Dust Storm Monitoring and Quantitative Prediction Experiment with NWP in Northeast Asian

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- Introduction
- Dust storm Monitoring System
- Numerical Prediction of Dust Storms
- Summary

Introduction

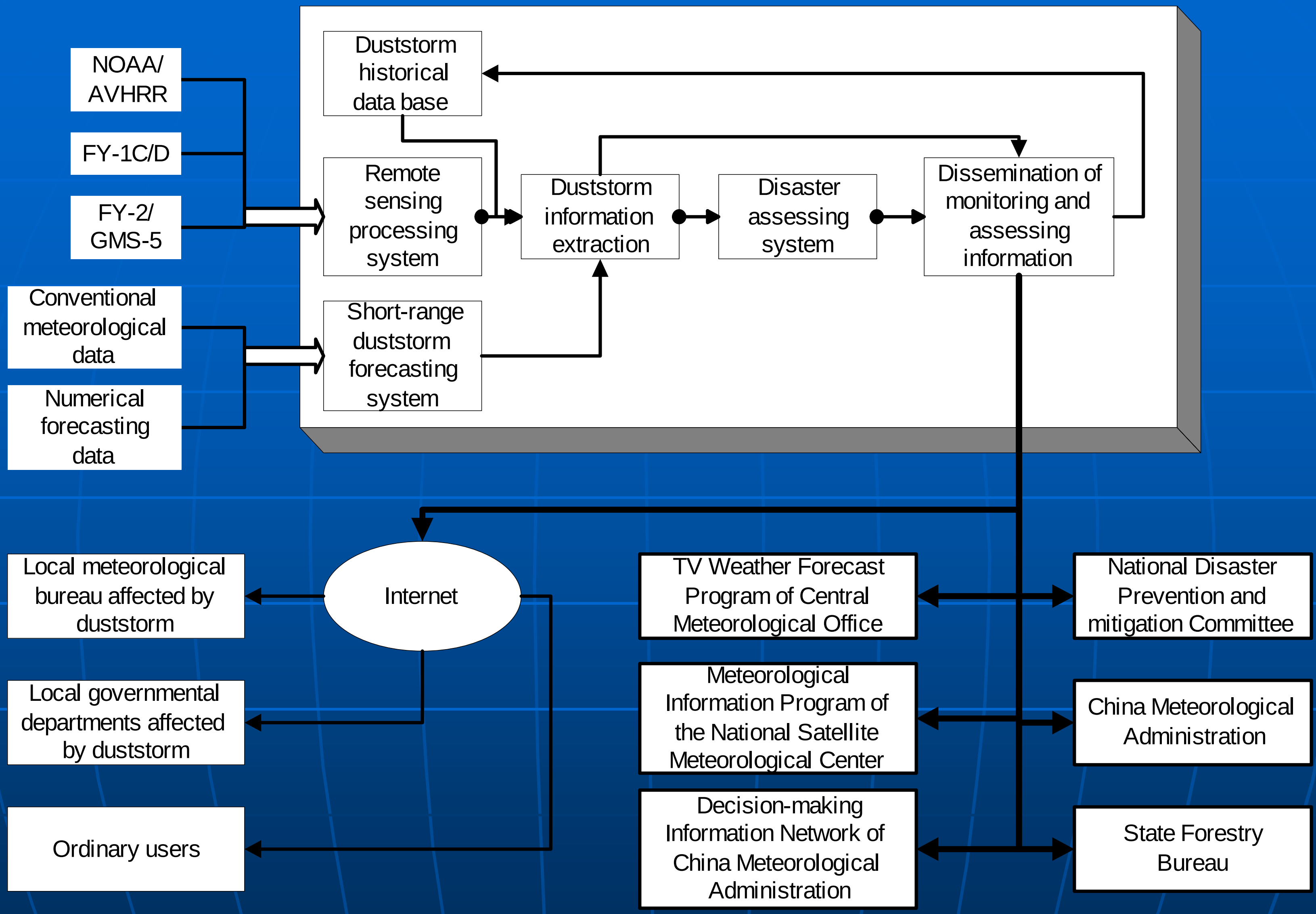
From spring to early summer, dust storms frequent occur in Northeast Asian and Northern China was serious, affected by it. The real time monitoring and prediction of dust storms therefore are highly desirable as a meteorological service to the public. Some results are given here.

Meteorological satellite features

- Wide coverage, about ten millions square kilometer area covered by polar satellite, and 1/3 surface of earth covered by geostationary satellite.
- High frequency, real time monitoring, fast detection of dust storm information from satellite data.
- Good continuity, dust storm images can be acquired hourly and daily.

Dust storm Monitoring System

- An operational dust storm monitoring system that uses meteorological satellite data was established in National Satellite Meteorological Center of China Meteorological Administration on March 1, 2001. It can continuously work day and night.
- By using this system, we can dynamically monitor dust storm, analyze <u>dust storm sources and transport paths, calculate dust storm influencing area and aerosol strength.</u>

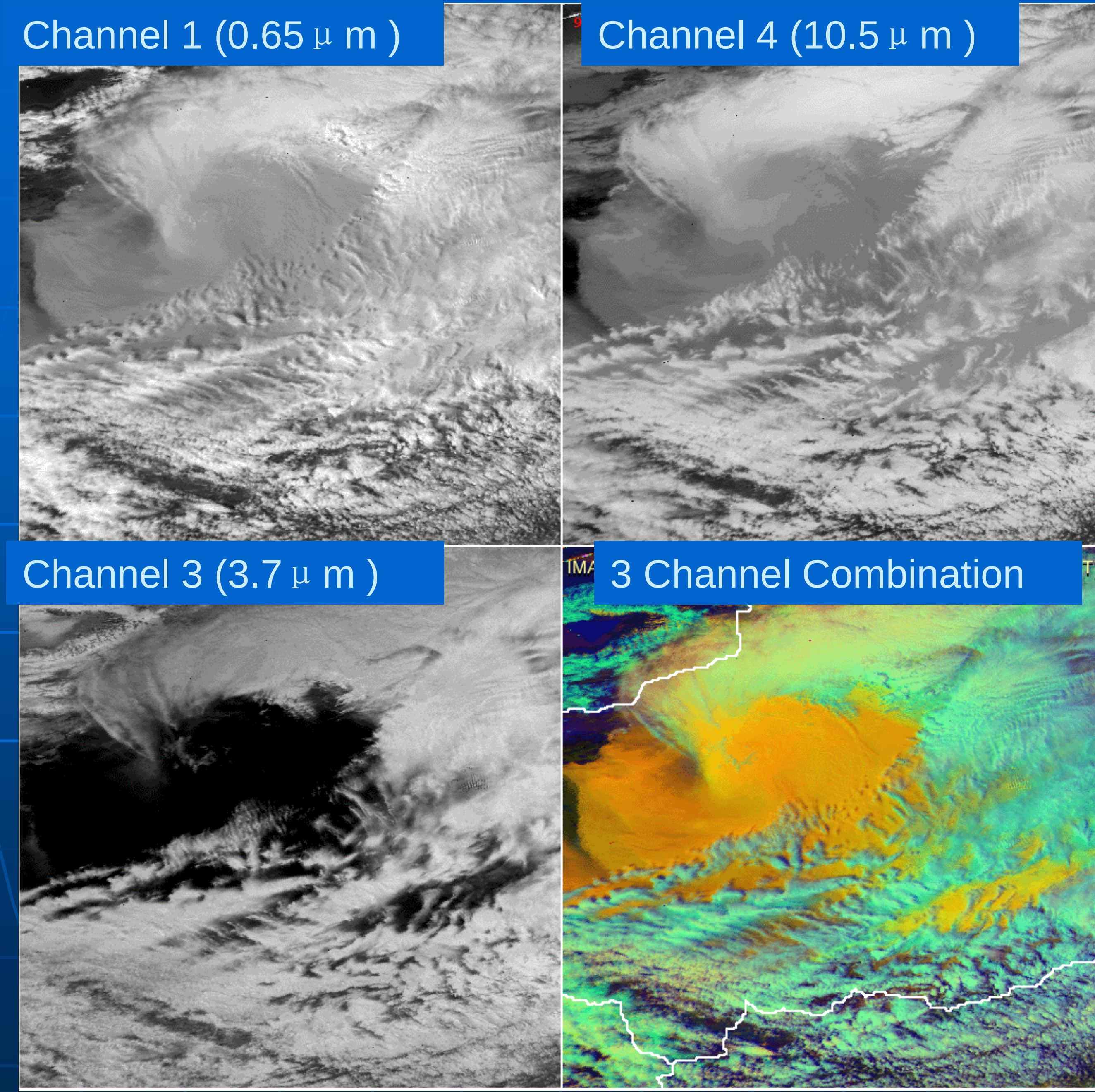


The overall design for the meteorological satellite dust storm monitoring system

Dust storm Monitoring

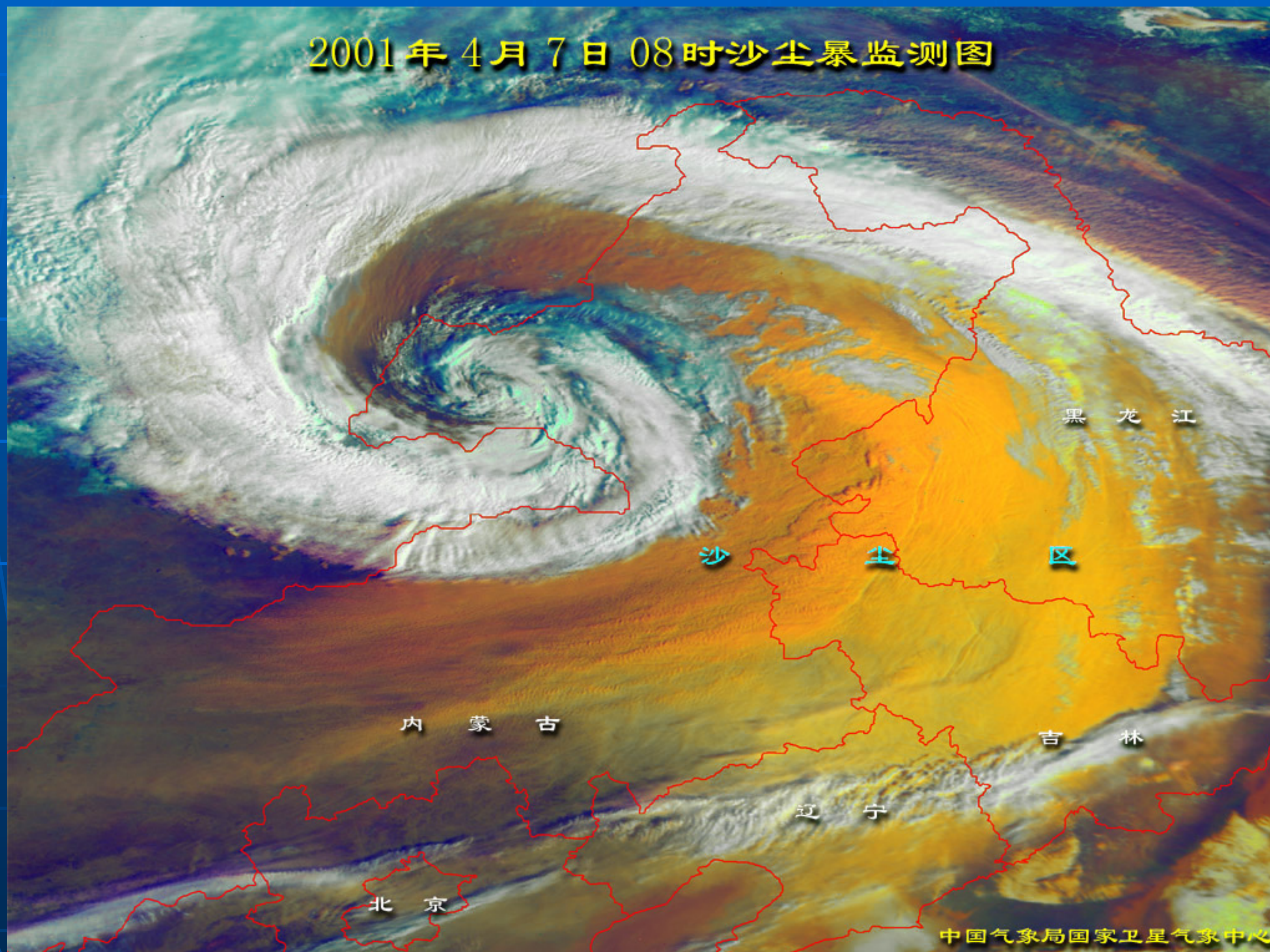
Making use of the radiation difference among spectrum channels of satellite data, it is possible to detect dust storm area, and monitor the source, path and diffusion of dust storm .

Spectral data: 0.65 μm, 3.7 μm, 10.5 μm, 11.5 μm


Channel 1 (0.65 μ m)
Channel 4 (10.5 μ m)
Channel 3 (3.7 μ m)
3 Channel Combination

Severe Dust storm

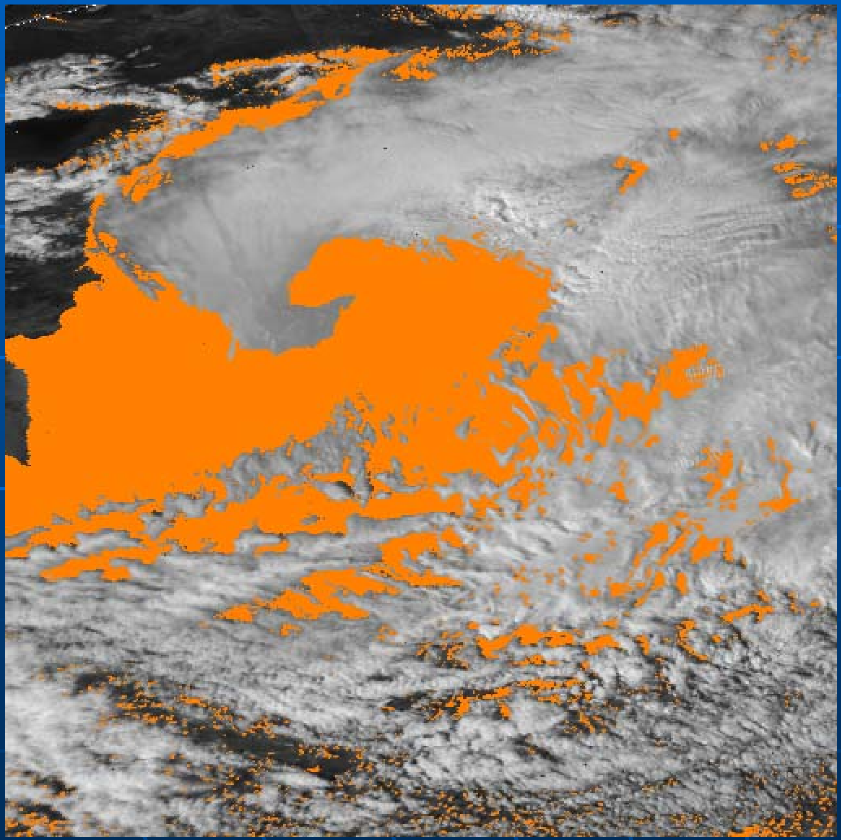
April 7, 2001 at 00z (0.4Mkm^2)

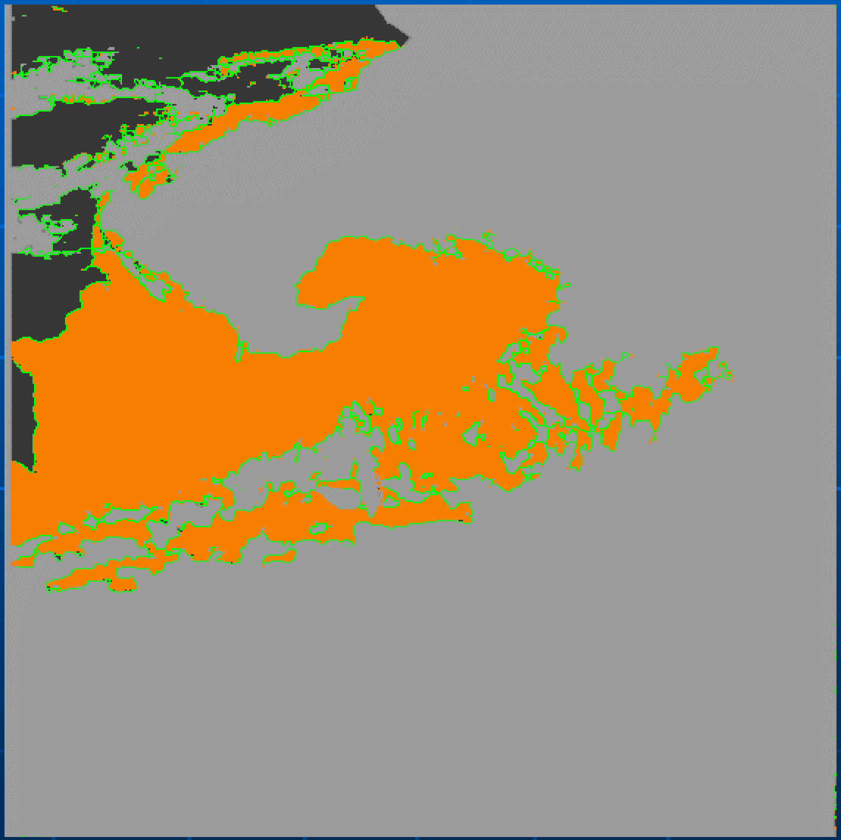


Dust storm detecting result

Red area is the dust storm influence area.

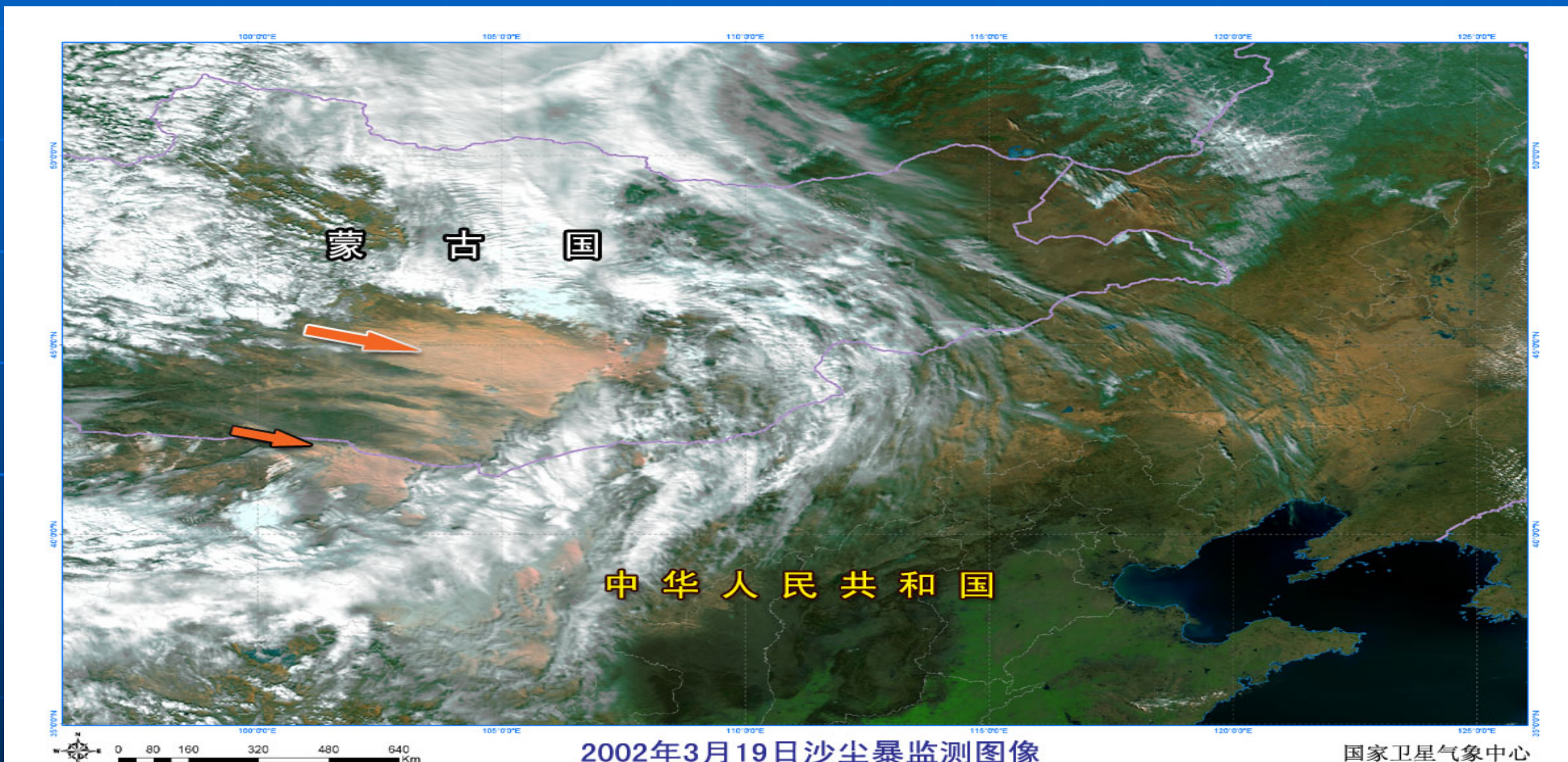
Green line is the boundary of the dust storm influence area.





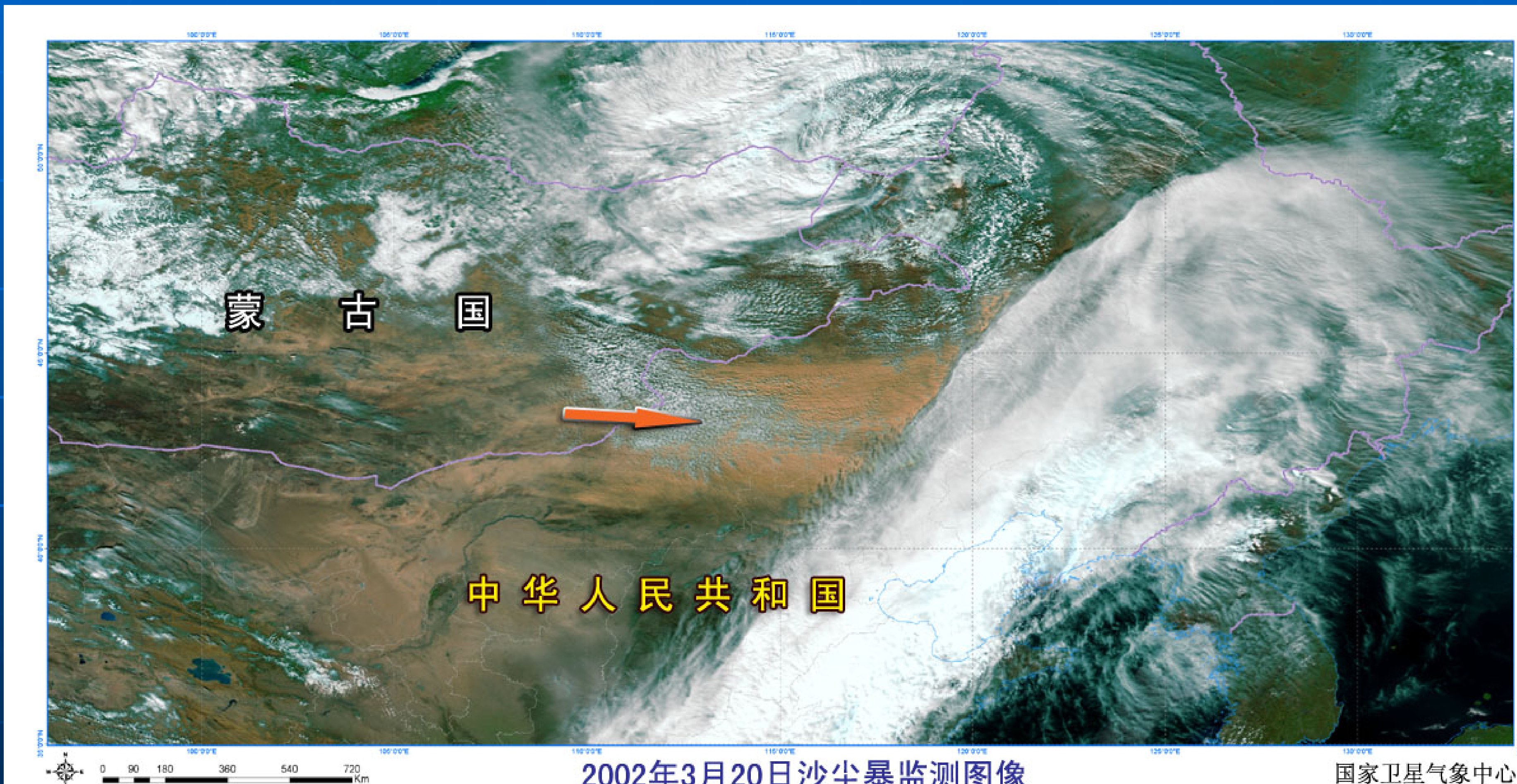
Typical Example:

The severe dust storm observed by FY-1C on March 19, 2002



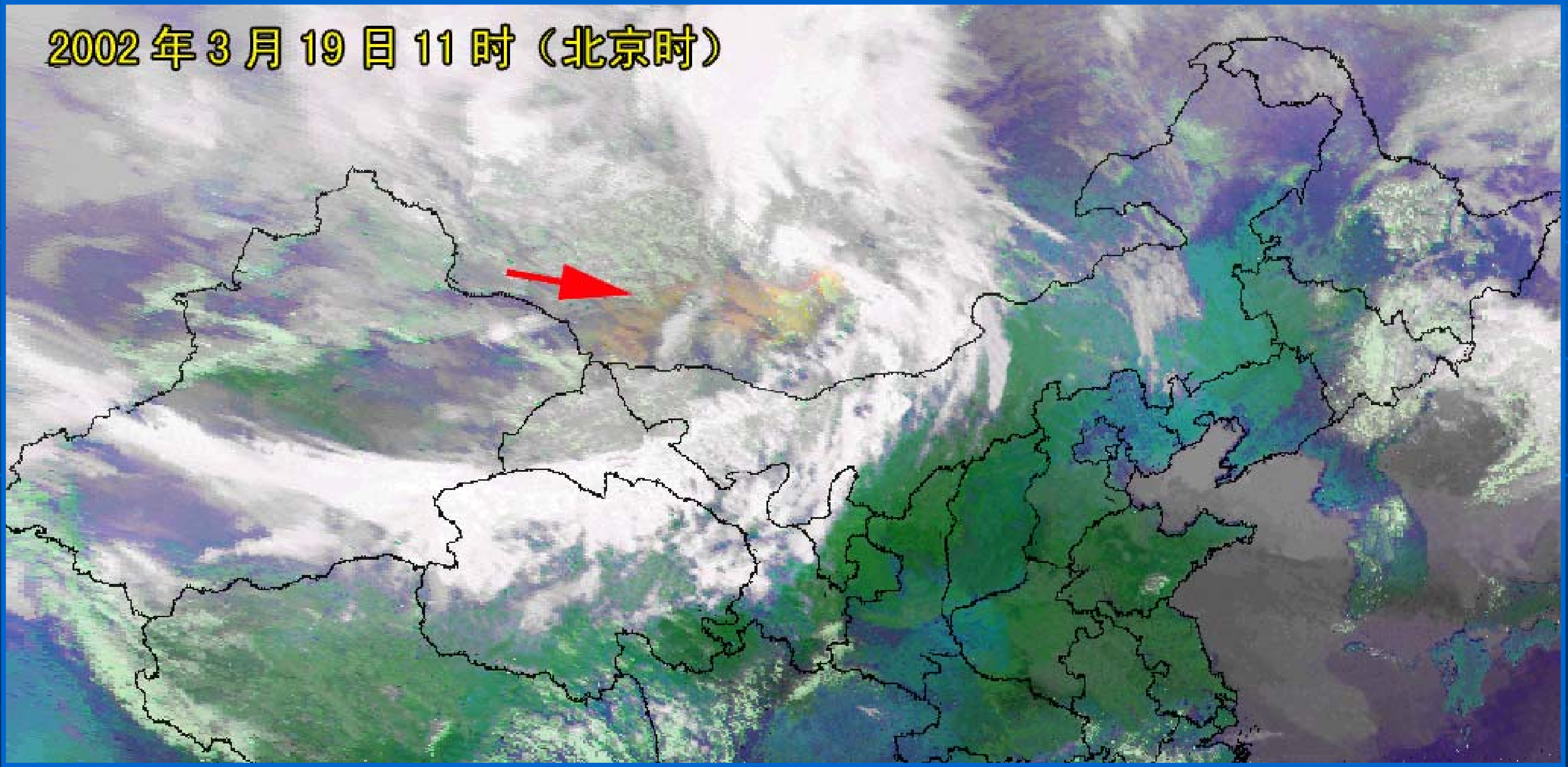
Typical Example:

The severe dust storm observed by FY-1C on March 20, 2002



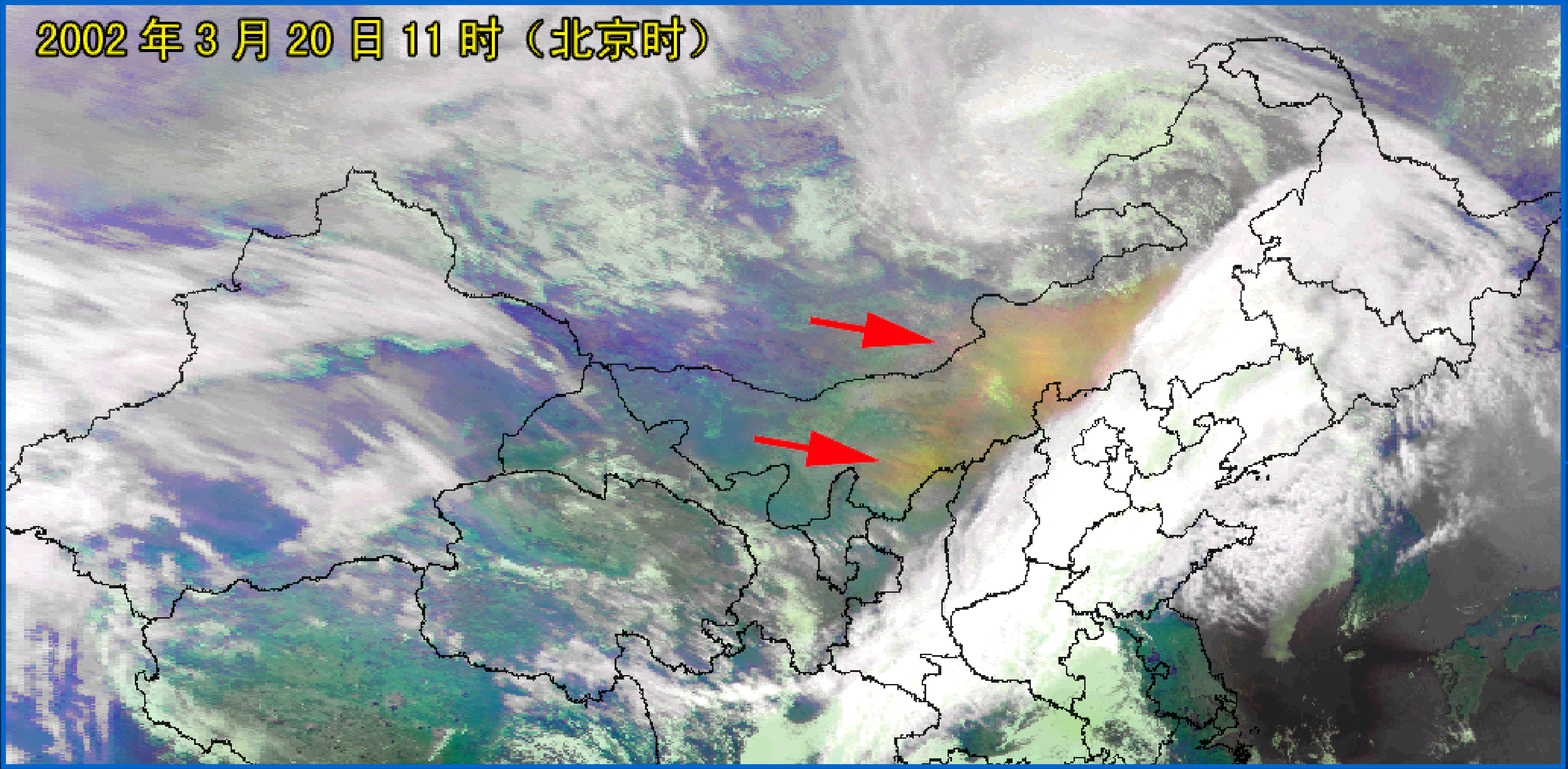
Typical Example:

The animation of dust storm by GMS data on March 19, 2002



Typical Example:

The animation of dust storm by GMS data on March 20, 2002



Physical parameter computation

- Some kinds of ground surface parameters can be derived by using remote sensing data, such as NDVI,DDI (Dust storm detecting index), Snow cover, Land cover, Drought, Land surface temperature and so on.
- By inputting these ground surface parameters into numerical weather prediction model, it have proved that better forecast result can be obtained.

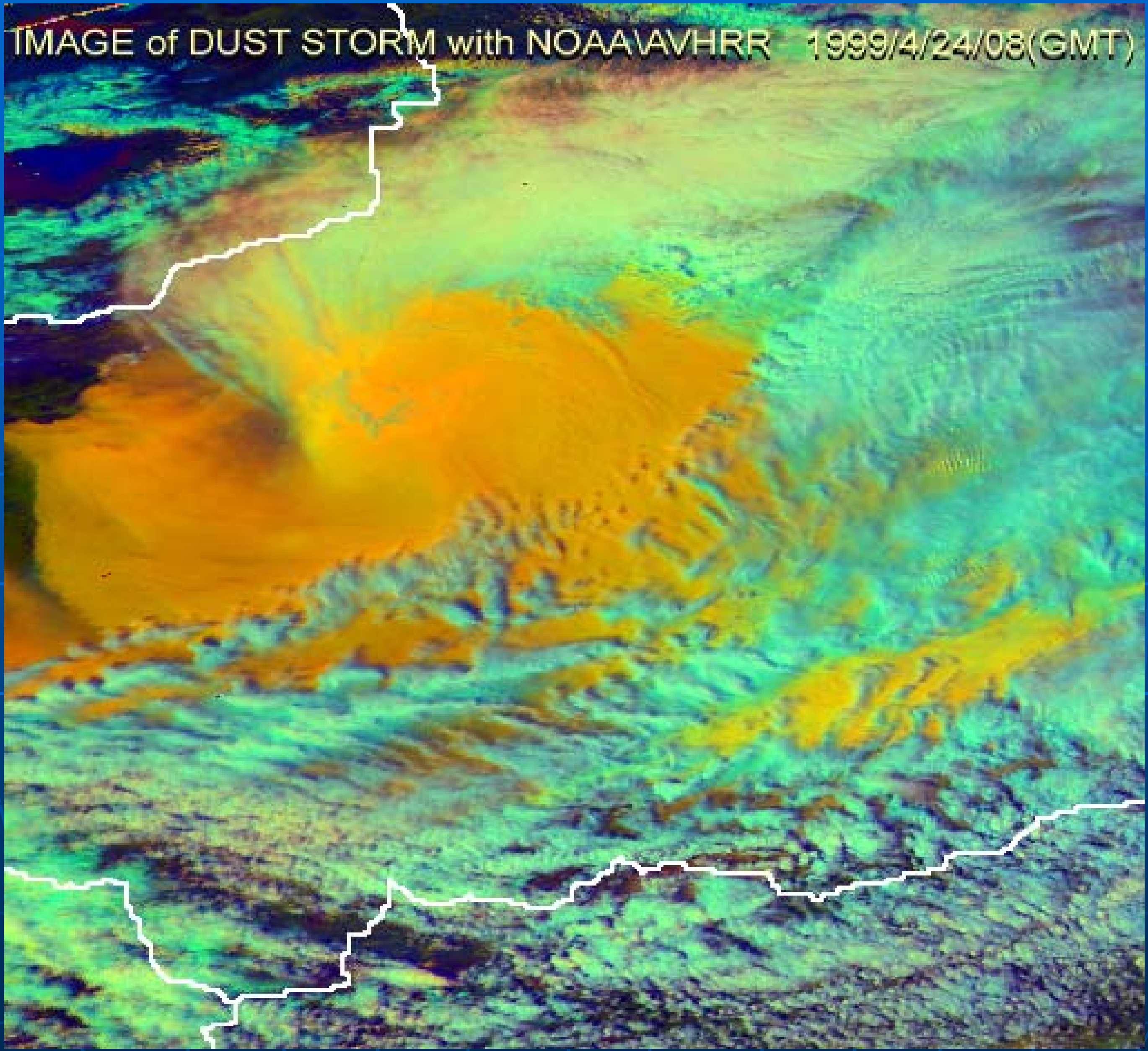
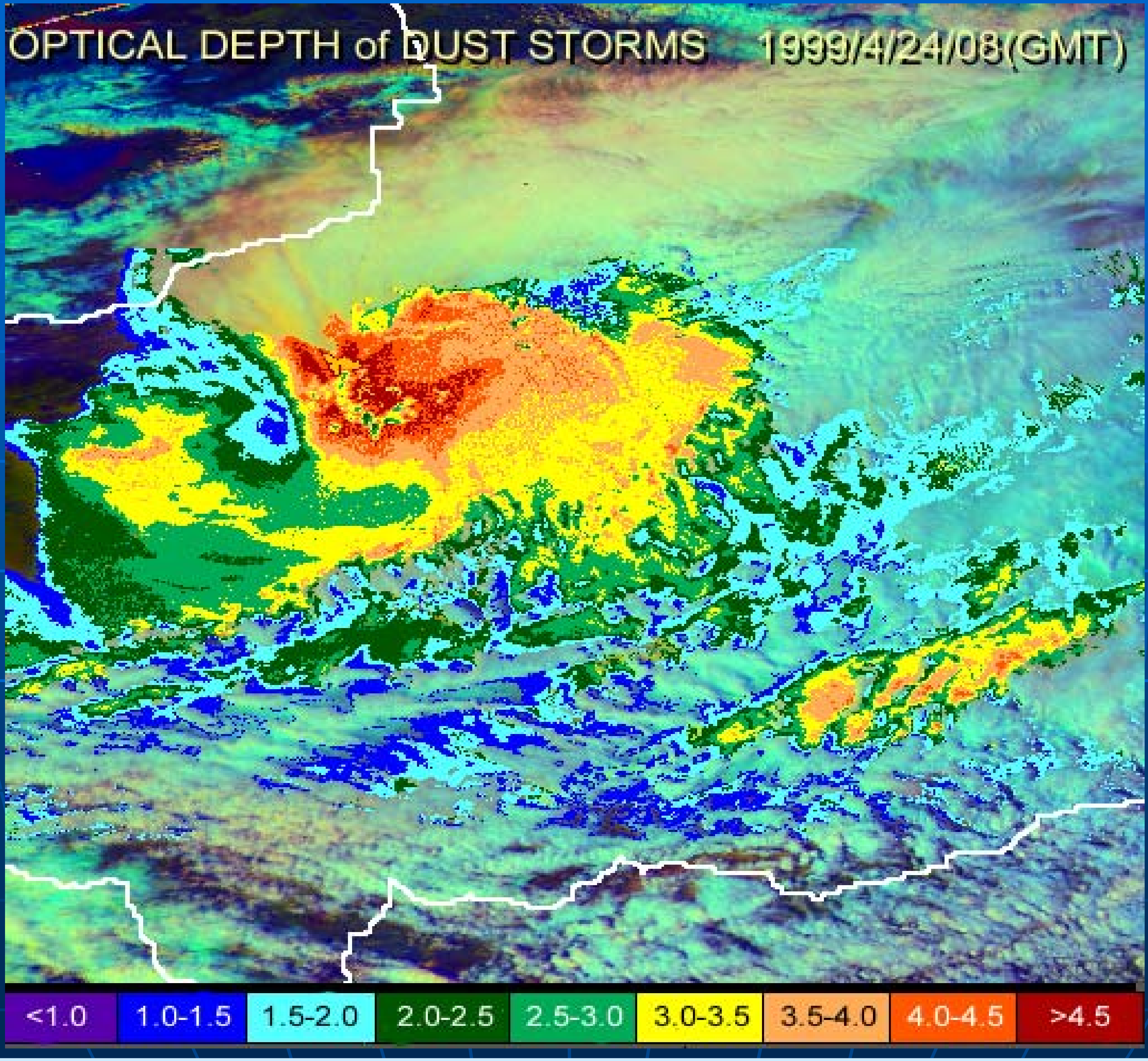
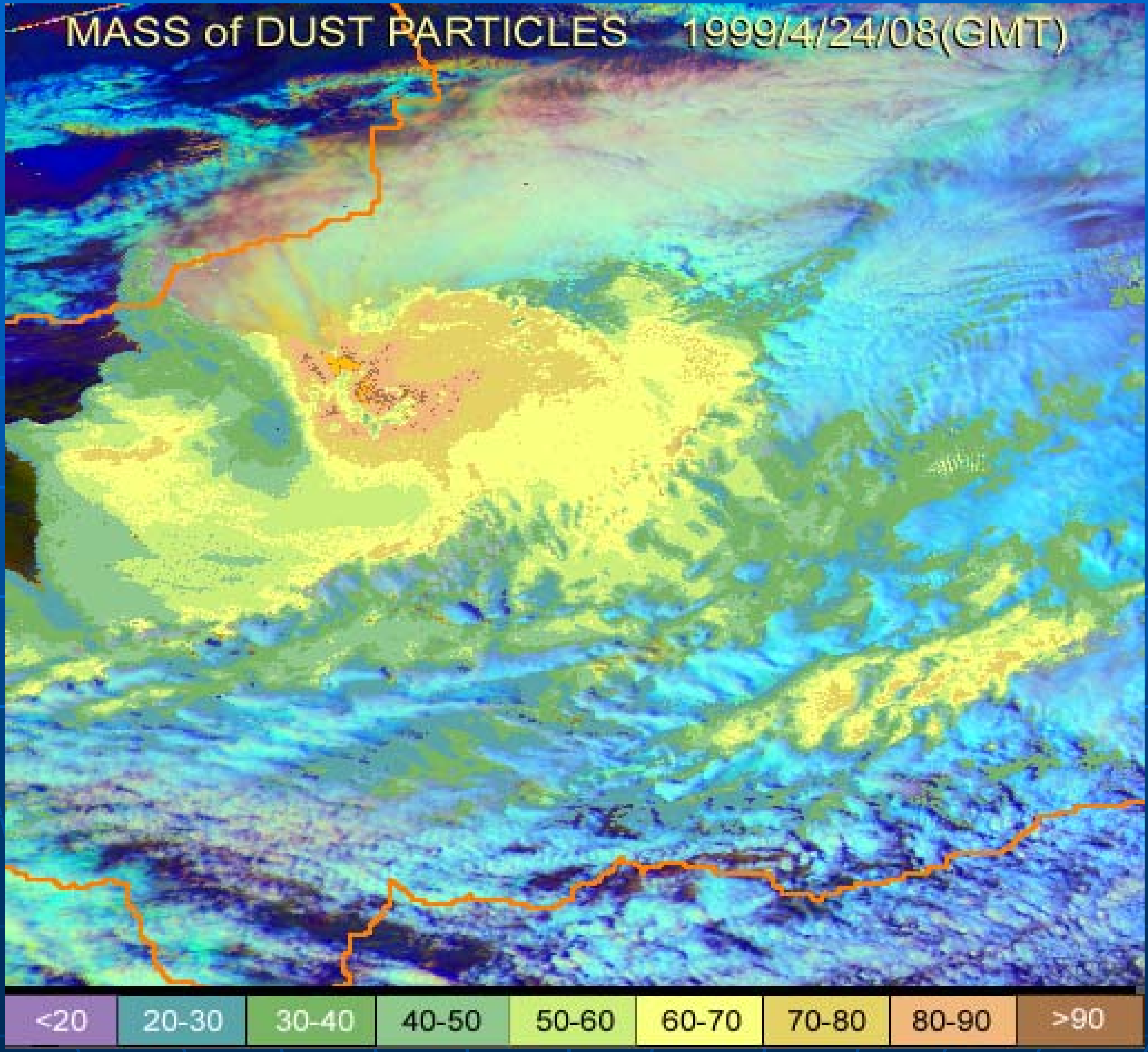
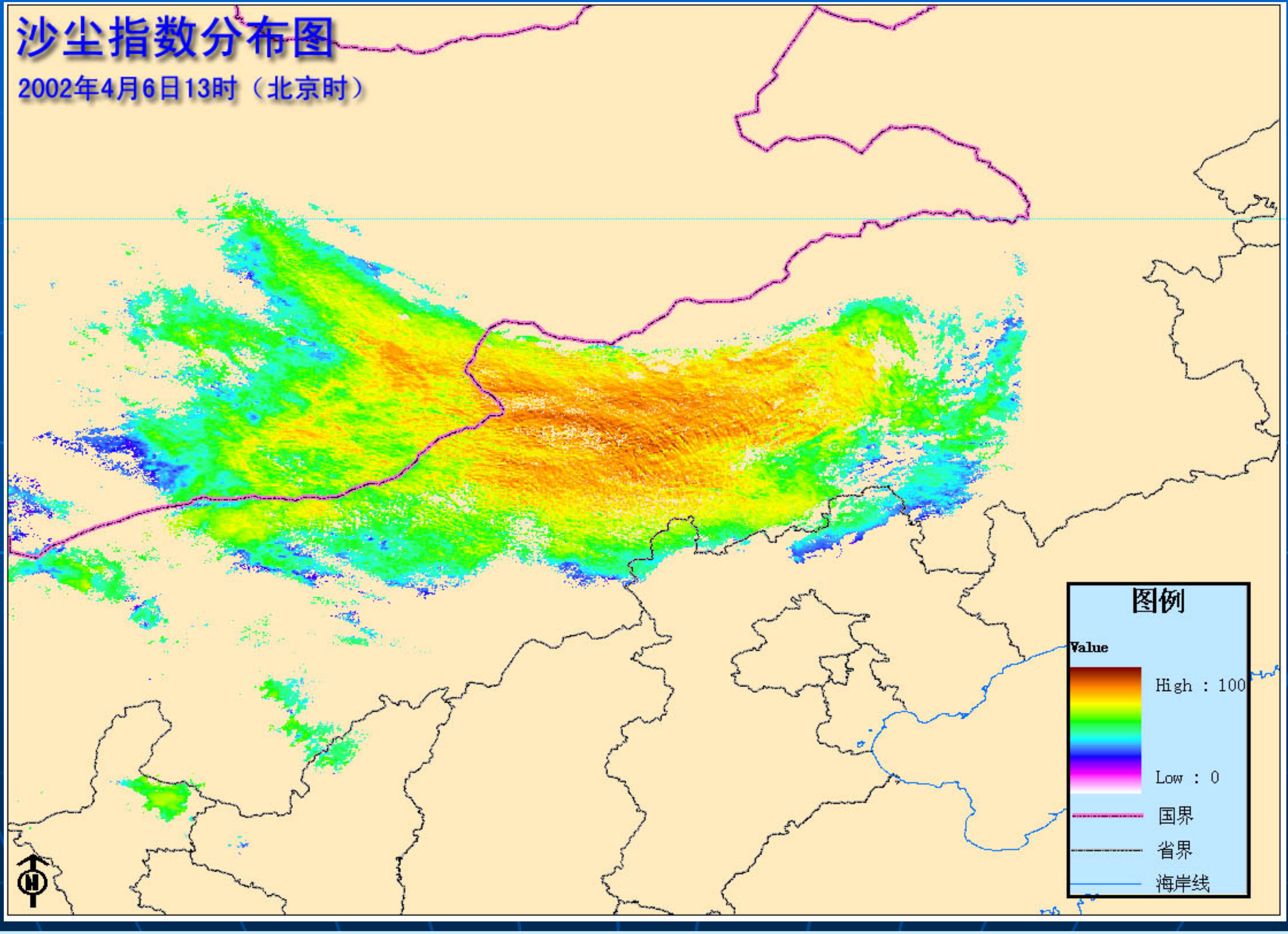


IMAGE of DUST STORM with NOAA\AVHRR 1999/4/24/08(GMT)

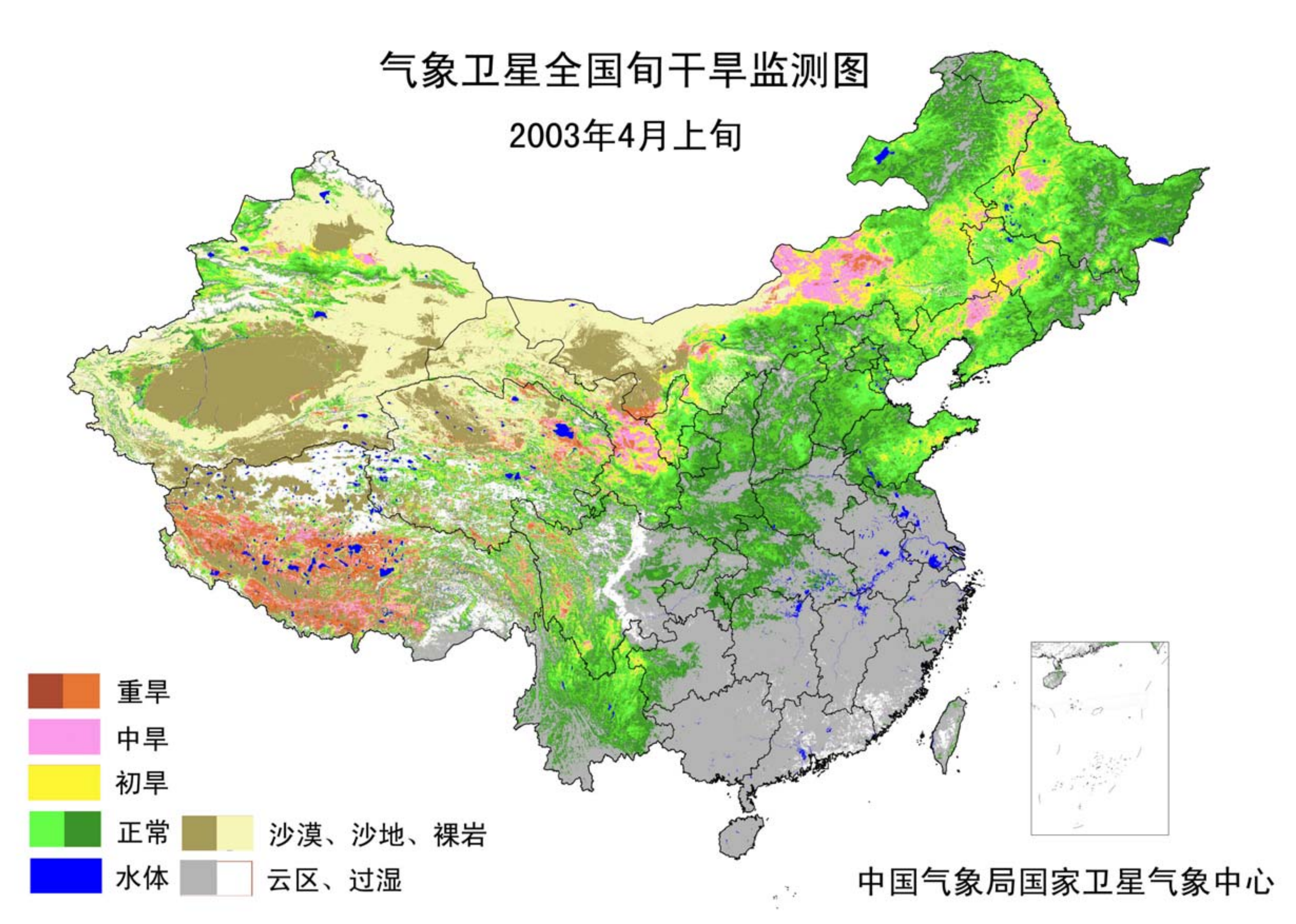

OPTICAL DEPTH of DUST STORMS
1999/4/24/08(GMT)
<1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
4.0-4.5
>4.5


MASS of DUST PARTICLES 1999/4/24/08(GMT)
<20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
>90

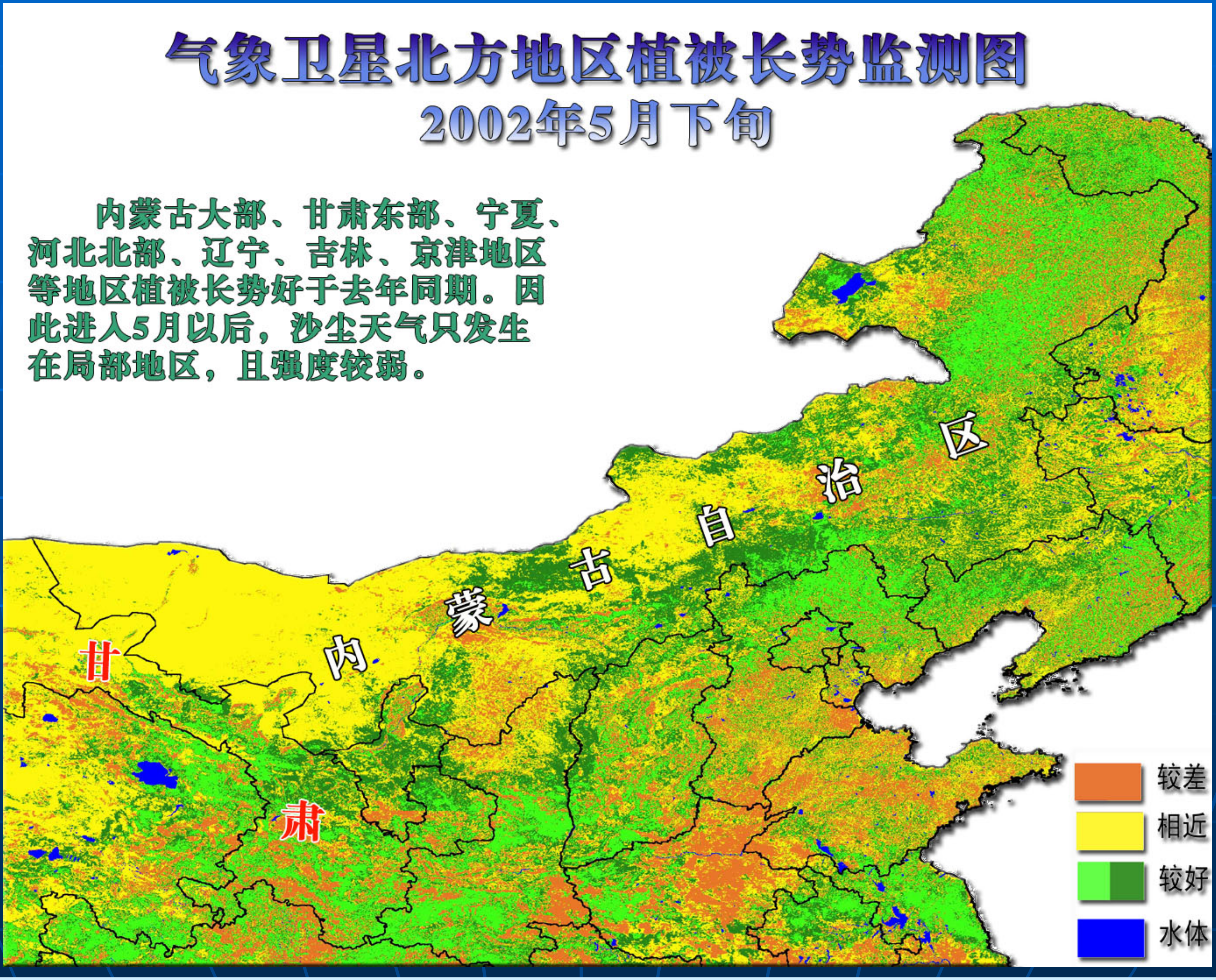
DDI (Dust storm detecting index)



Drought monitoring

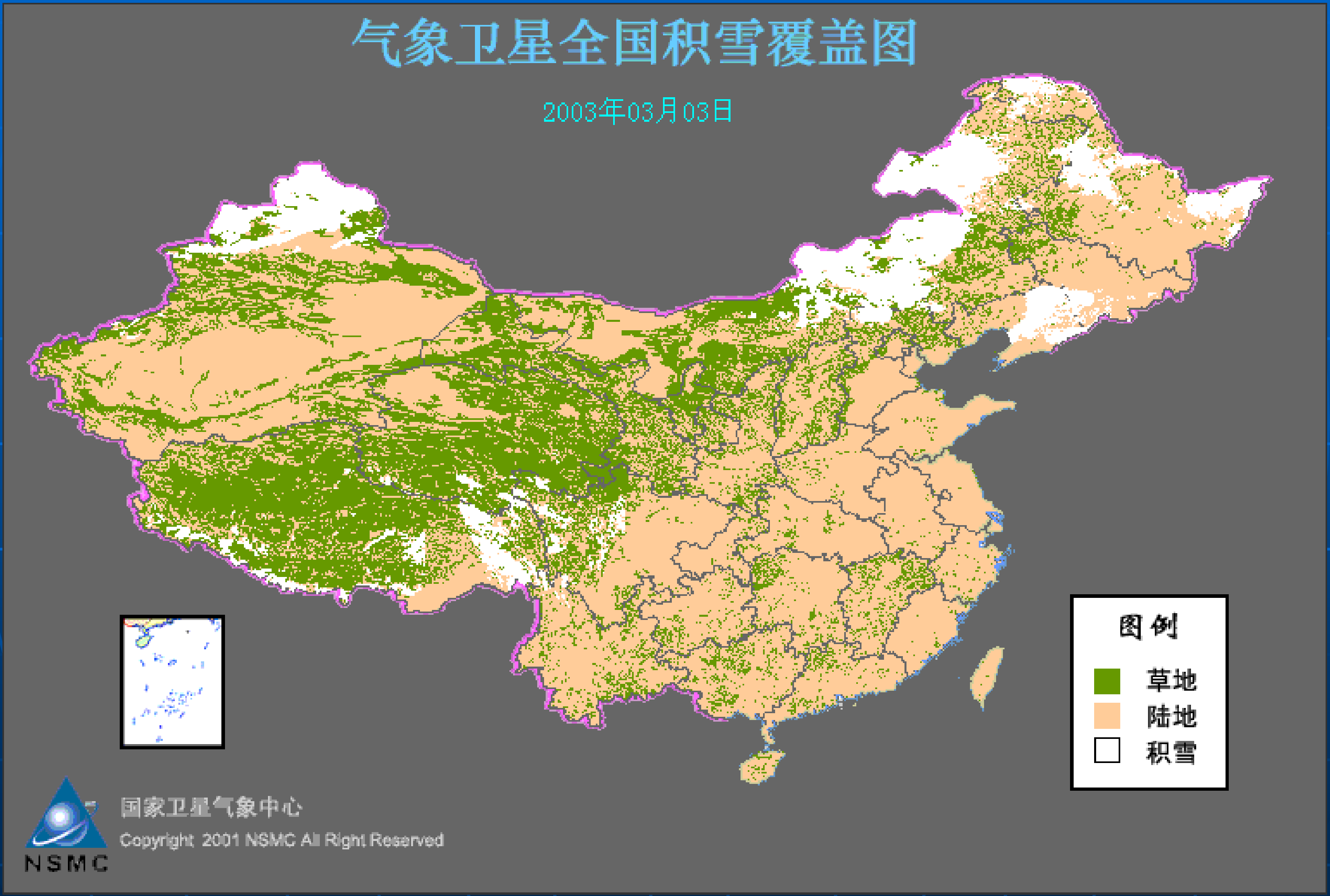


NDVI



气象卫星北方地区植被长势监测图
2002年5月下旬
内蒙古大部、甘肃东部、宁夏、河北北部、辽宁、吉林、京津地区等地区植被长势好于去年同期。因此进入5月以后，沙尘天气只发生在局部地区，且强度较弱。
内蒙古自治区
甘肃
较差
相近
较好
水体

Snow cover



气象卫星全国积雪覆盖图
2003年03月03日
图例
草地
陆地
积雪
国家卫星气象中心
Copyright 2001 NSMC All Right Reserved
NSMC

Dust storm Assessing System

- Using GIS technique , we have developed a dust storm disaster assessing mode, and established a real-time dust storm assessing system.
- Based on this system, we can analyze the ground status, area and population affected by dust storm, and then estimate the economic loss.

product of dust storm assessment

April 6, 2000

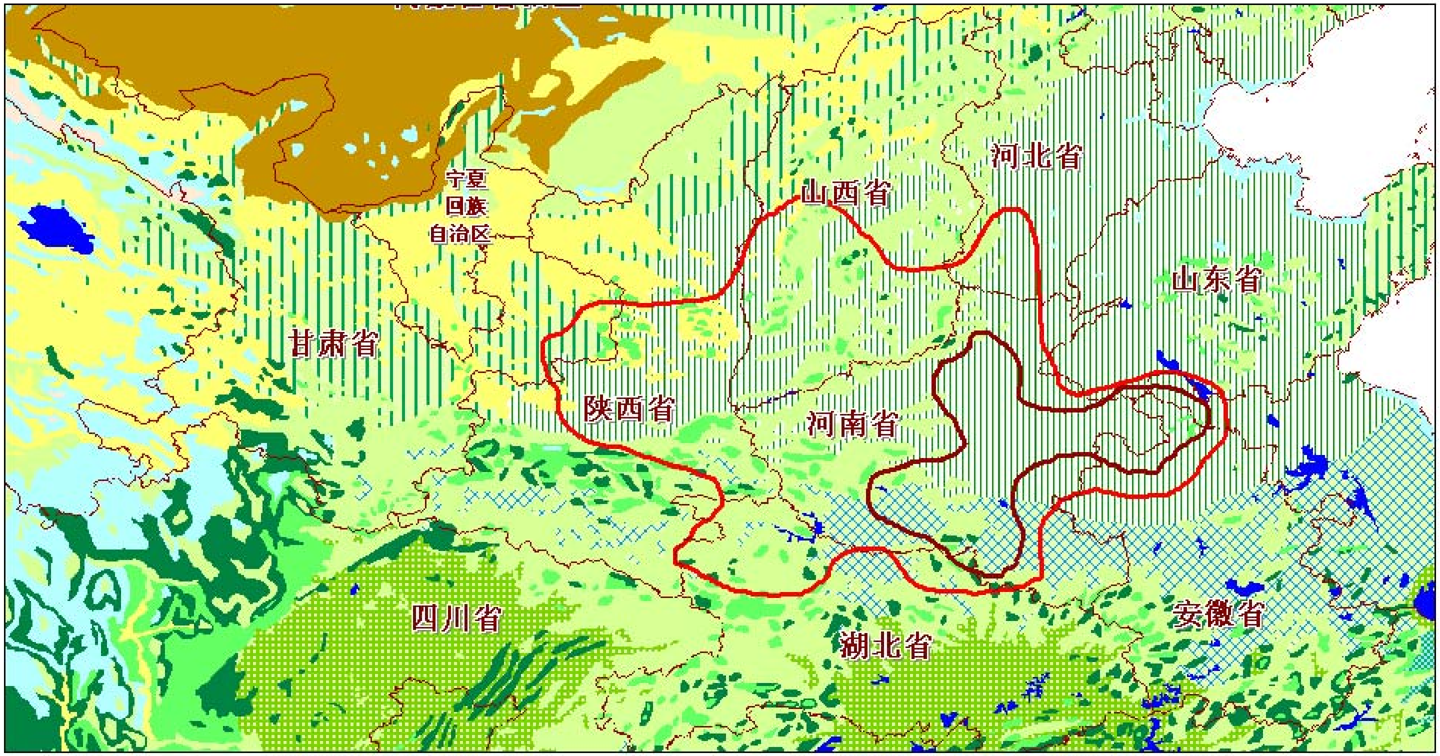
Background: The Vegetation Classification of China

Red Line: The boundary of the dust storm influence area.

Brown Line: The boundary of the severe dust storm influence area.

Product of dust storm assessment

March 14, 2001



Background: The Vegetation Classification of China

Red Line: The boundary of the dust storm influence area.

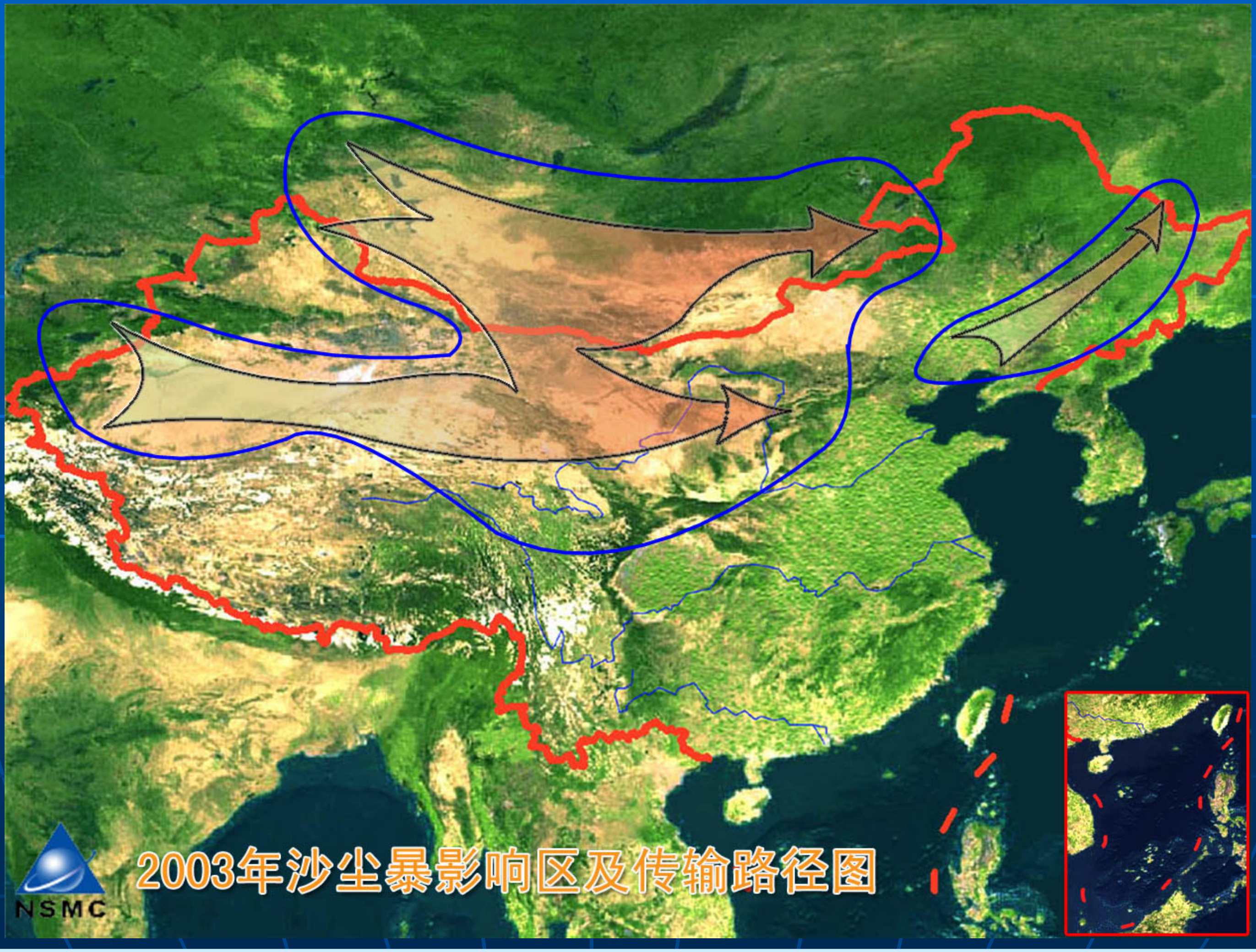
Brown Line: The boundary of the severe dust storm influence area.

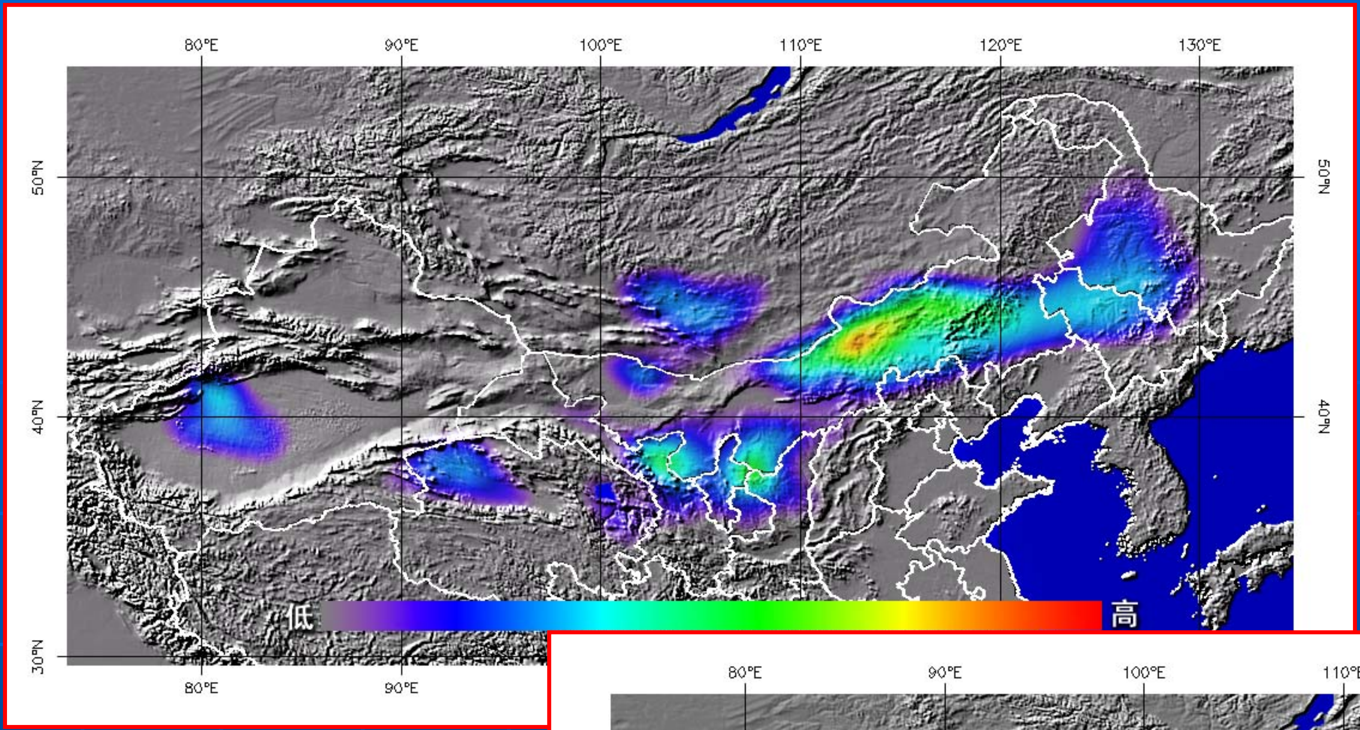
Dust storm path （2002）

This image shows the 3 paths affecting Beijing in 2002 .

Dust storm path: （2003）

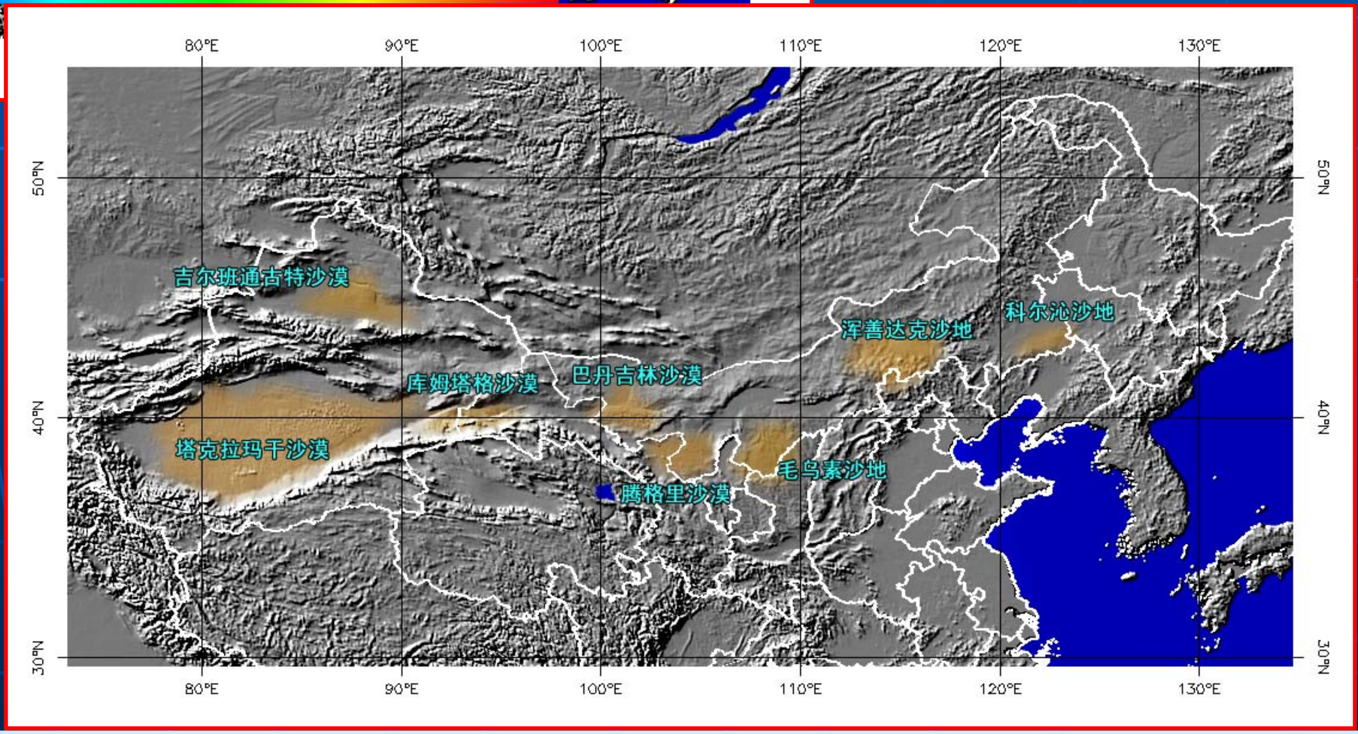
Based on every year data , We can analyze dust storm transferring paths in China. This image shows the results in 2003.

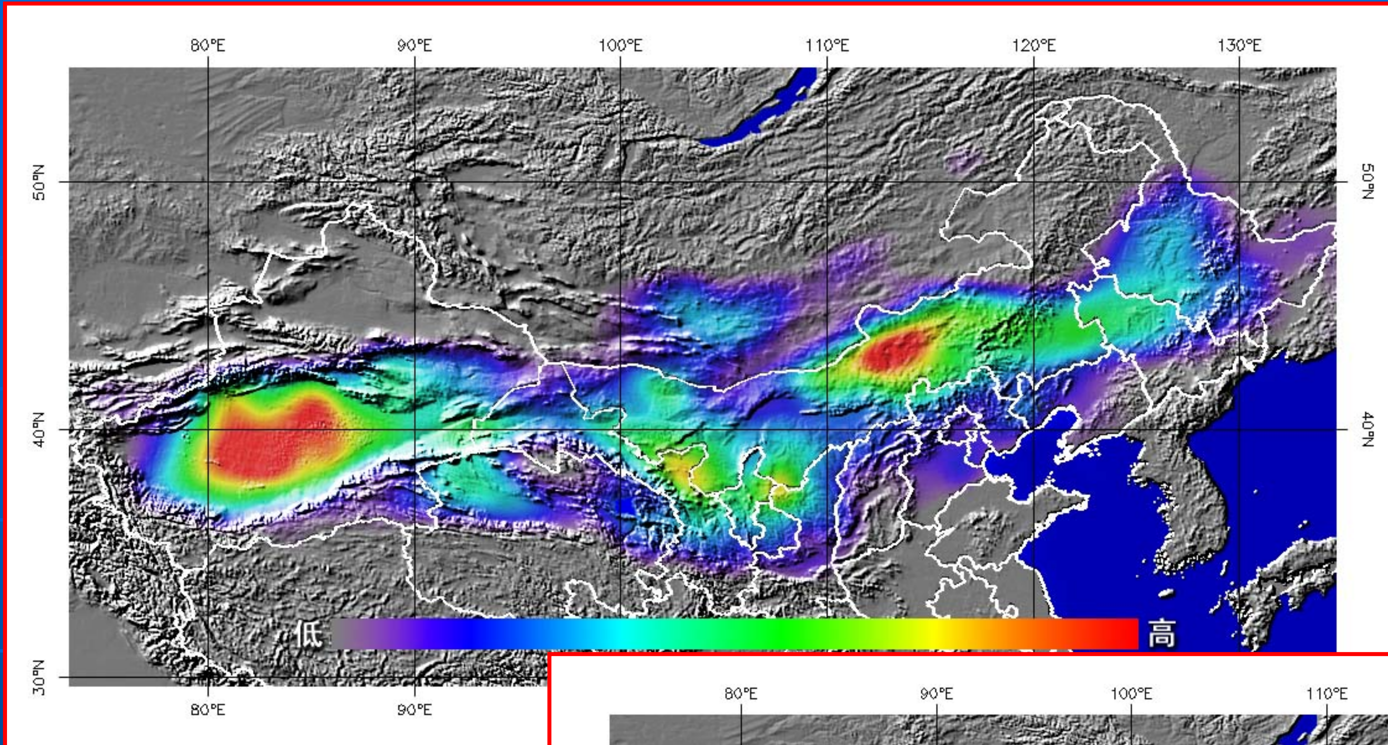




Dust Sources in 2001 spring

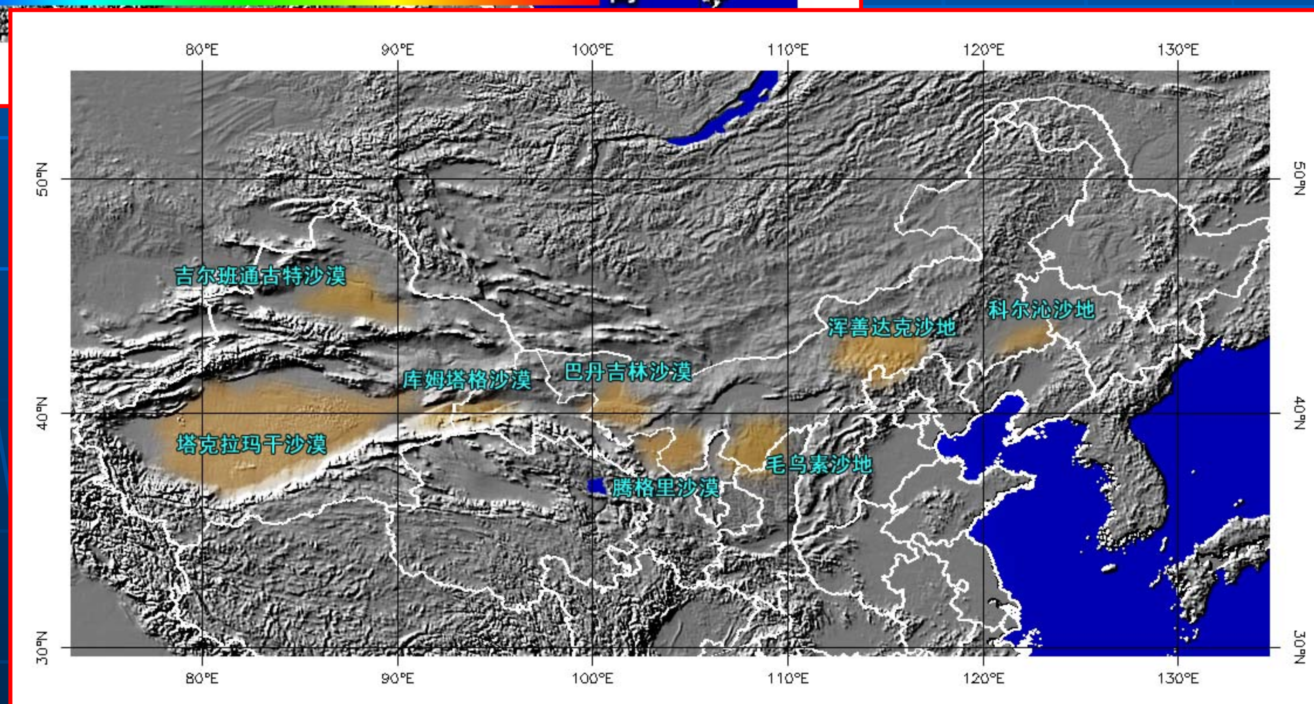
Deserts



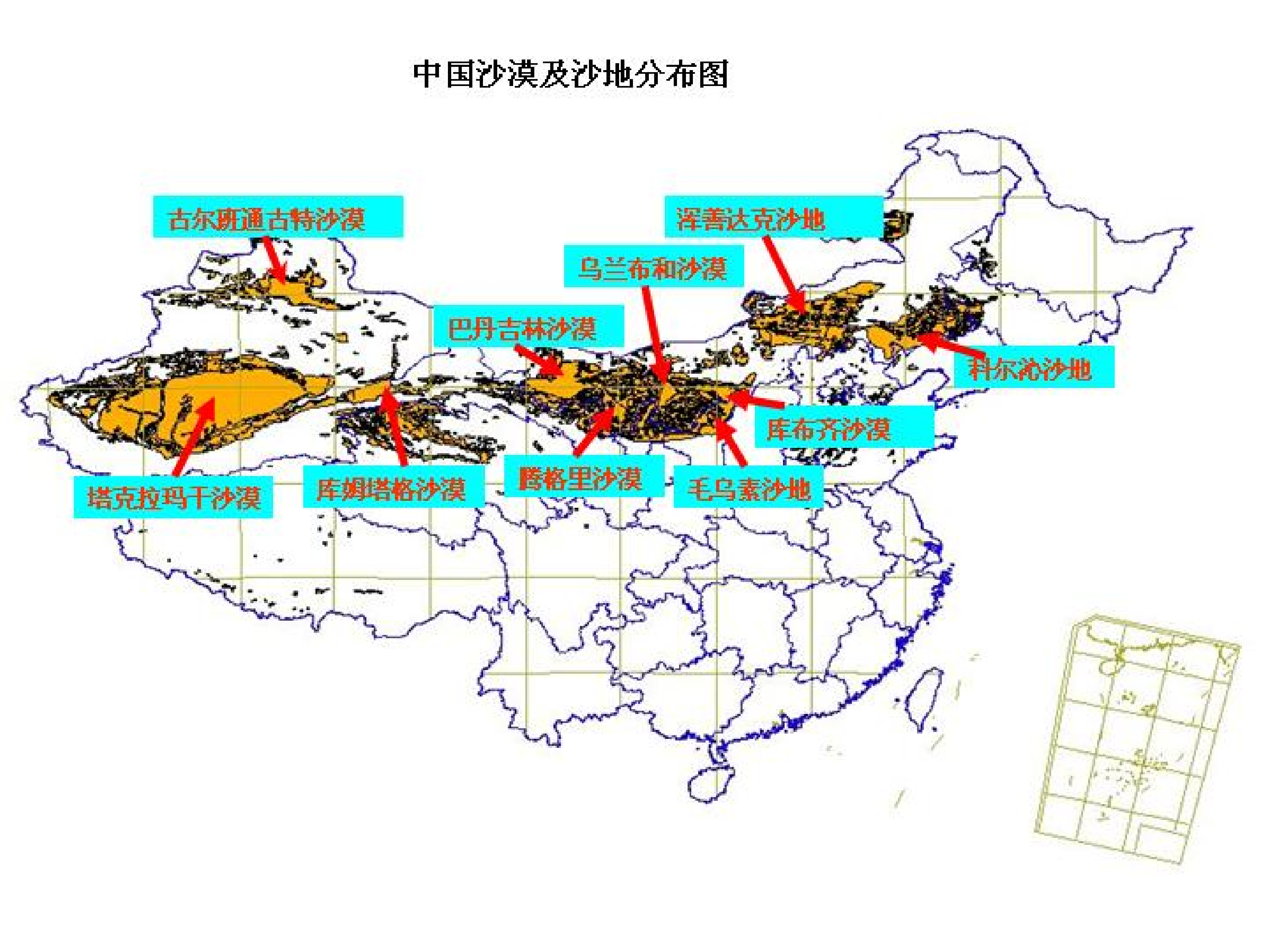


Dust Activities in 2001 spring

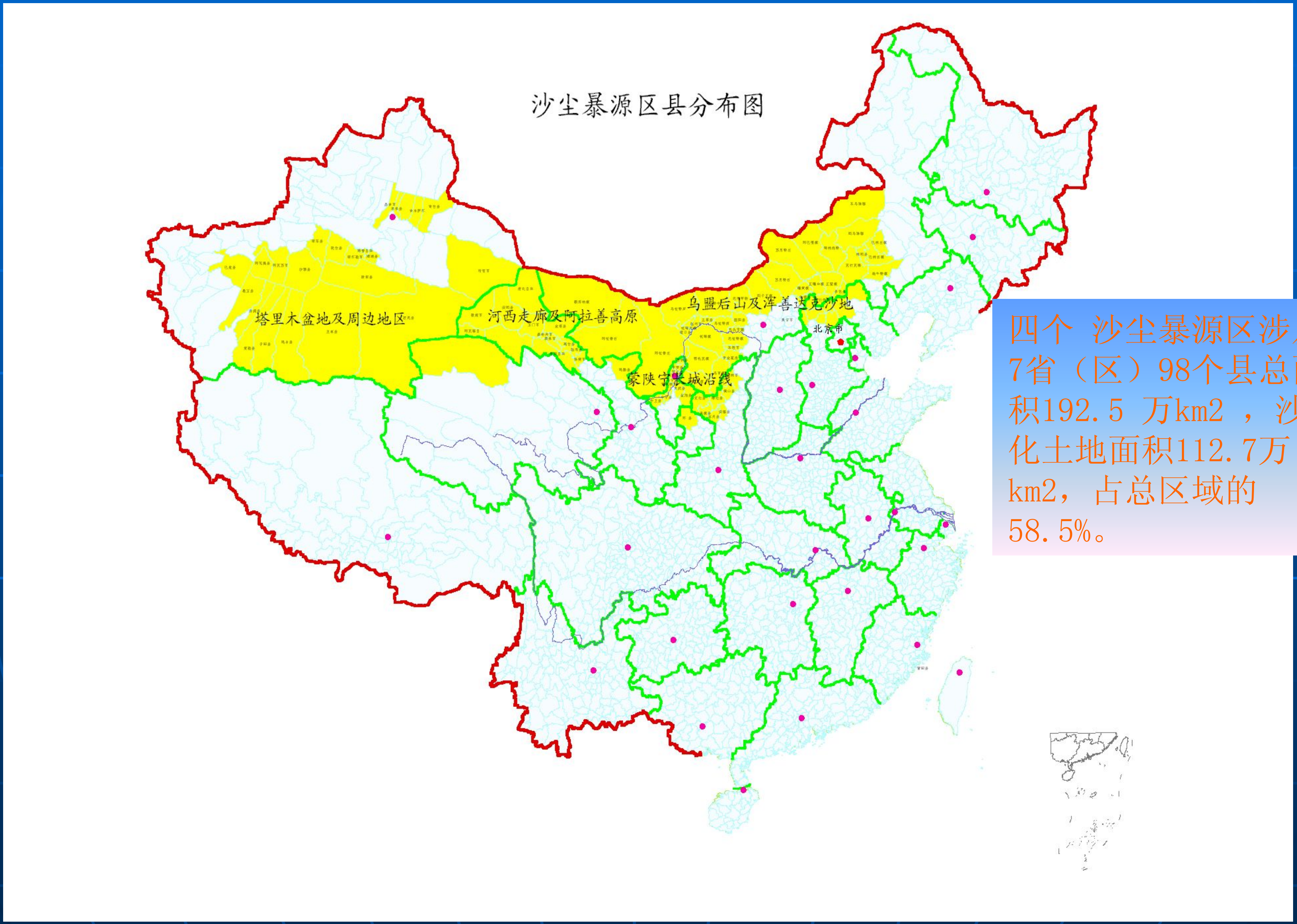
Deserts



Deserts in China



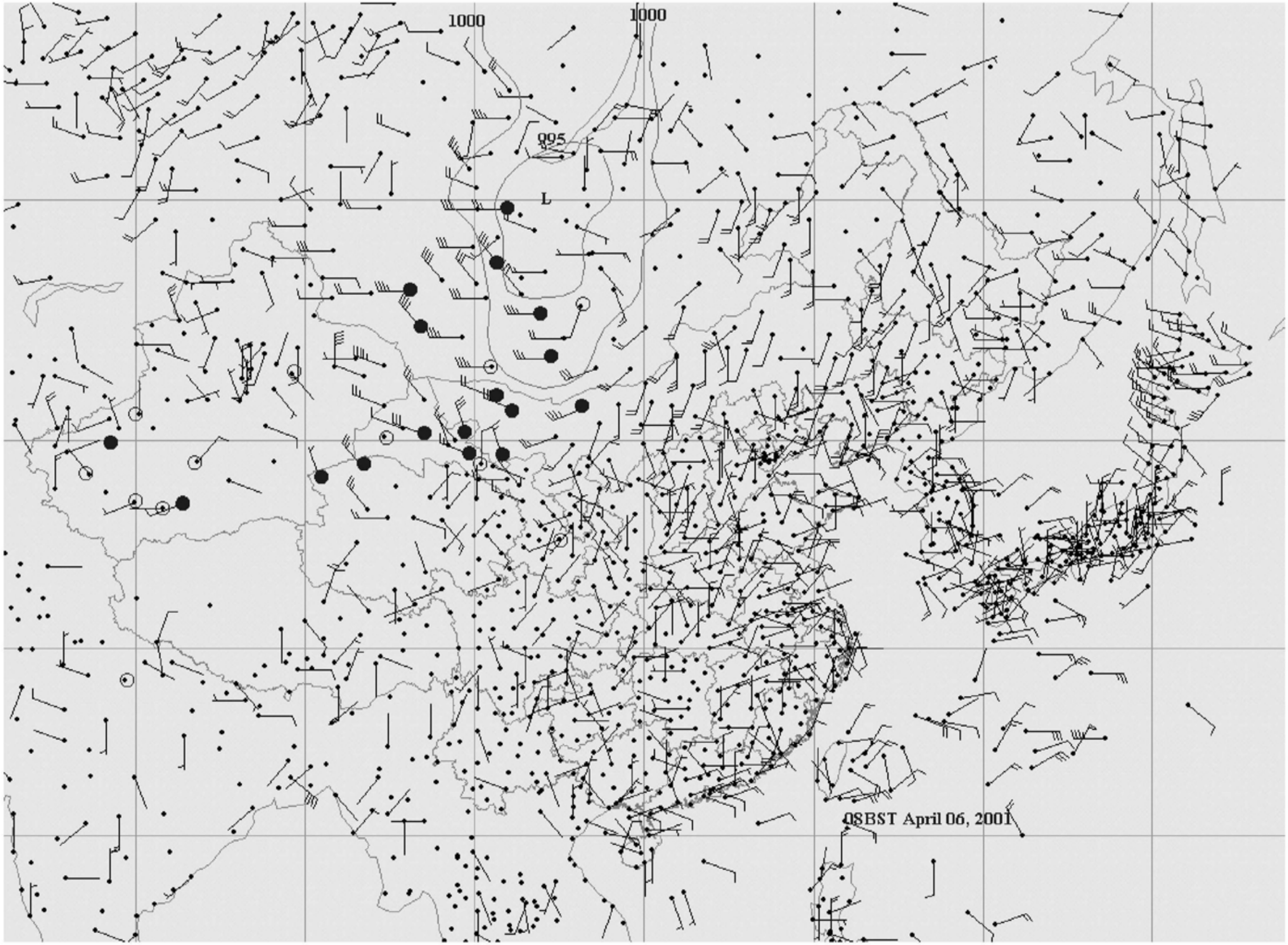
Dust Sources



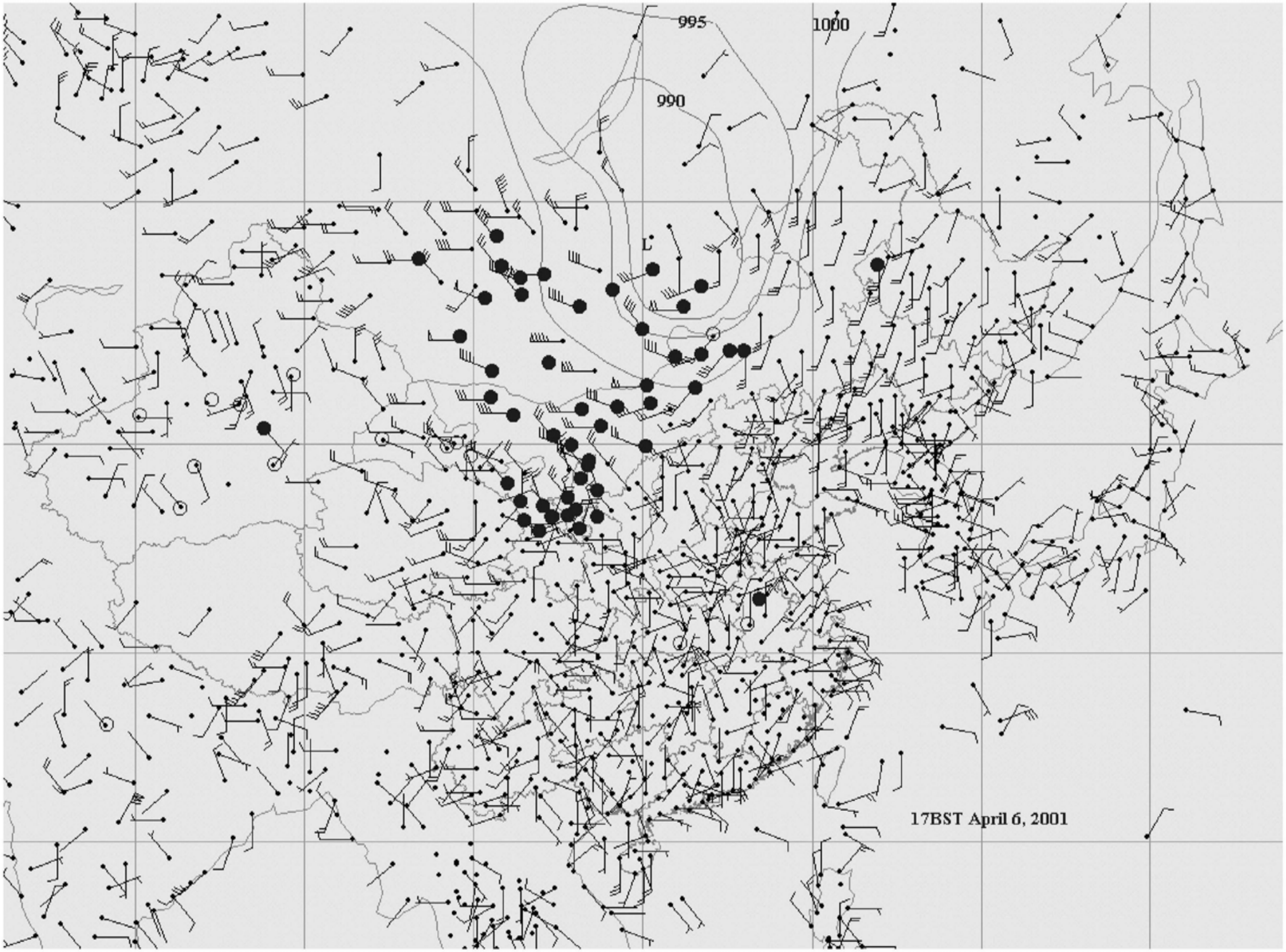
四个 沙尘暴源区涉及7省（区）98个县总面积192.5 万km2 ，沙化土地面积112.7万km2，占总区域的58.5%。

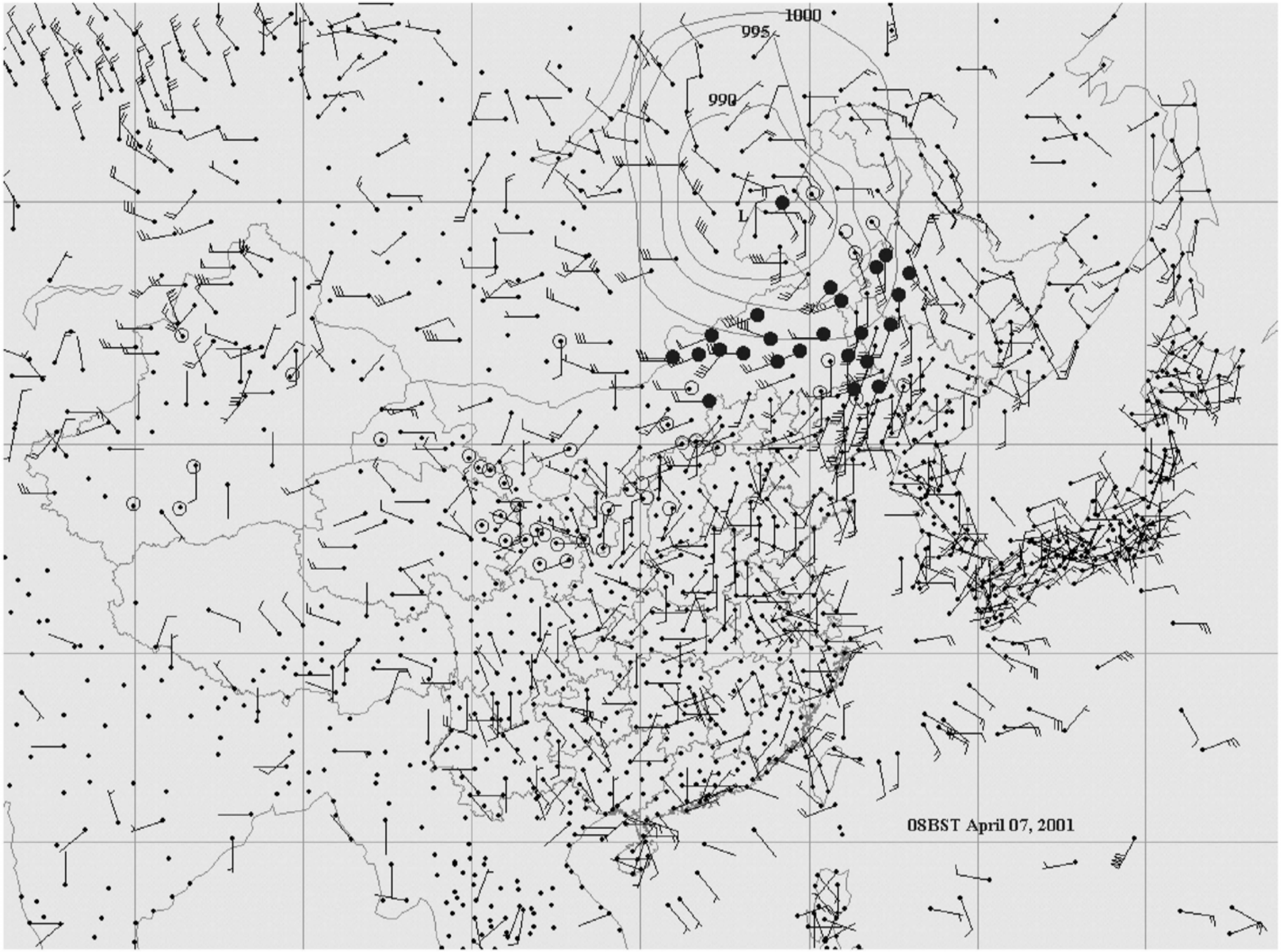
Synoptic System

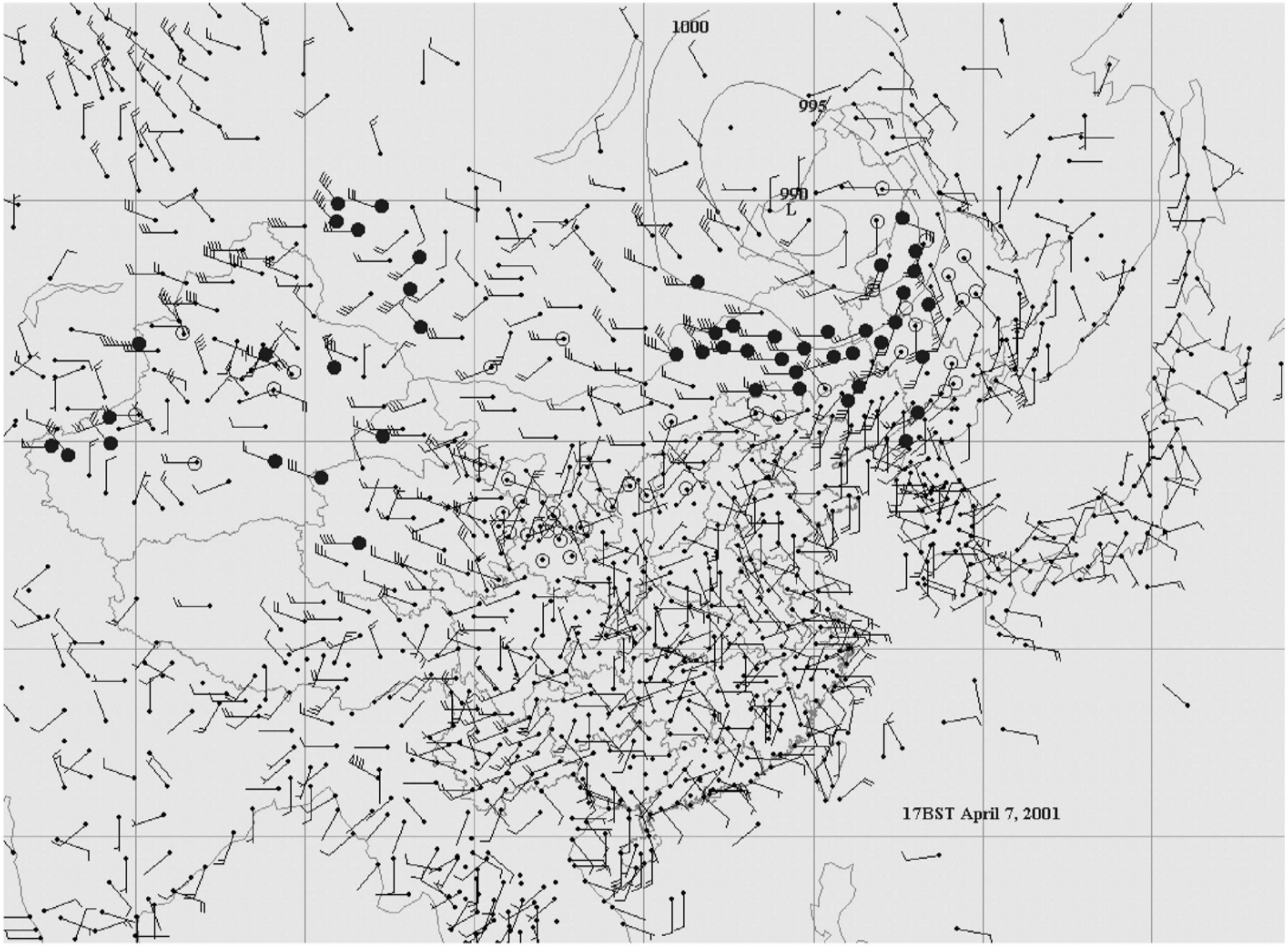
- Southern Mongolia and Northern China is mainly affected by the low pressure frontal system
- Tarim Basin is mainly affected by the northeasterly flow from eastern end of basin



1000
1000
995
L
08BST April 06, 2001


995
1000
990
L
17BST April 6, 2001


1000
995
990
L
08BST April 07, 2001

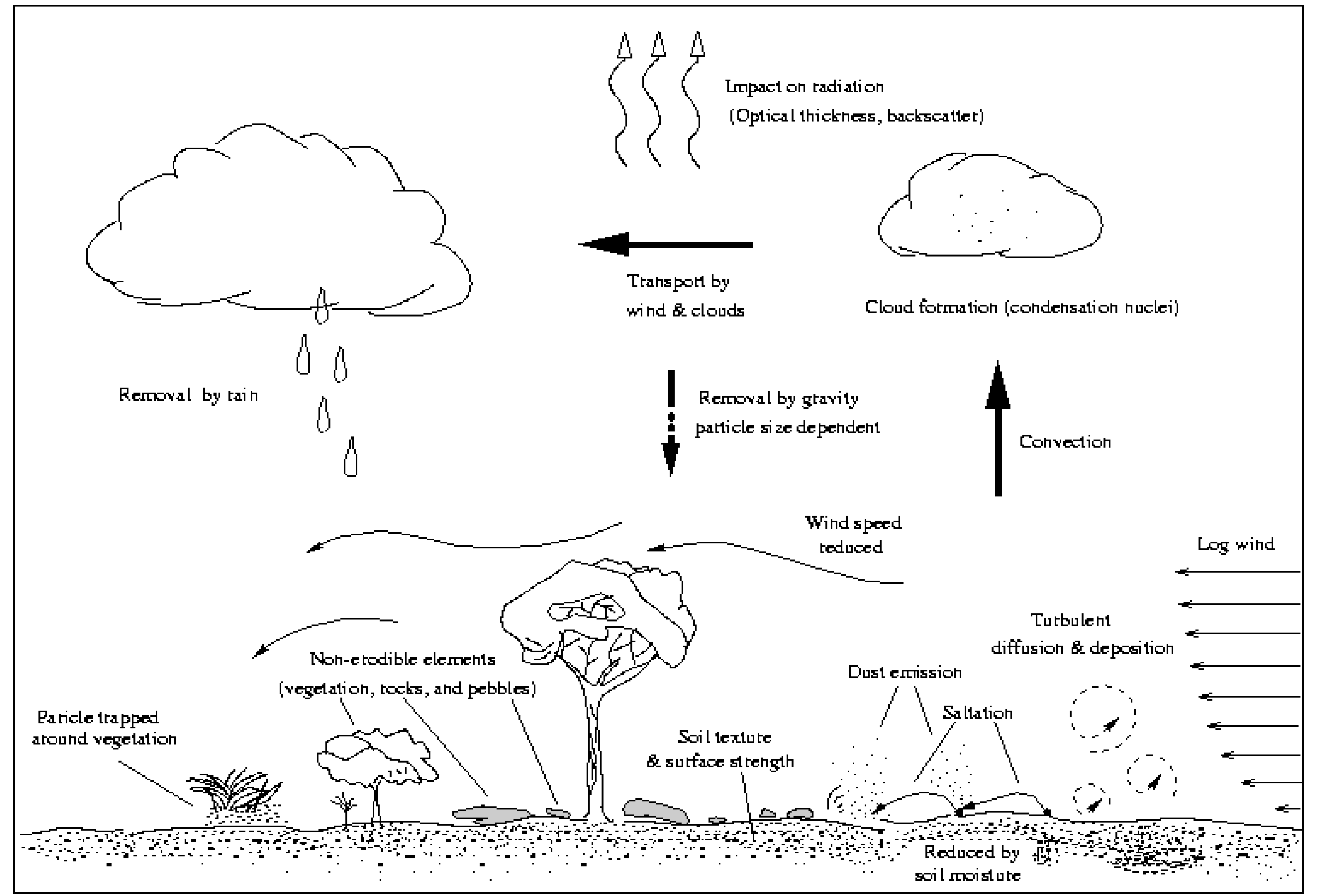

1000
995
990
L
17BST April 7, 2001

Numerical Prediction of Dust Storms

Physical Processes

- Entrainment: **atmosphere and land-surface interactions; multi-disciplinary**
- Transport: **atmospheric circulation; atmospheric boundary layers turbulence; two phase flow problem**
- Deposition: **turbulent diffusion; clouds and precipitation**

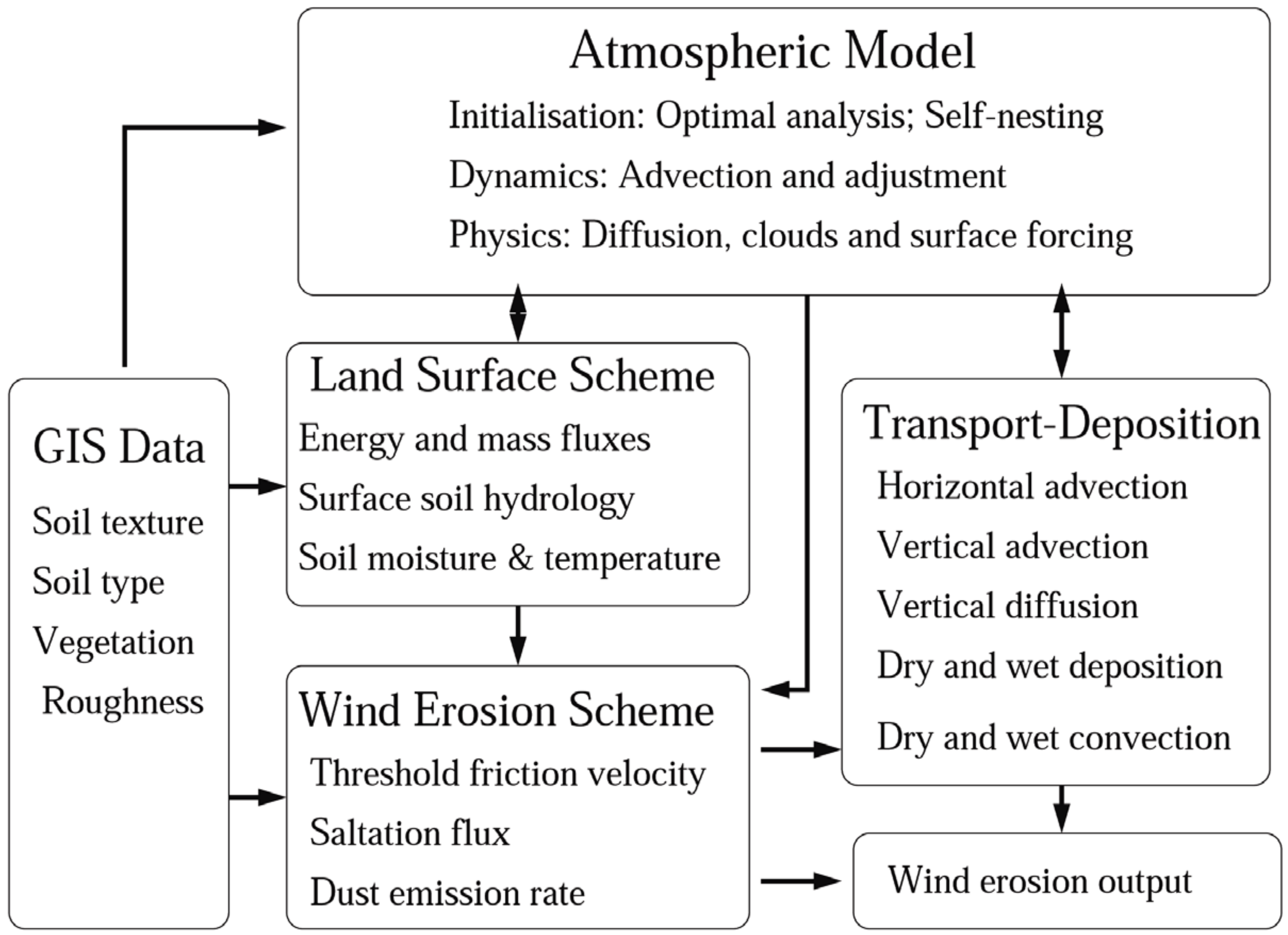
Physical processes involved in wind erosion



Integrated wind erosion modelling

Wind erosion modelling system consists of

- Atmospheric prediction model
- Land-surface model
- Wind-erosion model
- Geographic information system
- Remote sensing


Atmospheric Model
Initialisation: Optimal analysis; Self-nesting
Dynamics: Advection and adjustment
Physics: Diffusion, clouds and surface forcing
GIS Data
Soil texture
Soil type
Vegetation
Roughness
Land Surface Scheme
Energy and mass fluxes
Surface soil hydrology
Soil moisture & temperature
Wind Erosion Scheme
Threshold friction velocity
Saltation flux
Dust emission rate
Transport-Deposition
Horizontal advection
Vertical advection
Vertical diffusion
Dry and wet deposition
Dry and wet convection
Wind erosion output

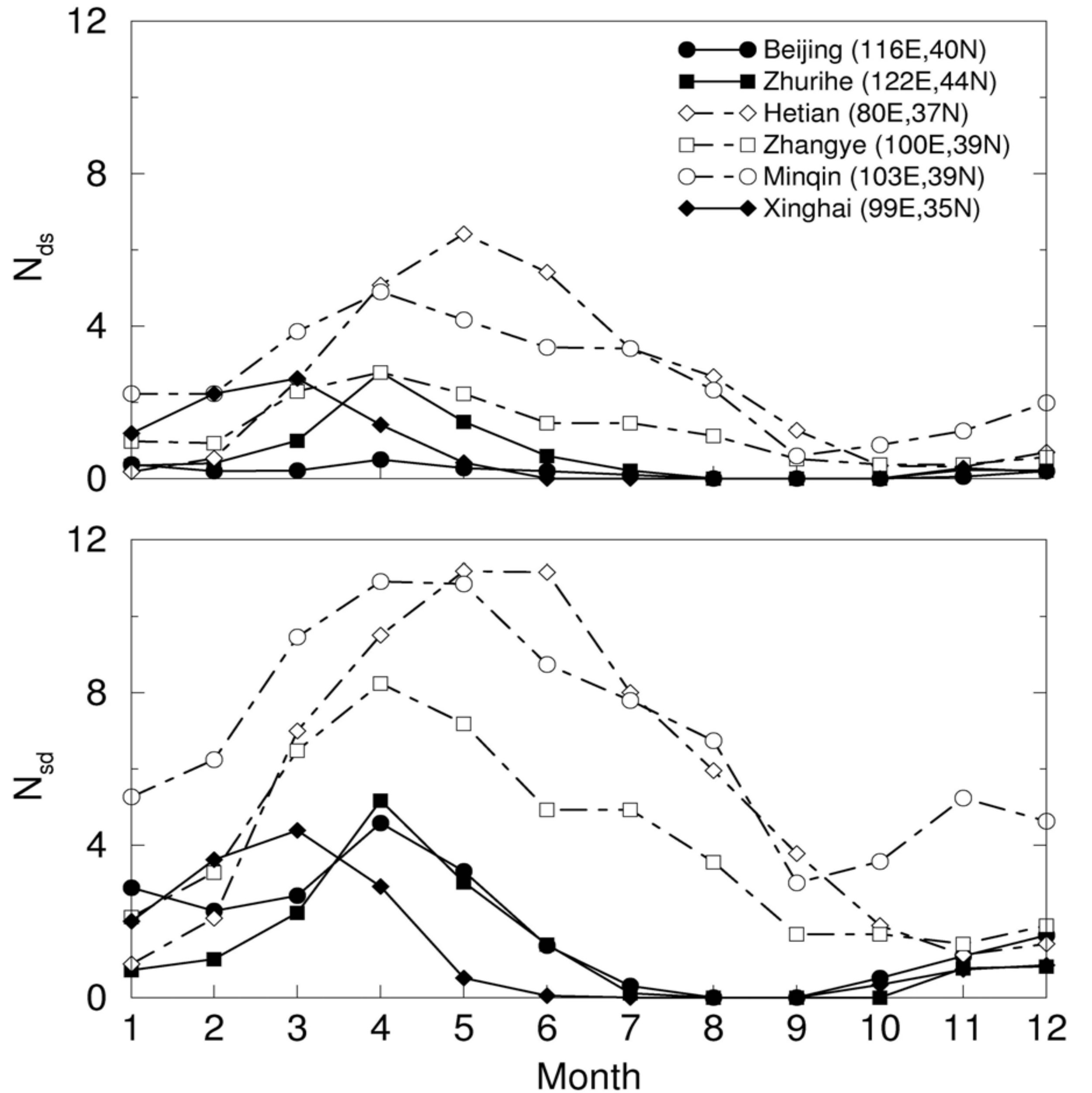
Computational Environmental Modelling System CEMSYS4

- **Atmospheric prediction model:** high-resolution limited-area; nested in GCM, self-nested; 3rd order upwinding and semi-lagrangian schemes; clouds and radiation.
- **Land surface (ALSIS):** Soil moisture, temperature; fluxes of energy, mass and momentum;
- **Aerosol cycle:** entrainment, transport and deposition.
- **GIS**

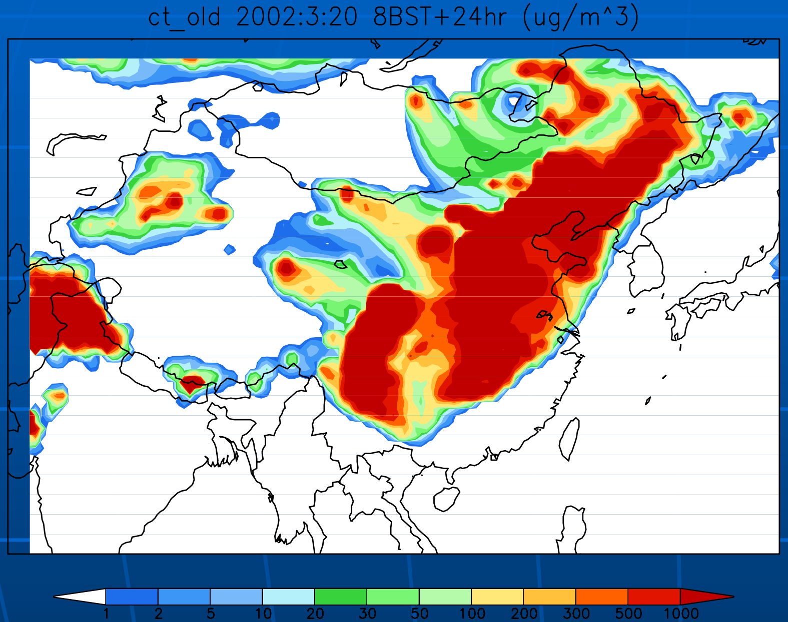
Real Time Prediction: MAM 2002

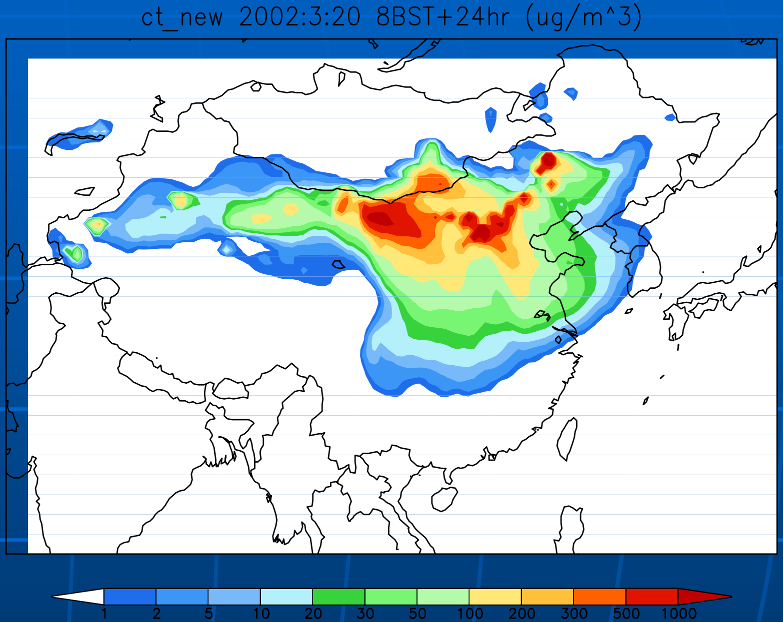
- CEMSYS4 has been applied for real-time (24, 48 & 72hr) predictions of dust storms for MAM 2002
- CEMSYS4 is nested within the T213 GCM of CMA
- Area of simulation is (30E, 5N) to (180E, 65N)
- Spatial resolution is 50 km
- Area of data analysis is (72E, 5N) to (148E, 53N)
- CEMSYS4 predicts a number of variables for the assessment and prediction of the entire dust cycle, including dust entrainment, concentration (transport) and deposition

Seasonality of dust activities



Result of numerical prediction model

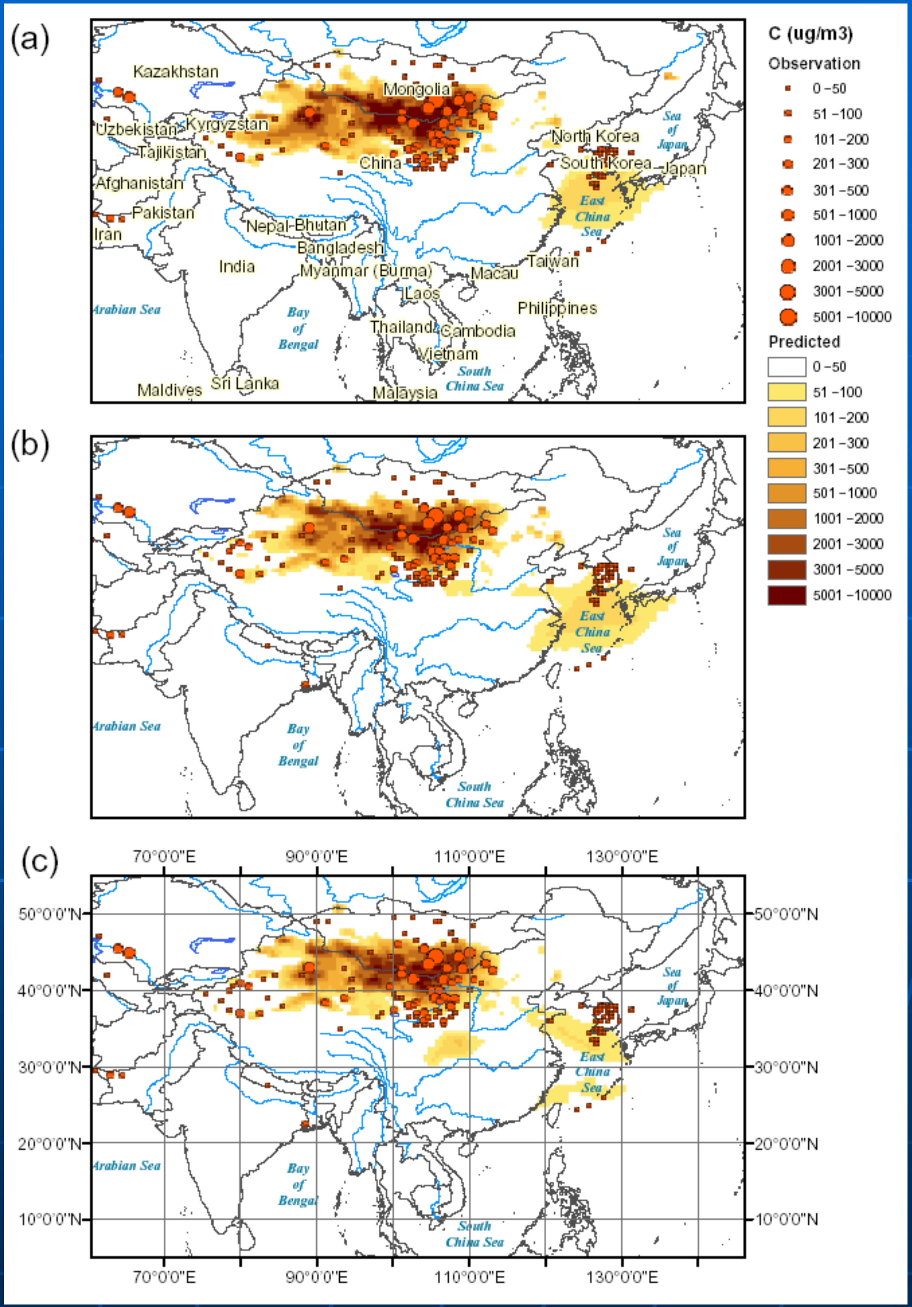




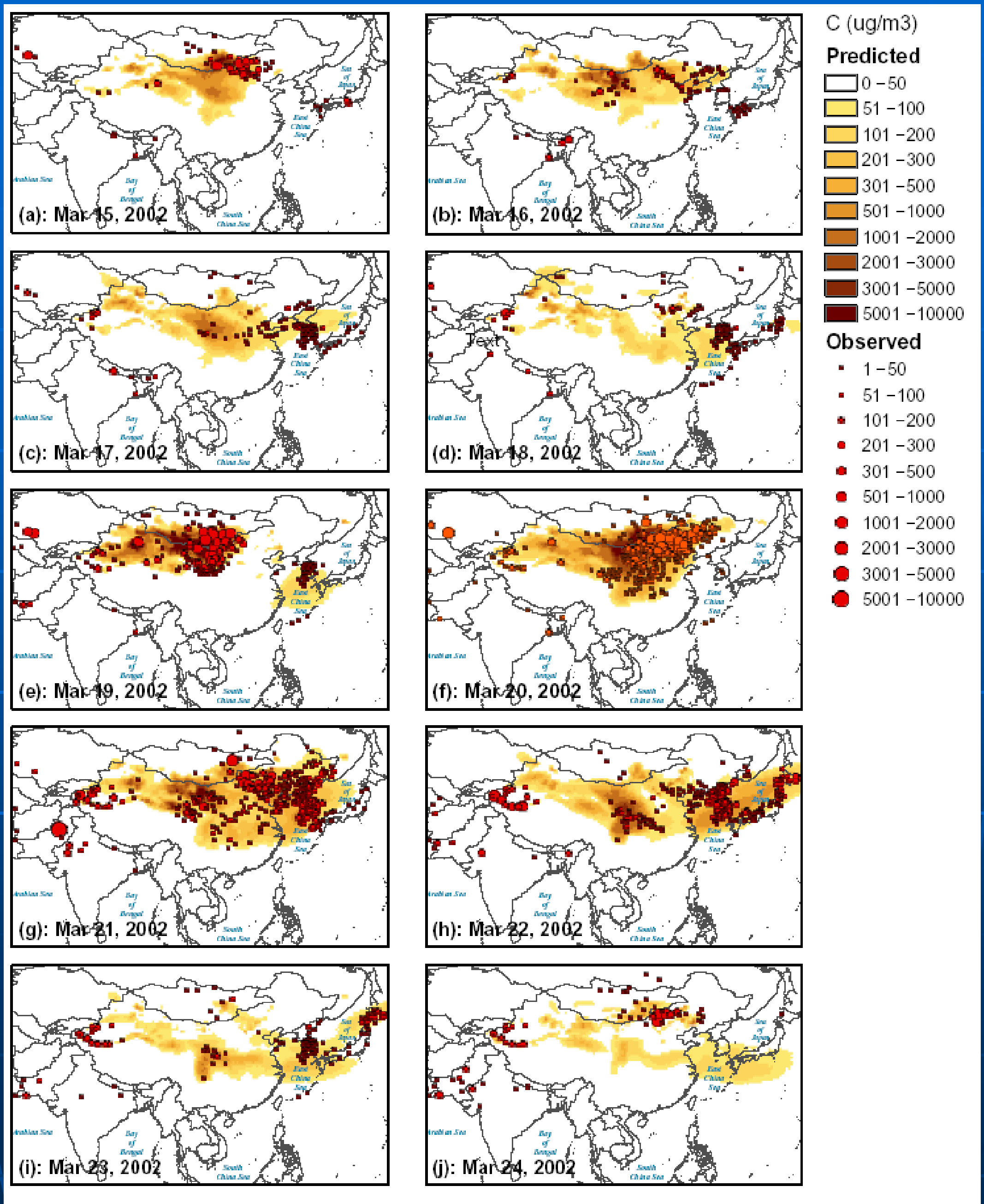
Without Satellite Data

With Satellite Data

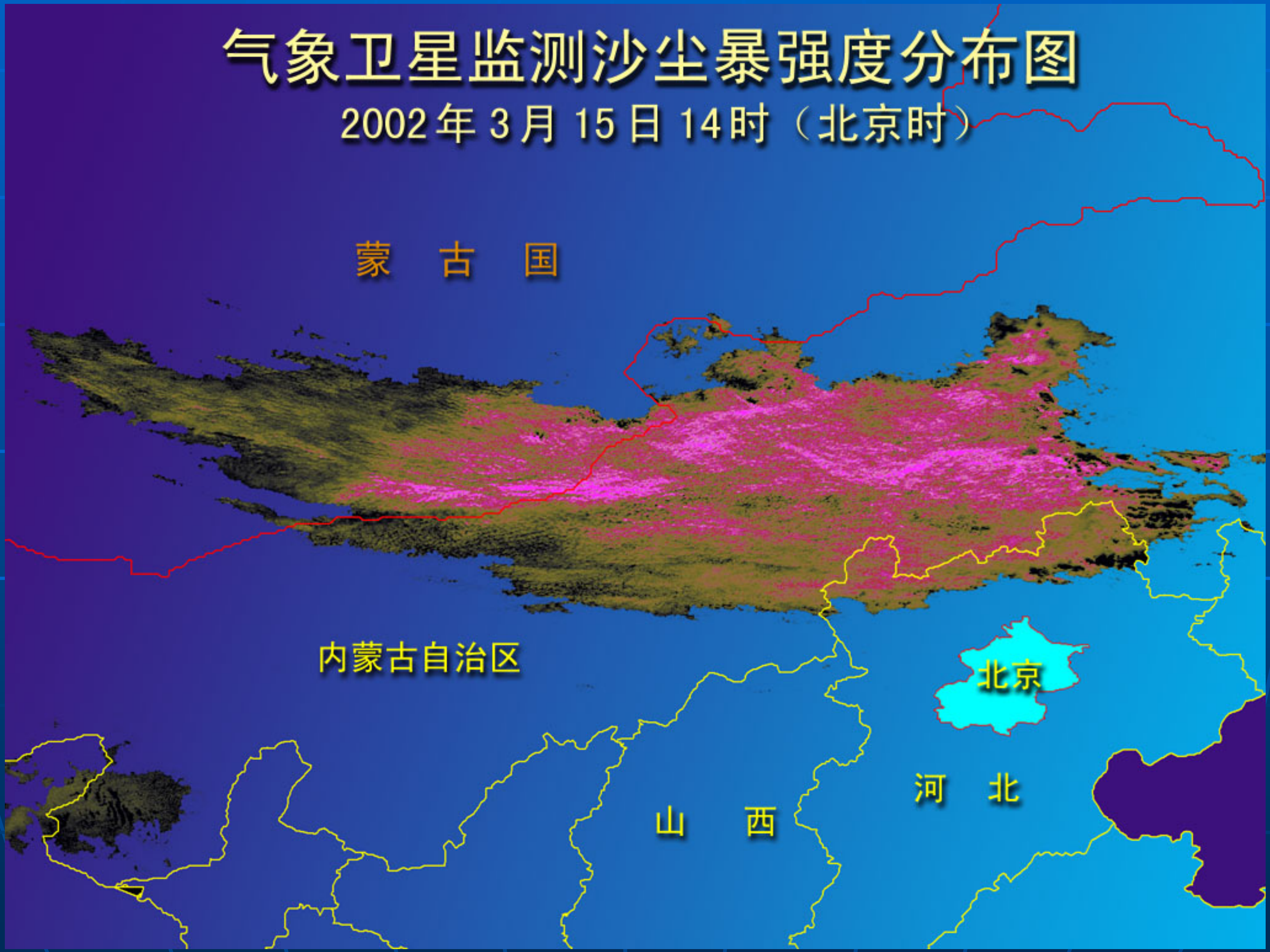
Comparisons of the predicted and observed near surface dust concentration for **March 19**. (a) the 24hr forecast; (b) the 48hr forecast; and (c) the 72hr forecast. Full dots represent the stations where dust activities were observed and the size of dots represents the magnitude of dust concentration .



Comparisons of the predicted and observed near surface dust concentration for 10 successive days from **15 to 24 March 2002**. The model results are the 24hr forecasts.



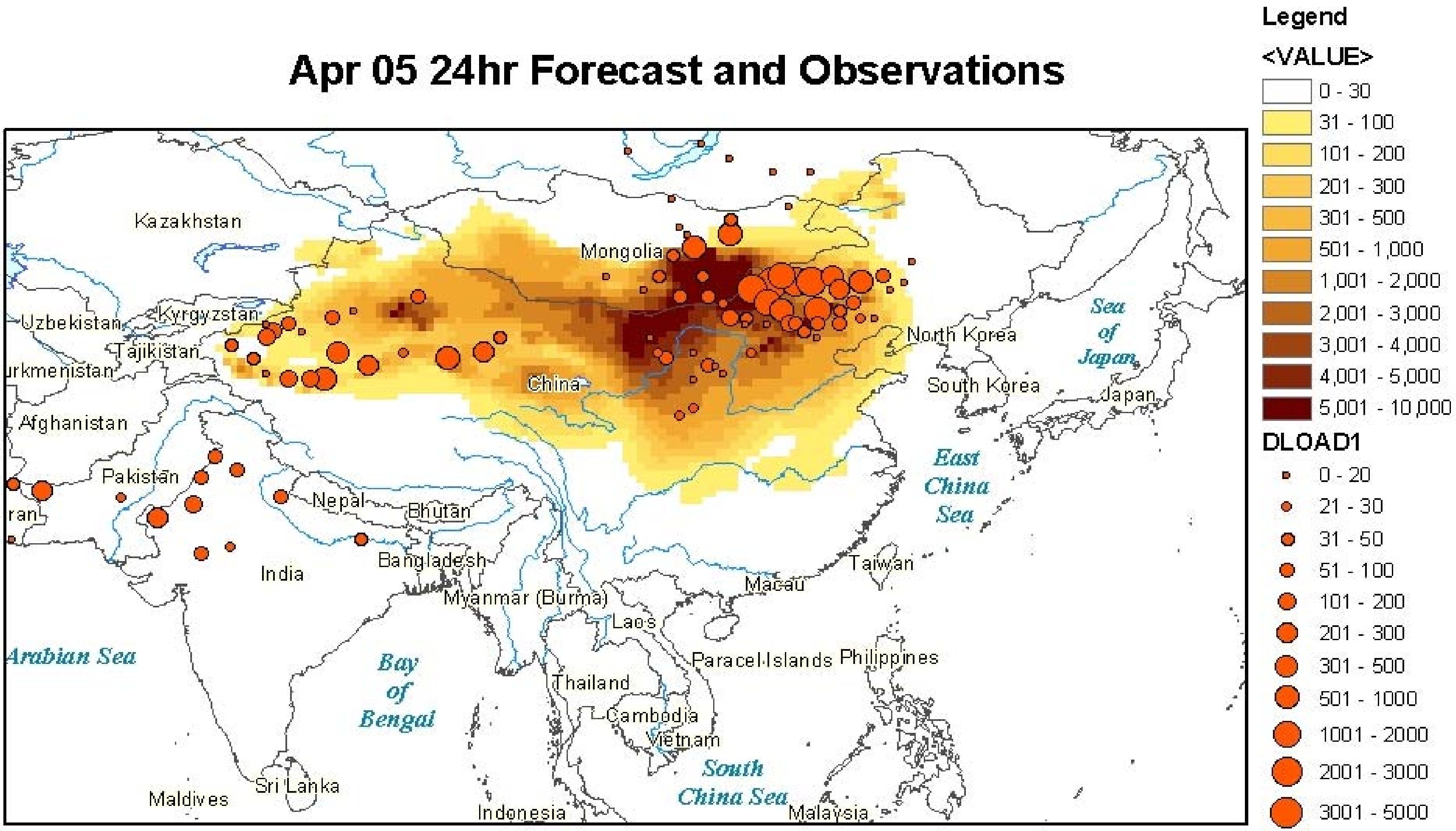
Dust storm Observed by Satellite at 06:00 on March 15, 2002



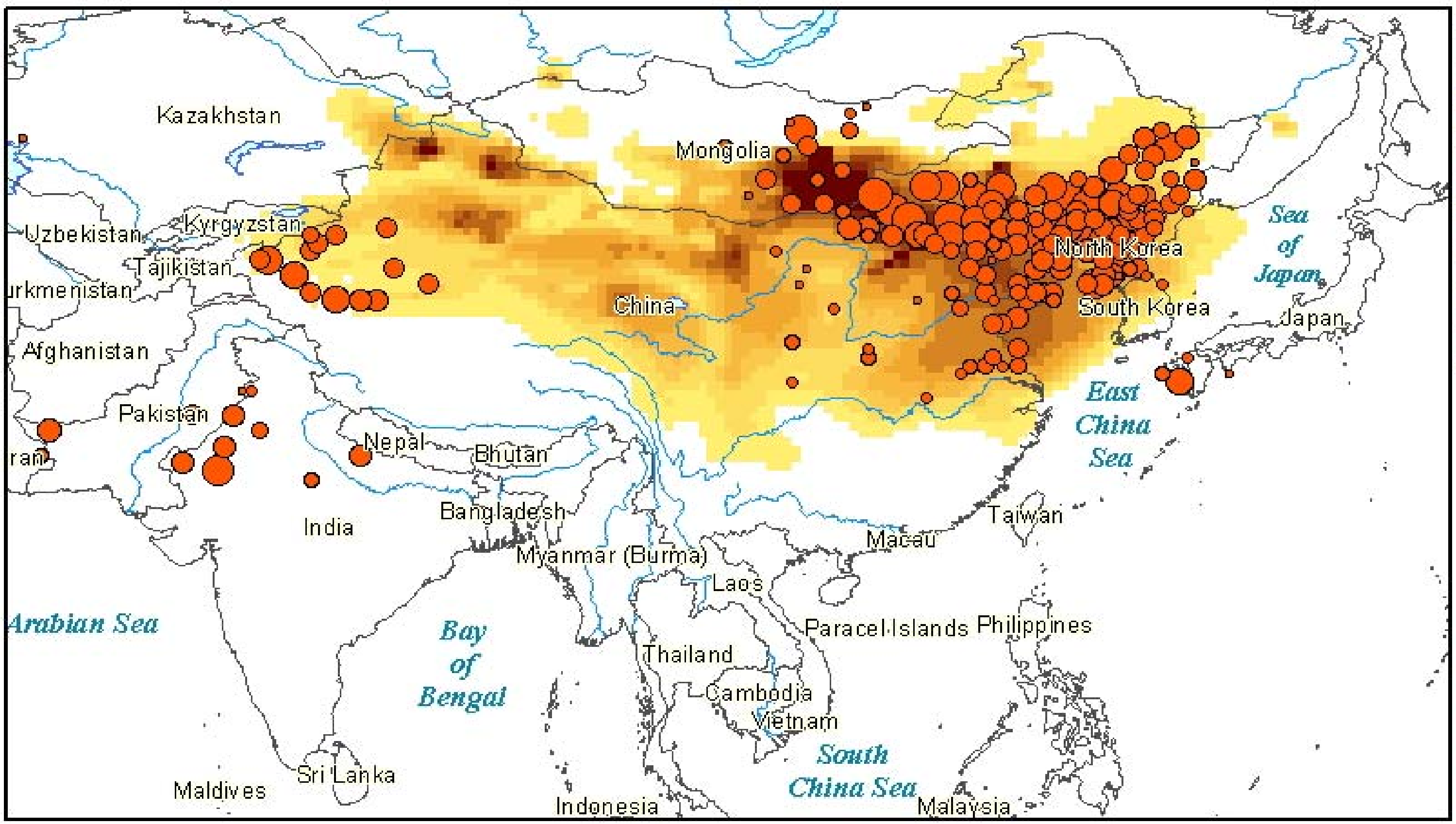
April 5—9, 2002
Severe Dust Storm

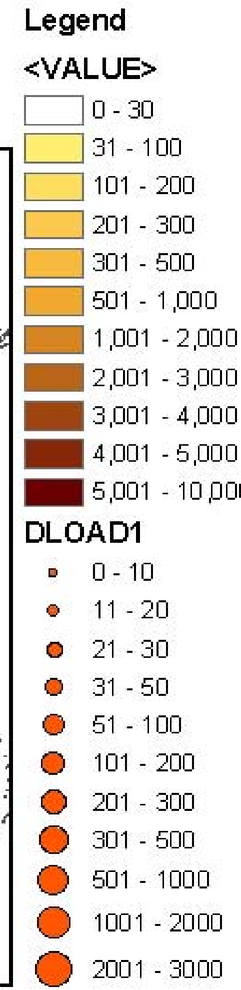
Associate with cold air outbreak and mongolian cyclone, BS in S Xingjiang, NW Qinghai, N Ningxia, N Shaanxi, N Hebei, Beijing, Tianjin, MW and SEE Inner Mongolia, NE China, Gansu, Shandong and Anhui; DS to SDS in areas of S Xingjinag, NW Qinghai, M and SEE of Inner Mongolia, S Liaoning, M Jilin, S Heilongjiang. Wind speed reached 5—7 up to 8 .

Apr 05 24hr Forecast and Observations

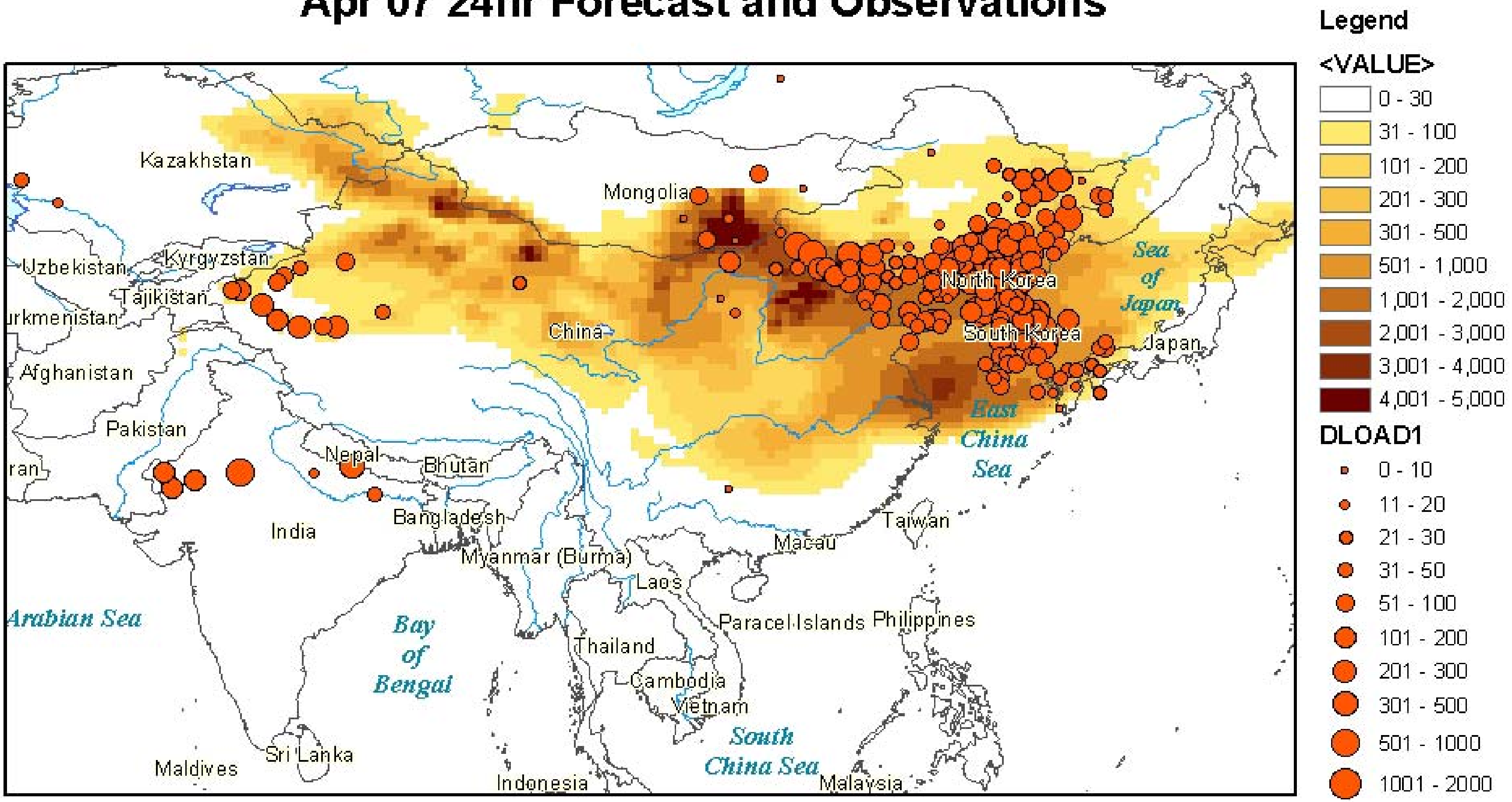


Apr 06 24hr Forecast and Observations

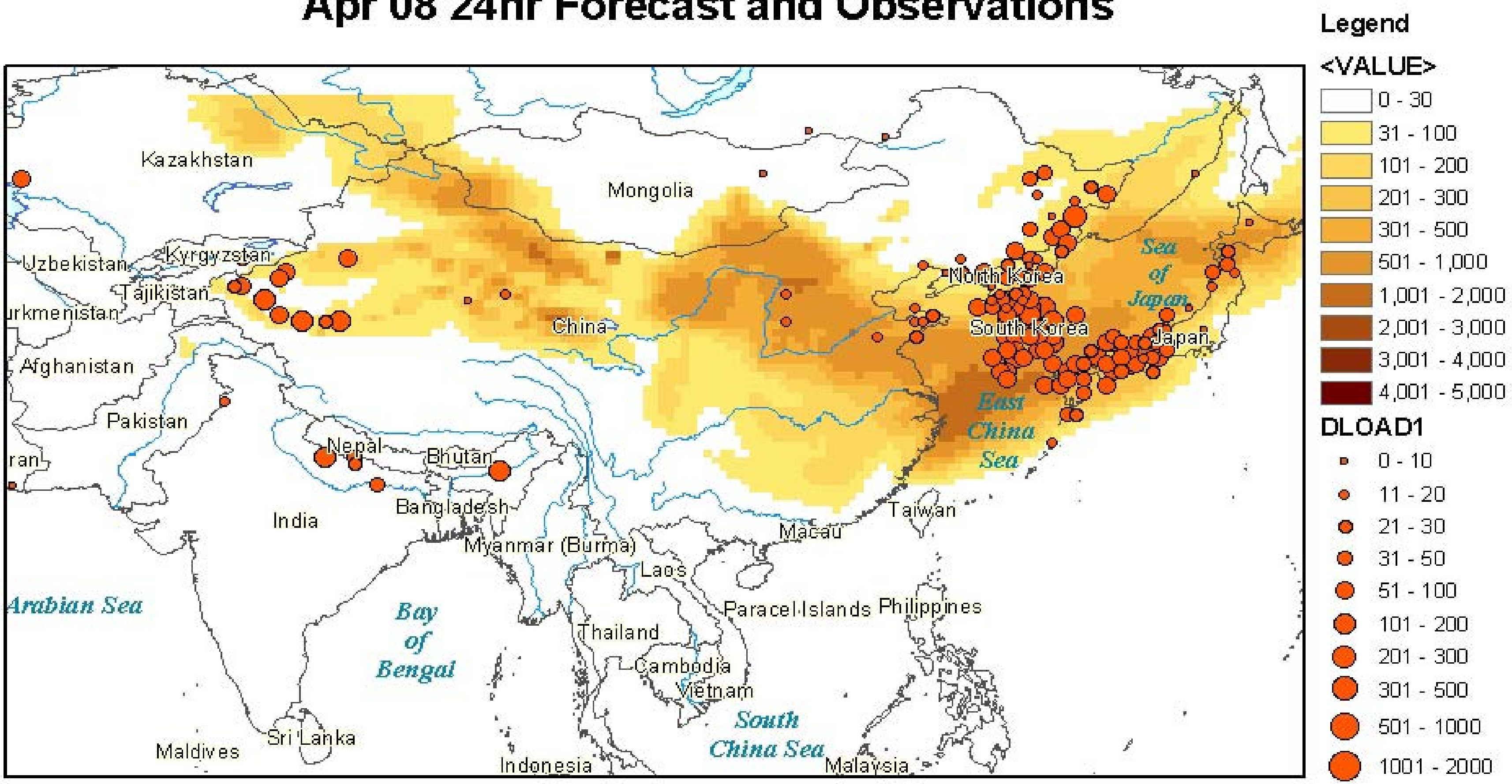




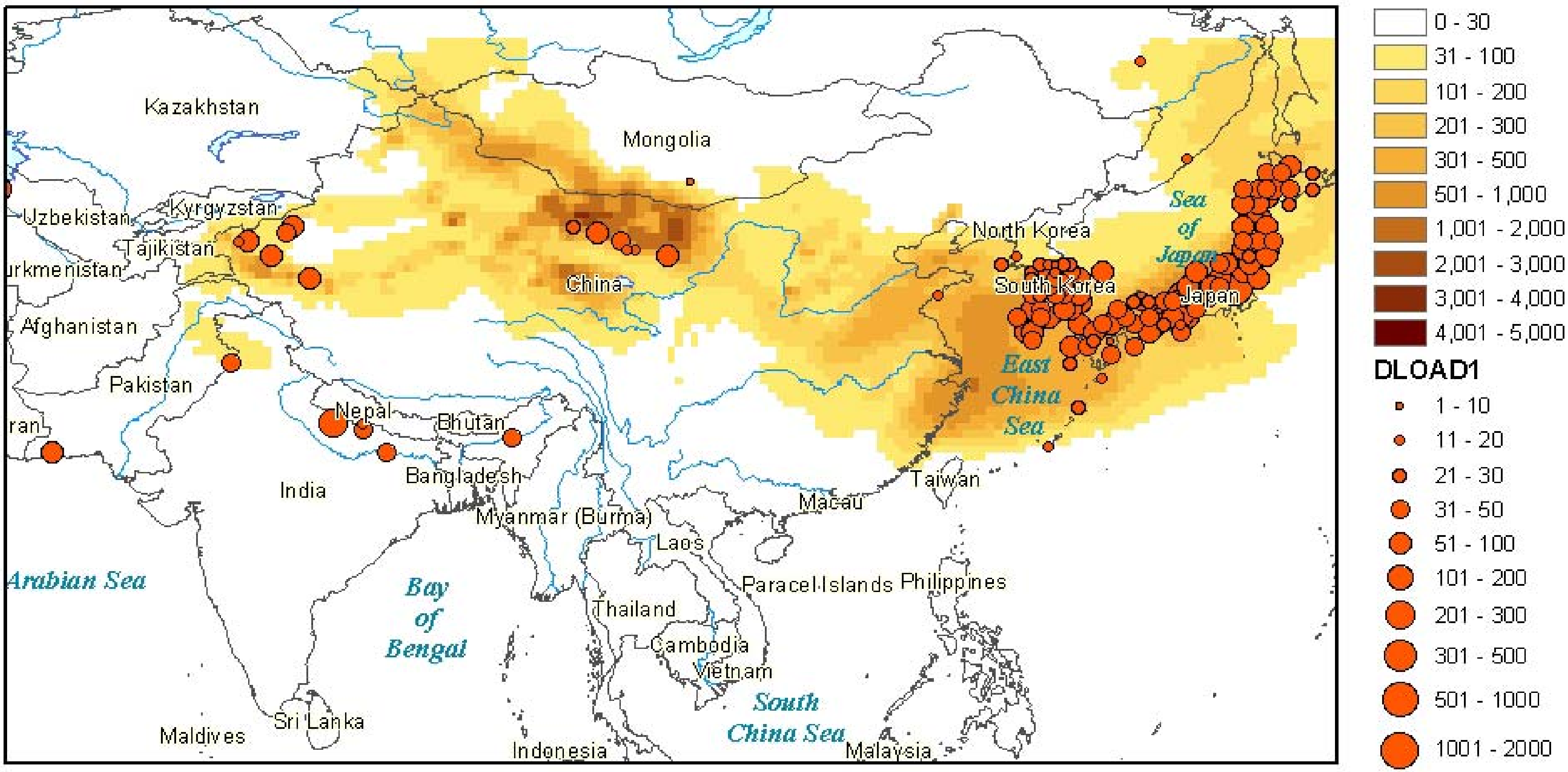
Apr 07 24hr Forecast and Observations

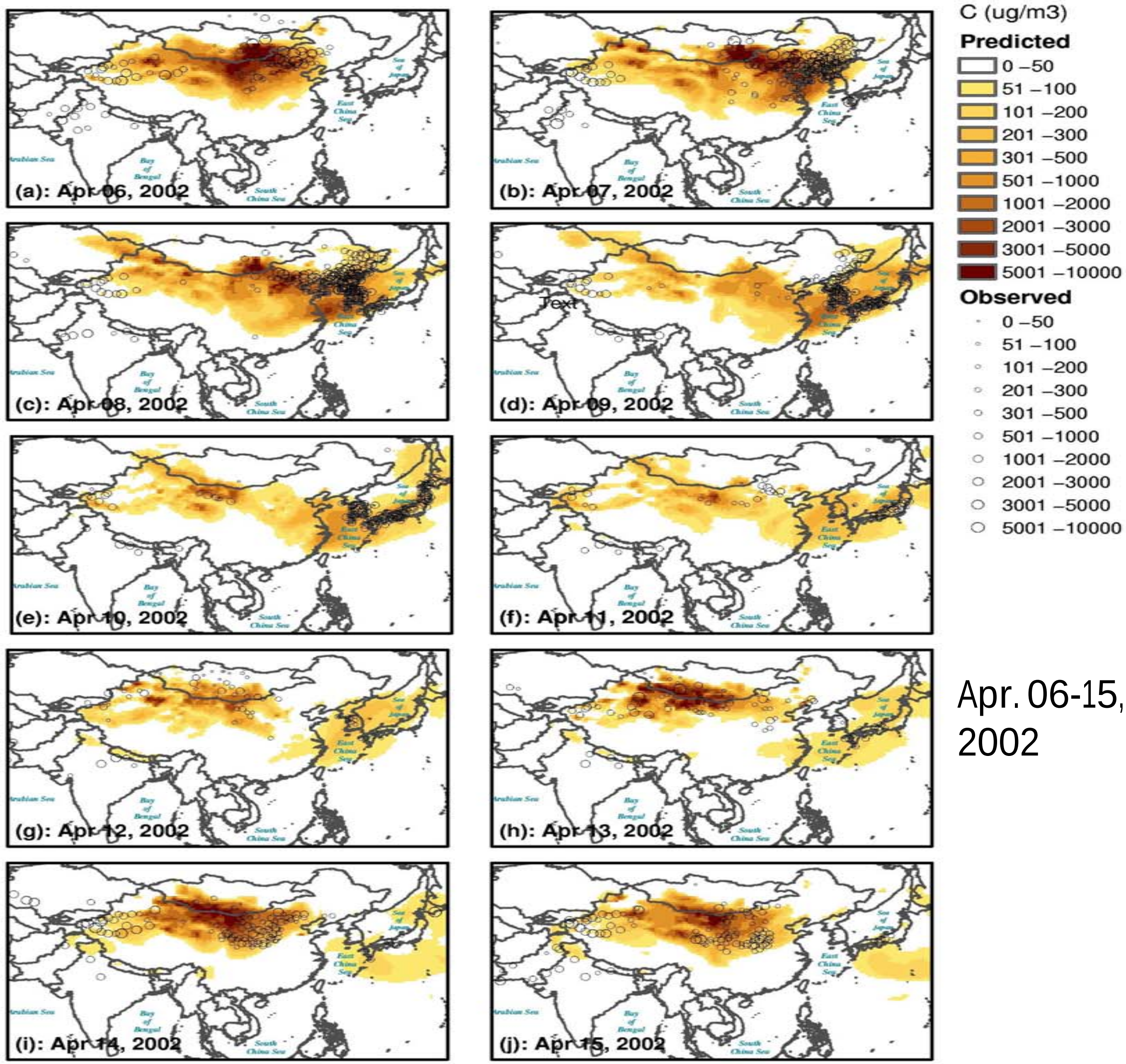


Apr 08 24hr Forecast and Observations



Apr 09 24hr Forecast and Observations





Apr. 06-15, 2002

TOTAL DUST EMISSION:

11.5 x10^6 tn day-1 (maximum 65.7 x10^6 tn day -1)

TOTAL DUST DEPOSITION:

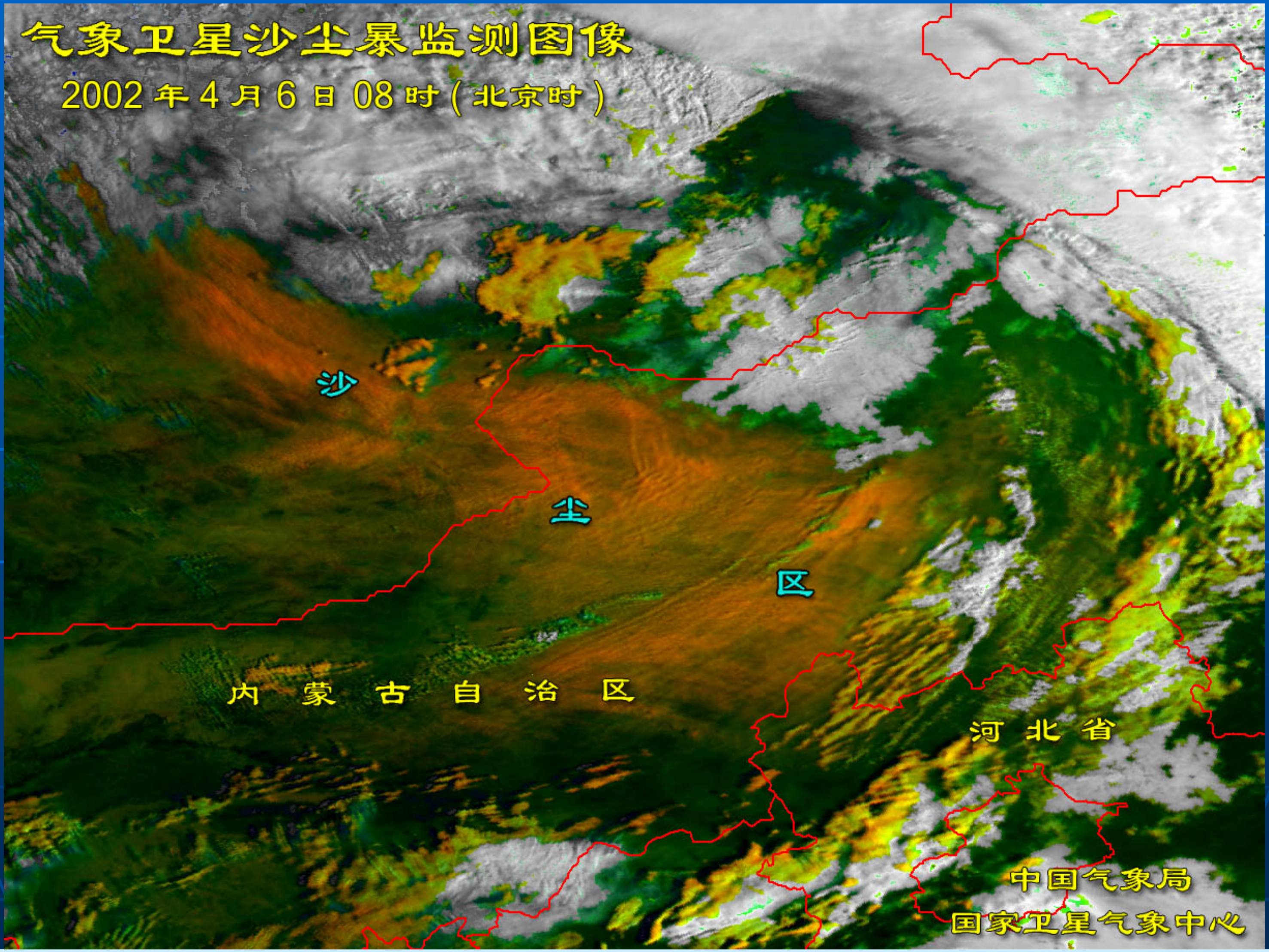
10.8 x10^6 tn day –1 ((maximum 51.4 x10^6 tn day -1)

TOTAL DUST LOAD:

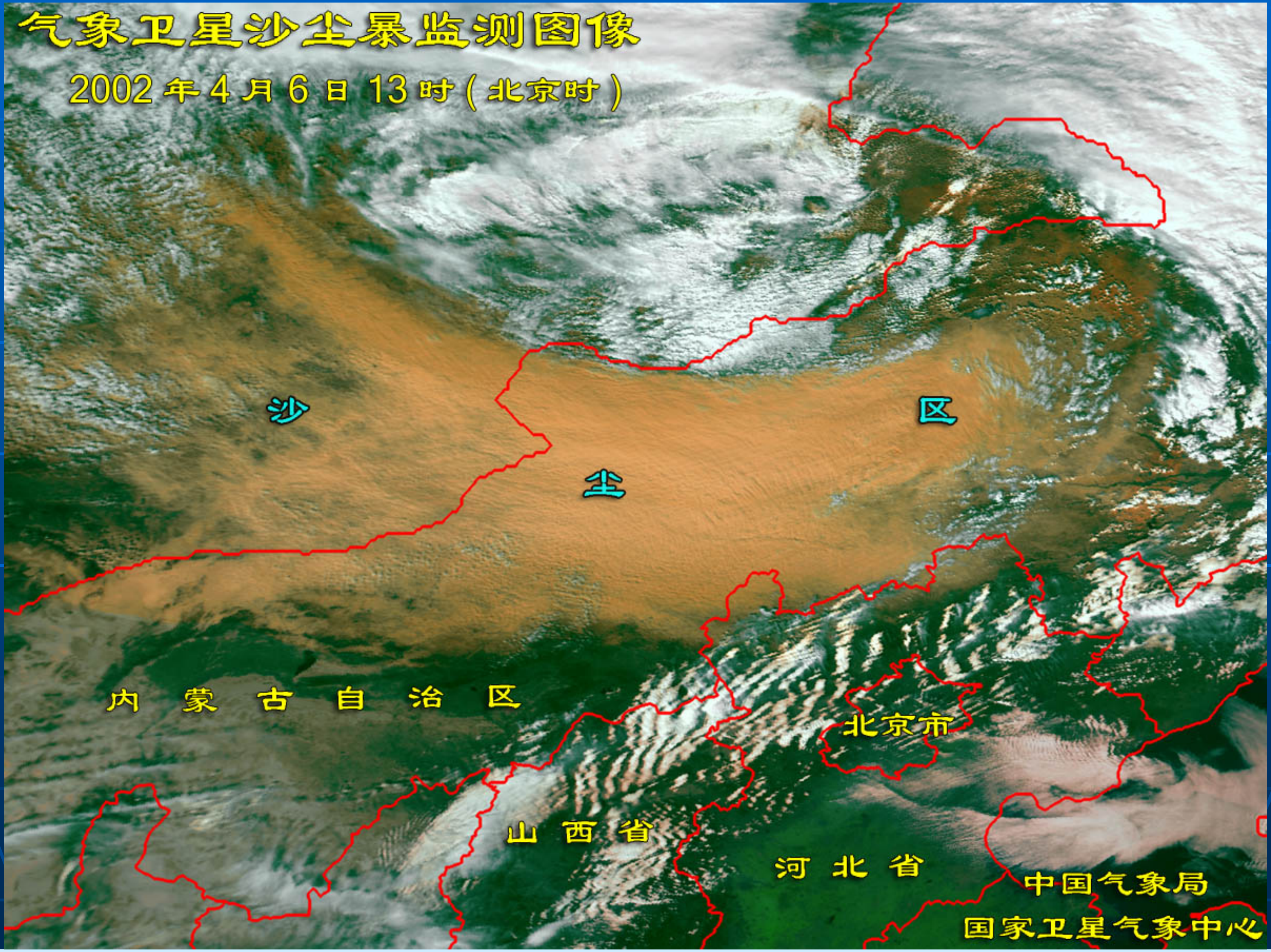
5.5 x10^6 tn with a maximum of 15.9 x10^6 tn.

Comparison with satellite observations for the period 6 to 8 April, 2002

Dust storm for 00z on April 6, 2002 (a)

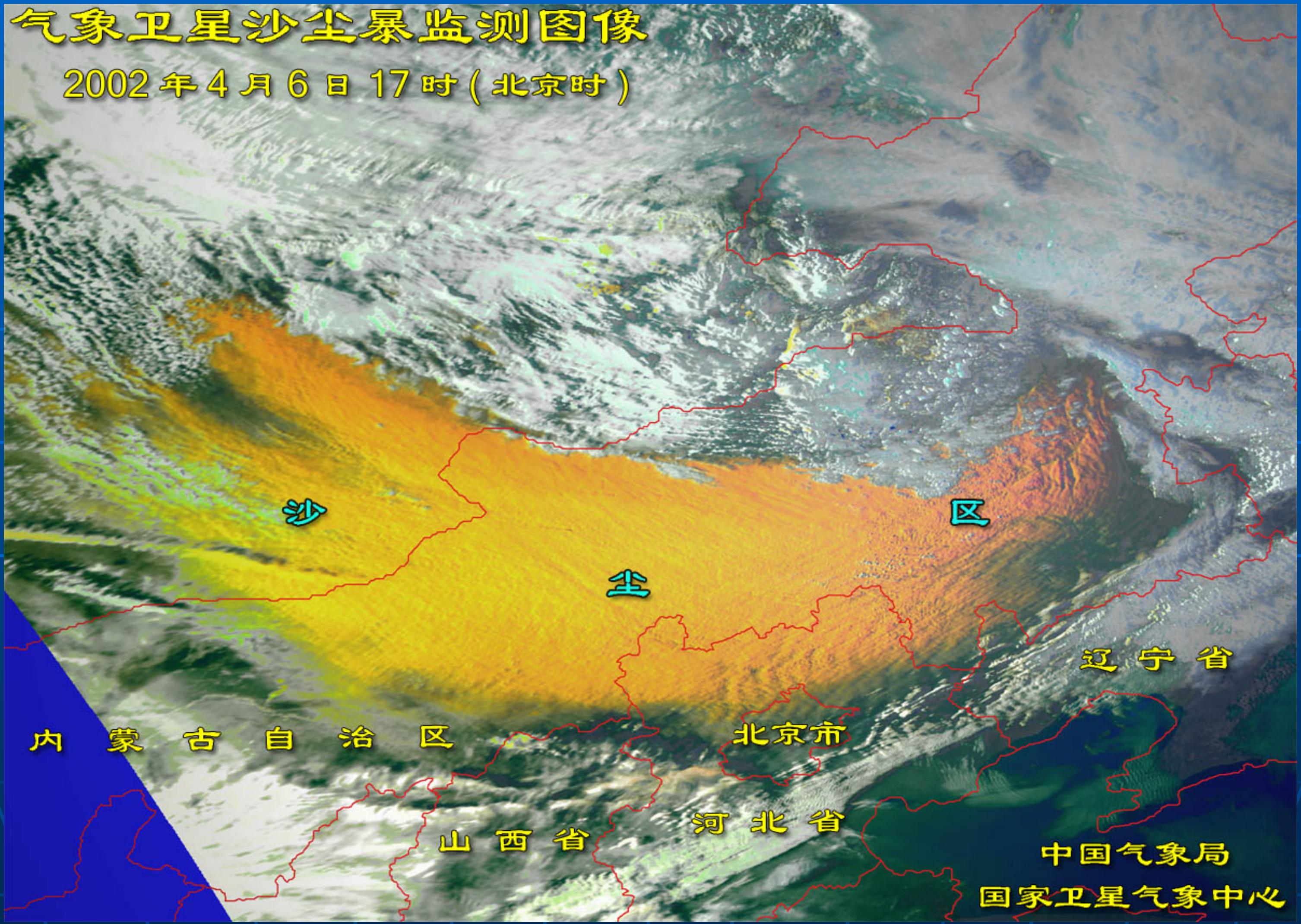


Dust storm for 05z on April 6, 2002 (b)



Dust storm for 09z on April 6, 2002 (c)

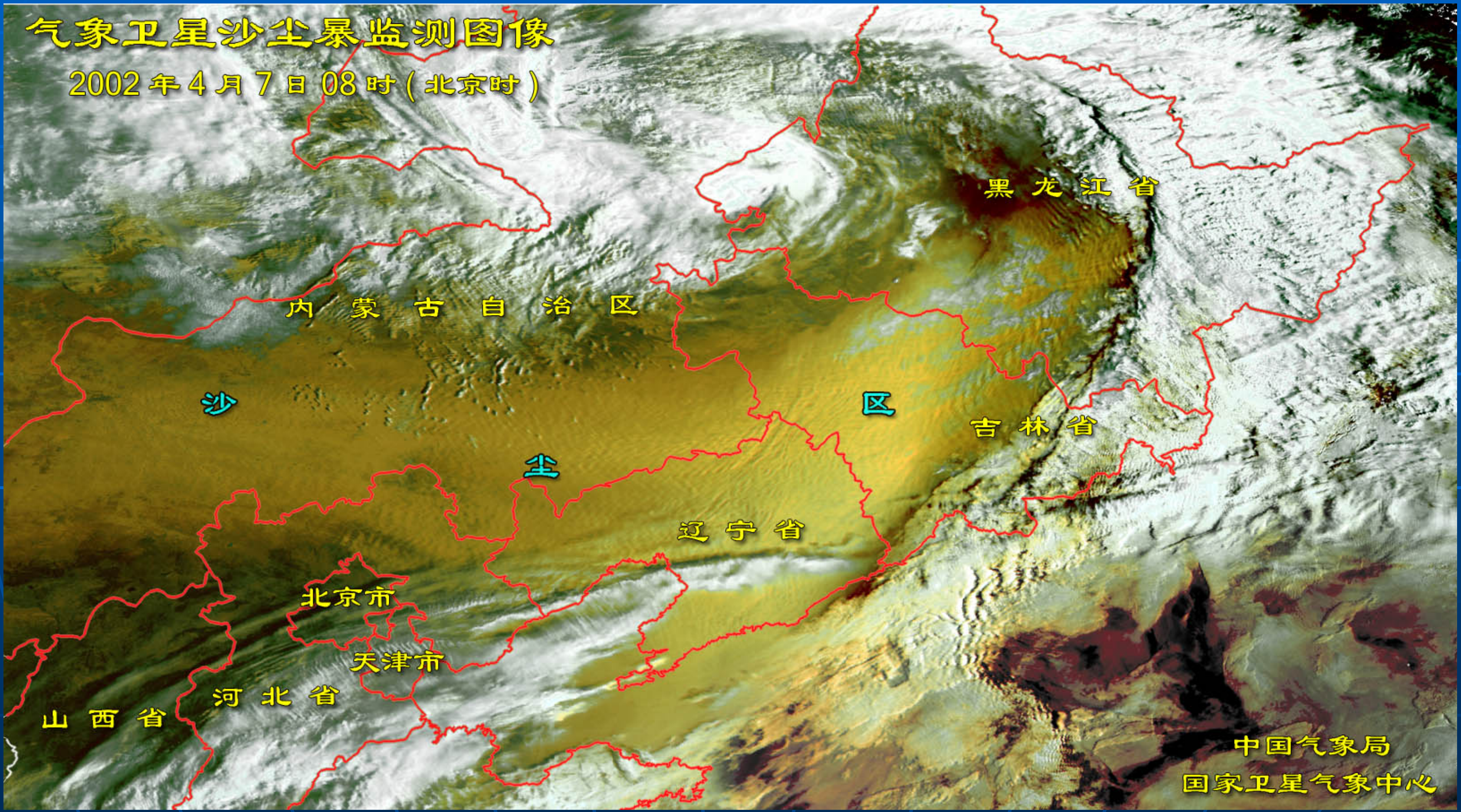
(0.7Mkm^2)



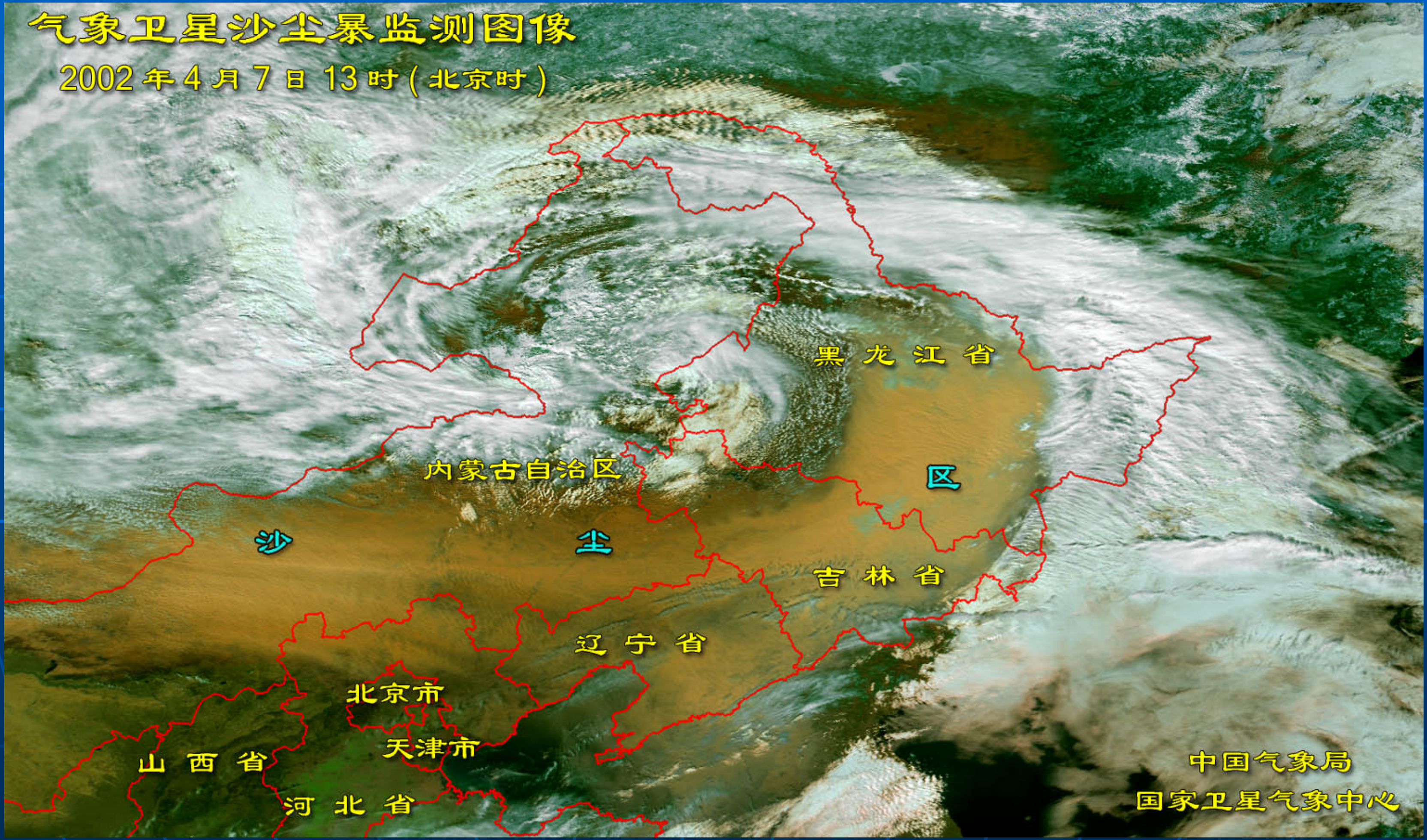
National Satellite Meteorological Center / China Meteorological Administration

Dust storm for 00z on April 7, 2002 (d)

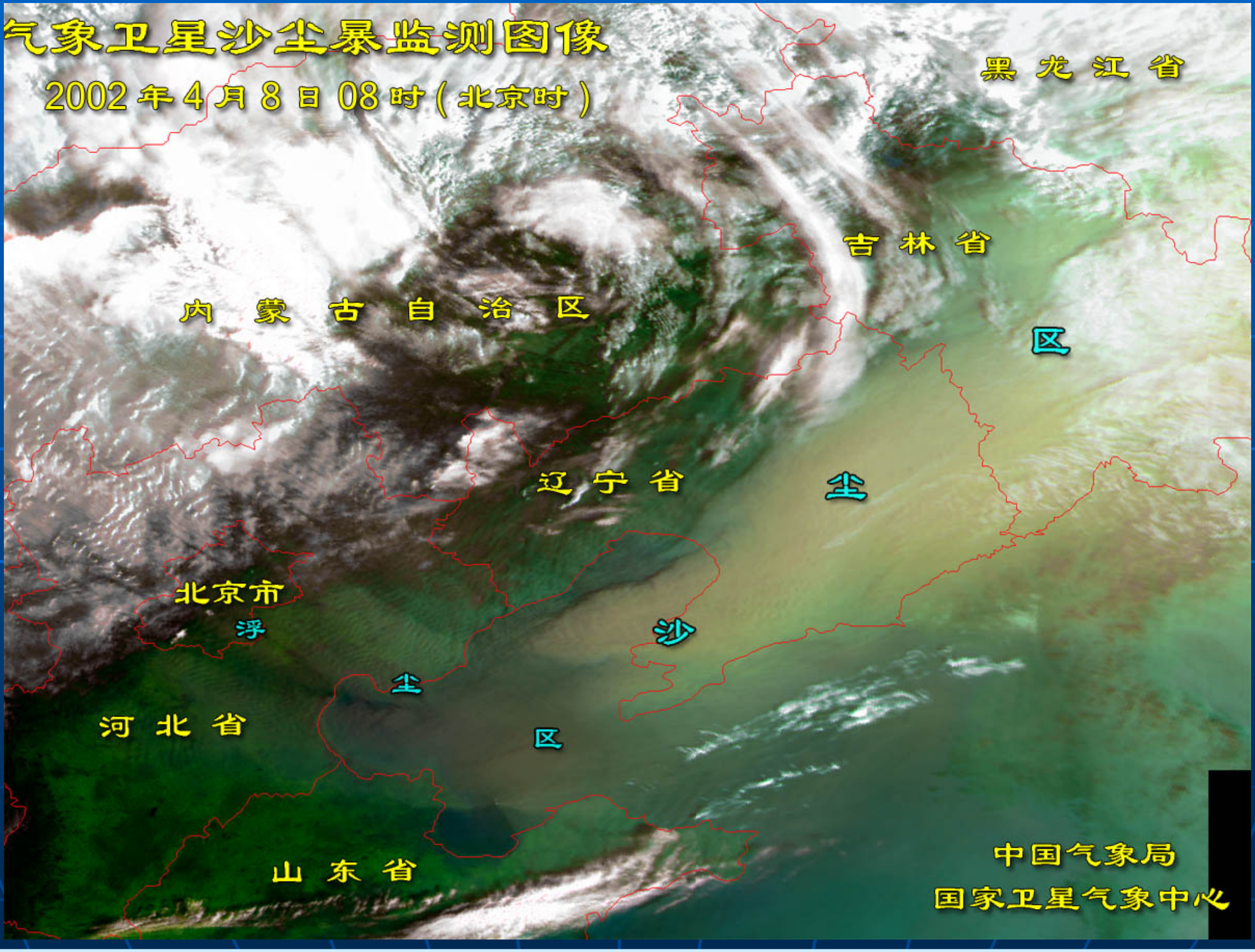
(1.04Mkm^2)

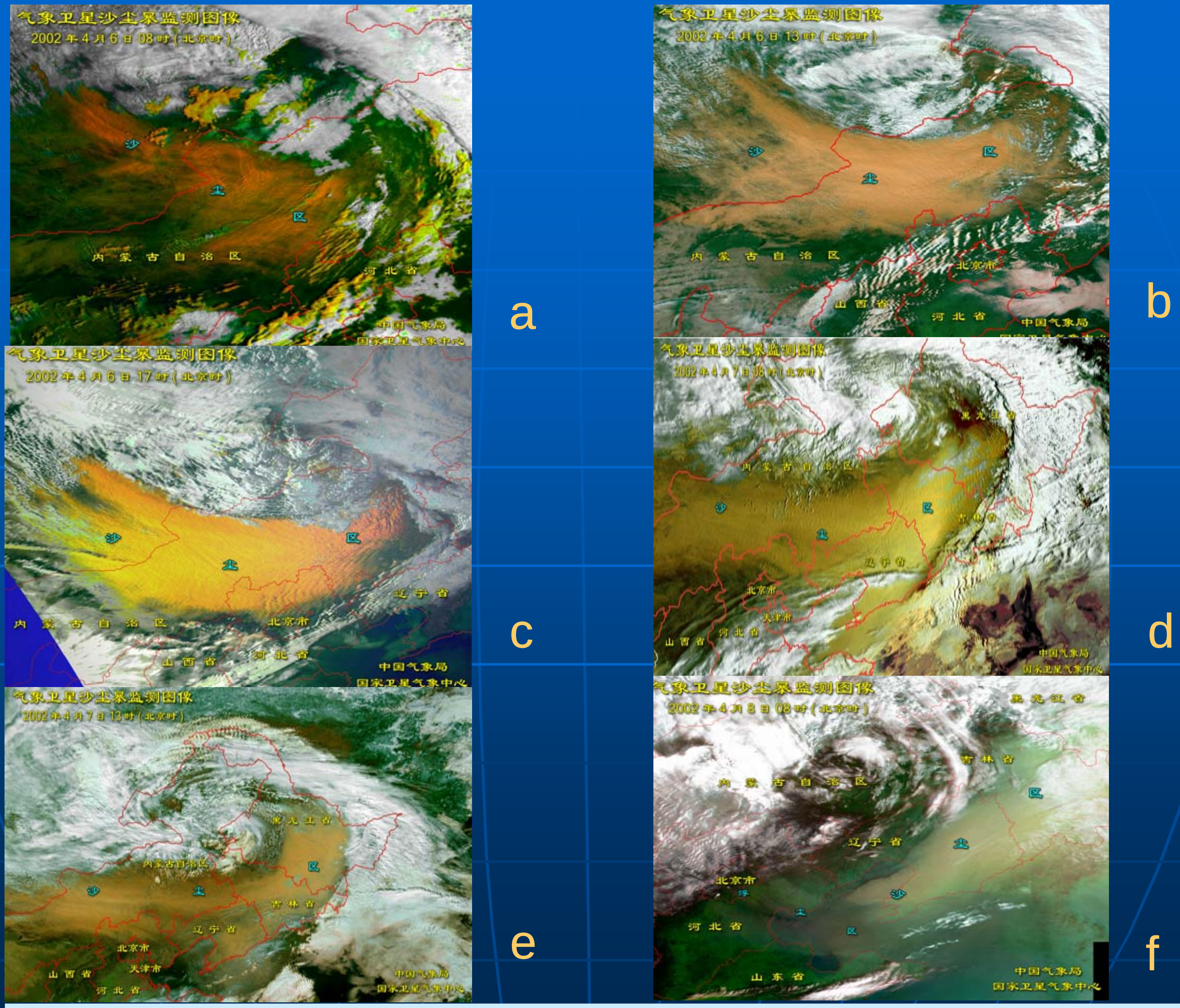


Dust storm for 05z on April 7, 2002 (e)



Dust storm for 00z on April 8, 2002 (f)





气象卫星沙尘暴监测图像
2002年4月6日08时(北京时)
沙
尘
区
内蒙古自治区
河北省
中国气象局
国家卫星气象中心
a
气象卫星沙尘暴监测图像
2002年4月6日13时(北京时)
沙
尘
区
内蒙古自治区
北京市
山西省
河北省
中国气象局
b
气象卫星沙尘暴监测图像
2002年4月6日17时(北京时)
沙
尘
区
辽宁省
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Summery

- Remote Sensing data are important for monitoring dust storm source, path and diffusion of dust storm weather system.

- The prediction of dust activities requires the coupling of dust emission scheme with an atmospheric model. Supported by other modules and adequate Land-Surface parameters.

- Prediction of dust storm spatial pattern, temporal evolution and some parameter, can be given by the NWP model in real time.

- The main dust source regions are the Gobi Desert, the Hexi corridor and deserts in Northeast Asia.

The End