Understanding climate prediction and climate predicting operation in China

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I. Scientific bases of climate prediction
II. Strategy of climate prediction
III. climate prediction operation in China

Forecasting time periods

< 2 weeks weather forecasting day by day

Monthly to seasonal monthly mean

Inter-annual

Inter-decadal

Climate projection

Climate prediction

climate system is chaotic, prediction depends on **initial conditions**

effective predicting period ~ 2 weeks

for longer time

to predict departure from climatic mean – **anomaly** , i.e. probability with changing range

Is climate predictable?

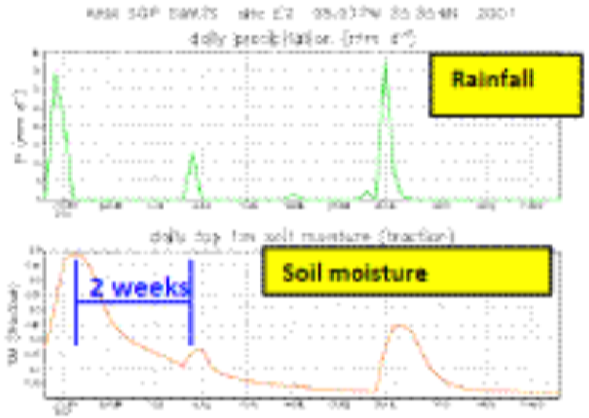
To depend on timescale of prediction

Resource of climate predictability

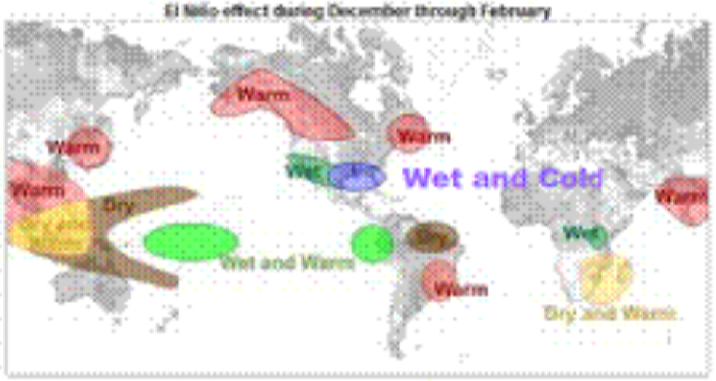
- ‘ inertia’ of climate variables

  ‘ long memory ‘
- Internal interaction and feedback of system
- response to external forcing

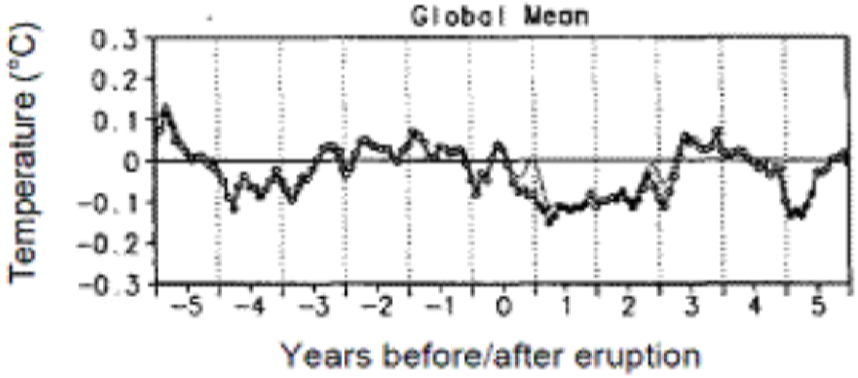
a. Inertial memory



b. Patterns of variability



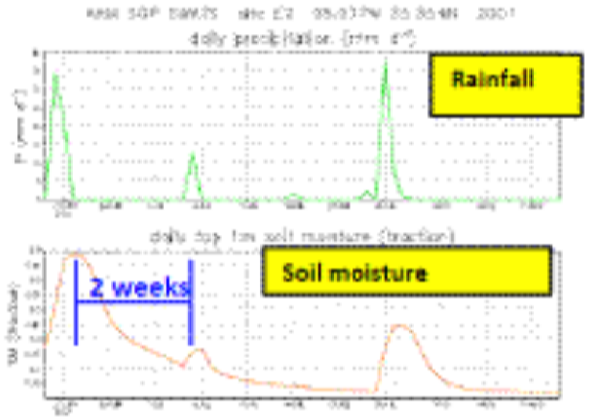
c. External forcing



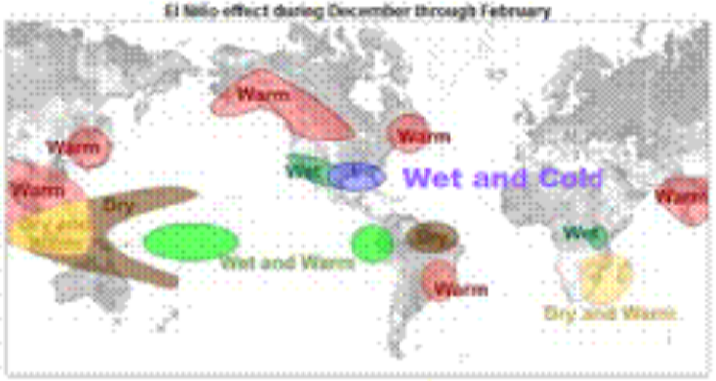
Internal multi-scale variability

seasonal MJO
interannual ENSO NAO IDO
inter-decadal NPO PDO IPO
climate abrupt change

a. Inertial memory



b. Patterns of variability



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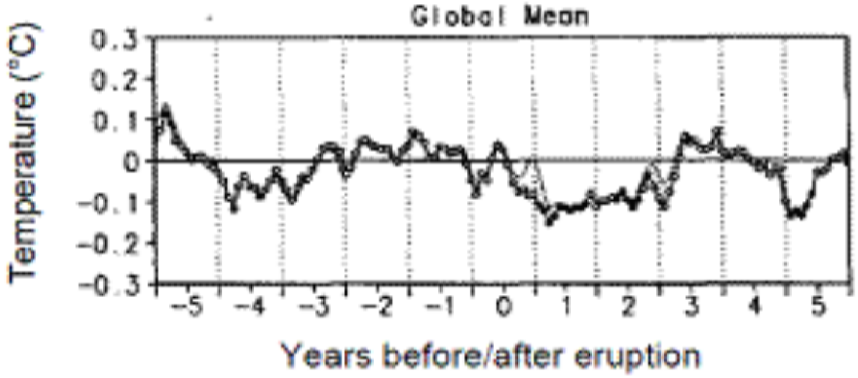
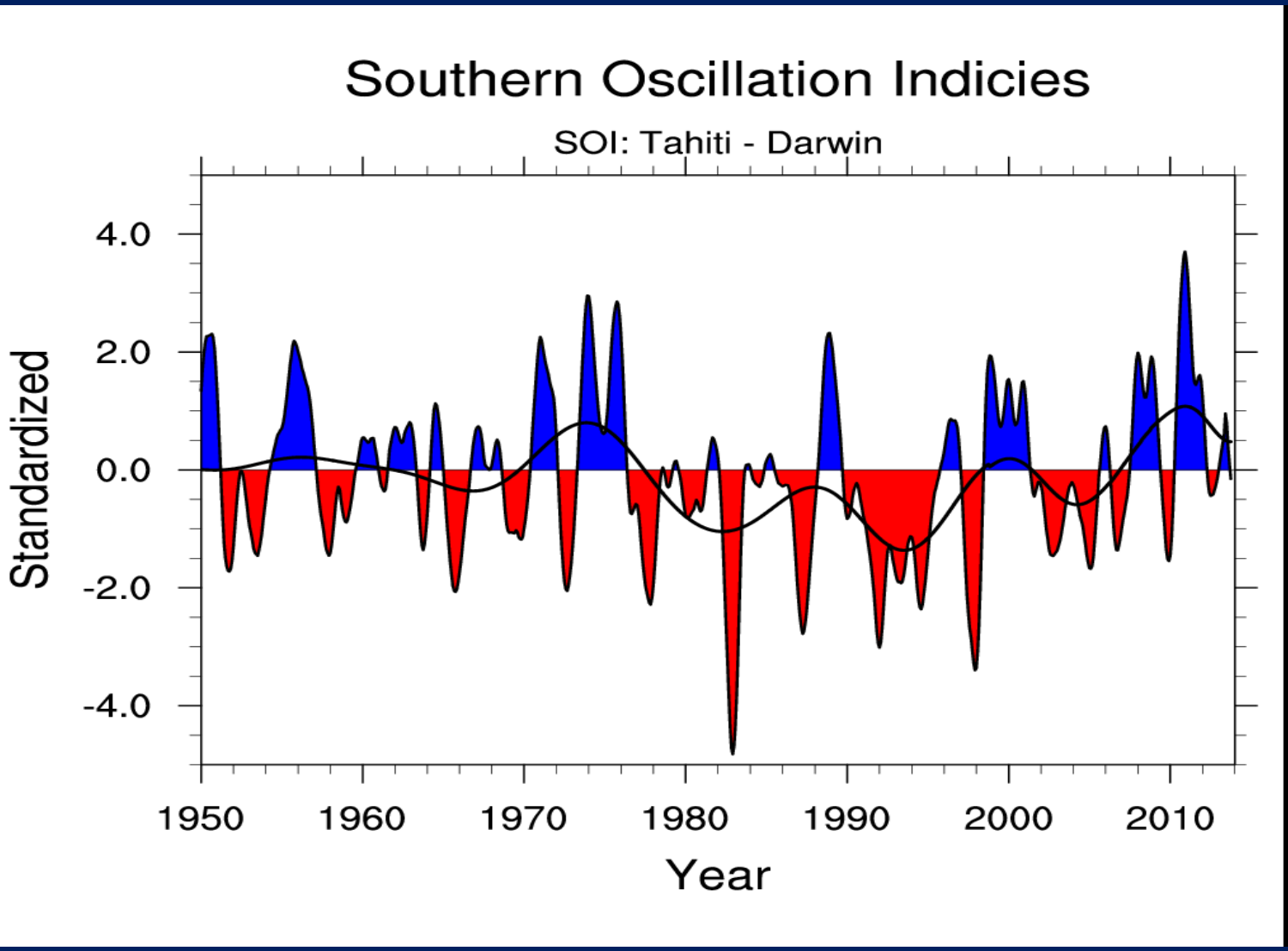
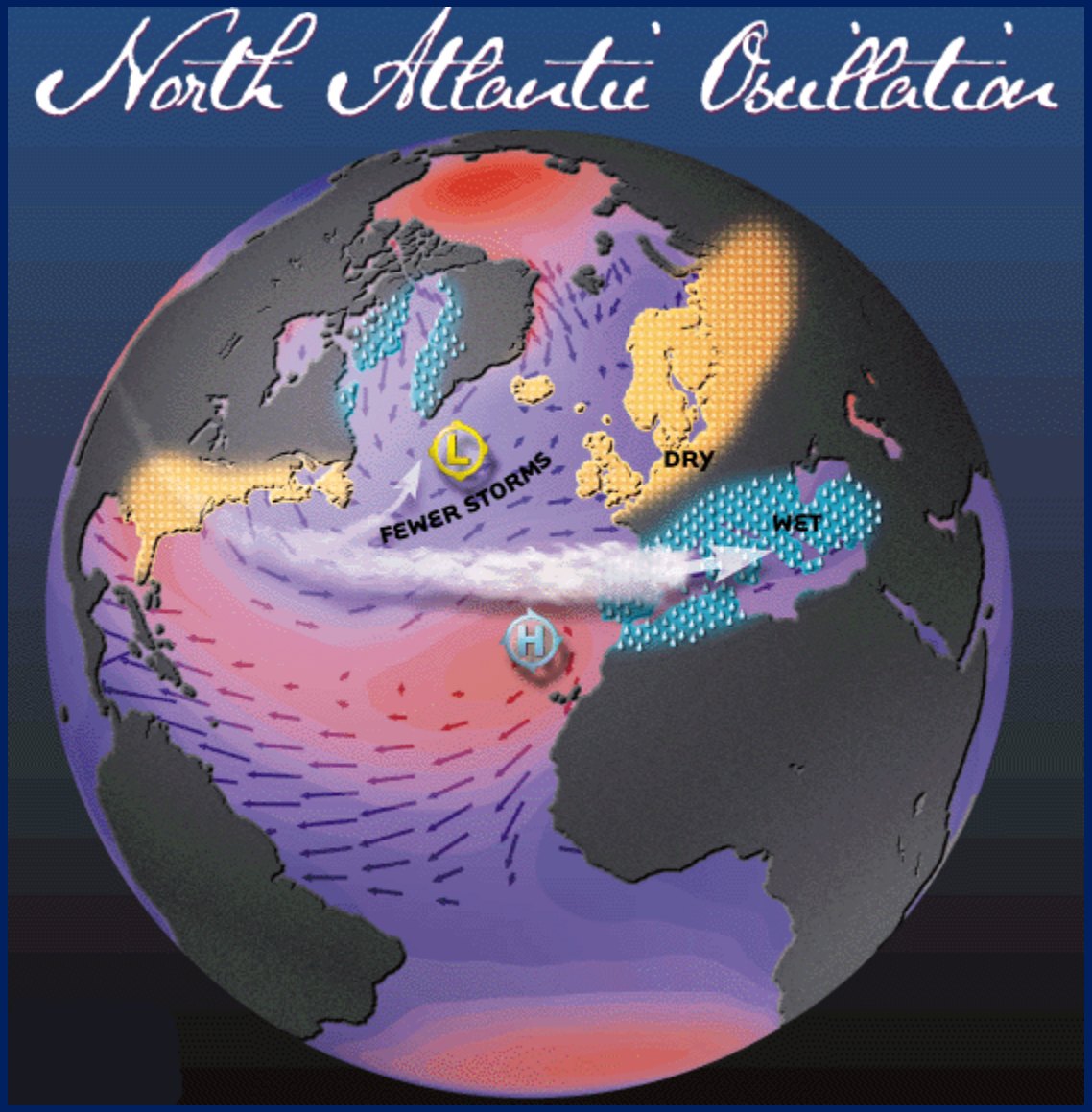
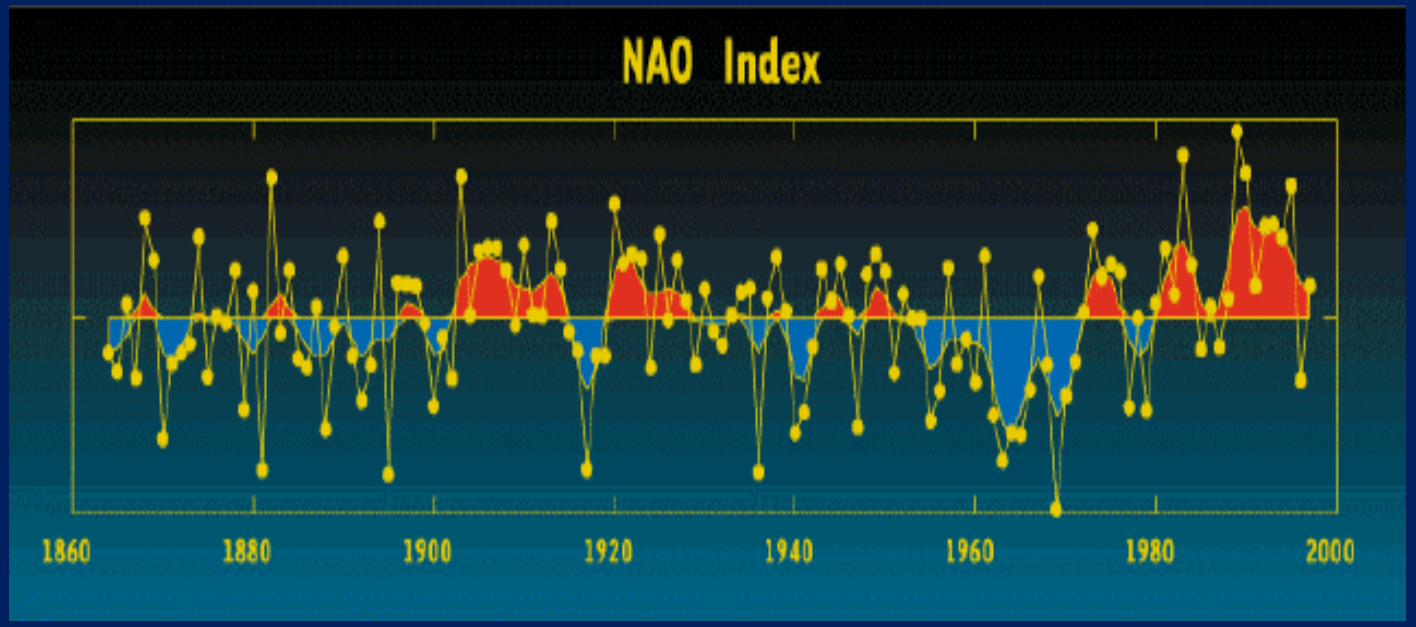
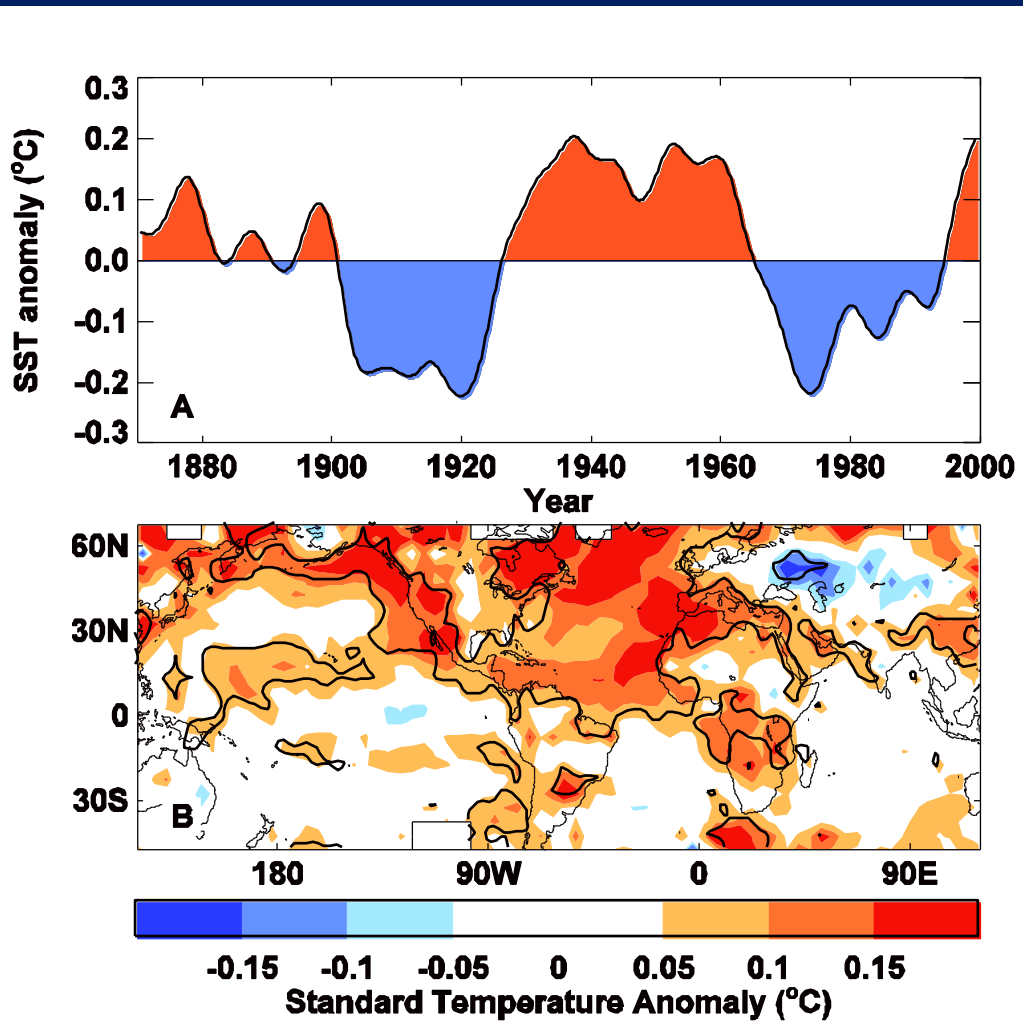



Southern Oscillation Indicies
SOI: Tahiti - Darwin
Standardized
4.0
2.0
0.0
-2.0
-4.0
1950
1960
1970
1980
1990
2000
2010
Year

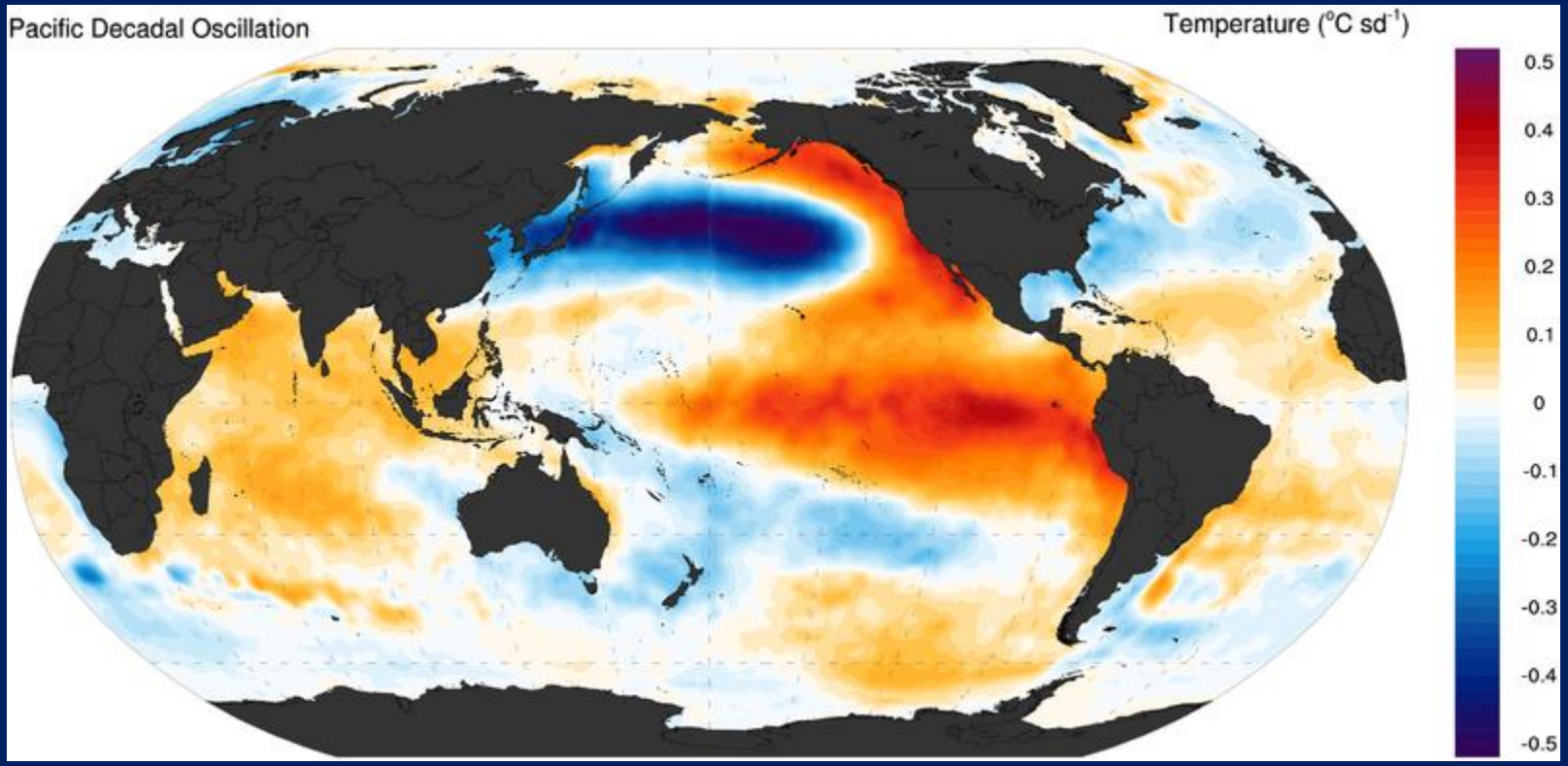

North Atlantic Oscillation
L
FEWER STORMS
DRY
WET
H

North Atlantic Oscillation

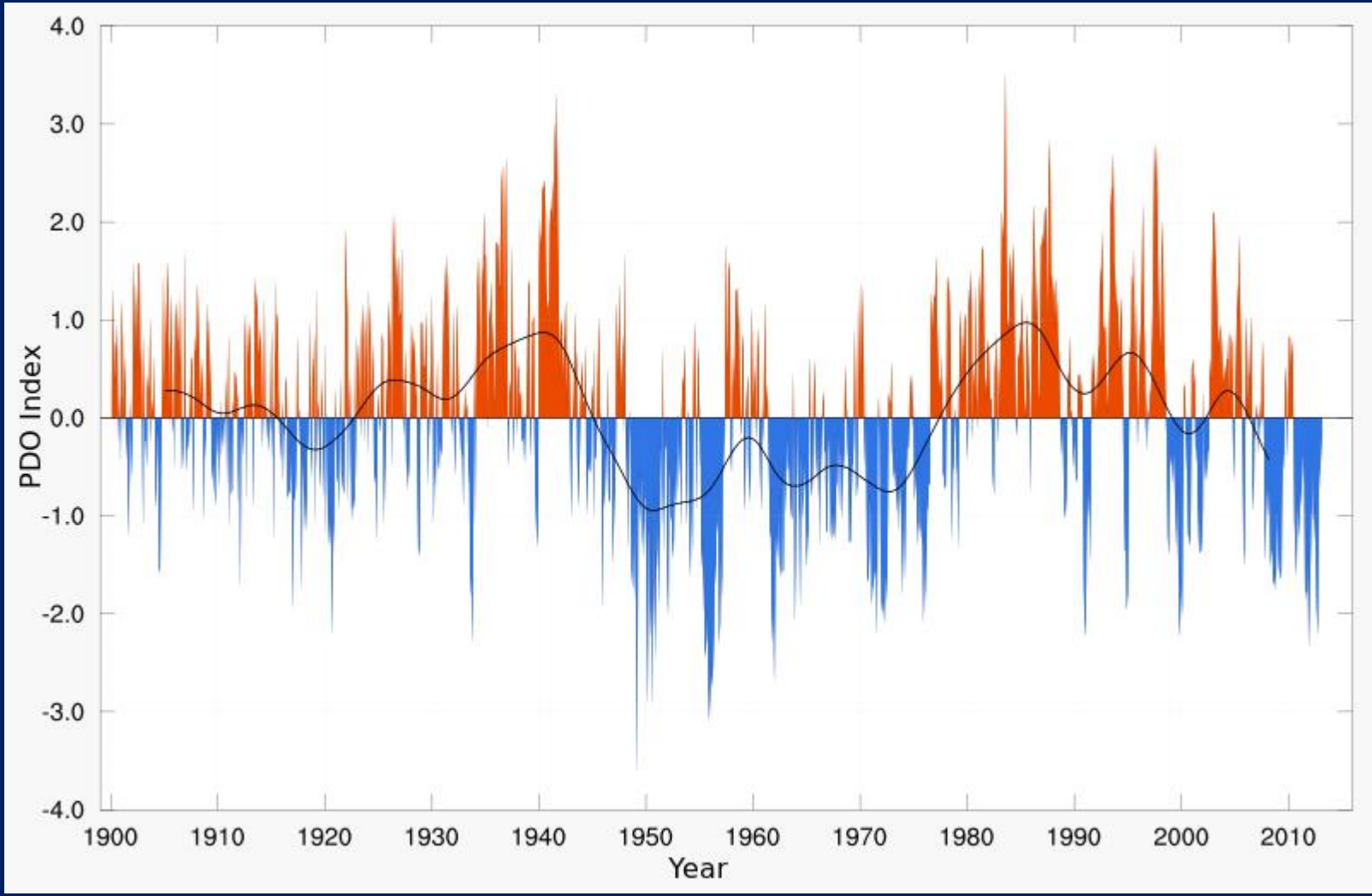


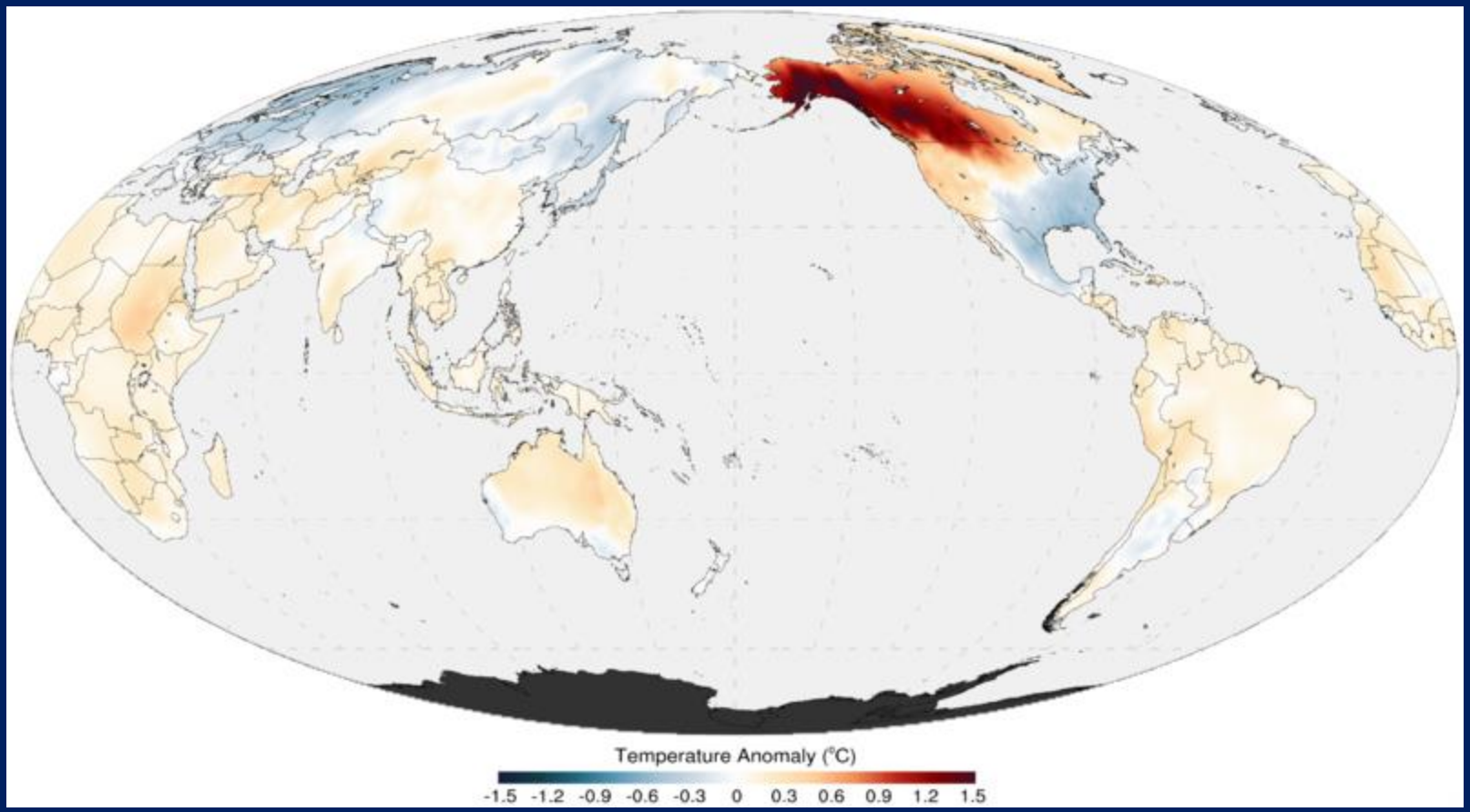


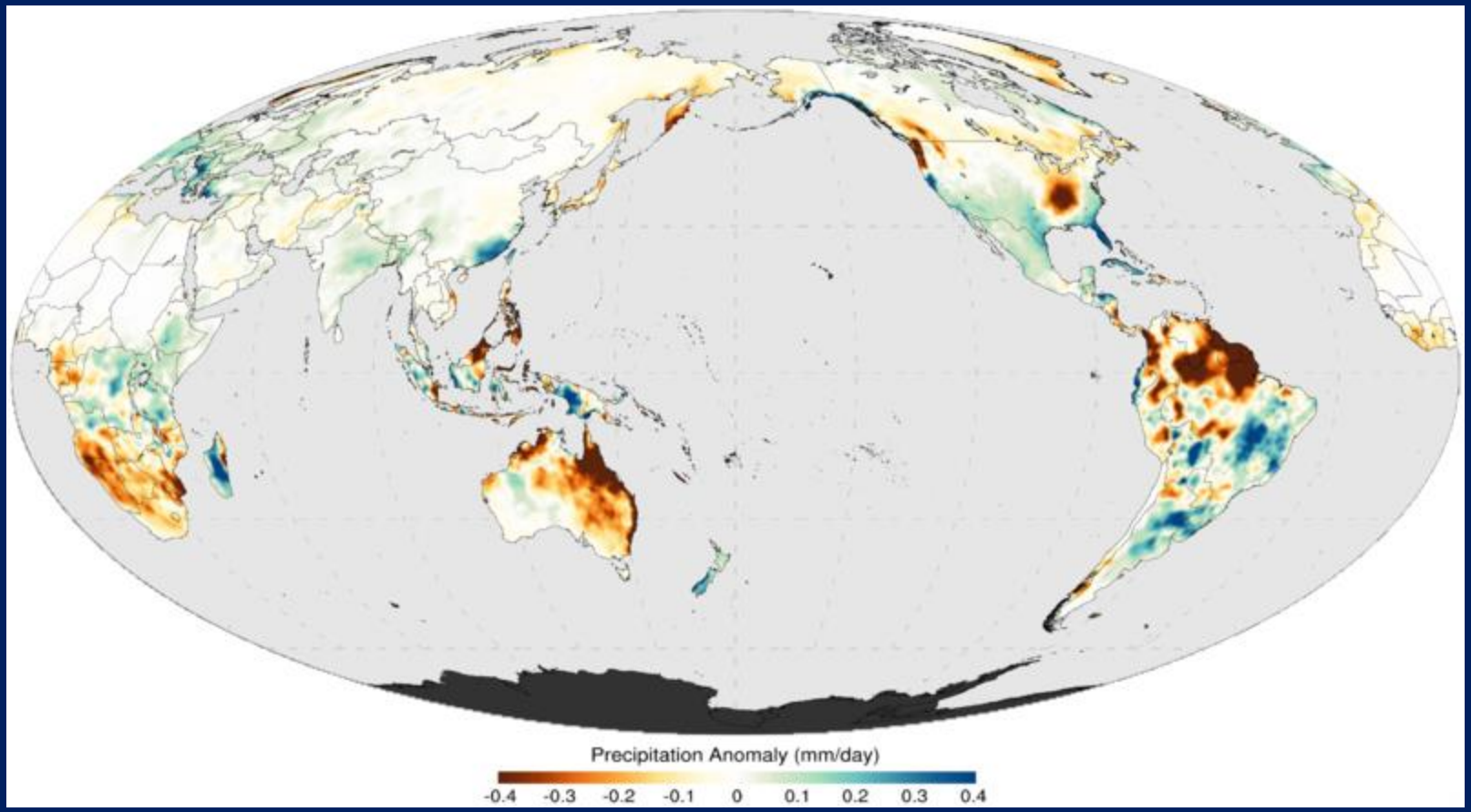
AMO (Atlantic Multi-decadal Oscillation) SSTA in N Atlantic (upper) , STA (lower)


Pacific Decadal Oscillation
Temperature (°C sd-1)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5

PDO index


4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
PDO Index
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


Temperature Anomaly (°C)
-1.5 -1.2 -0.9 -0.6 -0.3 0 0.3 0.6 0.9 1.2 1.5


Precipitation Anomaly (mm/day)
-0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4

External forcing

For **seasonal –inter-annual** climate change

SST,

snow cover,

Soil moisture and temperature

…..

For **longer time scale**

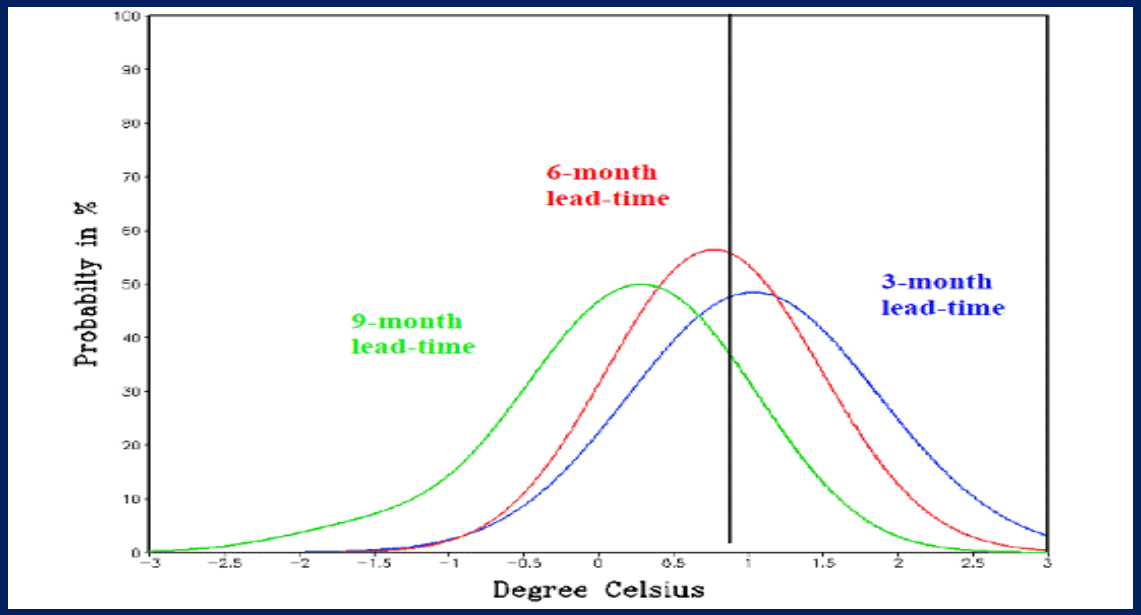
- Solar radiation
  - 11 22yrs sunspot cycles
- Lunar tidal 18.6yrs
- Volcano eruption
- Earth rotation rate …
- Trace gas emission
- Land cover/land use

- climate system is high unlinear system , climate prediction provides climatic probability (with uncertainty) in future.
- More understanding climate change , more predictable
- To assess climatic impacts must consider climatic uncertainty

Strategy of climate prediction

Probability density function (PDF)

predictable signal / unpredictable noise



Nino 3,4 SST
Predicting PDF

1. Statistic (based on long time series)

MGF(mean generate function),

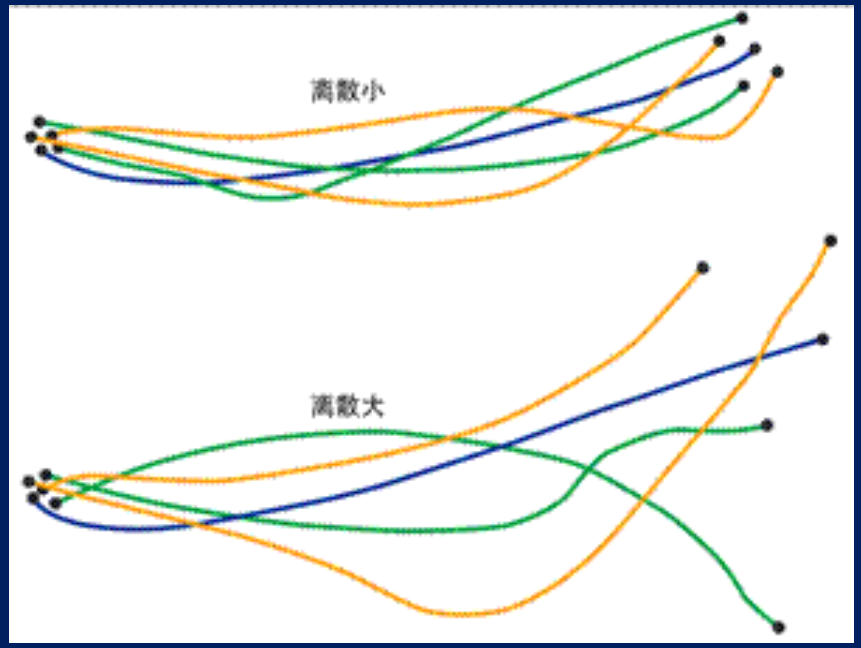
OSR(optimal subset regression,

EMD(empirical mode decomposition)

2. Stochastic dynamical model

3. Dynamic model

Prediction of dynamical model depend strongly on initial conditions



Ensemble

One model with a set of random initial conditions

One model ensemble mean + corrections

ensemble skill related to system structure and geographical location

Multimodel ensemble (superensemble, MME)

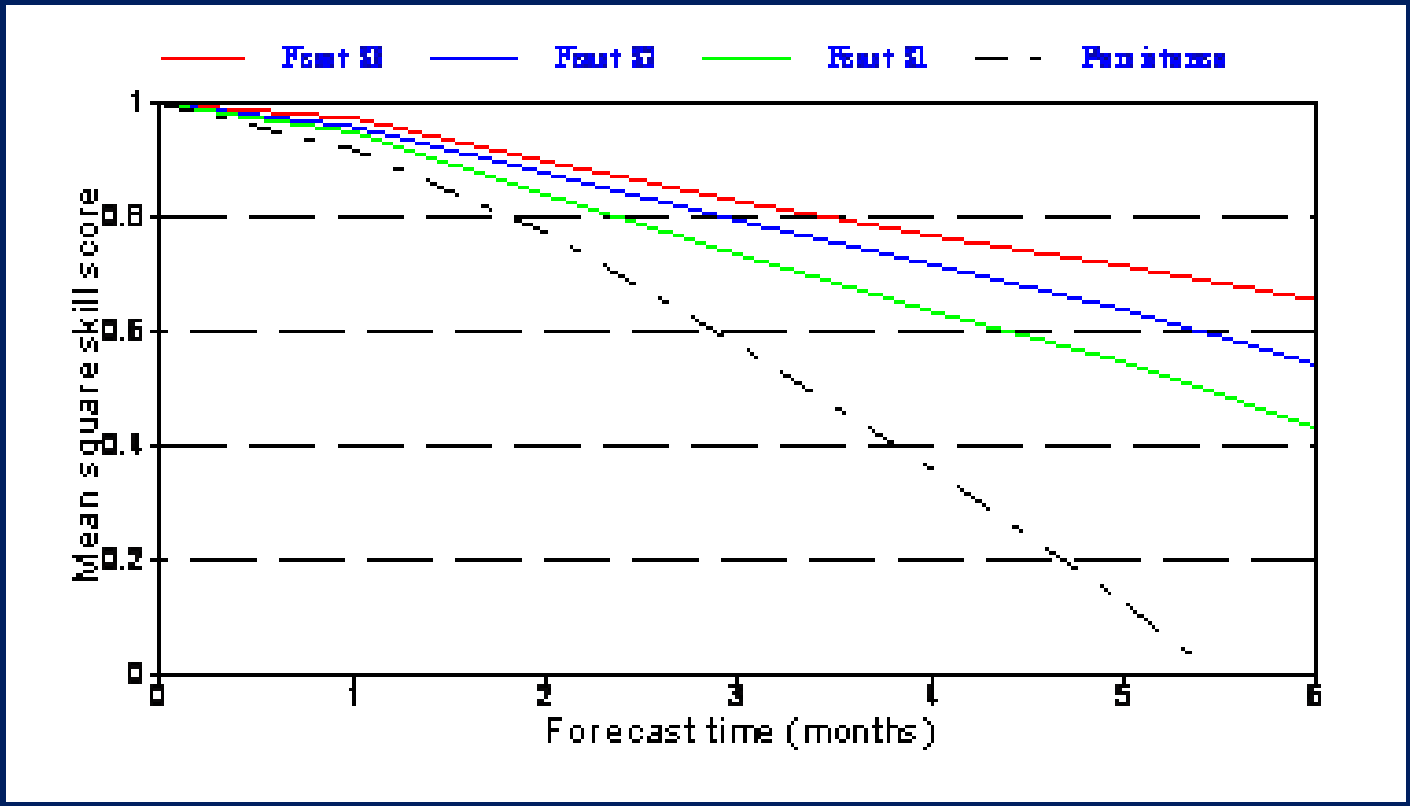
multi model

multi parameter

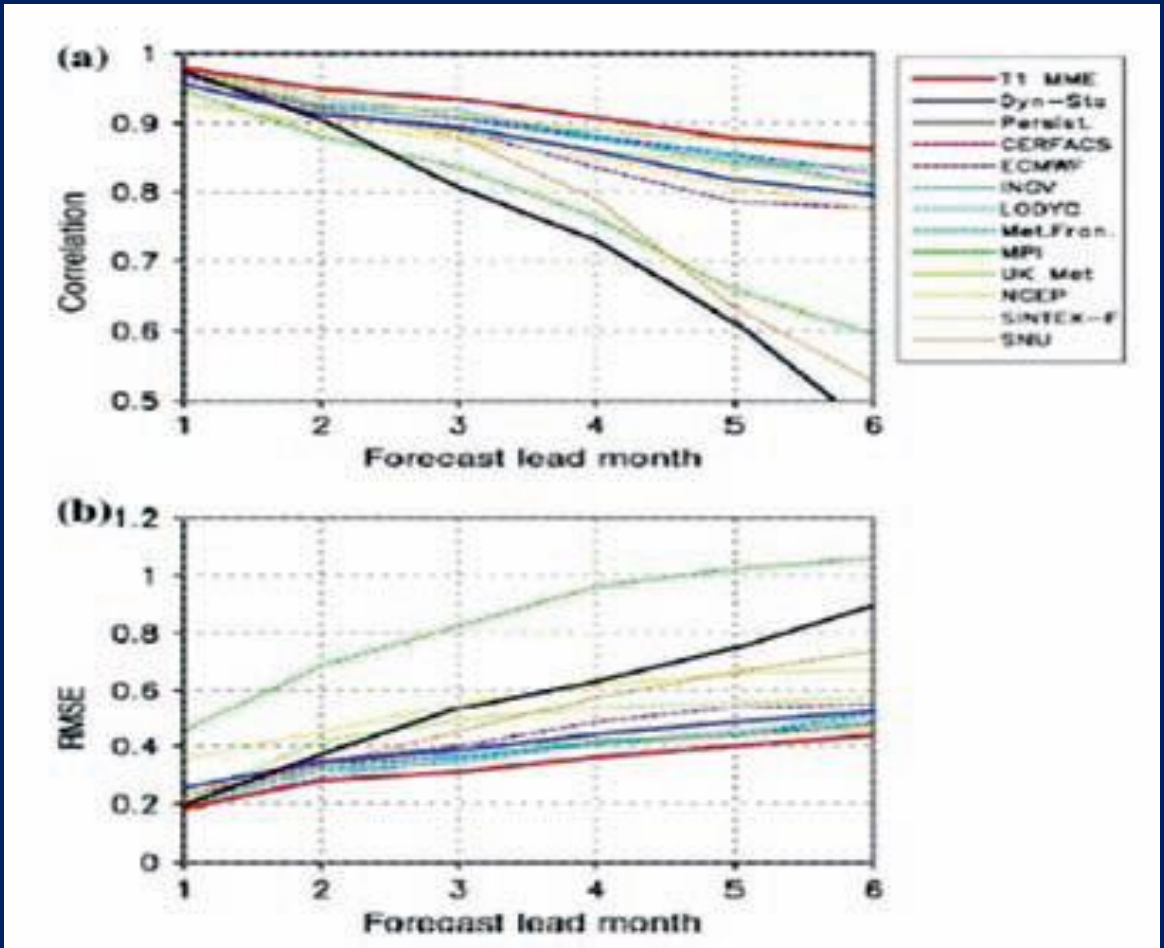
multi parameterization

Ensemble predicting skill is higher than individual model prediction

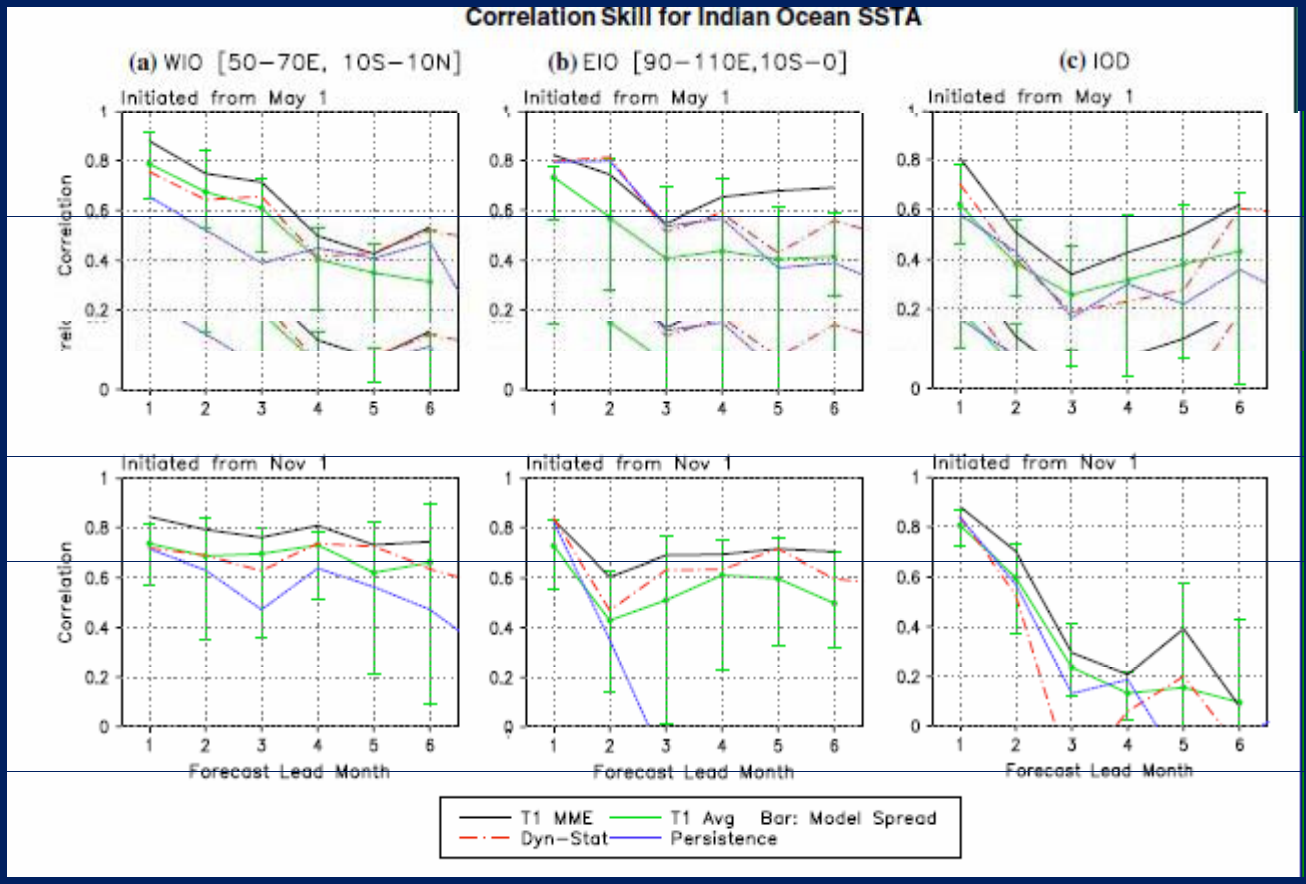
MME higher one model ensemble

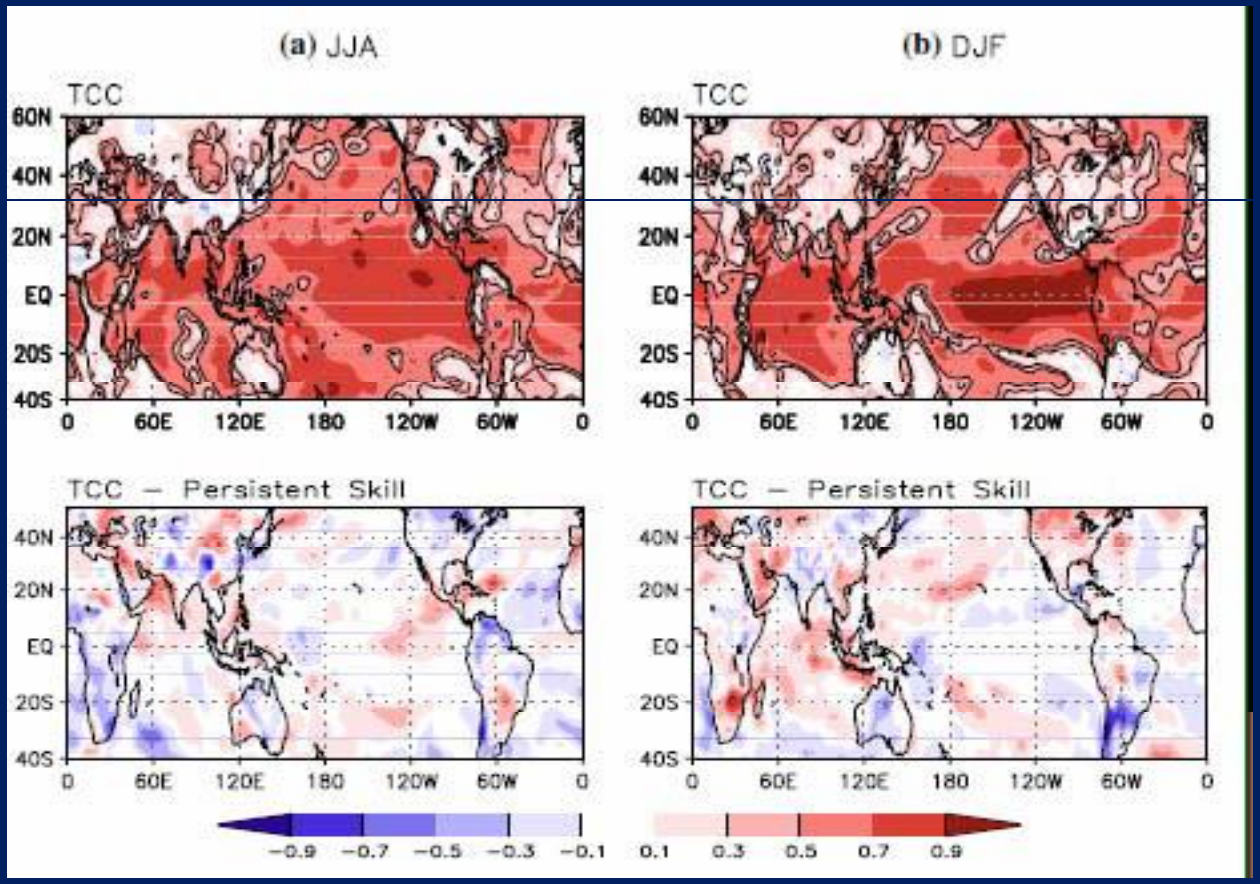


Mean square skill score for Nino 3,4 , ECMWF

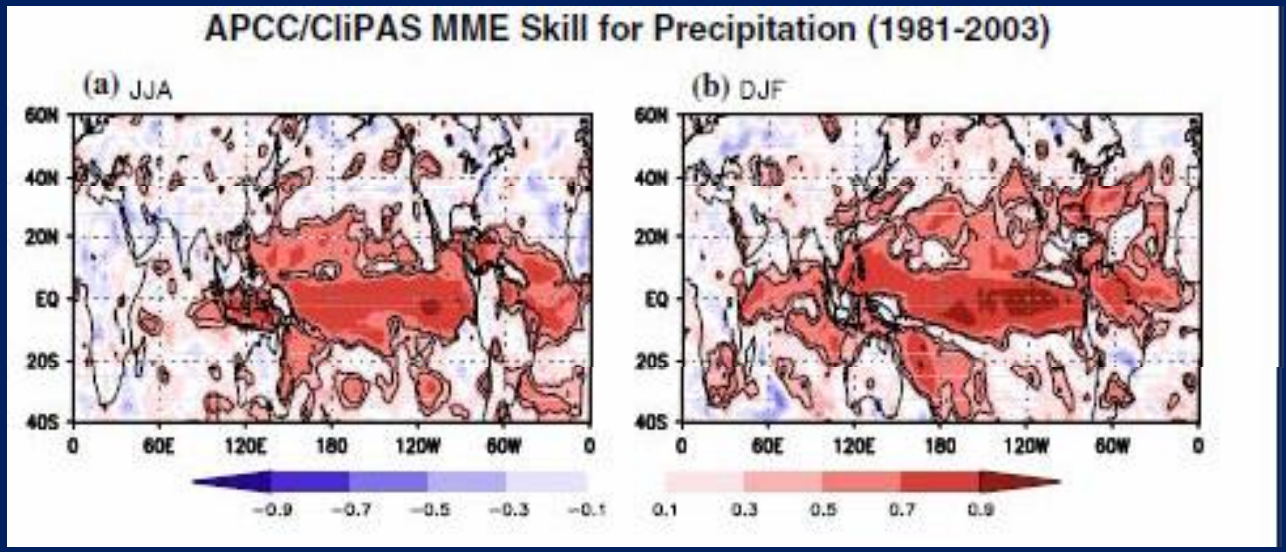


ENSO ensemble skill, red line: MME


Correlation Skill for Indian Ocean SSTA
(a) WIO [50–70E, 10S–10N]
(b) EIO [90–110E,10S–0]
(c) IOD
Initiated from May 1
Initiated from May 1
Initiated from May 1
Initiated from Nov 1
Initiated from Nov 1
Initiated from Nov 1
Correlation
Correlation
Forecast Lead Month
Forecast Lead Month
Forecast Lead Month
T1 MME
T1 Avg
Bar: Model Spread
Dyn–Stat
Persistence



1981-2003 APCC MME ensemble skill 2m Temperature


APCC/CliPAS MME Skill for Precipitation (1981-2003)
(a) JJA
(b) DJF
60N
40N
20N
EQ
20S
40S
0
60E
120E
180
120W
60W
0
−0.9
−0.7
−0.5
−0.3
−0.1
0.1
0.3
0.5
0.7
0.9

MME skill

Depend on seasons and regions

Related to ENSO highest

Indian Ocean high

Eastern Asia low

Tropic higher than mid-latitude

Temperature better than precipitation

Climate prediction operation in China

1980's to start dynamic prediction tests in IAP

NCC Dynamic prediction operation started at the beginning of 21th century

Monthly Forecast(Monthly "30 days" Forecast)

- runs at the end of each dekad
- 32 members of maximum ensemble size.
- The initial condition come from global atmospheric data assimilation of T213
- the boundary conditions are latest weekly persist SSTA
- Products:
  - circulation and factors in the 40 days of future

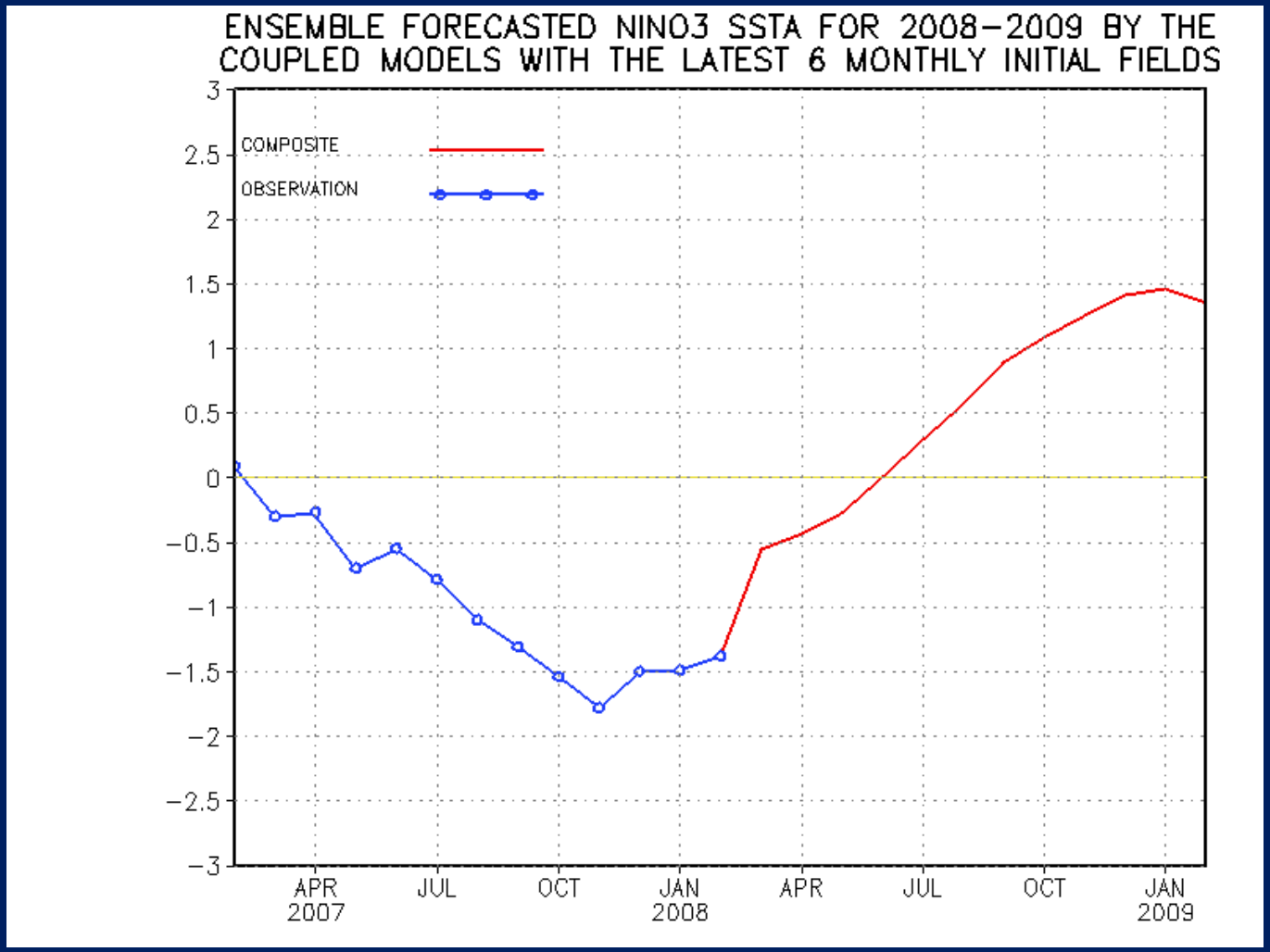
Seasonal Forecast(Seasonal "90 days" Prediction)

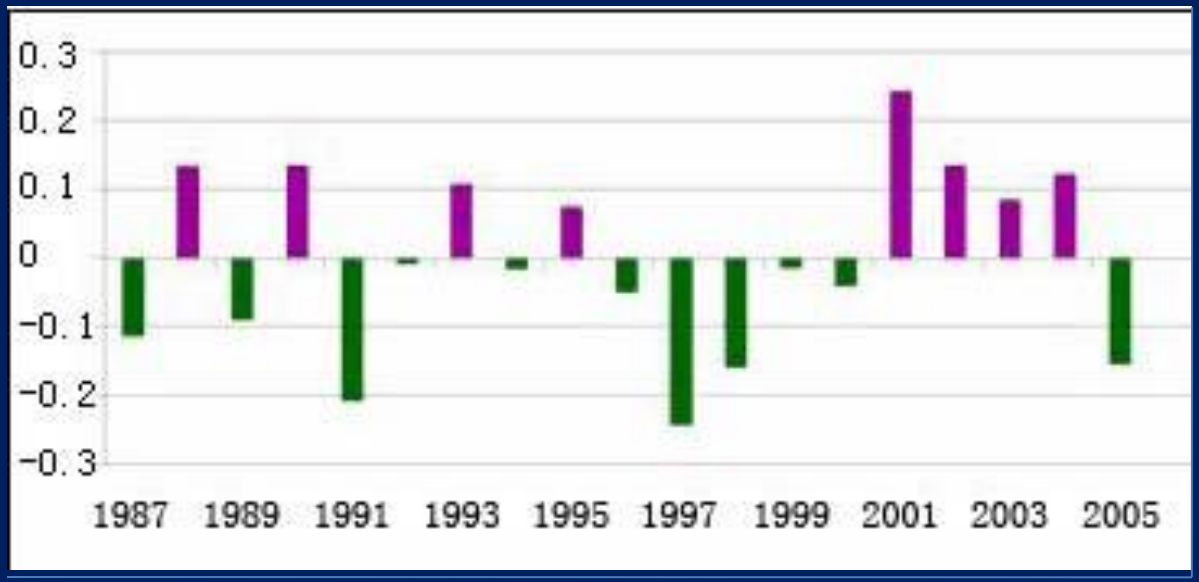
1. by CGCM
Ensemble mean of 8 members:
Spring Forecast ： issued at Feb. for MAM
Flood Season Forecast ： issued at Mar. for JJA
Summer Forecast ： issued at May. for JJA
Flood Season Supplyment Forecast ： issued at Jun. for JA & JAS
Autumn Forecast ： issued at Aug. for SON
Annual Forecast ： issued at Oct. for DJF & next MAM JJA
Winter Forecast ： issued at Nov. for DJF

2. by RegCM for EastAsia
RegCM nested with CGCM
Flood Season Forecast ： issued at Mar. for JJA
Annual Forecast ： issued at Oct. for DJF & next MAM JJA

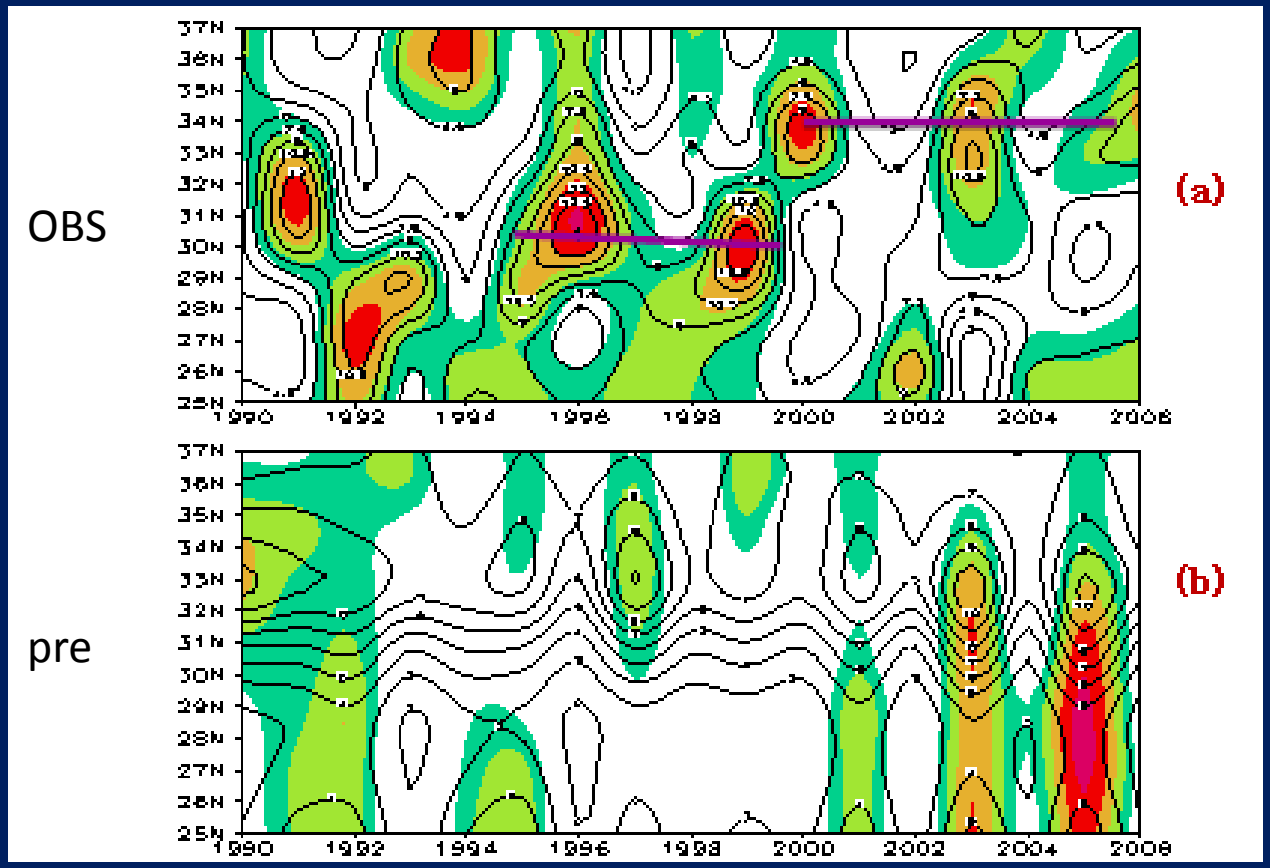
ENSO Prediction

simplified ENSO model
run at the end of each season , to predict
the Nino3 Index of next 2-3 seasons


ENSEMBLE FORECASTED NINO3 SSTA FOR 2008–2009 BY THE COUPLED MODELS WITH THE LATEST 6 MONTHLY INITIAL FIELDS
COMPOSITE
OBSERVATION
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
APR 2007
JUL
OCT
JAN 2008
APR
JUL
OCT
JAN 2009

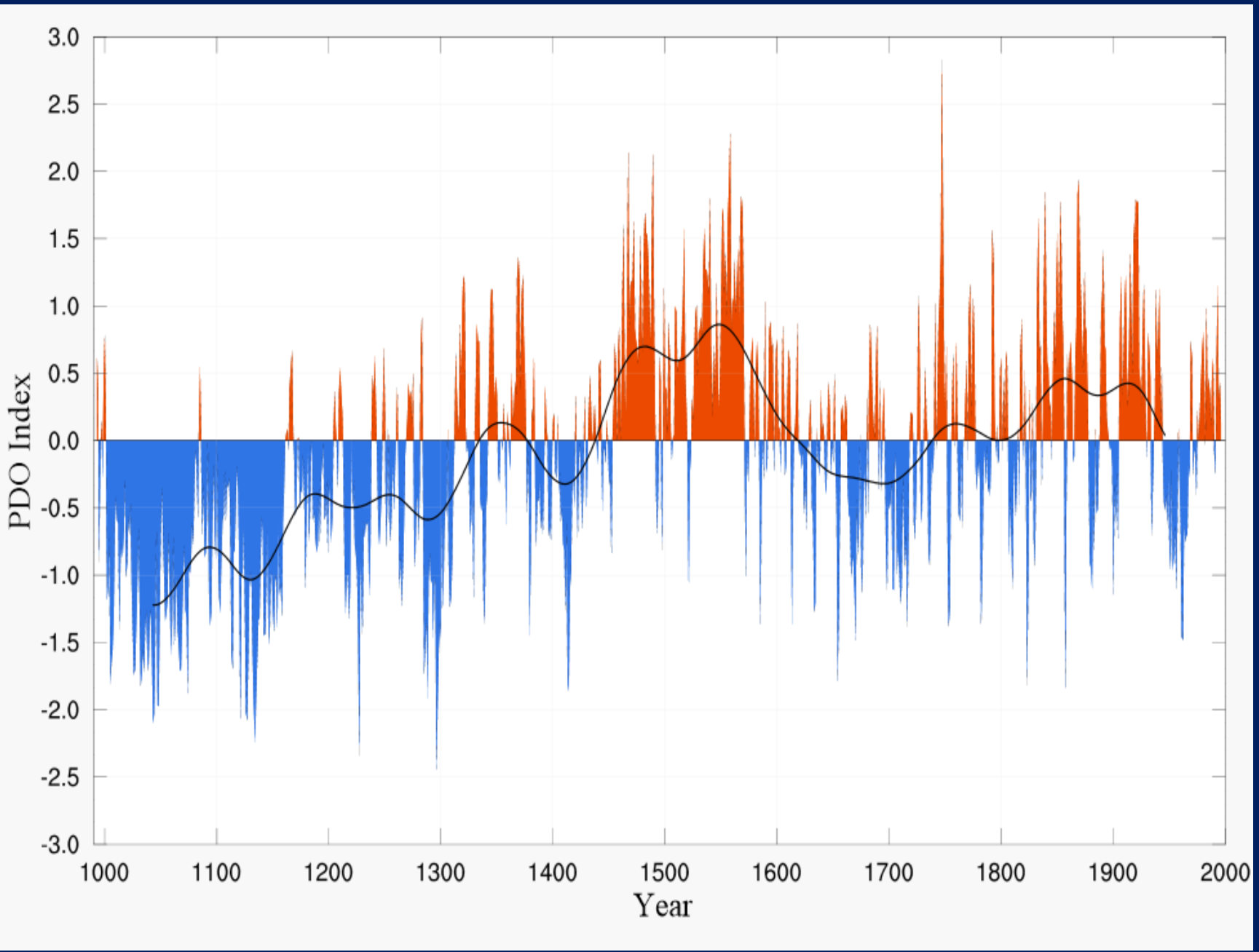


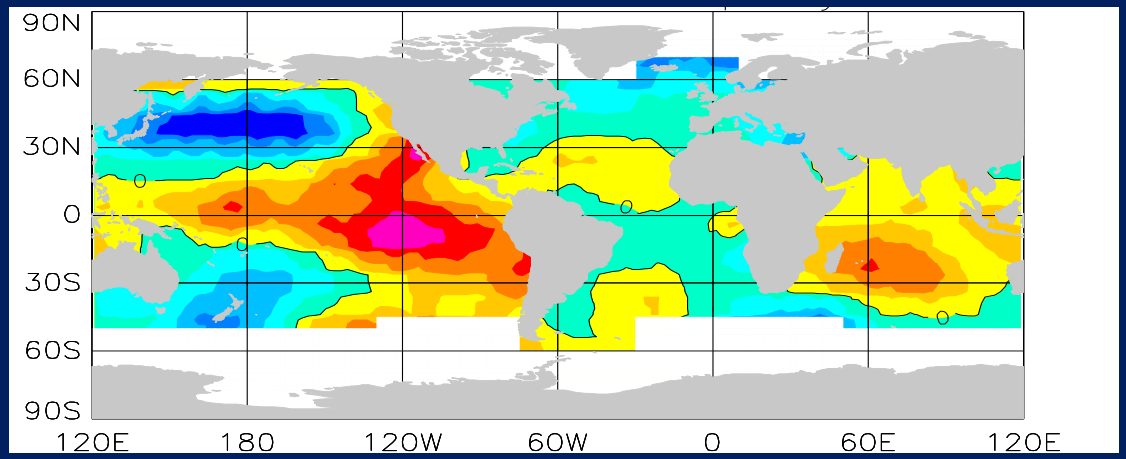
Correlation coefficient between Obs. and predicted Mei-Yu rainfall. 1987-2006

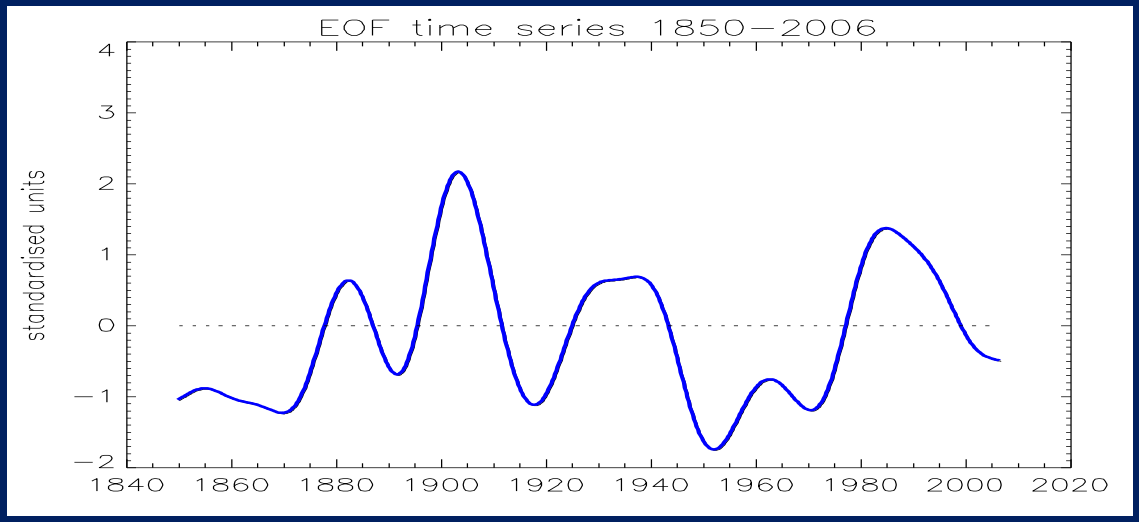


Mei-Yu rainfall (mm/d) 1990-2006

Thank you


3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
PDO Index
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Year





Interdecadal Pacific Oscillation , SSTA