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Impact of land surface conditions on the potential seasonal predictability over East Asia

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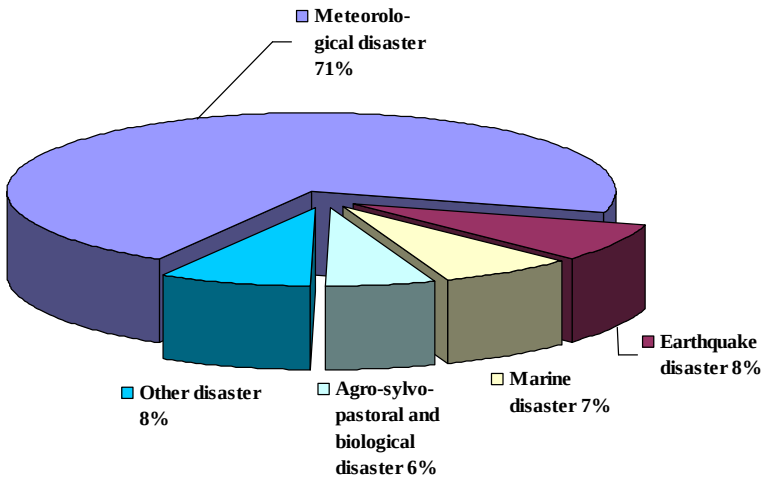
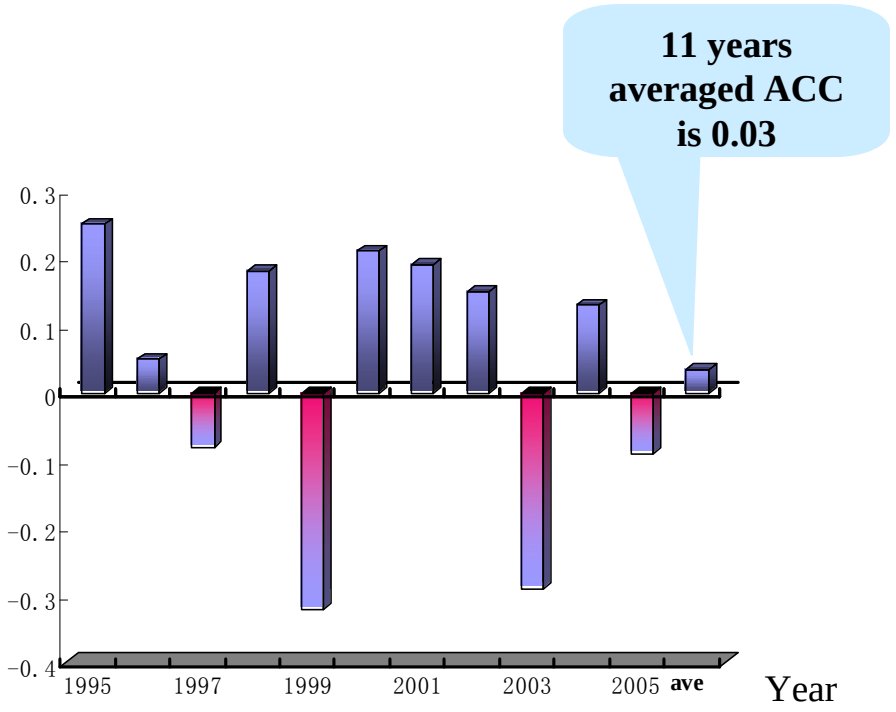
Outline

- Introduction
- Model and experiment design
- Impact of land conditions on Seasonal predictability
- Summary

Introduction

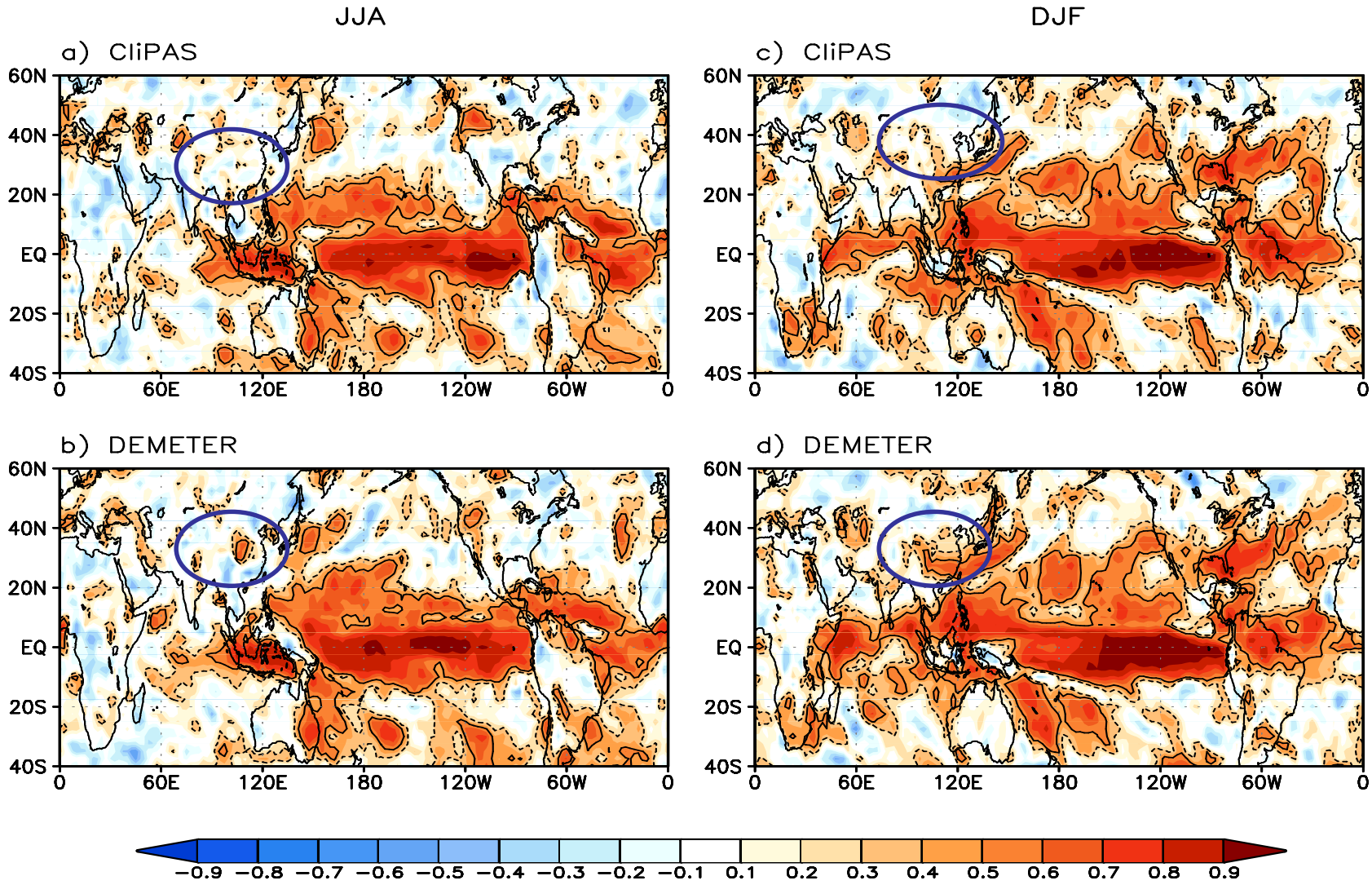
Annual economic loss caused by natural disasters in China



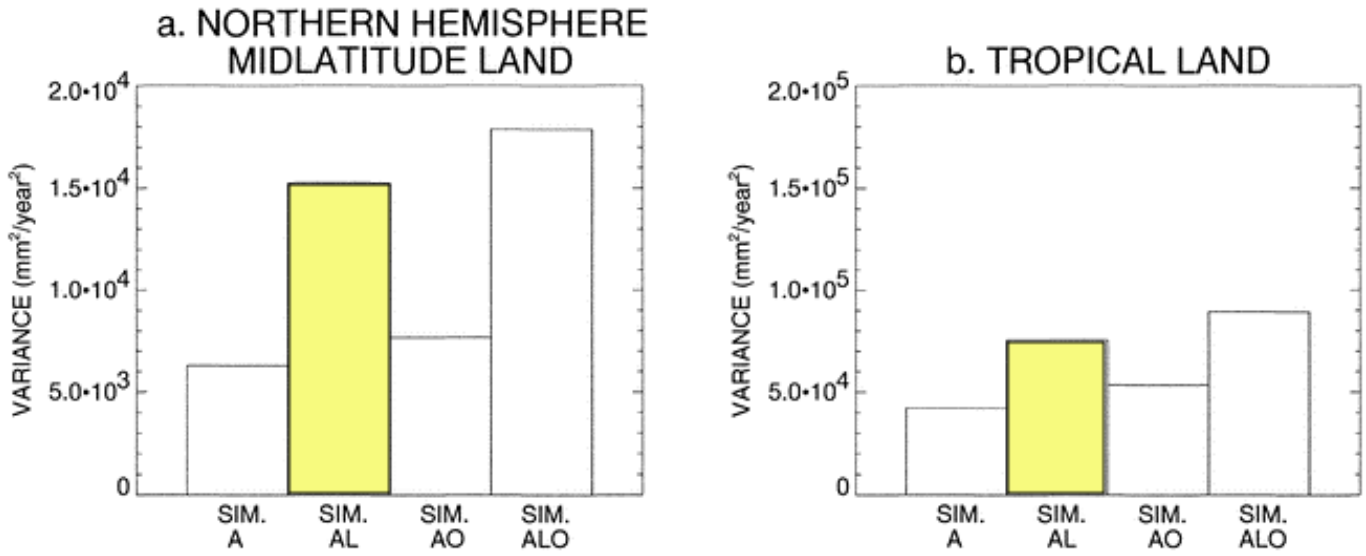


Anomaly correlation coefficients between forecast and observed precipitation （NCC/CMA)

Temporal Correlation / Precipitation



Land regions are lacking skills. (From Bin Wang, 2006)

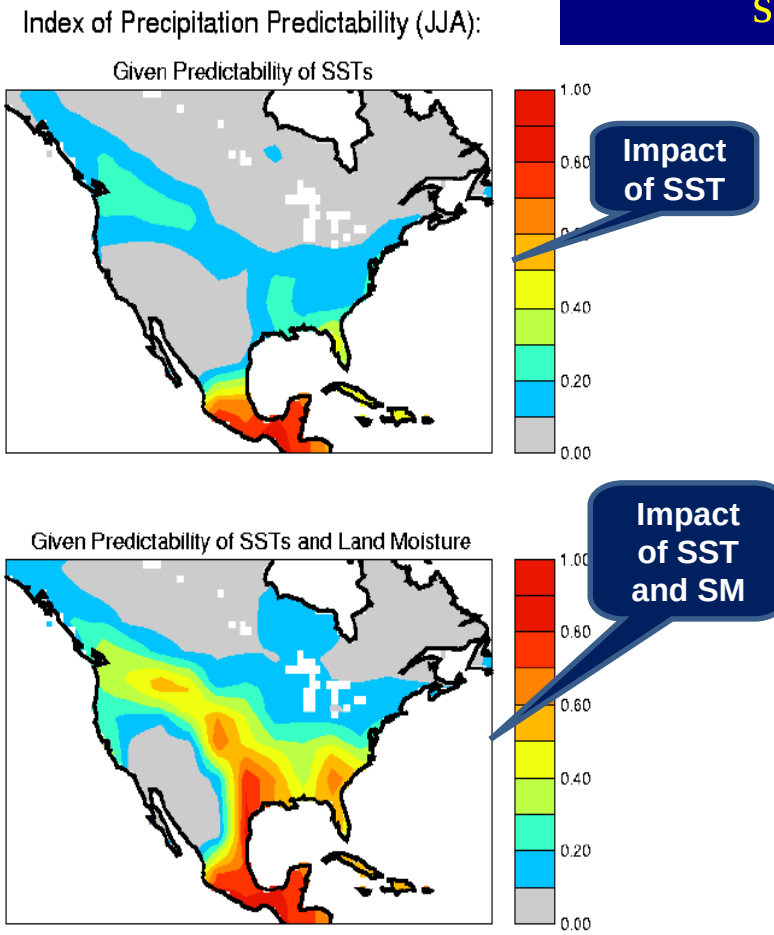


Experiment identifier	No. of simulations in ensemble	Length of each simulation	Total years	Experiment description
A	4	200 yr	800	Prescribed, climatological land; climatological ocean
AL	4	200 yr	800	Interactive land; climatological ocean
AO	16	45 yr	720	Prescribed, climatological land; interannually varying ocean
ALO	16	45 yr	720	Interactive land; interannually varying ocean

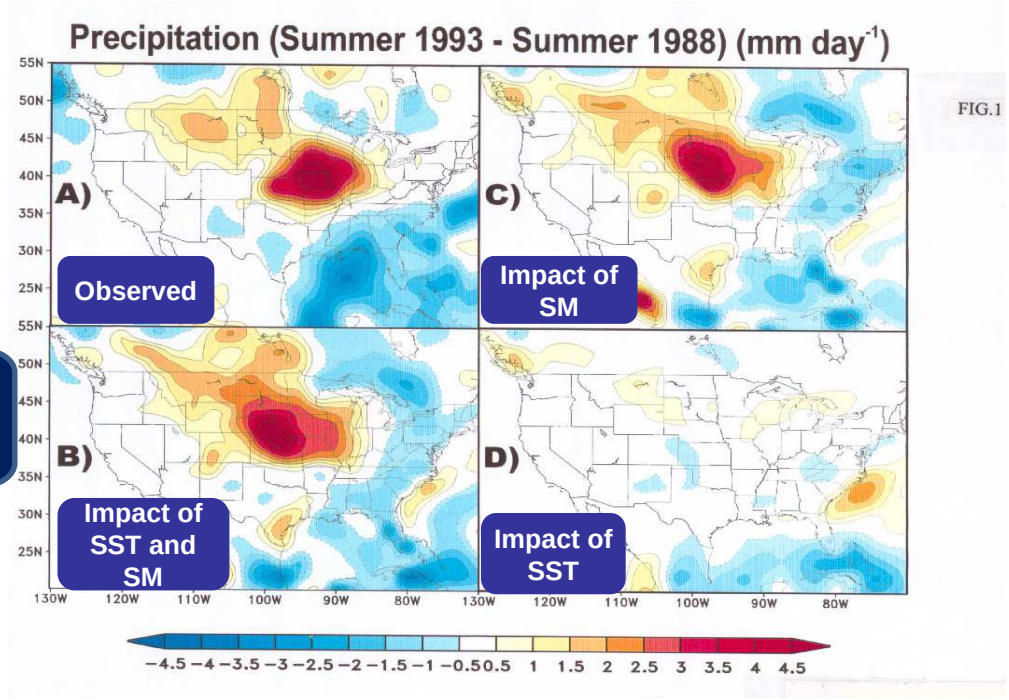
The effect of land surface processes on the inter-annual variability of precipitation is larger than that of ocean in mid latitude land regions in northern hemisphere, and even in tropical land.

Koster et al., 1995, 2000

Impact of soil moisture on seasonal predictability of summer rainfall over North America



Koster et al., 2000, J. Hydometeorol., **1**, 26-46.



Schubert et al., 2004, J. Climate, **17**, 485–503.

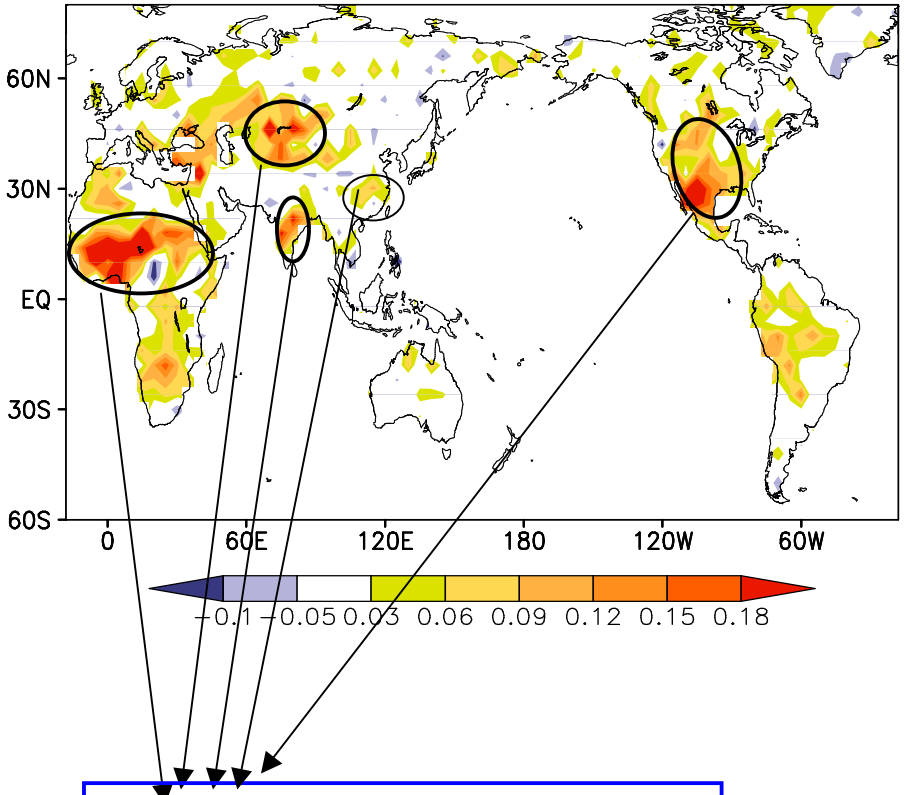
What is the impact of land surface conditions on potential seasonal predictability of summer climate over East Asia?

Brief Description of IAP9L_CoLM

- Originating from the end of 80's of 20th century
  - Zeng et al. 1990, Zhang 1990, Liang 1996, Bi 1993, Zhang 2004
- Widely used in climate numerical simulation research over global and East Asia
  - Wang and Bi 1996, Lin et al. 1999, Li et al. 2000, Xue et al. 2003, Wang 2002, Jiang et al. 2003
- Also used in short-term climate prediction, such as summer flood and drought, spring sand trend, and so on.
  - Lang et al. 2003, Wang et al. 2004
- Coupled IAP 9L AGCM with the Common Land Model (Dai et al. 2003)
  - Liu et al. 2007

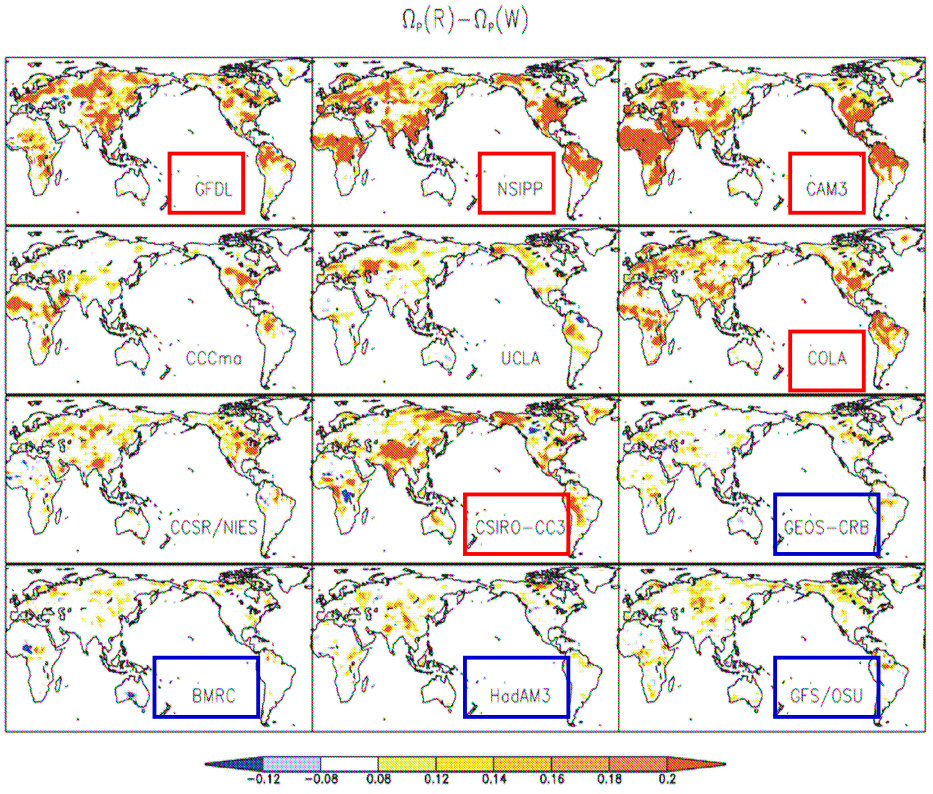
✓ Land-Atmosphere Coupling Strength in IAP 9L-CoLM

IAP9L_CoLM



Regions with strong Coupling strength between soil moisture and precipitation

GLACE-I Results



Experiment design

- Two sets of ensemble hindcast （EXP_SSTs and EXP_SSTs+SM) with 10 ensemble members have been conducted, with atmospheric initial conditions taken from NCEP/DOE reanalysis from 0000 UTC of 10-19 May during 1981-2000.
  - EXP_SSTs: Land surface condition is generated by the IAP coupled Atmospheric-Land Model (IAP9L_CoLM)
  - EXP_SSTs+SM: Land surface condition is obtained by driving the Land component of IAP AGCM (i.e., CoLM) with GPCP precipitation, instead of the model generated precipitation as in EXP_SSTs.
- The observed SST is taken from the HadISST
- Hindcast period: 1981-2000

Variance analysis method

- Let P_{ni} represent the summer precipitation anomaly at a given grid cell during year n of member i of EXP_SSTs

$$\bar{P} = \frac{1}{NI}\sum_{n=1}^{N}\sum_{i=1}^{I} P_{ni}$$ --overall average

$$\hat{P}_n = \frac{1}{I}\sum_{i=1}^{I} P_{ni}$$ --I ensemble members averaged during year n

$$\sigma_P^2 = \frac{1}{NI}\sum_{n=1}^{N}\sum_{i=1}^{I}(P_{ni} - \bar{P})^2$$ --total variance

$$\sigma_{\hat{P}}^2 = \frac{1}{N}\sum_{n=1}^{N}(\hat{P}_n - \bar{P})^2$$ --external variance

Effect of SST

Effect of SST and atmosphere

$$\Omega_{P,EXP\_SSTs} = \frac{I\sigma^2_{\hat{P},EXP\_SSTs} - \sigma^2_{P,EXP\_SSTs}}{(I-1)\sigma^2_{P,EXP\_SSTs}}$$

→ **Contribution of SST**

Effect of SST and SM

Effect of SST, SM and atmosphere

$$\Omega_{P,EXP\_SSTs+SM} = \frac{I\sigma^2_{\hat{P},EXP\_SSTs+SM} - \sigma^2_{P,EXP\_SSTs+SM}}{(I-1)\sigma^2_{P,EXP\_SSTs+SM}}$$

→ **Contribution of SST and LSC**

$$\Omega_{P,SSTs+SM} - \Omega_{P,SSTs}$$

→ **Contribution of LSC**

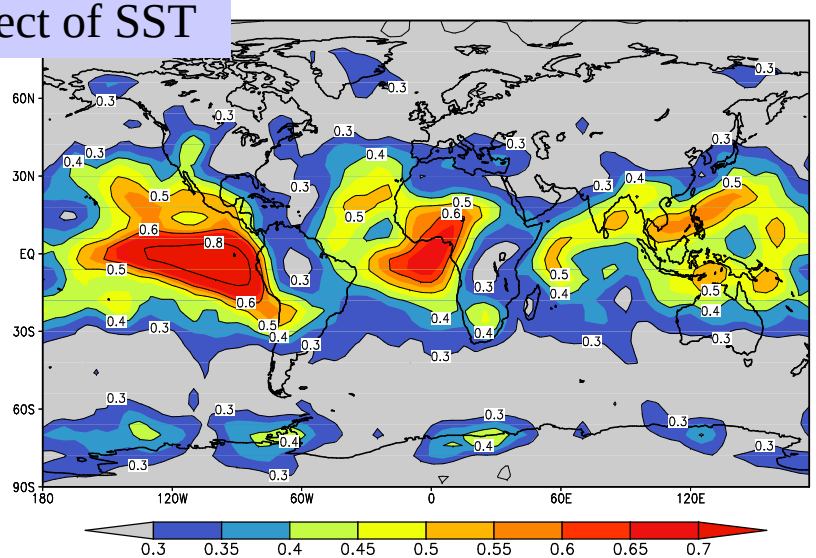
(Koster et al. 2000)

Observation Datasets

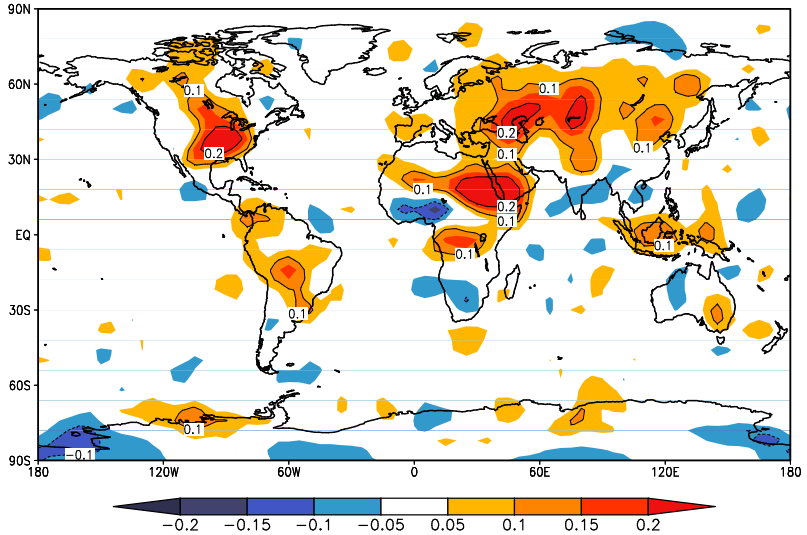
- Precipitation:
  - Observed: GPCP monthly data, climatology is based on the data of 1981-2000.
- Surface air temperature:
  - Observed: CRU TS 2.1, climatology is based on the data of 1981-2000.
- Method: Anomaly correlation coefficient (ACC).
- Region division:
  - East Asia (80ºE–180ºE, 10ºN–60ºN),
  - South Asia (50ºE–160ºE, 15ºS–40ºN),
  - Russia (25ºE–180ºE, 40ºN–80ºN),
  - Australia (80ºE–180ºE, 50ºS–10ºN),
  - North America (180ºW–50ºW, 10ºN–80ºN),
  - Southern America (90ºW–30ºW, 60ºS–10ºN).

Potential predictability of summer precipitation

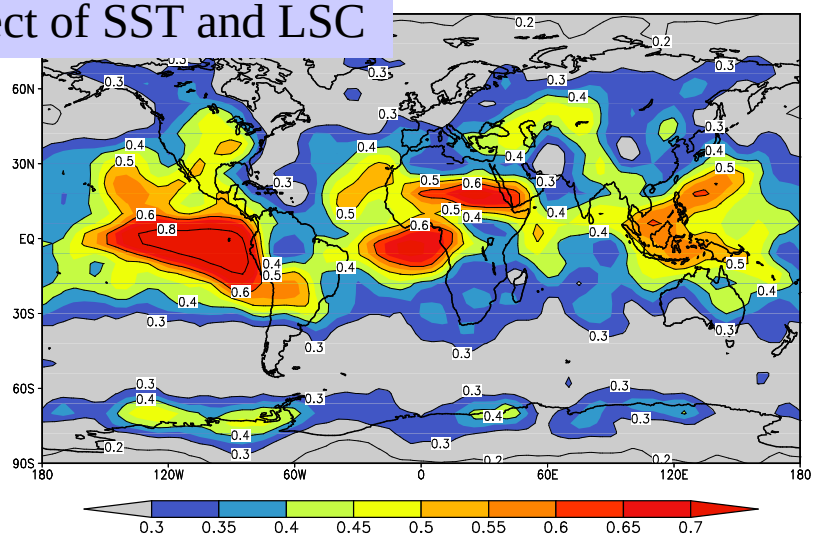
Effect of SST



Impact from LSC



Effect of SST and LSC

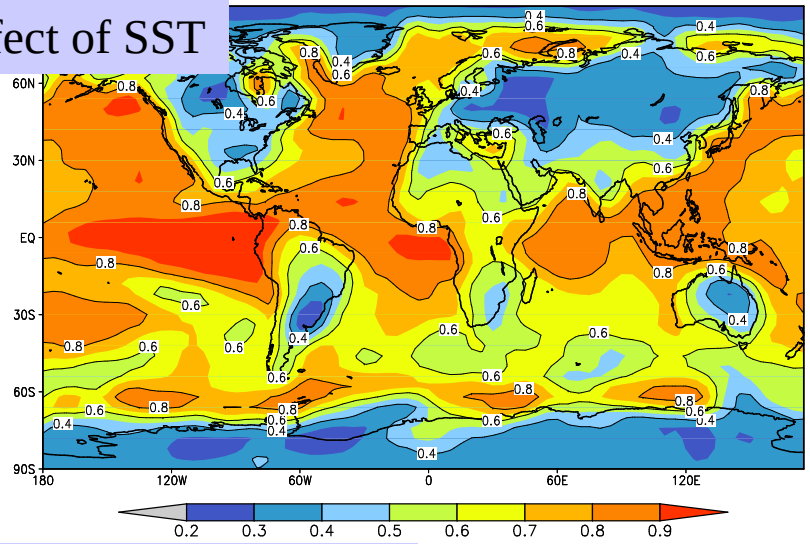


When considering the impact of SST, the potential predictability is larger in the tropical ocean.

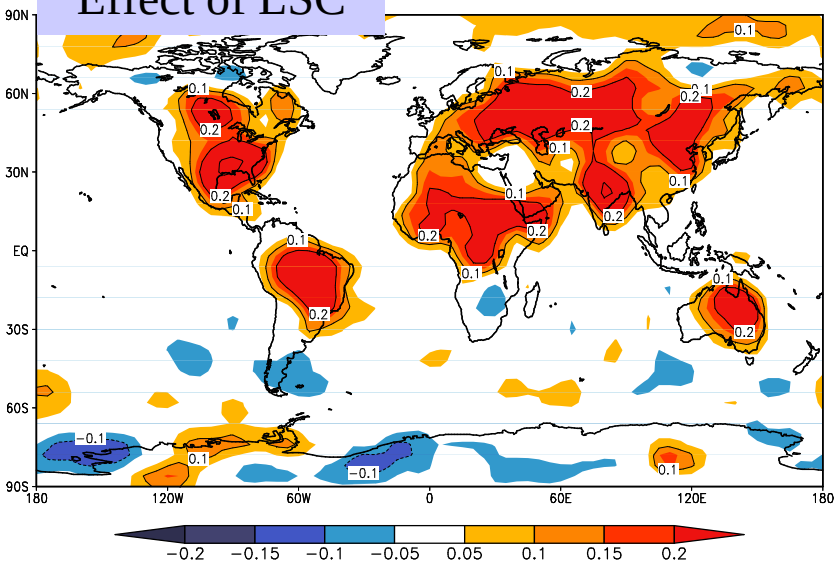
When SSTA and more realistic land surface conditions are both considered, the potential predictability increases over most part of global land areas, especially over mid-high latitude of and areas, with significant increases exceeding 0.2 in mid-latitude of Eurasian continent, eastern Africa, Northern America.

Potential predictability of summer surface air temperature

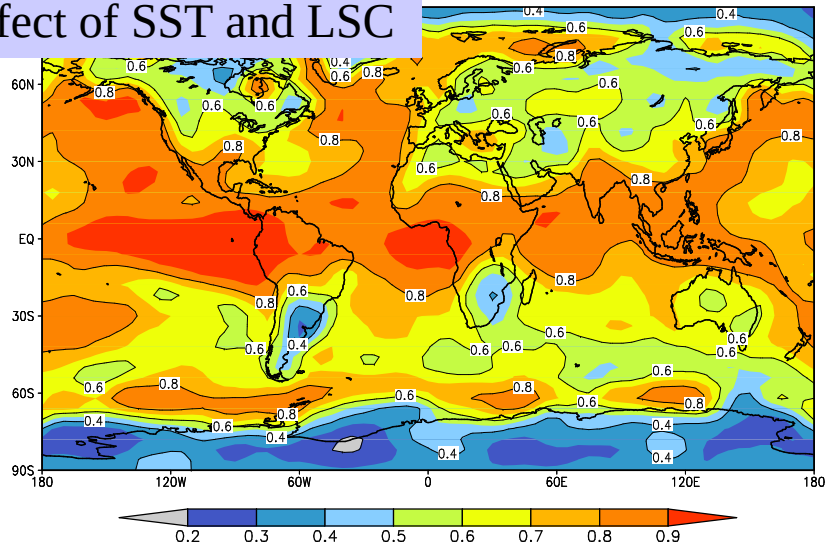
Effect of SST



Effect of LSC



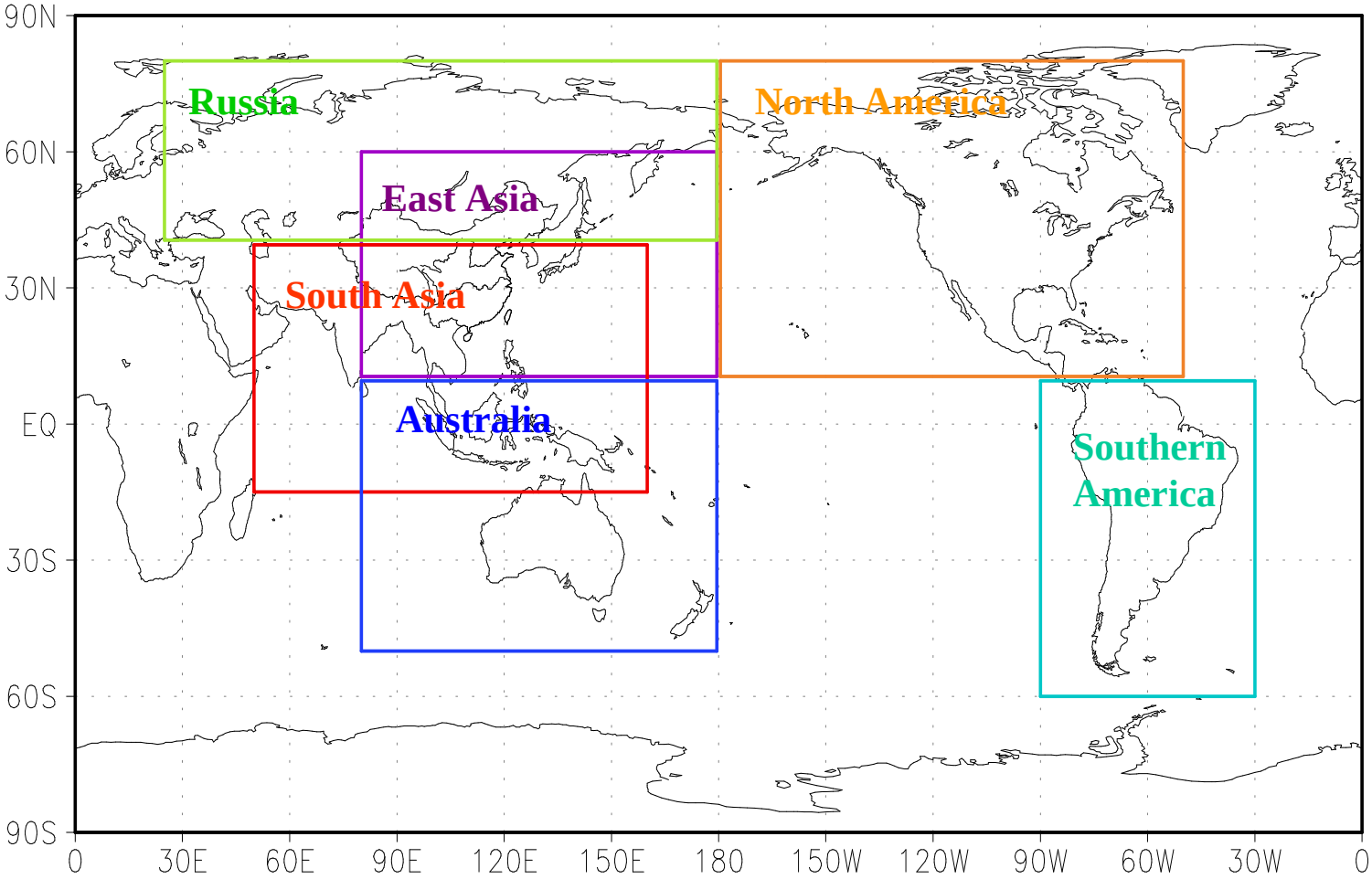
Effect of SST and LSC



the potential predictability is larger in ocean, especially in the tropical ocean, when considering the impact of SST,.

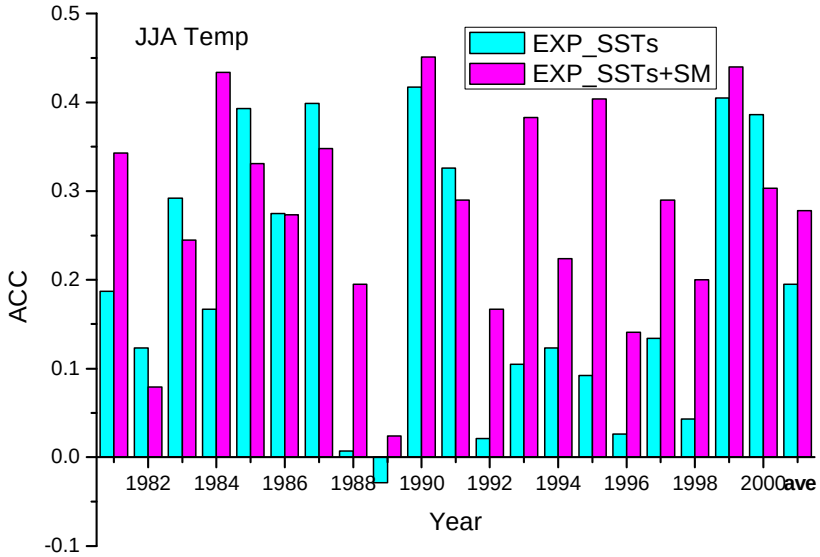
When considering the effect of SST and more realistic land surface conditions , the potential predictability increases significantly over global land areas, with increase of magnitude exceeding 0.2 over most land areas.

Region division



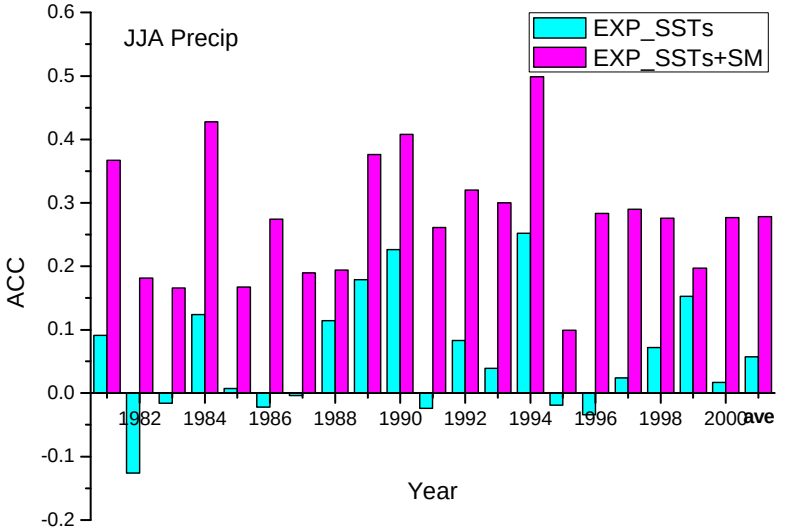
Anomaly Correlation Coefficients of JJA Precipittaion and surface air temperature (global land Areas）

ACC: 0.20→0.28



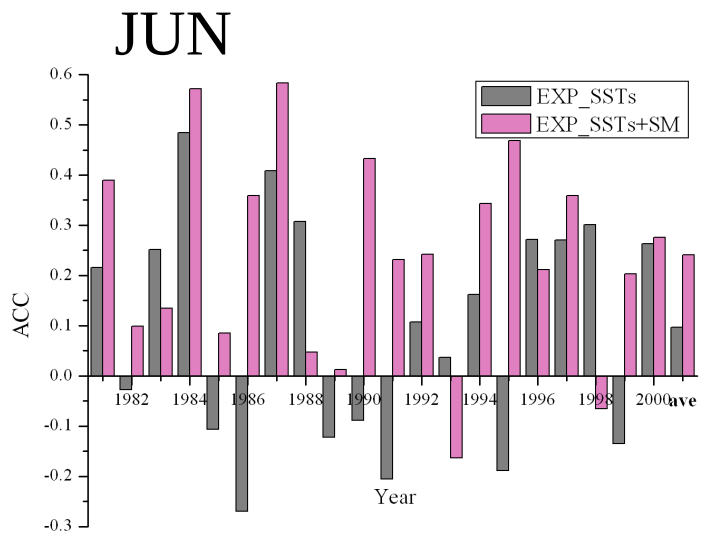
JJA Temperature

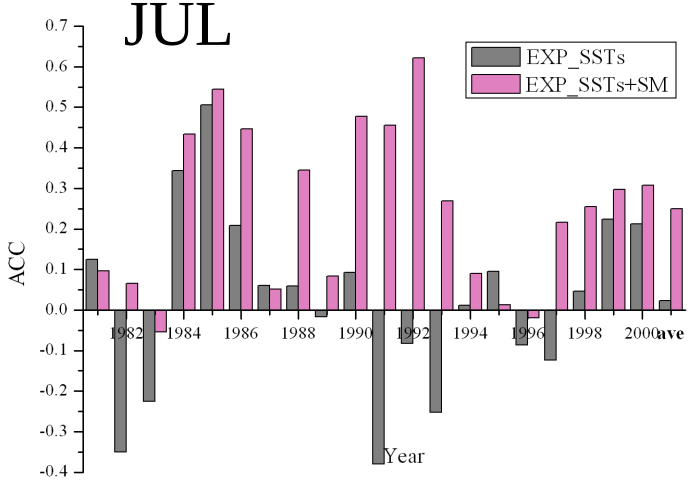
JJA Precipitation

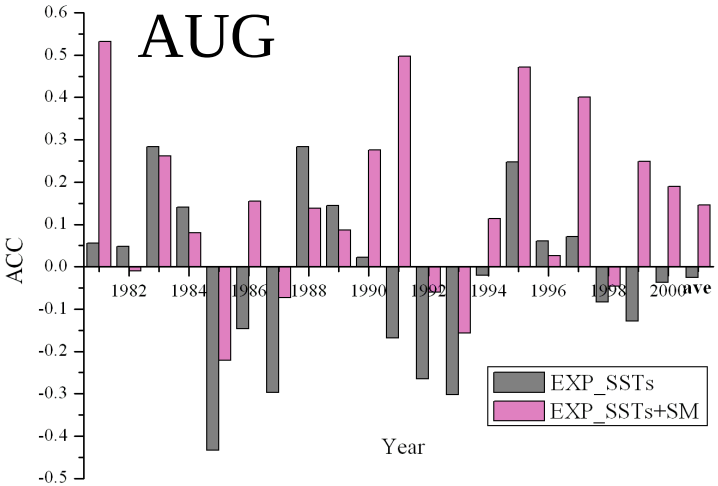


ACC : 0.06→0.28

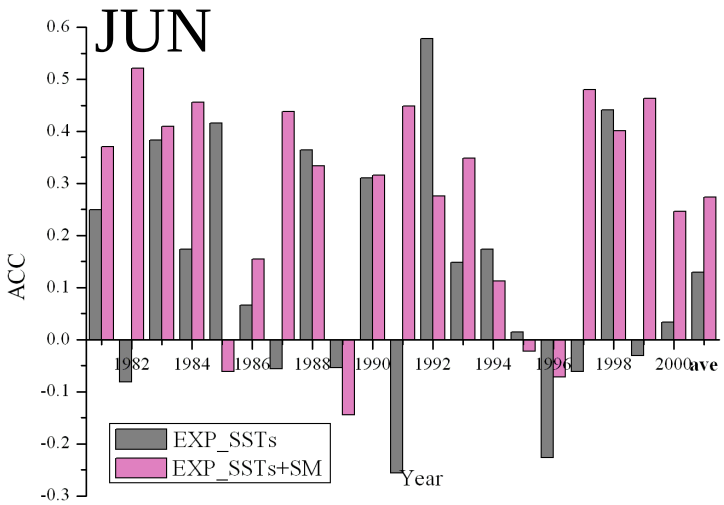
Anomaly Correlation Coefficients of precipitation over global land in June, July and August

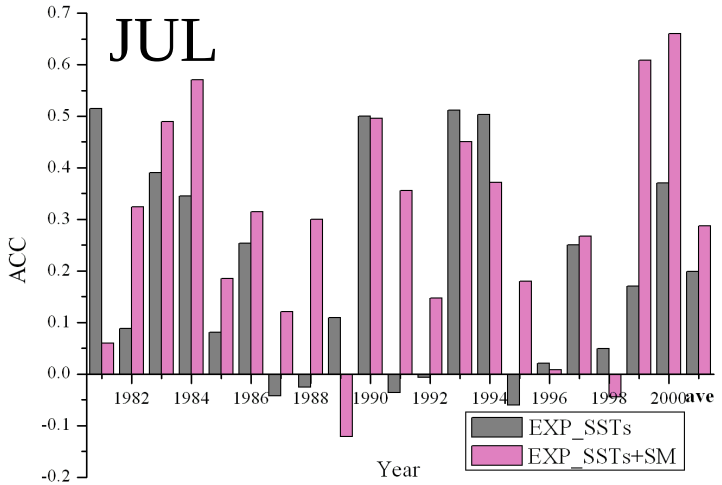


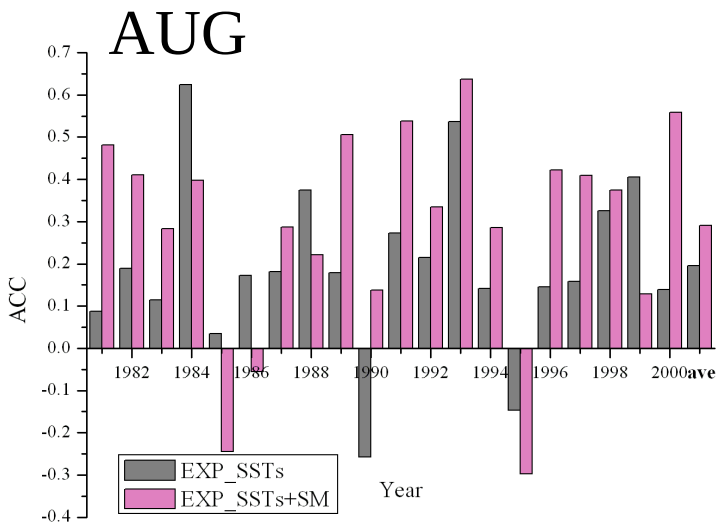




Anomaly Correlation Coefficients of surface air temperature over global land in June, July and August

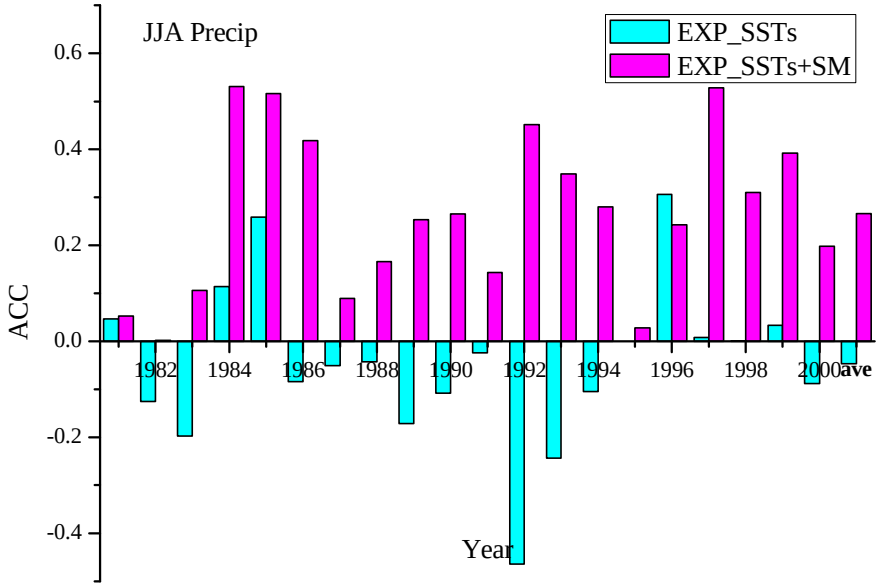






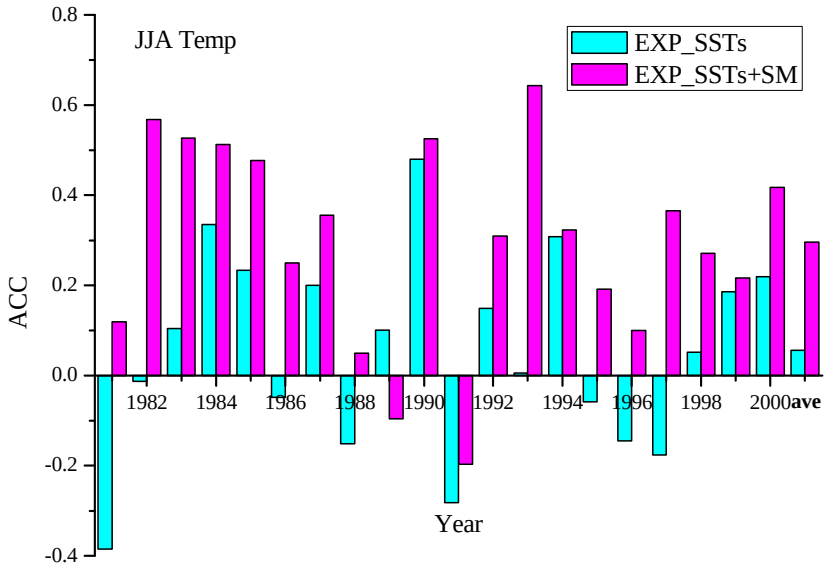
Anomaly Correlation Coefficients of JJA Precipittaion and surface air temperature (East Asia）

JJA Precipitation



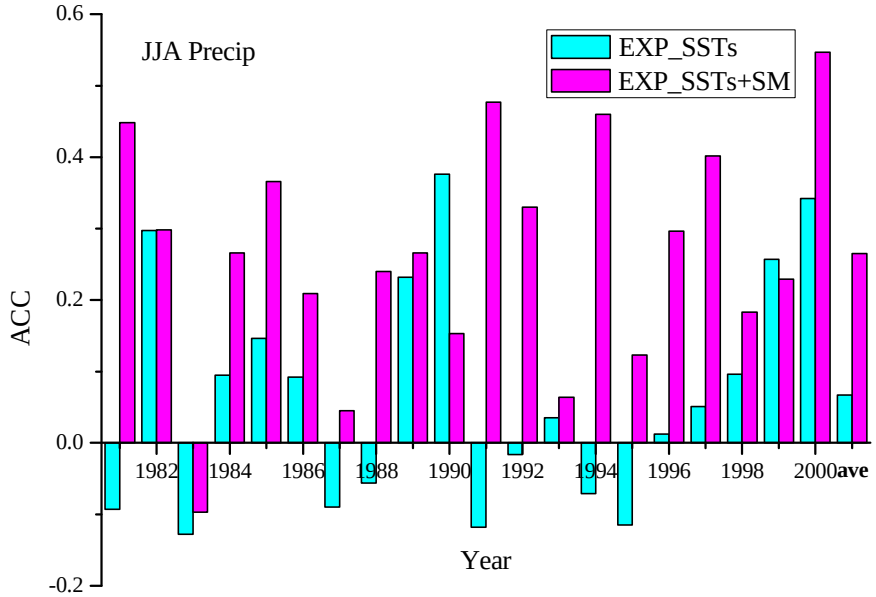
ACC: -0.05→0.27

JJA Temperature

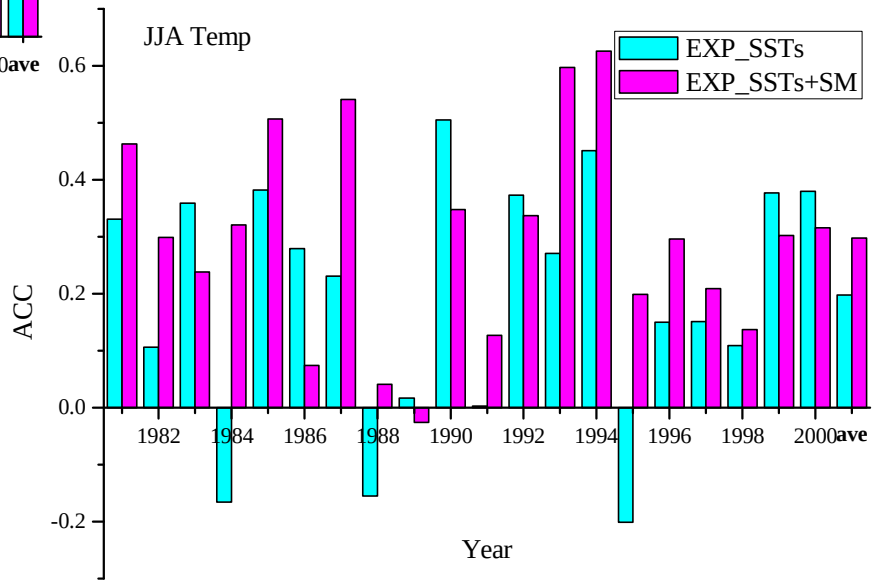


ACC: 0.06→0.30

Anomaly Correlation Coefficients of JJA Precipitation and surface air temperature (South Asia)



ACC: 0.07→0.27

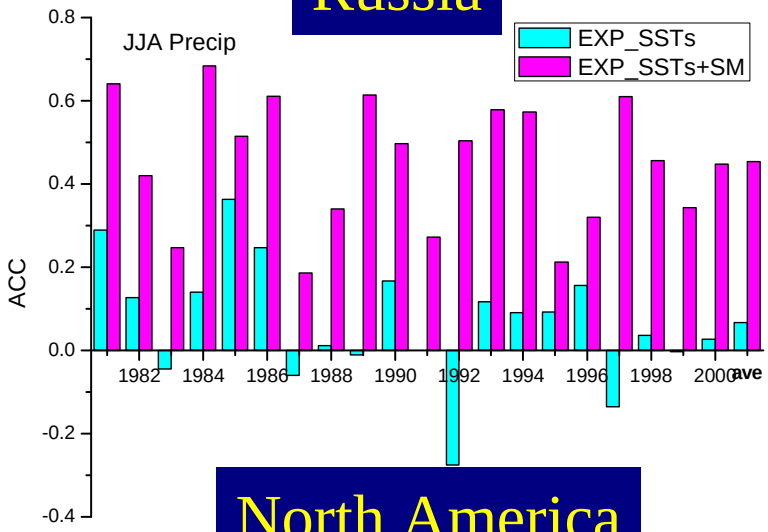


ACC: 0.20→0.30

Anomaly Correlation Coefficients of JJA precipitation

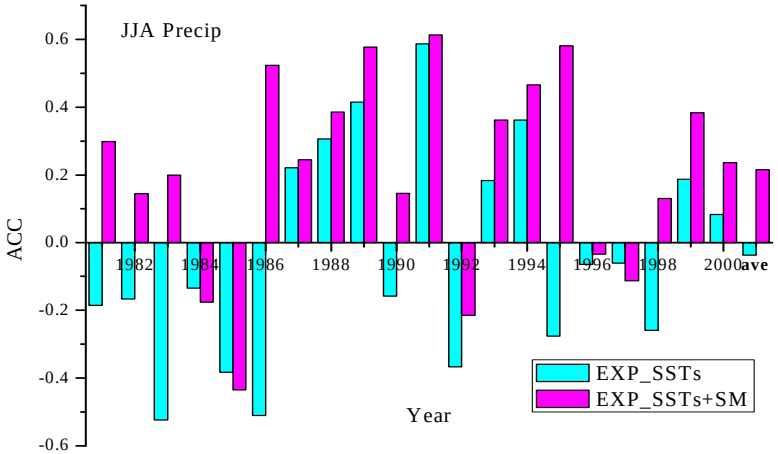
Russia

ACC: 0.07→0.45

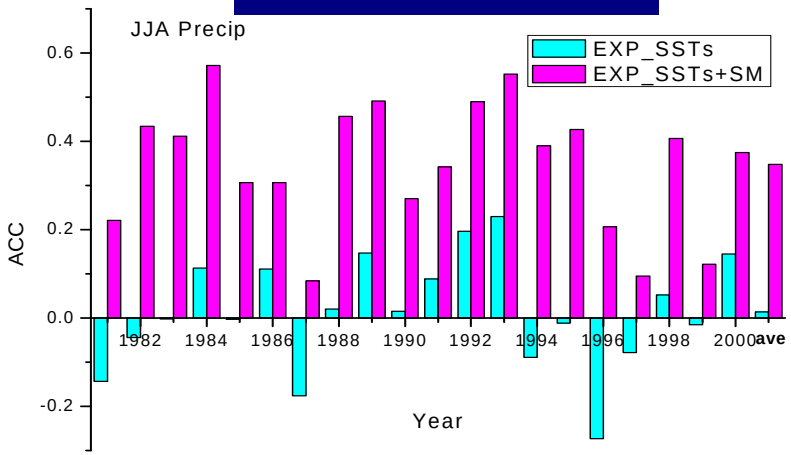


Australia

ACC: -0.04→0.22

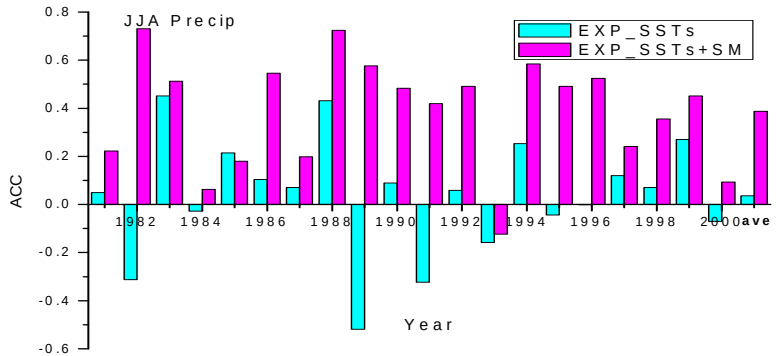


North America



ACC : 0.01→0.35

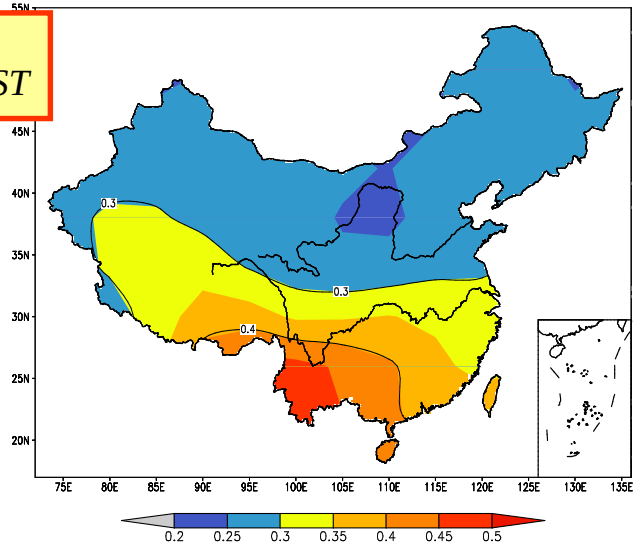
South America



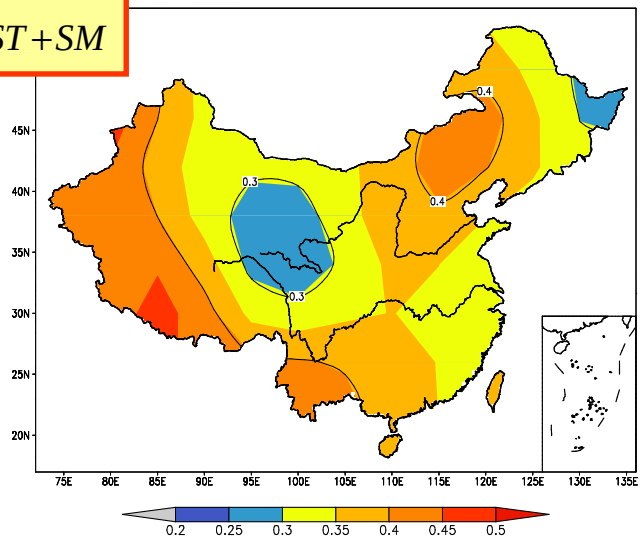
ACC: 0.04→0.39

Potential predictability of JJA precipitation over China

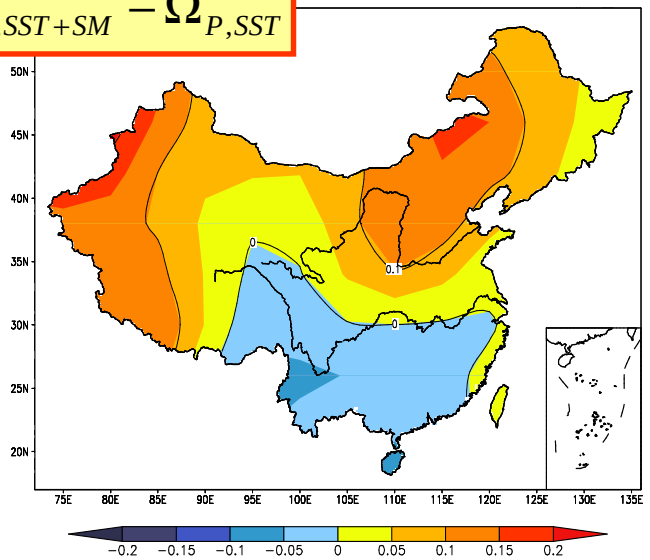
$\Omega_{P,SST}$



$\Omega_{P,SST+SM}$



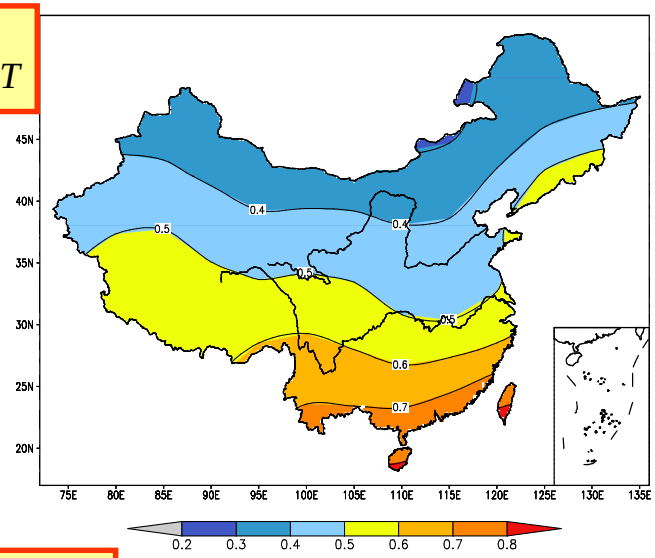
$\Omega_{P,SST+SM} - \Omega_{P,SST}$



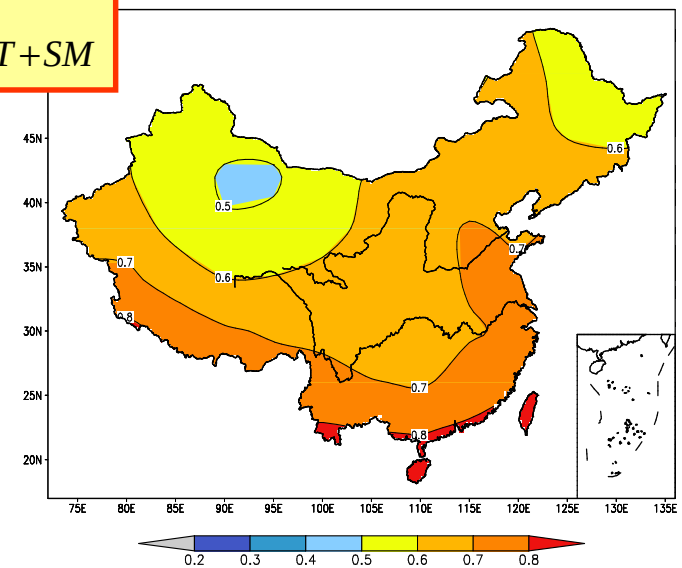
Significant Increase of potential seasonal predictability over North China, slight decrease in southern China

Potential predictability of JJA surface air temperature

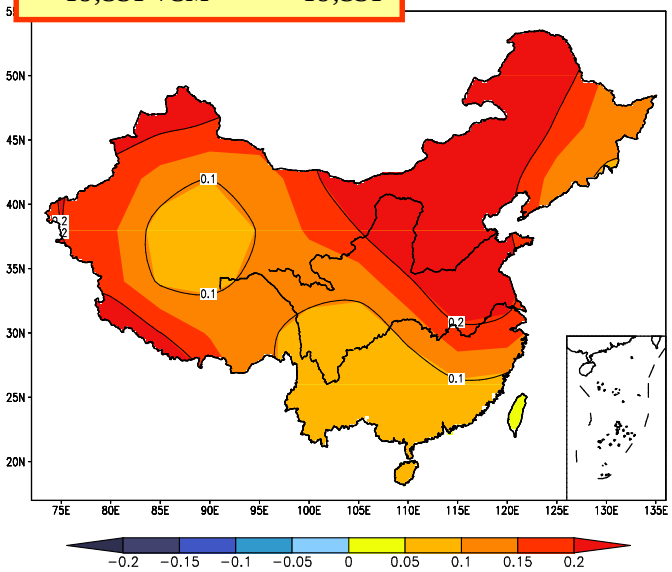
$\Omega_{Ts,SST}$



$\Omega_{Ts,SST+SM}$



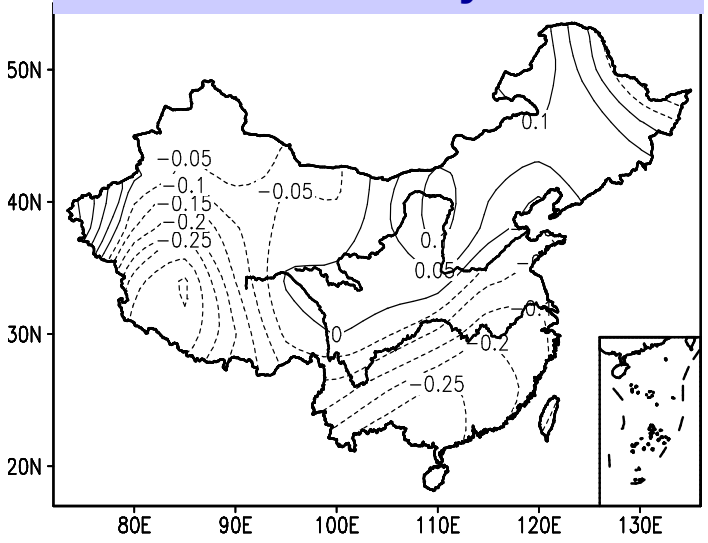
$\Omega_{Ts,SST+SM} - \Omega_{Ts,SST}$



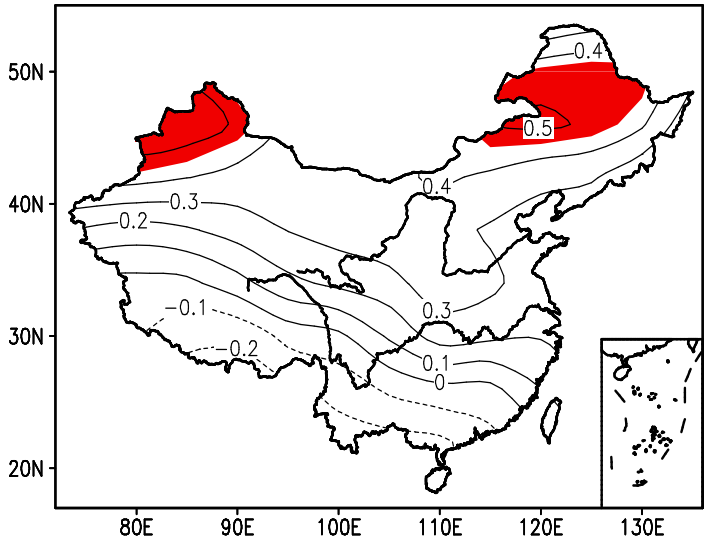
Potential predictability of summer surface air temperature over China, with significant increase over North China

Anomaly Correlation Coefficient of JJA Precip.

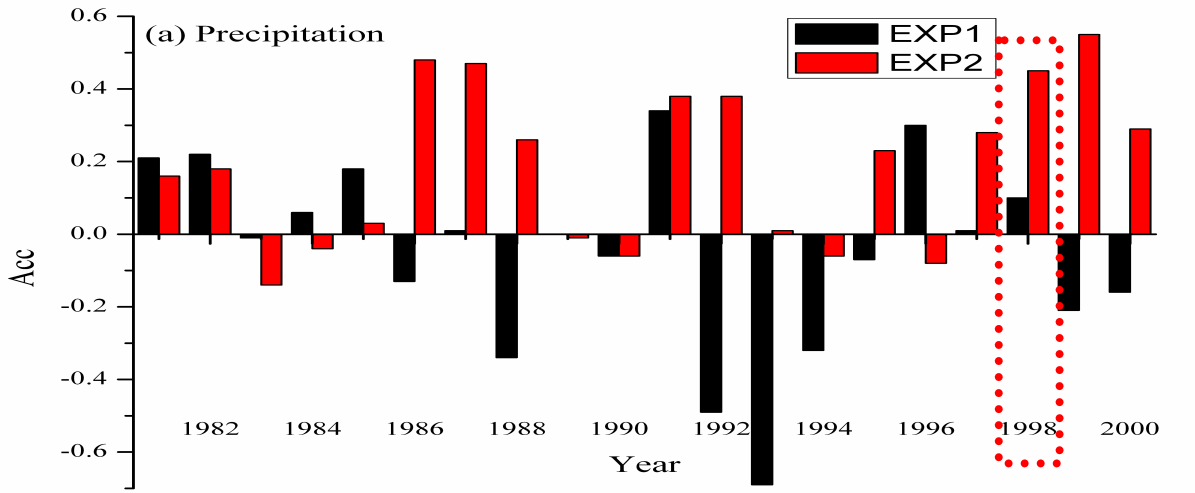
SST Only



SST and Land surface conditions

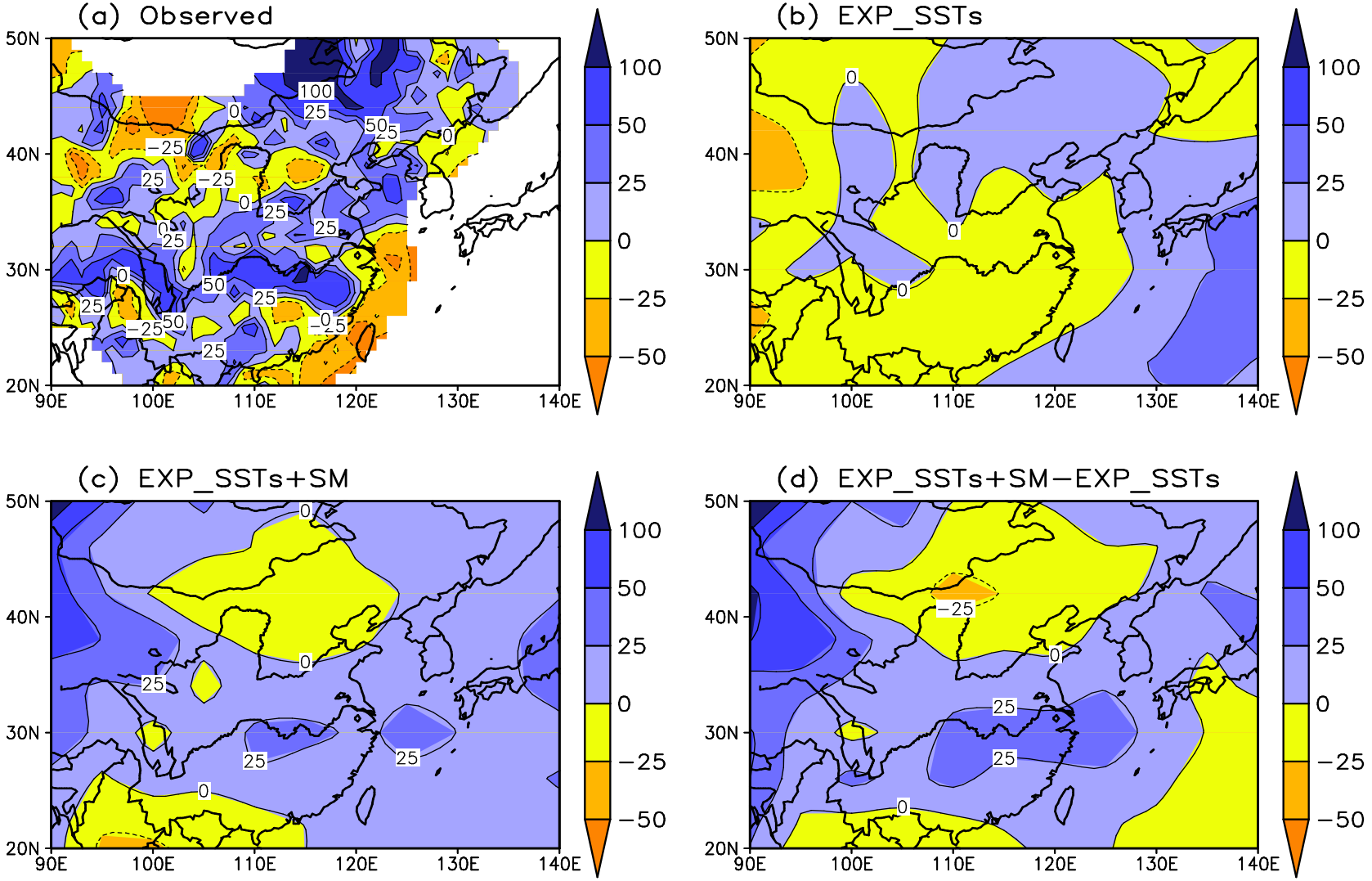


Precipitation

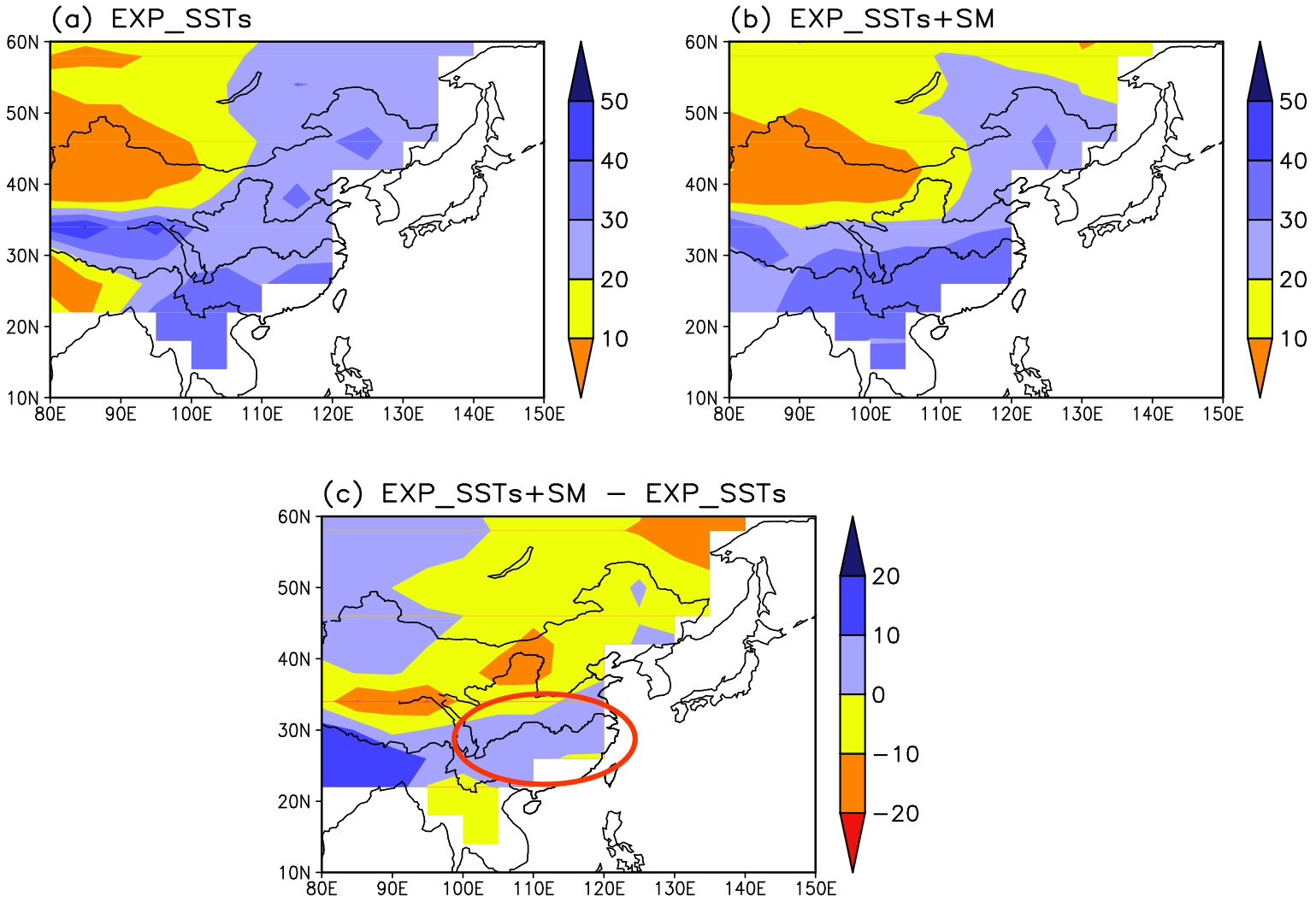


ACC: -0.05 to 0.19

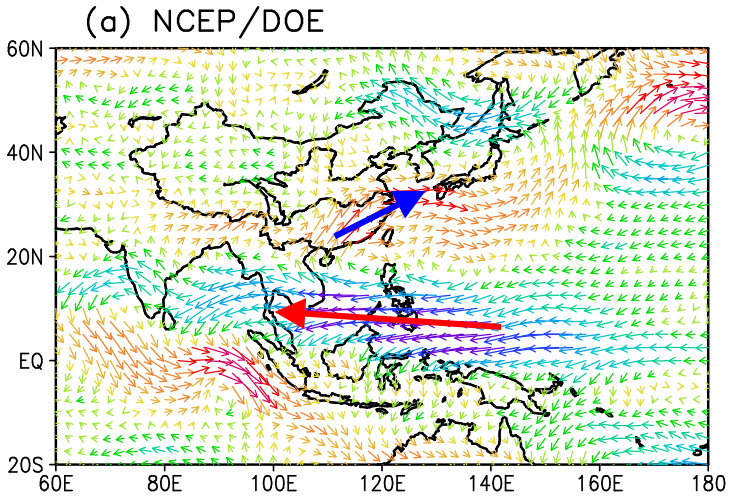
Percentage anomaly of precipitation over China (JJA, 1998)

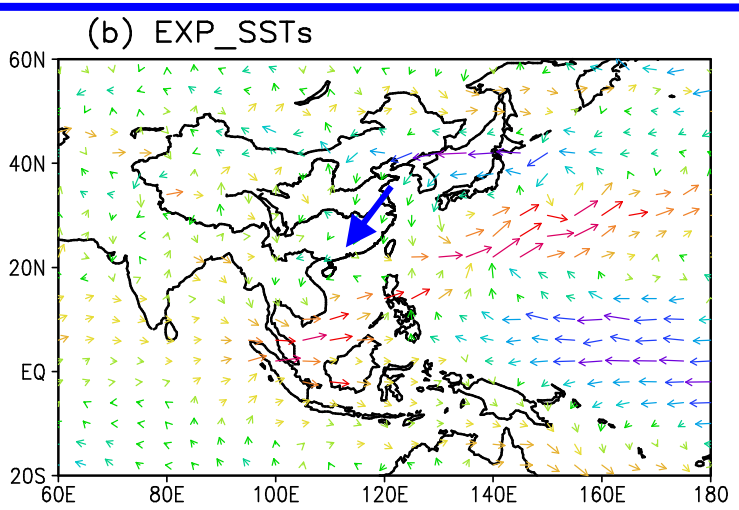


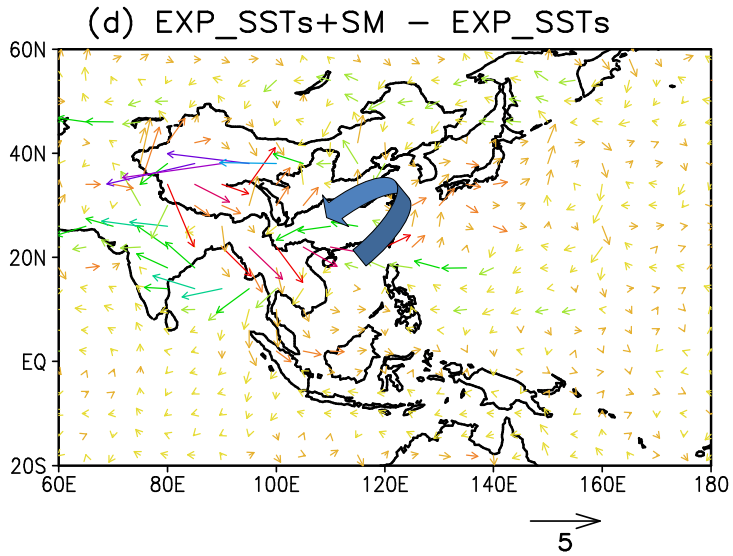
Volumetric soil moisture distribution and their differences



850mb wind Anomaly during JJA of 1998

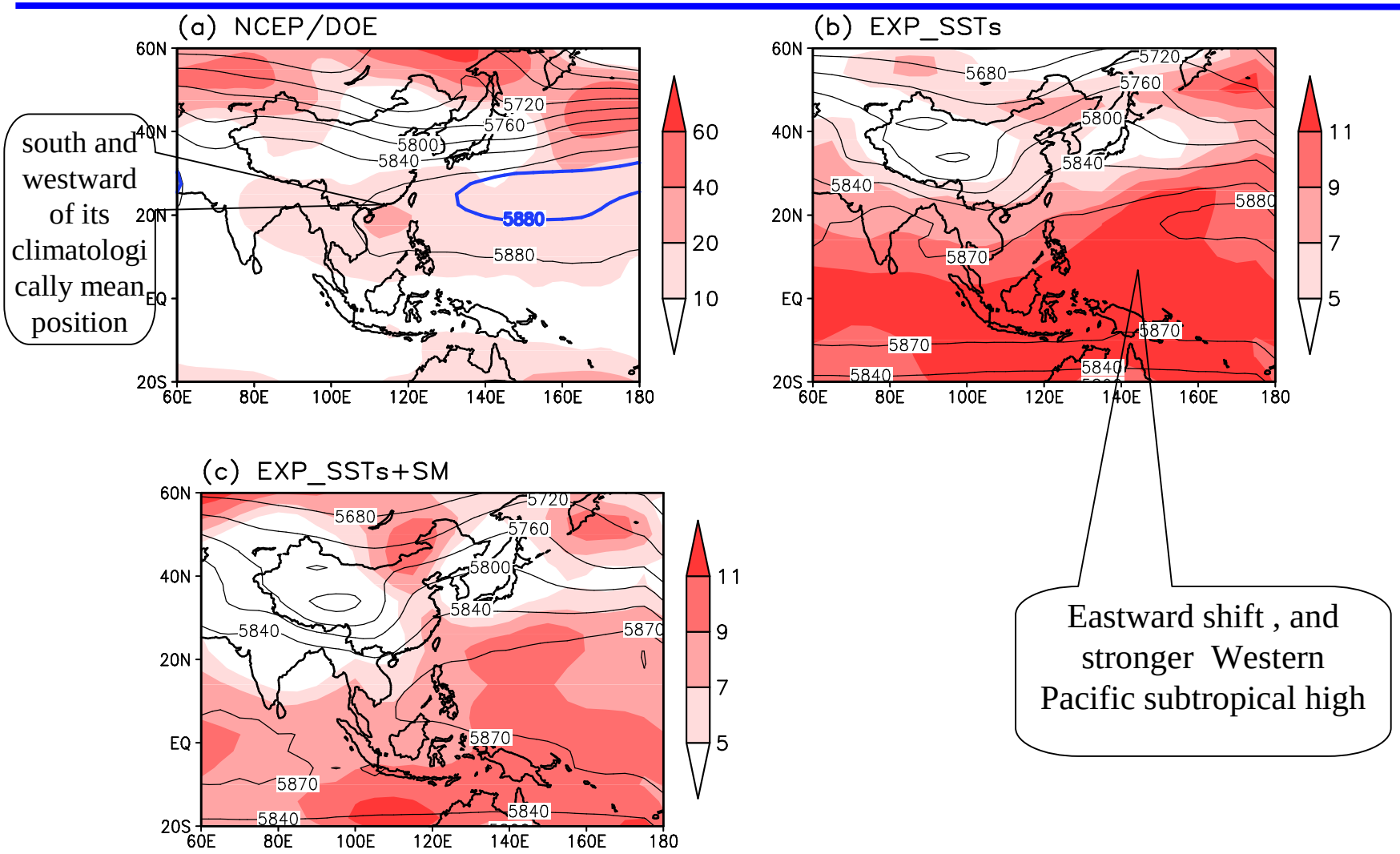






Anomalous Cyclonic circulation can be found over Yangtze River Basin, which is favorable for the flood over this region

Geopotential height at 500hPa in JJA of 1998



Shadings indicate the geopotential height anomaly (gpm).

Summary

- With more realistic land surface conditions, the potential predictability of JJA-mean precipitation increases over most part of global land areas, especially over mid-high latitude land areas, with significant increases exceeding 0.2 in mid-latitude of Eurasian continent, eastern Africa, Northern America. As for surface air temperature, the increase in the potential predictability is more remarkable over global land areas, with increase of magnitude exceeding 0.2 over most land areas.
- In terms of ACC, the increase of ACC for both JJA-mean precipitation and temperature are remarkable over global land regions, with 21-year mean of ACC increase from 0.06 to 0.28 for precipitation. As for East Asia, the increase of ACC is from -0.05 to 0.27 for Prec., and from 0.06 to 0.30 for Temp.
- For 1998 flood event, the wetter than normal surface moisture will induce anomalous cyclonic circulation over Yangtze and Huaihe River basin, which in turn leads to more realistic prediction of the observed 1998 flood over China.

Thank you for your attention