Simulation and prediction of the MJO with the NCEP coupled model

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What is the impact of ocean surface on MJO simulation and prediction?

What is the role of ocean surface on MJO simulation by NCEP atmospheric global forecast system (GFS)?

How should we treat the ocean surface for MJO prediction with NCEP GFS?

- **Use climatological SSTs**
- **Damp initial SST anomalies**
- **Couple GFS to an ocean model**

Objective

- Investigate the impact of the treatment of SSTs on MJO simulation and forecast by NCEP models

Approach

- Simulating and forecasting the MJO with specified and interactive ocean surface

Outline

- Models
- Simulations
- Forecasts
- Conclusions

The models

1. Atmospheric model (GFS03)
   - NCEP Global Forecast System 2003
   - T62; L64
2. Oceanic model (MOM3)
   - GFDL Modular Ocean Model V.3
   - 1/3°×1° in tropics; 1°×1° in extratropics; 40 layers
   - Quasi-global domain (74°S to 64°N)
   - Free surface
3. Coupled model (CFS03)
   - Once-a-day coupling
   - No flux adjustment
   - Sea ice extent taken as observed climatology

Simulations

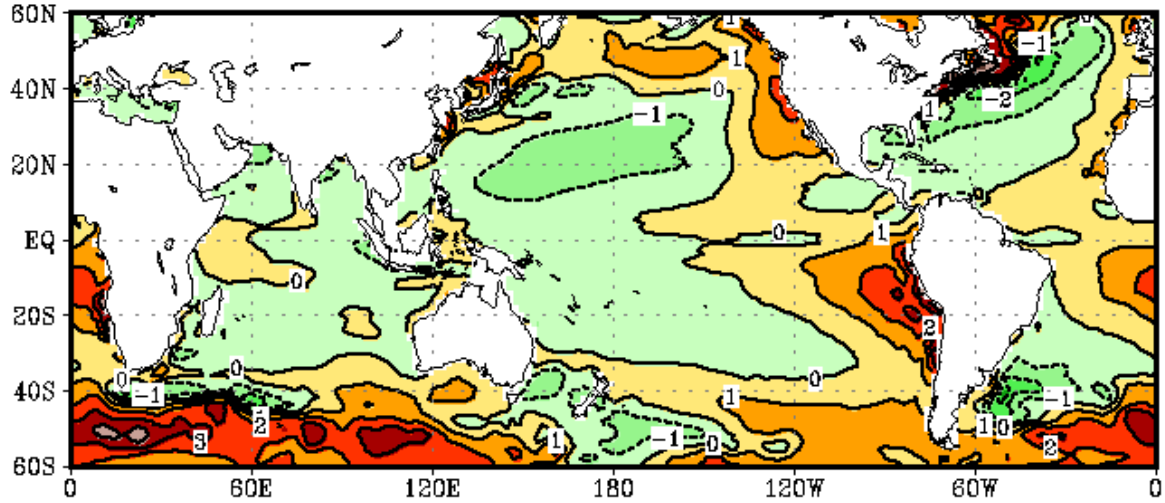
- **GFS03** AMIP with monthly-SSTs for 1982-2002
- **CFS03** 21-year coupled free run

Observations

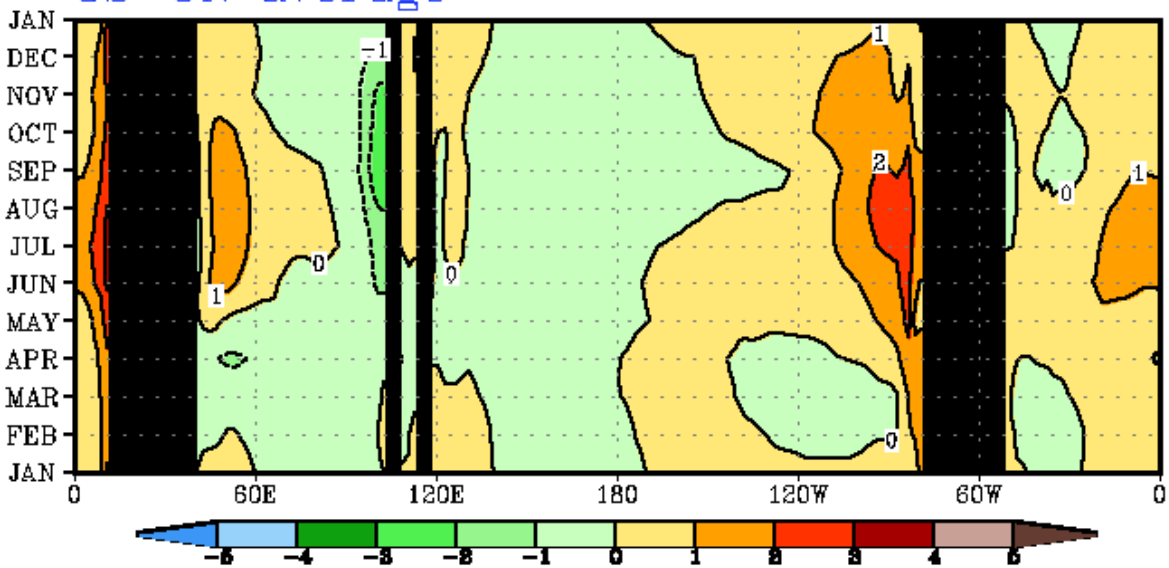
- **R2** NCEP/DOE reanalysis 2 (Kanamitsu et al., 2002)
- **CMAP** CPC merged anaylsis of precipitation (Xie & Arkin, 1997)

SST bias from CFS03 (K)

Annual mean

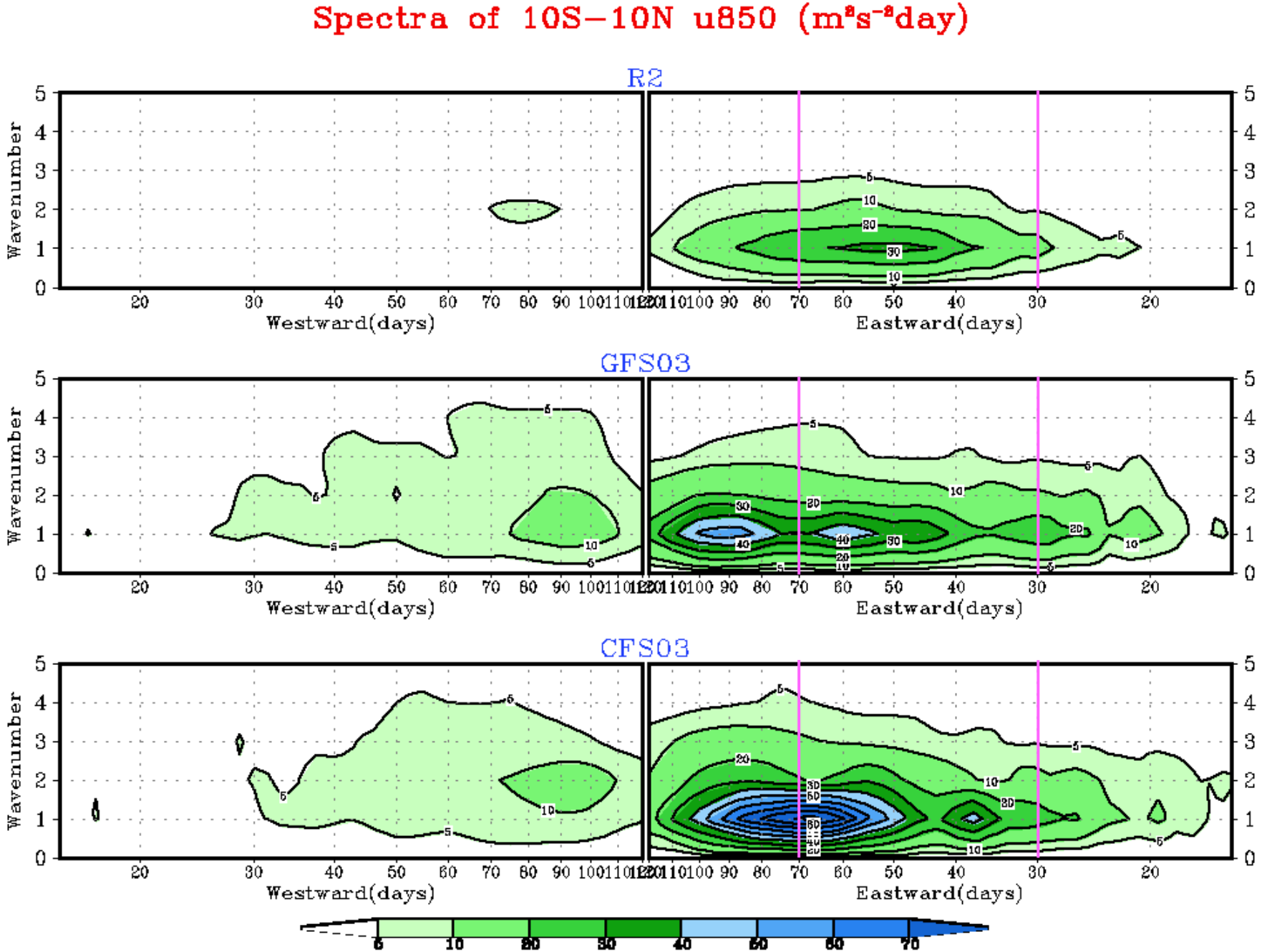


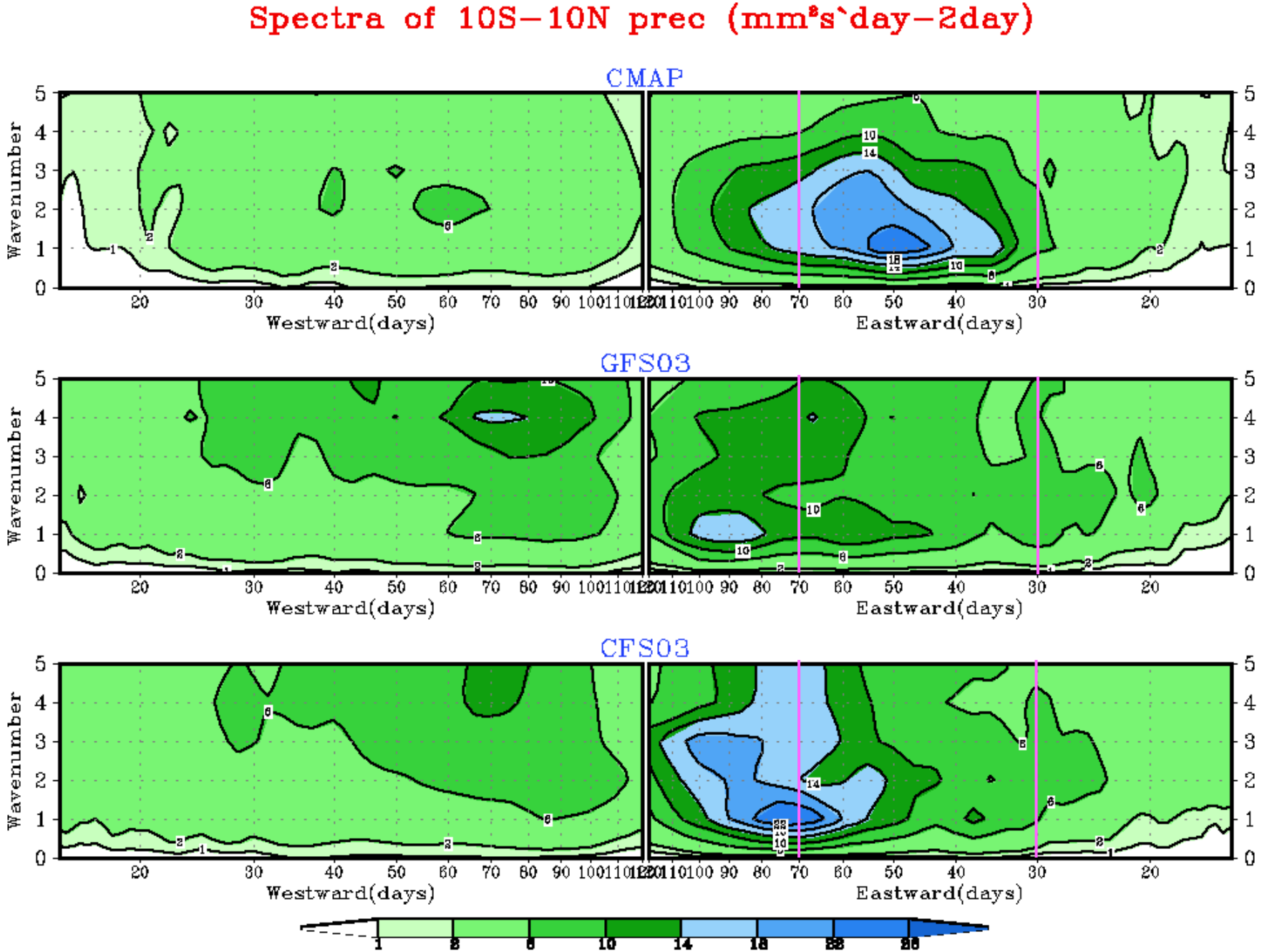
5S–5N average



Diagnoses for the simulations

- Wavenumber-frequency spectra
- EOF modes of Precipitation, U850, and U200
- Lag correlation between EOF PCs and individual fields

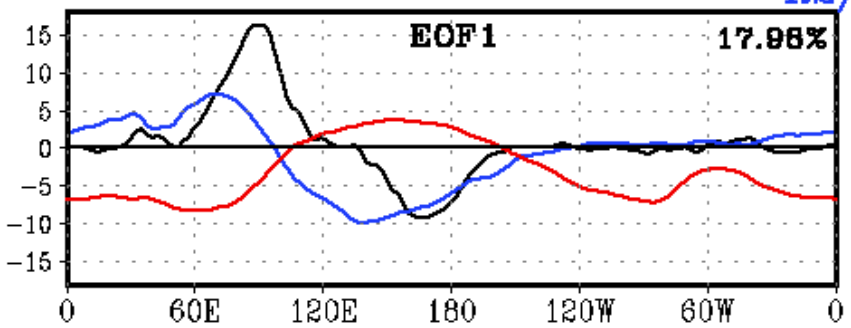

Spectra of 10S−10N u850 (m²s⁻²day)
R2
GFS03
CFS03
Wavenumber
Westward(days)
Eastward(days)
0
1
2
3
4
5
20
30
40
50
60
70
80
90
100
110
120
5
10
20
30
40
50
60
70

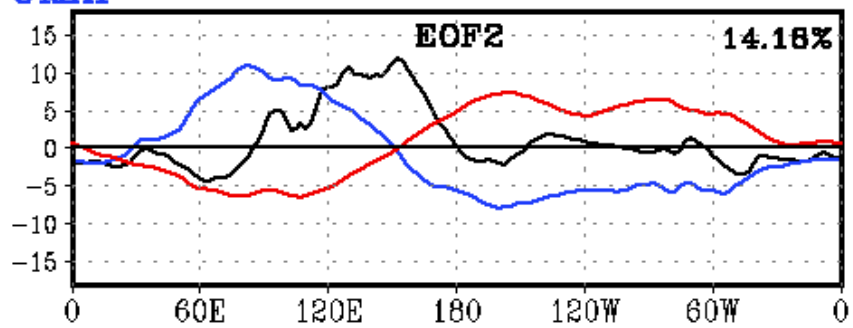

Spectra of 10S-10N prec (mm²s`day-2day)
CMAP
GFS03
CFS03
Wavenumber
Westward(days)
Eastward(days)
0
1
2
3
4
5
20
30
40
50
60
70
80
90
100
110
120
1
2
6
10
14
18
22
26

EOFs of combined fields (10S–10N average) for Nov to Mar

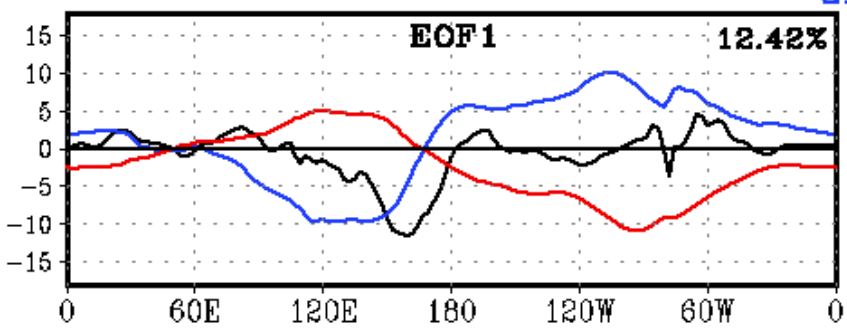
prec u850 u200

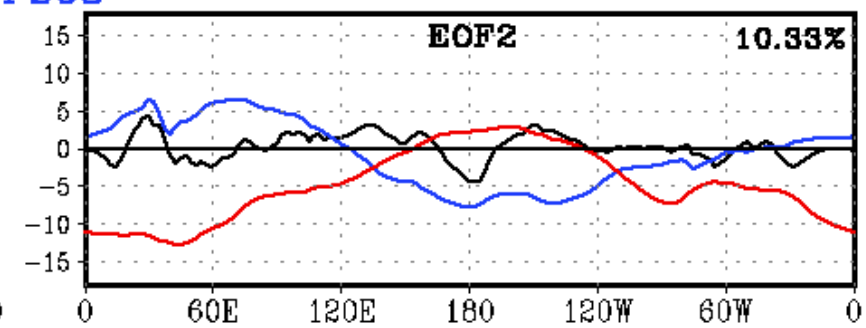
R2/CMAP



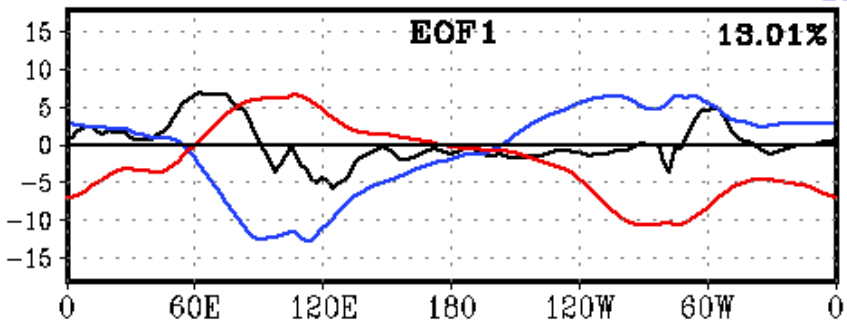


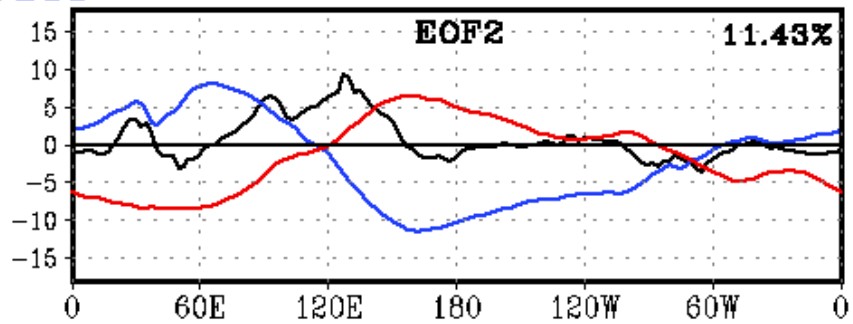
GFS03

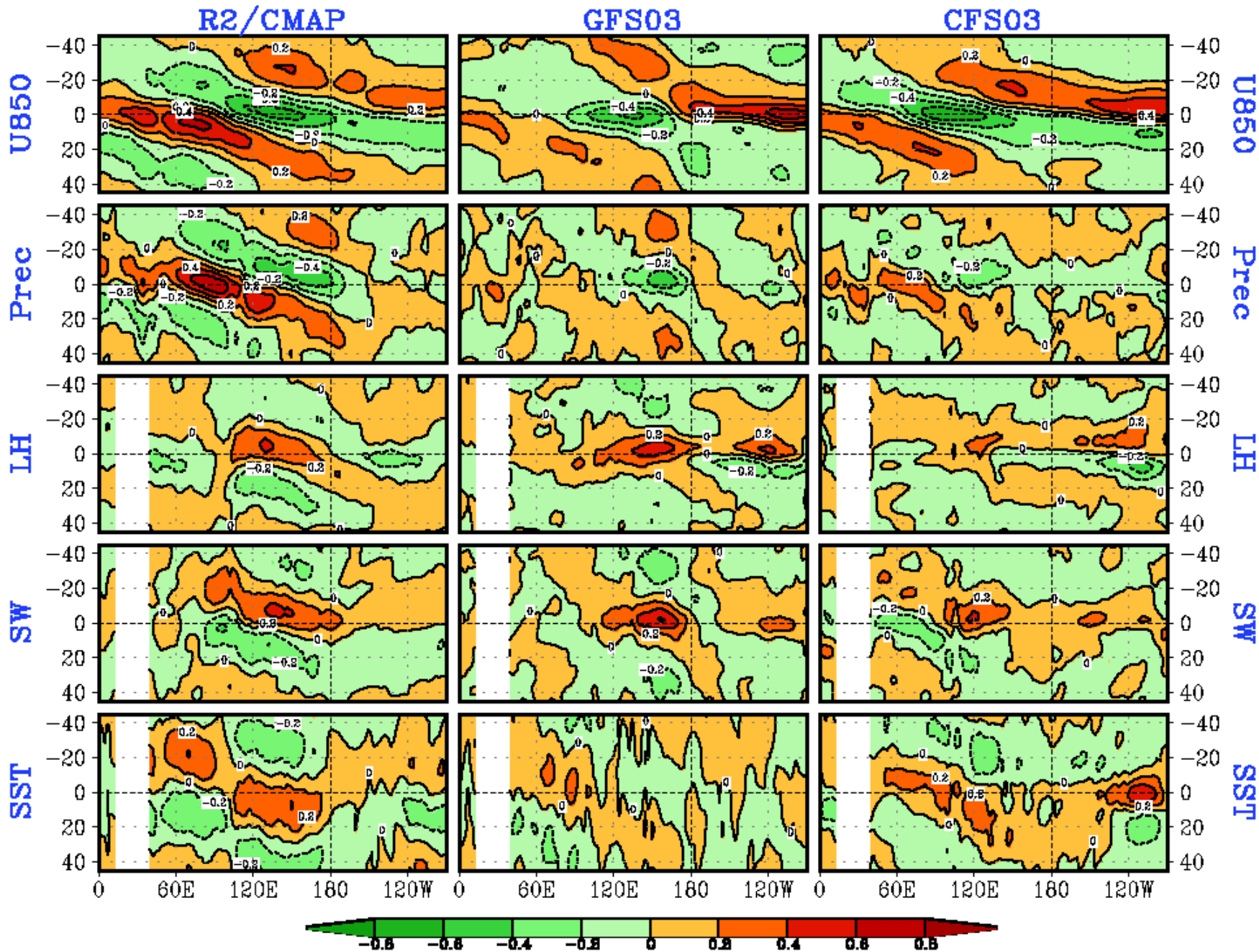


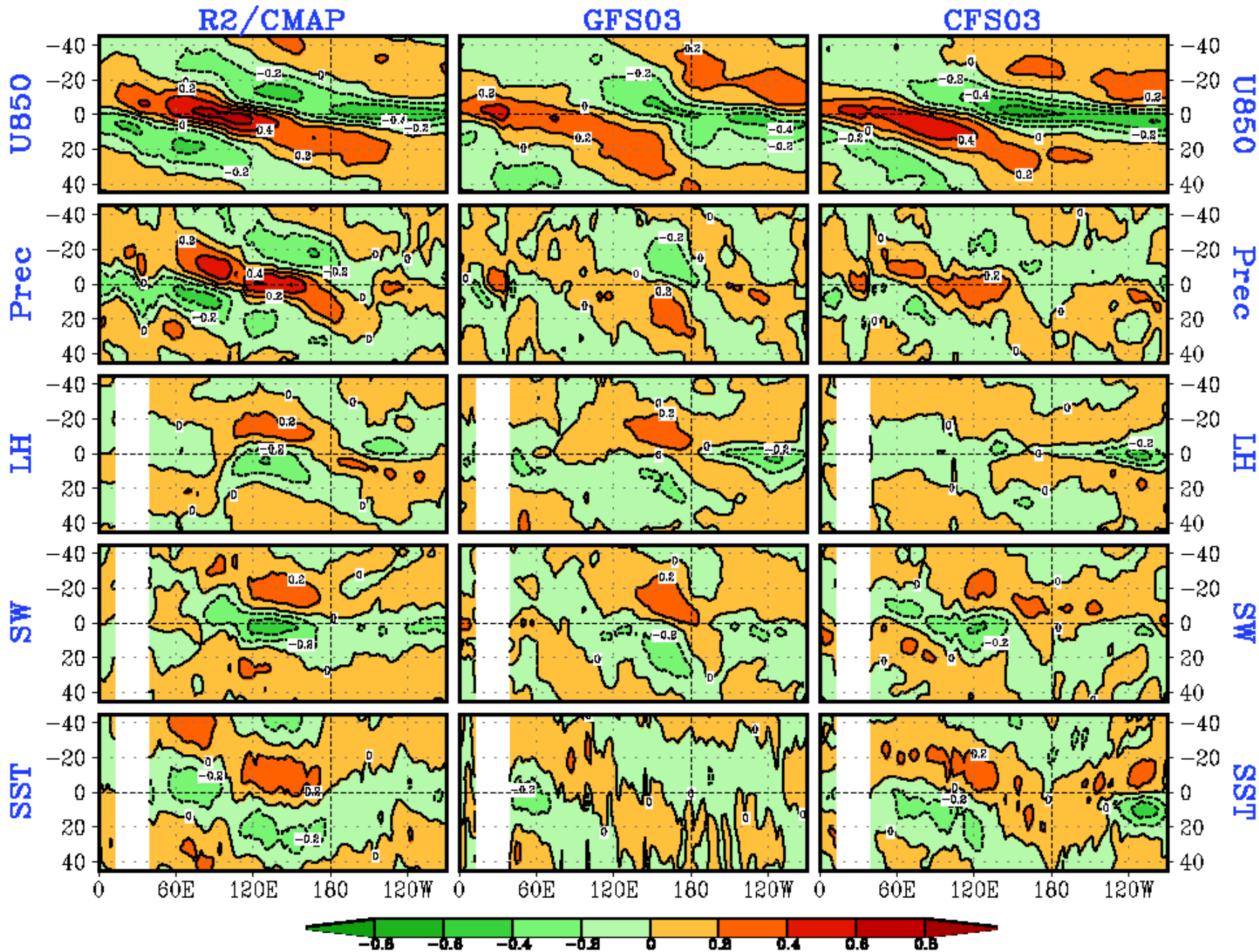


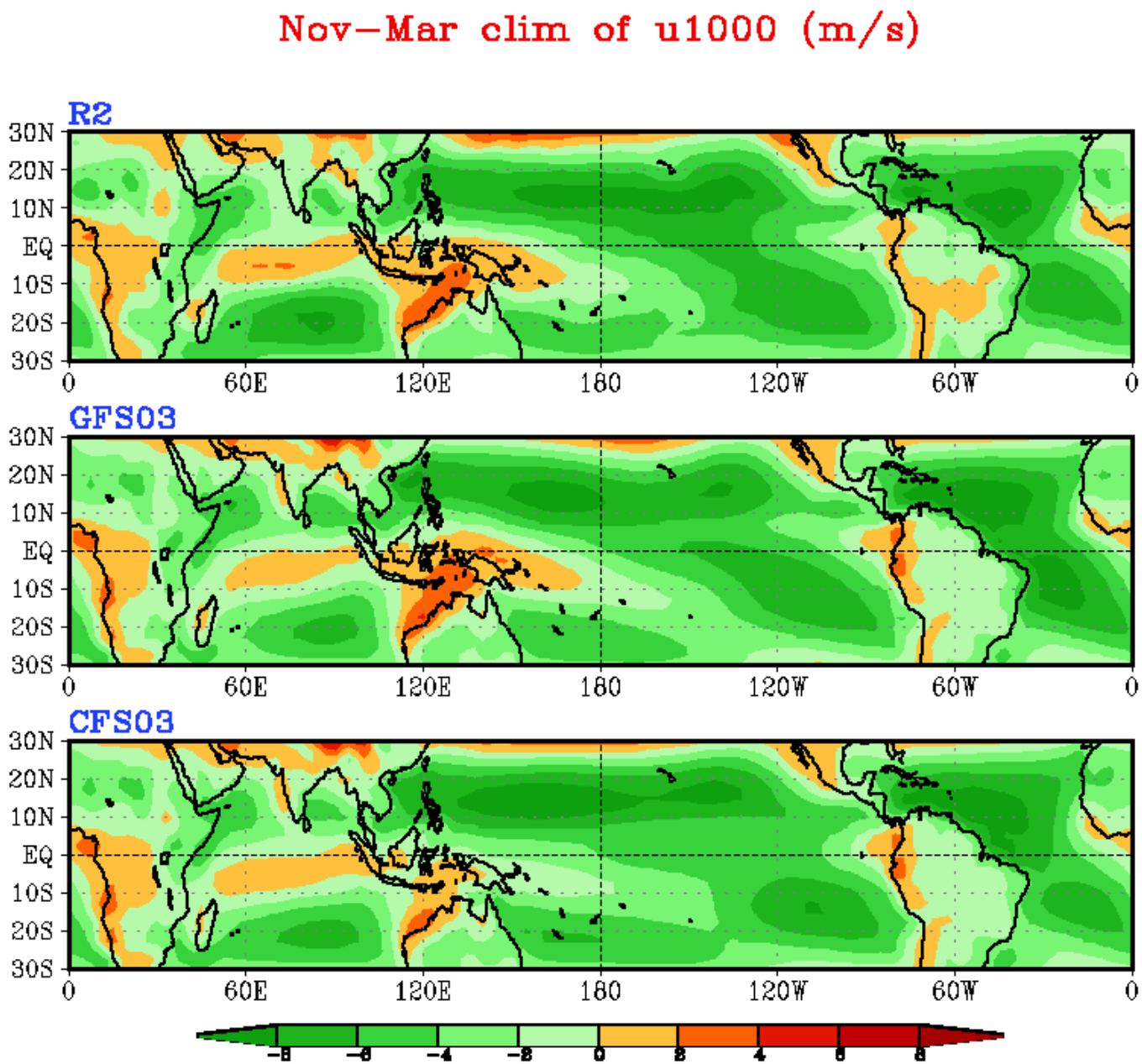
CFS03

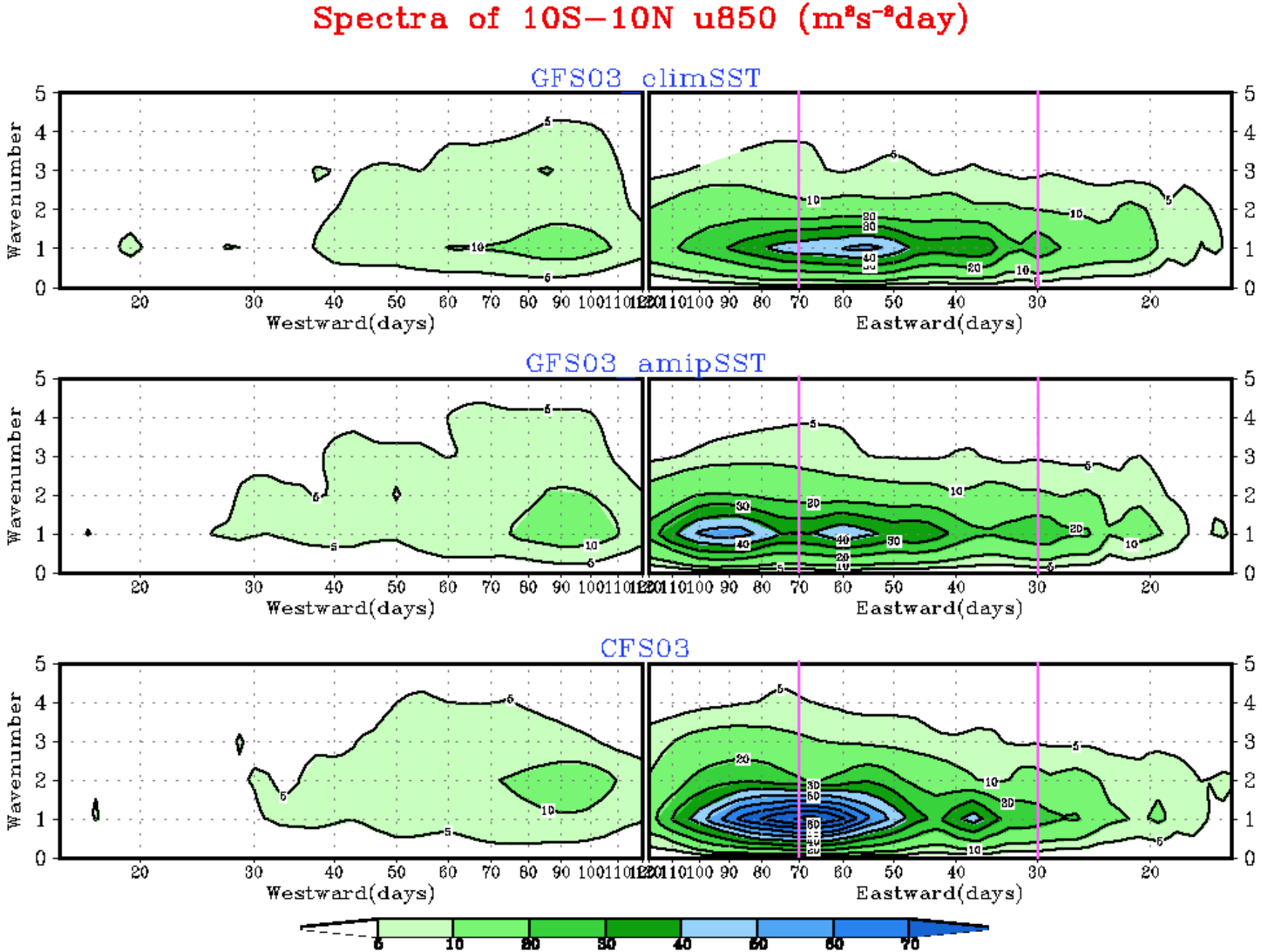


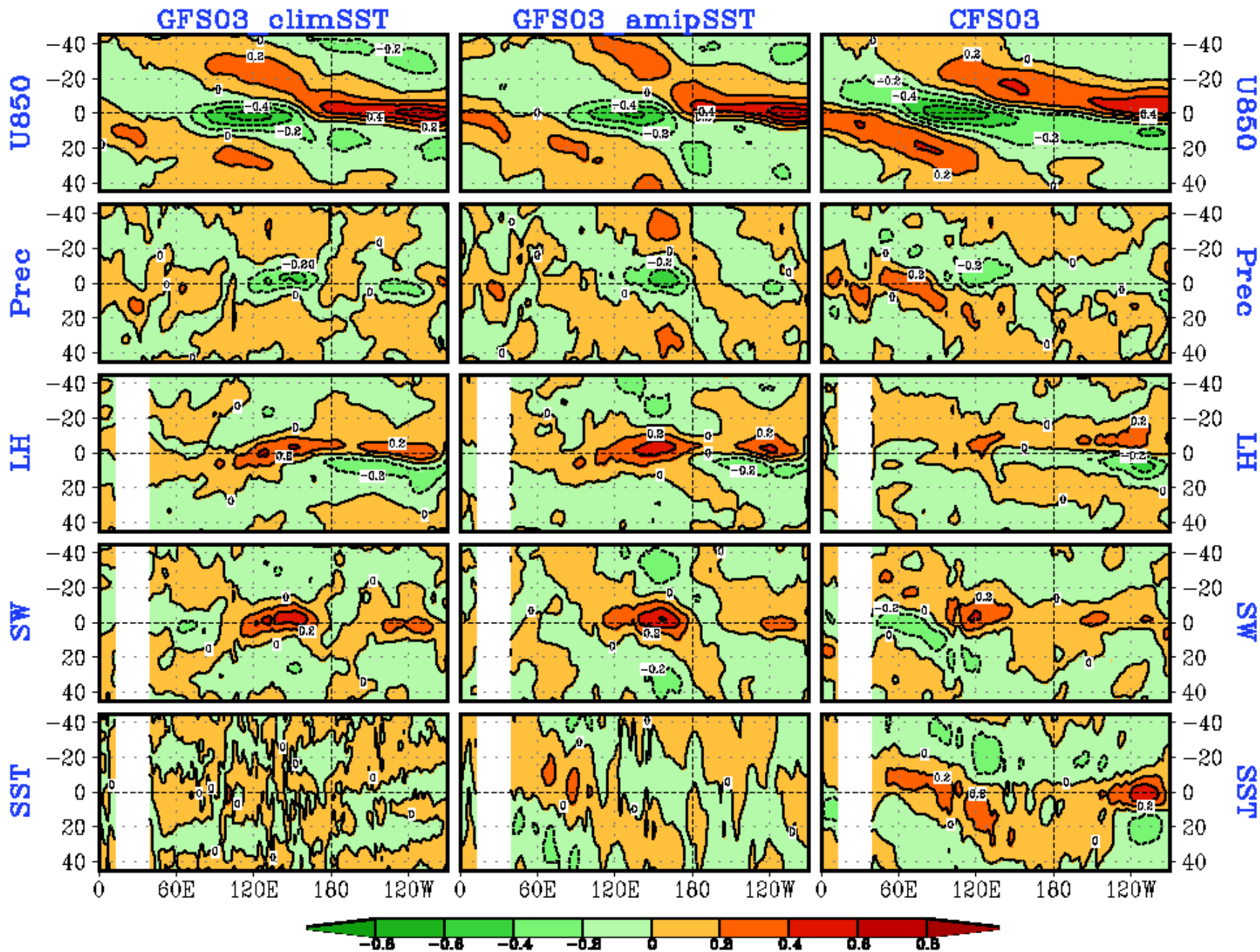



Lag correlation with PC1
R2/CMAP
GFS03
CFS03
U850
Prec
LH
SW
SST
−40
−20
0
20
40
0
60E
120E
180
120W
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8


Lag correlation with PC2
R2/CMAP
GFS03
CFS03
U850
Prec
LH
SW
SST
−40
−20
0
20
40
0
60E
120E
180
120W
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8


Nov–Mar clim of u1000 (m/s)
R2
GFS03
CFS03
30N
20N
10N
EQ
10S
20S
30S
0
60E
120E
180
120W
60W
0
-8
-6
-4
-2
0
2
4
6
8


Spectra of 10S-10N u850 (m²s⁻²day)
GFS03_climSST
GFS03_amipSST
CFS03
Wavenumber
Westward(days)
Eastward(days)
0
1
2
3
4
5
20
30
40
50
60
70
80
90
100
110
120
5
10
20
30
40
50
60
70


Lag correlation with PC1
GFS03_climSST
GFS03_amipSST
CFS03
U850
Prec
LH
SW
SST
−40
−20
0
20
40
0
60E
120E
180
120W
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8

Conclusions from simulations

- Improvements due to air-sea coupling
  - convection and circulation is more coherent
  - propagation is more clear
  - strong intraseasonal variance band is more narrow
- The MJO simulated by CFS03 is too strong and a little too slow
- Latent heat flux pattern in CFS03 is not consistent with that in reanalysis, possibly due to that the mean surface westerly in the Indian ocean and western Pacific is too weak
- The MJO in AMIP run may contain response to SST anomalies

Forecasts

Models

- GFS03
- CFS03

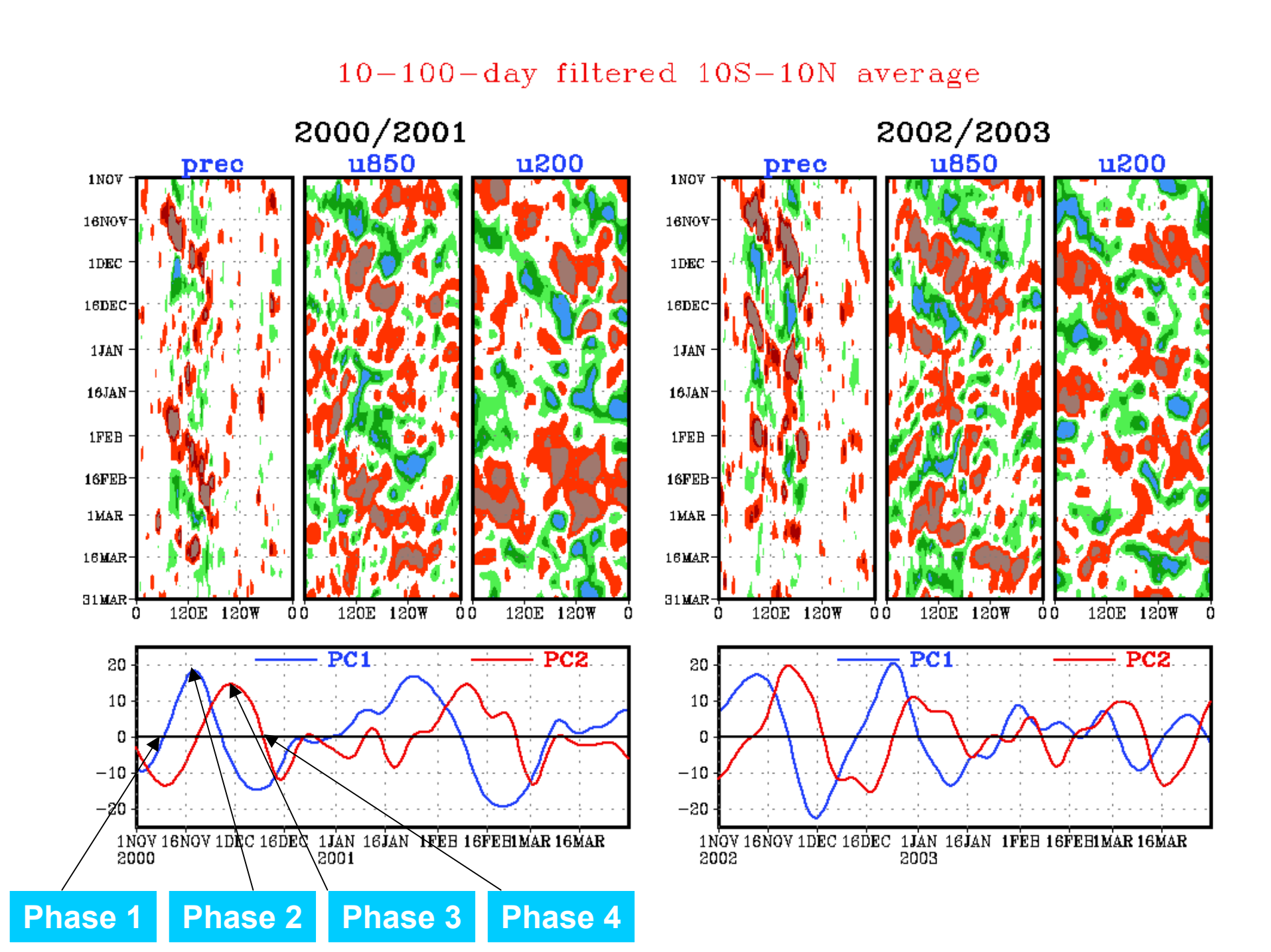
Initial dates

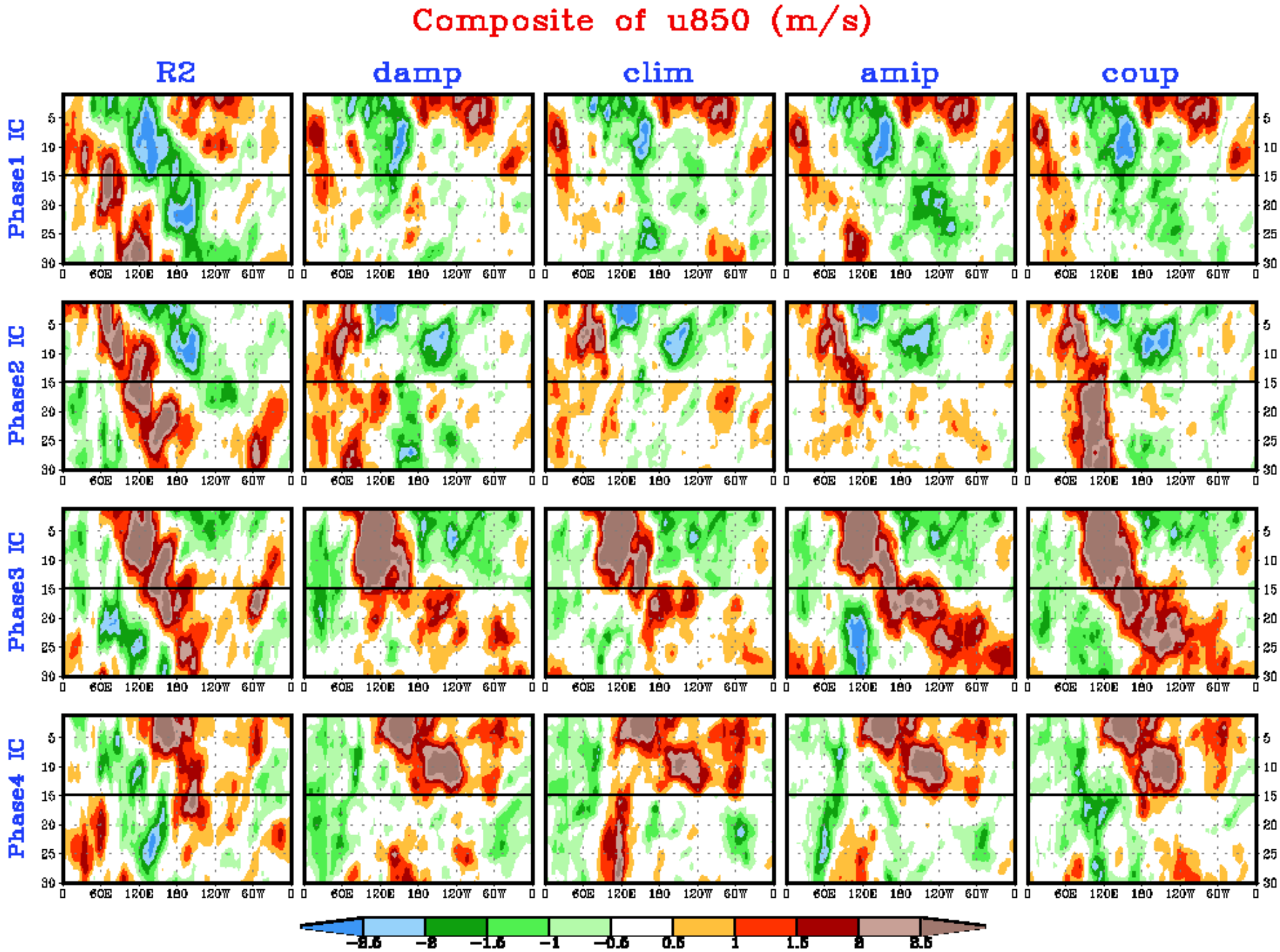
- November 1 to February 28
- 2000/2001, 2001/2002, 2002/2003

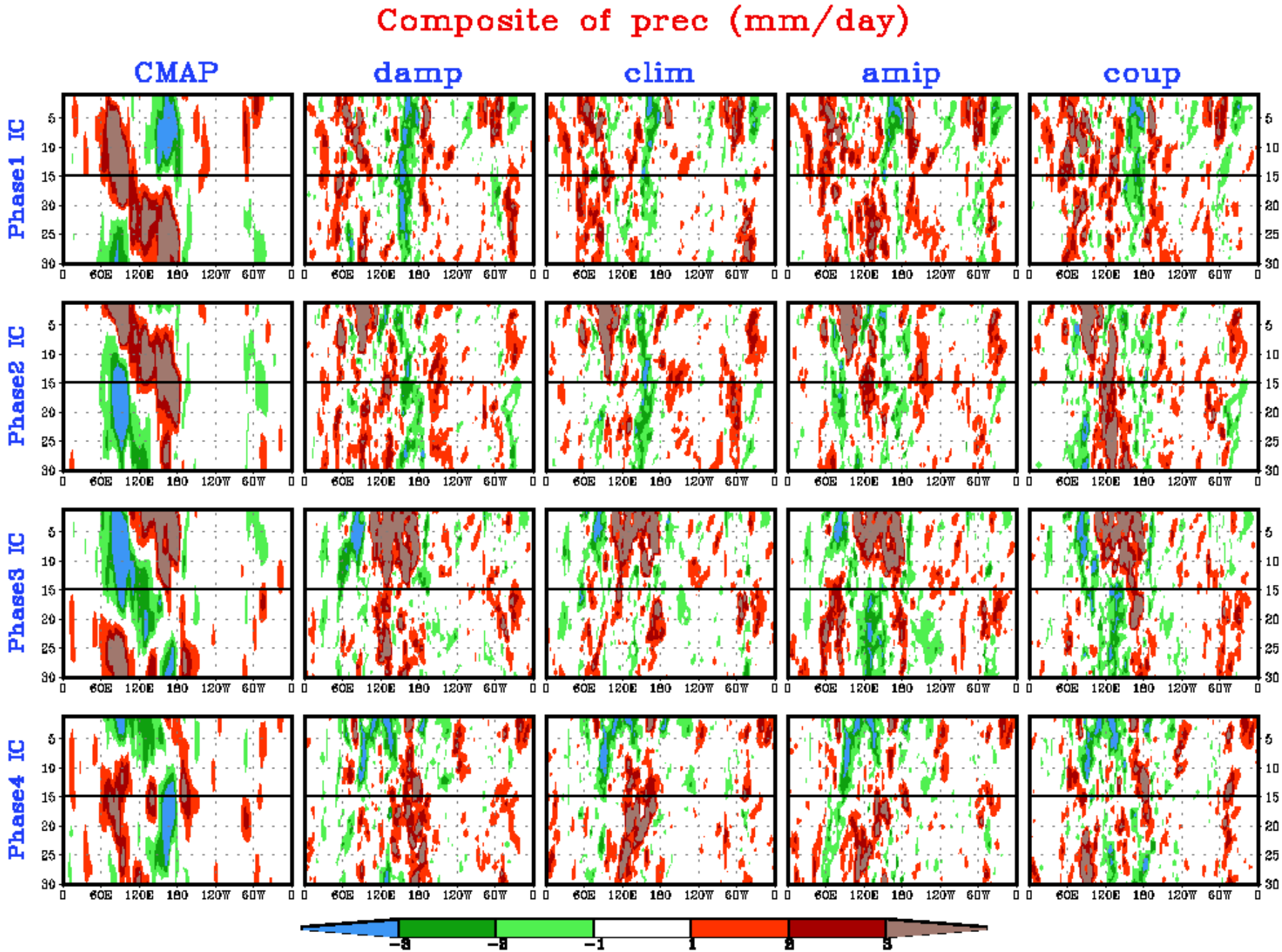
Forecasts

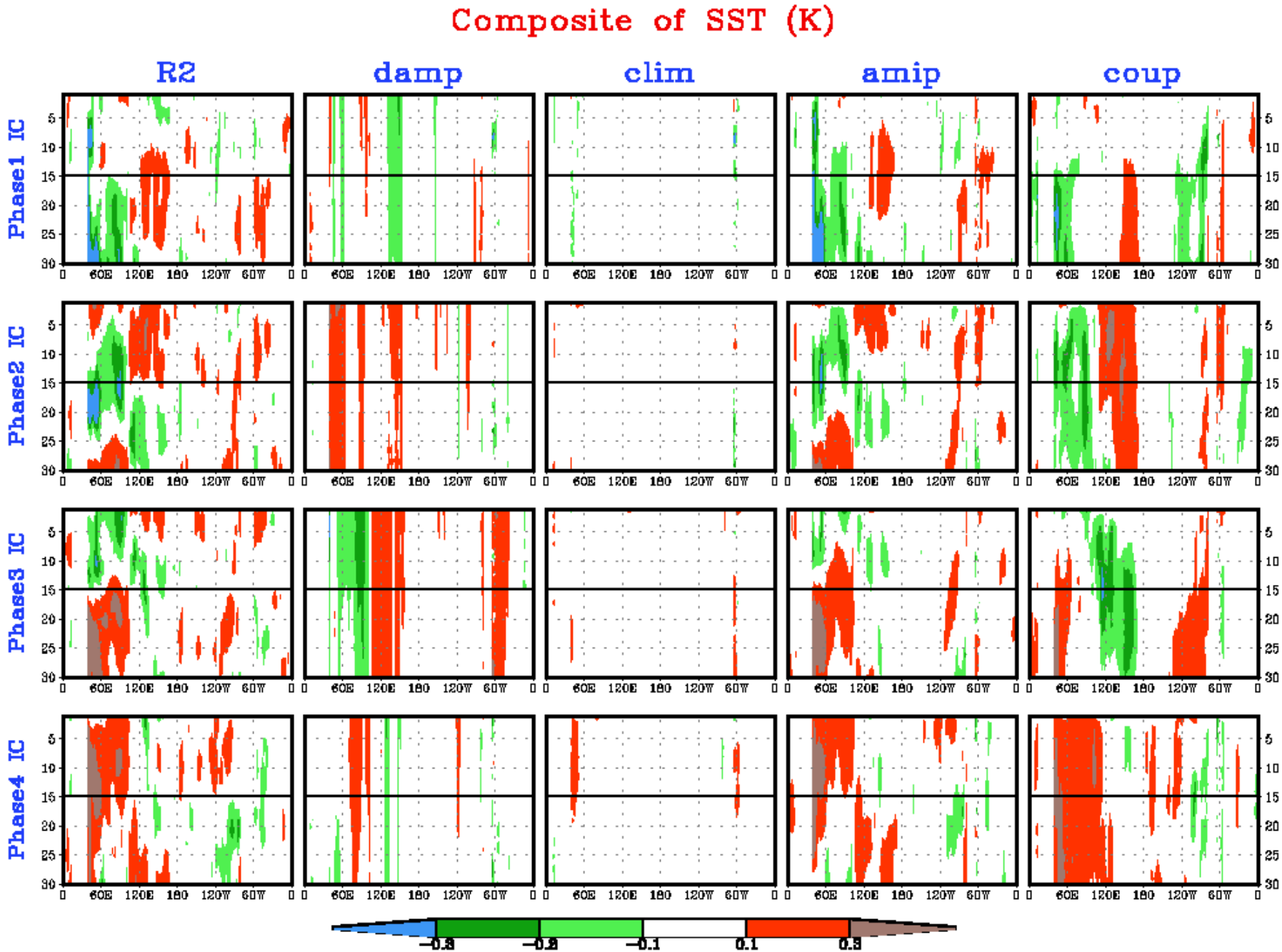
Experiments

- damp — GFS03 with decaying SST anomalies
- clim — GFS03 with clomatological SSTs
- amip — GFS03 with observed weekly SSTs
- coup — CFS03 with initial ocean state from NCEP GODAS


10–100–day filtered 10S–10N average
2000/2001
2002/2003
prec
u850
u200
1NOV
16NOV
1DEC
16DEC
1JAN
16JAN
1FEB
16FEB
1MAR
16MAR
31MAR
0
120E
120W
PC1
PC2
20
10
0
−10
−20
1NOV 16NOV 1DEC 16DEC 1JAN 16JAN 1FEB 16FEB 1MAR 16MAR
2000
2001
2002
2003
Phase 1
Phase 2
Phase 3
Phase 4

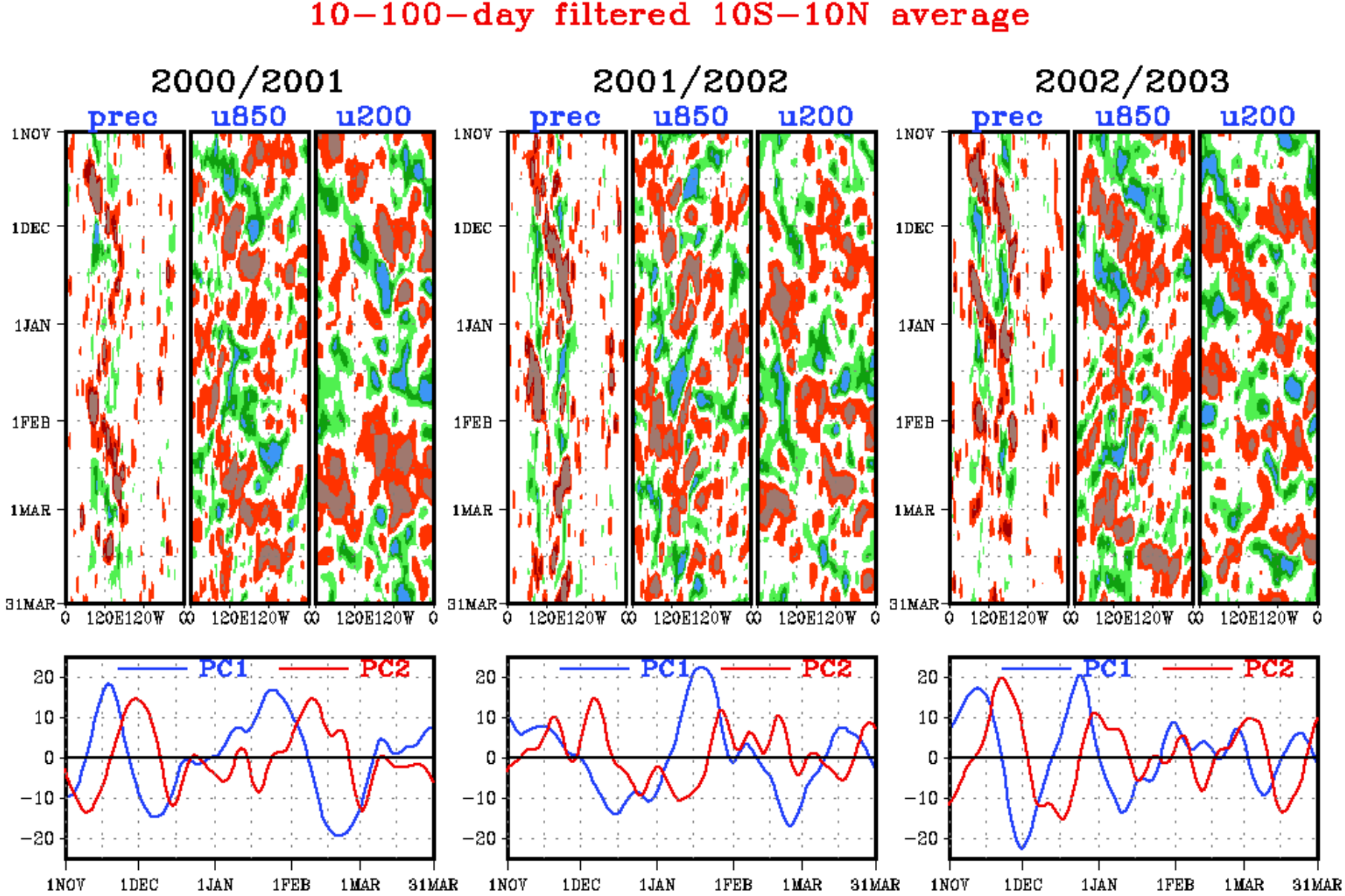

Composite of u850 (m/s)
R2
damp
clim
amip
coup
Phase1 IC
Phase2 IC
Phase3 IC
Phase4 IC
5
10
15
20
25
30
0
60E
120E
180
120W
60W
−2.5
−2
−1.5
−1
−0.5
0.5
1
1.5
2
2.5


Composite of prec (mm/day)
CMAP
damp
clim
amip
coup
Phase1 IC
Phase2 IC
Phase3 IC
Phase4 IC
5
10
15
20
25
30
0
60E
120E
180
120W
60W
-3
-2
-1
1
2
3


Composite of SST (K)
R2
damp
clim
amip
coup
Phase1 IC
Phase2 IC
Phase3 IC
Phase4 IC
5
10
15
20
25
30
0
60E
120E
180
120W
60W
−0.3
−0.2
−0.1
0.1
0.3

Conclusions from forecast experiments

- Air-sea coupling is necessary for MJO forecast beyond week two
- The forecast MJO by CFS03 from peak phase of EOF1 propagates too slowly
- MJO Forecast by CFS03 from other phases is encouraging


10–100–day filtered 10S–10N average
2000/2001
2001/2002
2002/2003
prec
u850
u200
1NOV
1DEC
1JAN
1FEB
1MAR
31MAR
0 120E120W ∞ 120E120W ∞ 120E120W 0
PC1
PC2
20
10
0
−10
−20