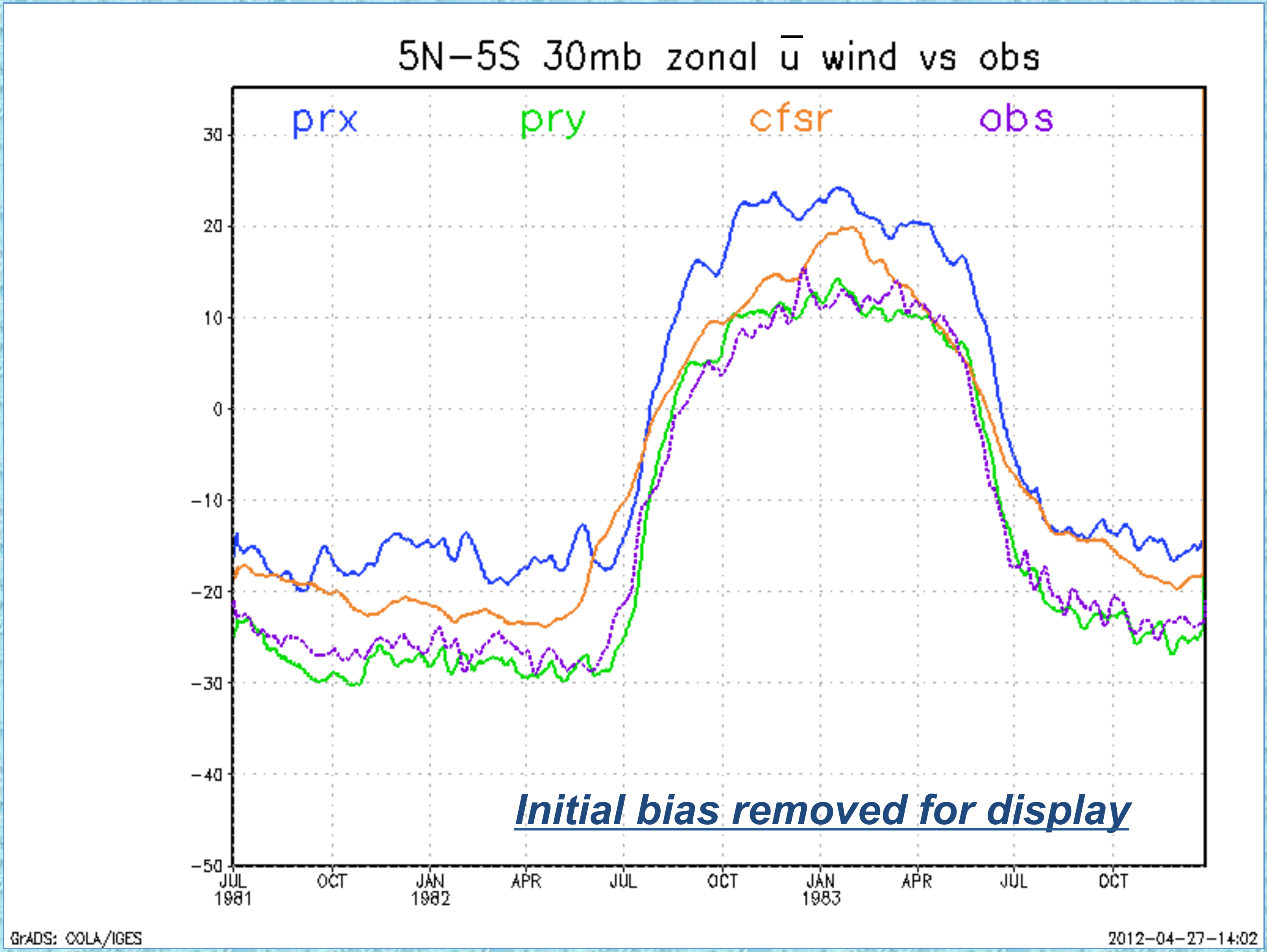
IC bias
5N-5S 20mb zonal ū wind vs obs
prx
pry
cfsr
obs
30
20
10
0
-10
-20
-30
-40
-50
JUL 1981
OCT
JAN 1982
APR
JUL
OCT
JAN 1983
APR
JUL
OCT
GrADS: COLA/IGES
2012-04-22-04:30


5N-5S 20mb zonal $\bar{u}$ wind vs obs
prx
pry
cfsr
obs
30
20
10
0
-10
-20
-30
-40
-50
JUL 1981
OCT
JAN 1982
APR
JUL
OCT
JAN 1983
APR
JUL
OCT
Initial bias removed for display
GrADS: COLA/IGES
2012-04-27-13:38

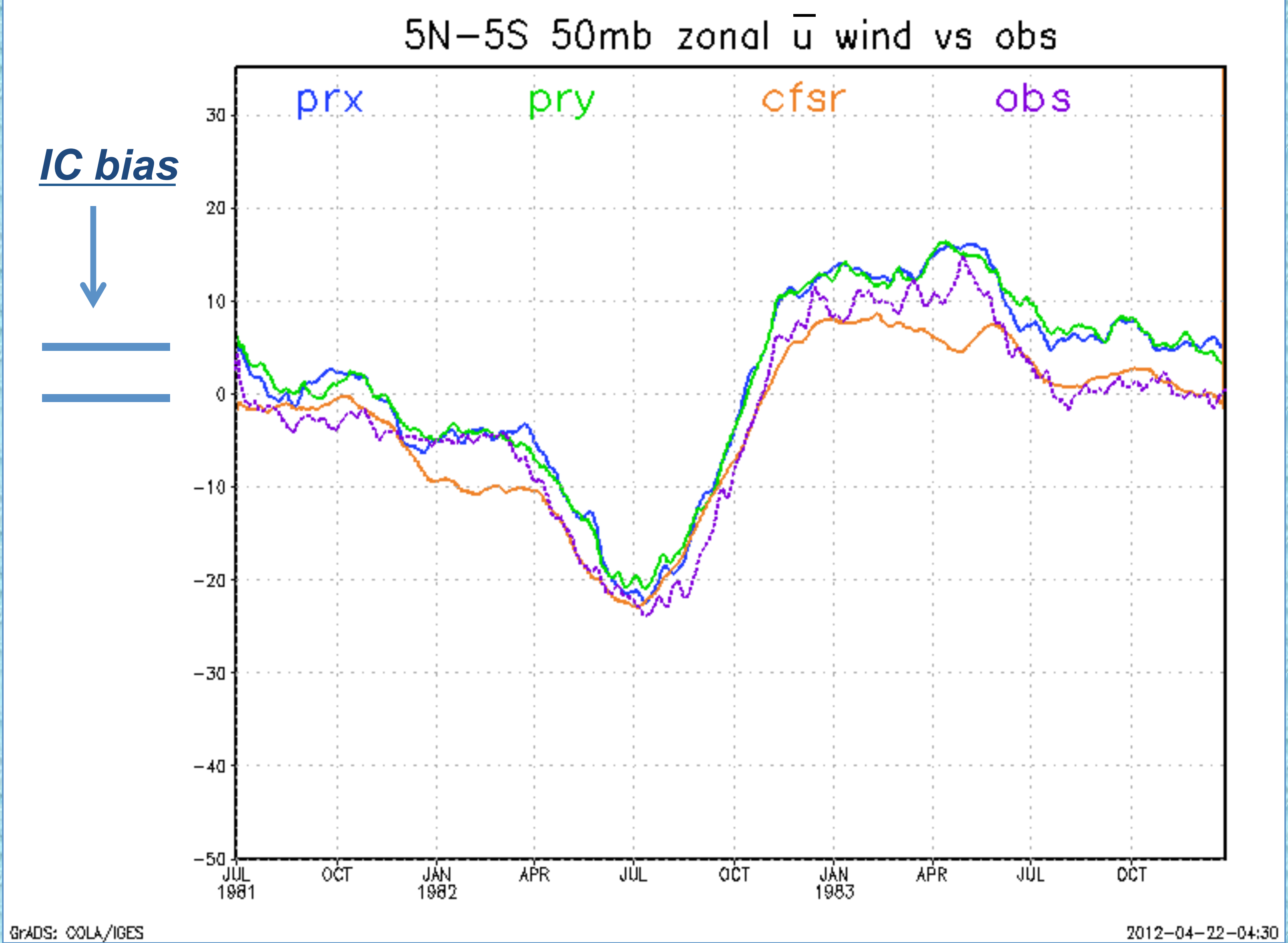
IC bias



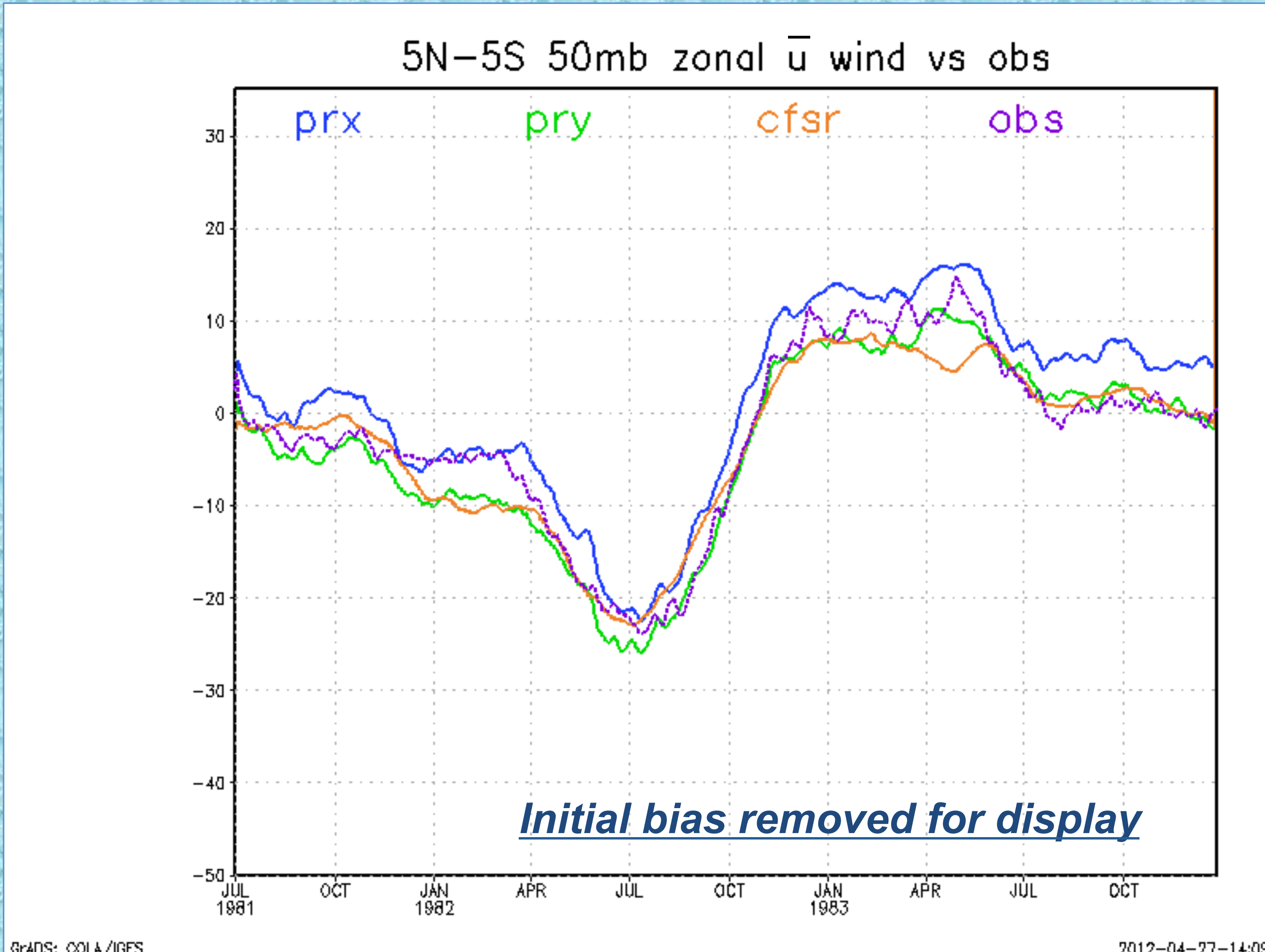
5N-5S 30mb zonal ū wind vs obs
prx
pry
cfsr
obs
30
20
10
0
-10
-20
-30
-40
-50
JUL 1981
OCT
JAN 1982
APR
JUL
OCT
JAN 1983
APR
JUL
OCT
GrADS: COLA/IGES
2012-04-22-04:30


5N-5S 30mb zonal ū wind vs obs
prx
pry
cfsr
obs
30
20
10
0
-10
-20
-30
-40
-50
JUL 1981
OCT
JAN 1982
APR
JUL
OCT
JAN 1983
APR
JUL
OCT
Initial bias removed for display
GrADS: COLA/IGES
2012-04-27-14:02

IC bias

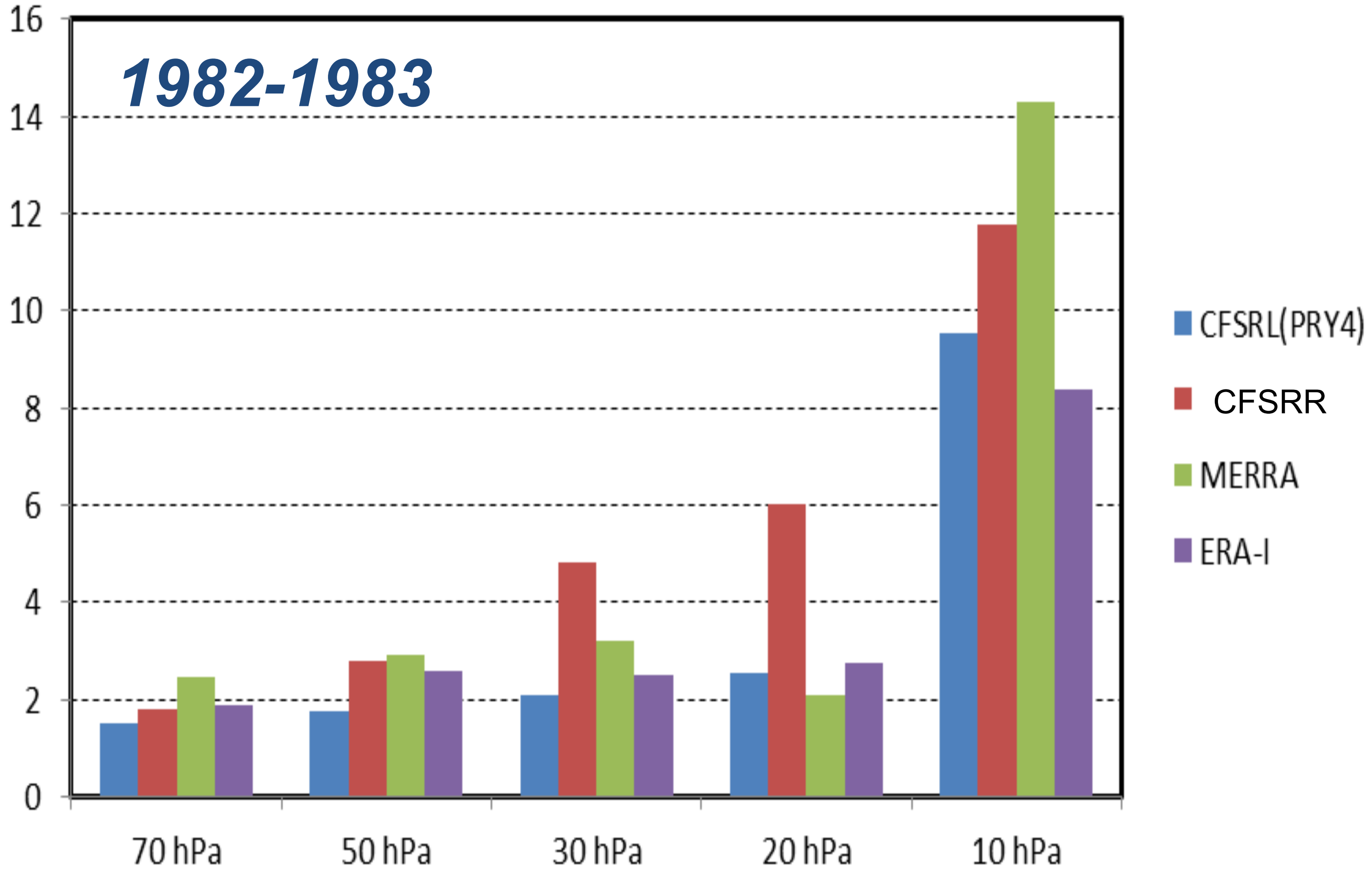


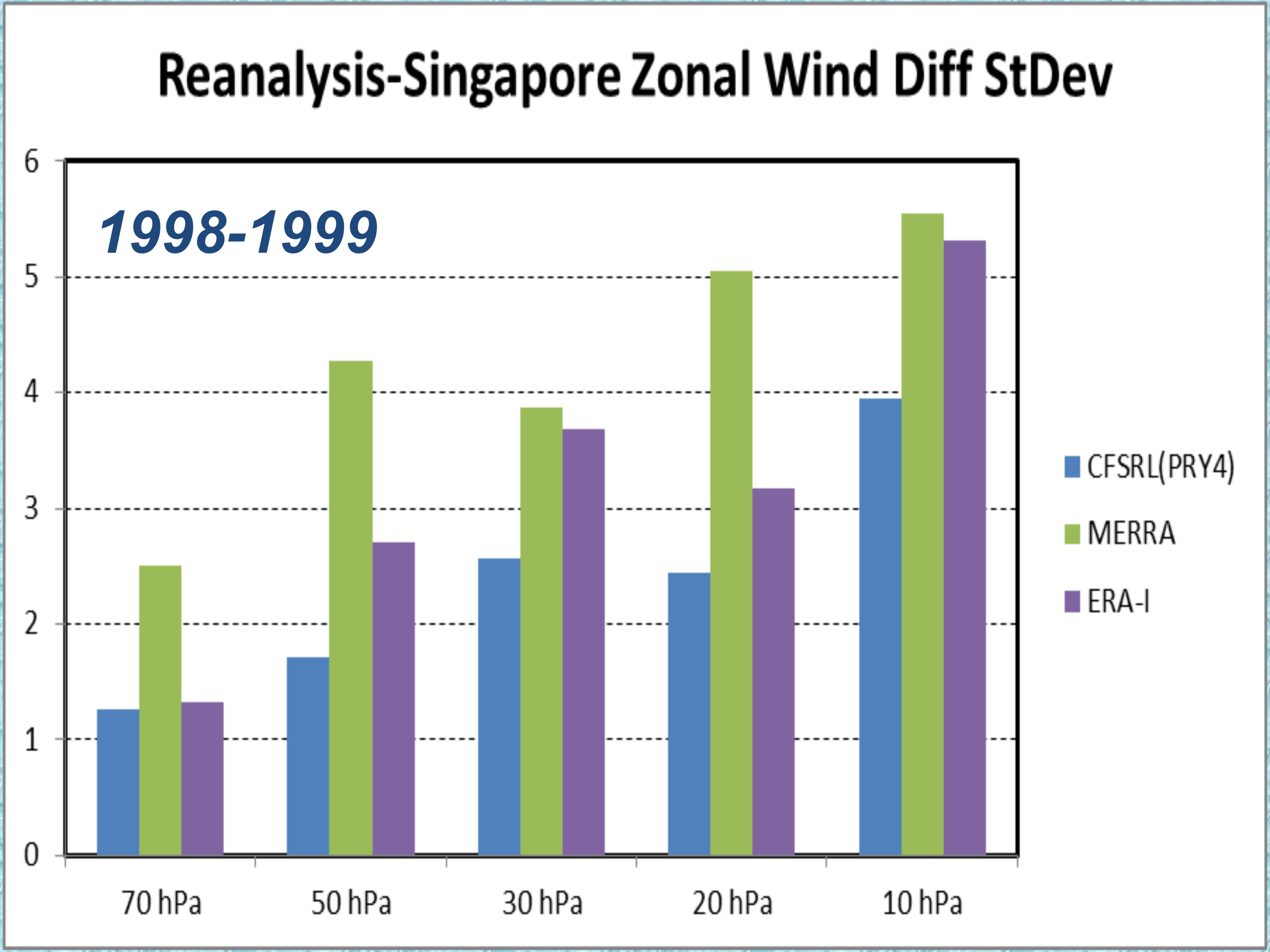
5N-5S 50mb zonal ū wind vs obs
prx
pry
cfsr
obs
30
20
10
0
-10
-20
-30
-40
-50
JUL 1981
OCT
JAN 1982
APR
JUL
OCT
JAN 1983
APR
JUL
OCT
GrADS: COLA/IGES
2012-04-22-04:30



Initial bias removed for display

Reanalysis-Singapore Zonal Wind Diff StDev




Reanalysis-Singapore Zonal Wind Diff StDev
1998-1999
6
5
4
3
2
1
0
70 hPa
50 hPa
30 hPa
20 hPa
10 hPa
CFSRL(PRY4)
MERRA
ERA-I

The End

Thanks!

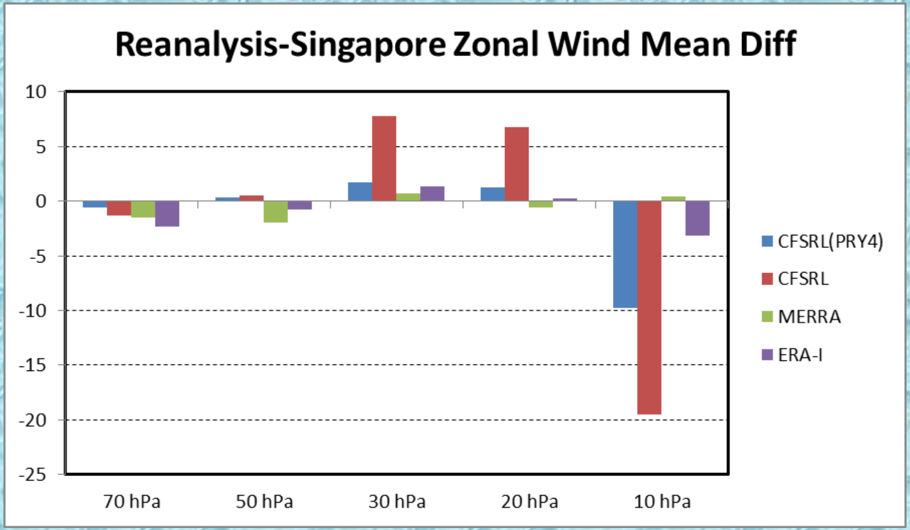
Some reference slides

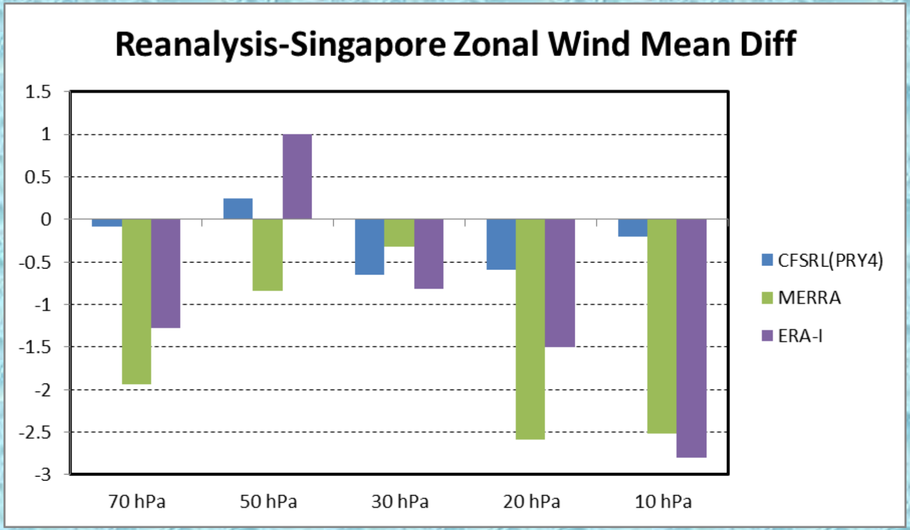
Reanalysis Comparisons with Singapore Winds

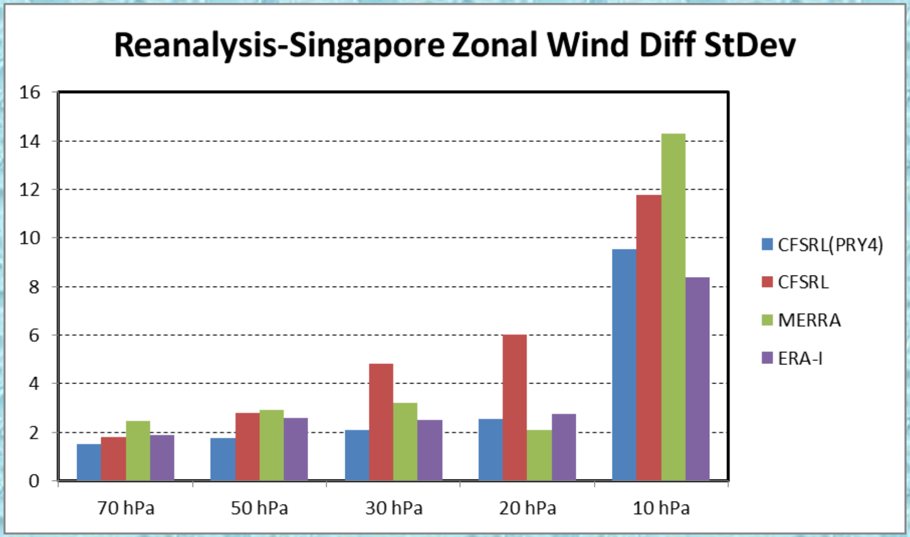
(Means Diff and Diff Variability)

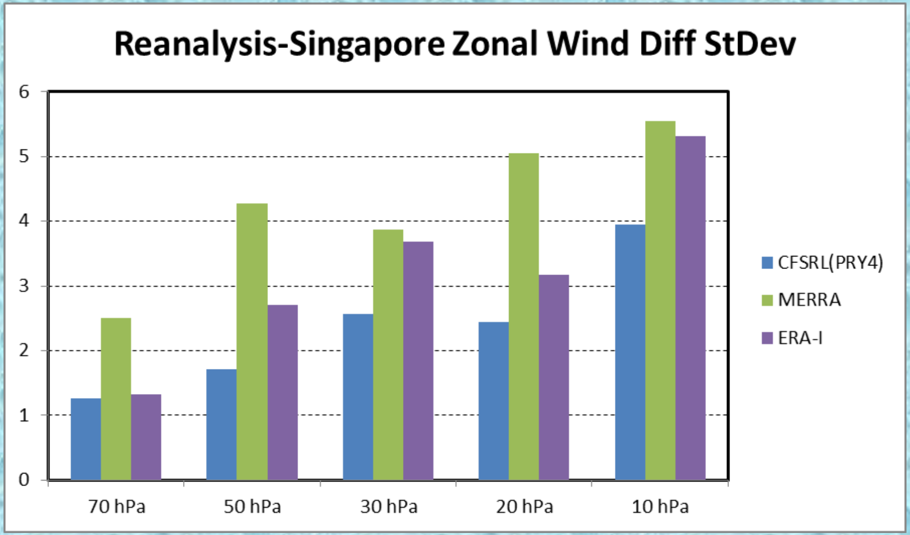
1982-1984

1998-1999









Adaptive RC procedure updated from R1 for CFSRL

Each month the composite (F-O) statistics for temperature are computed for each WMO block (01-99)

A profile of percentages of the (F-O) stats is defined as follows:
pob>=700 tfrac=0
pob==500 tfrac=.8*.333
pob==400 tfrac=.8*.666
pob< 400 tfrac=.8

A data density factor is defined: ddf=min(1,cnt/15)

A limiting factor is defined: abs(cor)<=tfrac*2.5

Next months corrections in each block is: cor=(F-O)*tfrac*ddf.

Finally the absolute value of the correction is limited to be <=tfrac*2.5.