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Regionalization of Precipitation Regimes and Downscaling Method used in Regional Summer Precipitation Prediction

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Outline

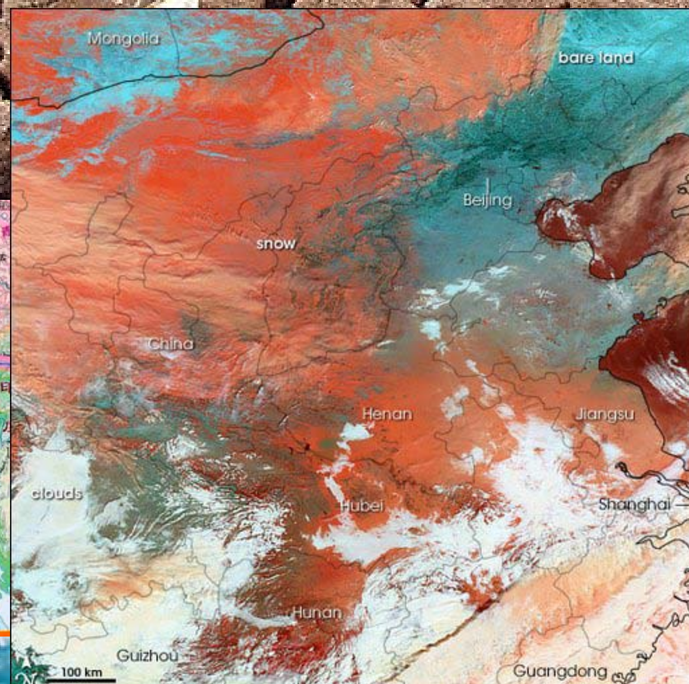
- Motivation
- Regionalization of precipitation regimes
- Downscaling Method used in Regional Summer Precipitation Prediction
- Summary

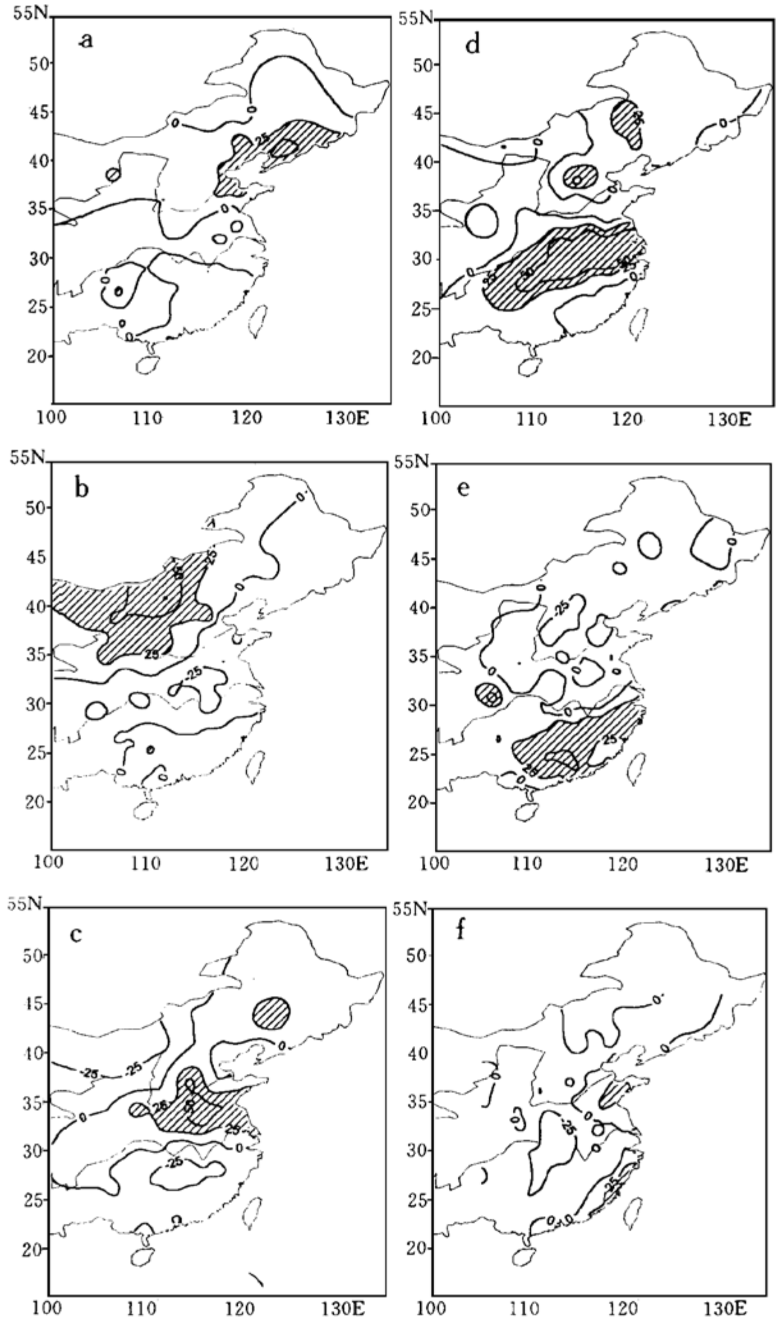
I Motivation

- Understand the main climate features and predictors of each region

- Get suitable regionalization results

- Predict regional climate


Mongolia
bare land
Beijing
snow
China
Henan
Jiangsu
clouds
Hubei
Shanghai
Hunan
Guizhou
Guangdong
100 km



Composite maps of the six rainfall regimes

(a) Northeast China、North China

(b) Northwest China

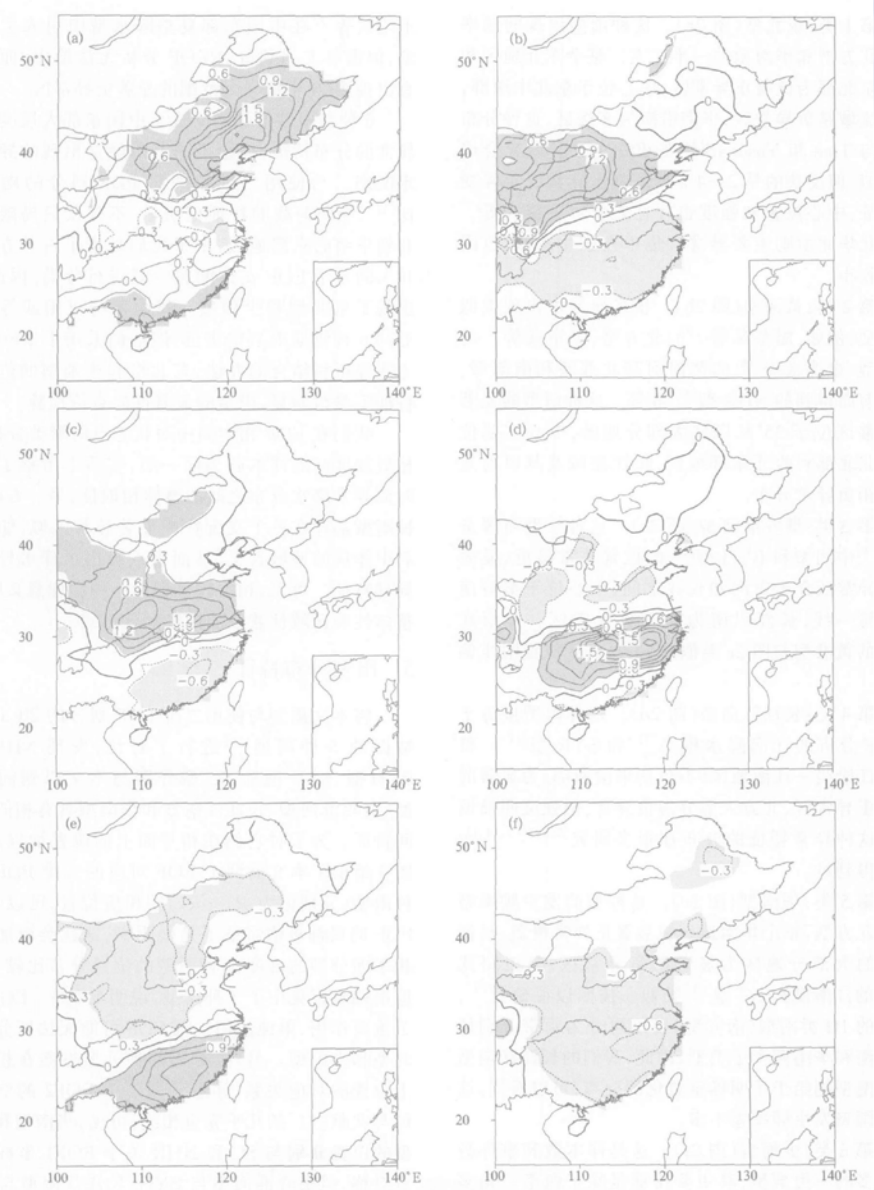
(c) Yellow-Huai basin region

(d) Yangtze River

(e) South of Yangtze River

(f) Drought pattern

WANG et al., J. Appl. Meteor. Sci. (in Chinese), 1998



Composite maps of the six rainfall regimes of the LFRR

a. northeastern China regime ;

b. Yellow River regime ,

c. Qinling-Huaihe regime ;

d. Yangtze River with its south regime ;

e. South China regime ;

f . rainless regime;

the areas over the 99 % confidence level of u-test are shaded ;interval of contours is 0. 3.

Large-scale low-frequency rainfall regimes and their transition modes in summertime over China ; REN et al.，Chinese Sci. Bull.,2006

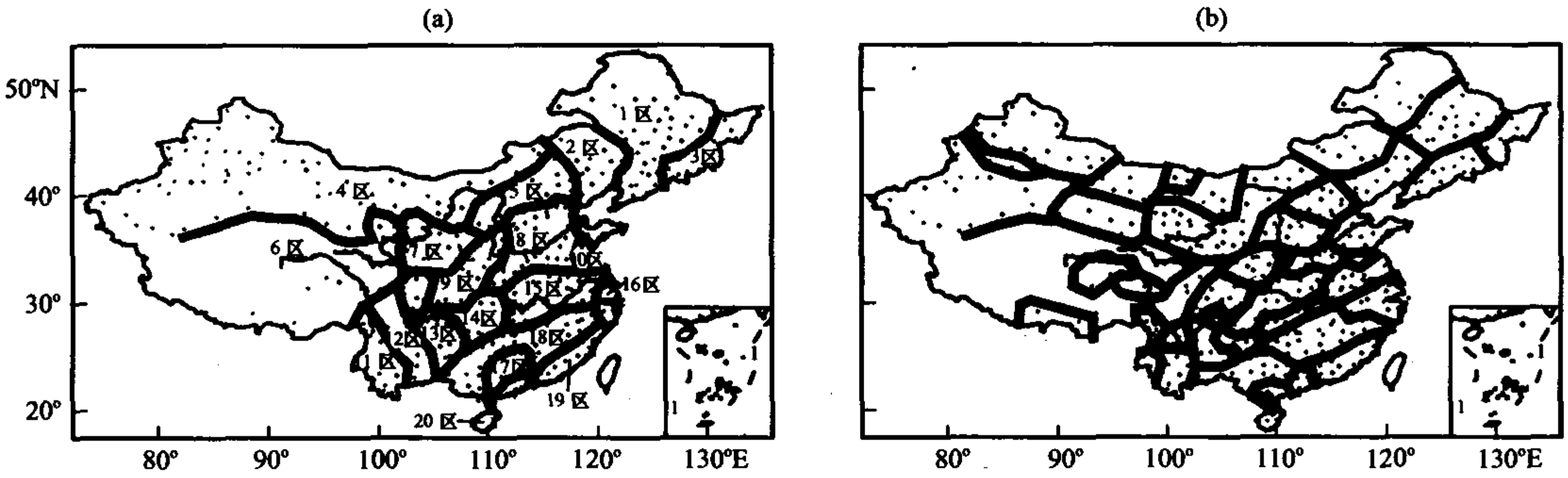


图 3　降水年内变程 20 个分区(a)和年际变化 40 个分区(b)

Fig. 3　20 sub-regions of seasonal variation (a) and 40 sub-regions of interannual variation (b) of precipitation

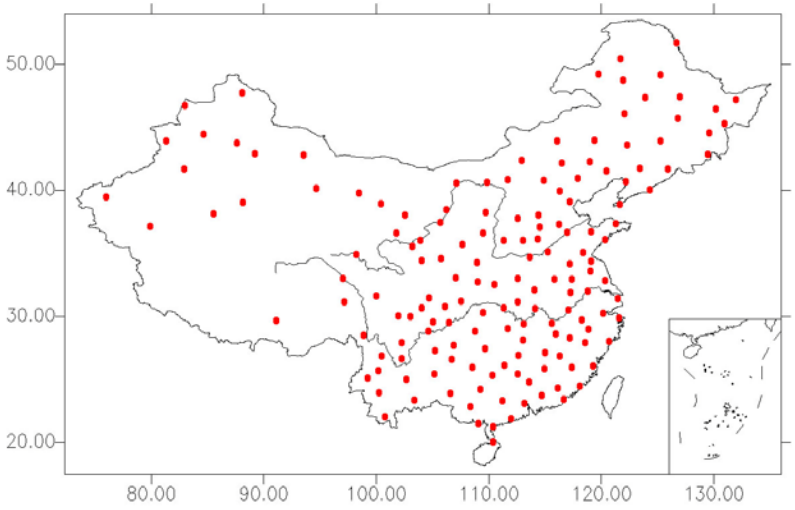
Qin et al., Plateau Meteor. (in Chinese), 2006

II Regionalization of precipitation regimes

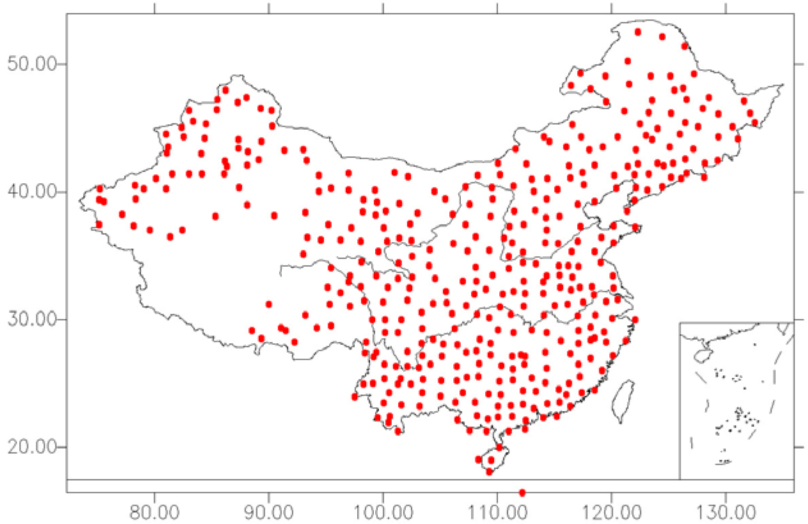
- Data
  - Monthly Precipitation, normalized
- Methods
- Experiments
- Results

Distribution of 160 stations (left) , and 400 stations (right)

160



400

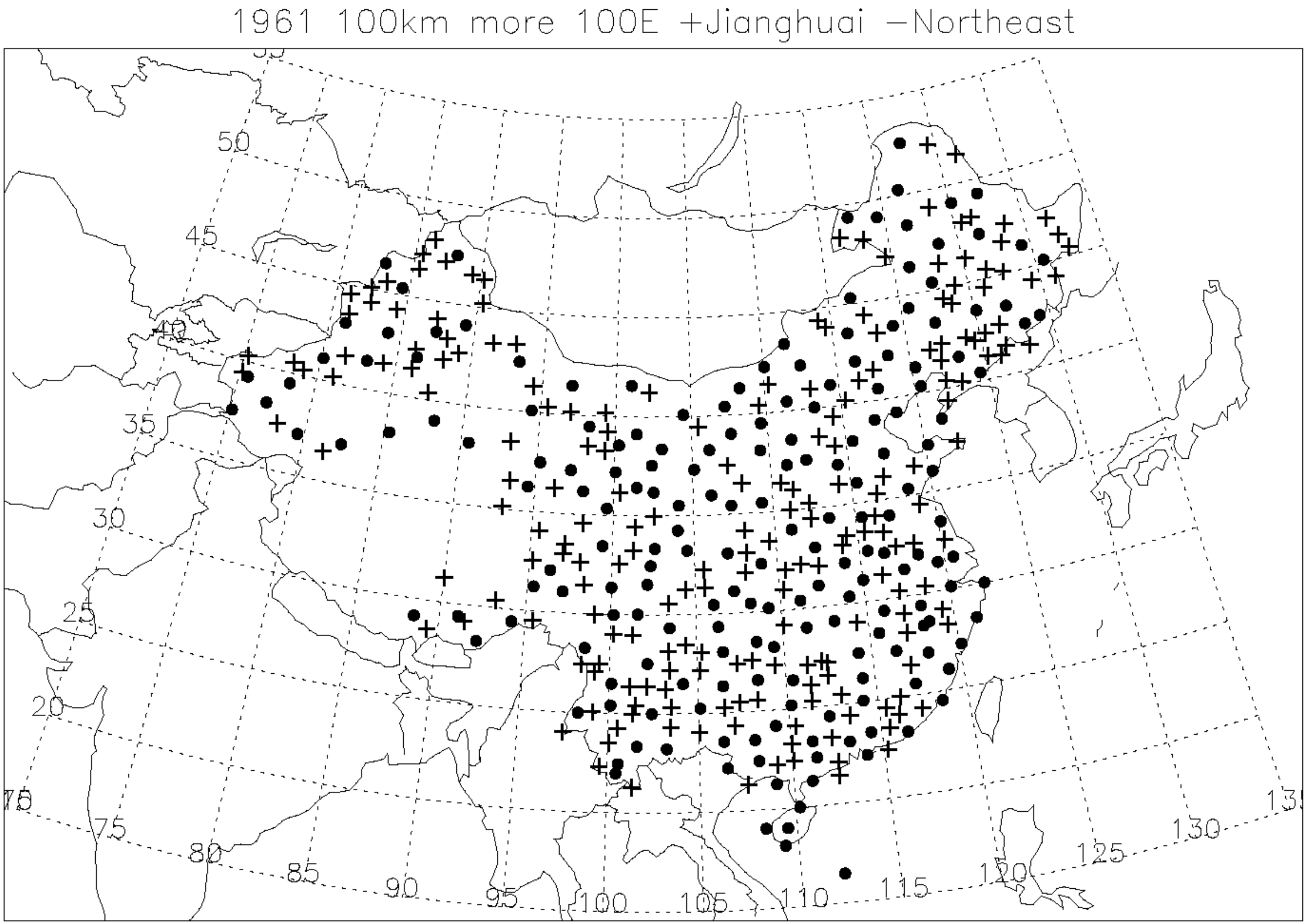


In 400 stations, there are more stations lies in West China.

Methods of choosing 400 stations

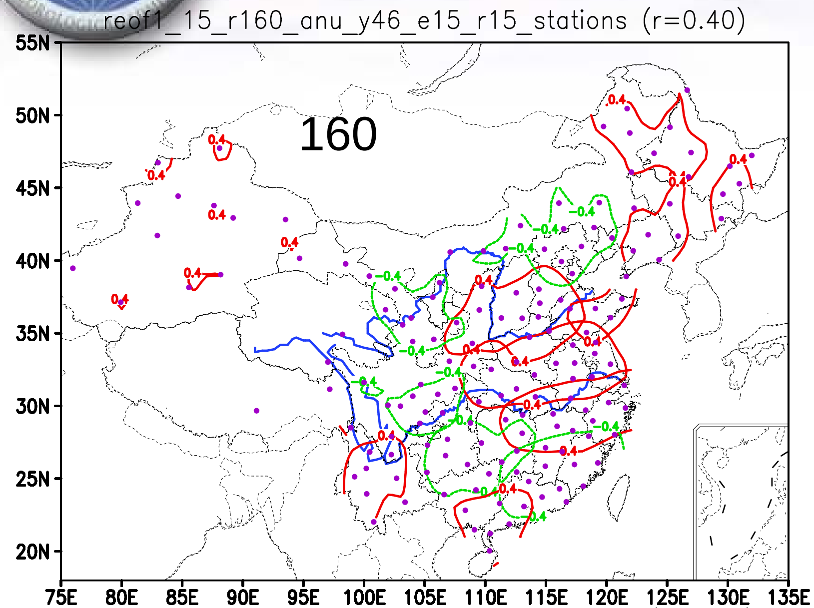
- 400 stations:
  - Keep all reference stations;
  - Keep all basic stations in the west of 100° E；
  - Keep all basic stations in region(115-120° E,32.5-35° N)；
  - Skip the basic stations which the distance between the basic station and nearby reference stations is less than 100 km。

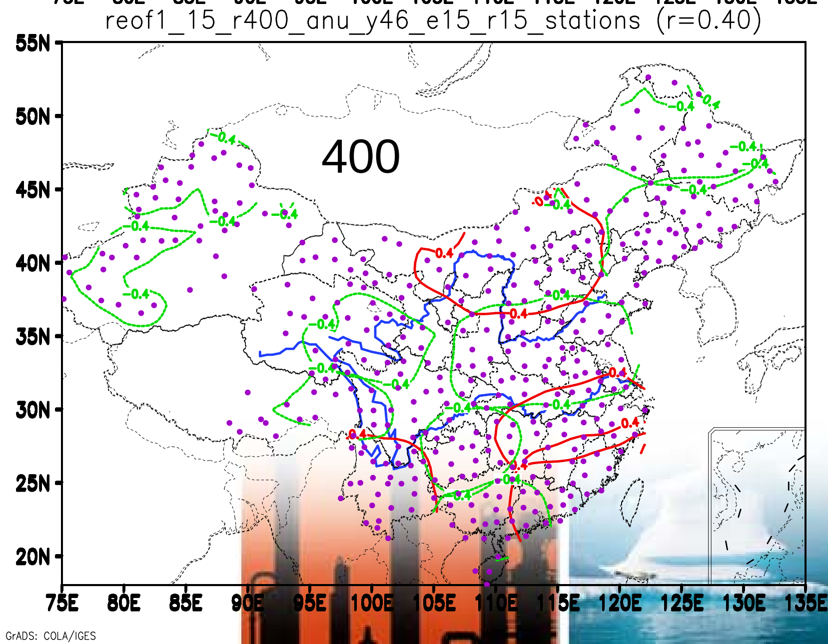
400 stations



Regionalization Methods

- principal components analysis (PCA)
  - (Comrie&Glenn,1998; Ronberg &Wang,1987;White et al.,1991;Uvo,2003; Miller,2007……)
- cluster analysis
- simple correlation analysis
- empirical orthogonal function (EOF)
  - rotated EOF
    - orthogonal rotation (Miller et al.,2007;Cook et al.,1999;Frei at al.,1999; McCabe et al.,2004)
      - Eigenvalue separation test (North et al.1982）was used to define the number of regions and maximum loading value approach is used to determine boundaries.

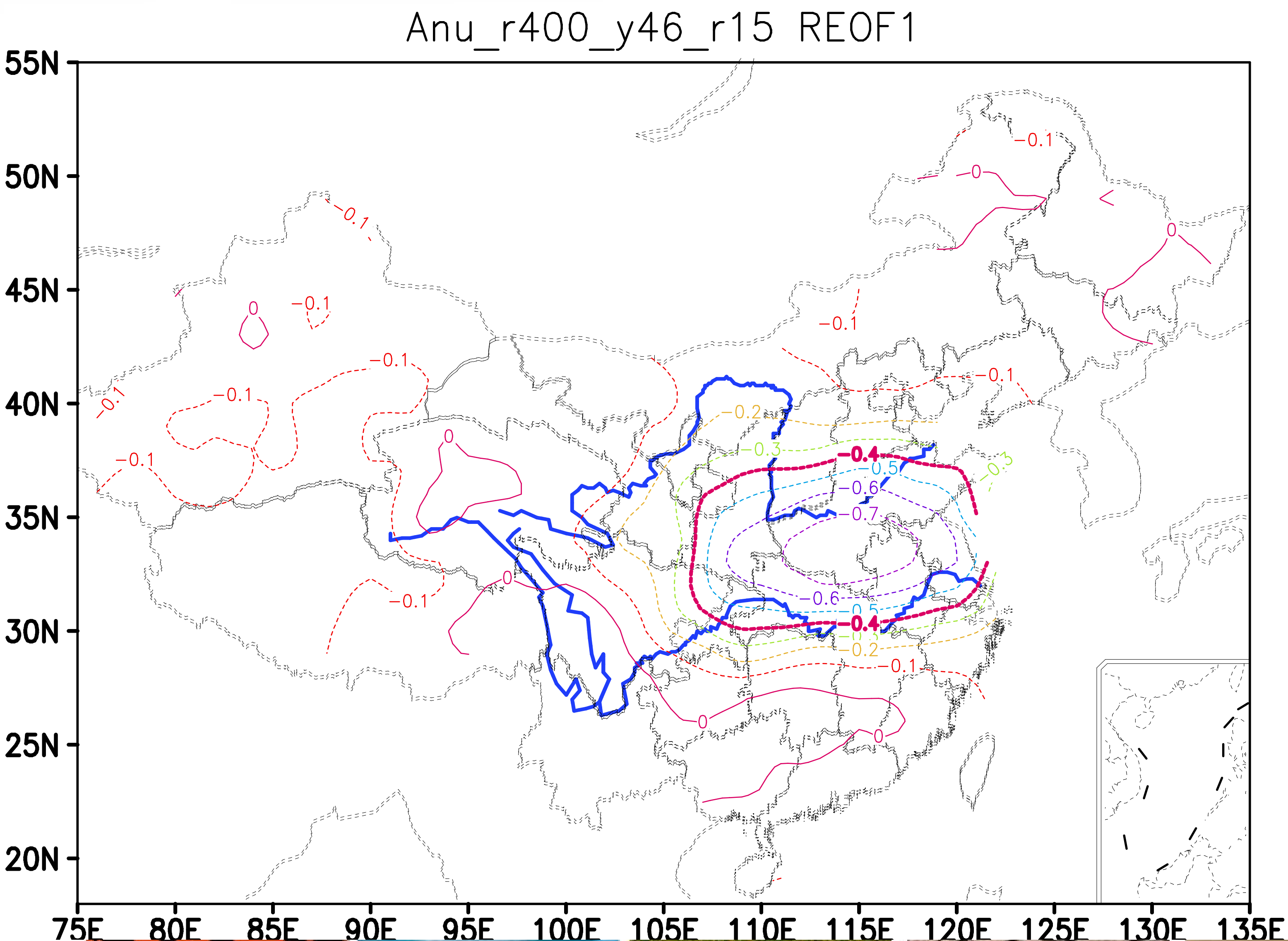




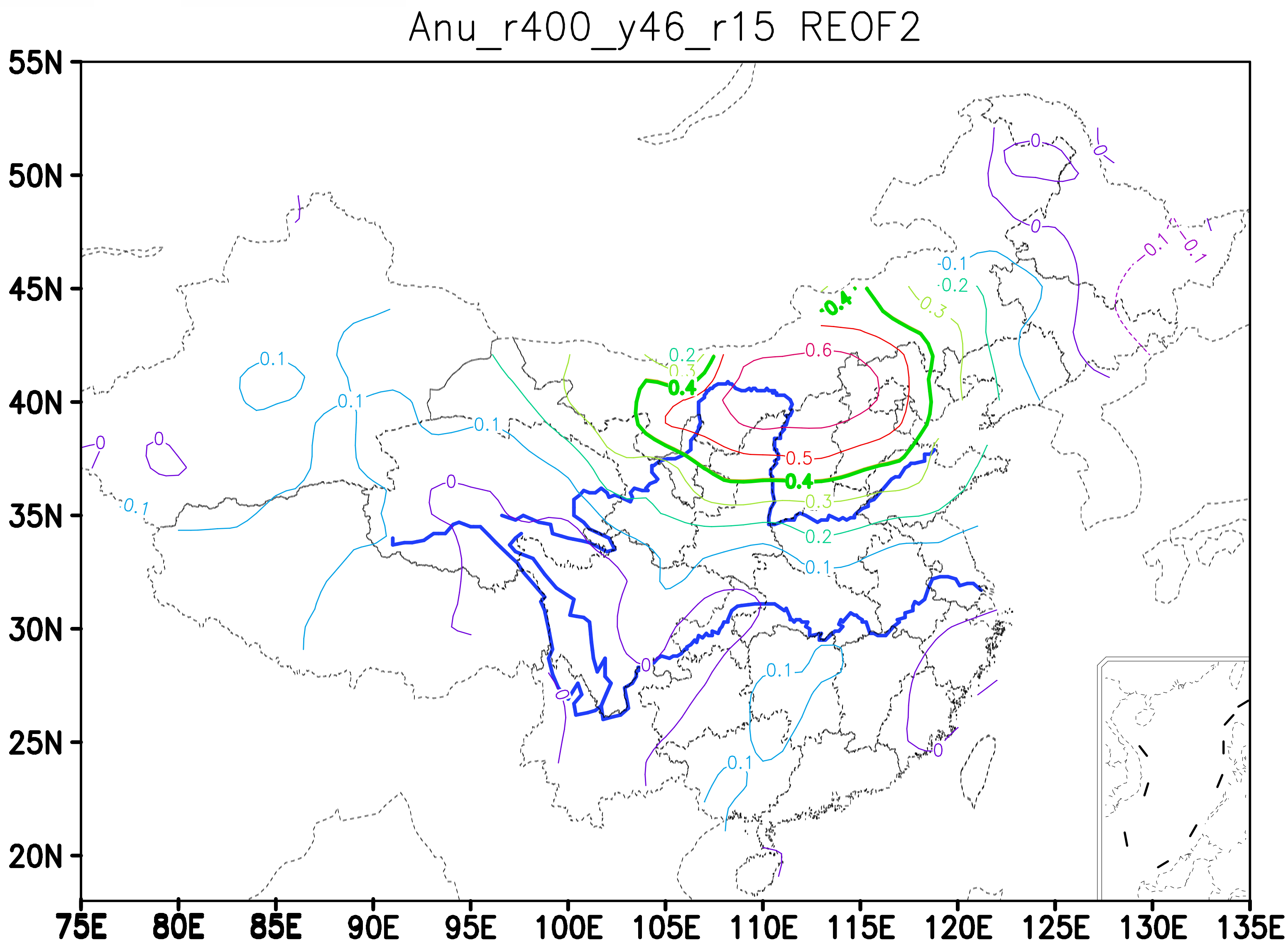
Regionalization of precipitation by 160stations and 400stations

The results of 160 stations are different from those of 400 stations especially in West-central China. 400 stations keep well distributed and have similar climate patterns of the whole country.

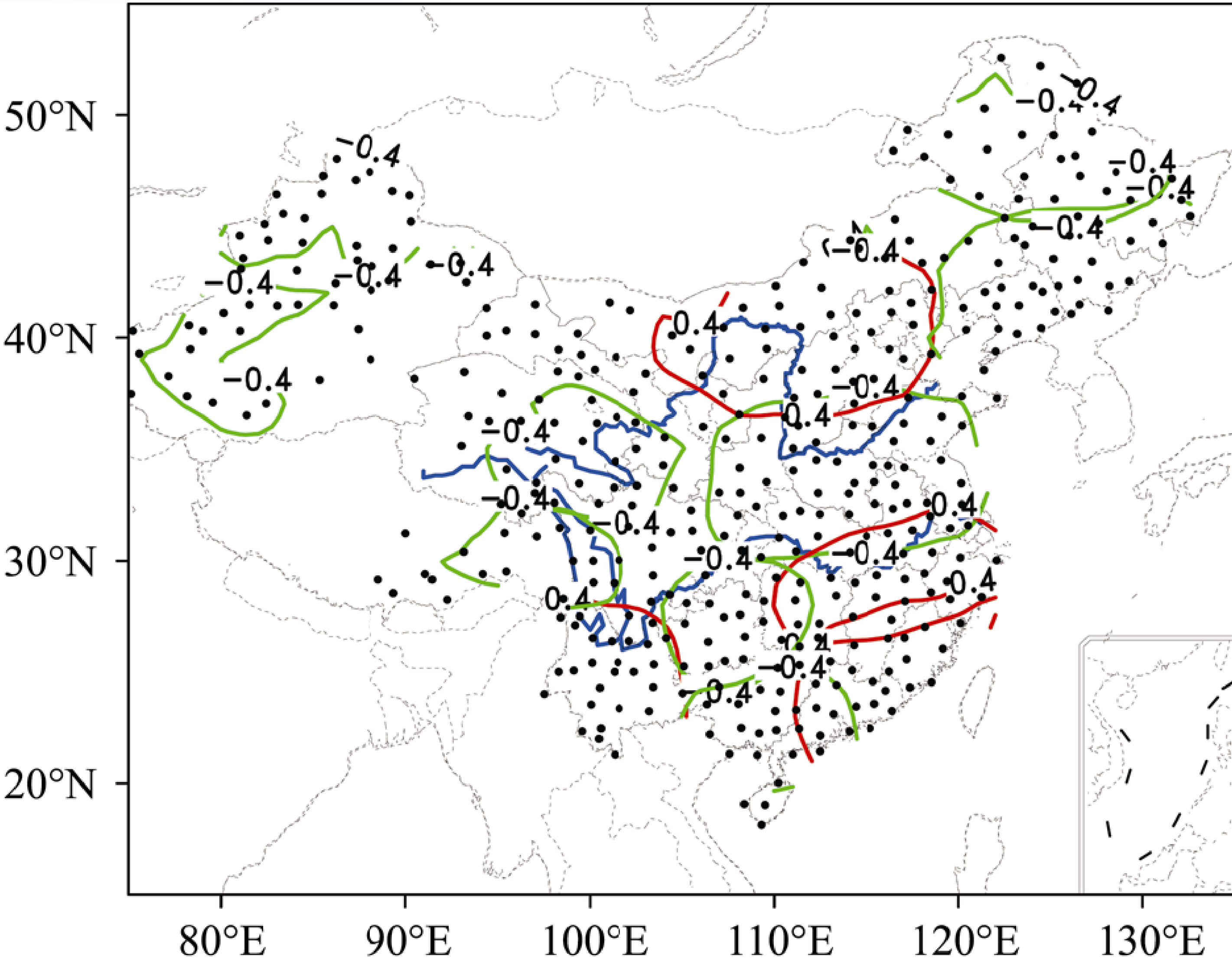
1st principle component



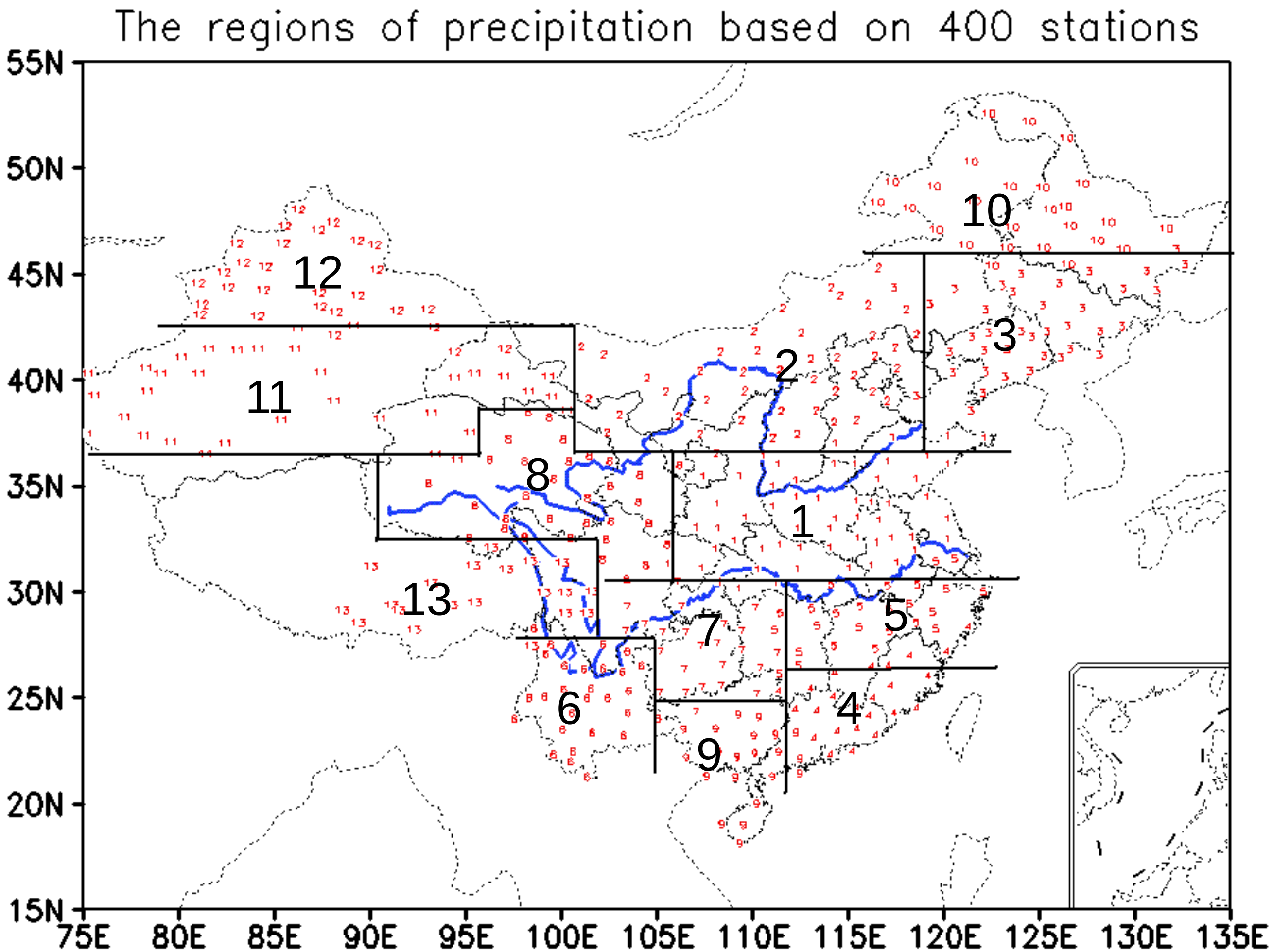
2nd principle component



REOF results based on 400 stations



Regionalization of precipitation(13)



REOF, Maximum-loading approach , regularization

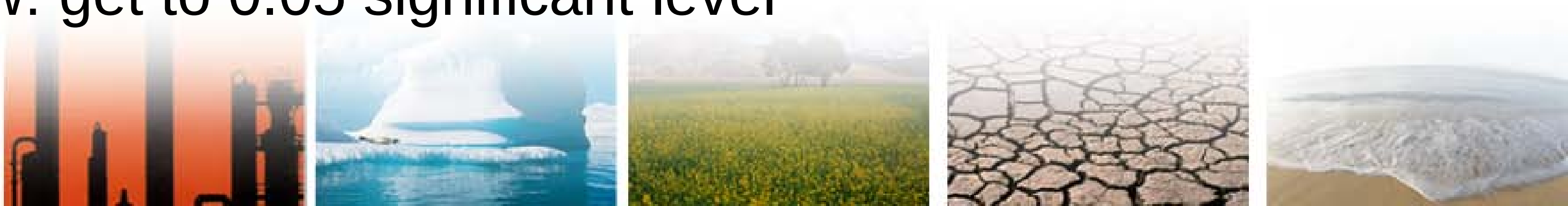
regions

No.	Name	Geographic range
1	Huanghuai region	30°–36.5°N, 105°–122°E
2	Hetao and North China	36.5°–46°N, 100°–119°E
3	Southern part of Northeast China	36.5°–46°N, 119°–133°E
4	Southeastern coastal areas	21°–26.5°N, 112°–120°E
5	Jiangnan region	26.5°–30°N, 112°–123°E
6	Yunnan area	21°–27.5°N, 97.5°–105°E
7	Xianggui areas	27.5°–30°N, 102°–105°E 25°–30°N, 105°–112°E
8	Qinghai area	32.5°–36.5°N, 90°–105°E 36.5°–39°N, 96°–100°E 30°–32.5°N, 102°–105°E
9	Guangxi area	18°–25°N, 105°–112°E
10	Northern part of Northeast China	46°–53°N, 116°–133°E
11	Southern Xinjiang area	36.5°–43°N, 75°–96°E 39°–43°N, 96°–100°E
12	Northern Xinjiang area	43°–48.5°N, 80°–95°E
13	Tibetan area	27.5°–32.5°N, 88°–102°E

Cor. of different regions

ACC	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.00	0.20	0.23	-0.14	0.06	-0.30	0.20	0.25	-0.36	0.38	0.22	0.02	0.18
2		1.00	0.53	-0.17	-0.17	-0.15	0.06	0.29	-0.05	0.15	0.08	0.09	-0.04
3			1.00	-0.11	-0.14	0.12	-0.17	0.05	-0.03	0.41	-0.02	0.05	0.00
4				1.00	0.55	0.16	0.11	0.01	0.56	0.01	-0.16	-0.02	-0.32
5					1.00	0.05	0.55	0.03	0.29	0.16	0.05	0.16	-0.04
6						1.00	0.18	-0.16	0.52	-0.15	-0.33	-0.18	0.15
7							1.00	-0.13	0.28	0.01	-0.10	-0.07	0.03
8								1.00	-0.07	0.17	0.11	0.01	-0.06
9									1.00	-0.11	-0.17	-0.12	-0.23
10										1.00	0.19	0.17	0.13
11											1.00	0.49	0.24
12												1.00	0.20
13													1.00

Yellow: get to 0.05 significant level



III Downscaling Method used in Regional Summer Precipitation Prediction (RSPP)

- Model and data
- Prediction method
- Results

		Model Origin	Improvement
GODAS		Indo-Pacific Regional Ocean Data Assimilation System	extended to global
CGCM 1.0/ BCC	AGCM	The operational medium-range prediction model (version T63) of NMC/CMA, derived from the 1988 version of T63 model of ECMWF	improve the accuracy of horizontal pressure gradient force Improve the moist advection calculation by using of the Semi-Lagrange method New Radiation scheme： Morcretts radiation scheme
	OGCM	OGCM of LASG/IAP (L20,4*5degree)	Adoption of Gent-MacWilliams' along/across Isopycnal mixing scheme Thermal-dynamical sea ice model
	Coupling Scheme	Daily Flux Anomaly (DFA)	

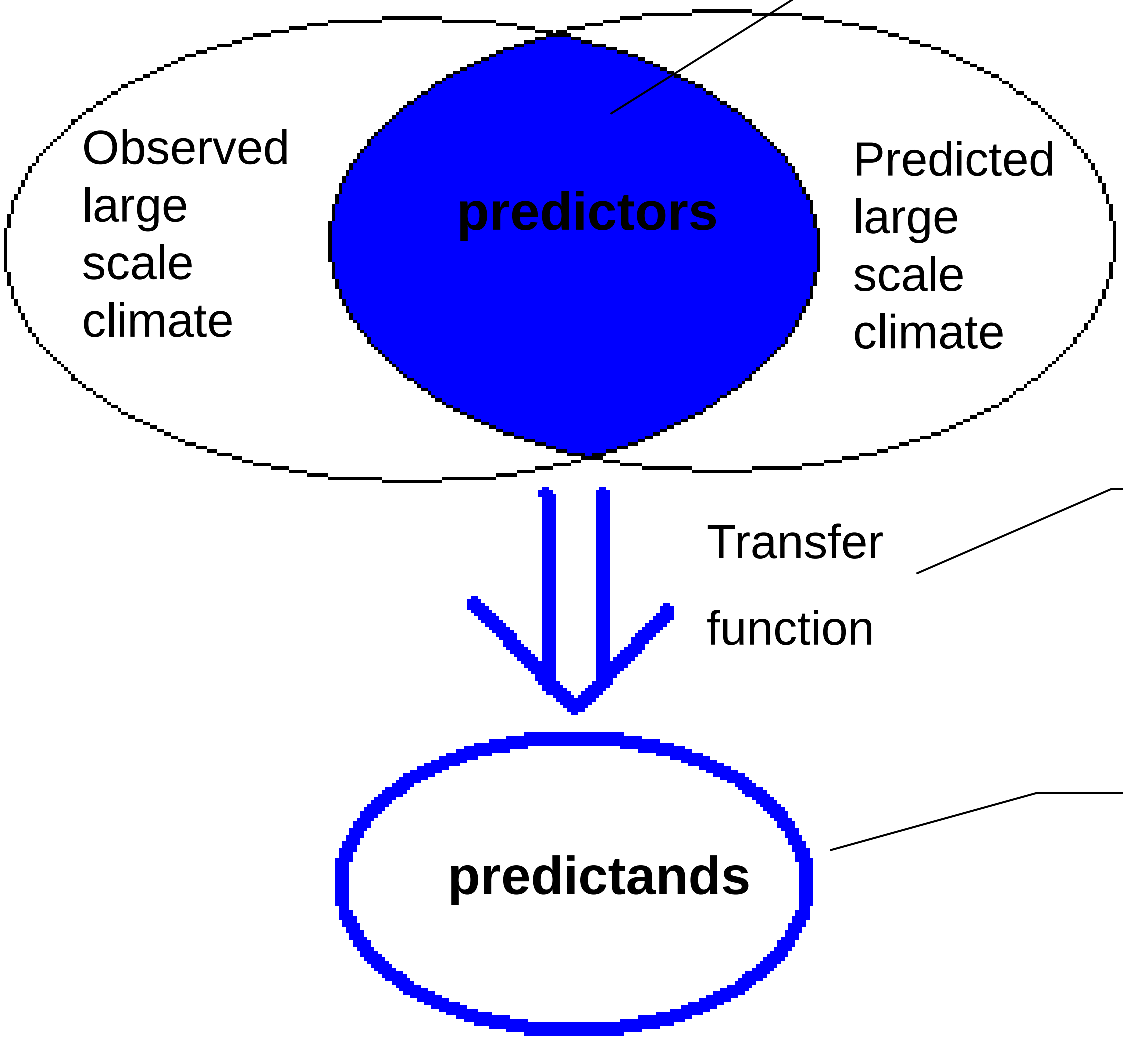
CGCM1.0/BCC

Atmosphere	The NCEP assimilated data at zero o’clock of last 8 days in February (H,U,V,T,Q)
Ocean	The instantaneous field derived from six projects by GODAS_BCC in 28th, February ［salinity, SST, wind stress et al］
Ensemble number	8×6＝48
Hindcast period	1983-2002
prediction period	2003-2011
Integration	from Mar. 1 , 11 months

Lead time=3 months

data

- 400 station data
- NCEP/NCAR reanalysis data
- Model output data
- Variables:
  - h200、h500
  - u200、u850
  - v200、v850
- Detrend



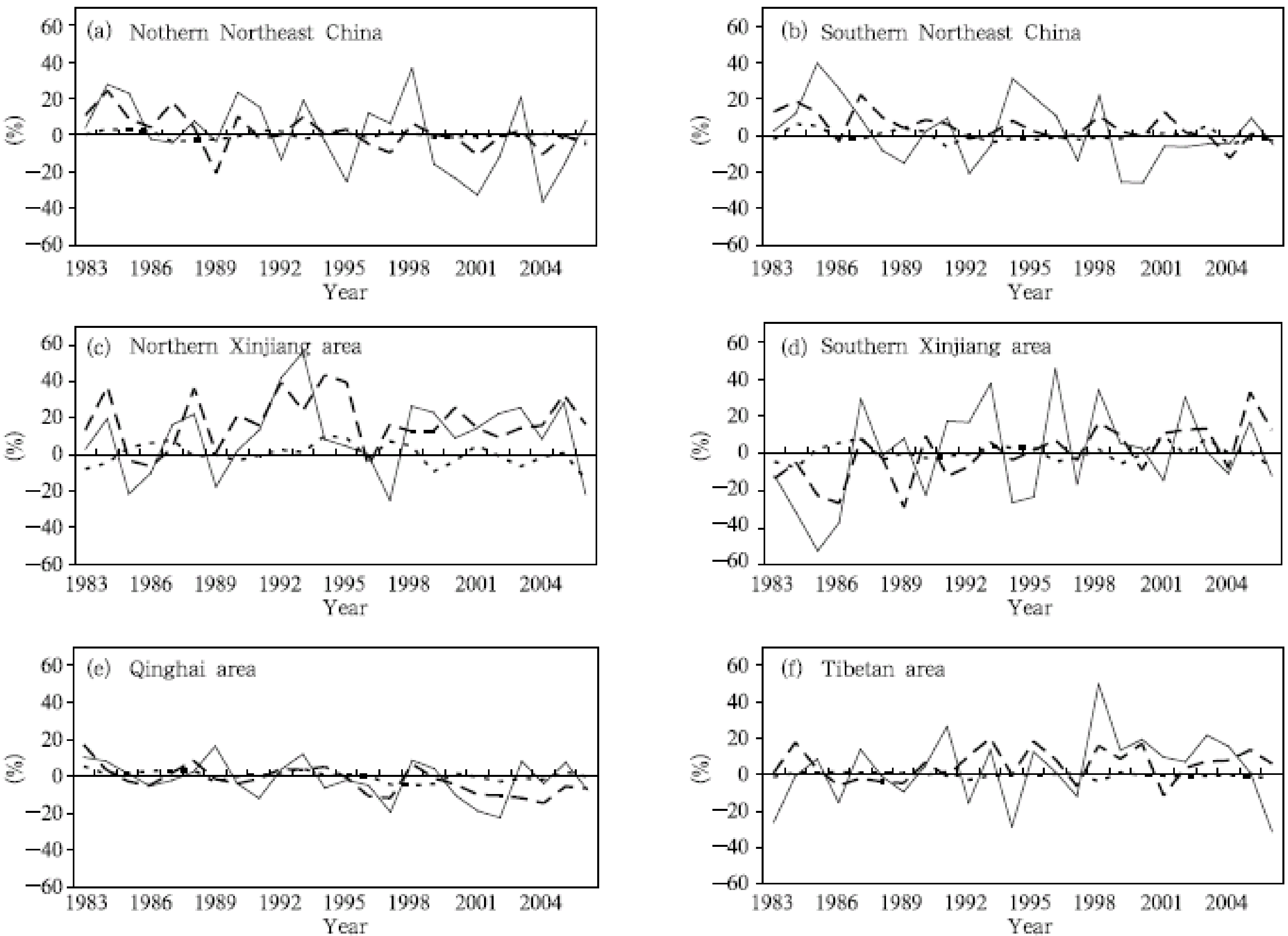
Region: >=4*4
Significant test:>=0.05
Predictors:<=10

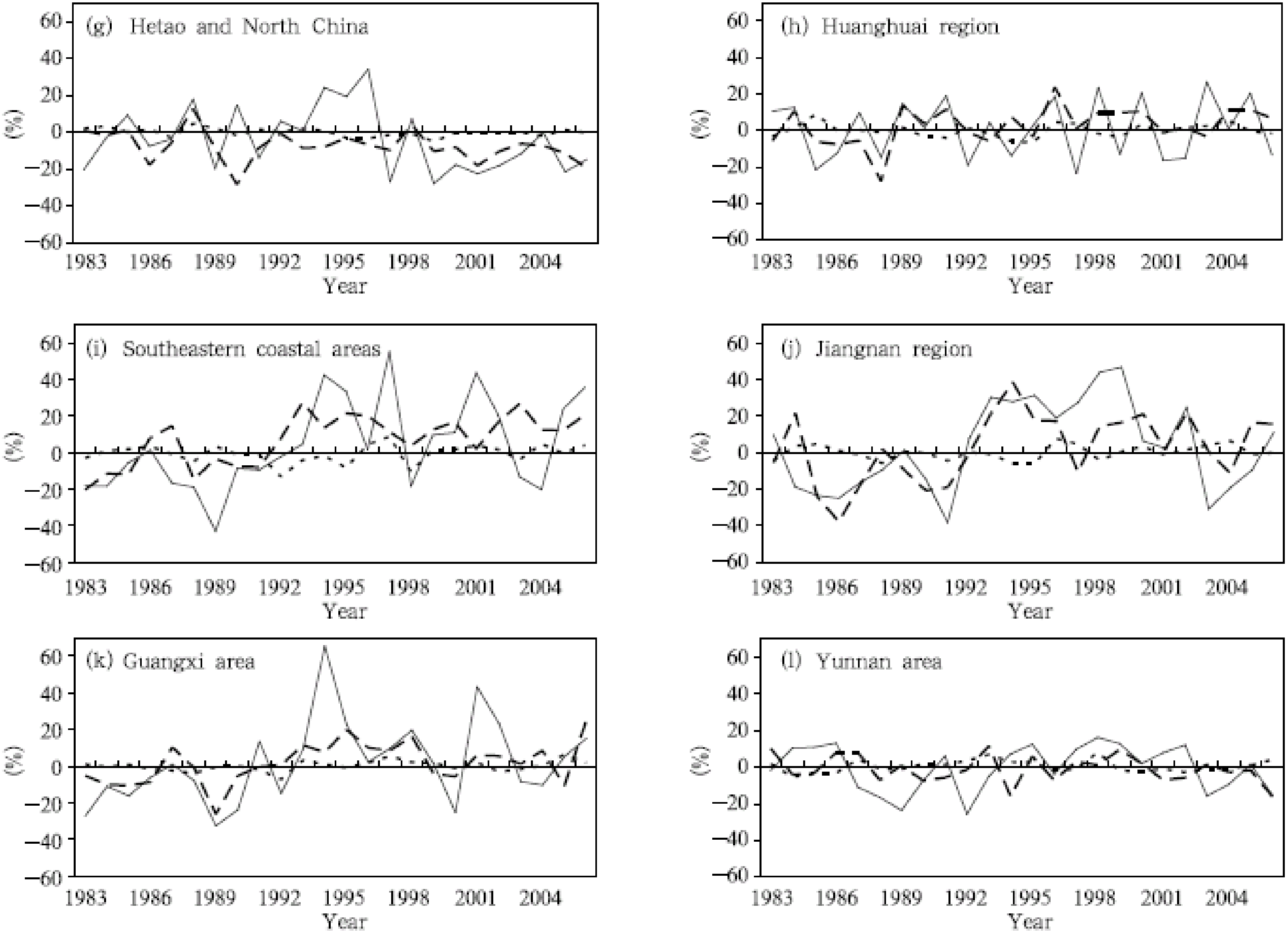
Optimal Subtree Regression (OSR)

Each regions' precipitation

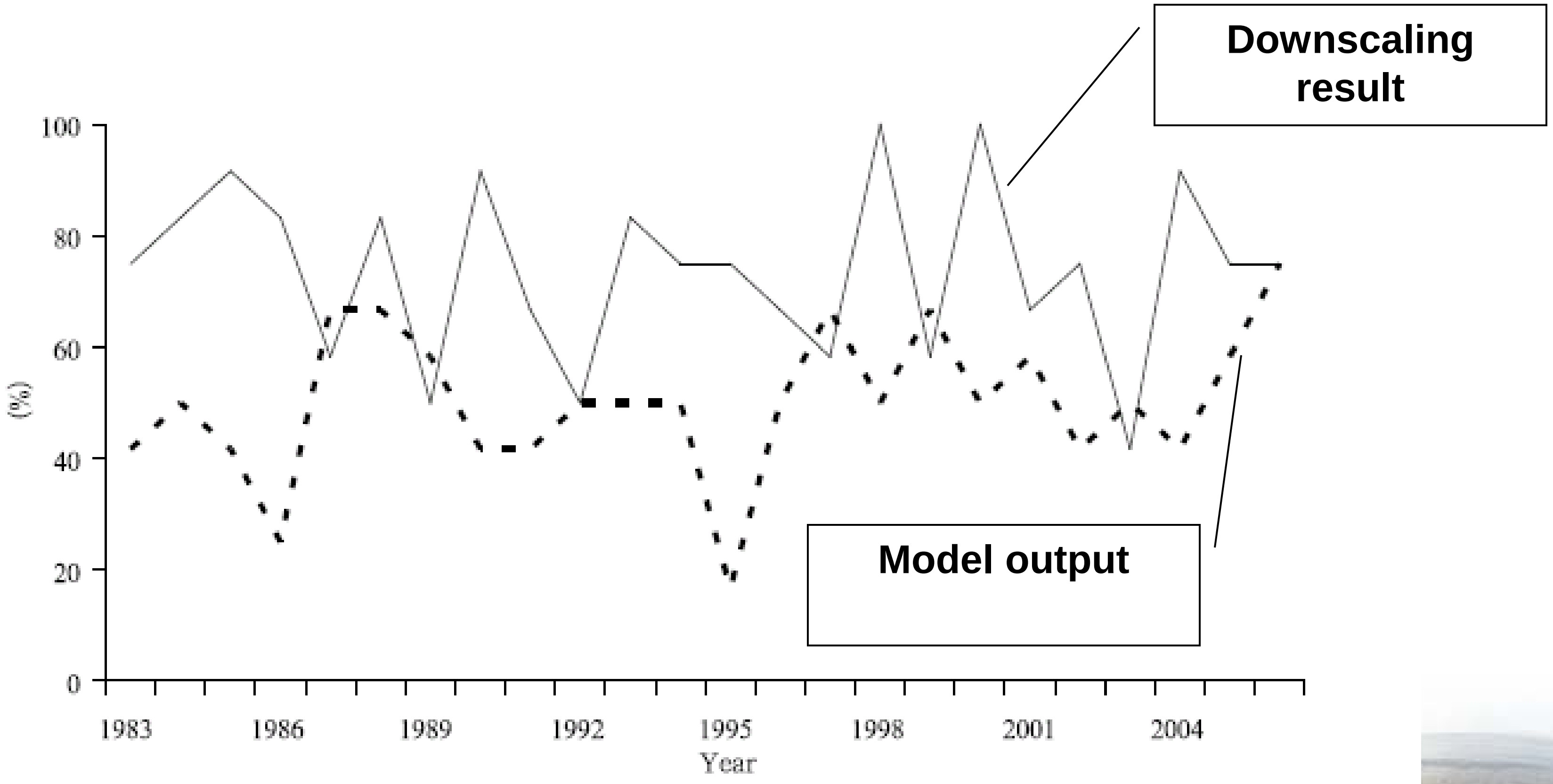
One year out cross validation

Comparison of downscaled RSPPs (dashed line), model outputs (dotted line), and observations (real line) of summer precipitation percentage anomalies (%) in each region

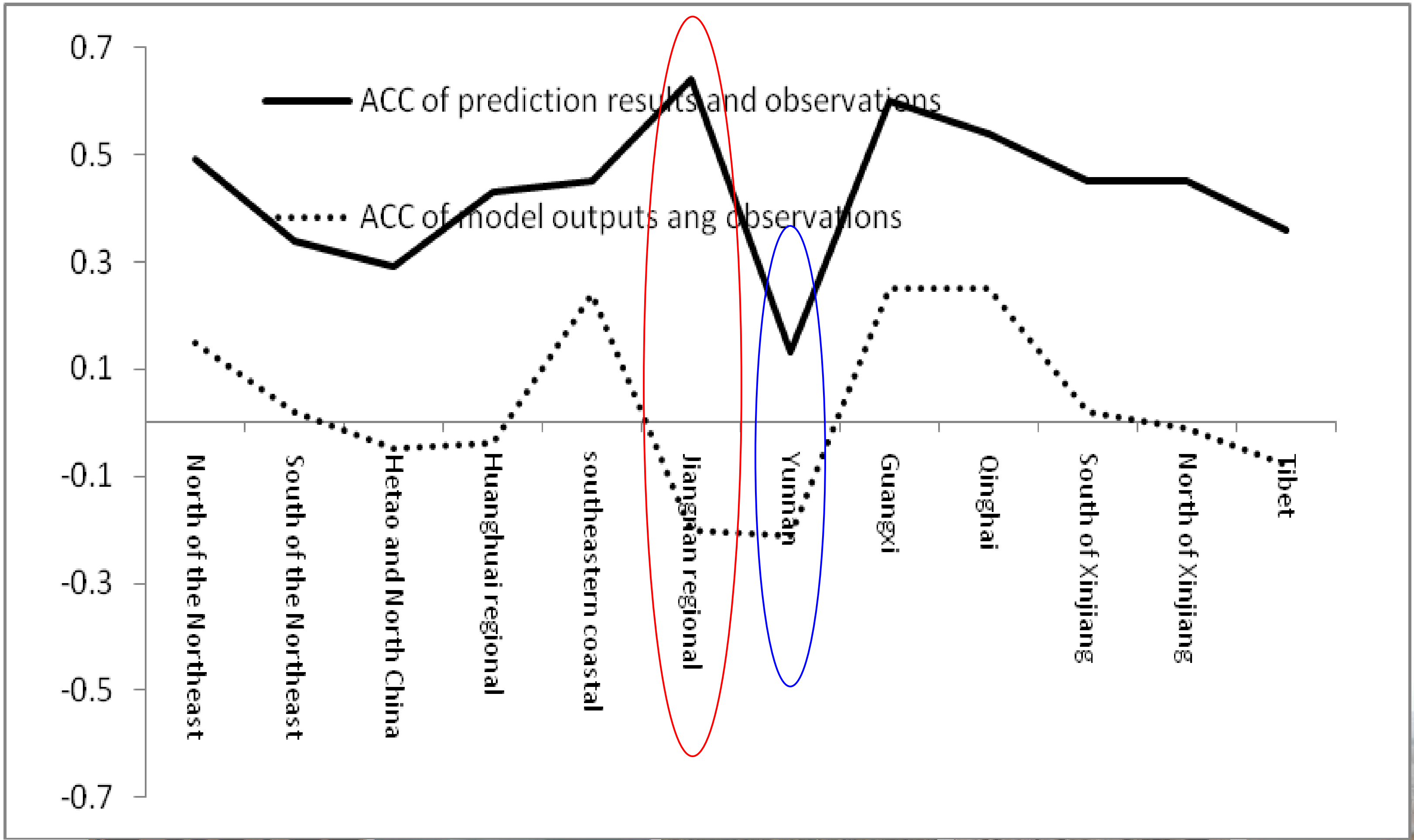



(g) Hetao and North China
(h) Huanghuai region
(i) Southeastern coastal areas
(j) Jiangnan region
(k) Guangxi area
(l) Yunnan area
(%)
60
40
20
0
−20
−40
−60
1983
1986
1989
1992
1995
1998
2001
2004
Year

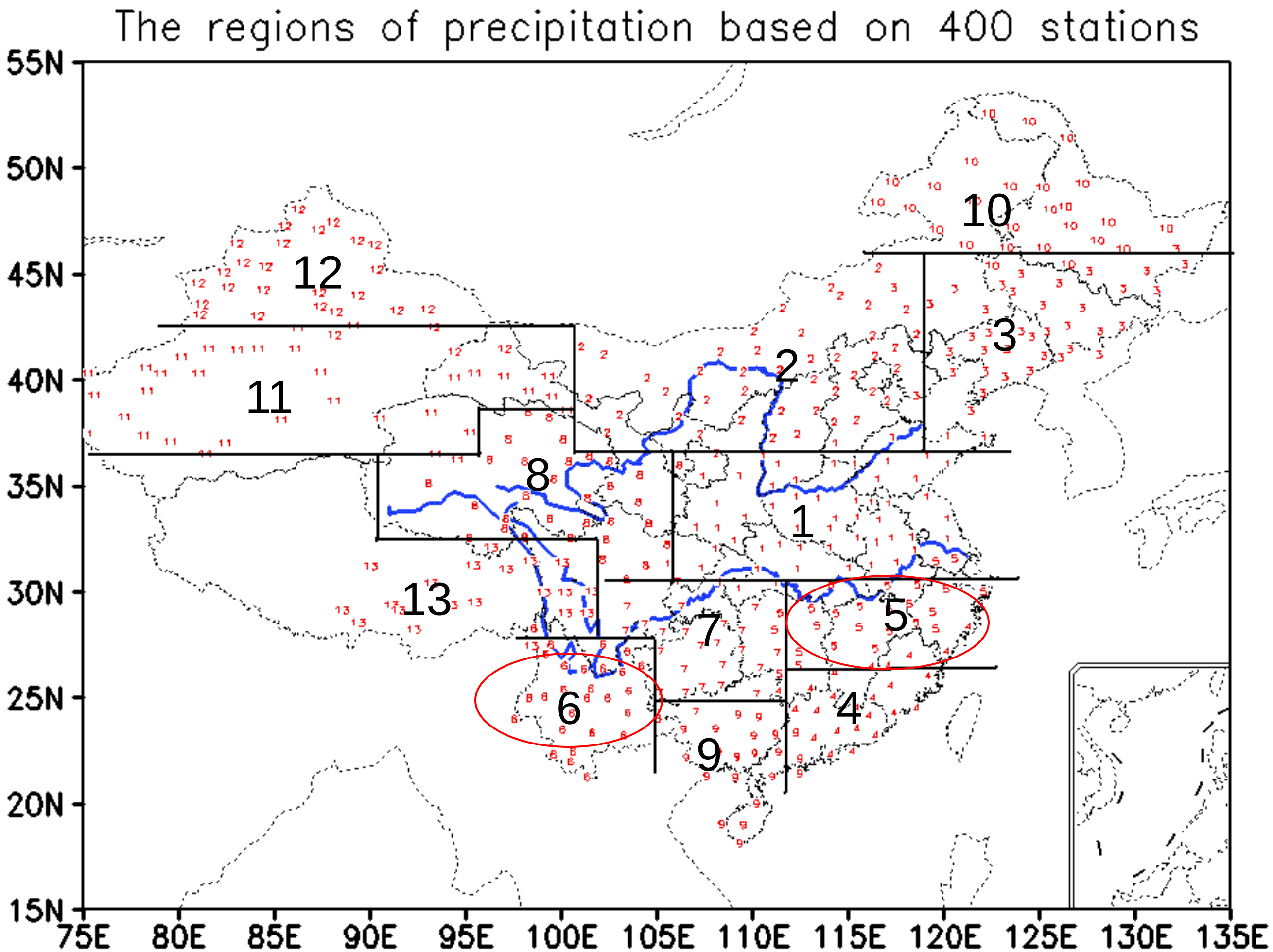
The skills of downscaled RSPPs (real line) and model outputs (dotted line) of precipitation anomalies during 1983-2006.
Vertical axis shows the ratio (%) of the consistency of regional precipitation anomaly signs between predictions and observations for all the 12 regions in each year.



ACCs of the regional prediction (dotted line), CGCM/NCC output and observation (real line) for each region in summer



Regionalization of precipitation(13)



REOF, Maximum-loading approach , regularization

The correlation coefficient between every two predictors for the Jiangnan region and Yunnan Area

Jiangnan Region

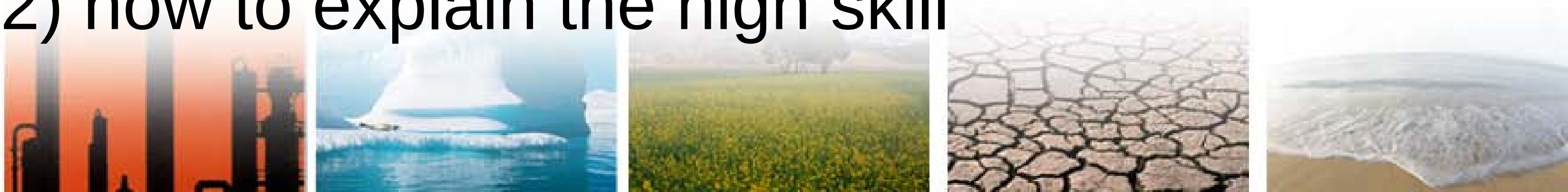
Correlation Coefficient	x_1(H200)	x_2(H500)	x_3(V850)
x_1(H200)	1	-0.22	0.17
x_2(H500)		1	-0.15
x_3(V850)			1

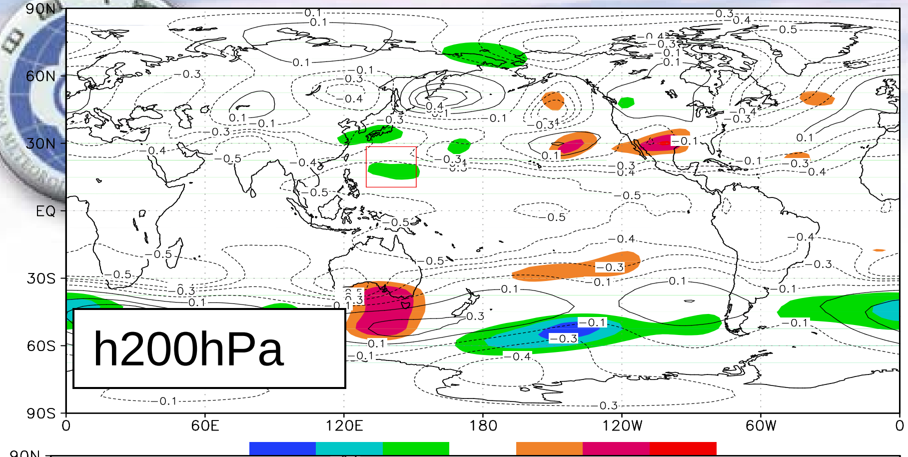
Yunnan Area

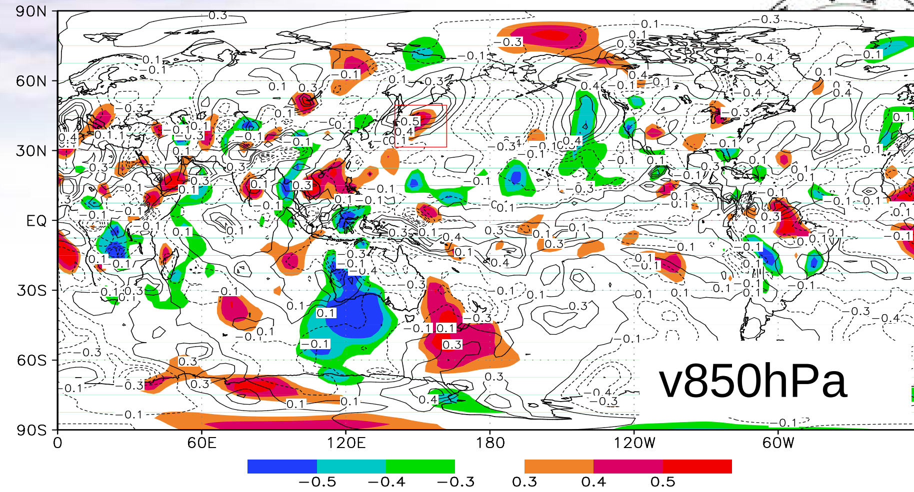
Correlation Coefficient	x_1(H200)	x_2(H500)	x_3(U200)	x_4(V200)
x_1(H200)	1	0.96	0.72	-0.7
x_2(H500)		1	0.71	-0.69
x_3(U200)			1	-0.5
x_4(V200)				1

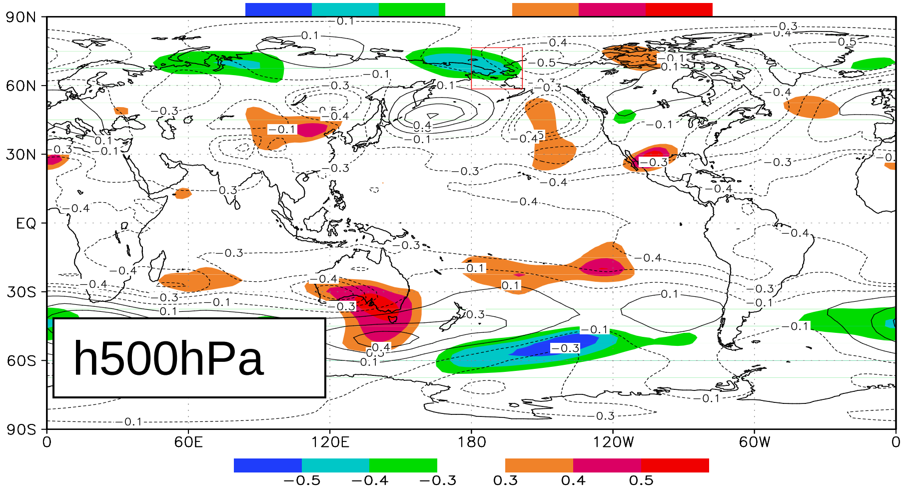
Skill origin

- To find good predictors is the focus: good predictors that represent not only the key factors influencing the regional predictand but also the high-skill elements in the CGCM/NCC output.
- two questions
  - 1) whether the predictor found this way is applicable
  - 2) how to explain the high skill









$$Y = a_1X_1 + -a_2X_2 + a_3X_3 + b$$

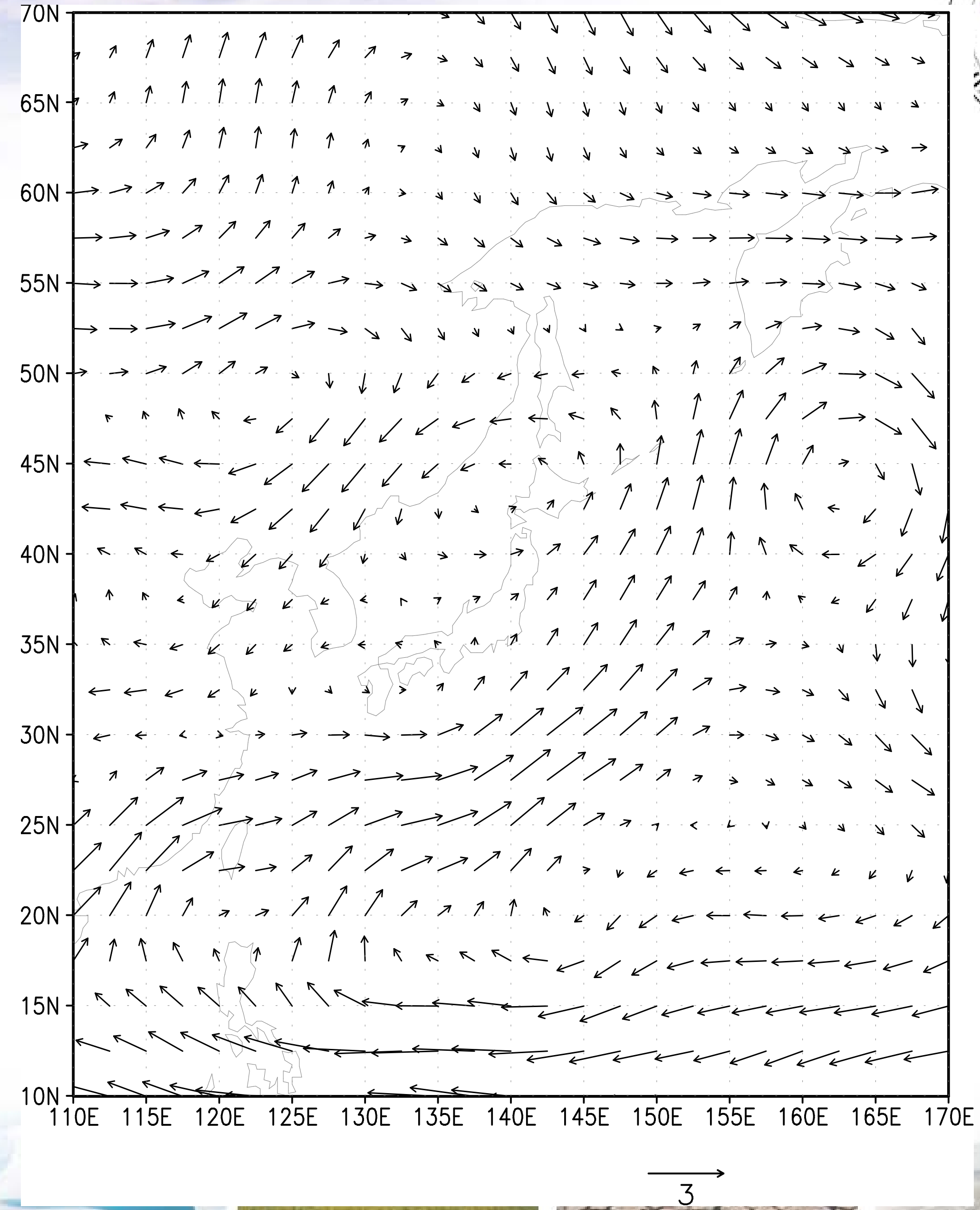
ACC between every two predictors for Jiangnan region

Correlation coefficient	x_1 (H200)	x_2 (H500)	x_3 (V850)
x_1 (H200)	1	–0.22	0.17
x_2 (H500)		1	–0.15
x_3 (V850)			1

Composite analysis

- To analyze the causes of the abnormal precipitation in the Jiangnan region, we define the years with summer precipitation anomaly percentage exceeding 20% as wet years, lower than -20% as dry years.
- wet years :1993, 1994, 1995, 1998, 1999,and 2002;
- dry years: 1985,1986, 1991, and 2003.

The difference (850 hPa wind field) between the wet and dry summer years in the Jiangnan region



IV Summary

- 13 consistent and largely contiguous precipitation regions were determined by using the maximum-loading approach for the EOF analysis, which helps to define regional boundaries. Most regions show distinctive climate patterns that are independent from each other.
- A downscaling method taking into account of precipitation regionalization is developed and used in the regional summer precipitation prediction (RSPP) in China.
- The data are detrended in order to remove the influence of the interannual variations on the selection of predictors for the RSPP.

Summary (cont.)

- One-year out cross-validation and independent sample tests indicate that the downscaling method is applicable in the prediction of summer precipitation anomaly across most of China with high and stable accuracy, and is much better than the direct CGCM/NCC prediction.
- The predictors used in the downscaling method for the RSPP are independent and have strong physical meanings, thus leading to the improvements in the prediction of regional precipitation anomalies.

more information

- CHEN Li-Juan, CHEN De-Liang, WANG Hui-Jun, and YAN Jing-Hui，Regionalization of Precipitation Regimes in China，ATMOSPHERIC AND OCEANIC SCIENCE LETTERS, 2009, VOL.2, NO. 5,301-307。
- Gu Weizong, Chen Lijuan, Li Weijing, et al., 2011: Development of a downscaling method in China regional summer precipitation prediction. Acta Meteor. Sinica, 25(3), 303-315, doi:10.1007/s13351-011-003x-x.

Thank you!

谢 谢!