

Dust Storm: An Extreme Climate Event in China

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Definitions of dust weather

Categories	Characteristics	Horizontal visibility	Weather condition
Drifting dust	Dust raised by the wind to a small height above the ground	< 10 km	Weak wind
Blowing dust	Dust raised by the wind to moderate heights above ground	1~10 km	Moderate wind
Dust storm	An ensemble of particles of dust energetically lifted to great heights by a strong and turbulent wind	< 1 km	Strong and turbulent wind



An aerial photograph of Lanzhou, China, taken on March 19. The image shows a wide river, likely the Yellow River, flowing through the city. A large bridge spans the river in the foreground. Several tall buildings are visible, including a prominent one with a circular top on the left and another with a red sign on the right. The city is surrounded by hills, and the overall atmosphere is hazy.

Lanzhou
March 19



Beijing
March 20

A grainy, low-light photograph of a busy street in Seoul, Korea. In the foreground, a group of pedestrians is walking from left to right. To their left, there are several vehicles, including a motorcycle and a car. The background is filled with tall buildings and streetlights, creating a hazy, urban atmosphere. A red traffic light is visible at the top center of the frame.

Seoul, Korea
March 22

Requirements for occurrence of dust storm

- ◆ Sustained high wind at low-level
- ◆ Thermally unstable atmospheric stratification
- ◆ Thick dry soil or sand layer



1. Climatology of dust storms in China

Data sources:

- ◆ Routine observations in surface weather observing stations once every 3 hours (1956-2002)

One day of the dust event is accounted if an individual station observed the dust weather in any time during the day

- ◆ Data from the geostationary and polar-orbit meteorological satellites



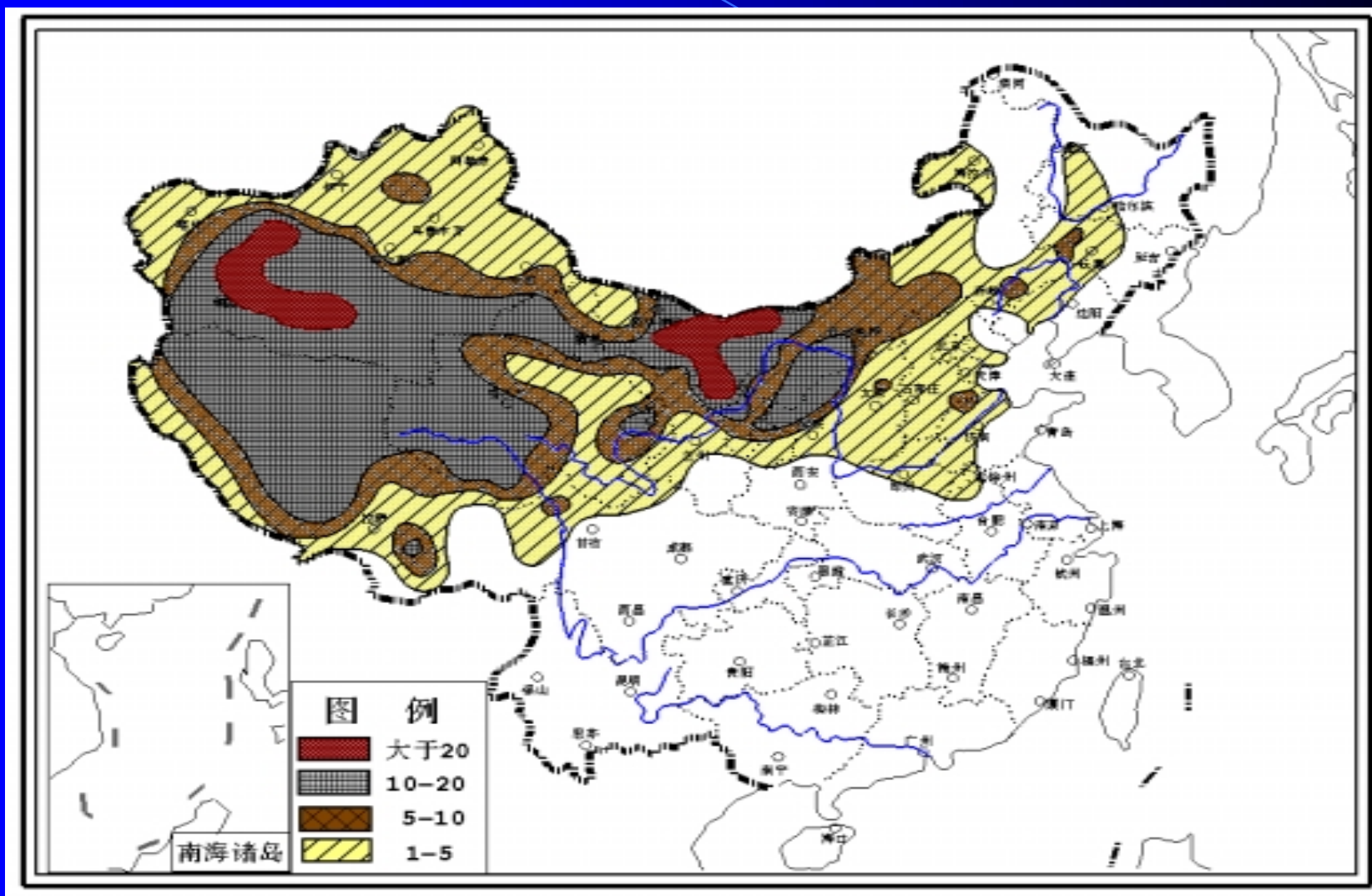
1.1 Geographical distribution of dust storms in China (1956-2000)

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Accumulated annual-mean days of dust storms in 1956-2000



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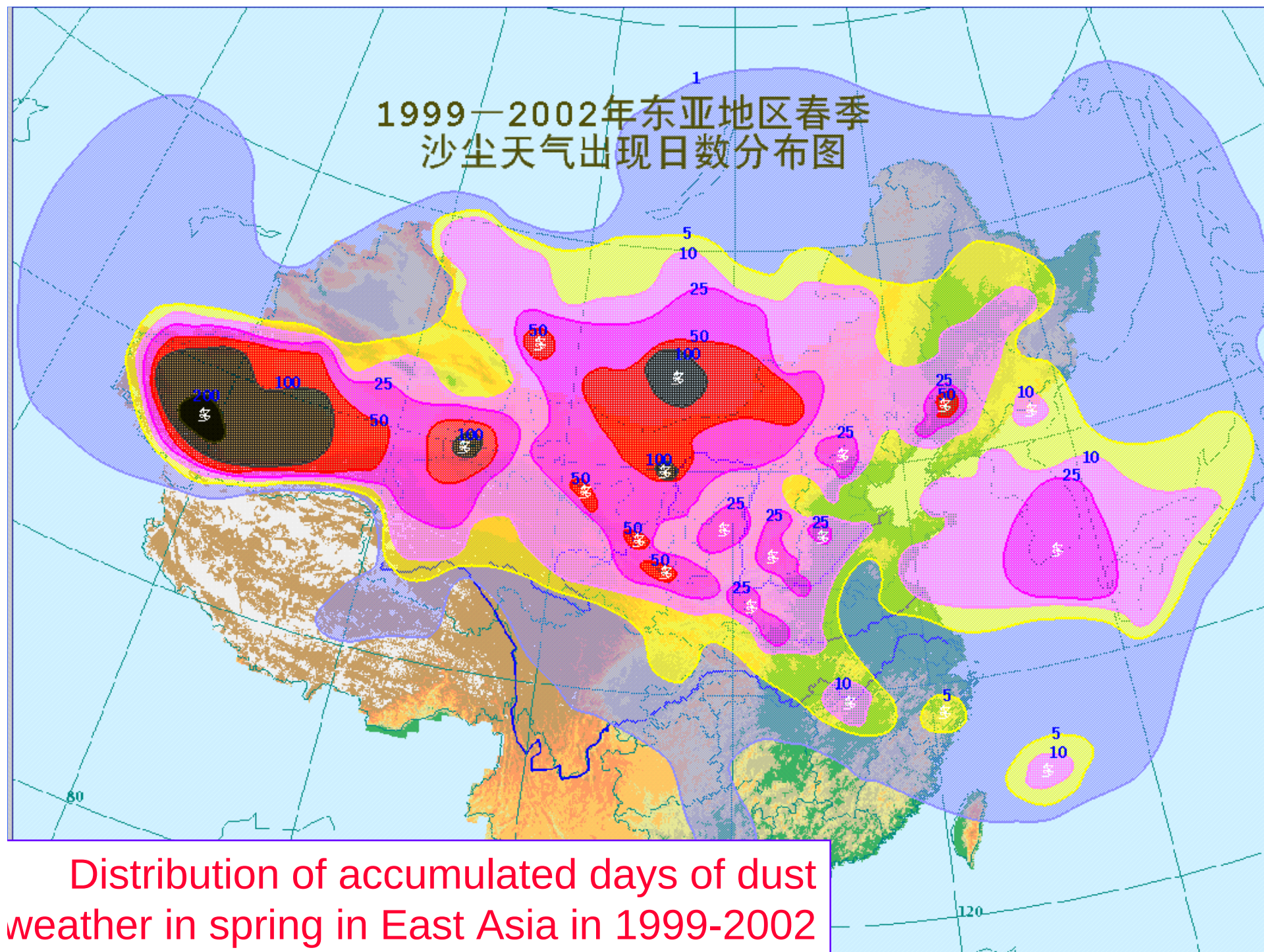
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Facts:

- ◆ Two regions of high frequency (• 10-15days)
 - Most of Xinjiang and southwest Qinghai (Tankla Makan Desert)
 - West Gansu and Inner Mongolia (Gobi Desert)
- ◆ South Xinjiang and West Inner Mongolia have maximum dust storm days (20-30days)



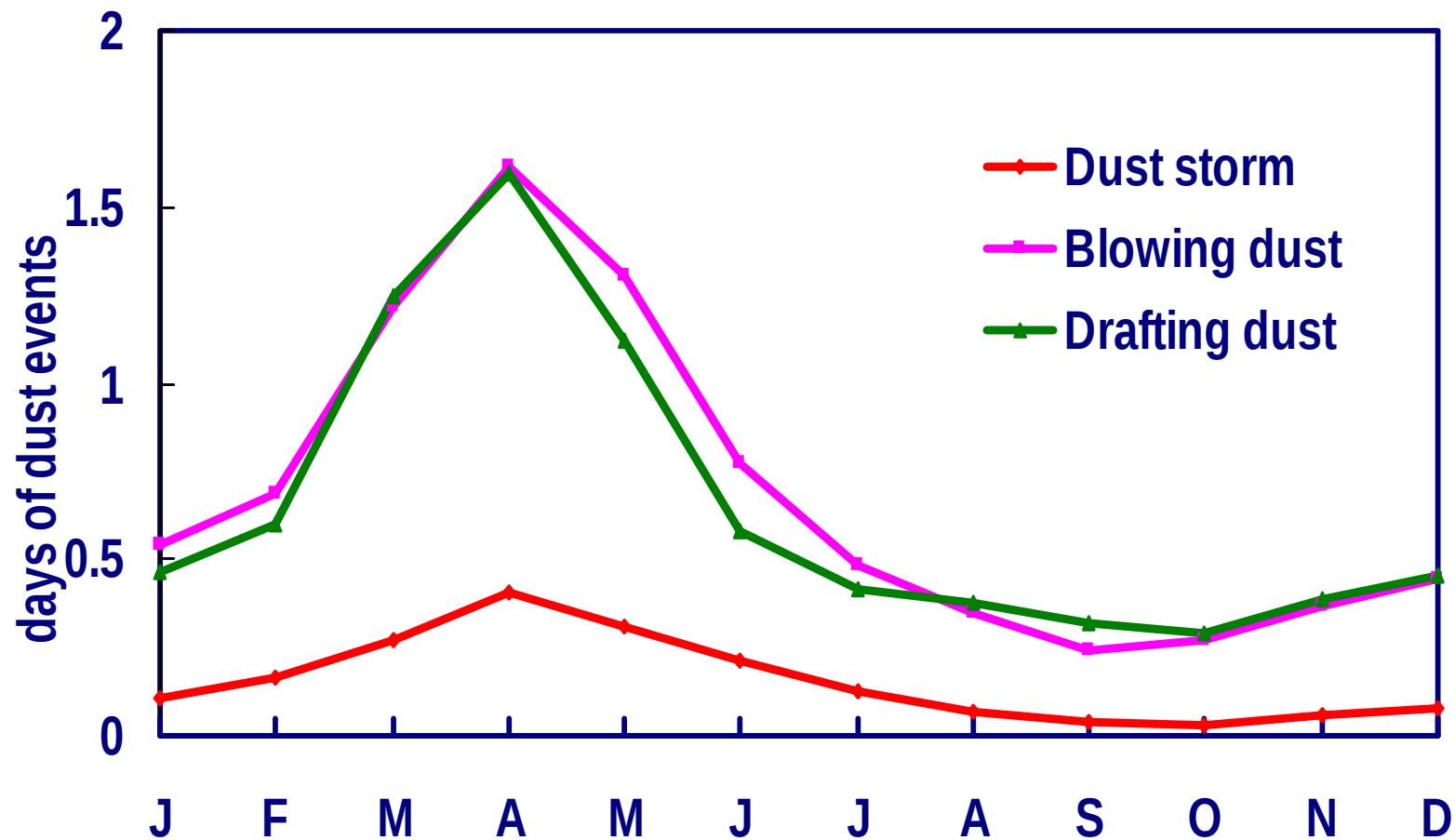


1.2 Seasonal distribution of occurrence of dust storms

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Monthly variation of dust-weather days in China
(data from 1961 to 2000)

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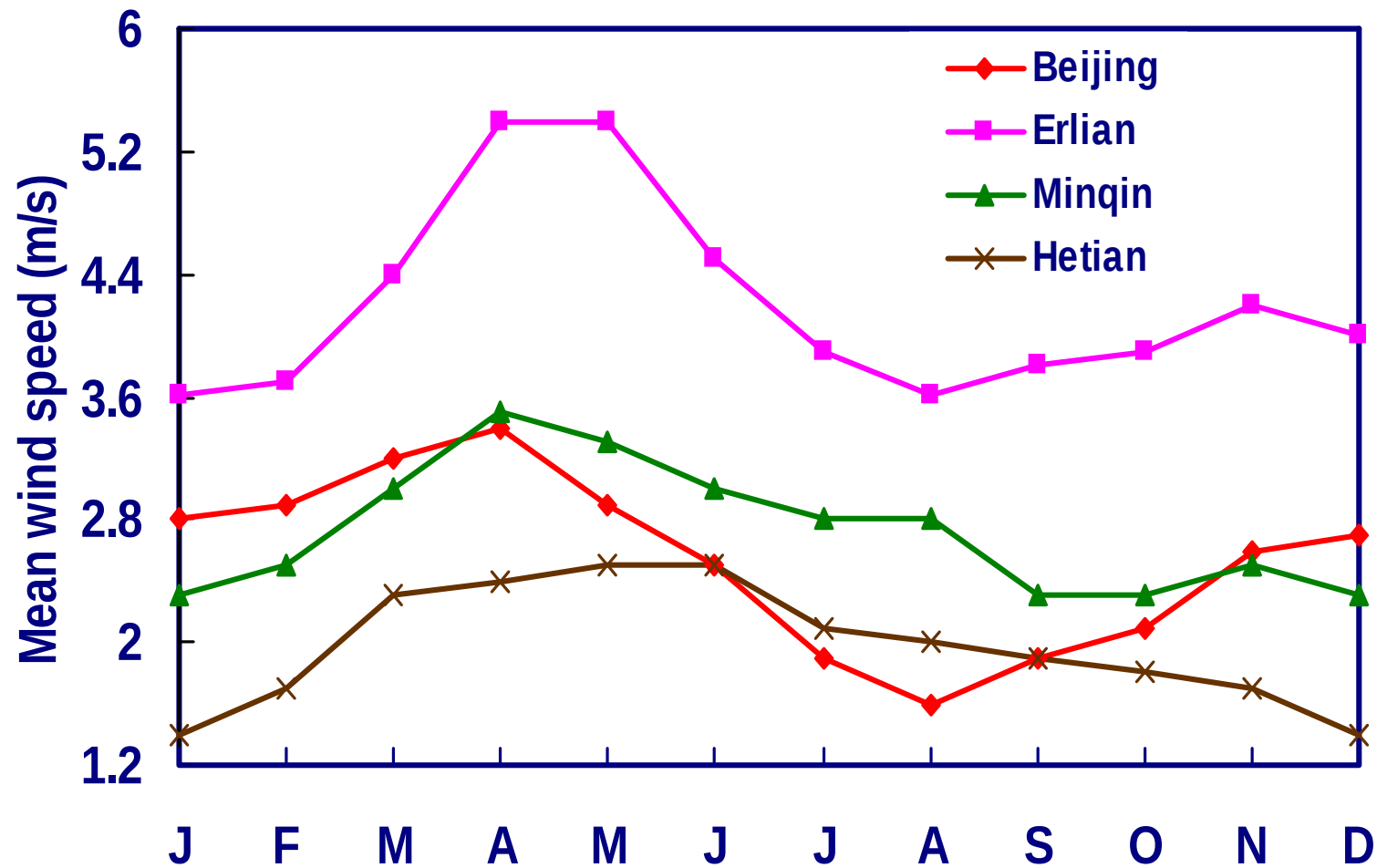
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Seasonal distribution

- ◆ The maximum frequency season: **spring**
(March-May) with peak in April
- ◆ The second peak season: **winter**
- ◆ The minimum occurrence season: **summer**





The variation of month-average wind speed

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1.3 Main tracks of dust storms in China

Three paths:

North-westerlies

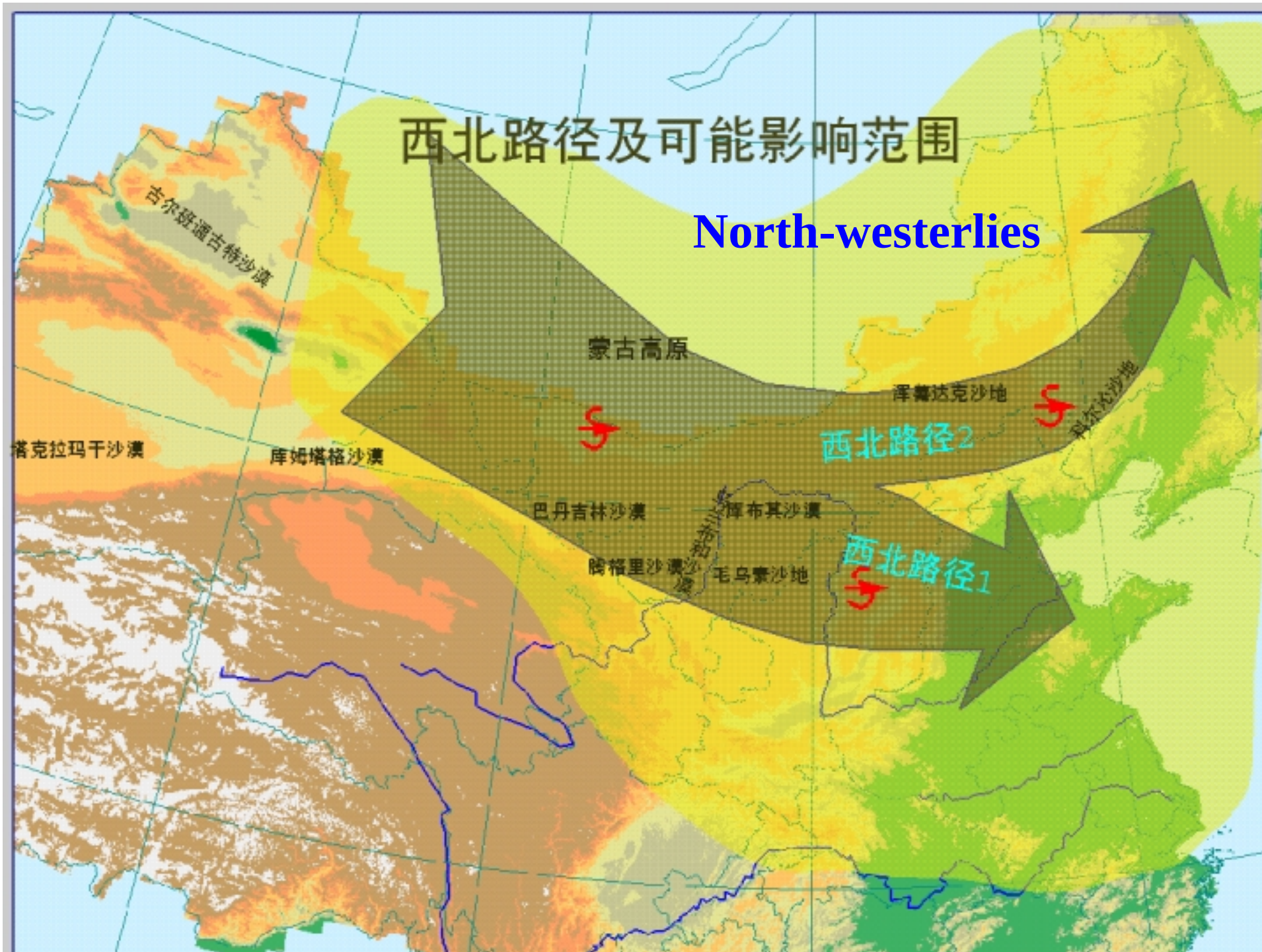
Westerlies

Northerlies



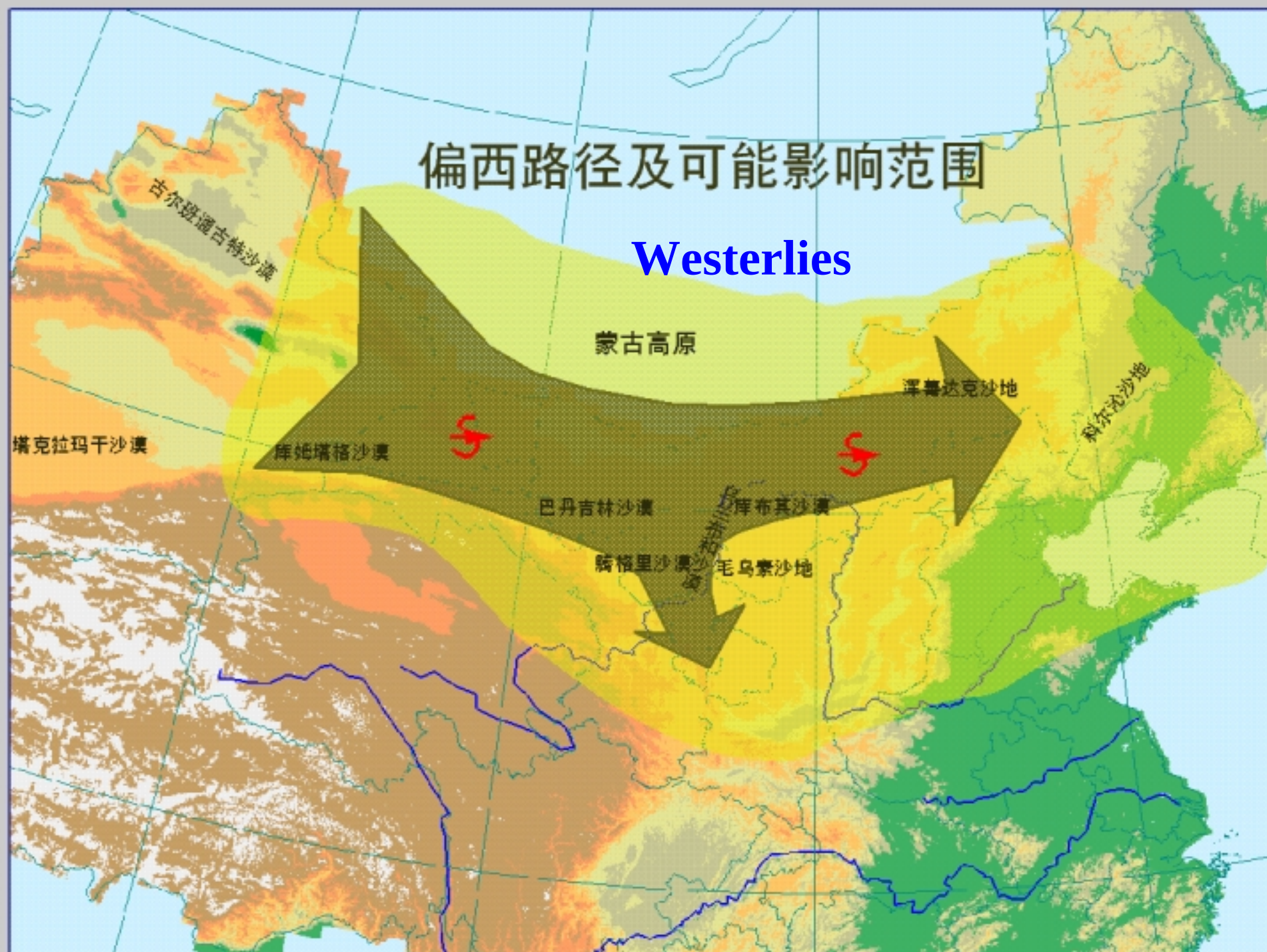
西北路径及可能影响范围

North-westerlies



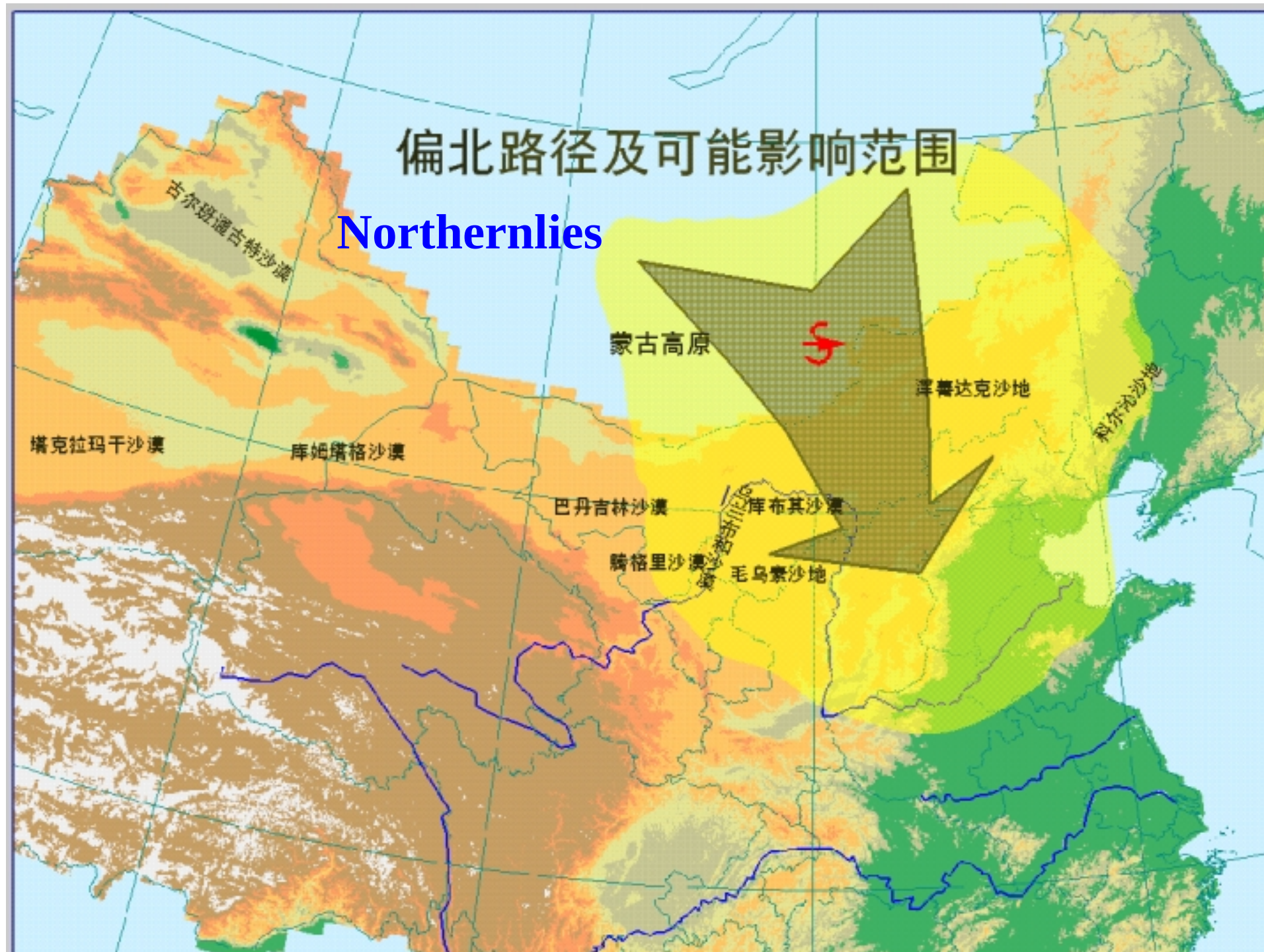
偏西路径及可能影响范围

Westerlies

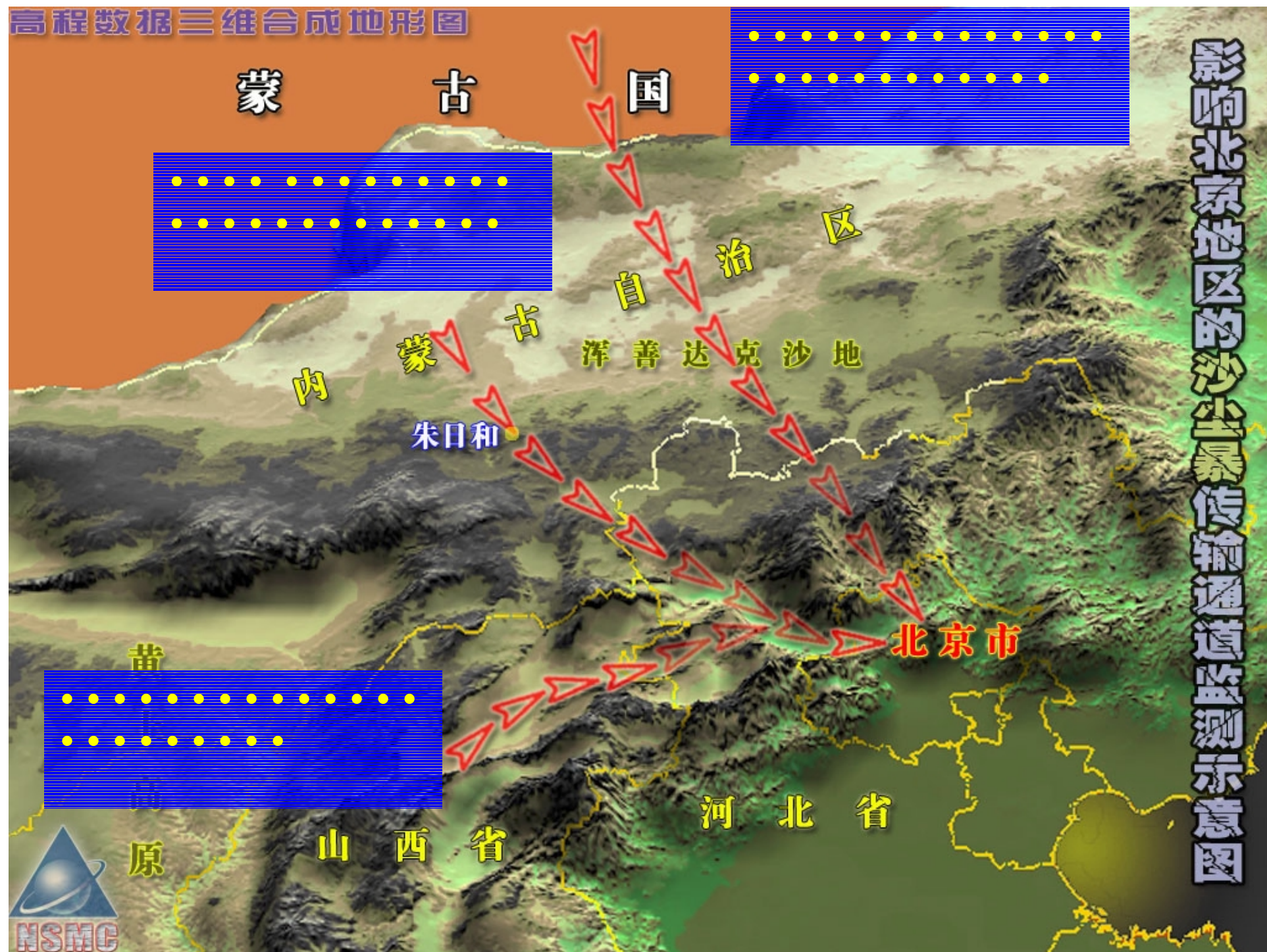


偏北路径及可能影响范围

Northernlies



高程数据三维合成地形图



Statistics of dust weather in China in 1999—2002

Year	NW 1	NW 2	West	North
1999	8	0	1	0
2000	8	0	1	5
2001	9	2	3	4
2002	6	2	2	2
Total	31	4	7	11
%	58%	8%	13%	21%



1.4 Source regions of dust weather events which hit China in 1999-2002

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Source regions of dust weather which hit China in 1999-2002

Year	Total dust events	Outside of China	Inside of China
1999	9	2	7
2000	14	9	5
2001	18	14	4
2002	12	8	4
Sum	53	33	20

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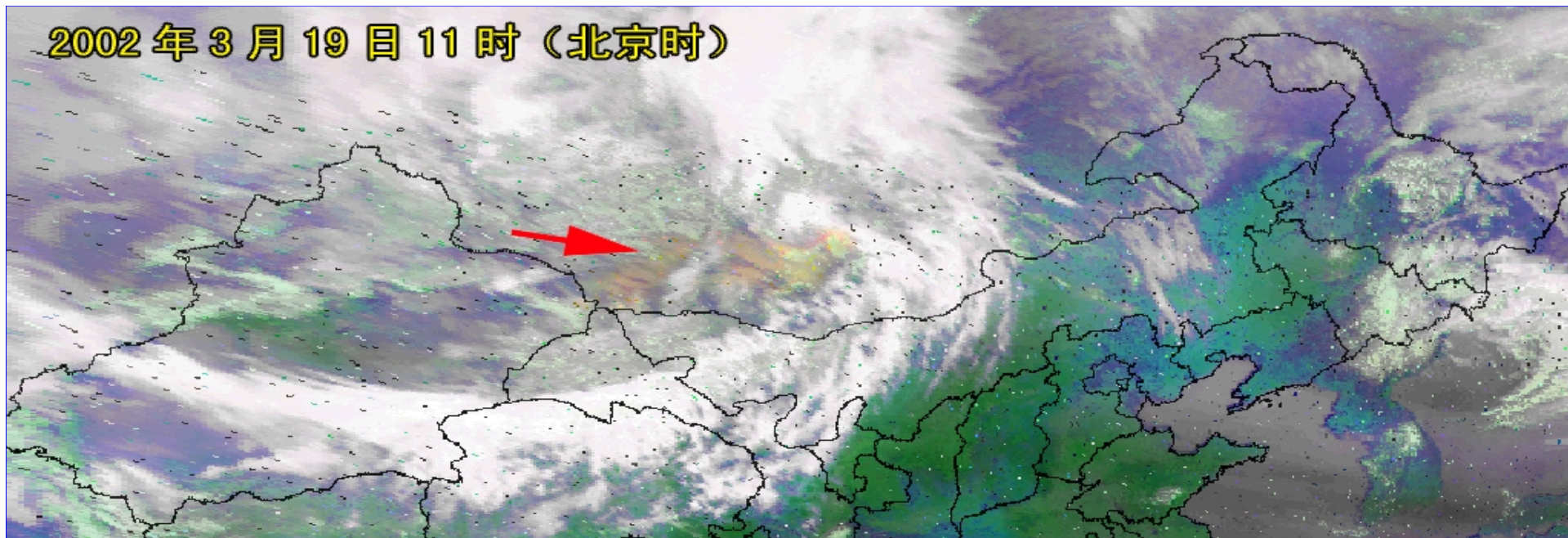
Satellite images showing the typical dust storms in 2002

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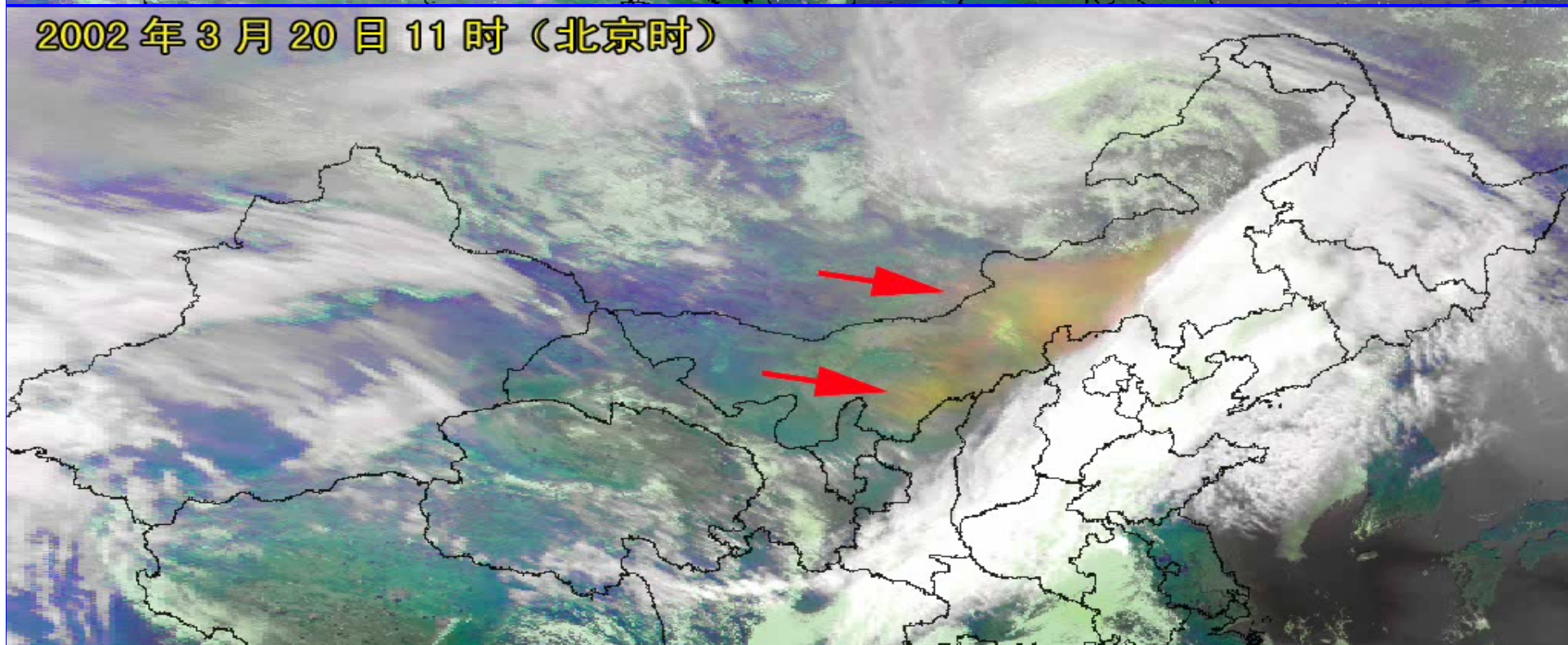
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2002 年 3 月 19 日 11 时 (北京时)

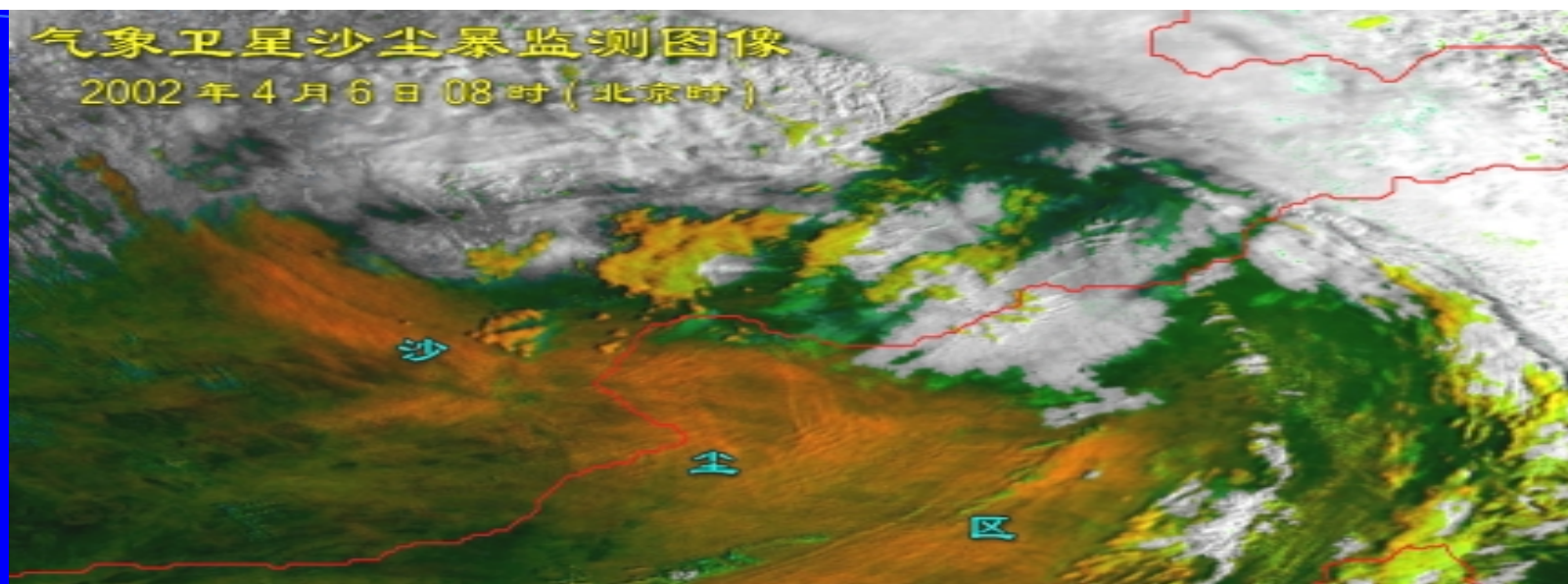


2002 年 3 月 20 日 11 时 (北京时)



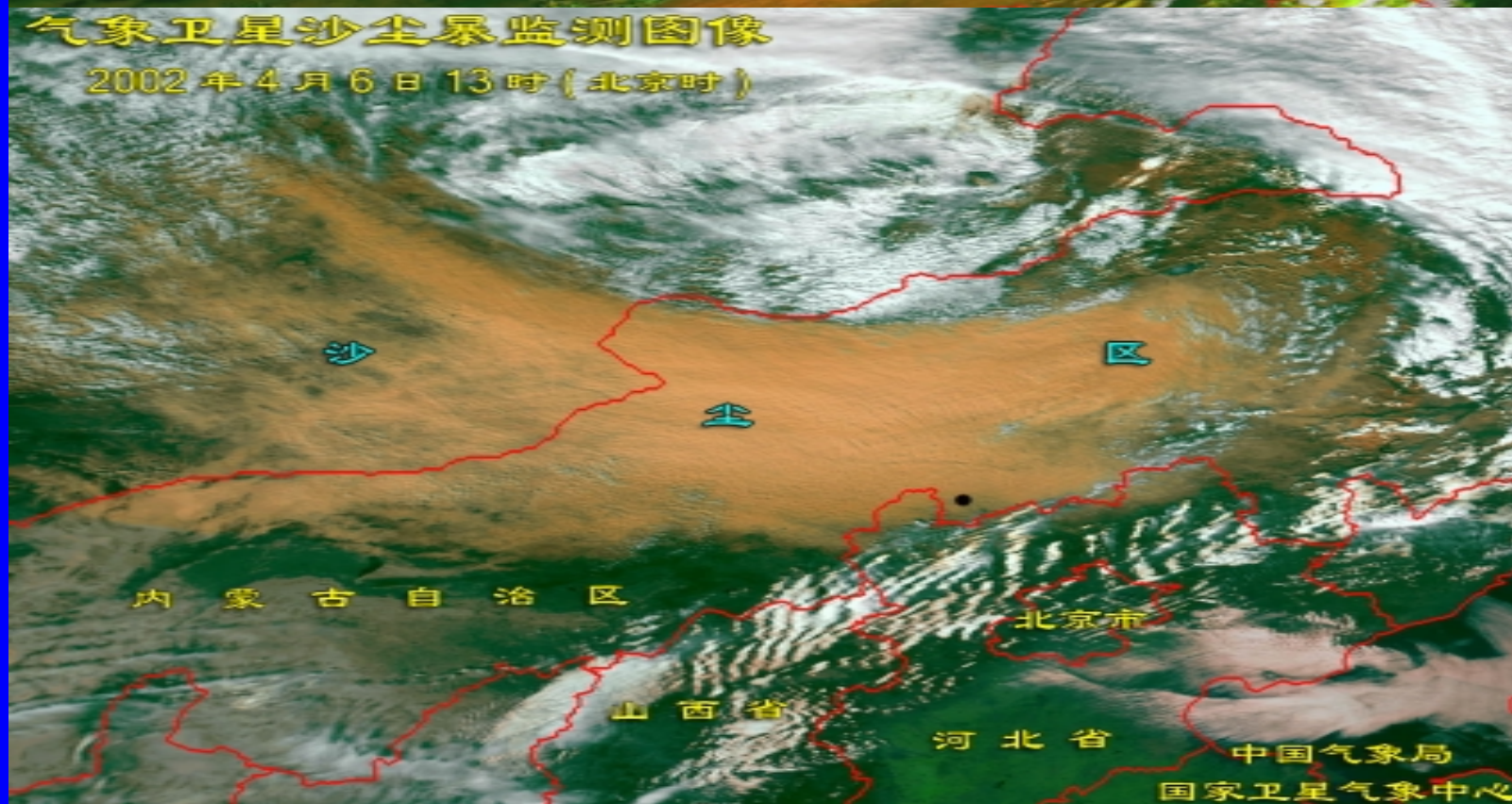
气象卫星沙尘暴监测图像

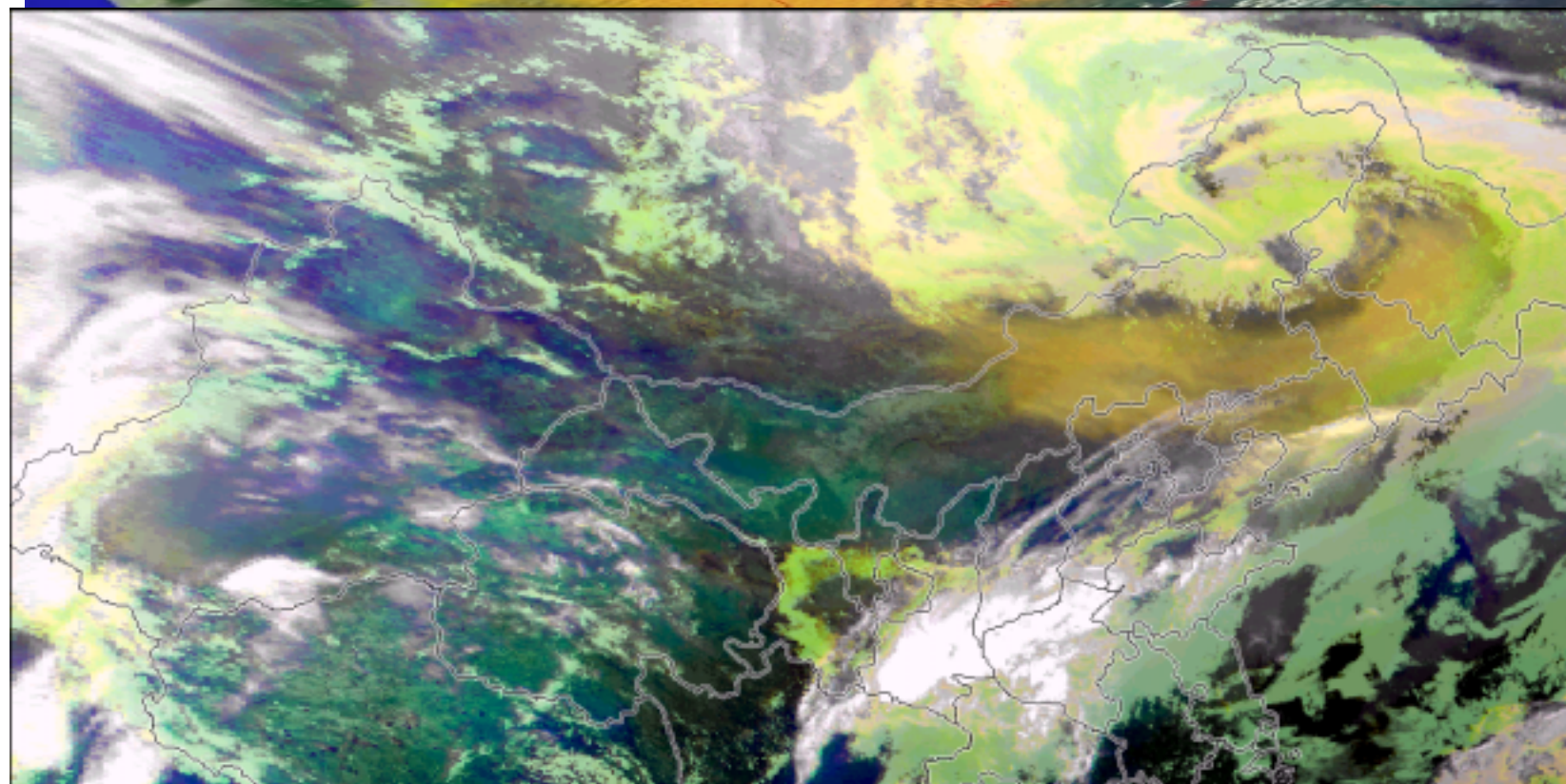
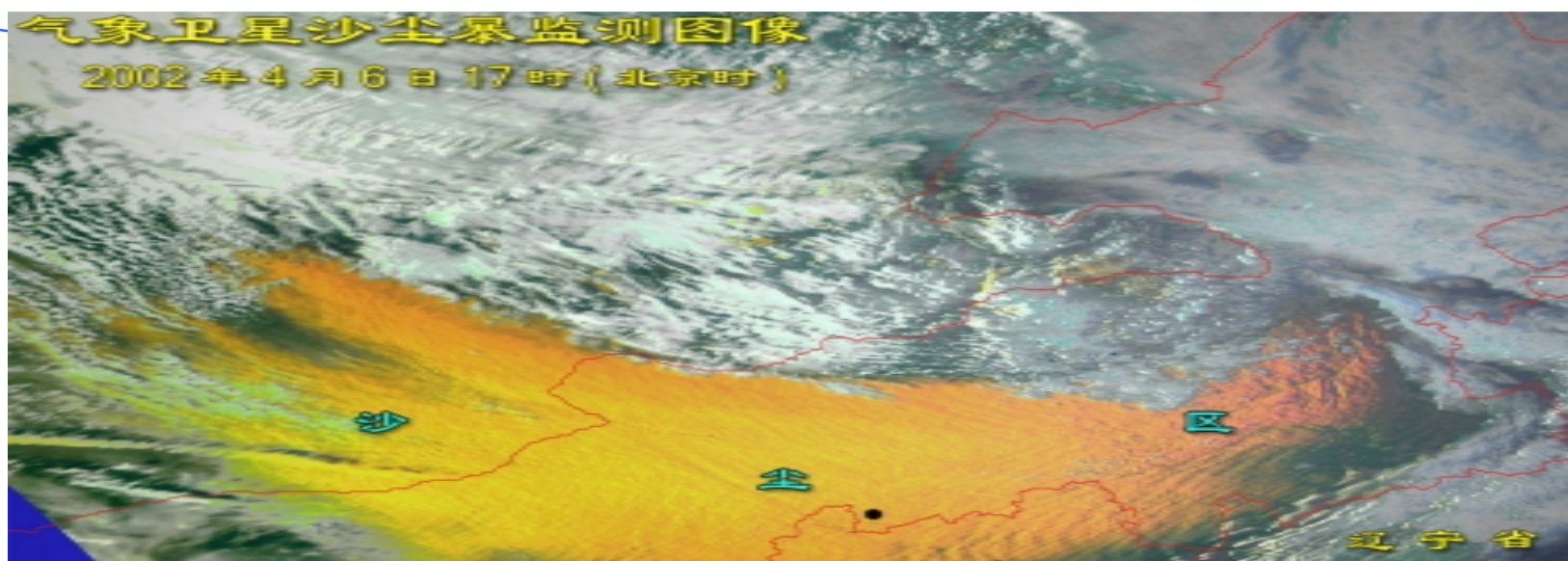
2002年4月6日08时(北京时间)



气象卫星沙尘暴监测图像

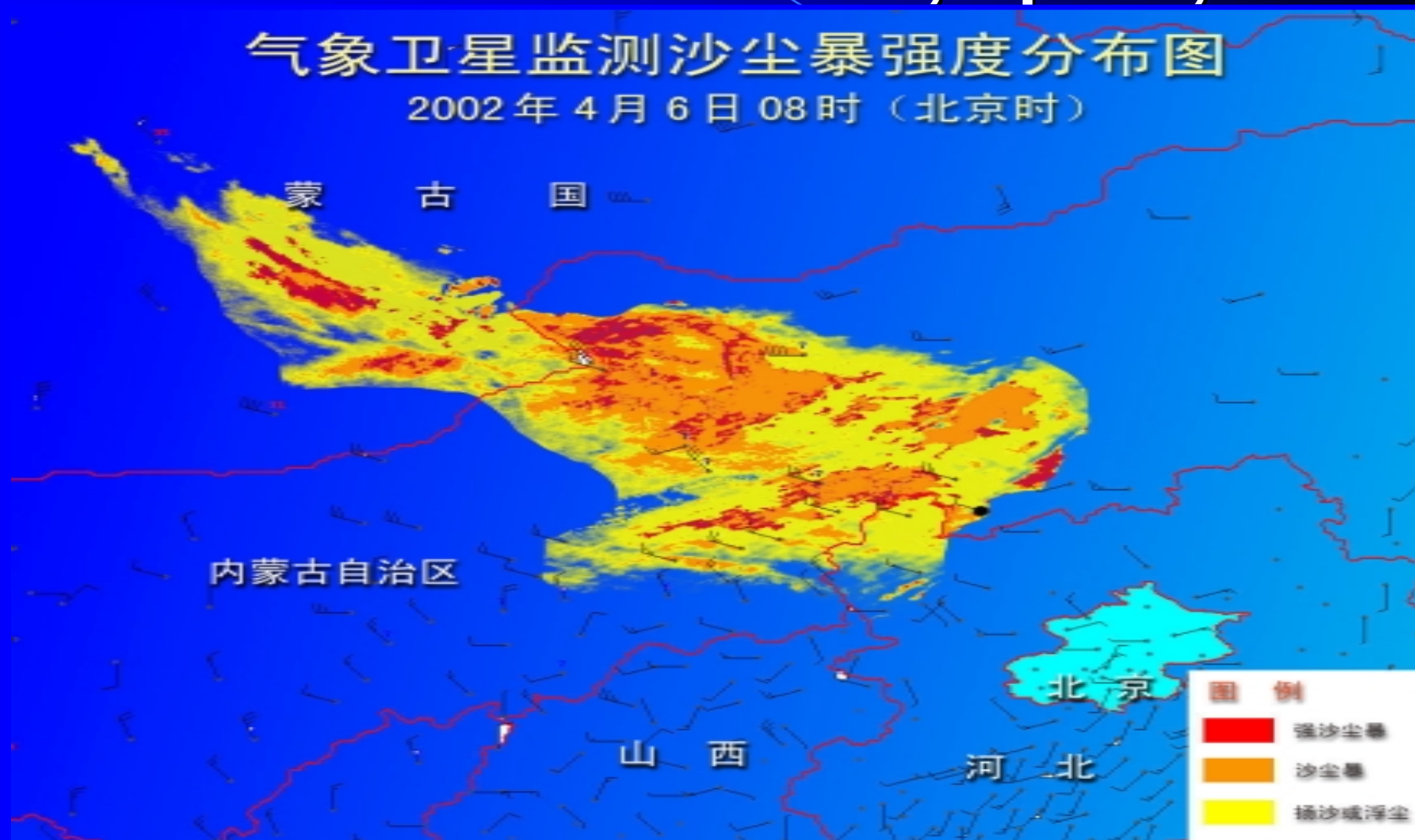
2002年4月6日13时(北京时间)





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Distribution of intensity of dust storm at 08:00, April 6, 2002



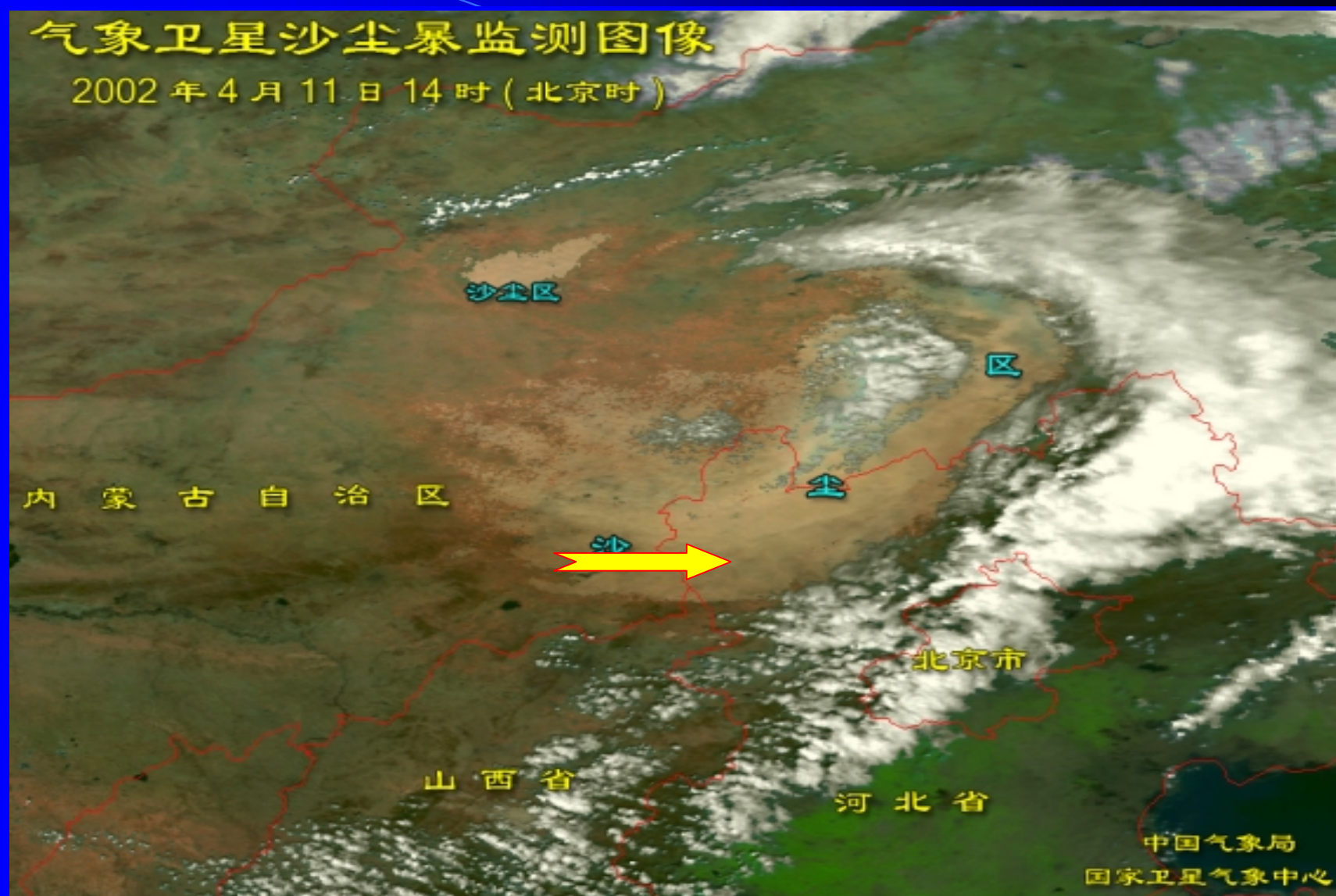
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气象卫星沙尘暴监测图像

2002年4月11日14时(北京时间)



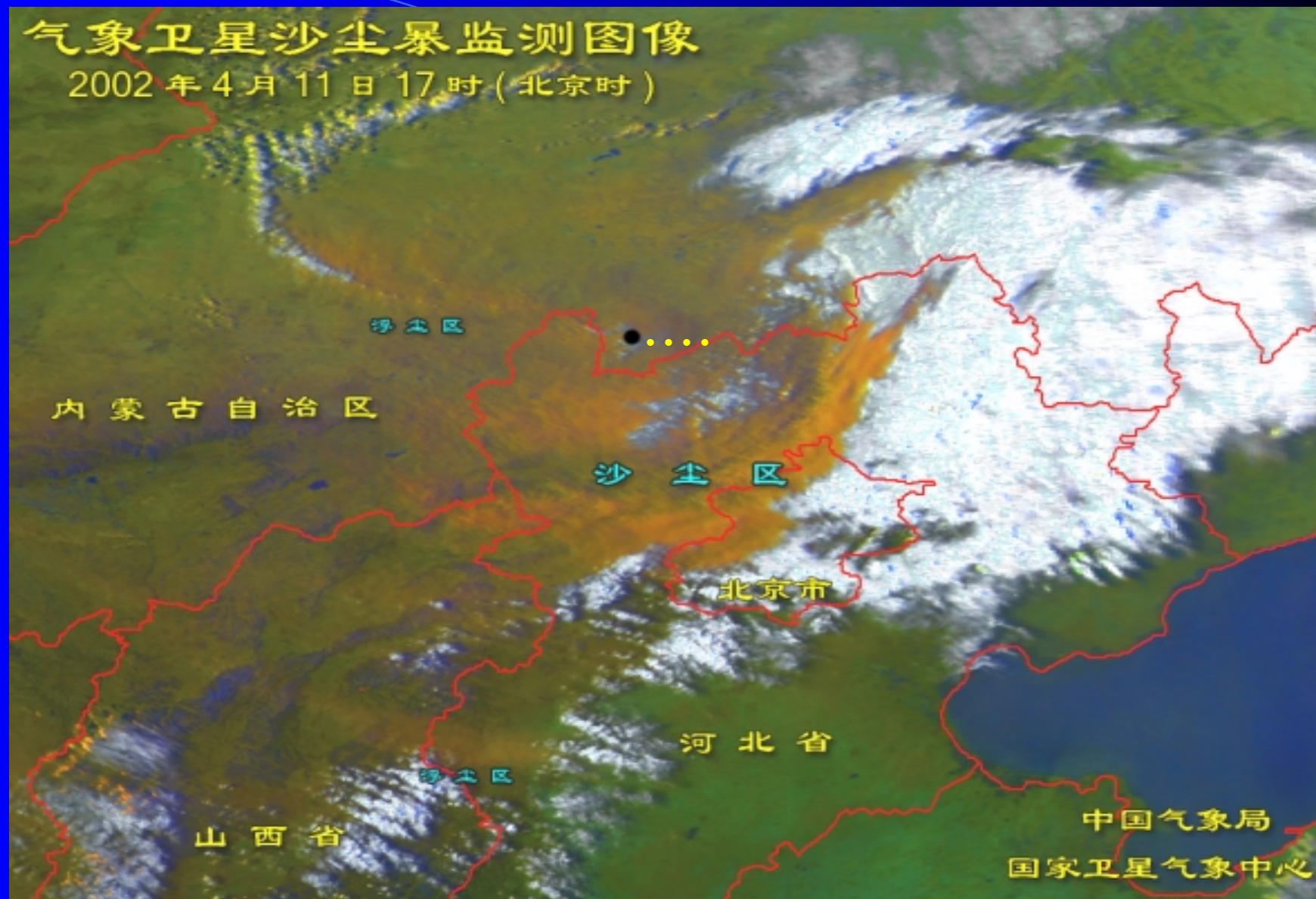
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气象卫星沙尘暴监测图像

2002年4月11日17时(北京时间)

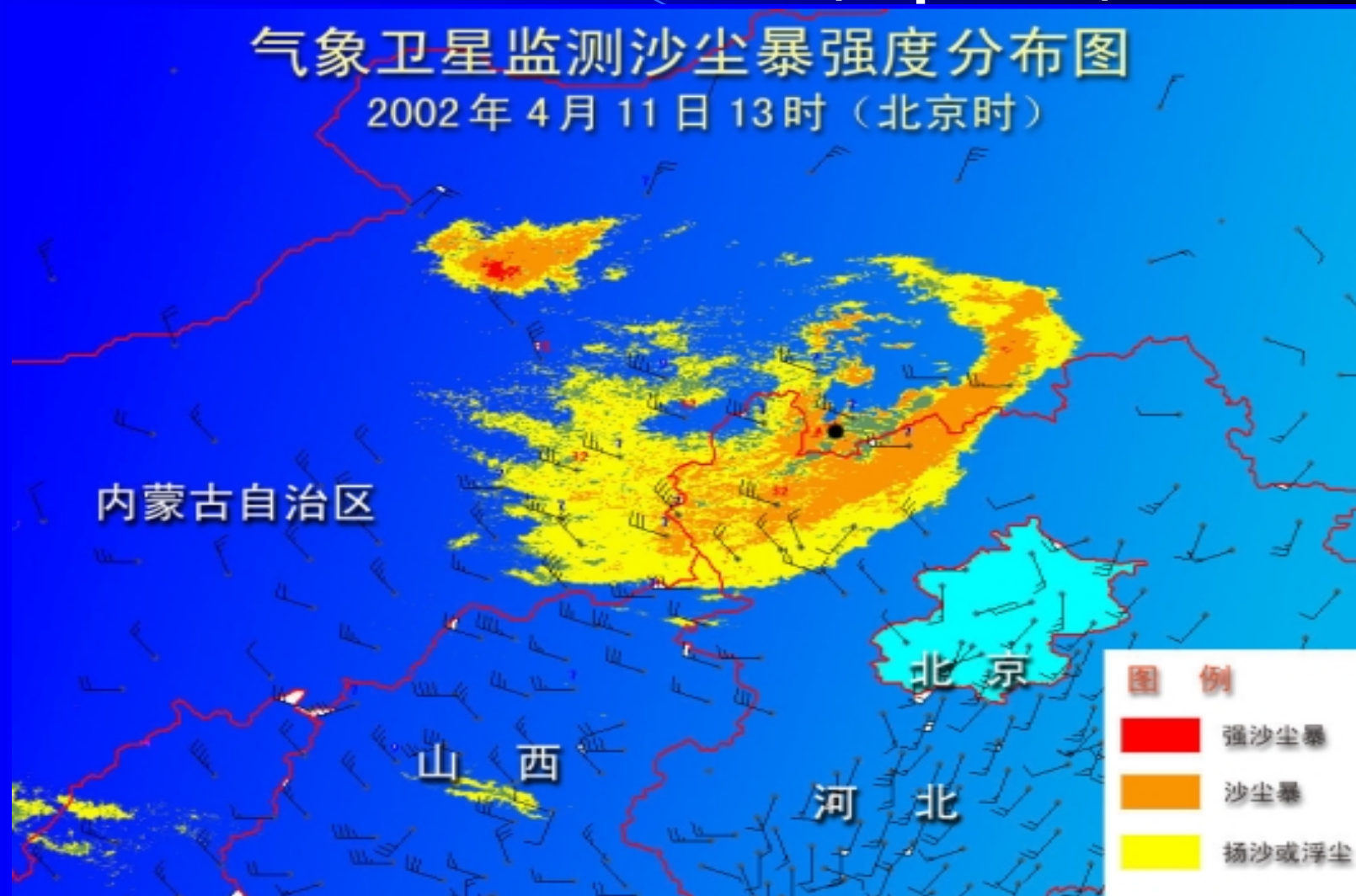


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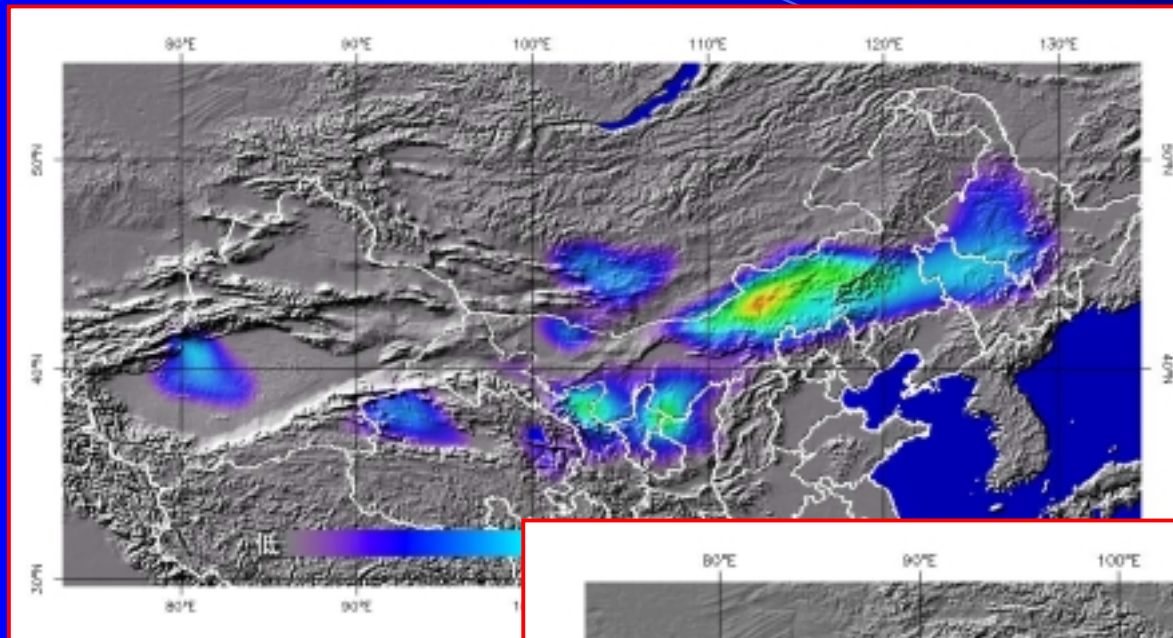
Distribution of intensity of dust storm at 13:00, April 11, 2002



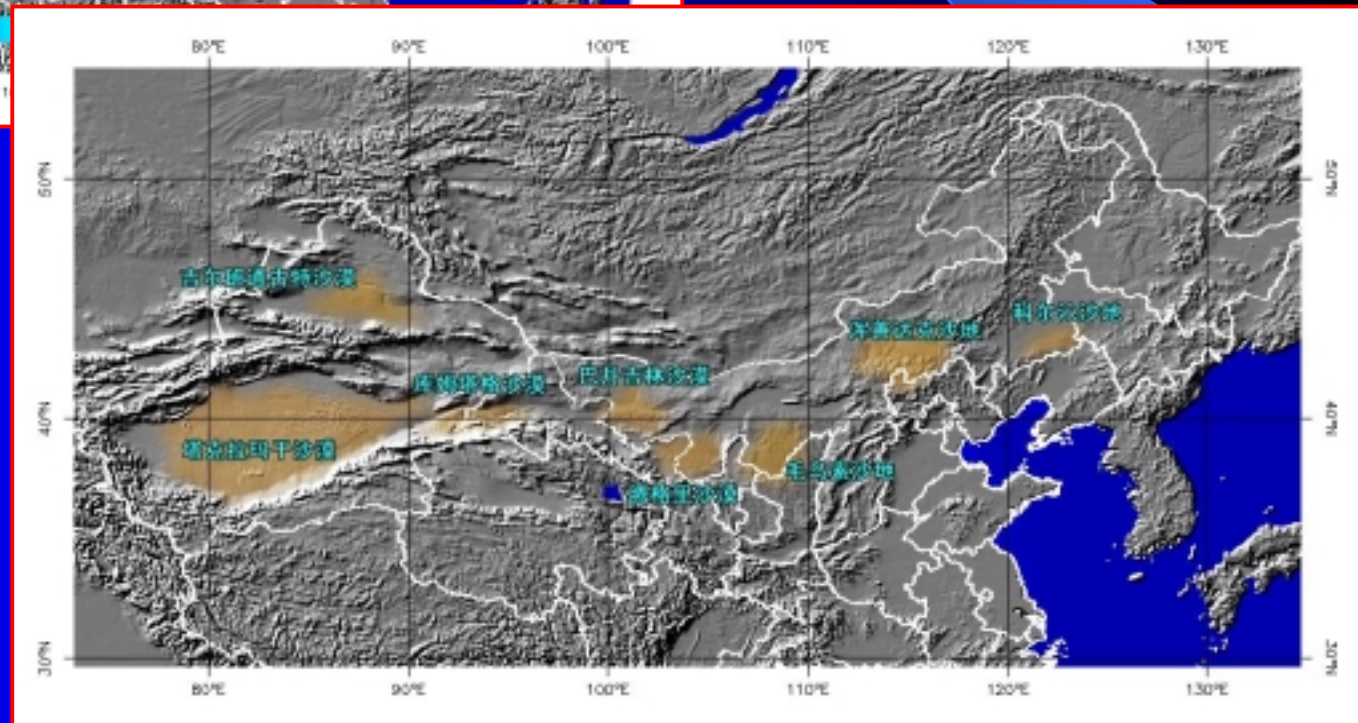
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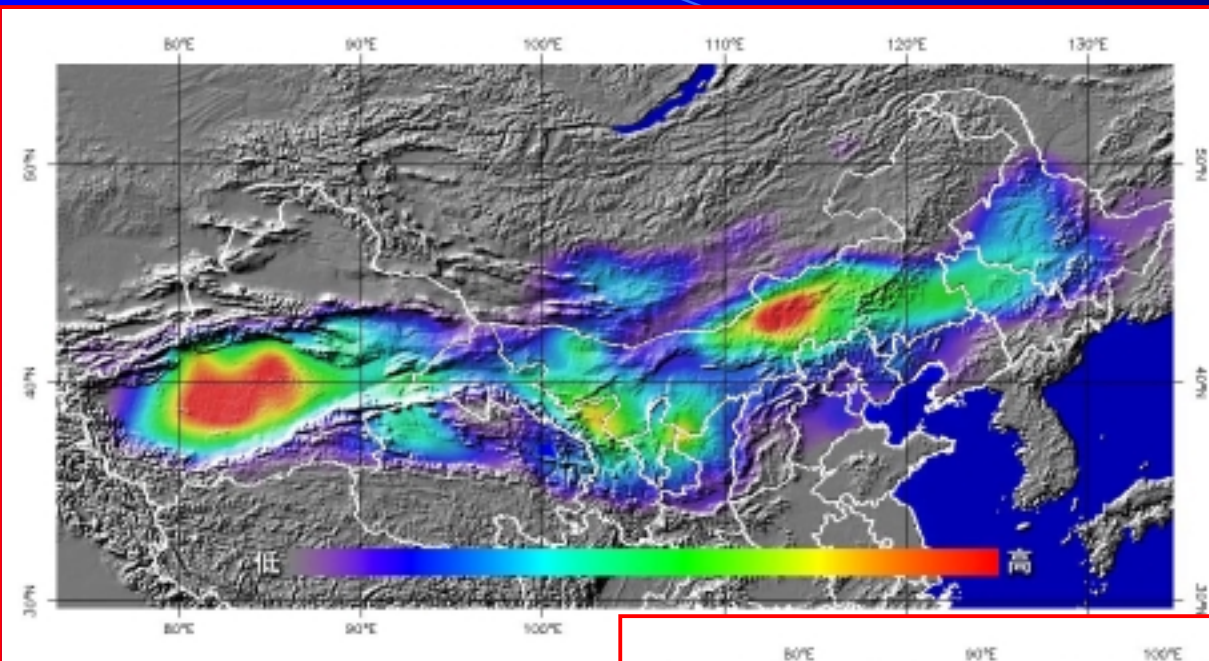




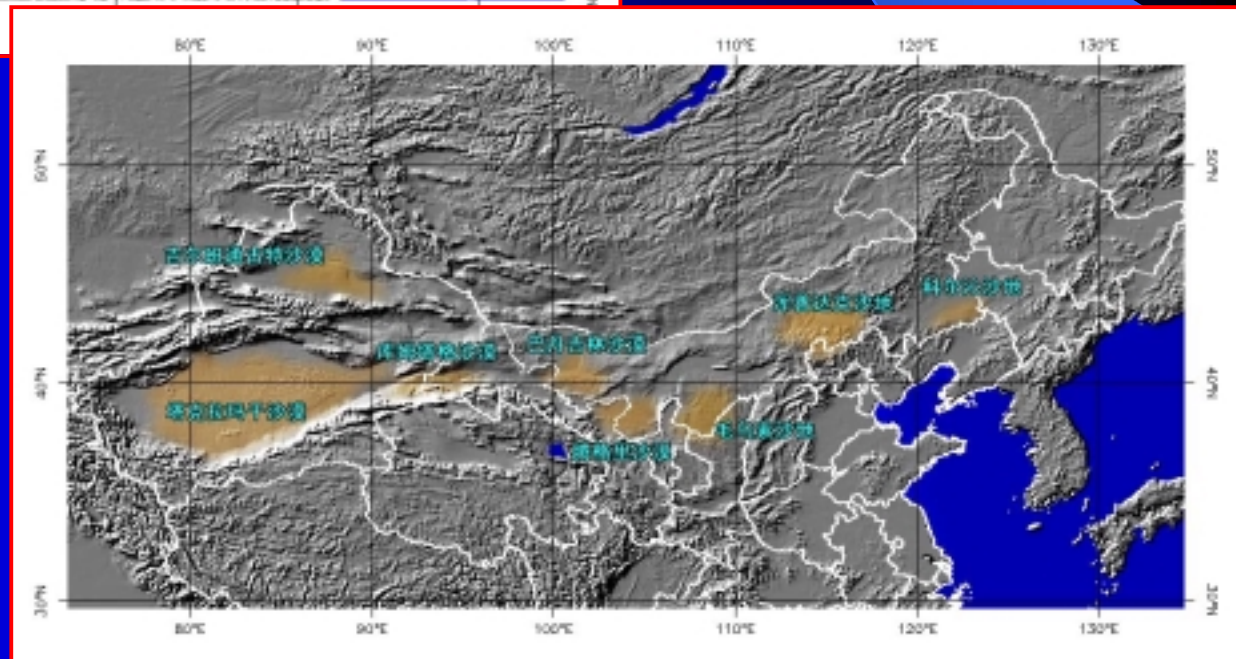
The regions which contribute to spring dust weather in East Asia



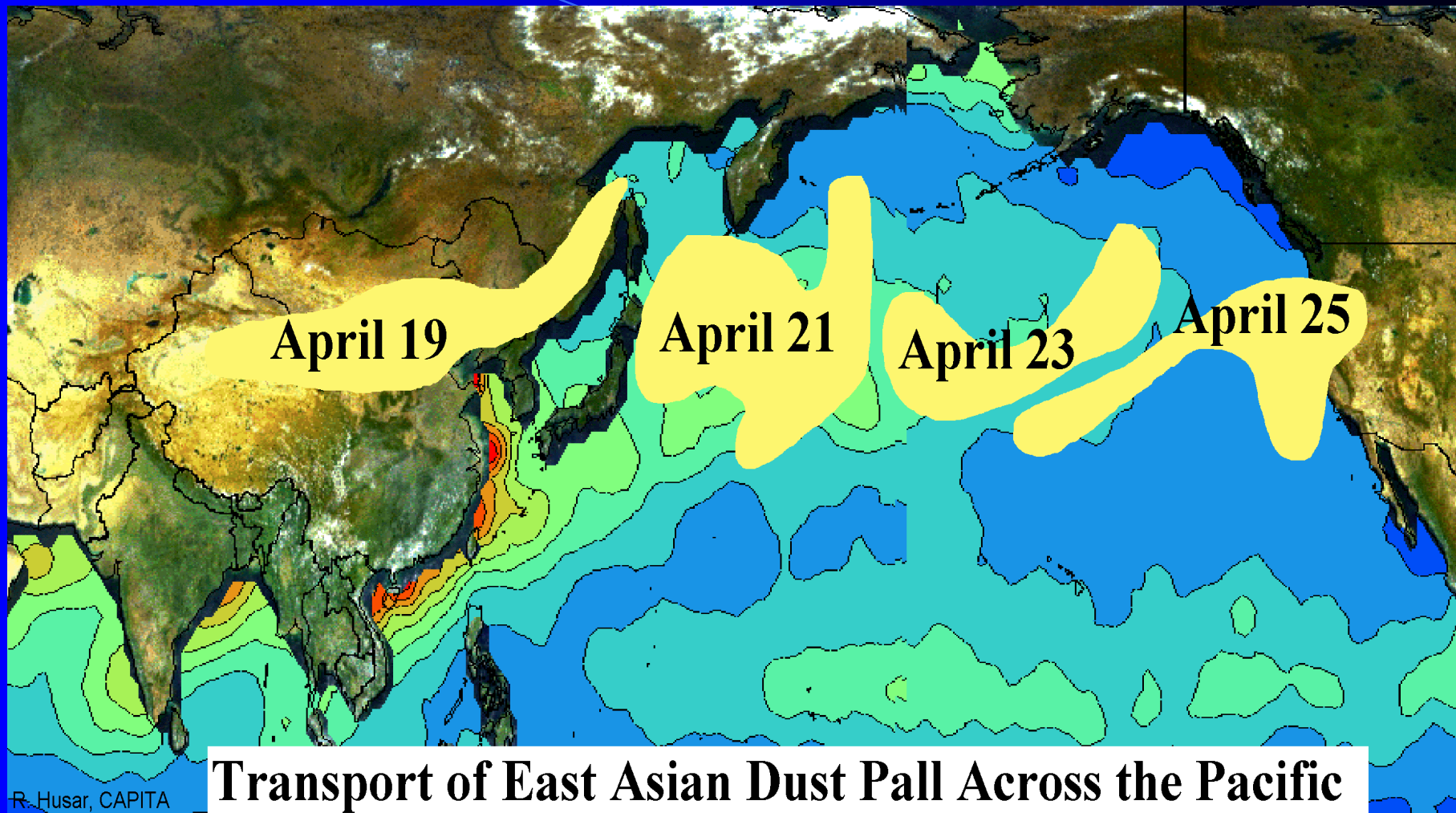
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The regions in the development of spring dust weather in East Asia



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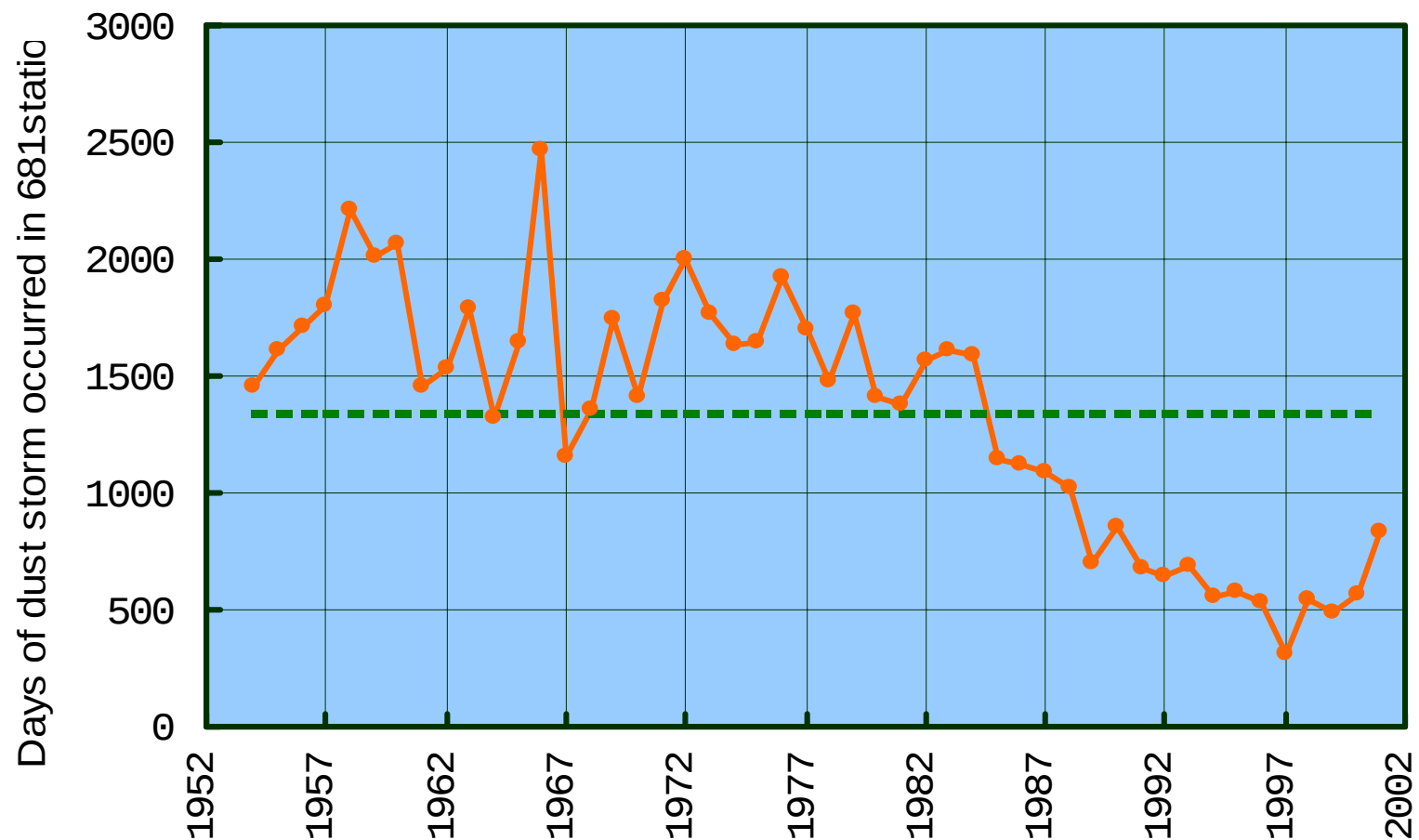
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2. Long-term variation of the frequency of dust storms and its possible link to climate change or variability in East Asia

2.1 Time-series of accumulated days of dust storms from 1954 to 2001





Long-term variation of annual accumulated days of dust weather in China (data from 681 surface stations)

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2.2 Significant decadal variation

- High frequency period: 50's-70's
- Decreasing frequency period: 1982-1997
- Recent increase since 1998

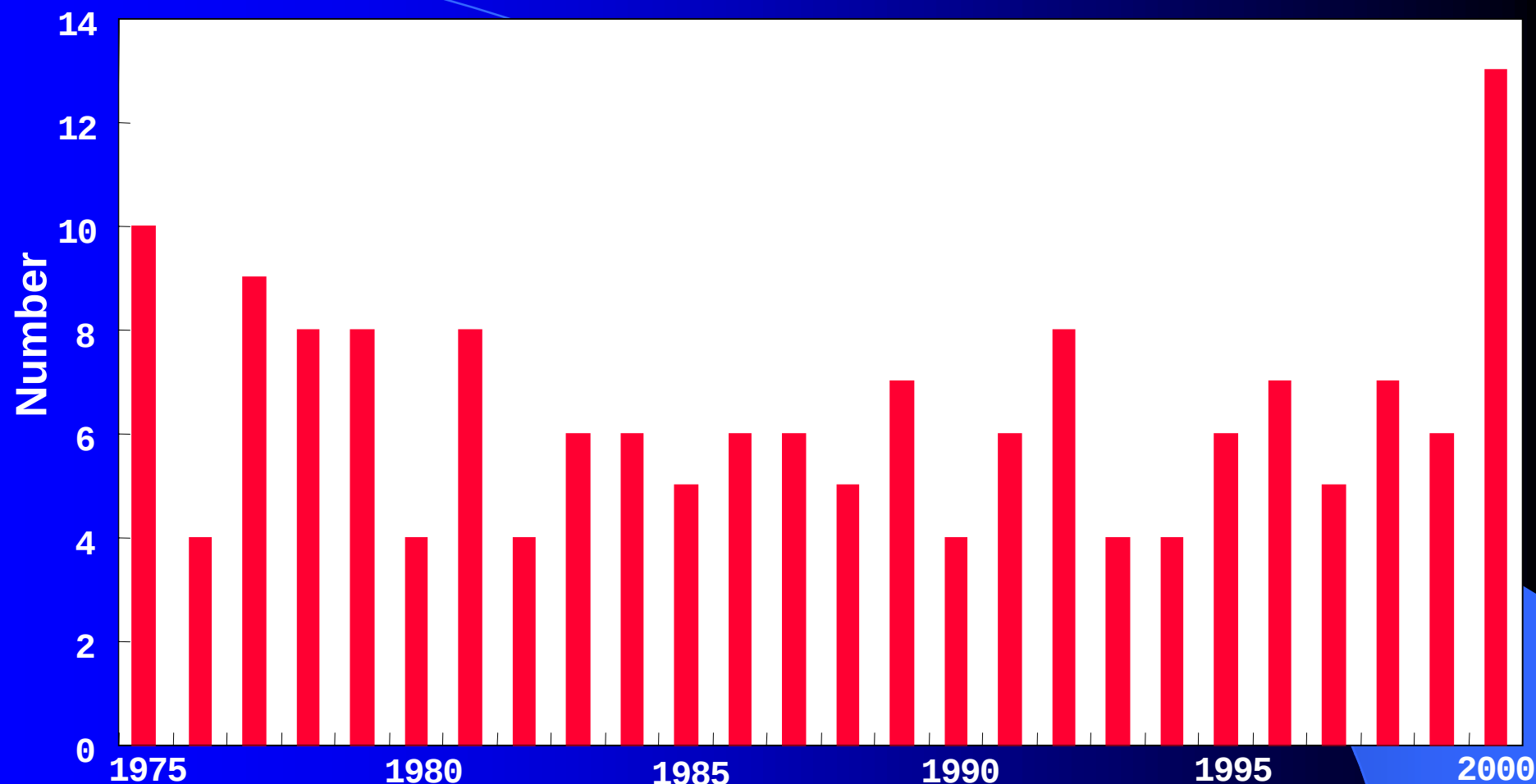


2.3 Significant seasonal variation

→ High frequency season:

Cold and dry seasons with frequent development of extra-tropical cyclones and cold waves



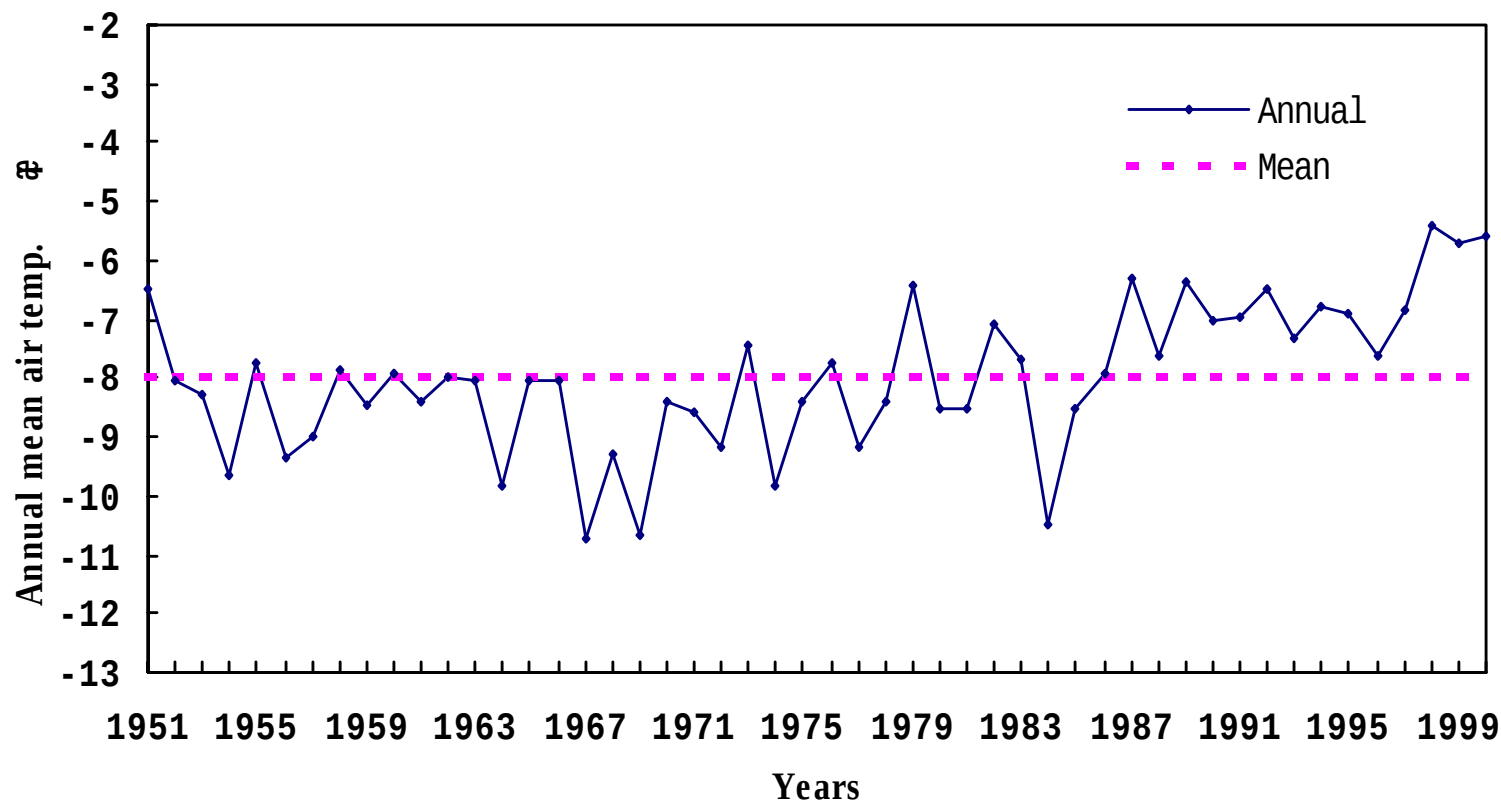


Long-term variation of numbers of extra-tropical cyclones in March-April in Mongolia and North China

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**Long-term variation of winter mean temp.
in the northern China** (Dec.-Feb. of 1951-1999)

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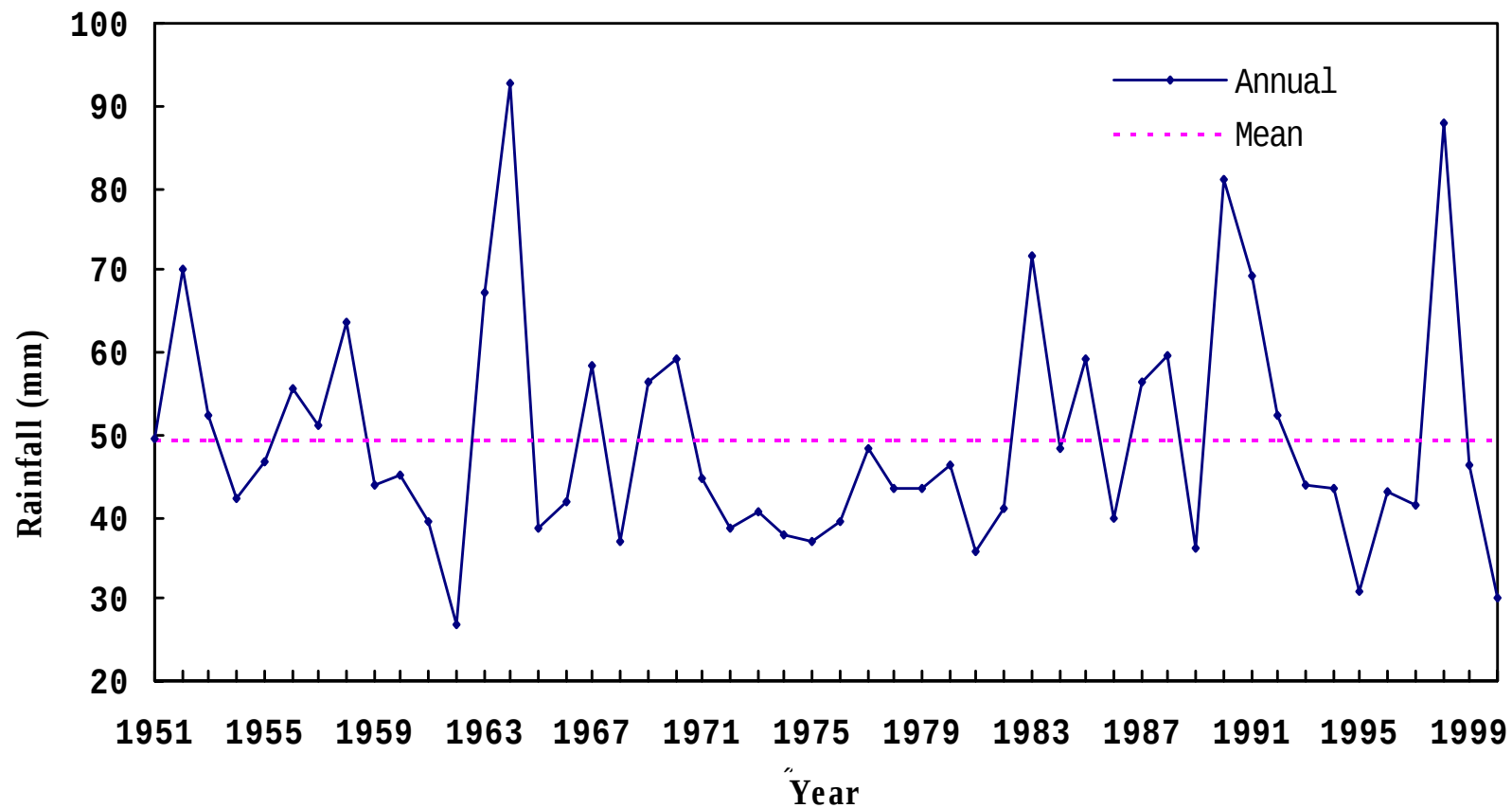
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Decade average temperature variation in the northwest China in past 50 years

	1951~ 1960	1961~ 1970	1971~ 1980	1981~ 1990	1991~ 1999
Temperature	-0.18	-0.28	-0.03	0.12	0.67





Long-term variation of spring rainfall in Northern China (Mar.-May of 1951-2000)

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Decadal variations of occurrence frequency of cold and warm years in the northwest China in past 50 years

	1951~ 1960	1961~ 1970	1971~ 1980	1981~ 1990	1991~ 1999
Frequency of warm years	1	0	0	5	8
Frequency of cold years	3	6	3	1	0
General feature		Very cold	cold	warm	Very warm

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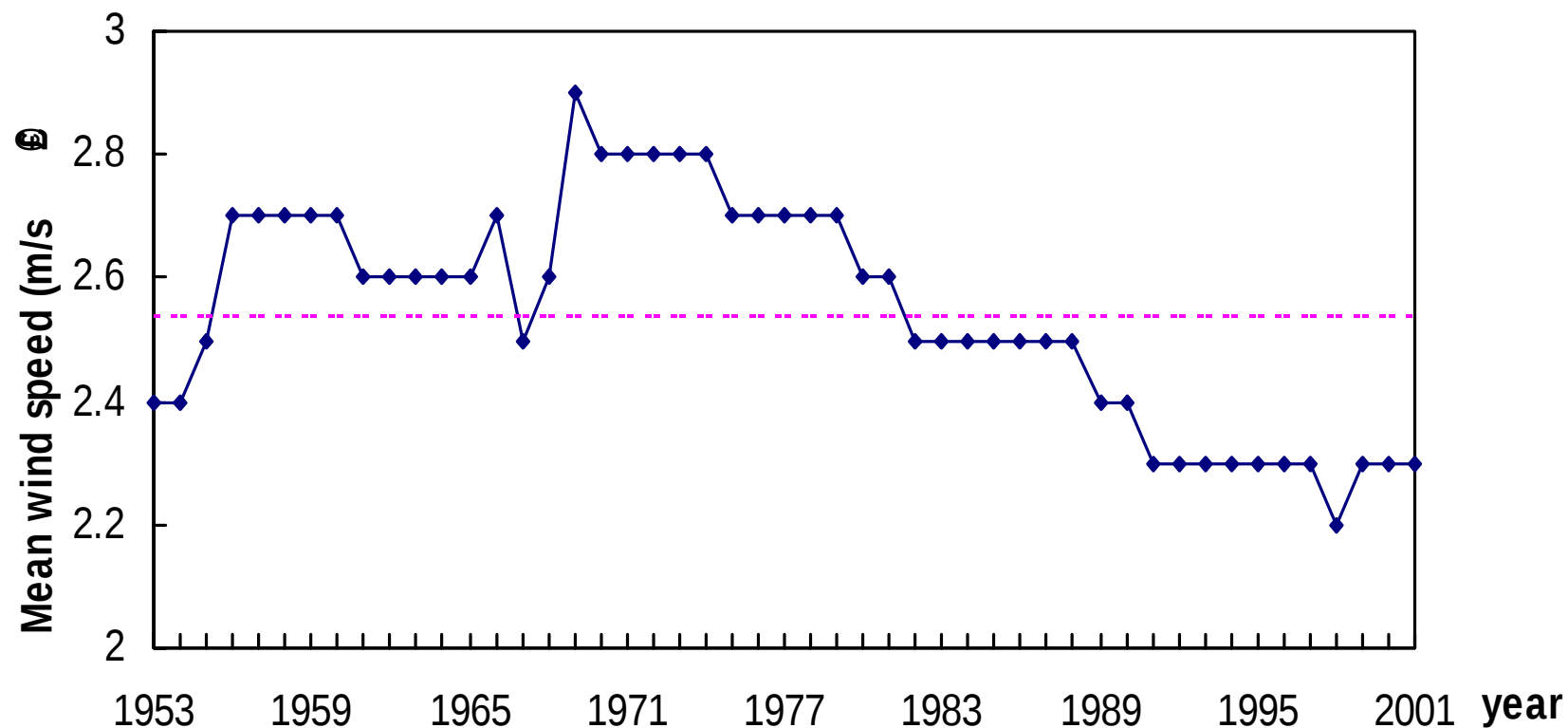
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Frequency of occurrence of cold waves in the northwest China during 50's-80's

Decade	Month									Total
	S	O	N	D	J	F	M	A	M	
50's	2	3	5	2	4	3	5	7	3	34
60's	1	4	4	2	3	3	1	5	0	23
70's	0	4	5	3	0	2	3	3	0	20
80's	0	1	1	2	0	1	1	1	1	8
Total	3	13	15	9	8	8	12	16	4	85





Time series of annual mean wind speed averaged for whole China

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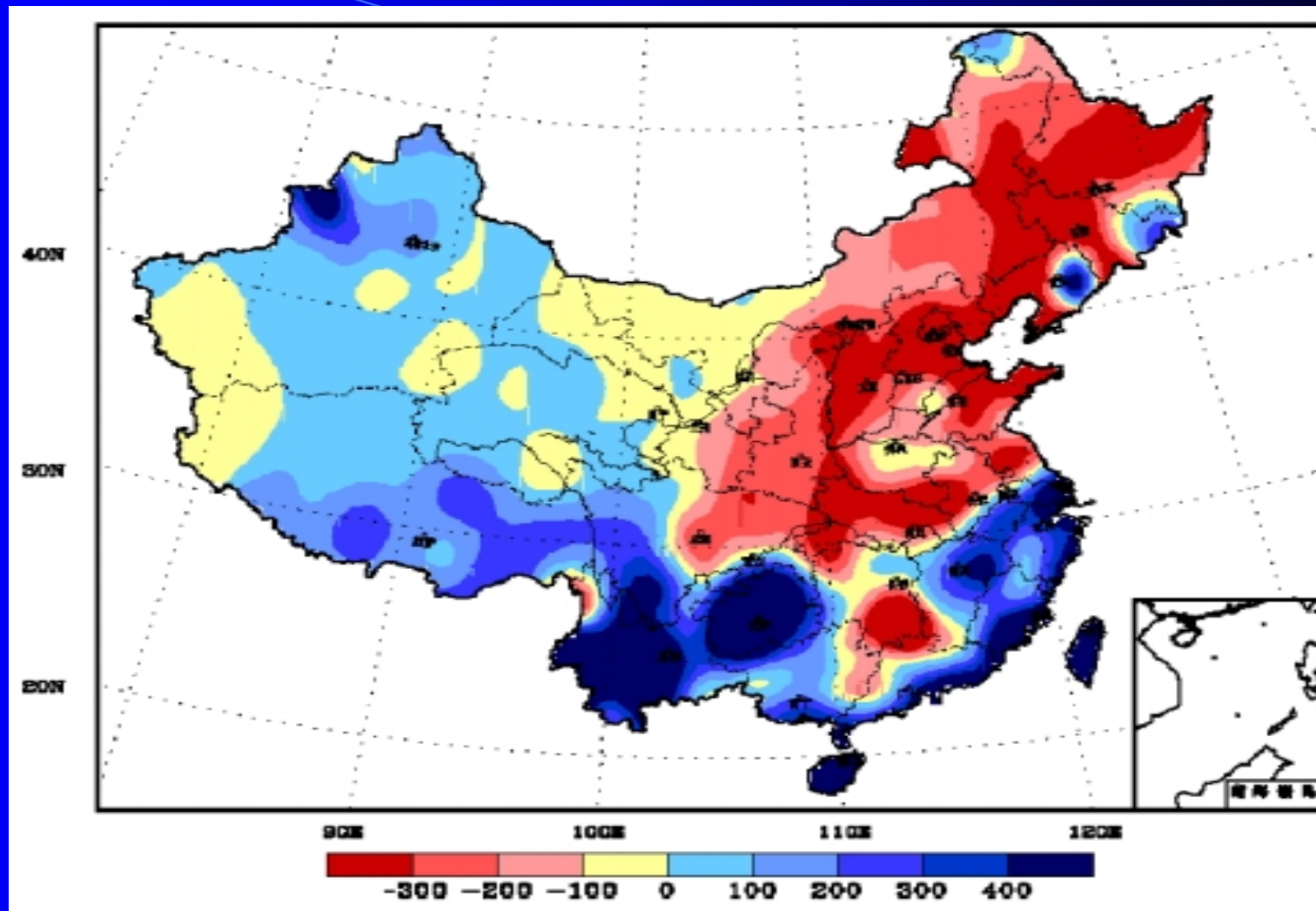
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→ Recent increase since 1998

- Dry climate condition
- Increasing station numbers with dry soil
- Warmer temperature layer thicker than 3cm





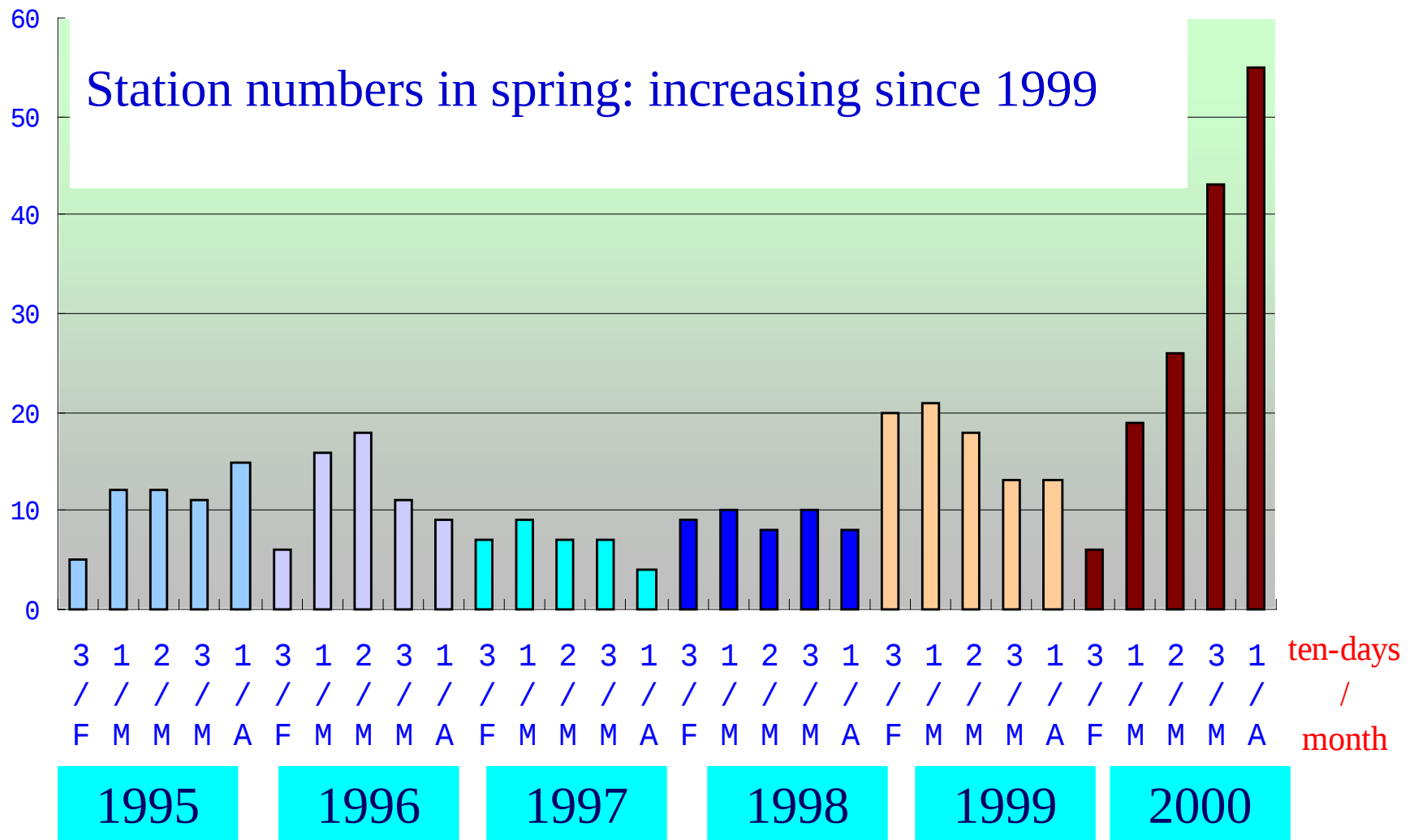
Departure pattern of mean precipitation for 1999-
2001 from long-term mean(mm)

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Percentage of stations with dry soil layer thickness > 3cm for 1995-2000 (3rd ten days, Feb.—1st ten days, Apr.)



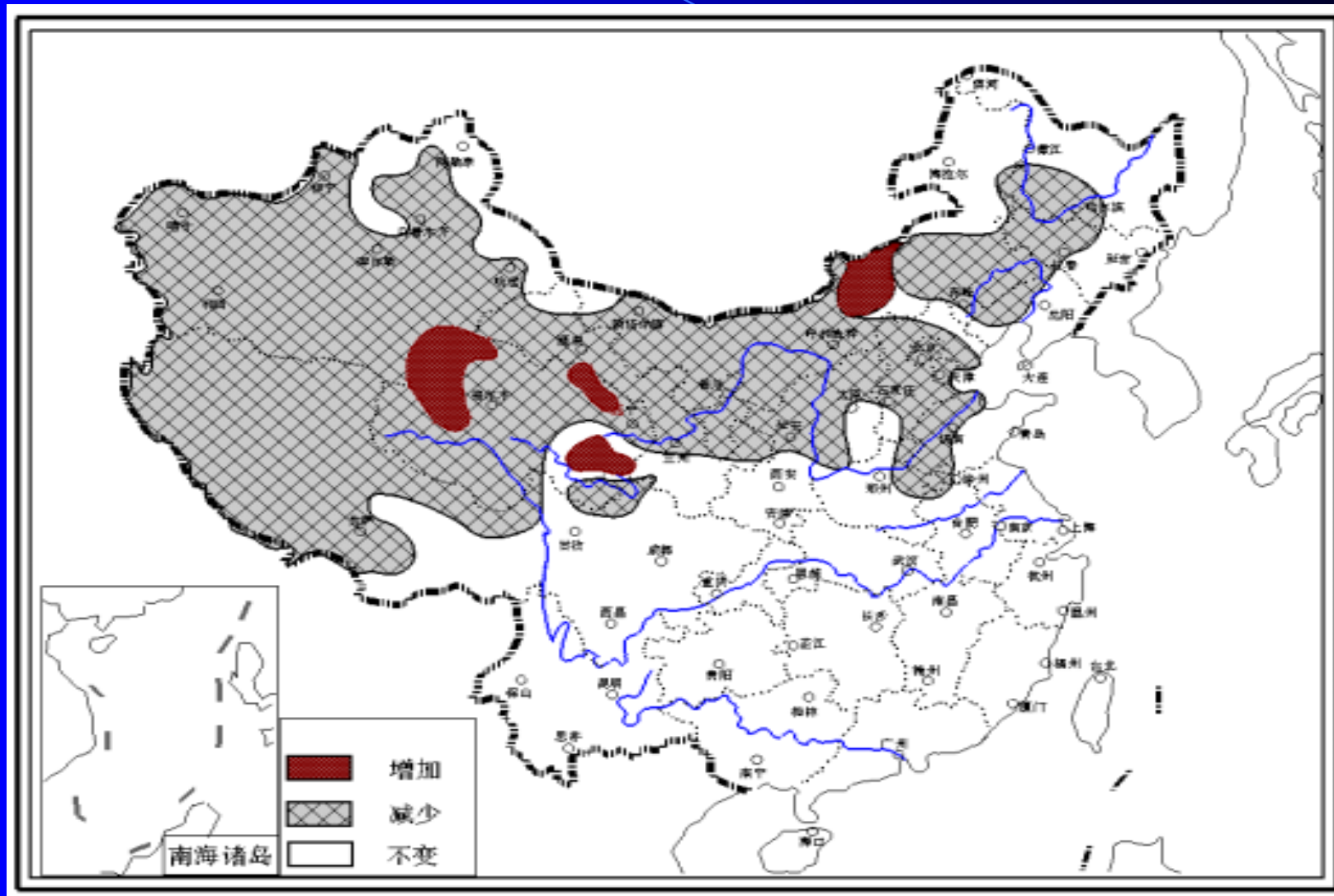
2.3 Geographical distribution of long-term trend of change in dust storms(days) (1954-2000)

Most of dust storm occurrence areas:

decreasing trend, only with a few
moderate areas having increasing trend



Geographical distribution of long-term variation of the occurrence of dust storms



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◆ Strong dust storm

(horizontal visibility • 400m, and wind speed • 20m/s)

Question:

Is the frequency increasing?



Variation of occurrence of strong dust storms in the northwest China in past 50 years

Decade	50's	60's	70's	80's	90's
Frequency	5	8	13	14	21



◆ The area of desertification is expanding

Rates of the desertification in China
in past 50 years (km²/a)

Decade	50's~60's	70's~80's	90's
Desertification area (km ²)	1560	2100	2460

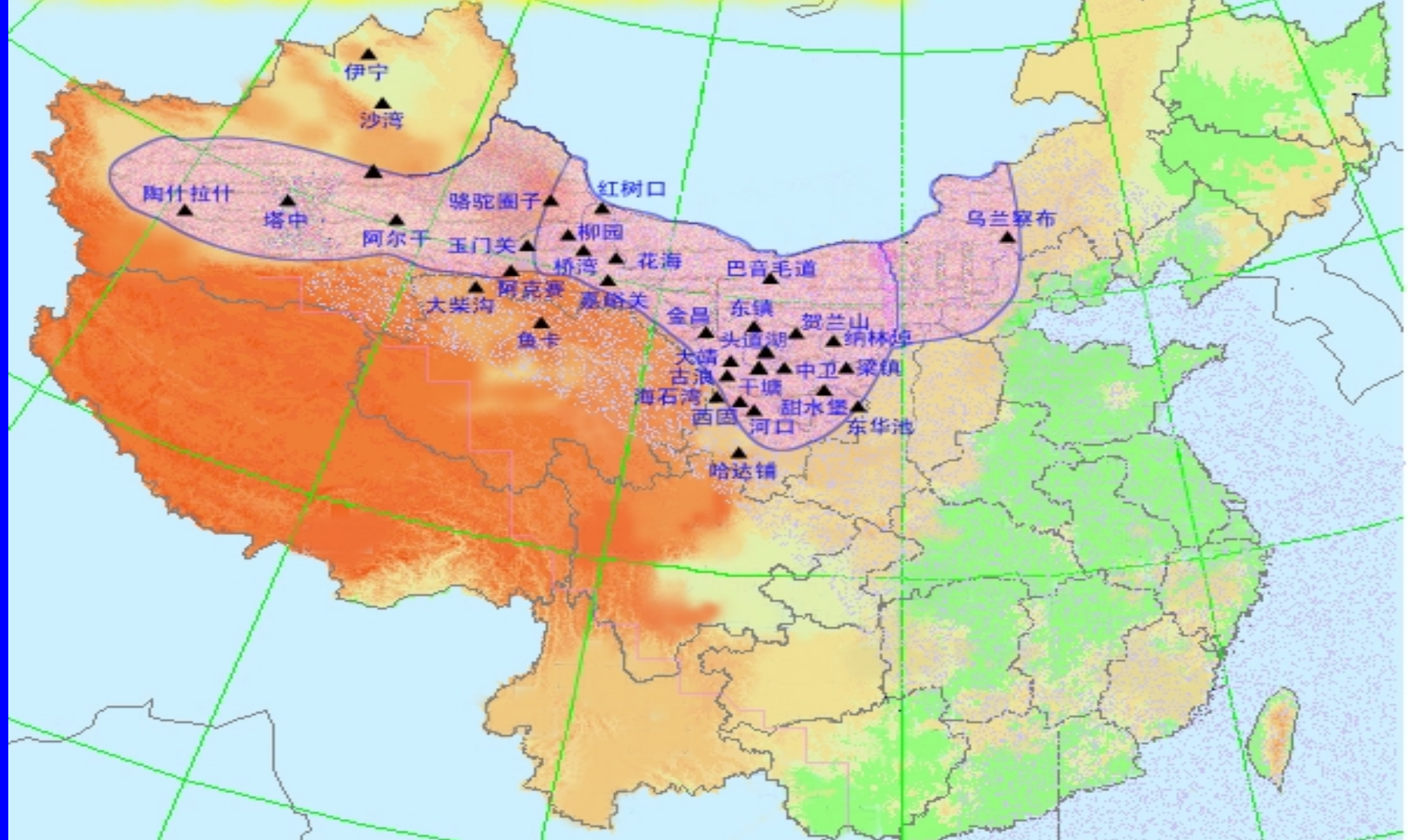


3. Efforts on dust storm monitoring and prediction in China

- ◆ The new monitoring network of dust storms is setting up in China to improve the real-time monitoring on dust weather

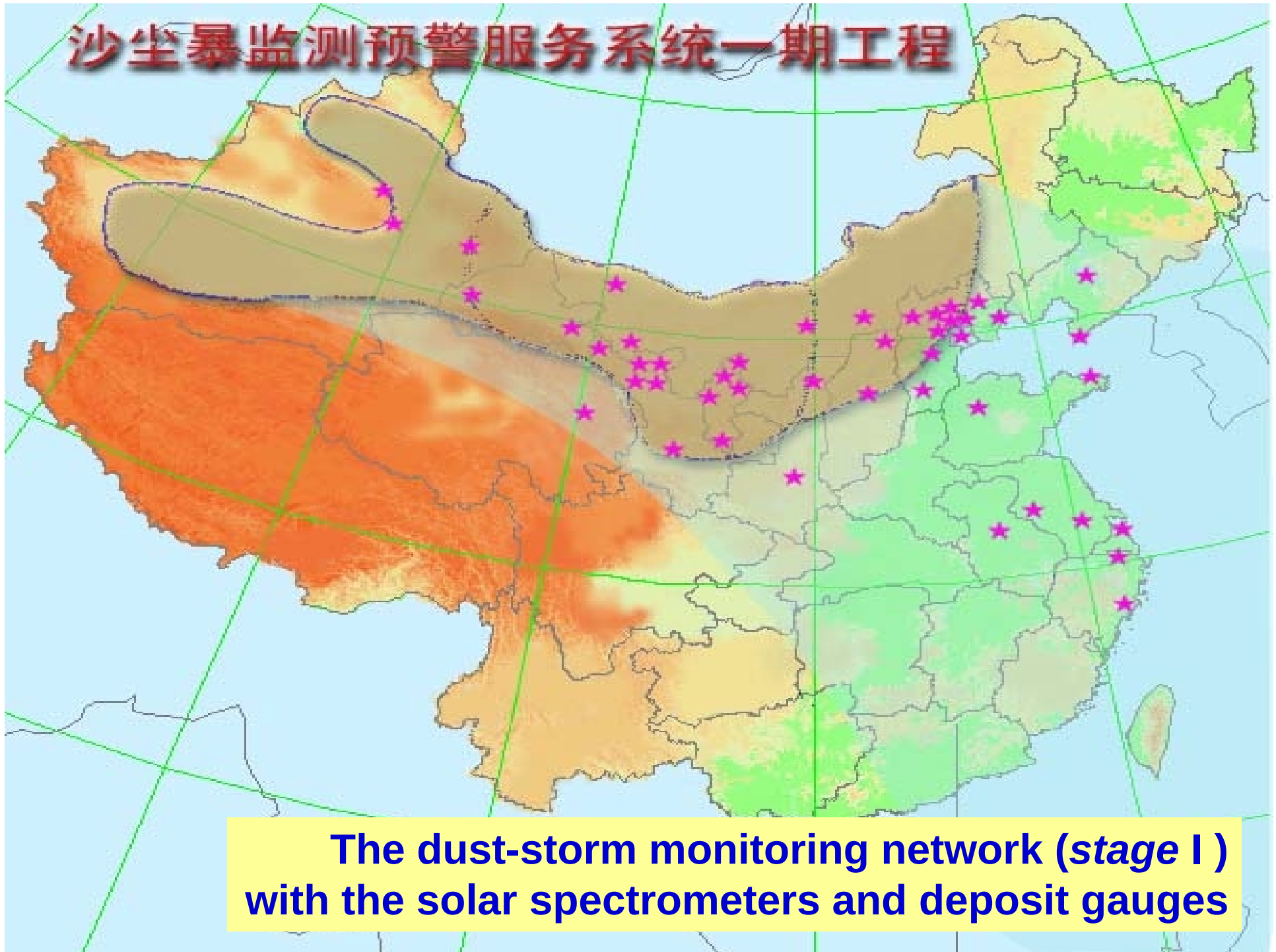


中国沙尘暴监测预警服务体系工程



The warning network with intensive observations of dust storms in the western China

沙尘暴监测预警服务系统一期工程



**The dust-storm monitoring network (stage I)
with the solar spectrometers and deposit gauges**

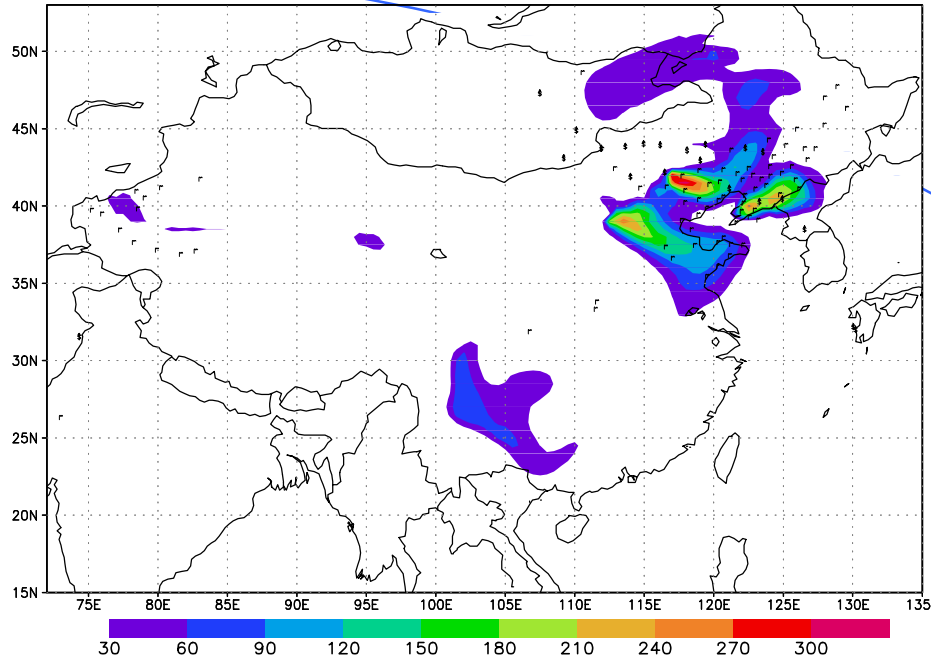
- ◆ Some key research programs on dust storm matter are undergoing (climatology, detection technique, formation mechanism, forecasting method etc.)



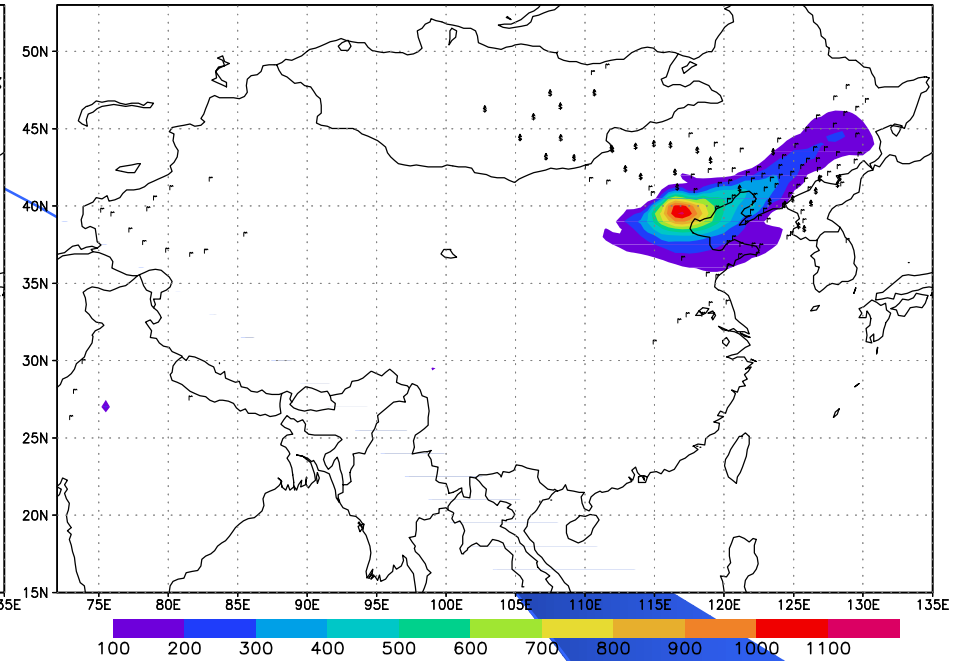
- ◆ Develop the numerical prediction models to improve the warning and prediction of dust storms in the National Meteorological Center (cooperate with the Australian meteorologists) and the Provincial Meteorological Services in the western China



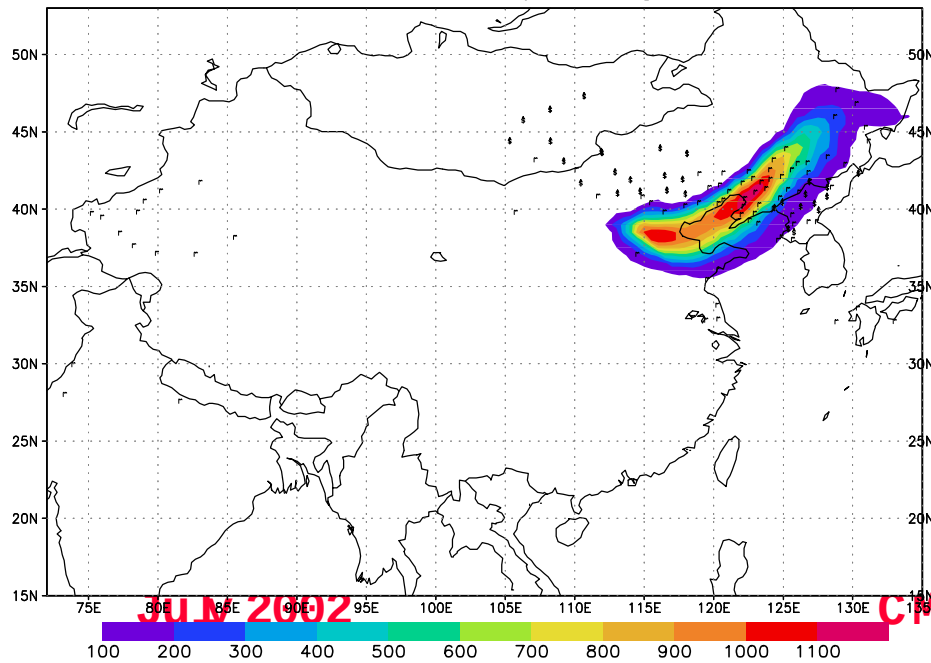
00Z07APR2002 vertically integrated mass



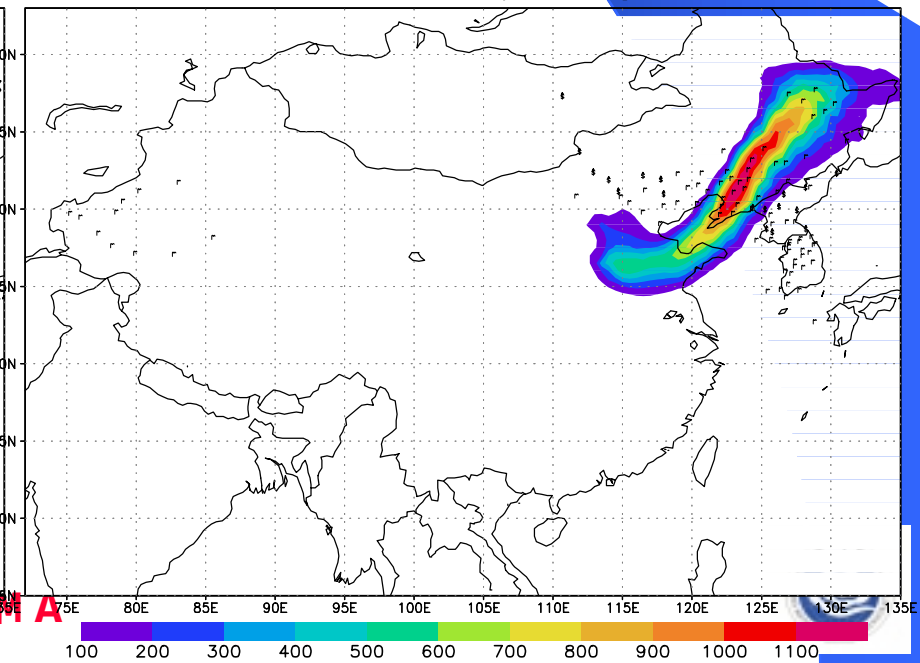
06Z07APR2002 vertically integrated mass



12Z07APR2002 vertically integrated mass



18Z07APR2002 vertically integrated mass



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- ◆ The international cooperation in the area of dust storm monitoring and prediction is also undergoing

With respect to a possible WWRP project on dust storms, an International Workshop on this matter, co-sponsored by WMO and CMA, was planned for 2003 in China



4. Concluding remarks

- ◆ The occurrence frequency of dust storms has the significant decade-scale variability
- ◆ The long-term variations are closely linked to the climate change in East Asia
- ◆ High frequency season is characterized by cold temperature, active cold wave, high wind and dry conditions; Low frequency season: warm temperature, inactive cold waves, weak wind and wet conditions



- ◆ There is some discrepancies in climatological statistics of occurrence of dust storms, due possibly to data availability, different definition and urbanization effect
- ◆ Conditions of occurrence of dust storms:
 - ➔ active cold waves bringing high wind
 - ➔ dry climate condition with little precipitation
 - ➔ thicker dry and soft soil layer and strong thermal instability



Acknowledgement

The contributions by

Mr. **LI Huang**, Deputy Administrator, CMA

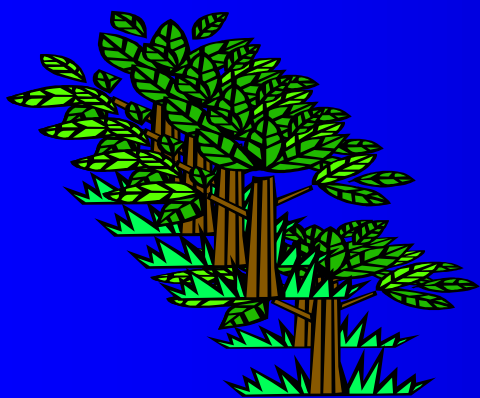
Prof. **DING Yihui**, National Climate Center, CMA

Dr. **LI Weijing**, National Climate Center, CMA

Prof. **ZENG Qingcun**, Institute of Atmospheric
Physics, Chinese Academy of Sciences



Thanks!



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