Multi-year Simulation over East Asia using a Regional climate model

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Backgrounds

- Regional climate model has been increasingly applied to obtain regional details from large-scale climate since the pioneering studies of Dickinson et al. (1989) and Giorgi (1990), because of the relatively refined physics representation and grid resolution of regional models.

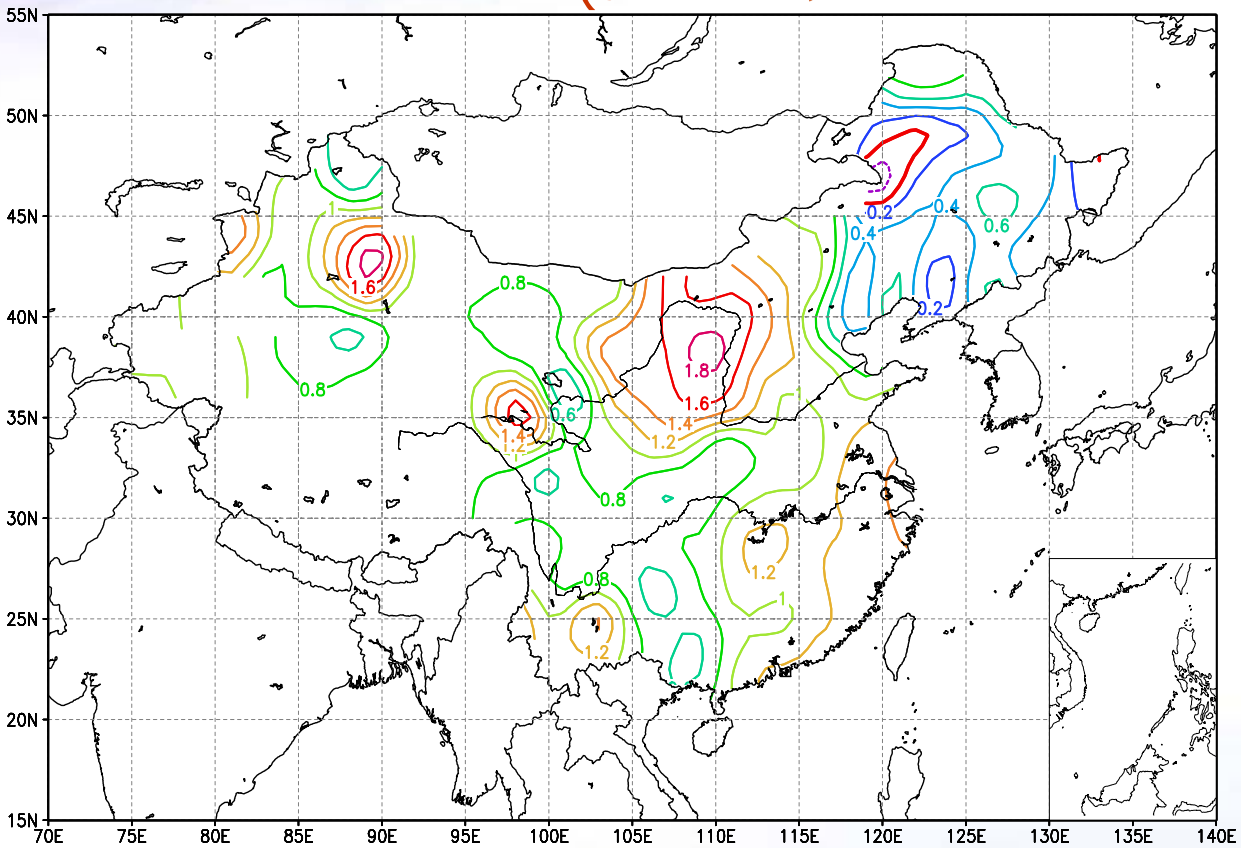
- In recent years, Regional climate model is widely used in studying regional climate variation. But, the previous studies are focused on some case of extremely weather or climate events(Girogi,1996; Liu,1996; Wang,2000; et al.), relatively little work was performed for long-term climate simulation over East Asia.

- A 5-year regional climate simulation over East Asia was conducted to examine the model's capability in reproducing seasonal variation of East Asia circulation and precipitation over China. The experiments will give us some clues about systematic bias of the model, which should be improved for the better simulation of East Asian climate.

Backgrounds

winter mean temp anomaly from climatology(1971~2000)

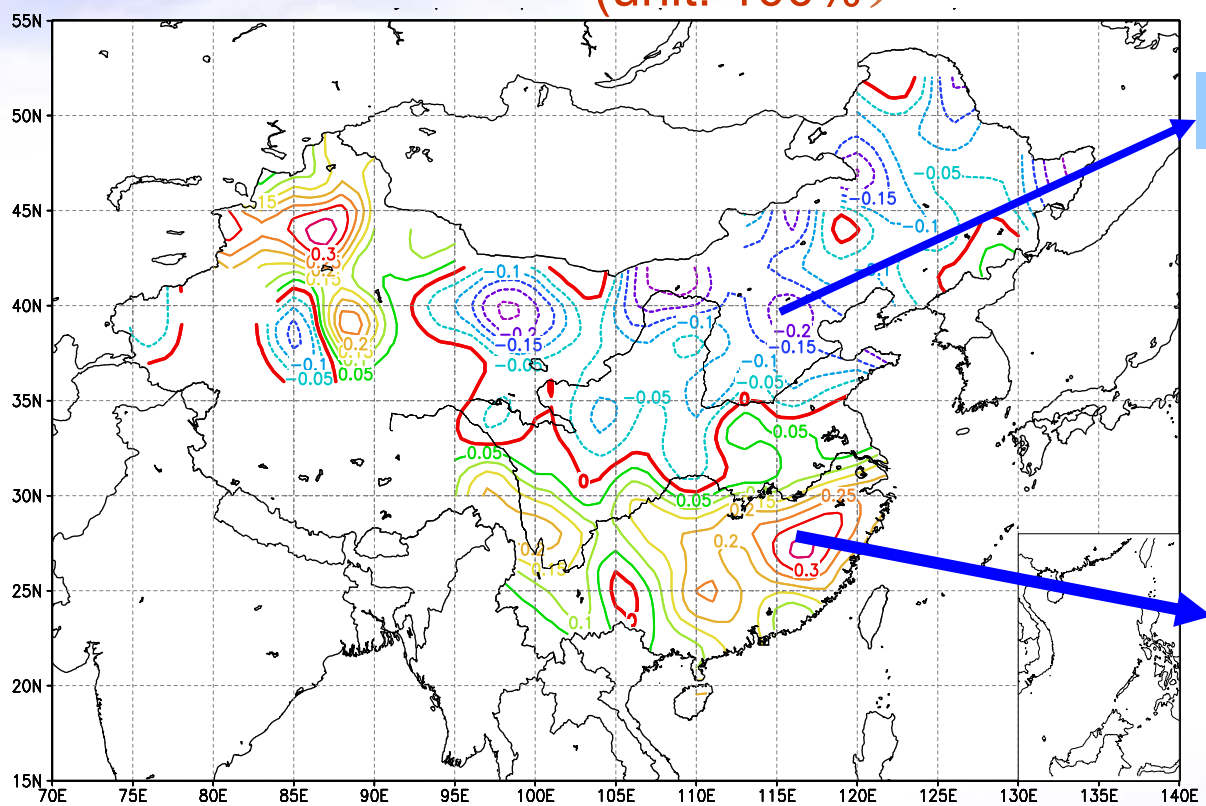
(unit: ° C)



Persistent warm winter,especially in 1998,2002

Backgrounds

summer mean precipitation anomaly from climatology(1971~2000)
(unit: 100%）



Drought

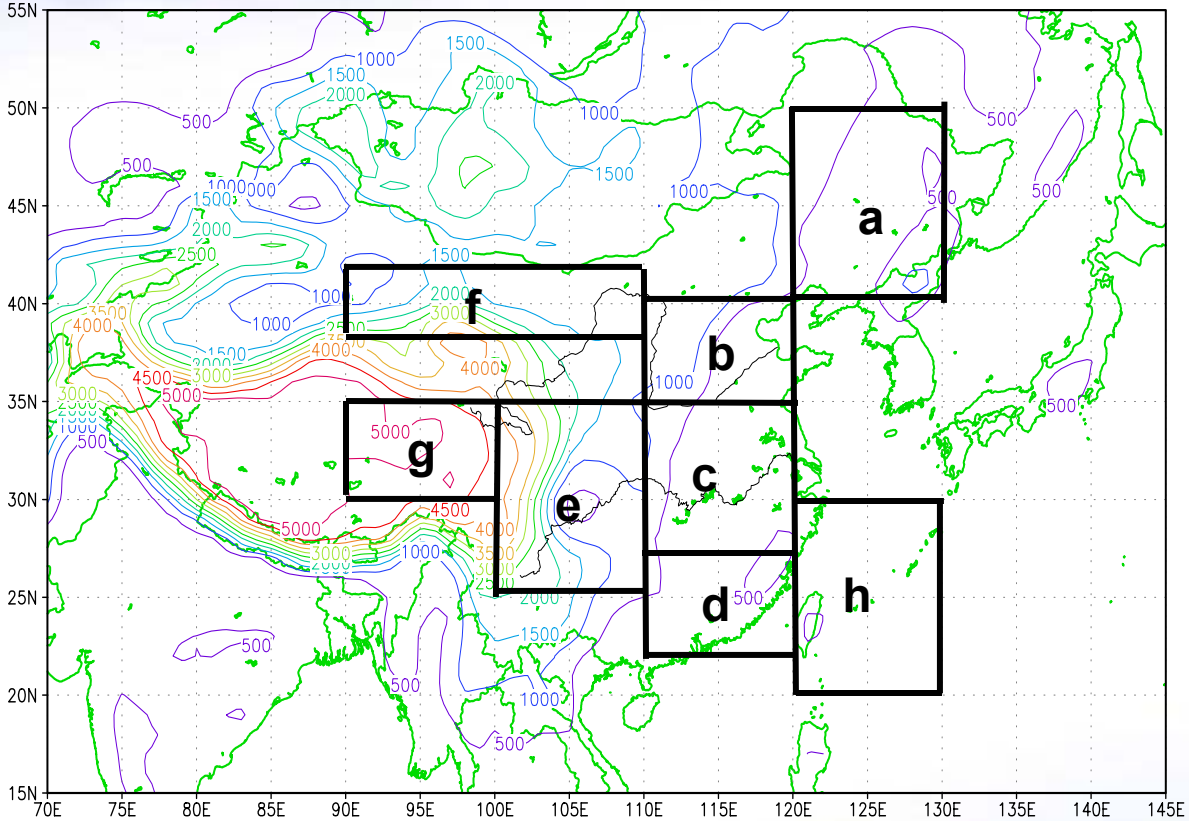
Flood

During this period, catastrophic floods occurred over Yangtze River basins in 1998, but severe drought occurred persistently in North China and North-west China. So the experiments can help us to examine the model's capability in reproducing the abnormal climate characteristics.

MODEL DESCRIPTION

Model Configuration	NCC/RegCM
Horizontal grids	60 km (79 X 151)
Vertical layers (top)	16 sigma layers (50 hPa)
Cumulus convection	Betts-Miller(Betts A K,1986; Zhai)
Moisture scheme	implicit
PBL	Holtslag(Holtslag et al.,1990)
Radiation	CCM3(Kiehl et al.,1996)
Land surface	NCC/ LPM(Zhang, Shi)
Boundary condition	Exponential laxation
Initial, boundary data and SST	NCEP/NCAR Reanalysis II
Simulation period	1997.12~ 2002. 12

Domain and sub-regions



a. Northeast China

b. North China

c. Central China (Mid – lower Yangtze River basins)

d. South China

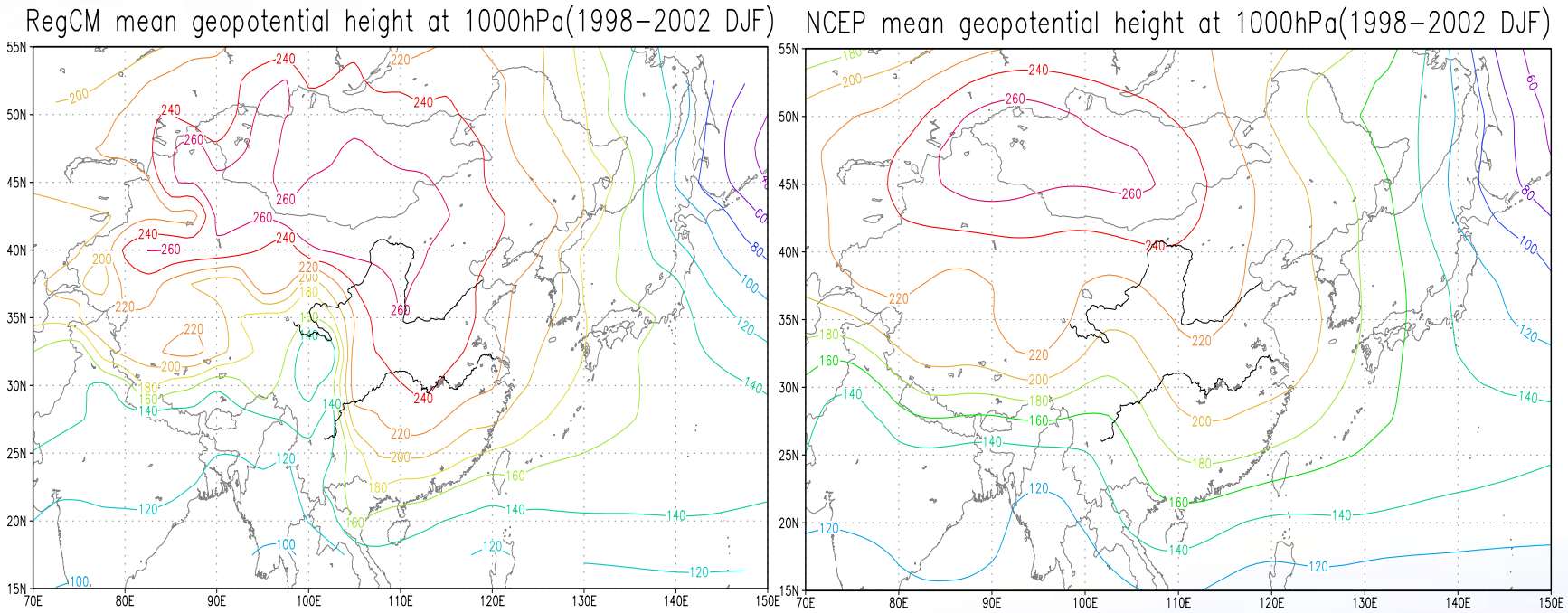
e. Southwest China

f. Northeast China

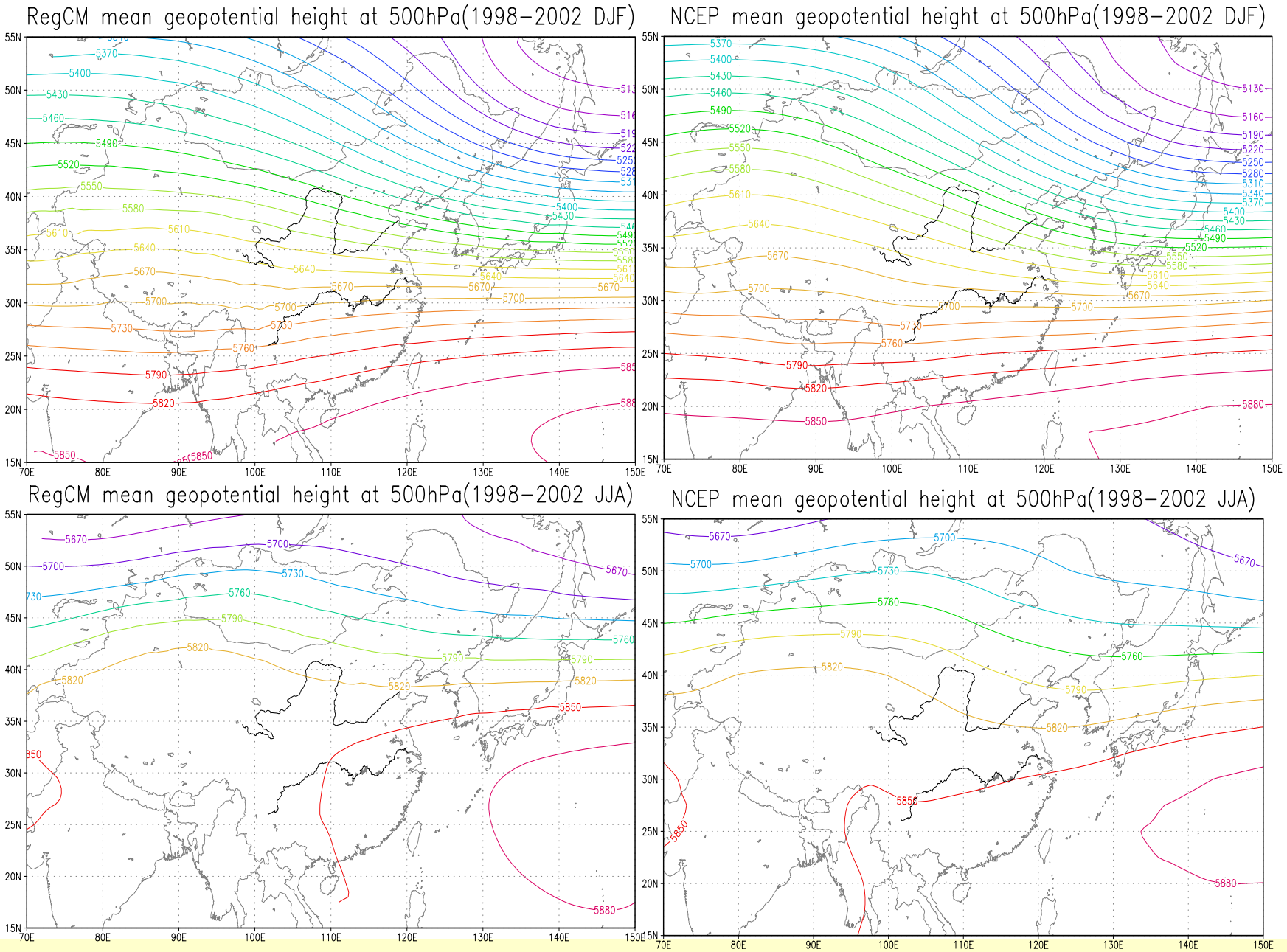
g. East of Tibetan Plateau

h. Adjacent margin seas

Simulated results comparisons

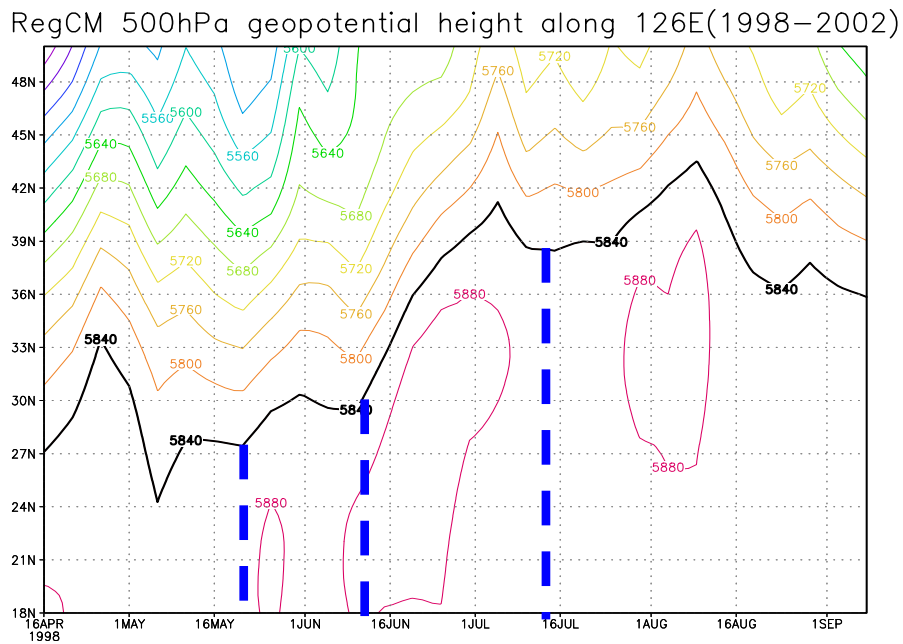


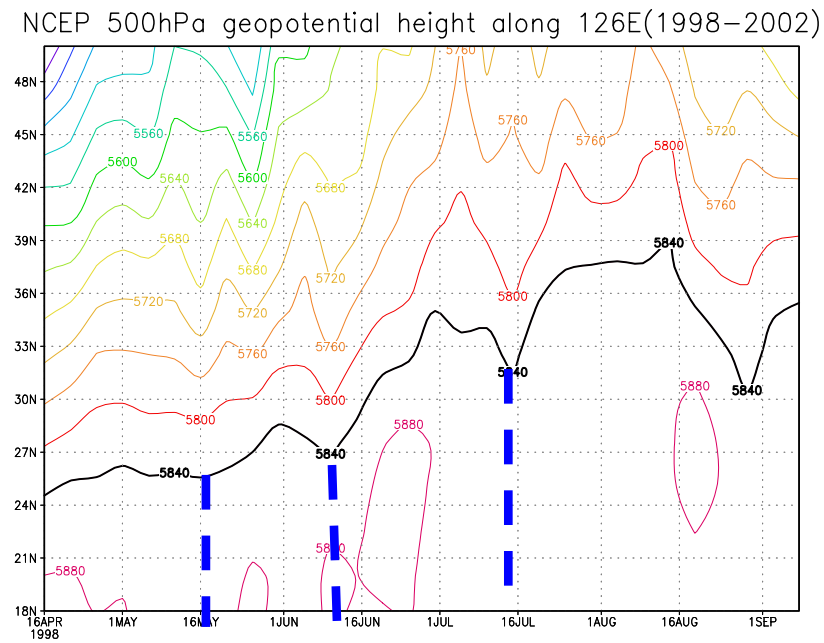
1000hPa mean geopotential height field in winter（unit: gpm）



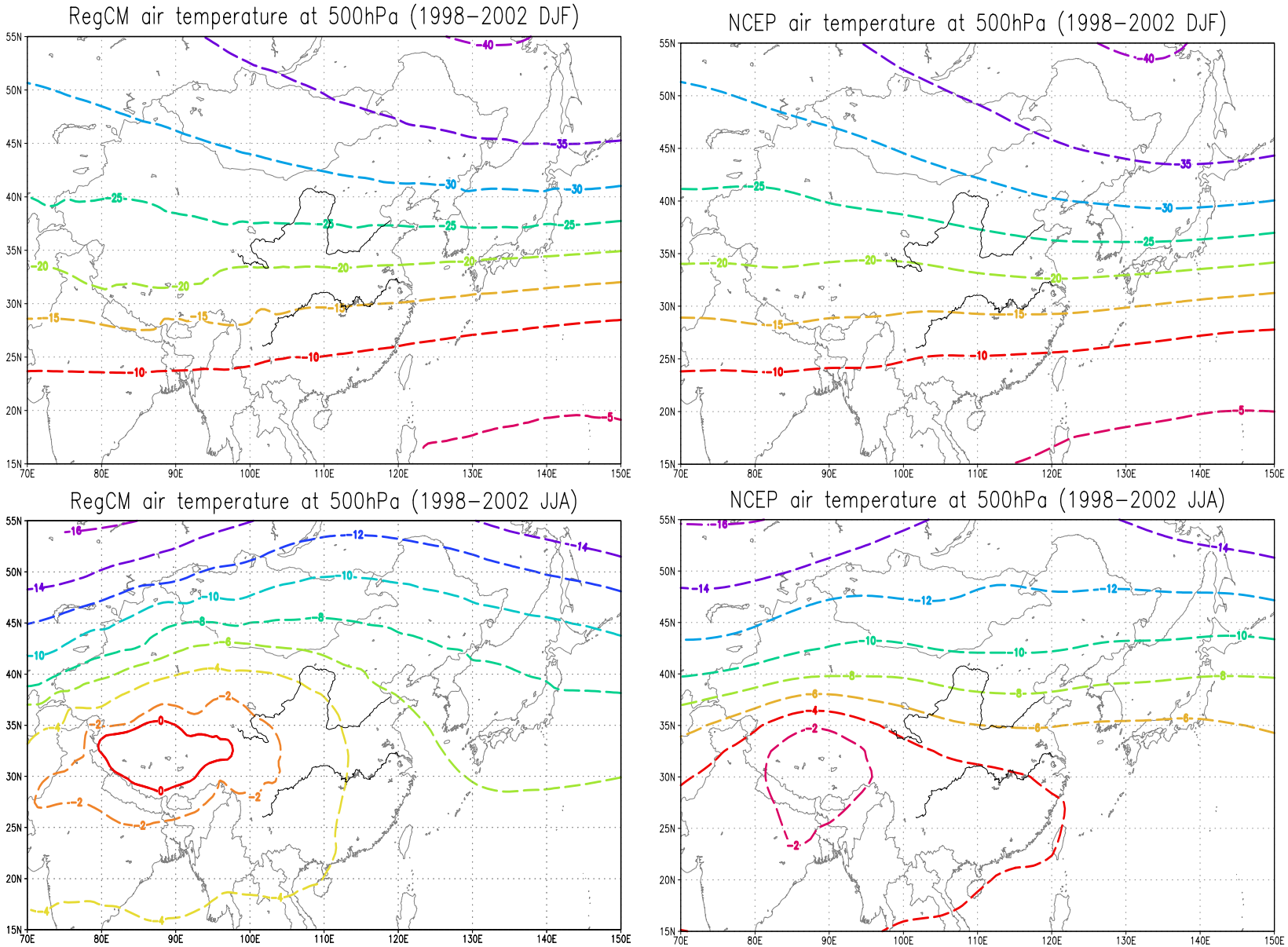
500hPa mean geopotential height field（unit: gpm）

Time-Lat section of 500hPa geopotential height field along 126° E (unit: gpm)

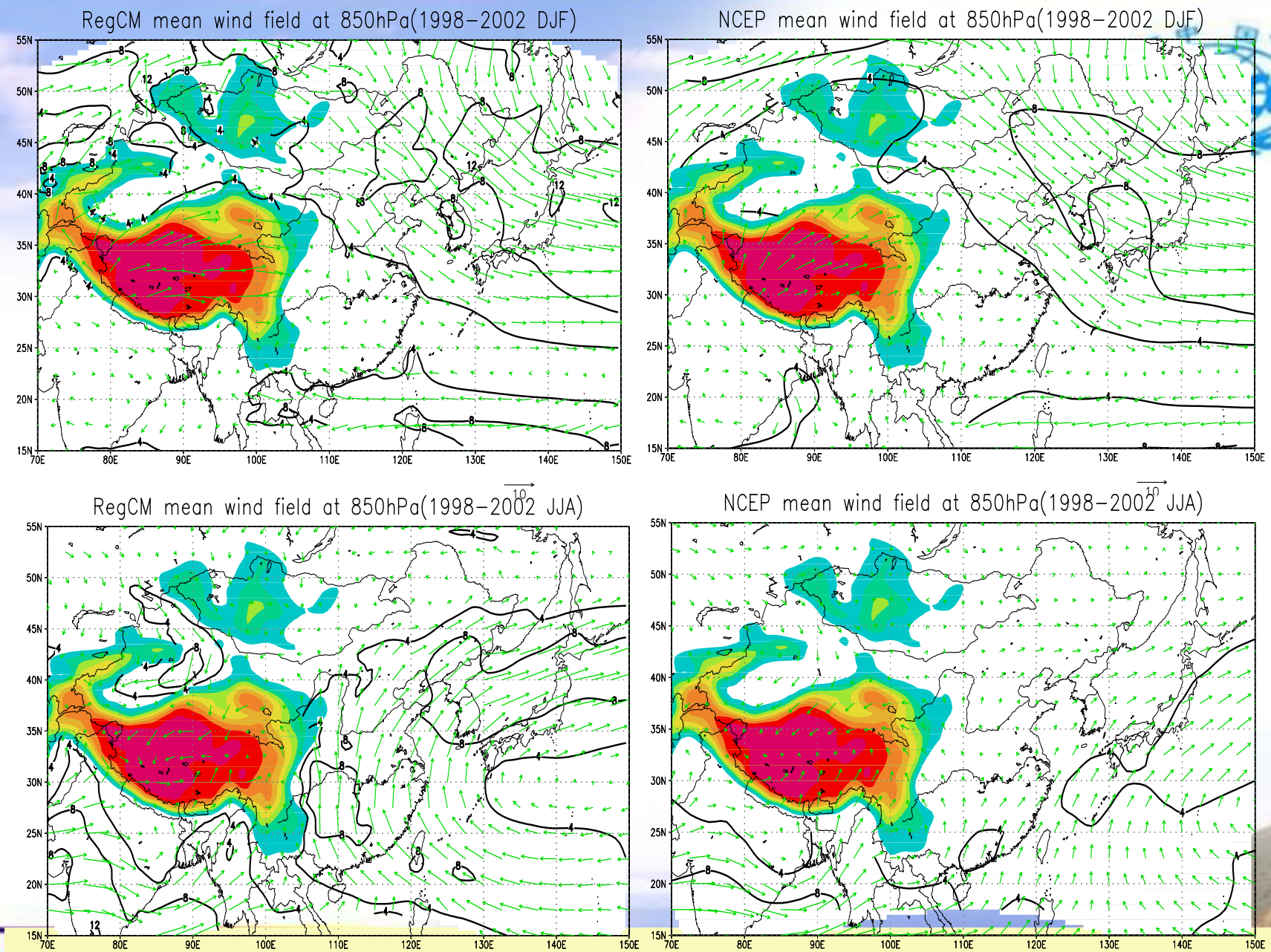




The contour line at 5840gpm(black) can be regarded as the approximate extension of the subtropical high, blue dashed lines indicate the leap time of the high from south to north. Which consist with three phases of summer monsoon's movement and the precipitation distribution over China.

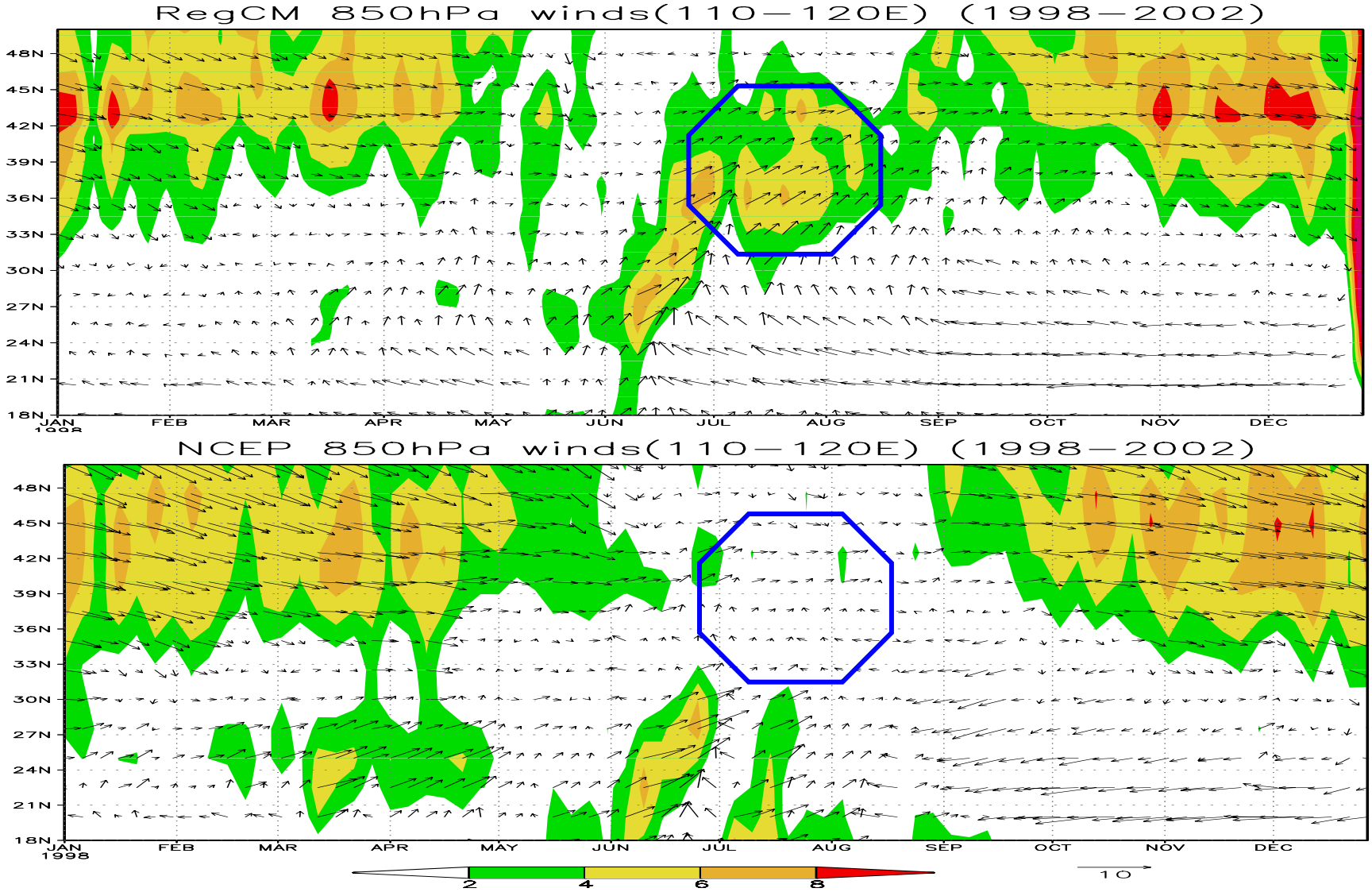


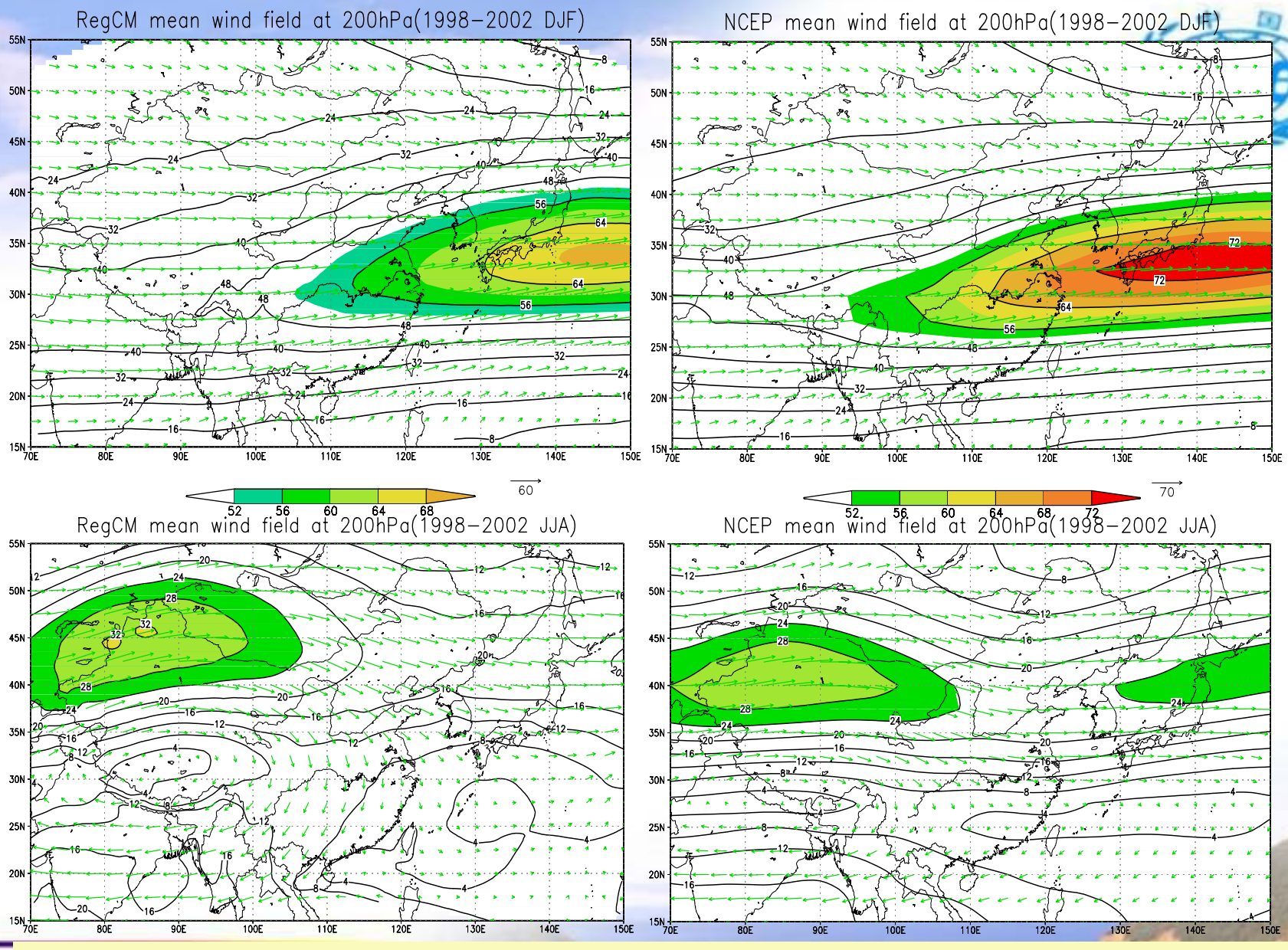
500hPa mean air temperature （unit: ° C）



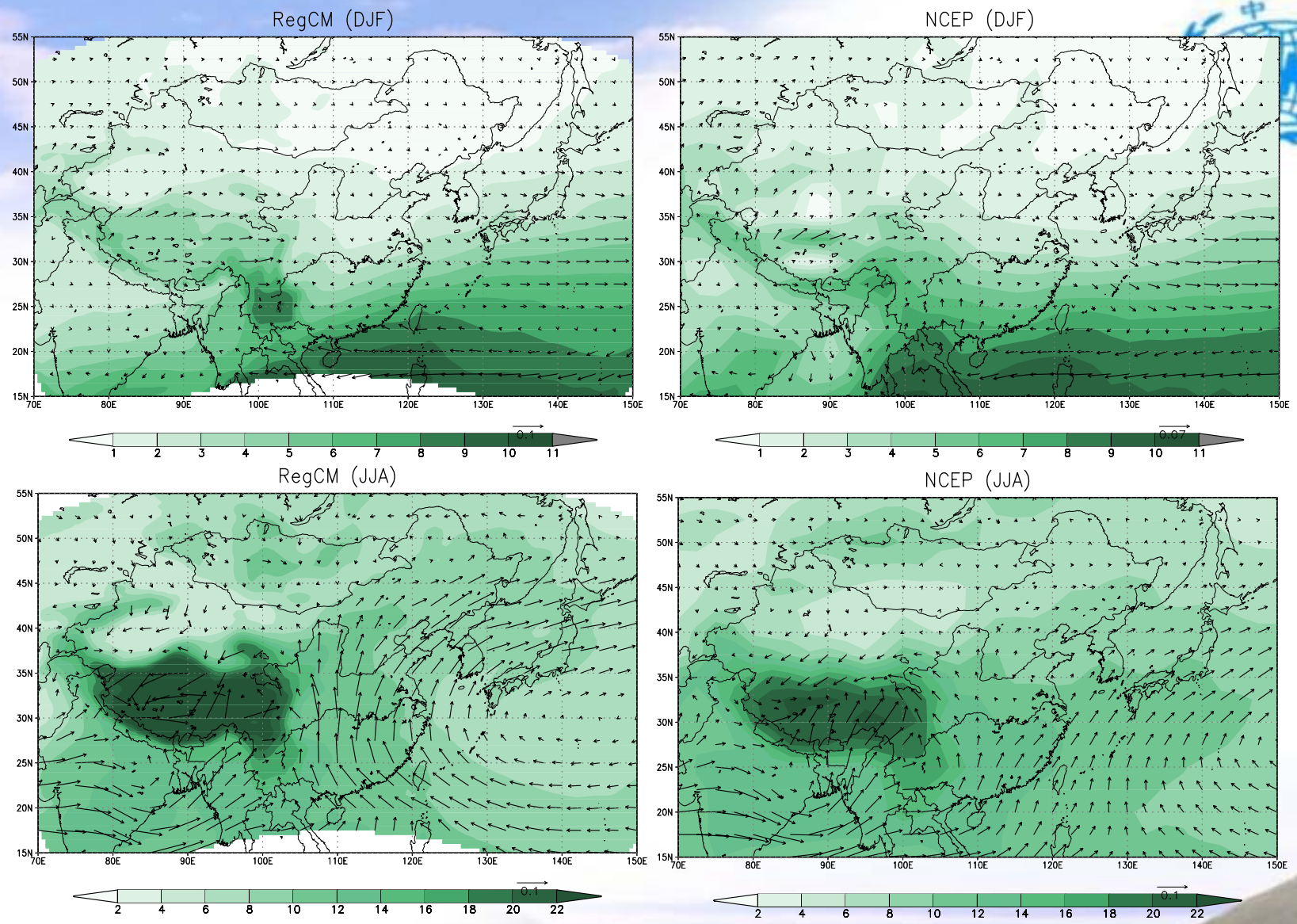
850hPa wind field (the shaded is Plateau)

Time-Lat section of 850hPa wind along 126° E (shaded area for U⩾2m/s)





200hPa mean wind field



850hPa q and Vq（unit：k/kg）

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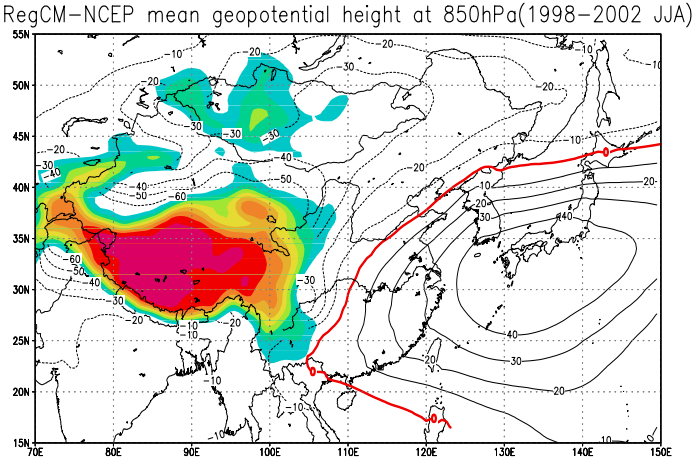
Summary(1)

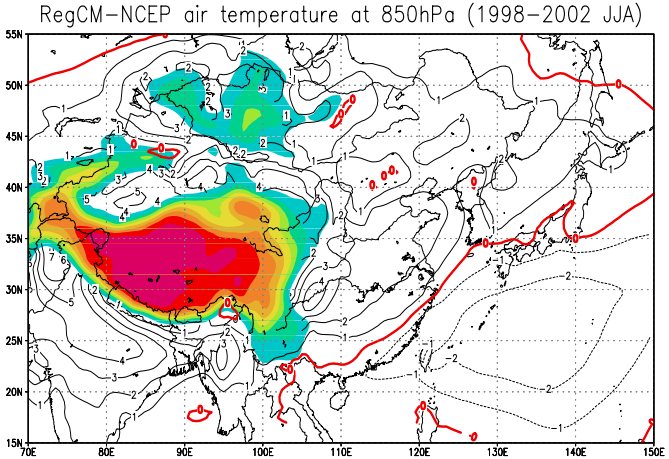
The model well reproduces the seasonal variation of large-scale circulation over East Asia, including variation of intensity and location of East Asia monsoon system. Exactly reveal the leap and retreat time of the subtropical high, but the simulated high is more intensive and shifted northward by 2-3 degrees. The simulated spatial-temporal characteristics of temperature, humidity and wind is in general agreement with the reanalysis. The main deficiency is the model overestimated intensity of East Asia summer monsoon.

Evaluation

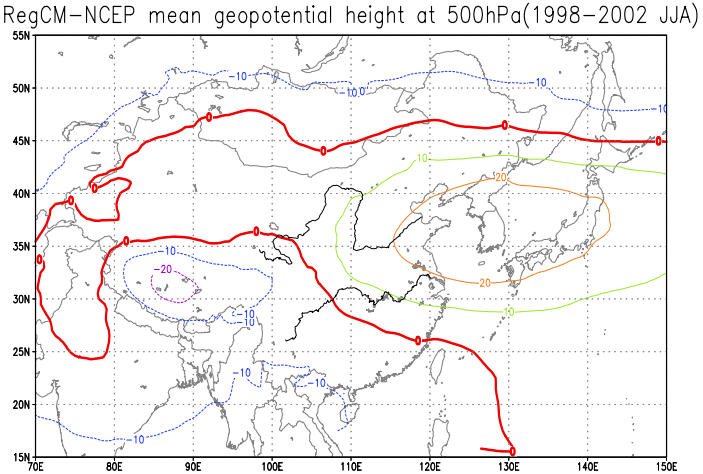
Seasonal mean bias(JJA)



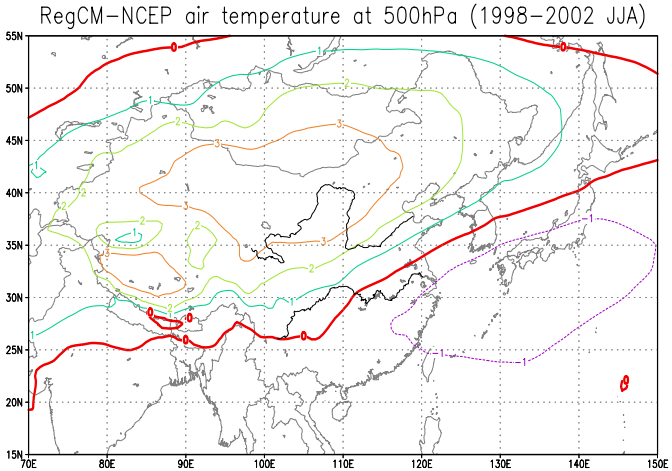
850hPa height field(unit: gpm)



850hPa air temperature(unit: K)

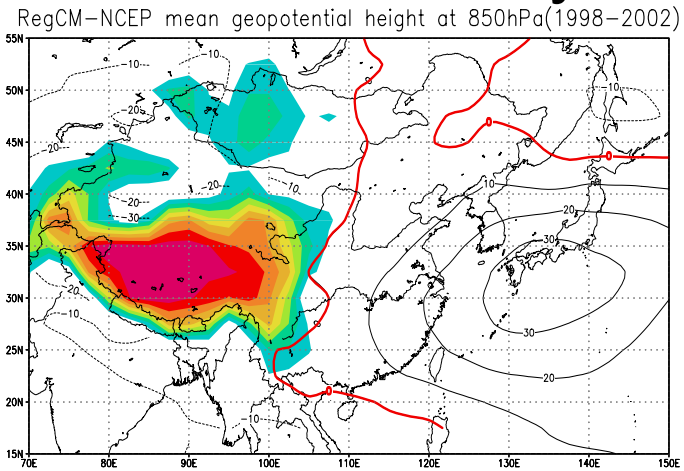


500hPa height field(unit: gpm)

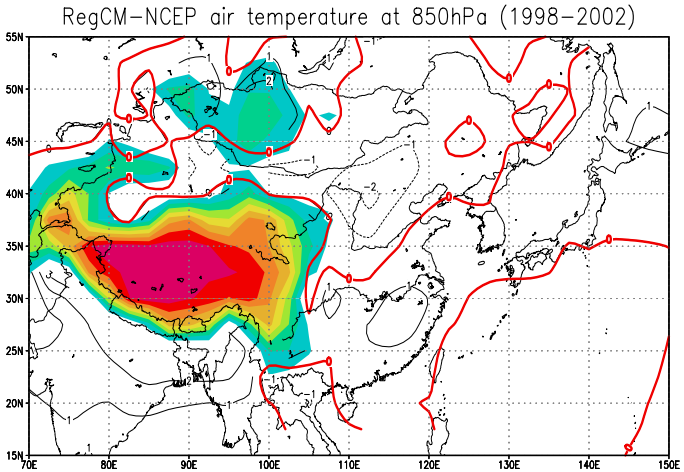


500hPa air temperature(unit: K)

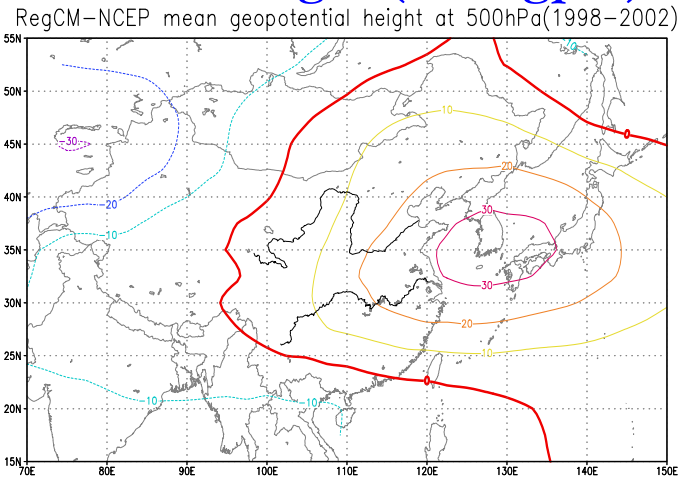
5-yr mean bias



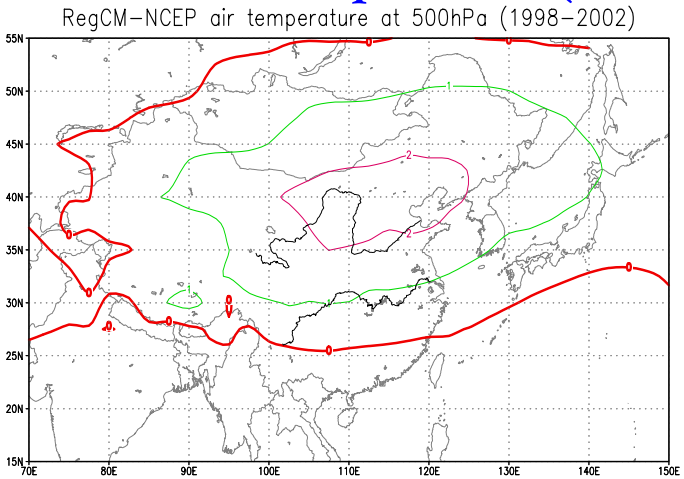
850hPa height (unit: gpm)



850hPa air temperature (unit: K)

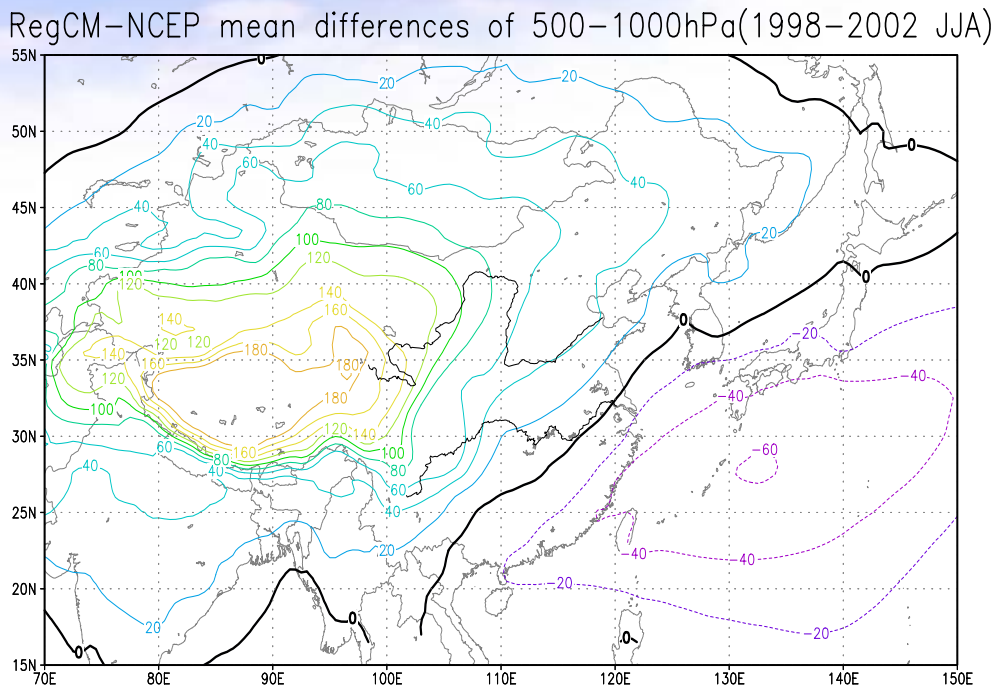


500hPa height (unit: gpm)

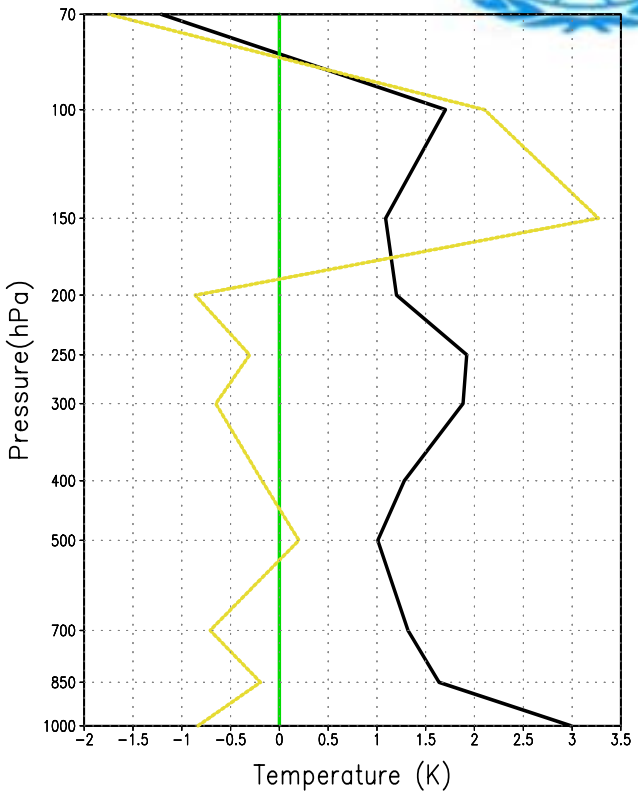


500hPa air temperature(unit: K)

Seasonal mean bias(JJA)



500-1000hPa thickness bias(unit: gpm)



Vertical profile of air temperature bias over land(solid line) and over ocean(dashed line)

The simulated summer mean temperature bias is negative over ocean and positive over land in lower troposphere, the bias pattern exaggerate the temperature difference between land and ocean, which must result in stronger summer monsoon.

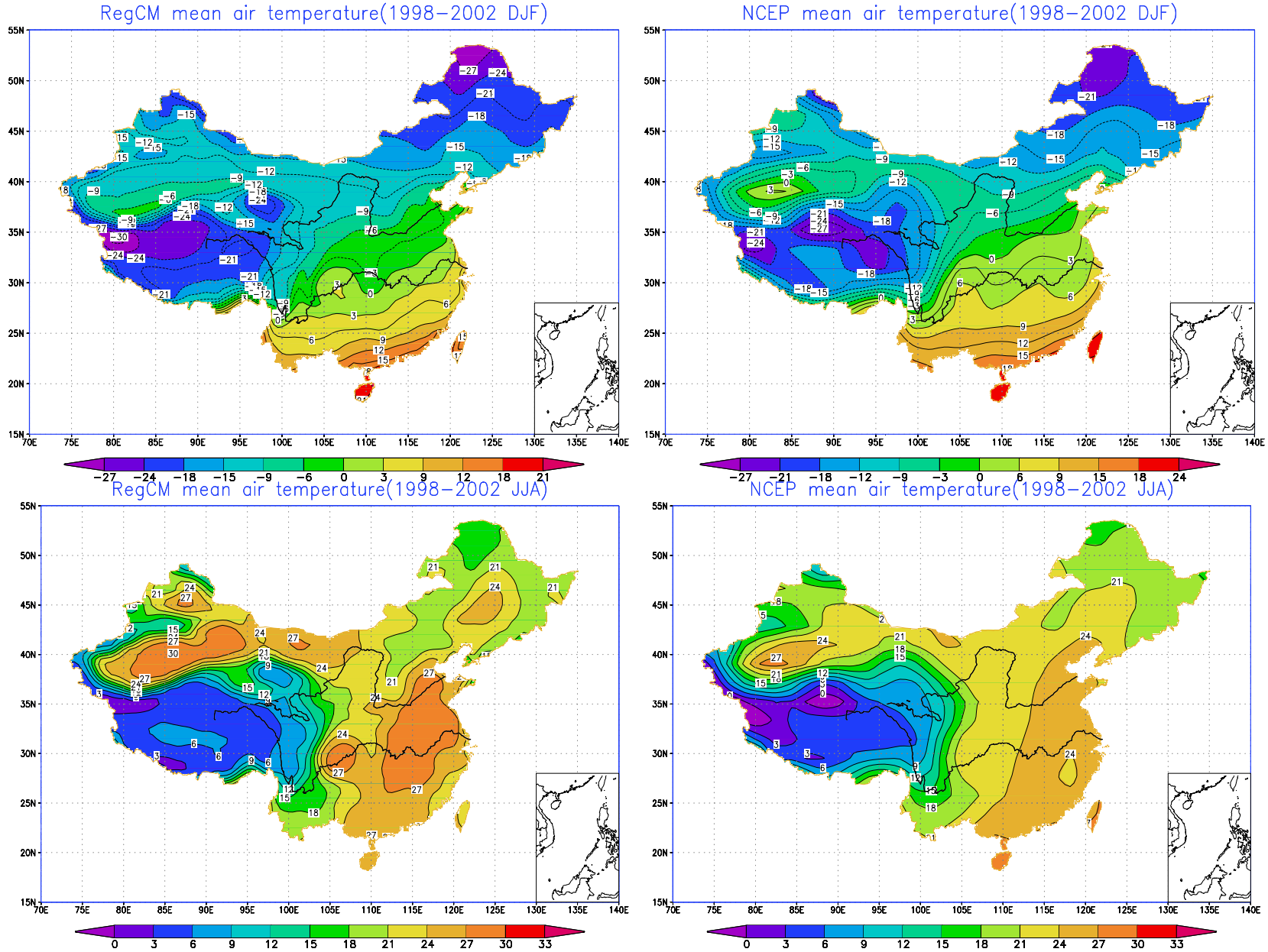
mean bias of air temperature(black)/ specific humidity(blue)

P (hPa)	1000	850	700	500	400	300	250	200	150	100	70
MAM	2.14/0.46	1.05/0.17	0.67/0.12	0.85/-0.02	0.91/-0.01	1.31/-0.05	1.85	1.08	1.07	1.01	-0.13
JJA	1.56/-0.35	1.37/-0.26	0.73/0.16	0.78/-0.31	0.62/-0.10	0.56/-0.11	0.65	0.63	2.23	2.66	-2.22
SON	1.27/-0.04	0.85/0.20	0.31/0.29	0.74/-0.12	0.75/-0.05	0.69/-0.08	0.93	0.37	1.66	1.47	-2.76
DJF	0.88/0.01	0.07/0.04	-0.07/0.14	0.09/0.01	0.35/-0.01	1.01/-0.03	1.24	0.50	1.16	0.62	-1.18
YEAR	1.41/0.02	0.77/0.02	0.37/0.11	0.57/-0.11	0.63/-0.04	0.90/-0.07	1.18	0.43	1.53	1.39	-1.45

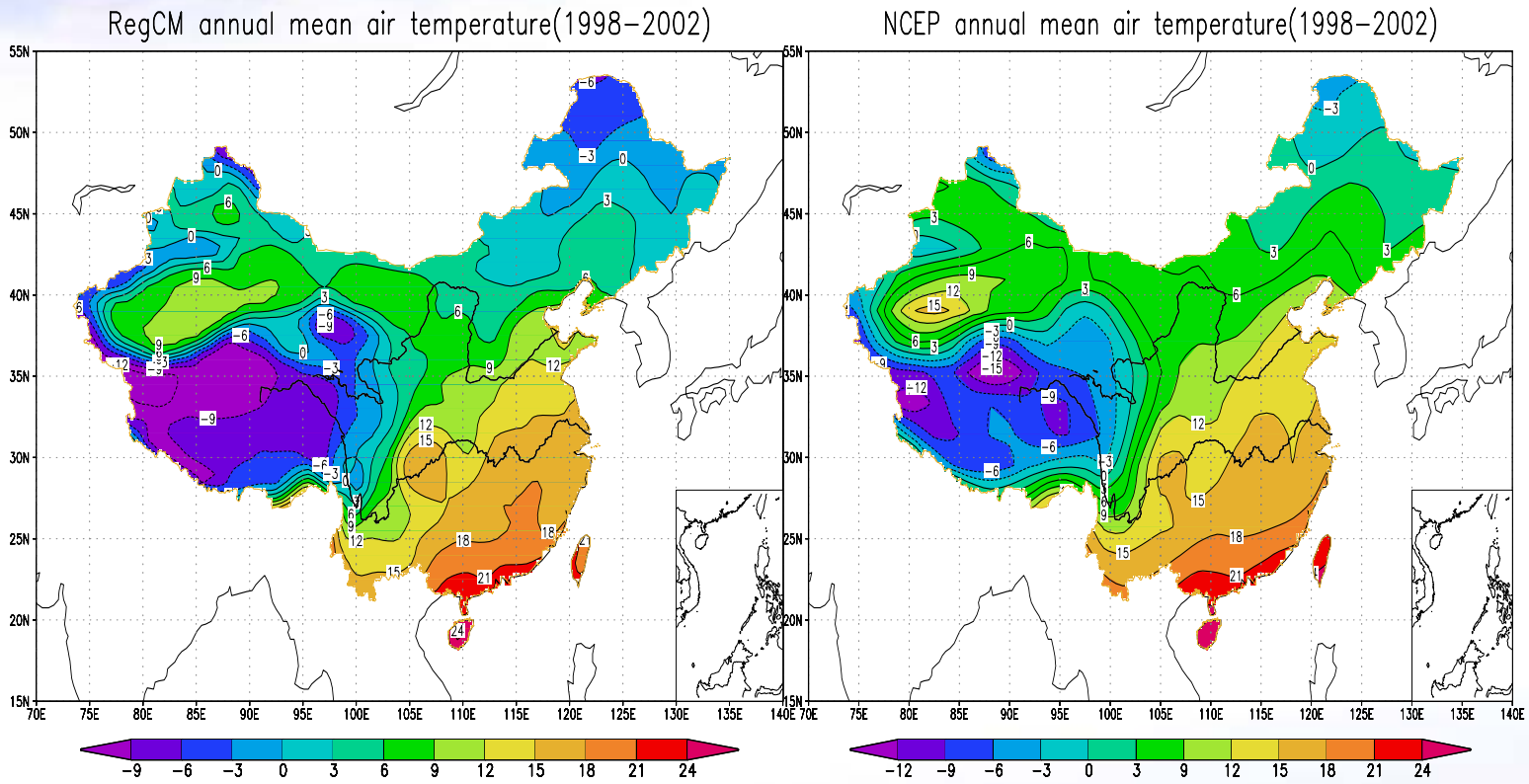
simulated temperature and moisture are warmer and wetter than the reanalysis in lower troposphere

Summary(2)

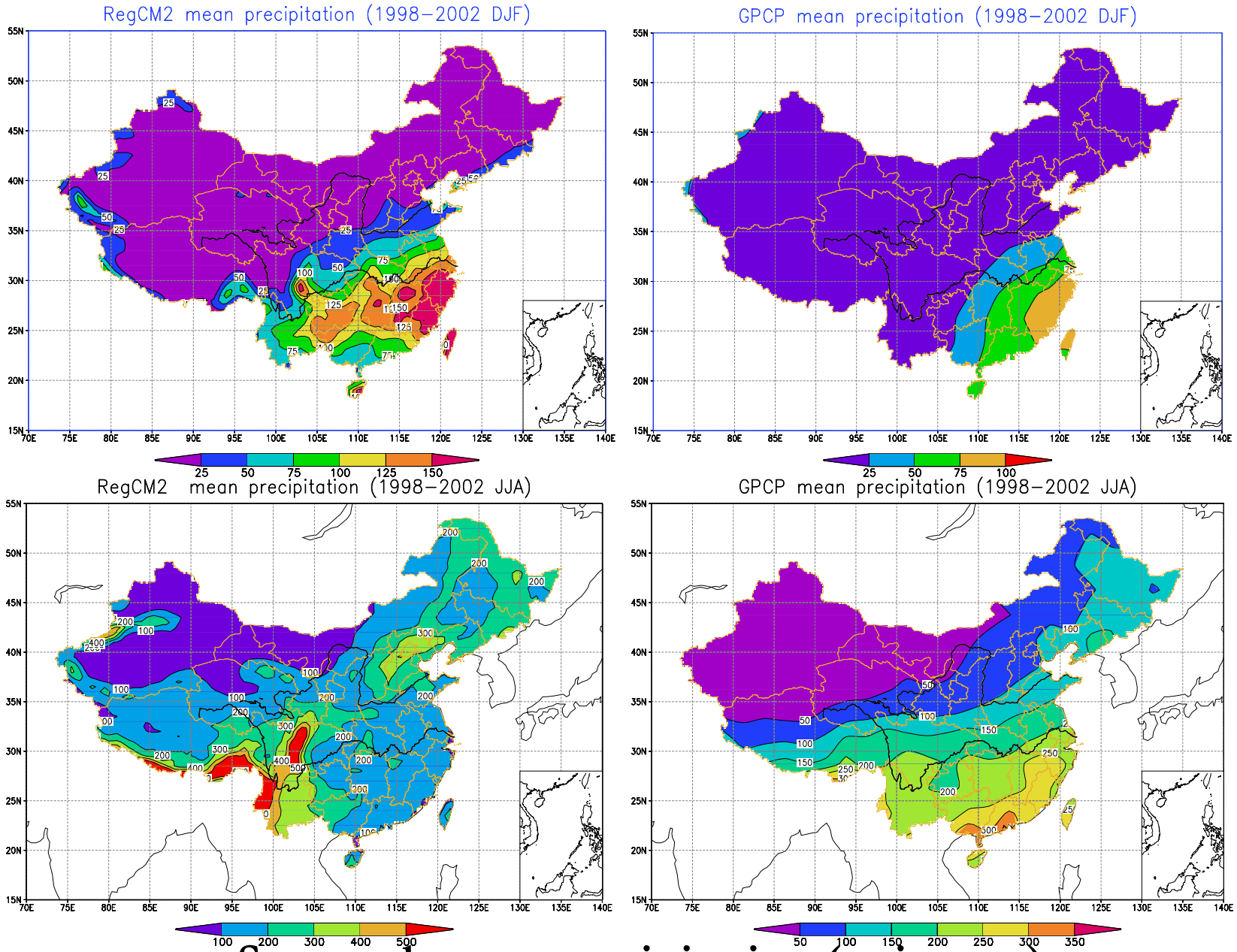
- Deviation of the simulated large-scale features from the reanalysis generally remains small. Domain-averaged bias of simulated temperature shows a maximum of 2.14K in the entire troposphere, and specific humidity bias less than 0.46g/kg. The simulated wind field is consistent with the observation.
- In mid-lower troposphere ,there is a discernible systematic bias in the simulation of air temperature in summer, which is positive over land and negative over ocean, and the systematic bias exaggerate summer temperature difference between land and ocean, which result in the simulated summer monsoon being stronger than the observation, the subtropical high being more intensive and be shifted northward by 2-3 degrees, so it would effect the precipitation distribution over China.



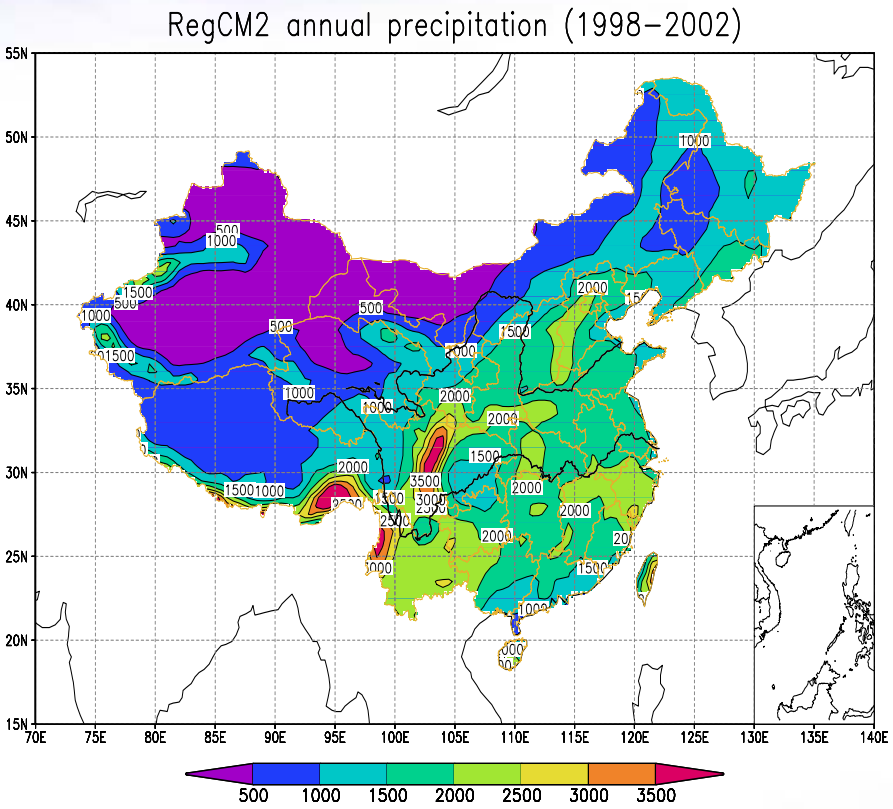
Seasonal mean ground air temperature (unit: ° C)

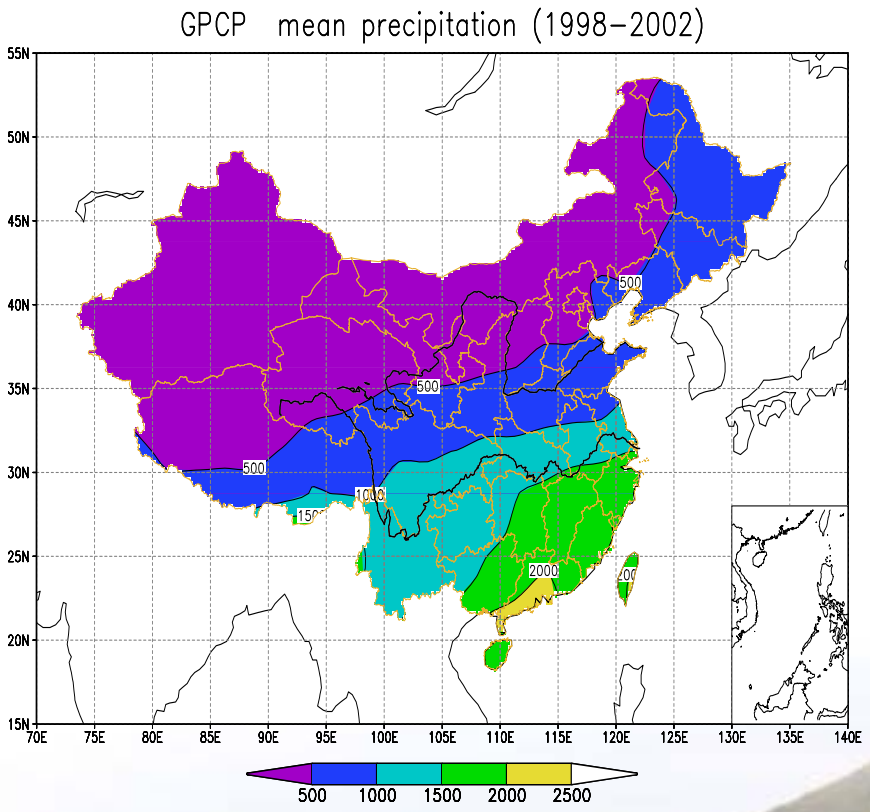


5yr mean ground air temperature (unit: ° C)

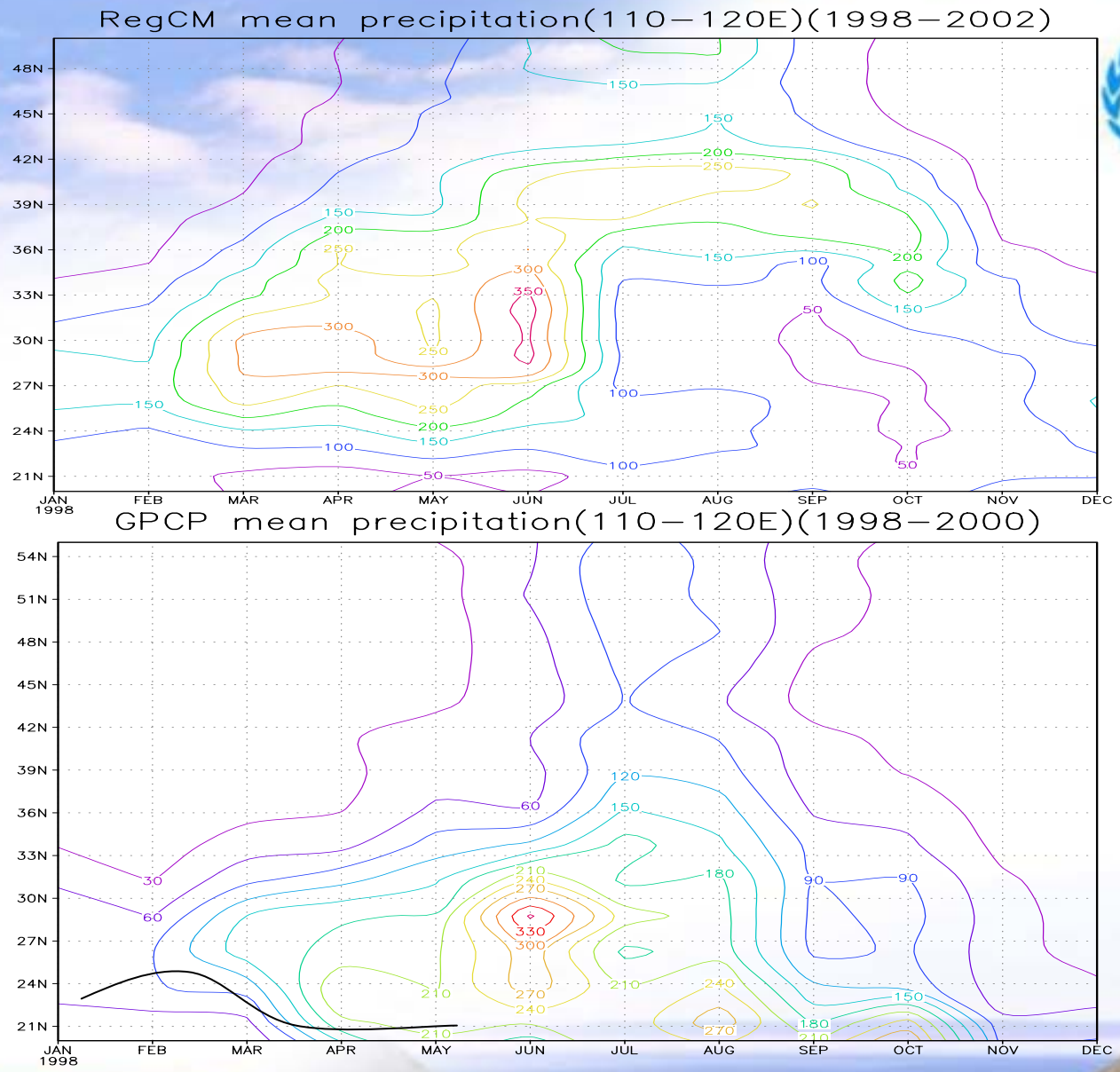


Seasonal mean precipitation (unit: mm)



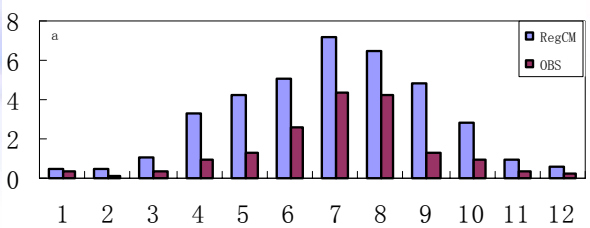


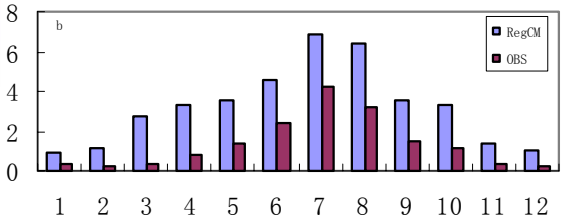
5-yr mean precipitation (unit: mm)



Time-Latitude section of mean precipitation（unit: mm）

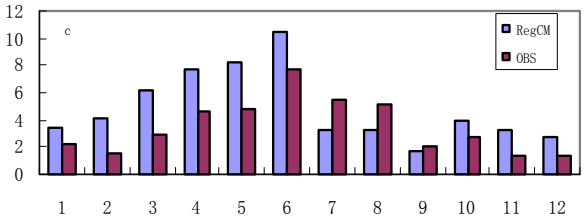
a

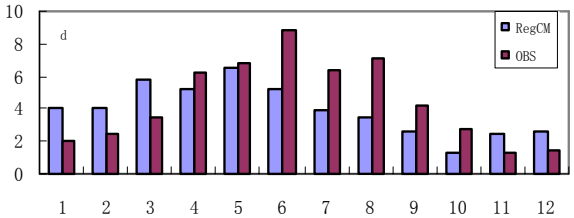




b

c





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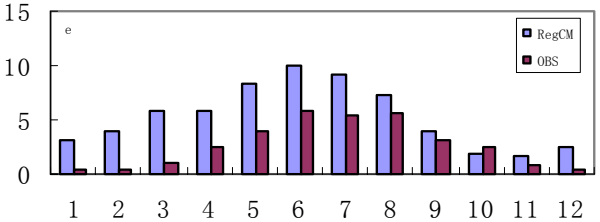

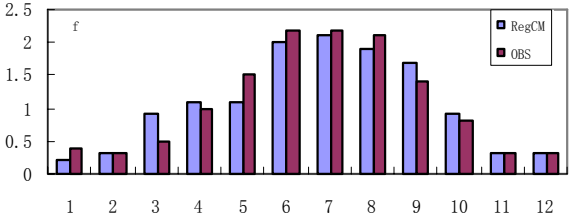

e

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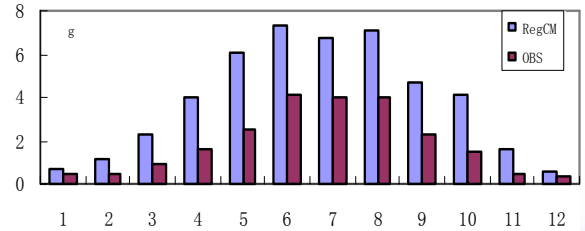
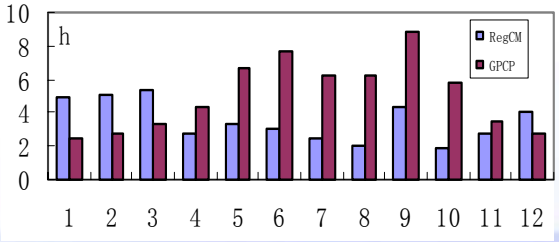




f

precipitation in sub-regions（unit: mm/day）

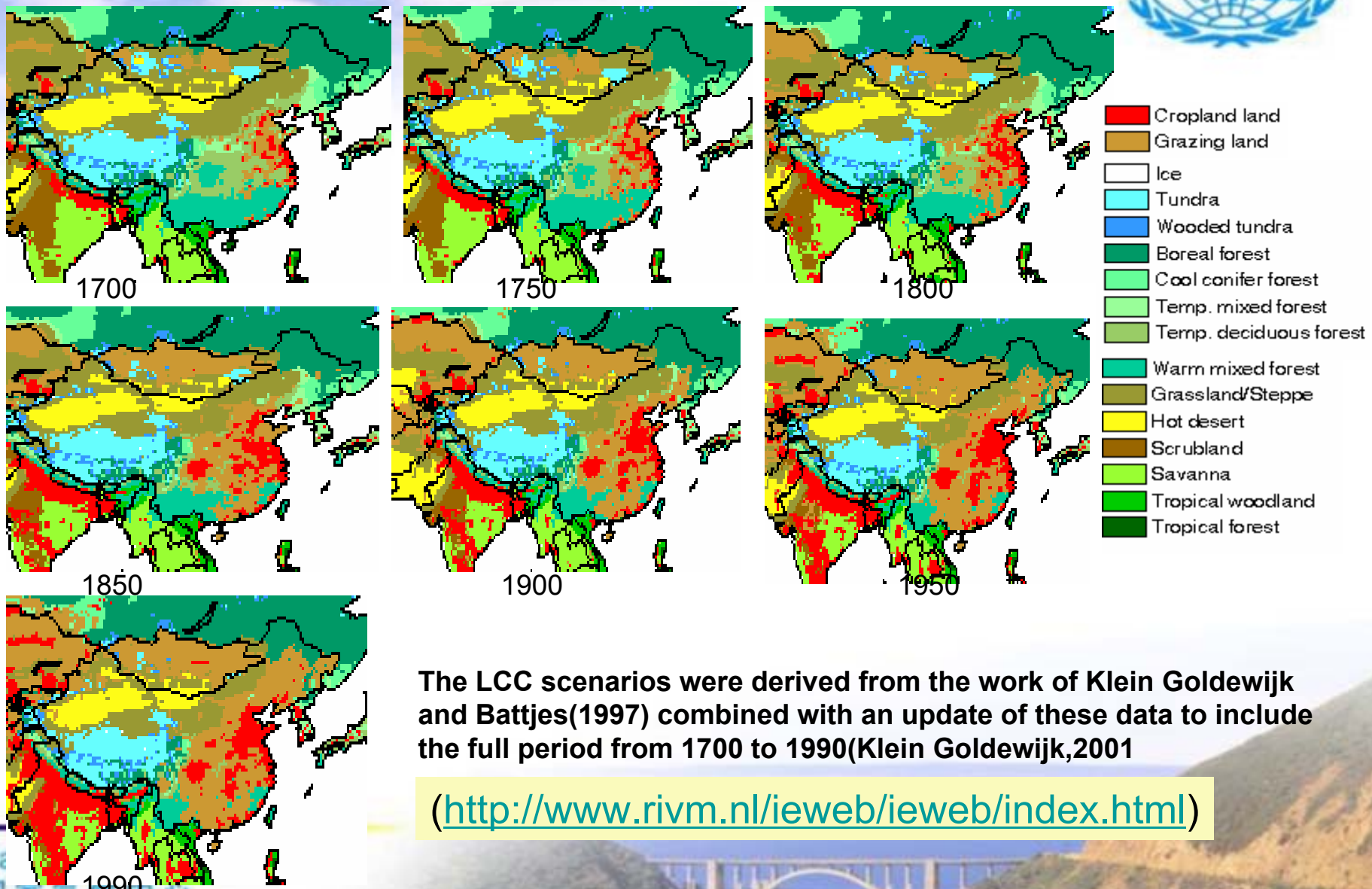
Summary(3)

The model well reproduced seasonal shift of rain belts and intra-seasonal variation of precipitation in sub-regions. The main deficiency is rain belts being shifted northward by about 3 degrees in summer, so the rainfall in North China is overestimated and not reveal the persistent drought over there. The bias may be mainly contributed to the systematic bias in simulation of air temperature. It also be related to the complex topography and cloud-radiation parameterization scheme. which would be the keystone for us to improve the model.

Further study

On the basis of the fore-mentioned control run, the further study would focused on the impacts of land cover change(LCC) on regional climate . Experiments will be done about the impacts of historical land cover changes in recent 300 years on regional climate change. It would give us some implications for land management over China.

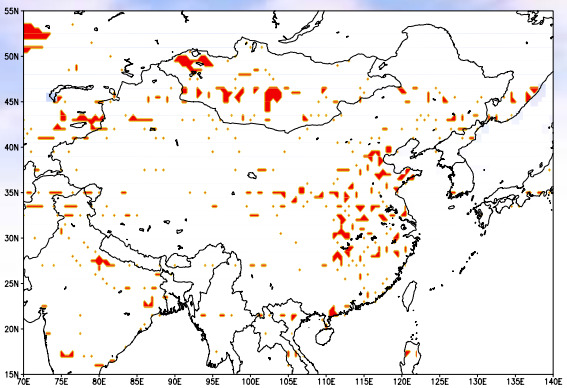
Land cover over East Asia



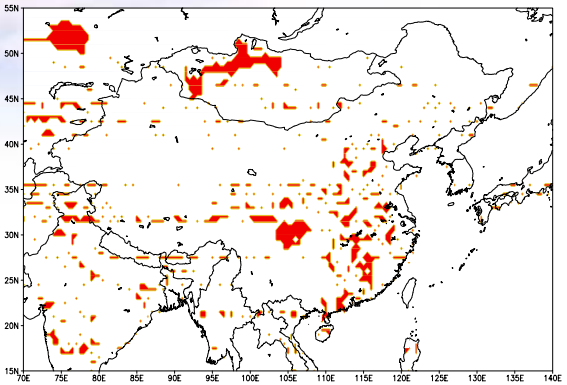
The LCC scenarios were derived from the work of Klein Goldewijk and Battjes(1997) combined with an update of these data to include the full period from 1700 to 1990(Klein Goldewijk,2001

(http://www.rivm.nl/ieweb/ieweb/index.html)

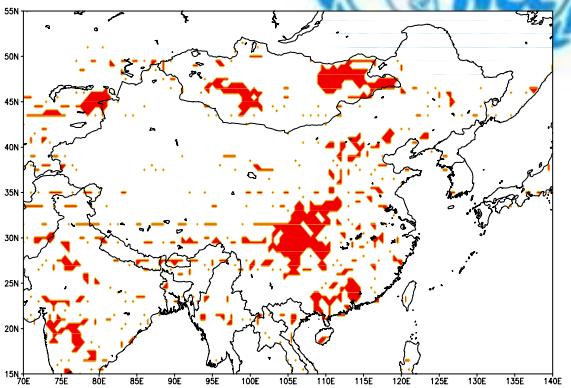
Land cover change(LCC)



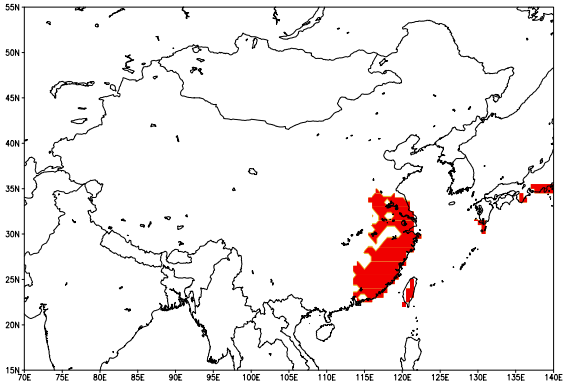
1700-1750(736 grids)



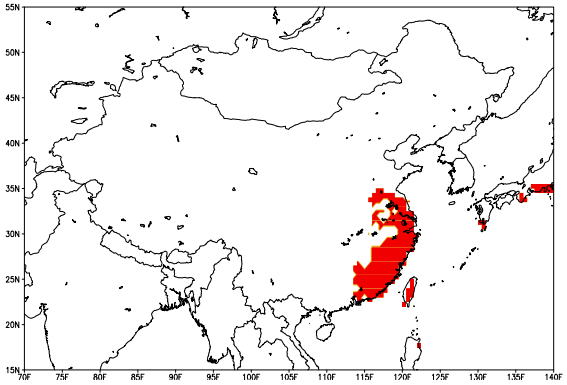
1750-1800（1029 grids）



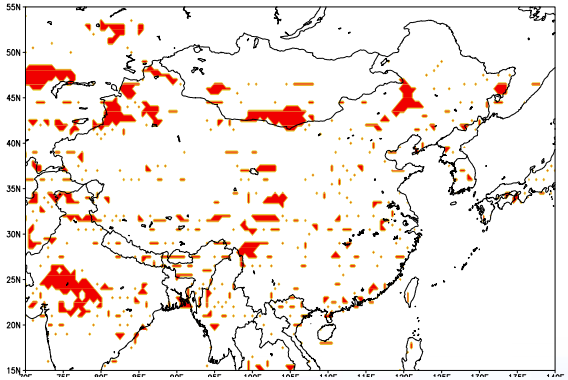
1800-1850(1248 grids)



1850-1900(353 grids)



1900-1950（342 grids）



1950-1990(1245 grids)

There are 3478 grids had been changed from 1700 to 1990, most of the modifications in land cover are of four major types: forest to grass or crops; short grass to crop; tall grass to grass or crop; and semi-desert to crops. So it is essential to investigate impacts of the LCC to regional climate over China.

Thanks !

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