The Experimental
Regional Seasonal Forecasting at NCEP

Hann-Ming Henry Juang

Environment Modeling Center, NCEP, Washington, DC

Jun Wang

SAIC contractor under NCEP/EMC

John Roads

Experimental Climate Prediction Center

Shyh Chen

US Forest Service

Contents

- Experimental routine RSF
  - Configurations
  - Verification and Applications
- Studies from RSF
  - Sensitivities related to cycle, ic, bc, regimes etc
  - Speedup model and Ensemble sizes

First Experiment Setup

- NCEP Regional Spectral Model

  Run NSM: (GSM + RSM)

  GSM: T62L28

  RSM: 2000 version, 1D MPI, 60km, 28levels over US continental

- Hindcast - (1982-2004)

  Run 4 month 1 member forecast for each month (23 years)

  Initial conditions: 00Z on the first day of each month, from reanalysis-II

  Boundary condition: observational SST

- Forecast- (Nov 2002 - Sept 2004)

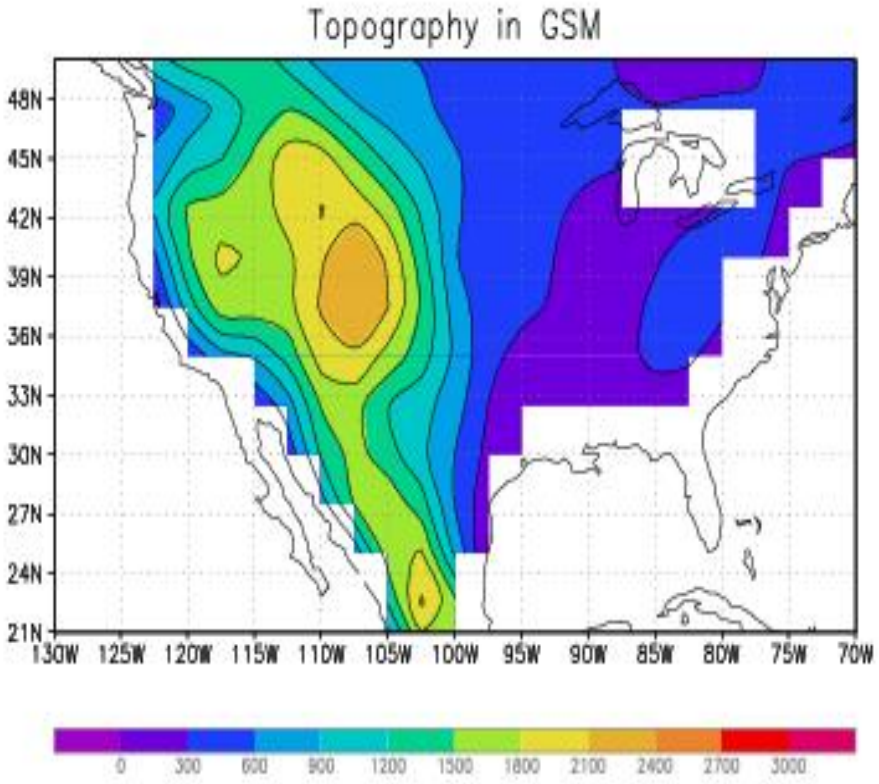
  Run 4 month 5 member ensemble forecast for each month from Nov 2002-Sept 2004

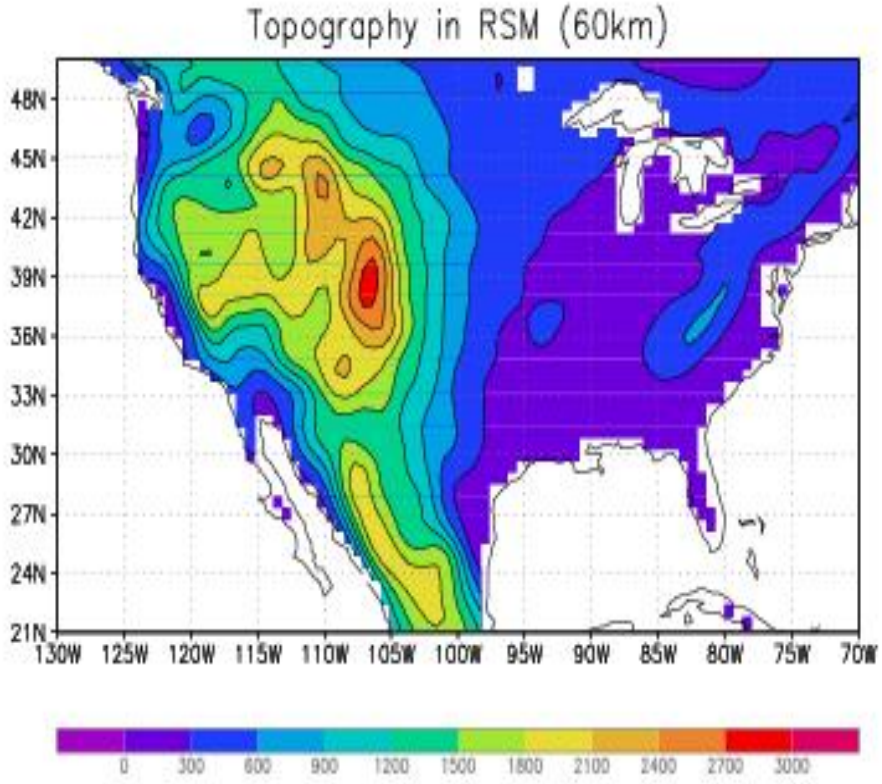
  Initial conditions: 00Z on the last two days of previous month and the first three days of current month

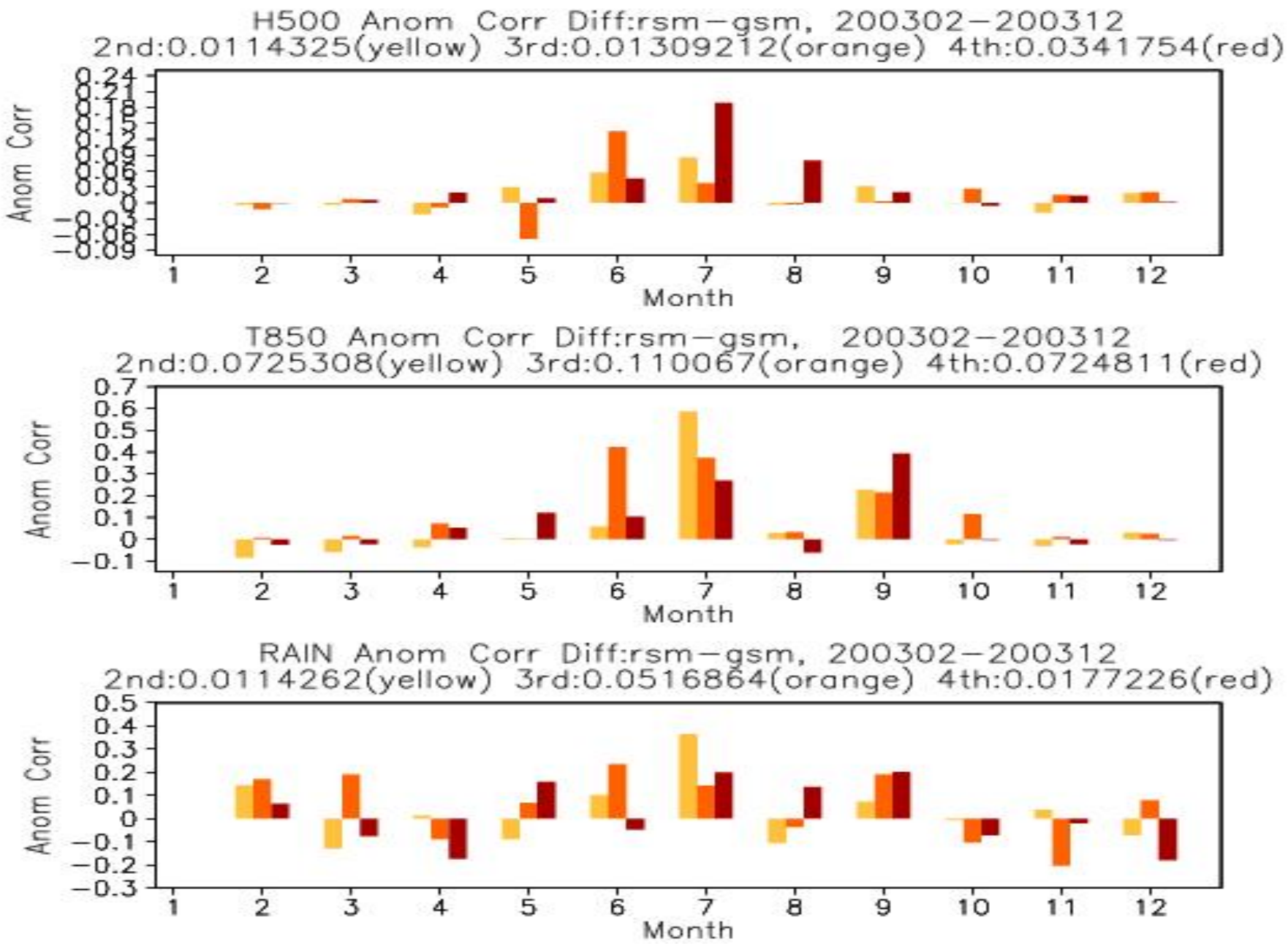
  Boundary condition: forecasted SST

Experiment Setup (Continued)

- Domain






H500 Anom Corr Diff:rsm−gsm, 200302−200312
2nd:0.0114325(yellow) 3rd:0.01309212(orange) 4th:0.0341754(red)
Anom Corr
Month
T850 Anom Corr Diff:rsm−gsm, 200302−200312
2nd:0.0725308(yellow) 3rd:0.110067(orange) 4th:0.0724811(red)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
Anom Corr
1 2 3 4 5 6 7 8 9 10 11 12
Month
RAIN Anom Corr Diff:rsm−gsm, 200302−200312
2nd:0.0114262(yellow) 3rd:0.0516864(orange) 4th:0.0177226(red)
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
Anom Corr
1 2 3 4 5 6 7 8 9 10 11 12
Month

Second Experiment Setup

- NCEP Regional Spectral Model

  Run NSM: (GSM + RSM)

  GSM: CFS2003 T62L28

  RSM: 2004 version, 2D MPI, 50km, 28levels over US continental (CONUS)

- Hindcast - (1982-2001)

  Run 7 month 3 member ensemble forecast for each month (20 years)

  Initial conditions: 00Z on the last day of the previous month and first two days of current month, from reanalysis-II

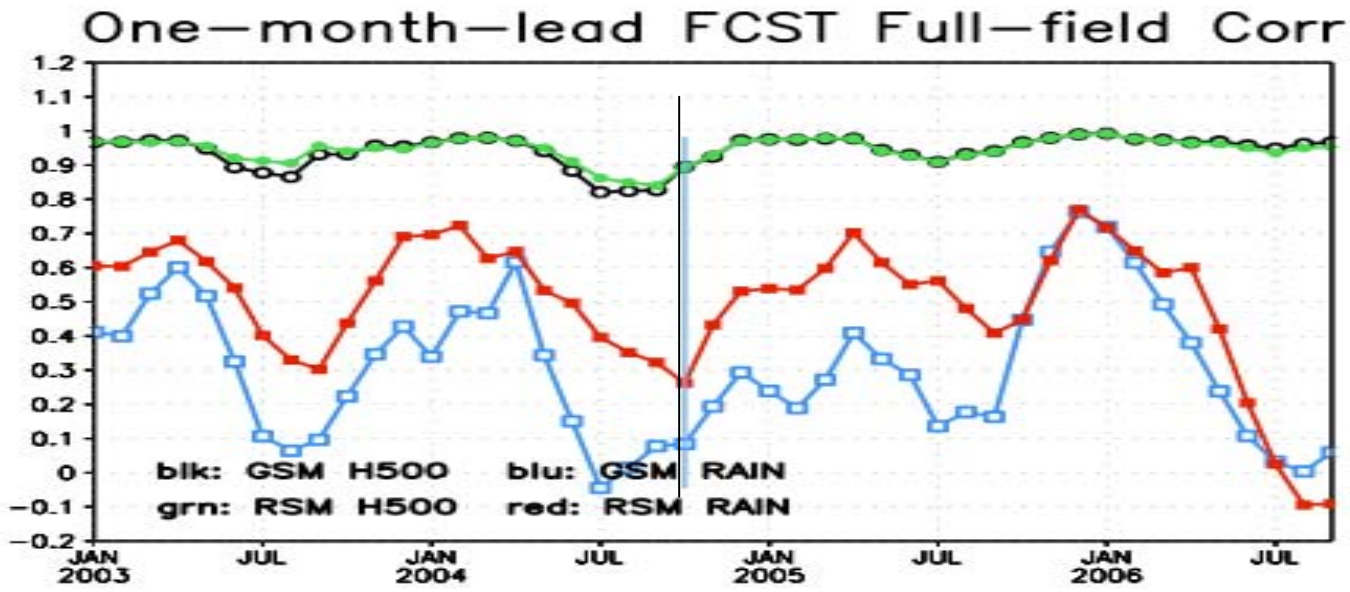
  Boundary condition: forecasted SST from CFS

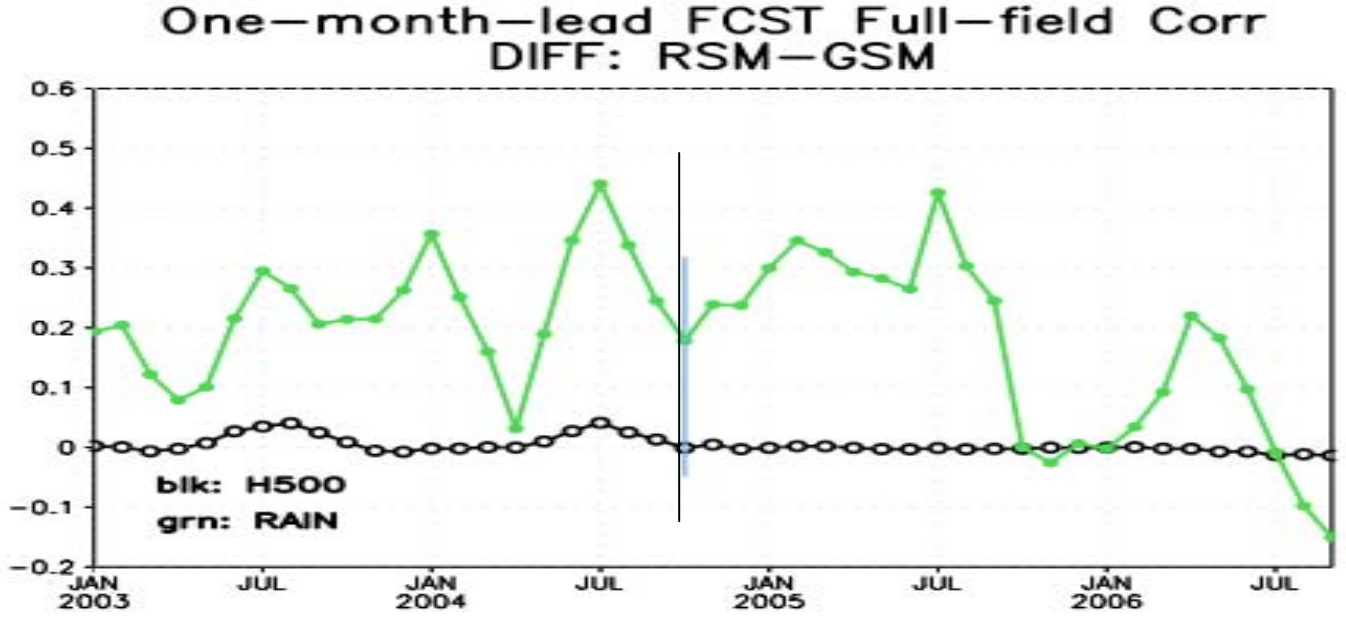
- Forecast- (Oct 2004 - current)

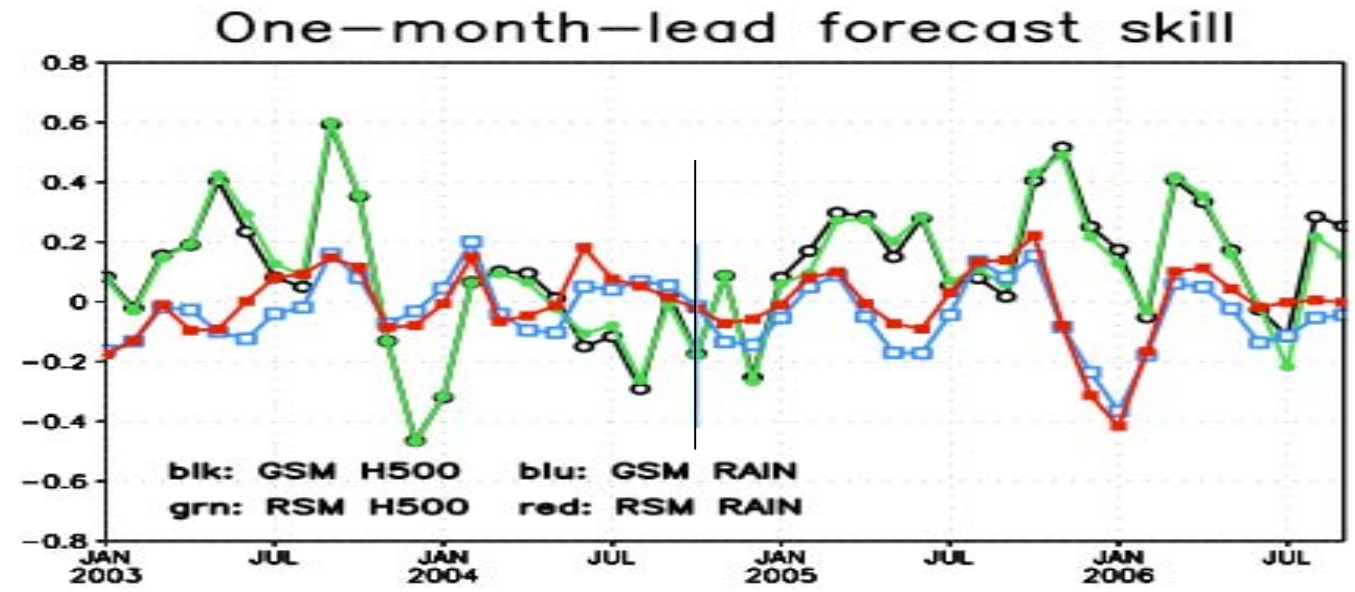
  Run 7 month 10 member ensemble forecast for each month

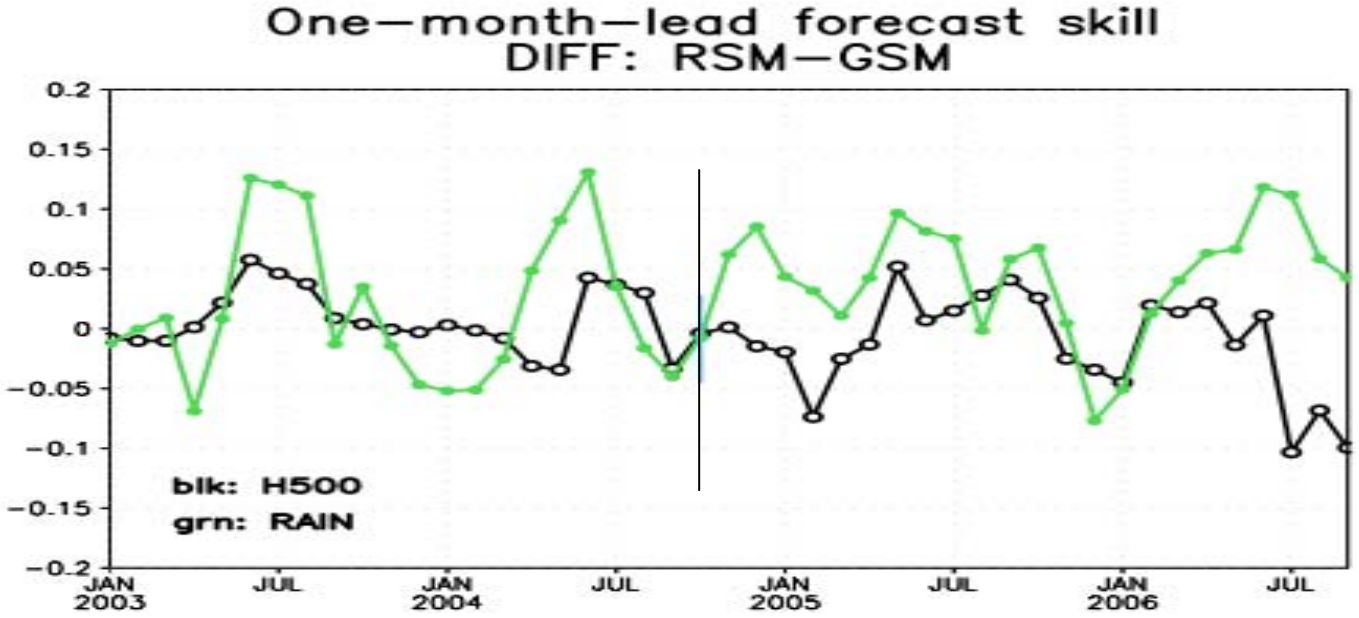
  Initial conditions: 00Z and 12Z on the last two days of previous month and the first three days of current month

  Boundary condition: forecasted SST from CFS


One−month−lead FCST Full−field Corr
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
blk: GSM H500
blu: GSM RAIN
grn: RSM H500
red: RSM RAIN
JAN 2003
JUL
JAN 2004
JUL
JAN 2005
JUL
JAN 2006
JUL

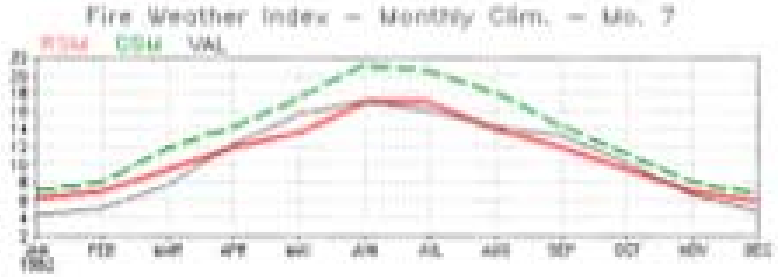

One−month−lead FCST Full−field Corr
DIFF: RSM−GSM
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
blk: H500
grn: RAIN
JAN 2003
JUL
JAN 2004
JUL
JAN 2005
JUL
JAN 2006
JUL

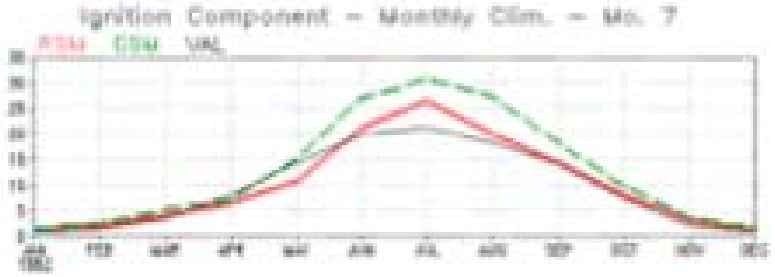

One−month−lead forecast skill
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
blk: GSM H500
blu: GSM RAIN
grn: RSM H500
red: RSM RAIN
JAN 2003
JUL
JAN 2004
JUL
JAN 2005
JUL
JAN 2006
JUL

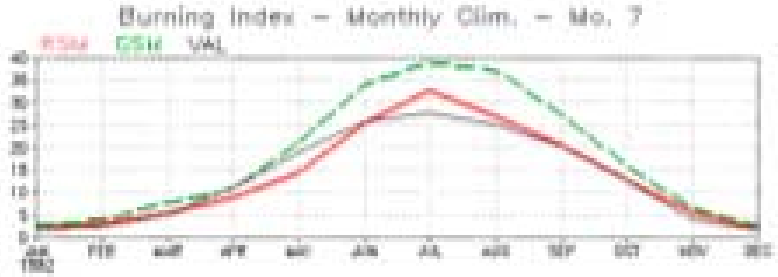

One−month−lead forecast skill
DIFF: RSM−GSM
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
blk: H500
grn: RAIN
JAN 2003
JUL
JAN 2004
JUL
JAN 2005
JUL
JAN 2006
JUL

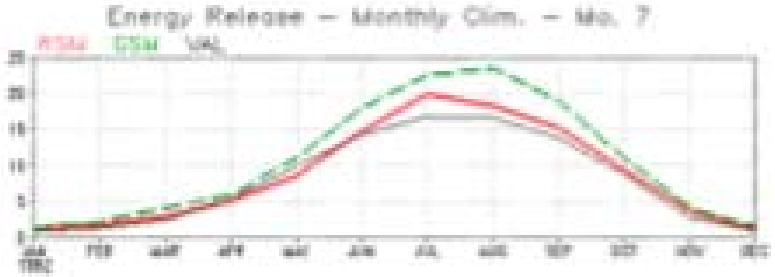
Applications

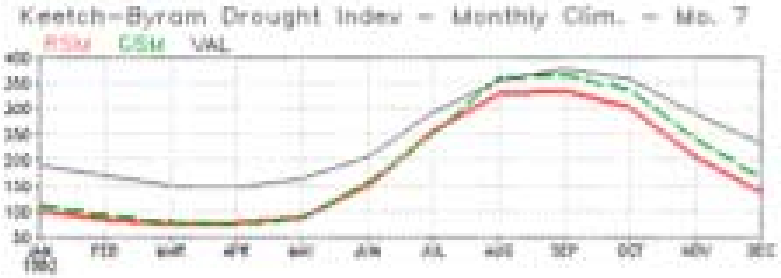
- This experimental regional seasonal forecast is to support a project for downscaling on fire danger seasonal forecast.
- Though the downscaling scores are not impressive, the regional model results are better than global model results

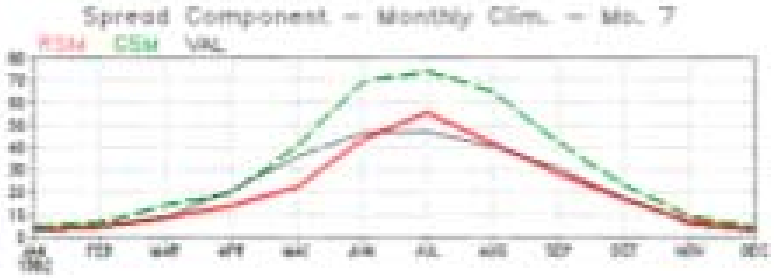

Fire Weather Index – Monthly Clim. – Mo. 7
RSM
GSM
VAL


Ignition Component – Monthly Clim. – Mo. 7
RSM
GSM
VAL


Burning Index – Monthly Clim. – Mo. 7
RSM
GSM
VAL


Energy Release – Monthly Clim. – Mo. 7
RSM
GSM
VAL

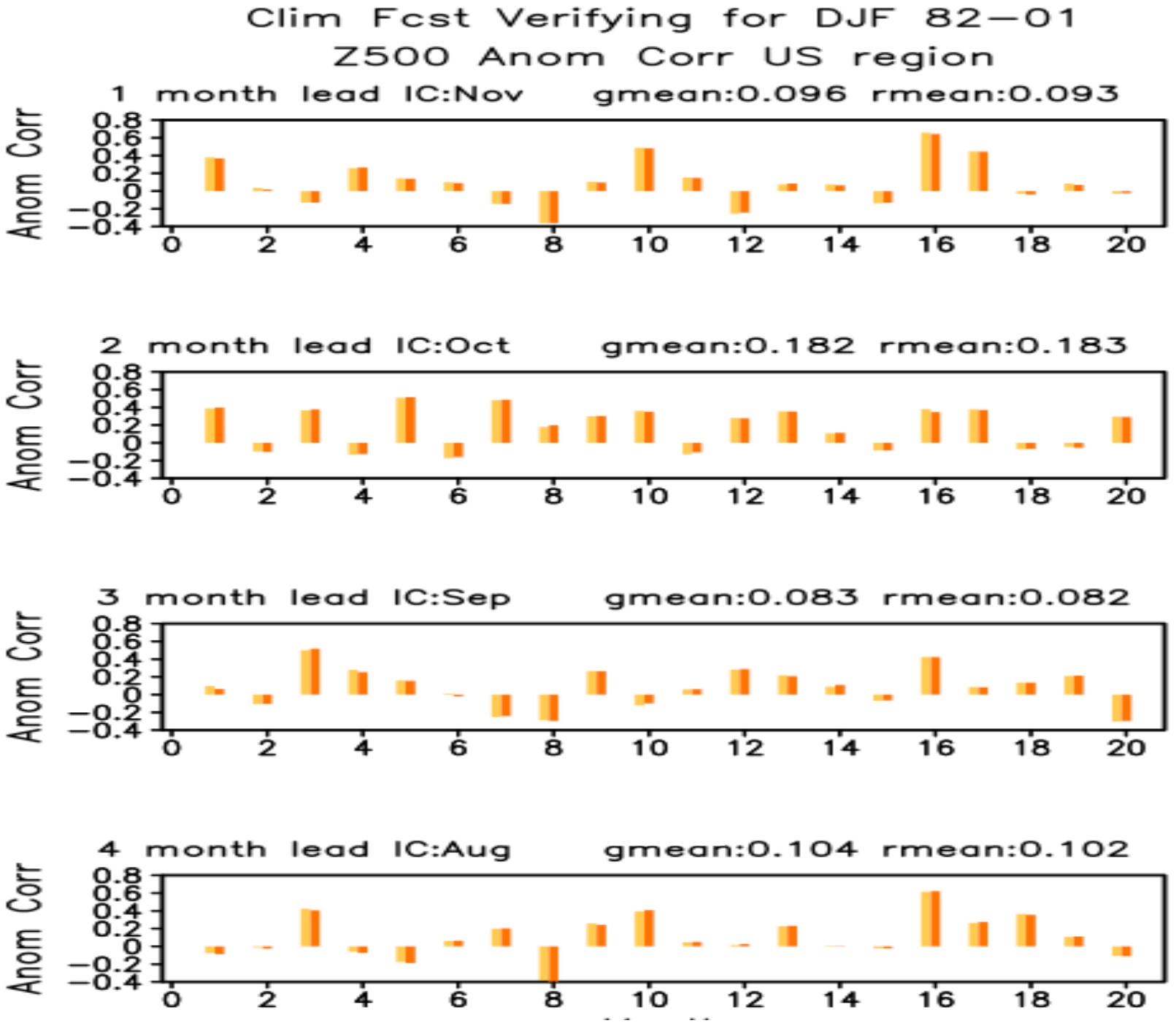

Keetch-Byram Drought Index – Monthly Clim. – Mo. 7
RSM
GSM
VAL


Spread Component – Monthly Clim. – Mo. 7
RSM
GSM
VAL

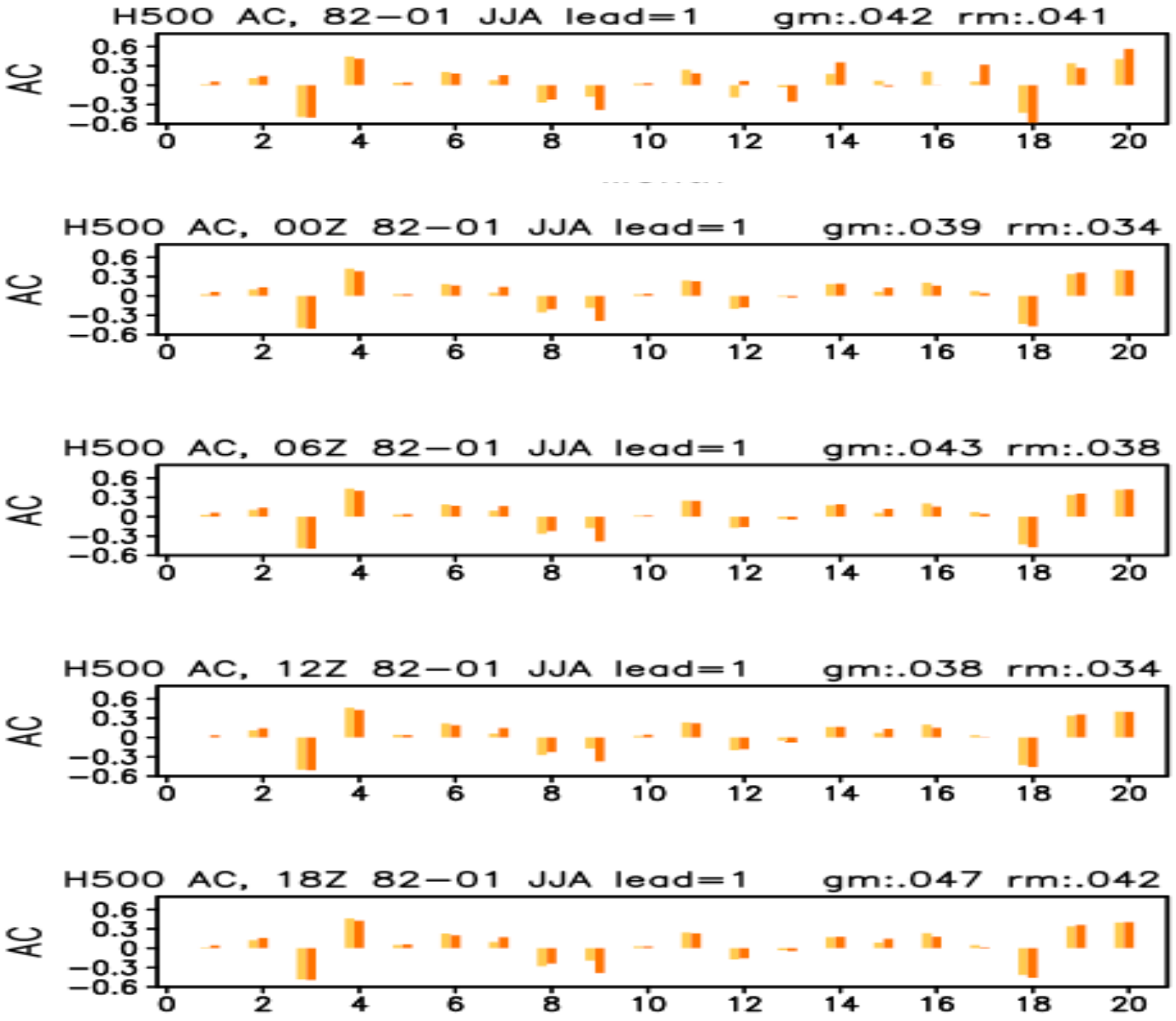
Analyzing and sensitivities

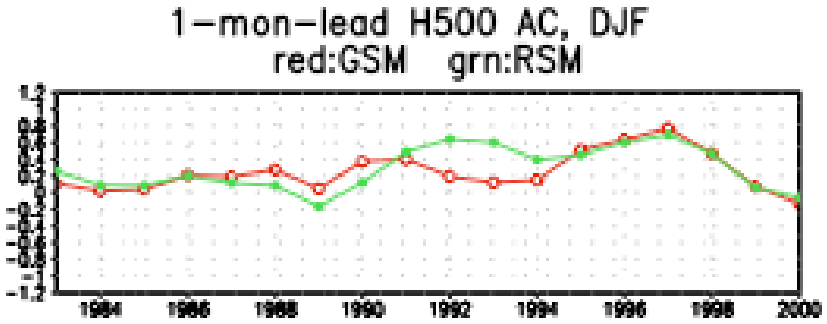
- Effect of initial conditions
  - Different month lead
- Effect of diurnal cycle
  - 4 different cycles
- Different regions
  - Eastern, mid-west, mountain and pacific coast.
- Effect of boundary conditions
  - Best boundary condition
  - Spread in boundary condition
- Effect of mean bias removal

IC

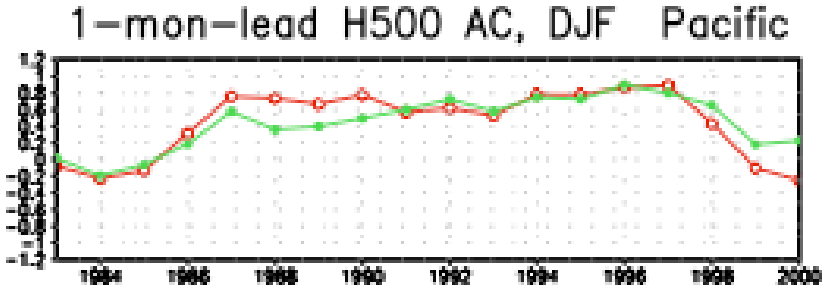

Clim Fcst Verifying for DJF 82—01
Z500 Anom Corr US region
1 month lead IC:Nov gmean:0.096 rmean:0.093
2 month lead IC:Oct gmean:0.182 rmean:0.183
3 month lead IC:Sep gmean:0.083 rmean:0.082
4 month lead IC:Aug gmean:0.104 rmean:0.102
Anom Corr
0.8
0.6
0.4
0.2
0
−0.2
−0.4
0 2 4 6 8 10 12 14 16 18 20

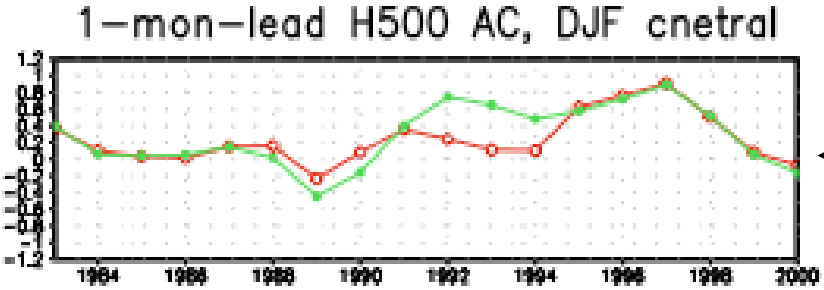
DC

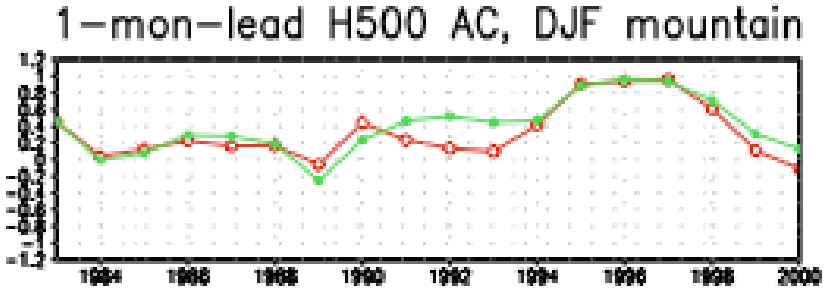

H500 AC, 82–01 JJA lead=1 gm:.042 rm:.041
H500 AC, 00Z 82–01 JJA lead=1 gm:.039 rm:.034
H500 AC, 06Z 82–01 JJA lead=1 gm:.043 rm:.038
H500 AC, 12Z 82–01 JJA lead=1 gm:.038 rm:.034
H500 AC, 18Z 82–01 JJA lead=1 gm:.047 rm:.042
AC
0.6
0.3
0
−0.3
−0.6
0
2
4
6
8
10
12
14
16
18
20

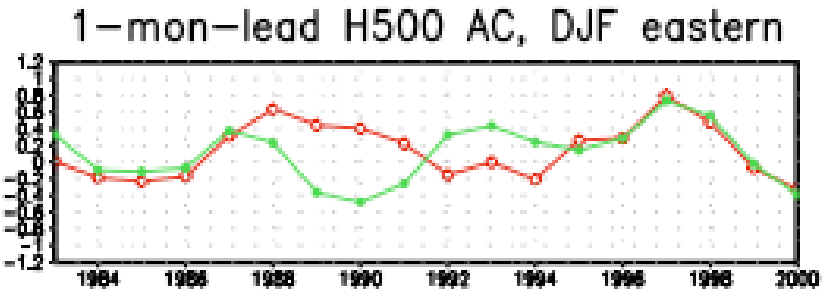


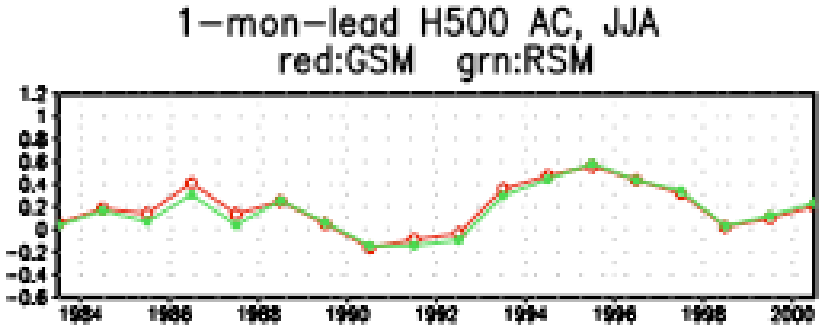
H500 AC winter



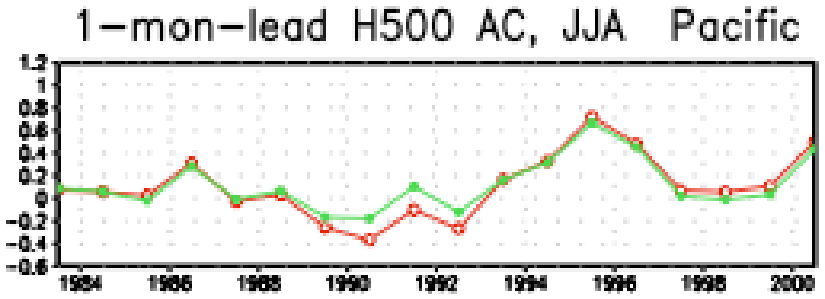


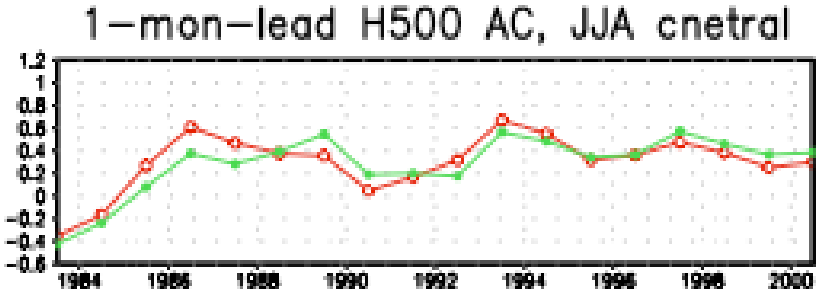


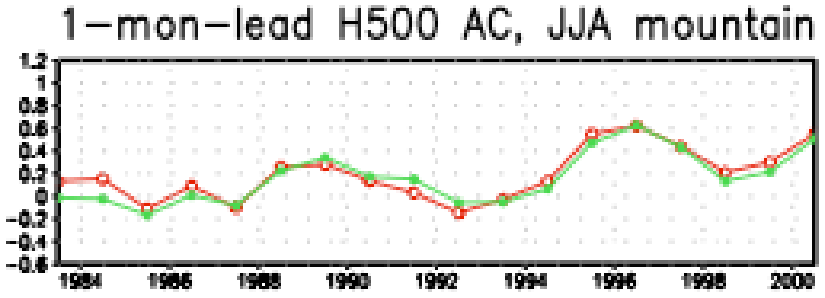


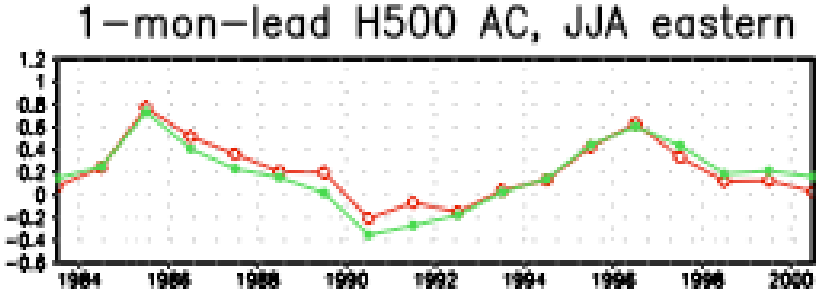


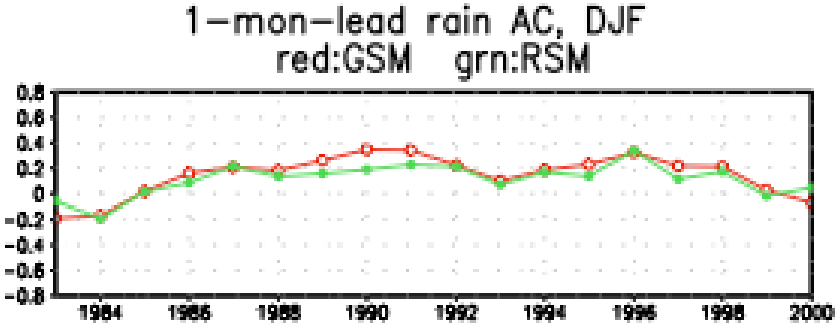
H500 AC summer



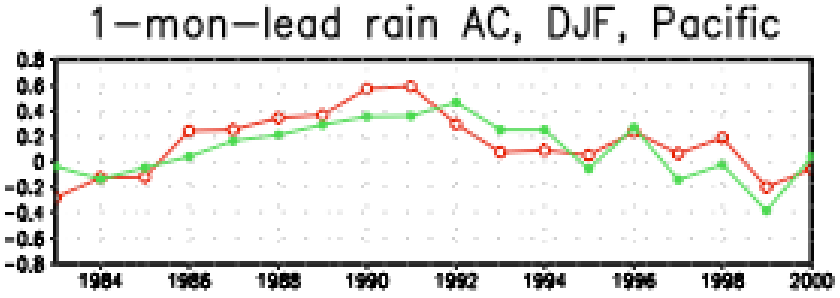


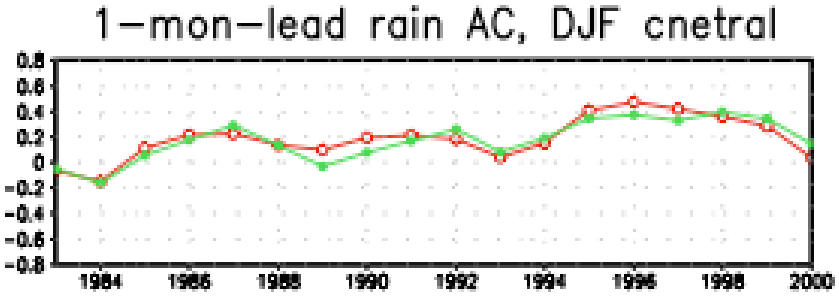


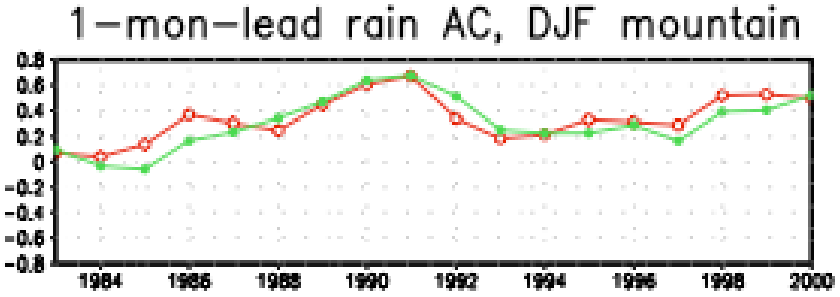


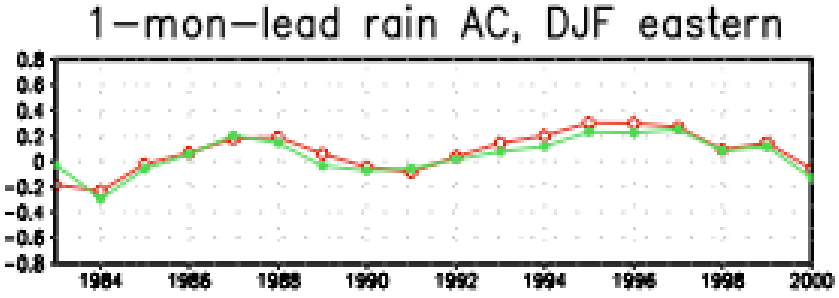


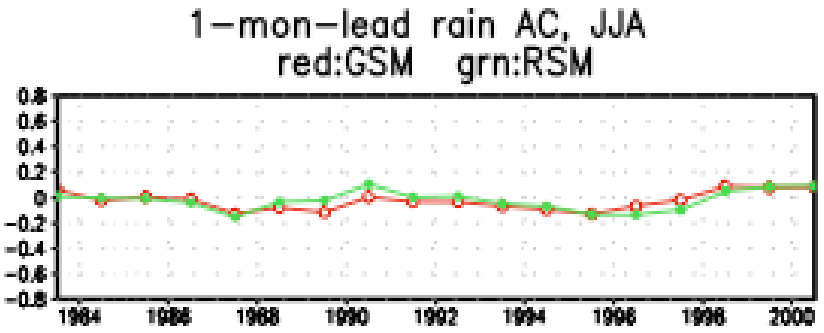
Rain AC winter



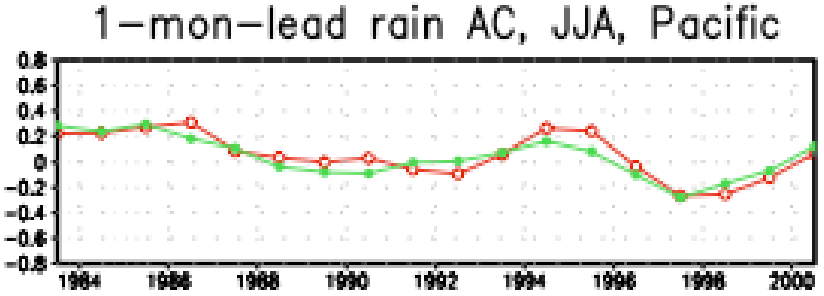


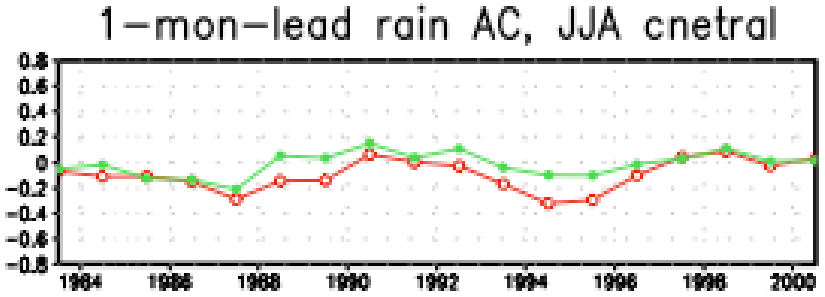


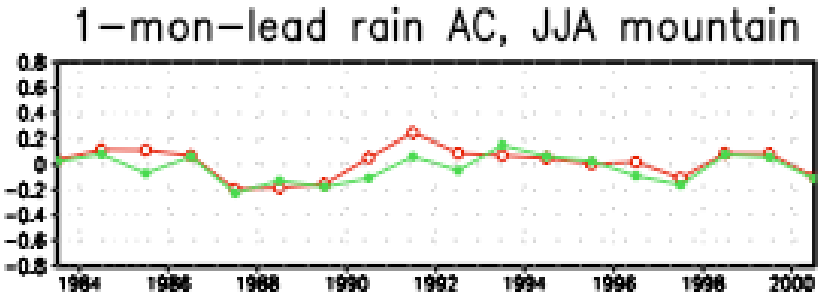


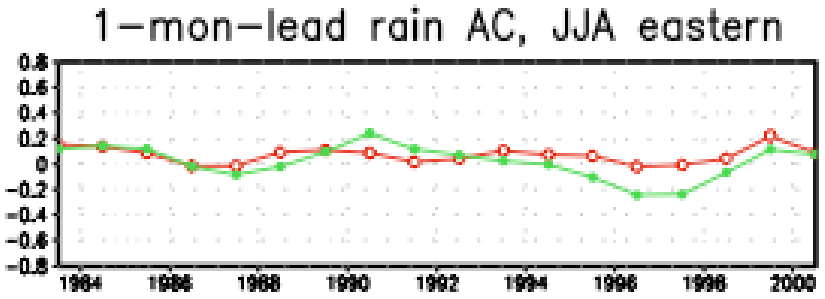


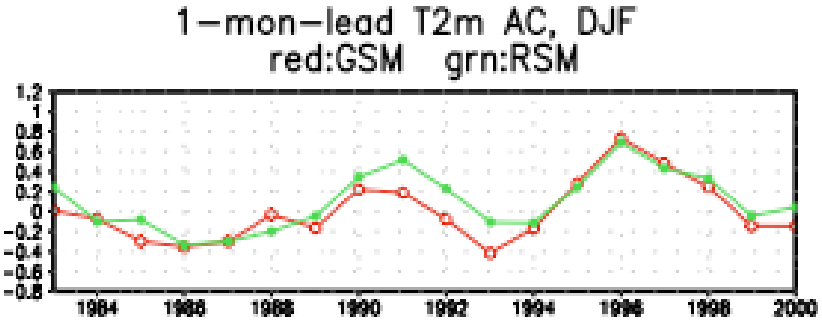
Rain AC summer



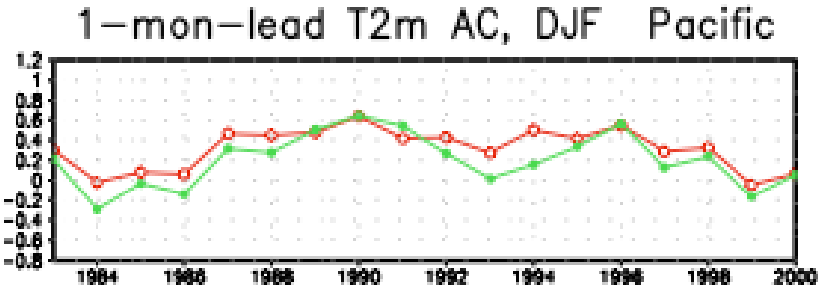


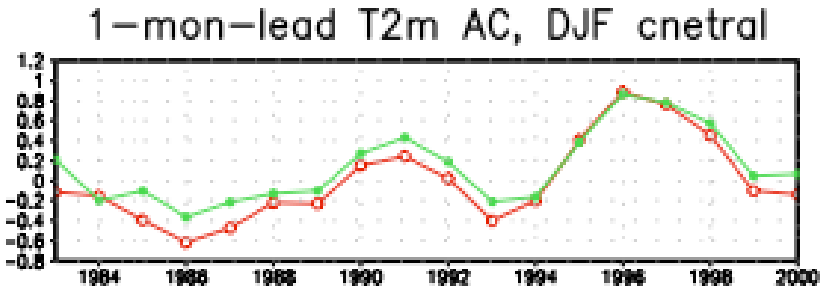


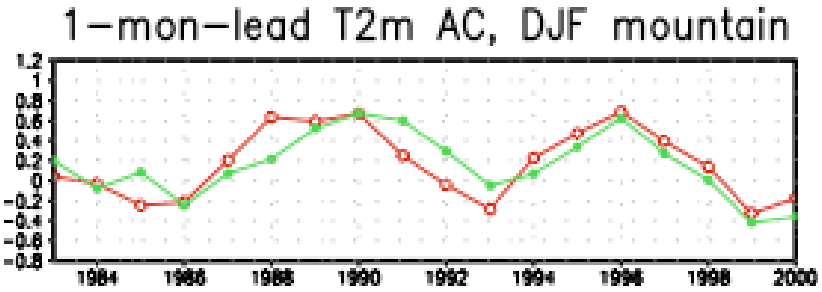


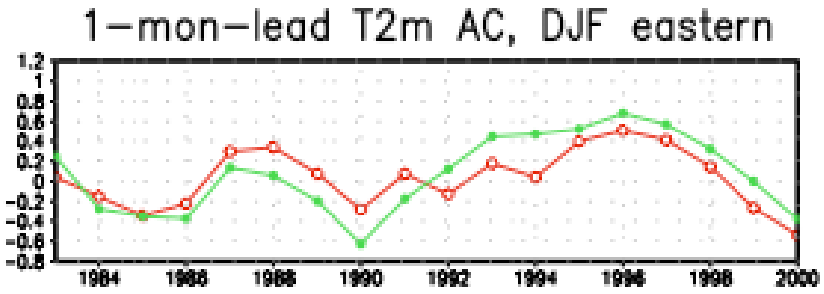


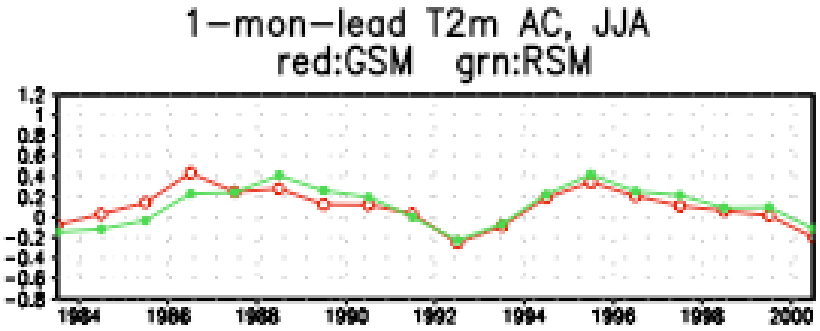
T2m AC winter



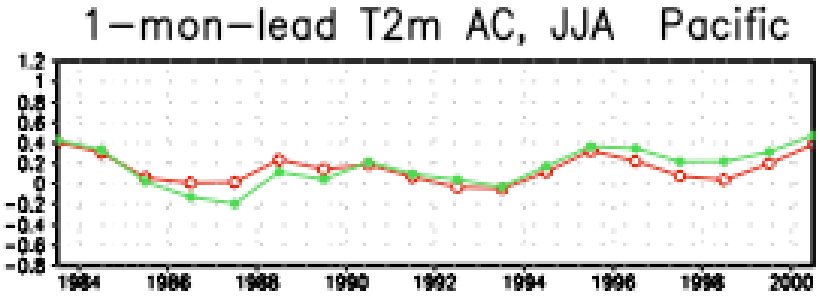


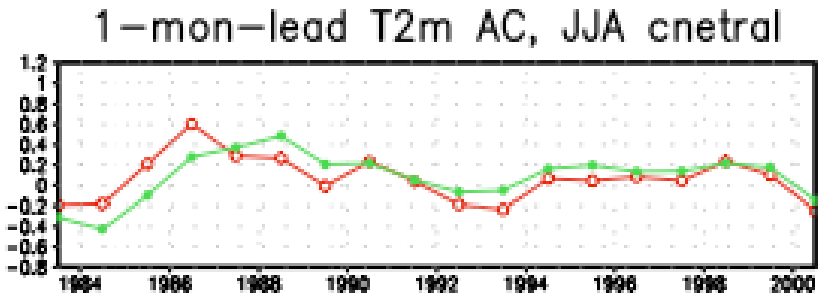




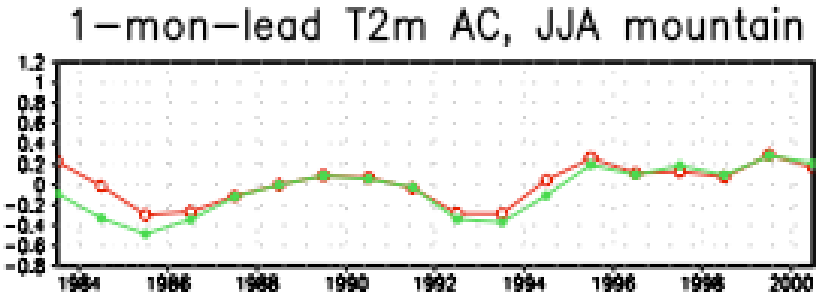


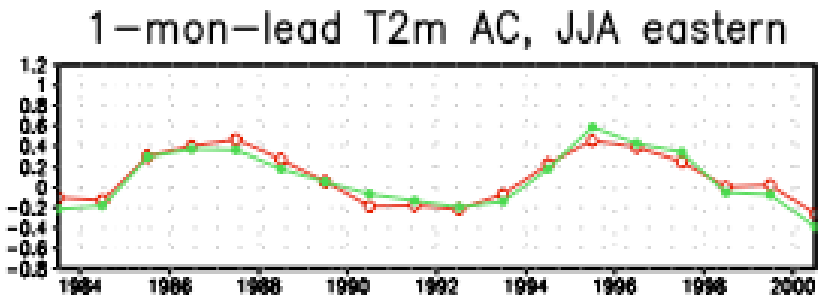
T2m AC summer





←





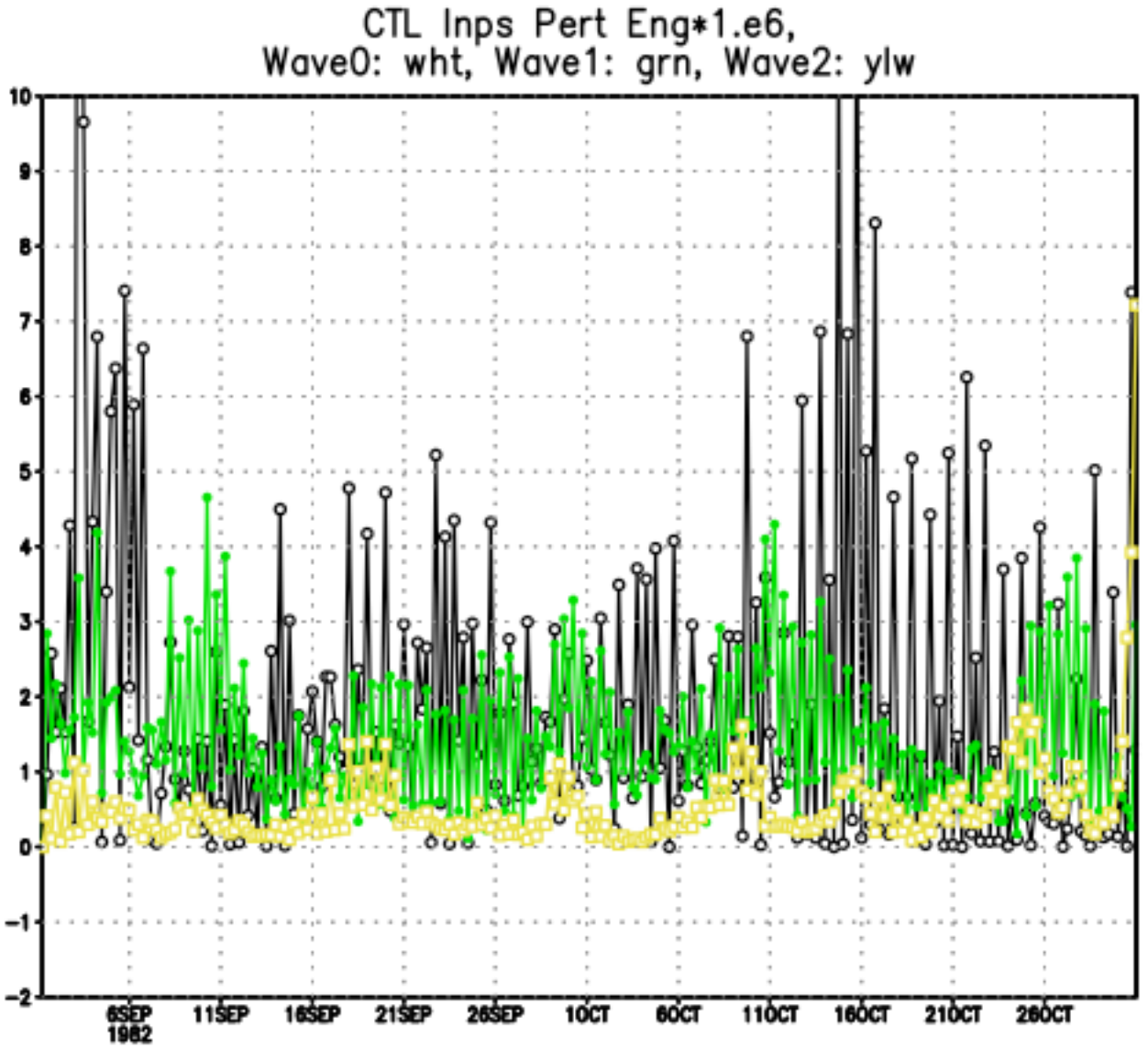
✓

Note for hindcast studies

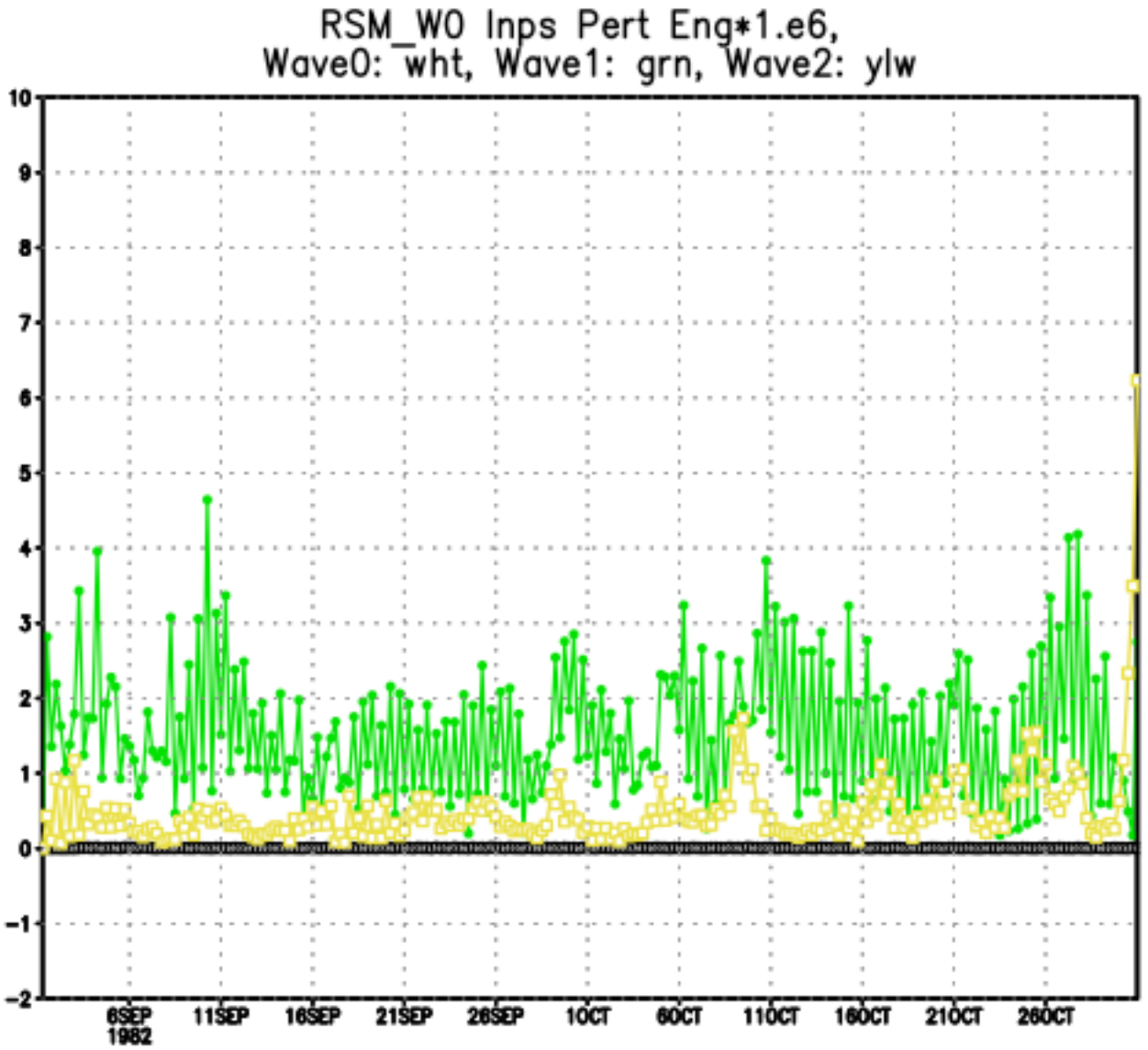
- There is no consistent results on
  - Different initial condition (but two month lead is better in general)
  - Different cycles
- RSM has better AC scores than GFS for all years.
  - H500: winter (central), summer (pacific)
  - Rain: winter (central), summer (central)
  - T2m: winter (central), summer (central area)
- Forecast period shows summer is better than winter, which is not completely right, since different year has different results, due to climate regimes.

Mean Bias Correction

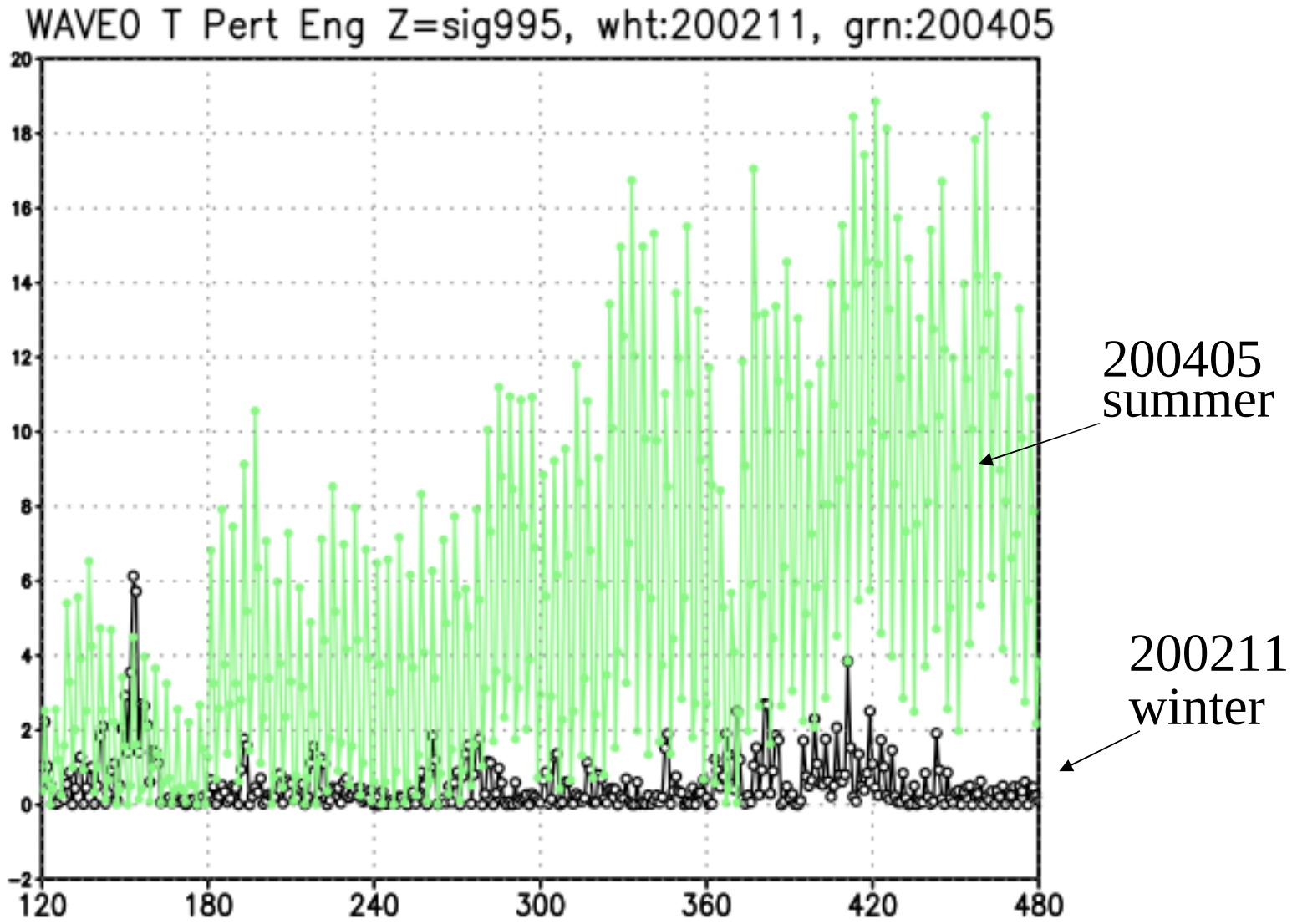
- It is found that there are some systematic difference between RSM forecasted large scale fields and global background fields.
- Since RSM use spectral filter to have perturbation, questions:
  - is the differences related to mean perturbation?
  - Can the systematic difference be corrected by removal of mean perturbation?

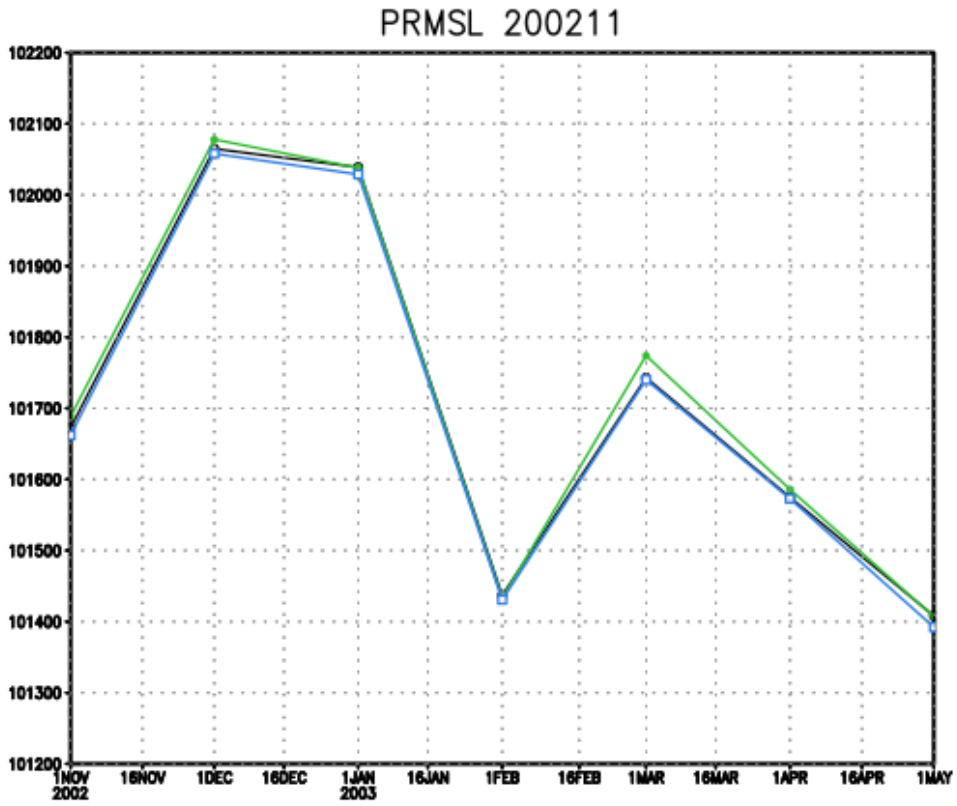

CTL Inps Pert Eng*1.e6,
Wave0: wht, Wave1: grn, Wave2: ylw
10
9
8
7
6
5
4
3
2
1
0
−1
−2
6SEP
1982
11SEP
16SEP
21SEP
26SEP
1OCT
6OCT
11OCT
16OCT
21OCT
26OCT

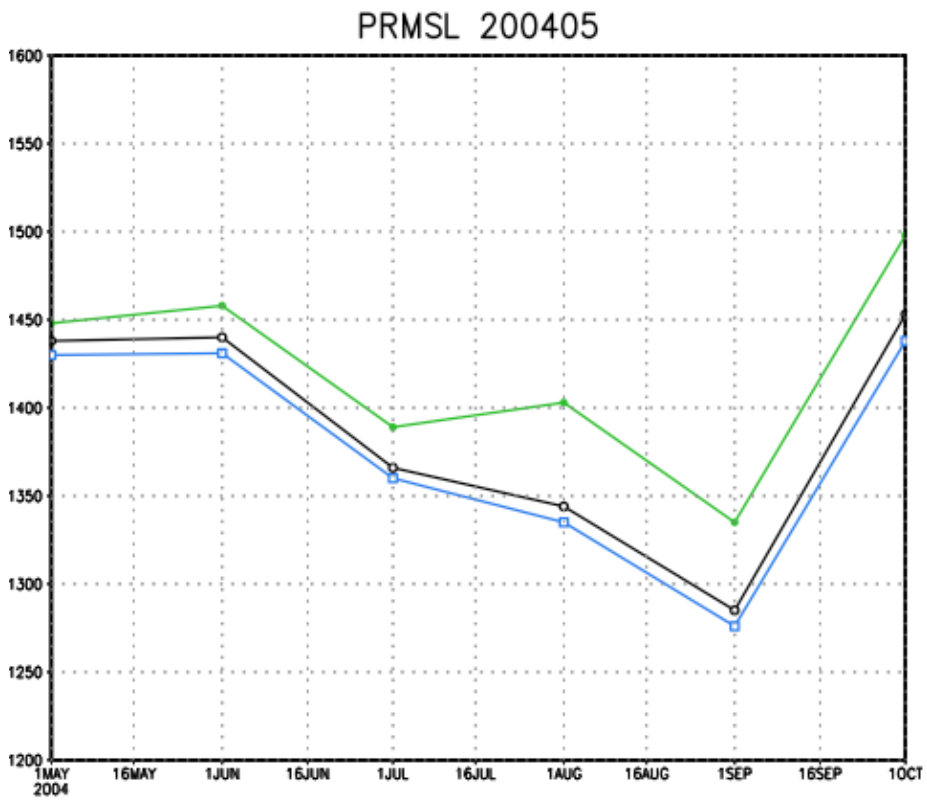
Sep - Oct 1982


RSM_W0 Inps Pert Eng*1.e6,
Wave0: wht, Wave1: grn, Wave2: ylw
10
9
8
7
6
5
4
3
2
1
0
-1
-2
6SEP
1982
11SEP
16SEP
21SEP
26SEP
1OCT
6OCT
11OCT
16OCT
21OCT
26OCT

Sep - Oct 1982


WAVE0 T Pert Eng Z=sig995, wht:200211, grn:200405
20
18
16
14
12
10
8
6
4
2
0
-2
120
180
240
300
360
420
480
200405
summer
200211
winter

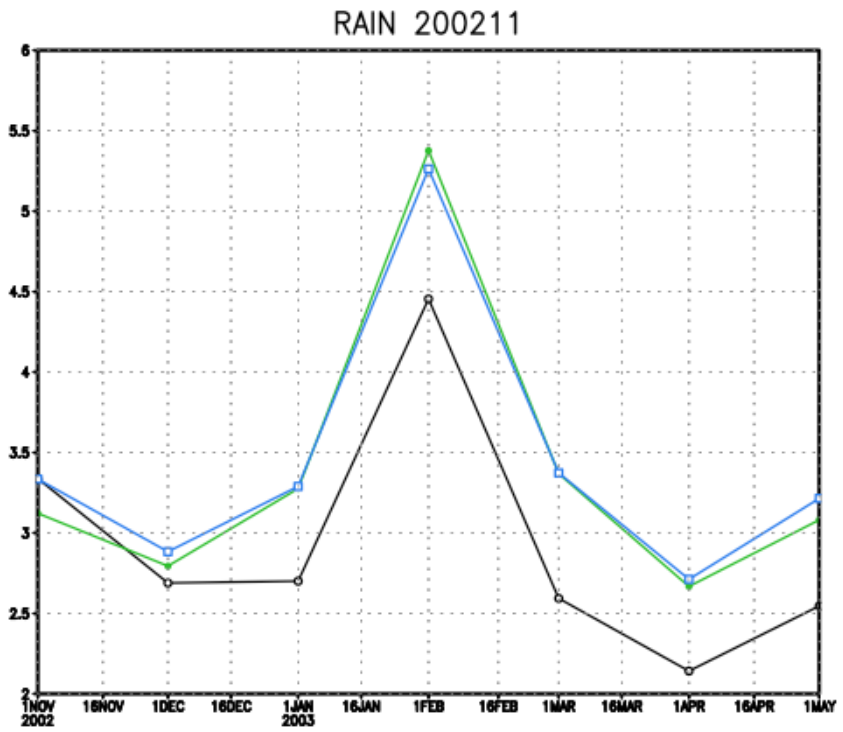


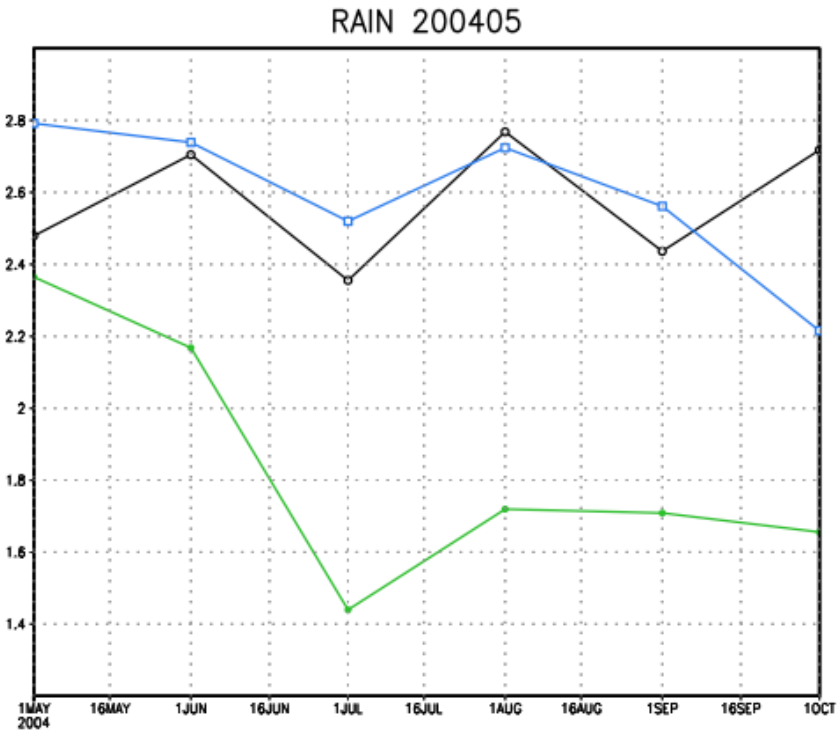


winter

summer

Black: GFS
Green : RSM
Blue : RSM-w0

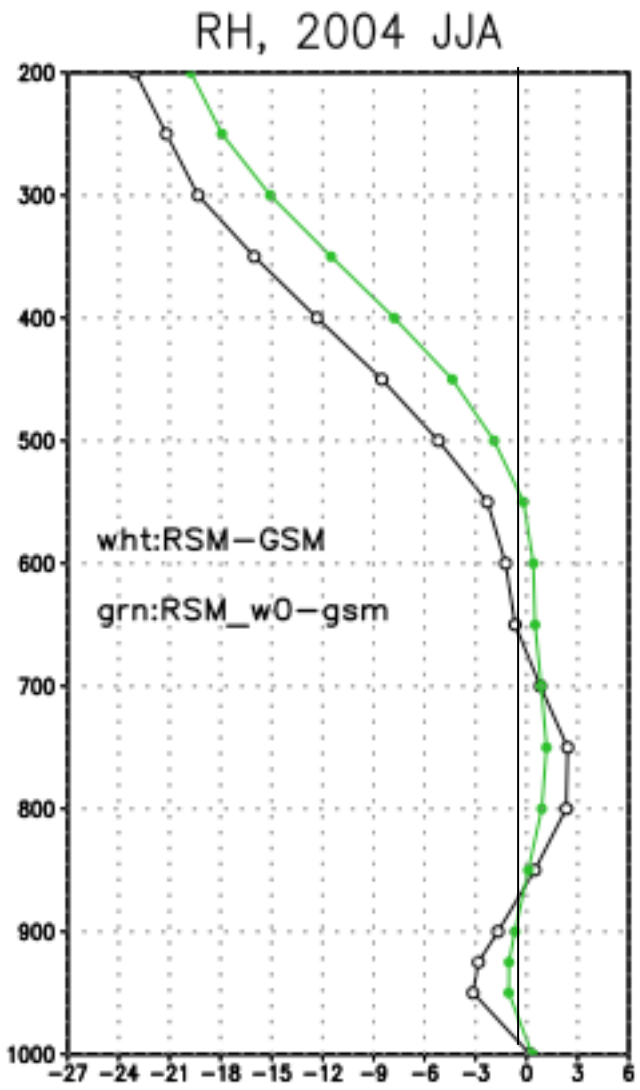


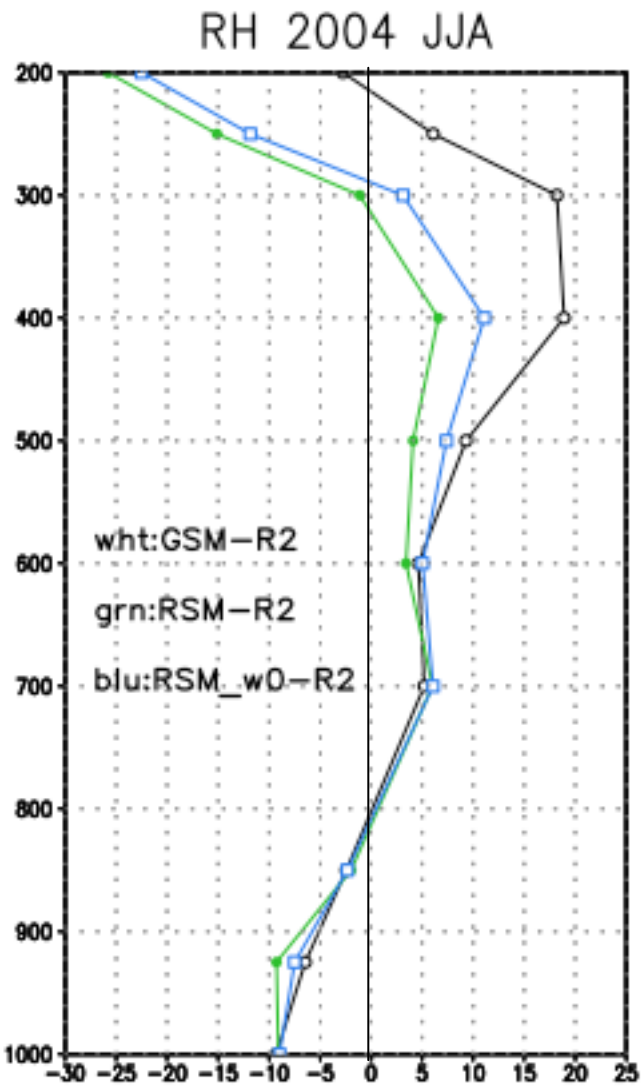


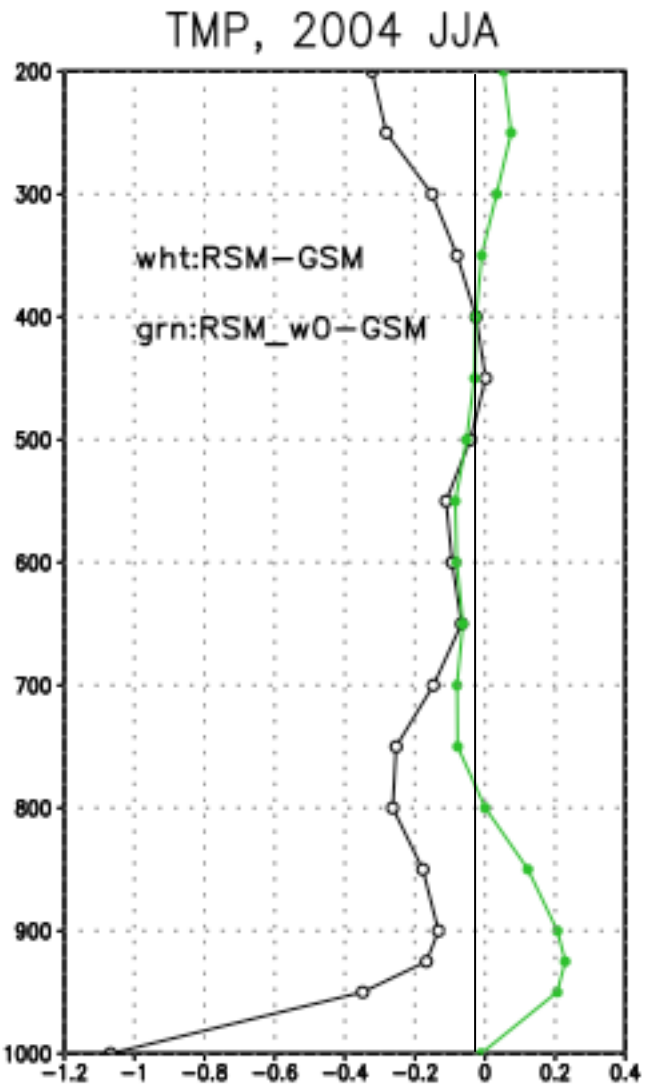
winter

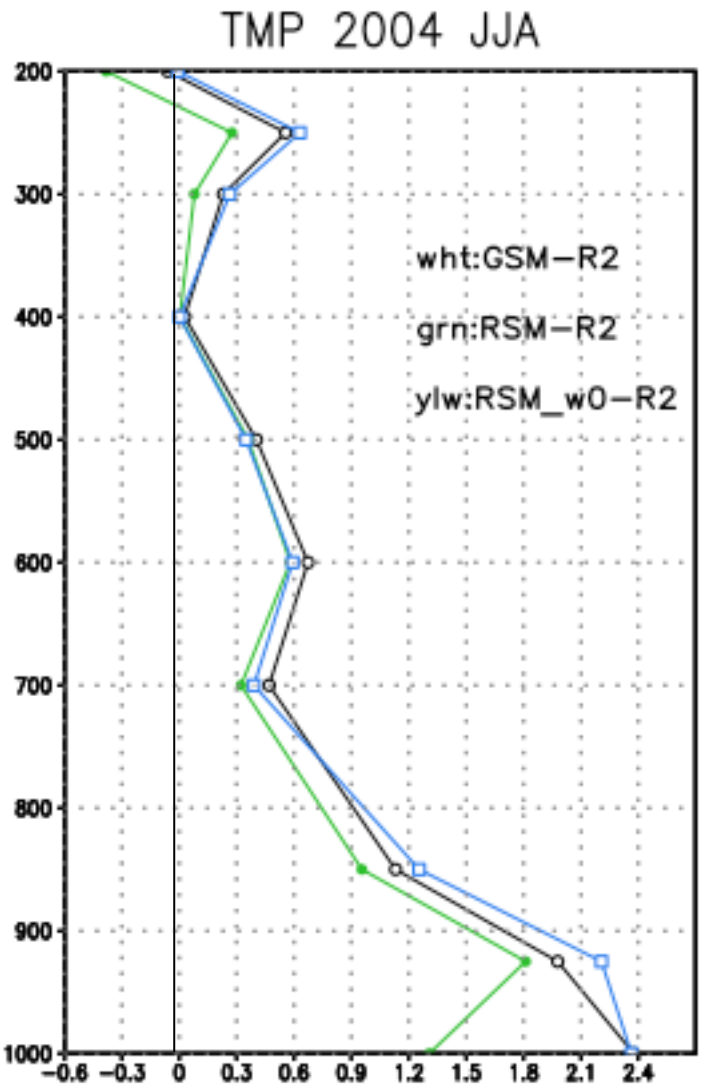
summer

Black : GFS
Green : RSM
Blue : RSM-w0


RH, 2004 JJA
wht:RSM−GSM
grn:RSM_w0−gsm
200
300
400
500
600
700
800
900
1000
−27 −24 −21 −18 −15 −12 −9 −6 −3 0 3 6


RH 2004 JJA
wht:GSM−R2
grn:RSM−R2
blu:RSM_w0−R2
200
300
400
500
600
700
800
900
1000
−30 −25 −20 −15 −10 −5 0 5 10 15 20 25


TMP, 2004 JJA
wht:RSM−GSM
grn:RSM_w0−GSM
200
300
400
500
600
700
800
900
1000
−1.2
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4


TMP 2004 JJA
wht:GSM−R2
grn:RSM−R2
ylw:RSM_w0−R2
200
300
400
500
600
700
800
900
1000
−0.6
−0.3
0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4

Note to bias correction

- Winter time has more large scale which is represented well through RSM nesting method, but summer has more smaller/local scale which is ill-represented through RSM nesting, so mean bias correction influence more in summer, winter has no need to correct, or the mean error is negligible.
- After correction, RSM atmospheric profile closes to global, may not be good as approach to reanalysis as the one without correction.
- We believe bias correction should be done, but what correction should we do?
  - Removal of nesting error, sound reasonable, but not enough.
  - Add back of observation/analysis bias?
  - Use analysis corrected GSM for RSM?

Impact of ensemble size

- 3 hindcast members may not be enough to form climatology for ensemble forecast anomaly.
- Questions:

  How to design an effective ensemble system

  a. How many ensemble member is enough for regional climate forecast?

  b. How to choose initial condition?

  1.The impact of initial condition on climate forecast skill

  2. Large spread initial condition

  3. 00Z/12Z

Ensemble size experiment setup

Model: GSM+RSM

GSM: CFS2003 version run with T62L28

RSM: RSM2007 (after the speed up, managed by SVN) 45km, 28 levels

Domain: US continental

Hindcast

A 30-member ensemble of 4 month integration for 1982-2004

Initial Condition: 00Z and 12Z for Feb 09-13, Feb 19-23 and Last two day of Feb and the first three days of March

Boundary Condition: Forecasted SST from CFS

Forecast period: 4 month forecast from March to Jun

Experiment setup

member	30	15				10											5								3
Set #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

Initial conditions for experiments:

Exp 1: all 30 members

Exp 2-3: 00Z or 12Z from Feb09-13, Feb19-23, Feb27/28 Mar 1-3

Exp 4-5: mixed 00Z and 12Z from Feb09-13, Feb19-23, Feb27/28 Mar 1-3

Exp 6-8: choose every other 3 from 30 initial conditions

Exp 9-11: 00/12 Z from Feb09-13(exp9),Feb19-23(exp10) and Feb27/28&Mar1-3(exp11)

Exp 12-14:00Z from Feb 19-23, Feb 27/28 &Mar1-3(exp12), Feb 09-13, Feb 27/28 &Mar1-3(exp13), Feb09-13,19-23(exp14)

Exp 15-17:12Z from Feb 19-23, Feb 27/28 &Mar1-3(exp12), Feb 09-13, Feb 27/28 &Mar1-3(exp13), Feb09-13,19-23(exp14)

Exp 18-19: Every other member from EXP11

Exp 20-21: Every other member from EXP10

Exp 22-23: Every other member from EXP8

Exp 24-25: Every other member from EXP7

Exp 26: 00Z from Feb 28(or 29), Mar 1-2

Verification methodologies

Ensemble verification skills

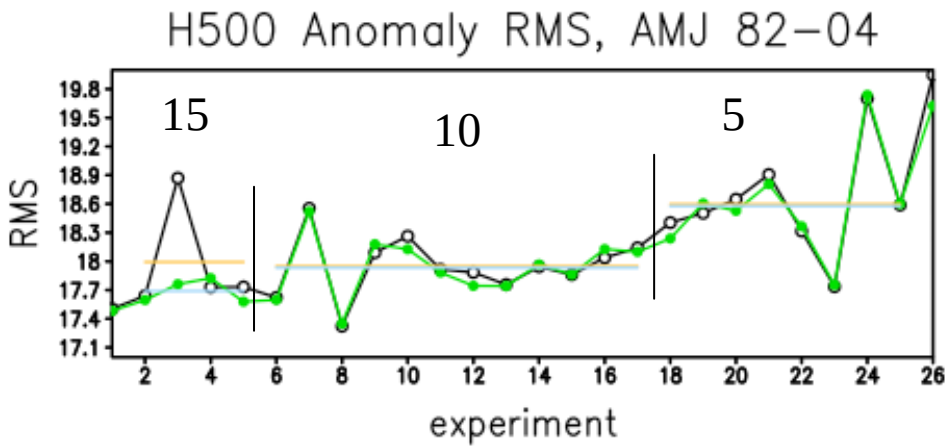
- a. Ensemble mean forecast skill

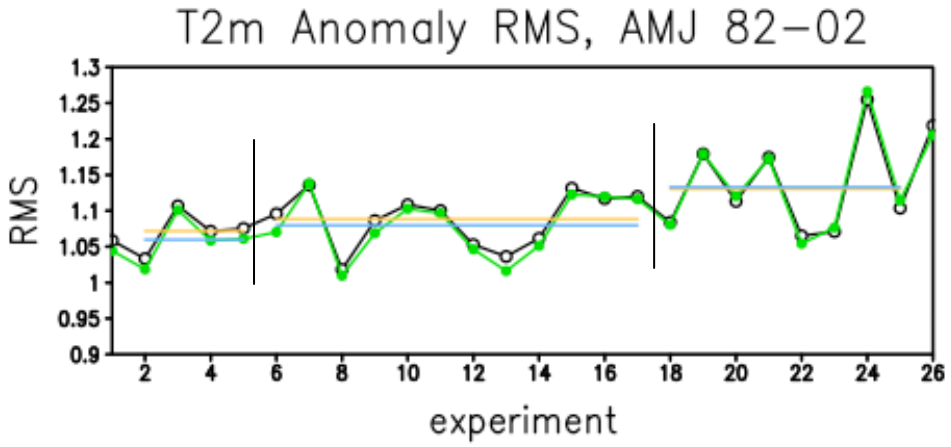
  Anomaly Correlation, Root Mean Square Error, Bias

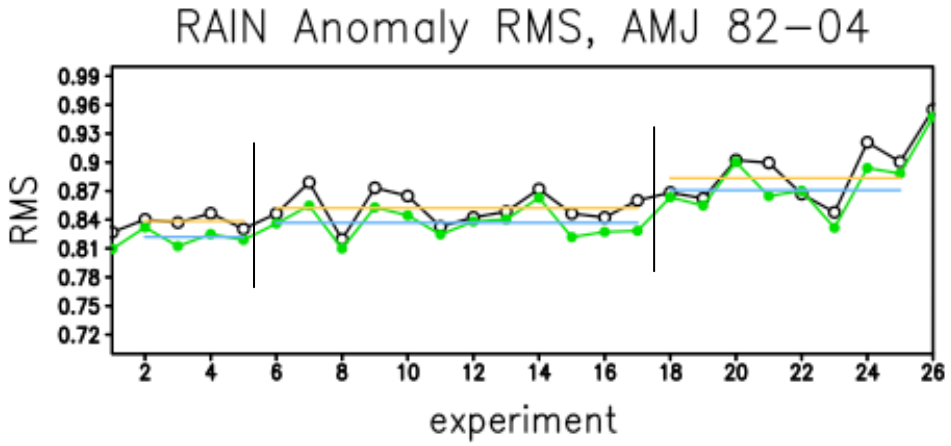
- b. Ensemble spread

Verification data:

- H500: NCEP_DOE reanalysis data
- T2m:CPC T2m regrid 2.5 degree data
- Rain: CPC US_MEX 1 degree rain gauge data



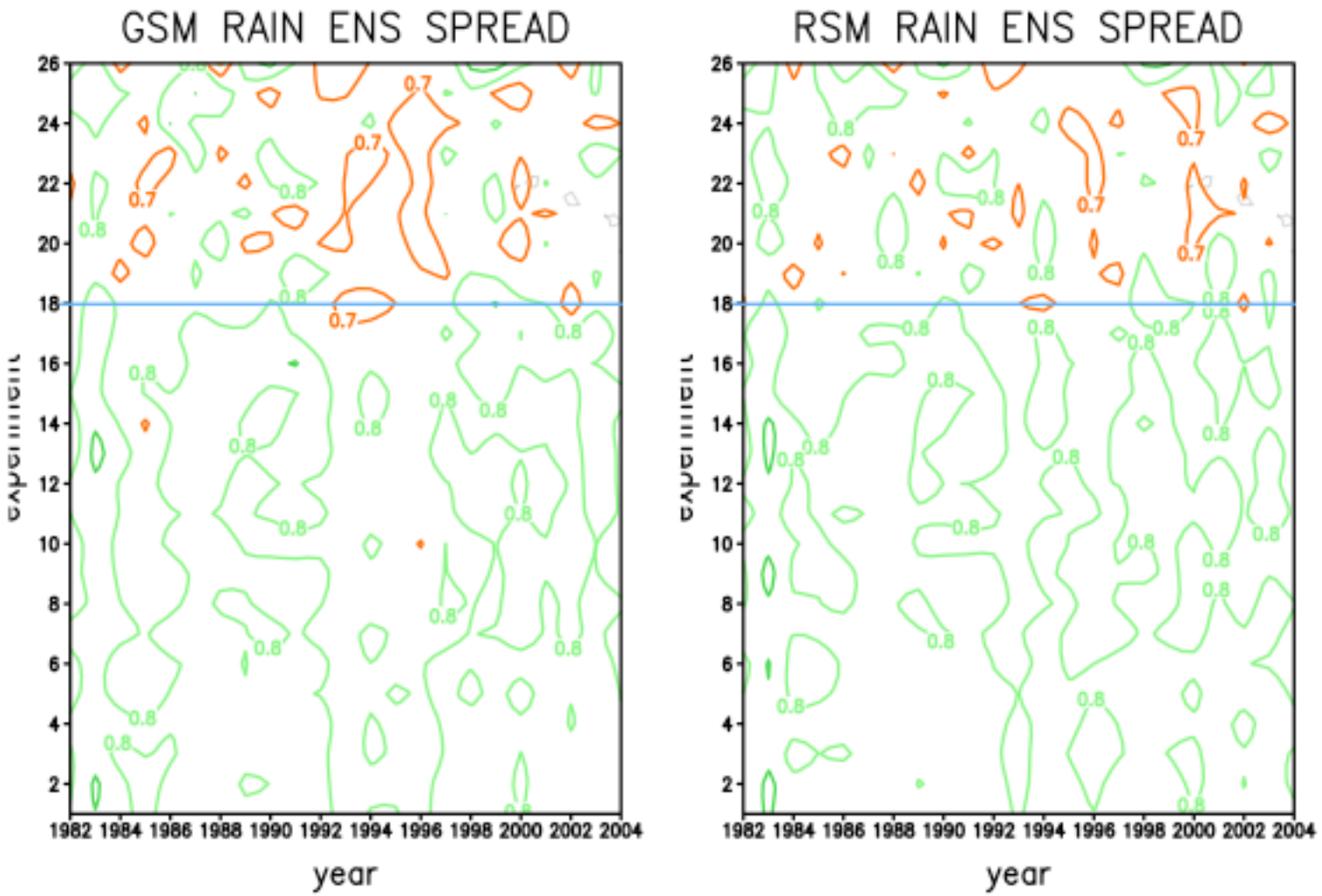




Black line: GSM
Green line: RSM

The means of skills for experiments with same ensemble member(15, 10 and 5)

Orange: GSM
Blue (RSM).


GSM RAIN ENS SPREAD
RSM RAIN ENS SPREAD
year
year
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
2 4 6 8 10 12 14 16 18 20 22 24 26
0.7
0.8

Summary

- Add-on values of regional climate model to global model are shown, though it is not huge, but useful.
- Predictability of regional model is based on **wide spread** with **enough members** and **bias correction**, not on best base/boundary condition, initial condition, lead time, and diurnal cycle.
- In terms of ensemble size, if resources are concerned, at least 10 members should be utilized, otherwise the more the better.