Assimilation of Total Precipitable Water in a 4D-Var System: A Case Study

Zhang Lei

Lanzhou University,Lanzhou,Gansu,China

Ma Gang, Fang Zongyi

National Satellite Meteorological Center,Beijing,China

outline

- ❖ Theory

- ❖ Experiment design

- ❖ Results and discussion

4D-Var

$$J(x(t_0)) = \frac{1}{2}(x(t_0) - x_b)^T B^{-1}(x(t_0) - x_b) +$$

$$\frac{1}{2}\int_0^\tau (y(t_n) - H(x(t_n)))^T O^{-1}(t_n)(y(t_n) - H(x(t_n)))dt$$

The objective of 4D-Var is to find an optimal model state that minimizes in a least-square sense the distance between a selected output quantity of the model and its observed equivalent, given a background constraint

For precipitation assimilation,the functional can be written as:

$$J(x(t_0)) = \frac{1}{2}(x(t_0) - x_b)^T B^{-1}(x(t_0) - x_b)$$

$$+ \frac{1}{2}\sum_{n=0}^{N}(pw(t_n) - pwobs(t_n))^T O^{-1}(t_n)(pw(t_n) - pwobs(t_n))$$

Experiment setup

❖MM5 4D-Var system

❖Test domain center:112.5°E, 31.5°N

❖Horizontal grid:61×61, vertical level:23, Horizontal resolution :54km

❖Integrate time: 20020722 00UTC—20020725 00 UTC

❖Background field: NMC T 213 00, 06, 12, 18GM T 4 global forecast, horizontal resolution:0.5625°×0.5625°

❖Satellite data: ATOVS retrieved total column water vapour

Case study

❖Period: July 22 – 25, 2002

❖Assimilation time-window: 6 hour
00UTC - 06UTC July 22 , 2002

❖Integrate time   72 hours

❖Control run: without satellite data

❖Test run : with satellite data

Satellite data over the test domain
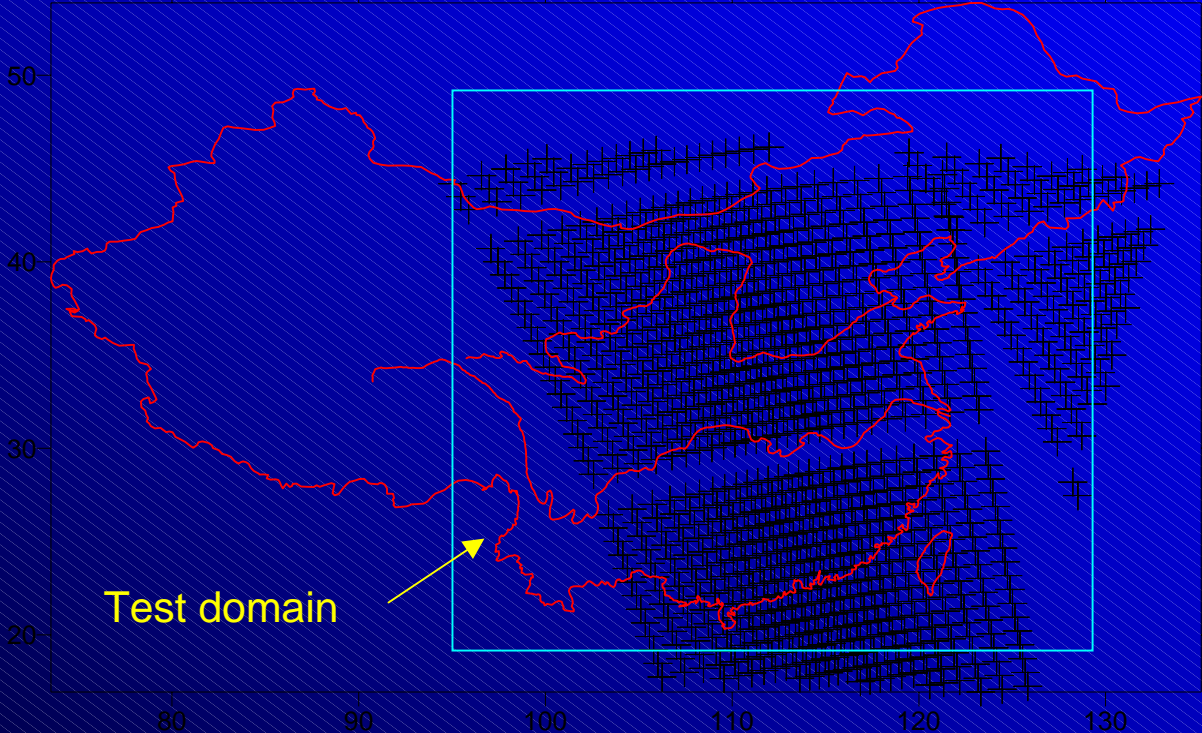
Test domain

❖ <u>Comparison between including and excluding satellite data at the initial time</u>
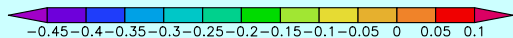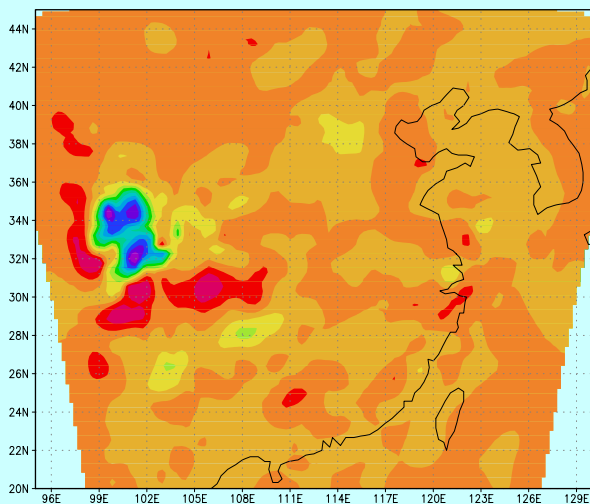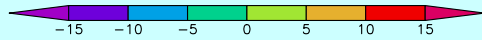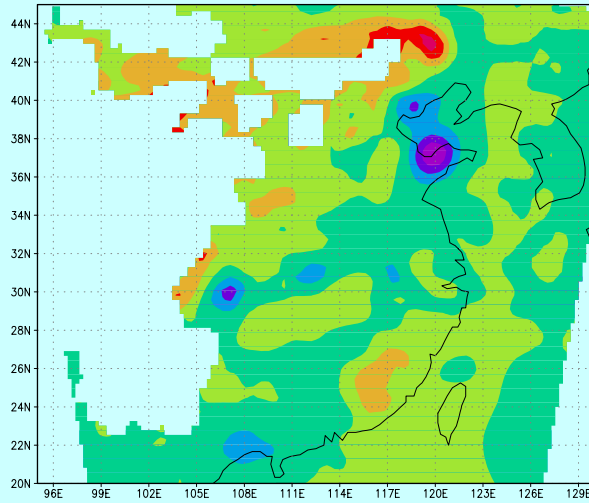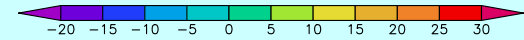
❖ <u>Effects on precipitation forecast</u>
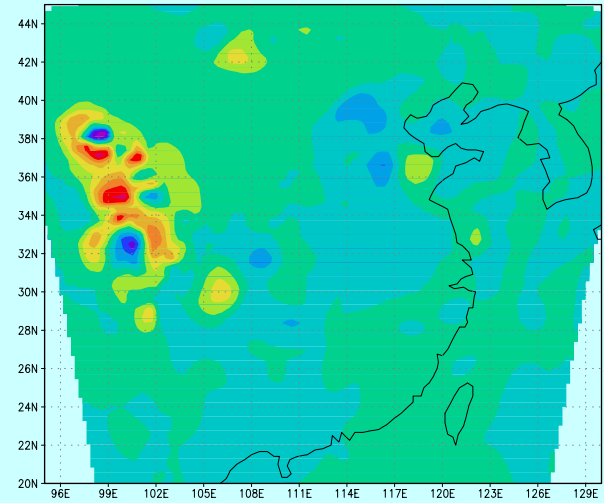
850
hpa

500
hpa
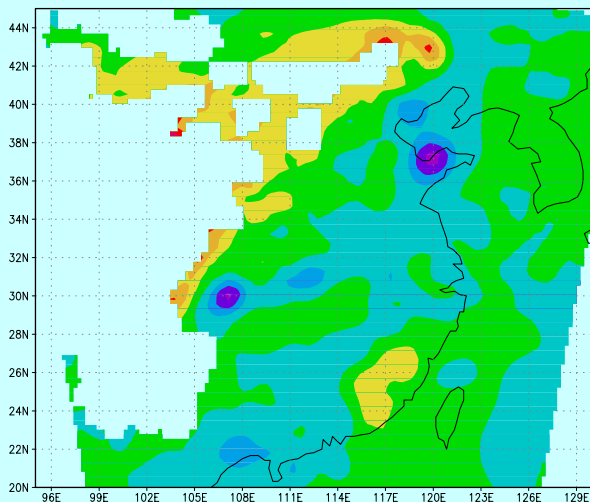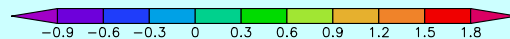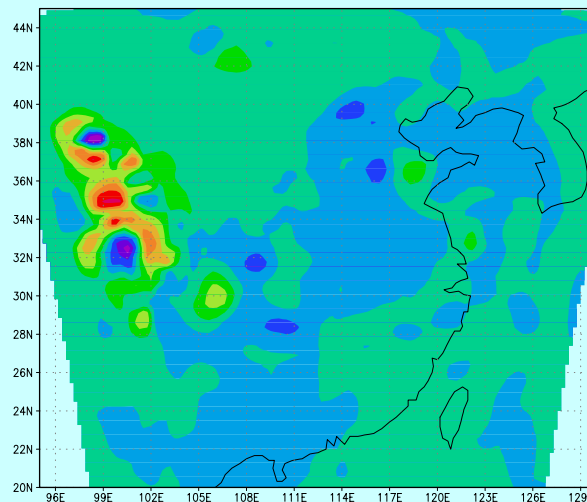
300
hpa

increment of specific
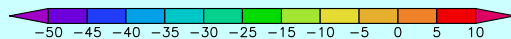humidity at the initial
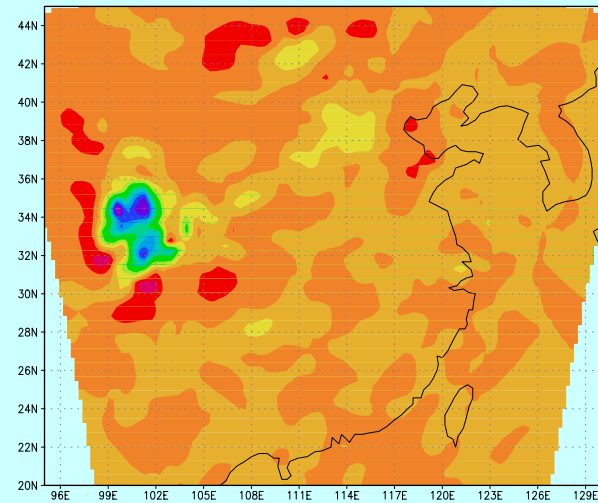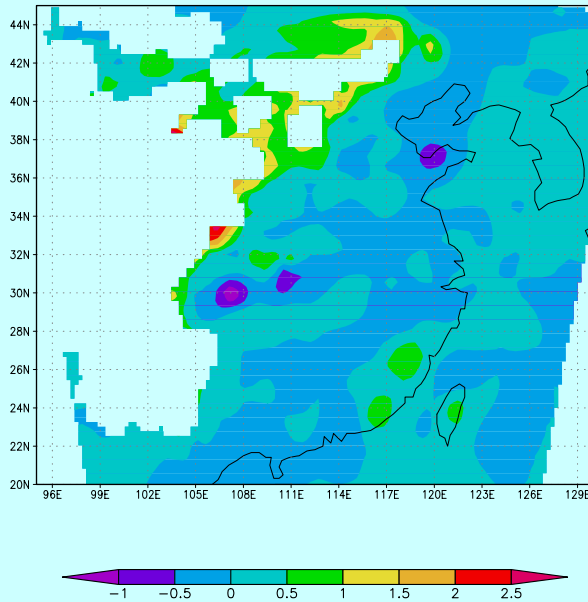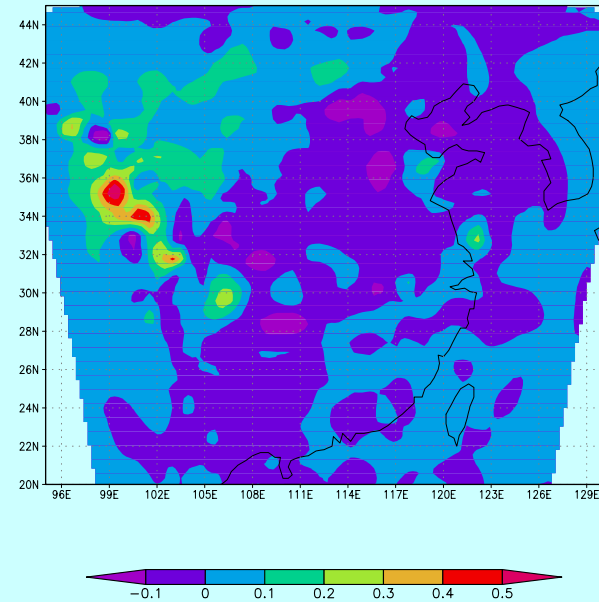time (test-control)

unit   g/kg

850 hpa

500 hpa

300 hpa

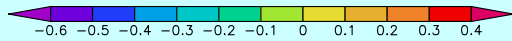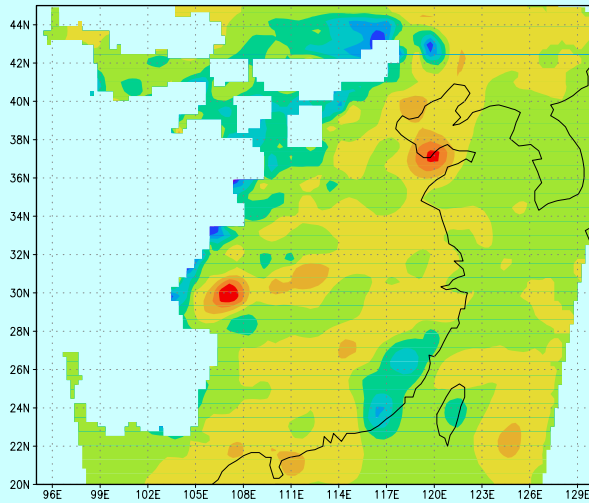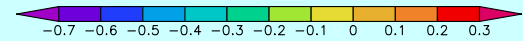Increment of relative humidity(test-control)
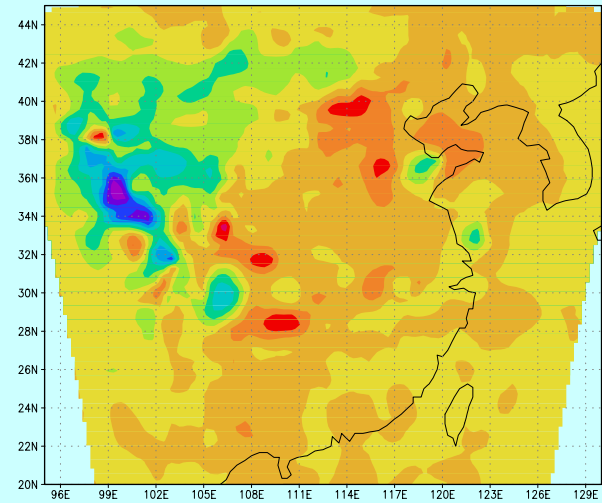
unit %

850
hpa

500
hpa

300
hpa
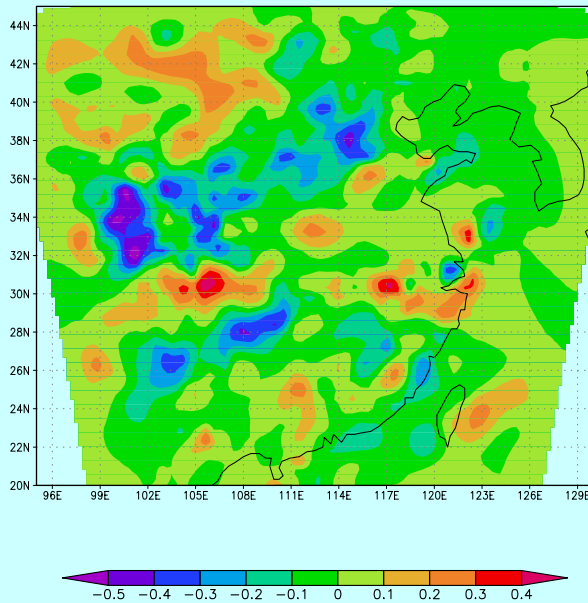
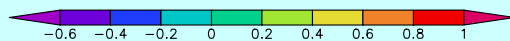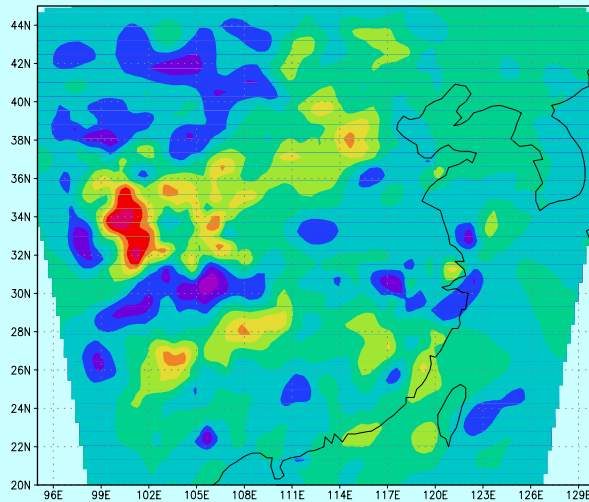Increment of
temperature
(test-control)

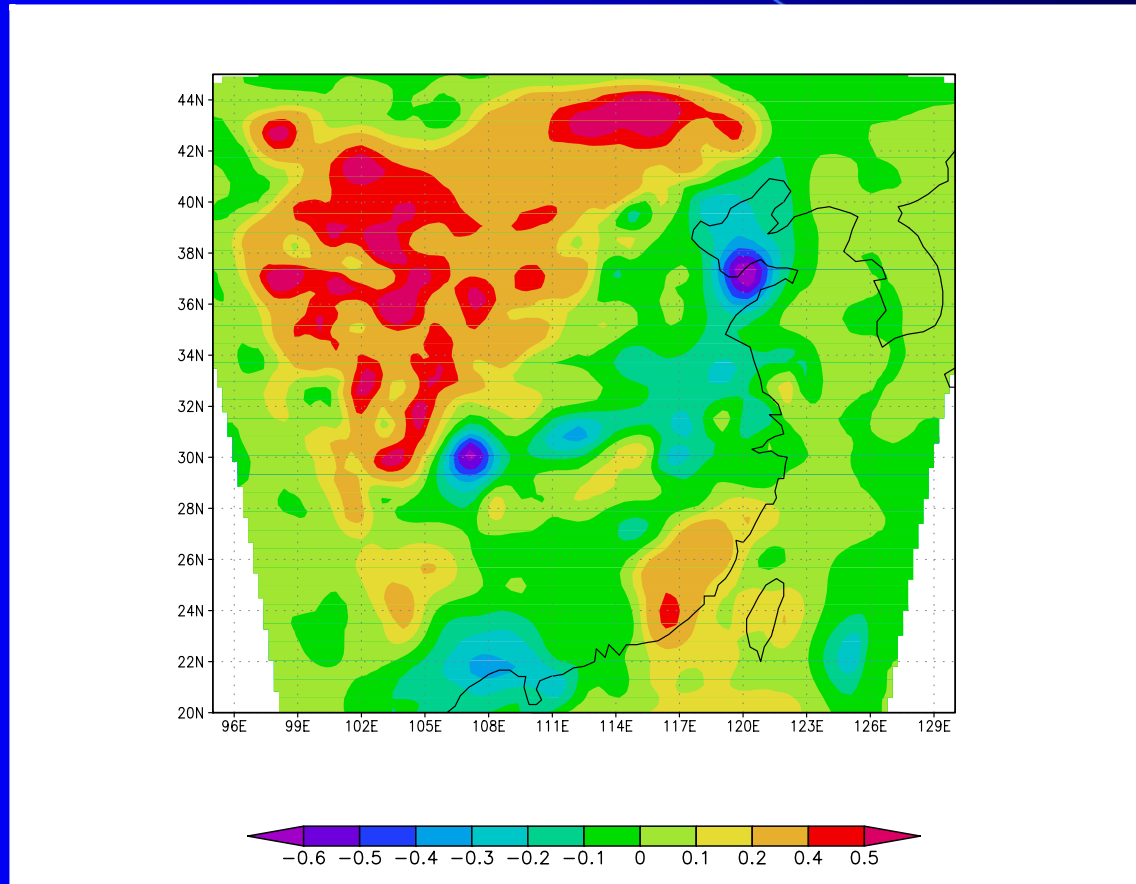unit   K

850
hpa

500
hpa

300
hpa

Increment of geopotential

Height(test-control)

unit   m

Increment of total precipitable water at the initial time
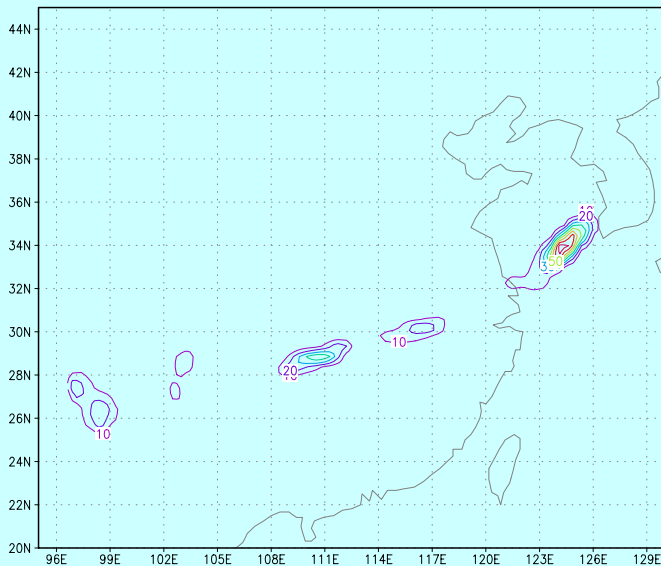

unit cm test-control

❖ <u>Comparison between including and excluding satellite data at the initial time</u>

❖ <u>Effects on precipitation forecast</u>
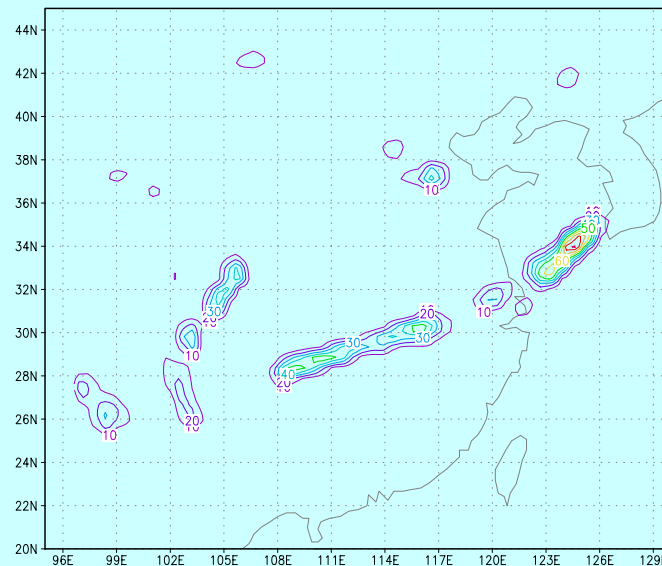
Effects on precipitation forecast

➢ Effects on 6-hour precipitation forecast

➢ Effects on 24-hour precipitation forecast

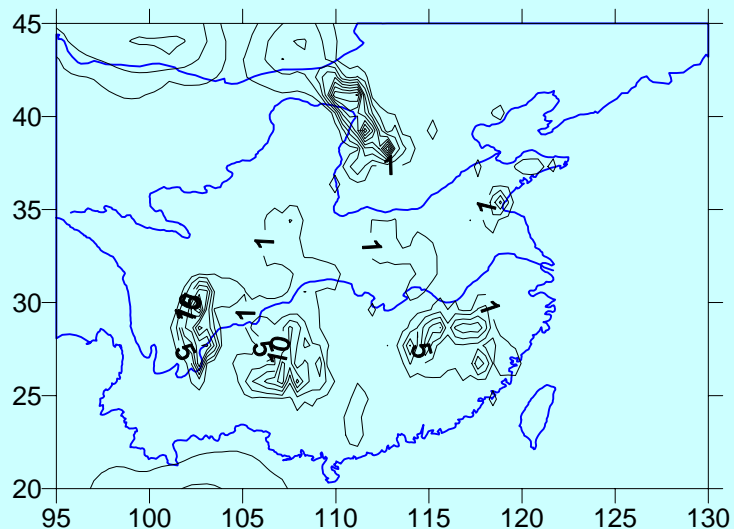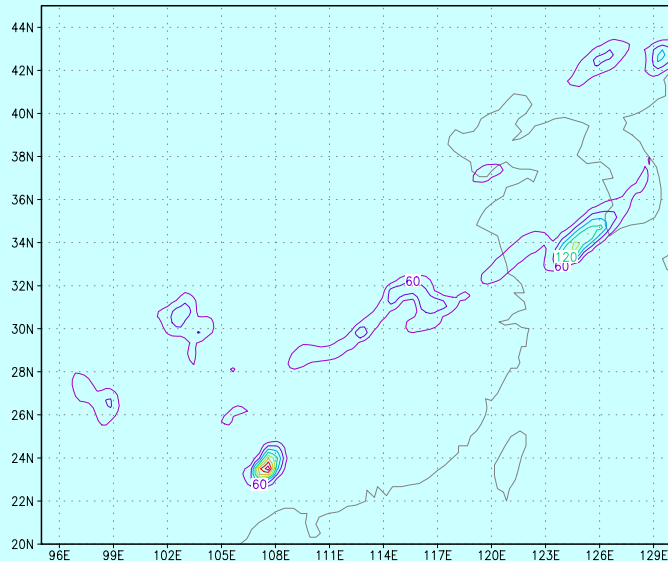# Effects on 6-hour precipitation forecast from t+00 to t+06

a

b

c

a.6-hour precipitation forecast without satellite data
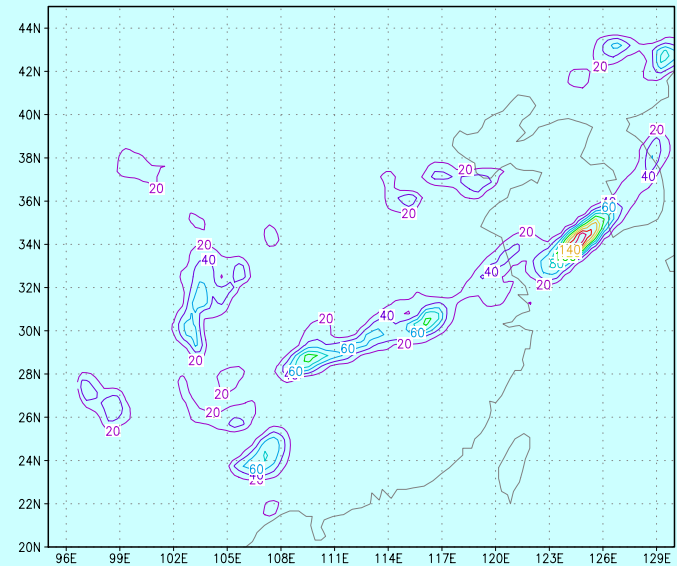
b.6-hour precipitation forecast with satellite data

c.observed 6-hour precipitation

unit   mm

Effects on 24-hour precipitation forecast:
from t+00 to t+24

a

b

c

a. 24-hour precipitation forecast without satellite data

b. 24-hour precipitation forecast with satellite data

c. observed 24-hour precipitation

unit   mm

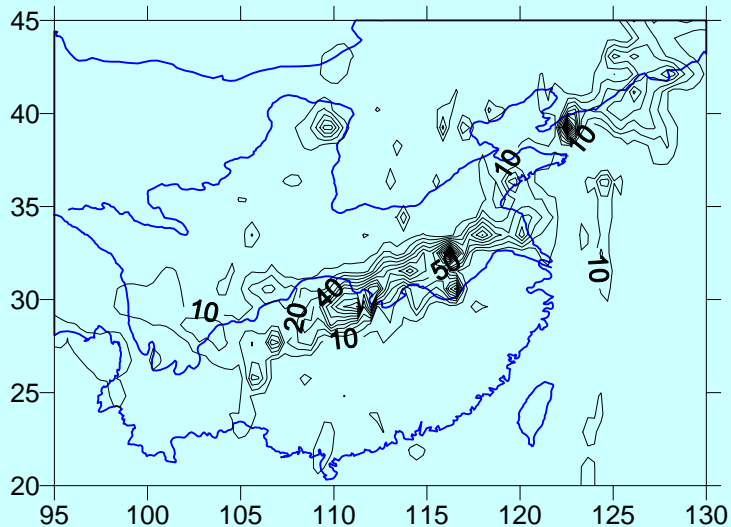# Effects on 24-hour precipitation forecast: from t+24 to t+48

a

b

c

a.24-hour precipitation forecast without satellite data
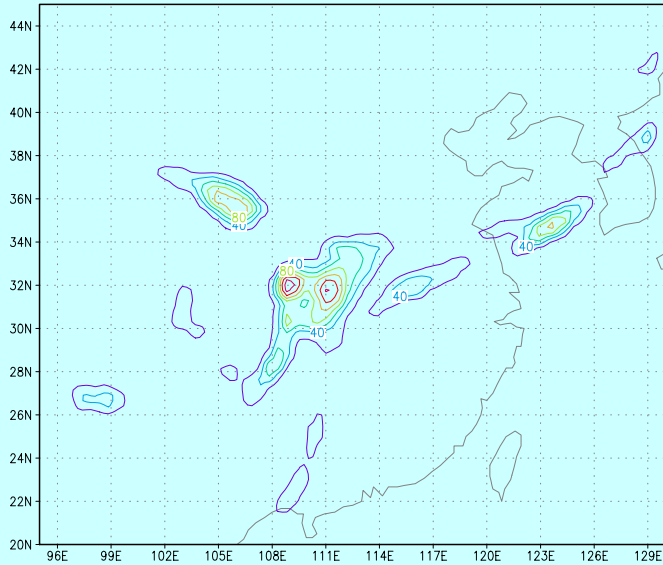
b.24-hour precipitation forecast with satellite data

c.observed 24-hour precipitation

unit   mm

Effects on 24-hour precipitation forecast: from t+48 to t+72

a

b

c

a.24-hour precipitation forecast without satellite data

b.24-hour precipitation forecast with satellite data
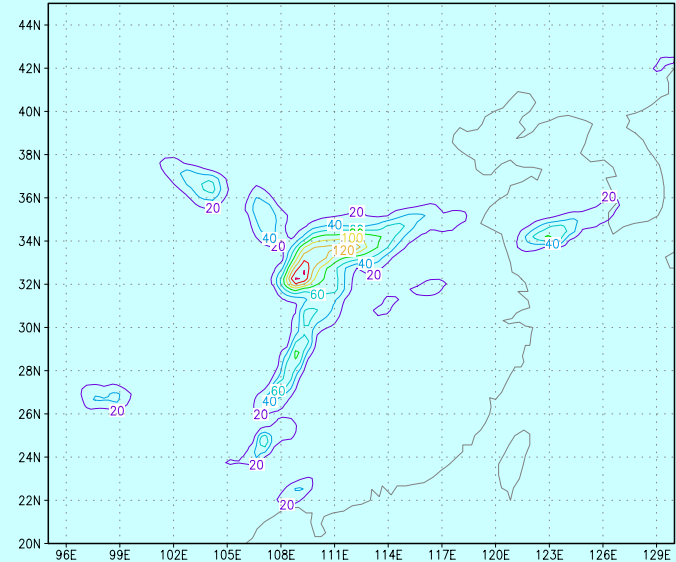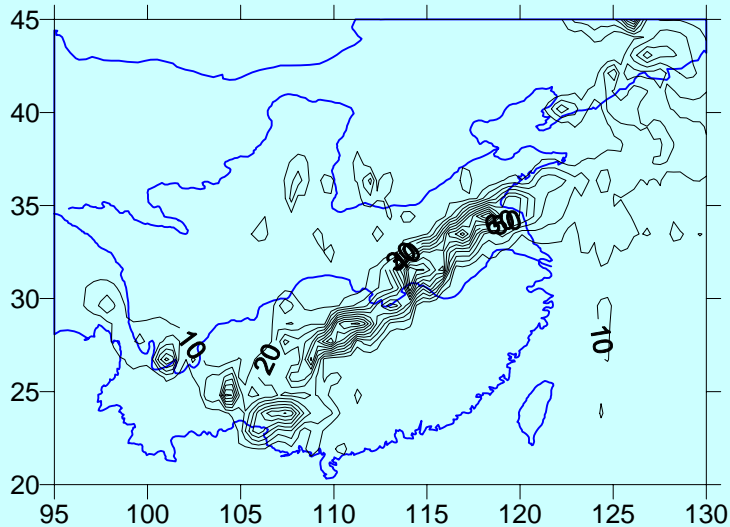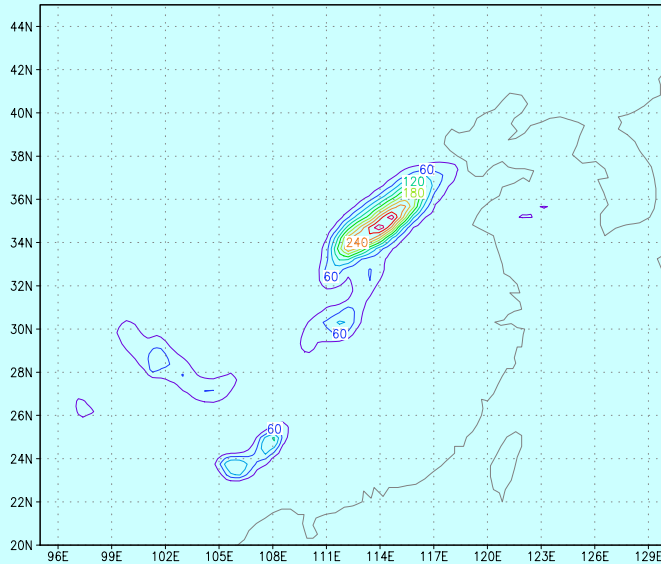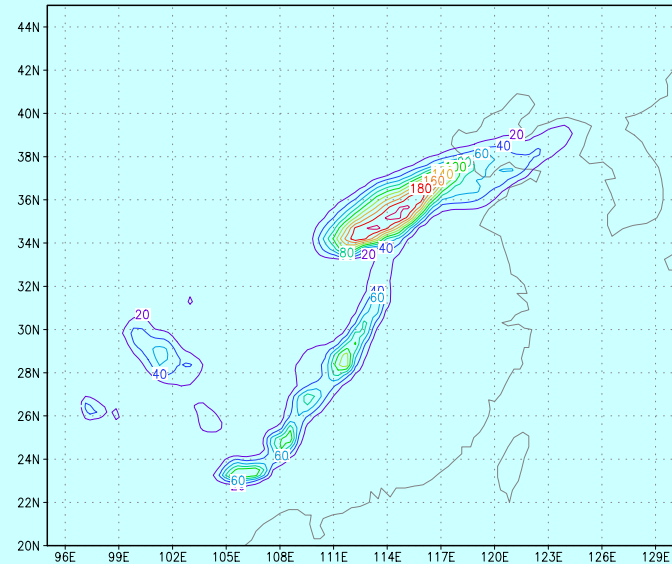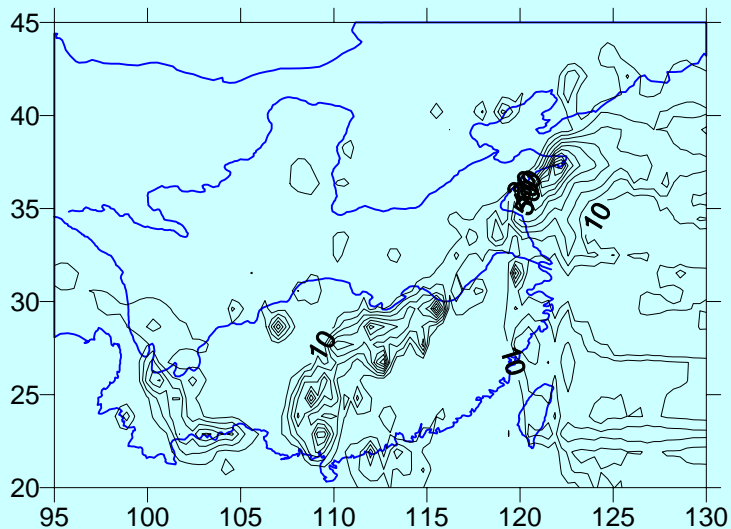
c.observed 24-hour precipitation

unit   mm

conclusion

❖ the initial humidity field was improved by assimilating the satellite retrieved total column water vapour, especially over the rainfall areas

❖ the initial temperature field and the geopotential height field were also improved after assimilating the satellite data

conclusion

❖ 6-hour precipitation forecast has been improved during the assimilation time-window after introducing satellite data into the modeling system

❖ 24-hour precipitation forecast also has been improved after assimilating satellite data into the modeling system more precipitation information can be obtained

Thank you !