Yale-NUIST Center on Atmospheric Environment

Influence of Dust-Weather and Wind Erosion Open Source on Atmospheric Particulate Matters in Ningxia

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2018-05-18

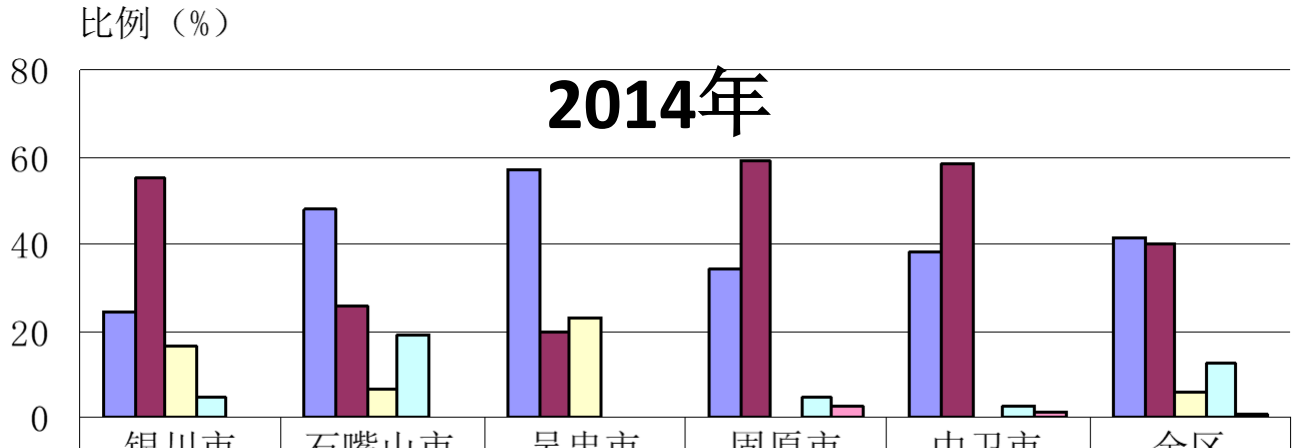
Outline

- **Background**
- **Objective**
- **Material and methods**
- **Quantitative research on dust weather effects on environmental air quality**
- **Transportation source and process of PM_{10} and $PM_{2.5}$**
- **$PM_{2.5}$ and PM_{10} dust release fluxes of different surface open sources**
- **Conclusions**

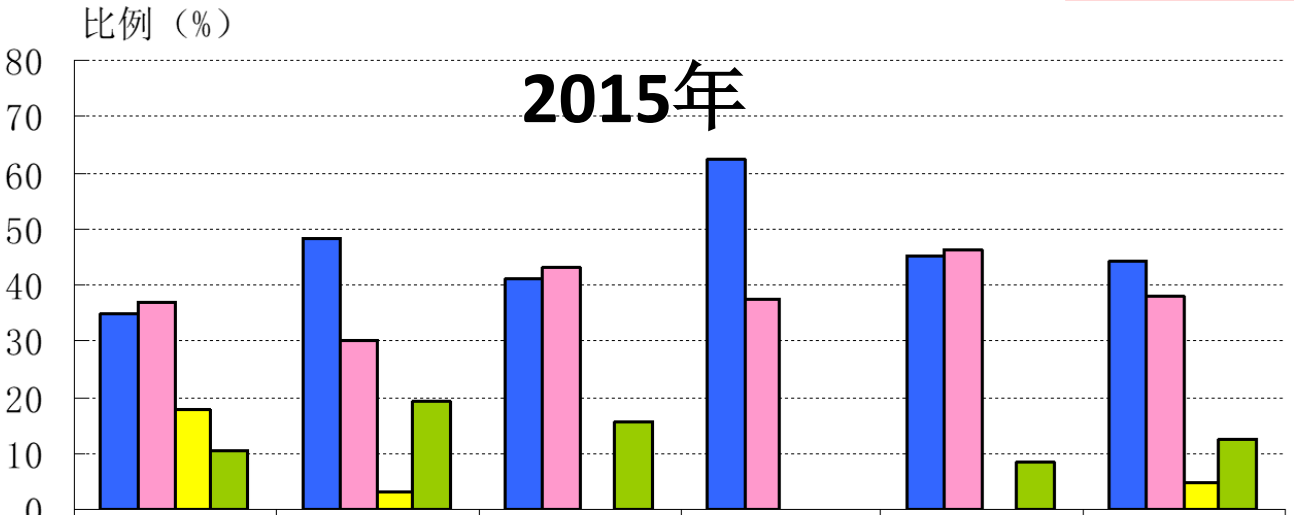
Background

Ningxia is located in the northwest of the Loess Plateau, the edge of the wind area, the climate is dry and rainless, with fragile eco-environment, low vegetation coverage, coupled with special geographical and land conditions, almost every spring there will be strong dust events.

proportion of primary pollutants affecting air quality



	银川市	石嘴山市	吴忠市	固原市	中卫市	全区
PM10	24.2	48.1	57.3	34.1	37.8	41.3
PM2.5	54.9	25.9	20.0	59.1	58.1	40.3



	银川市	石嘴山市	吴忠市	固原市	中卫市	全区
PM10	34.9	48.2	41.0	62.5	45.4	44.4
PM2.5	36.8	29.9	43.2	37.5	46.4	38.1

PM_{10} and $PM_{2.5}$ are the primary pollutants in Ningxia

- The analysis results of atmospheric particulate matter in Ningxia showed that the proportion of PM_{10} and $PM_{2.5}$ in wind erosion dust reached an average of 33% throughout the year(in 2013), first of all kinds of emission sources. The main source of wind erosion dust is dust weather.
- In northern China, the proportion of surface open source has reached 40%-80% (Dai et al ,2005； YU et al ,2010). The study of soil wind erosion at home and abroad shows that wind erosion dust injected into the atmosphere from surface wind erosion has become one of the main components of air particulates(Z T et al ,1996;Tegen,I. et al,1996).

Objective

- How to quantify the impact of dust weather on atmospheric environmental quality in Ningxia ?
- What are the main sources of dust weather affecting Ningxia?
- Influence of the wind erosion open source on atmospheric environment quality in Ningxia and the main transmission path.

Quantitative research

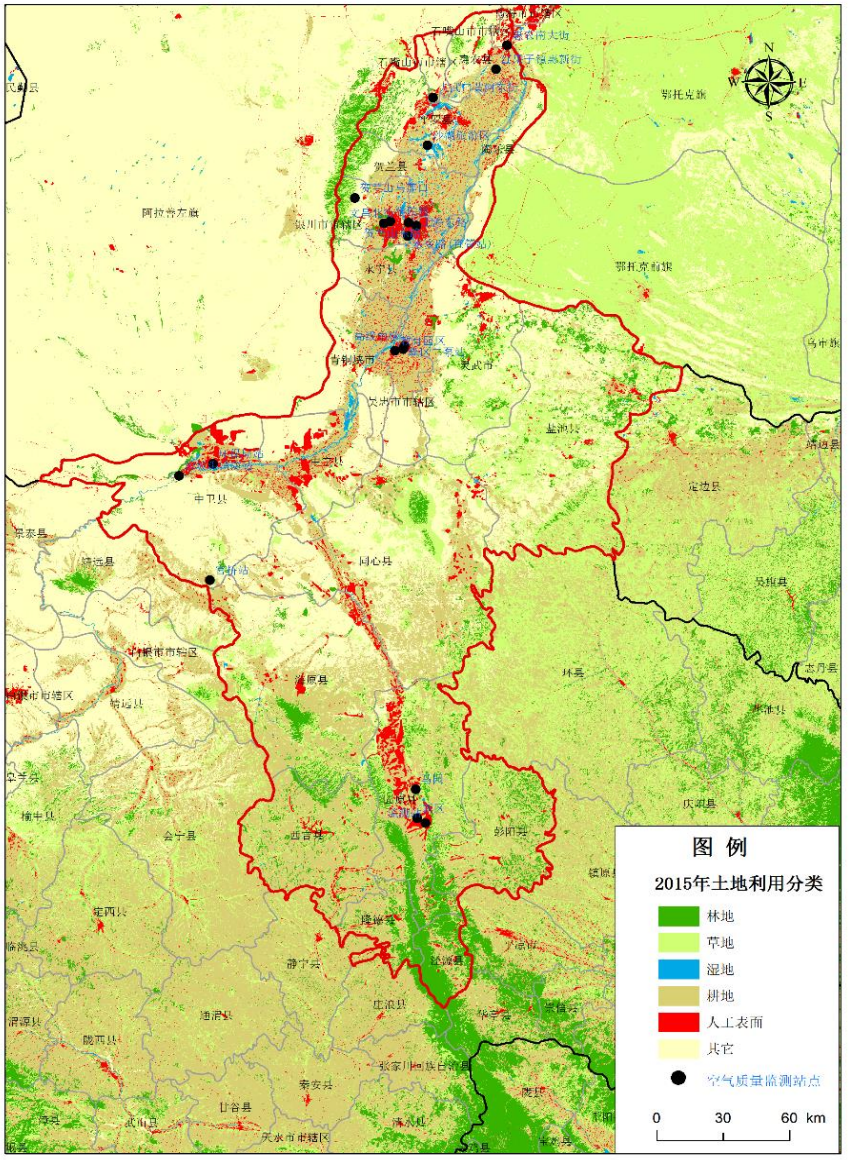
Material and methods

Methods：

Contribution rate $DC_{AQI}=（\Delta AQI/AQI_{ID}）\times 100\%$

$\Delta AQI=AQI_{ID}-AQI_{ED}$

Absolute contribution rate $PC=PC_{ID}-PC_{ED}$



Material：

19 air quality monitoring sites (2013-2016):

- Hourly PM_{10} and $PM_{2.5}$ concentration data in Ningxia
- Monitoring reports on dust events process in Ningxia

Fig. Distribution of Air Quality Monitoring Sites in Ningxia

Frequency of Dust Weather and Its Contribution to Atmospheric Environmental Quality from 2013 to 2016

月份	沙尘天气发生频次/次	所占比例	贡献率				
			固原市	石嘴山市	银川市	吴忠市	中卫市
2月	4	12.90%	6.57%	1.25%	2.24%	2.95%	6.49%
3月	10	32.26%	16.61%	18.65%	18.05%	15.02%	16.97%
4月	6	19.35%	7.31%	10.53%	8.88%	7.54%	15.84%
5月	8	25.81%	9.81%	16.45%	11.30%	7.33%	12.57%
6月	3	9.68%	1.10%	2.27%	2.03%	1.06%	2.04%
合计	31	100%					
平均值			8.28%	9.83%	8.50%	6.78%	10.78%

The highest contribution rate of dust weather to the atmospheric environment quality of five cities in Ningxia is March, with an average contribution rate of 17.02%.

In addition, the maximum contribution rate appeared in March.

The lowest contribution month was June, and the average contribution rate to five cities was 1.7%.

Absolute contribution of dust weather to Ningxia ρ(PM10) from 2013 to 2016

月份	指标	2013年	2014年	2015年	2016年
2月	绝对贡献(μg/m³)	3.02	0	0	20.51
	所占比例	2.01%	0	0	13.67%
3月	绝对贡献(μg/m³)	22	31.11	17.25	20.58
	所占比例	14.67%	20.74%	11.50%	13.72%
4月	绝对贡献(μg/m³)	-0.22	2.08	15.46	1.15
	所占比例	-0.15%	1.39%	10.31%	0.77%
5月	绝对贡献(μg/m³)	0.77	-1.66	3.04	31.71
	所占比例	0.51%	-1.11%	2.02%	21.14%
6月	绝对贡献(μg/m³)	2.28	0	0	6.87
	所占比例	1.52%	0	0	4.58%
平均值	绝对贡献(μg/m³)	5.57	6.31	7.15	16.16
	所占比例	3.71%	4.20%	4.77%	10.78%

Transportation source and process of PM_{10} and $PM_{2.5}$

Material and methods

Methods：

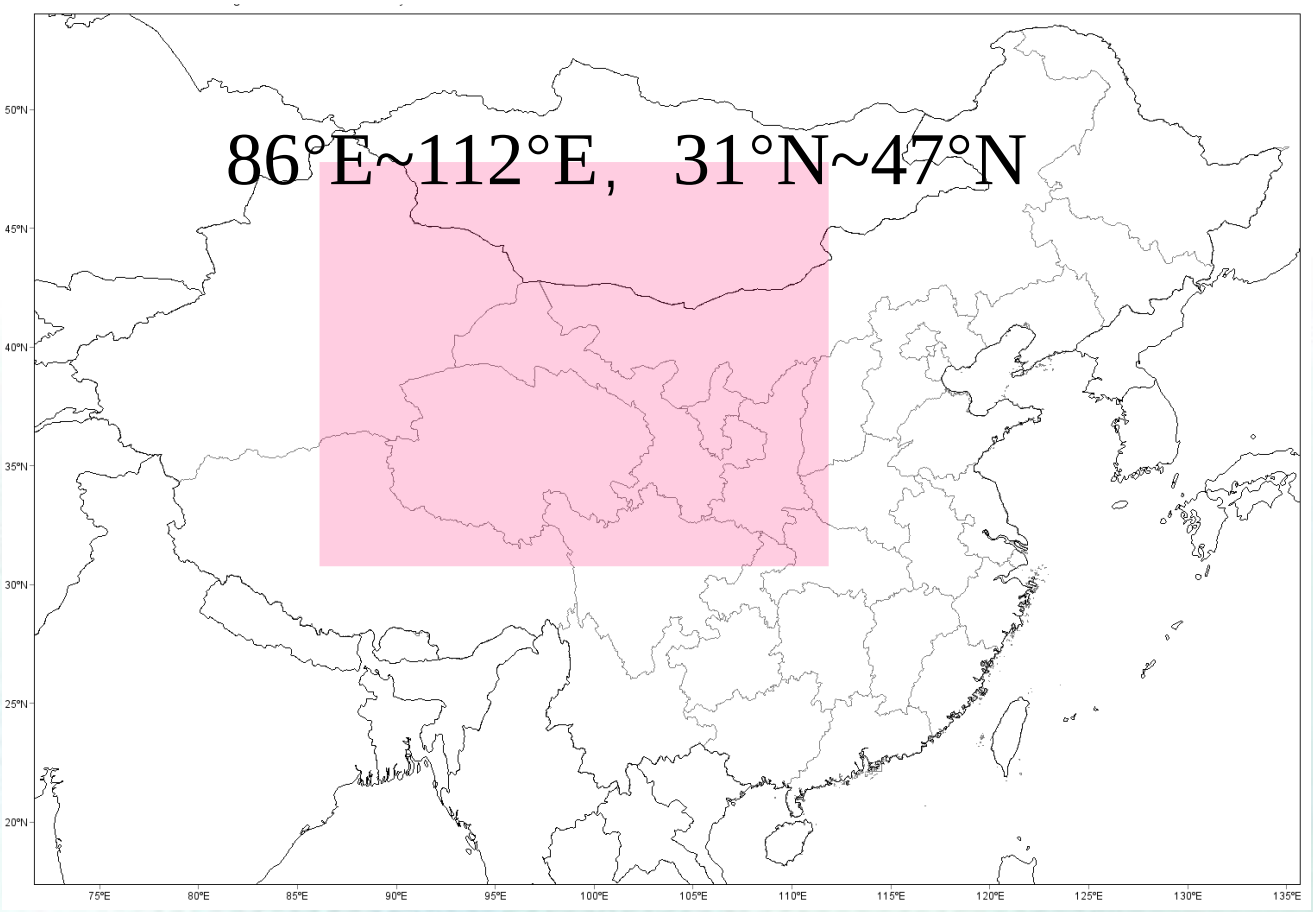
- **HYSPLIT** - Hybrid Single Particle Lagrangian Integrated Trajectory Model
- PSCF-potential source contribution function $$P_{\mathrm{SCF}_{ij}} = \frac{m_{ij}}{n_{ij}}$$
- CWT- concentration weighted trajectory method $$C_{ij} = \frac{1}{\sum_{l=1}^{M} \tau_{ijl}} \sum_{l=1}^{M} C_{l\tau ijl}$$

Material：

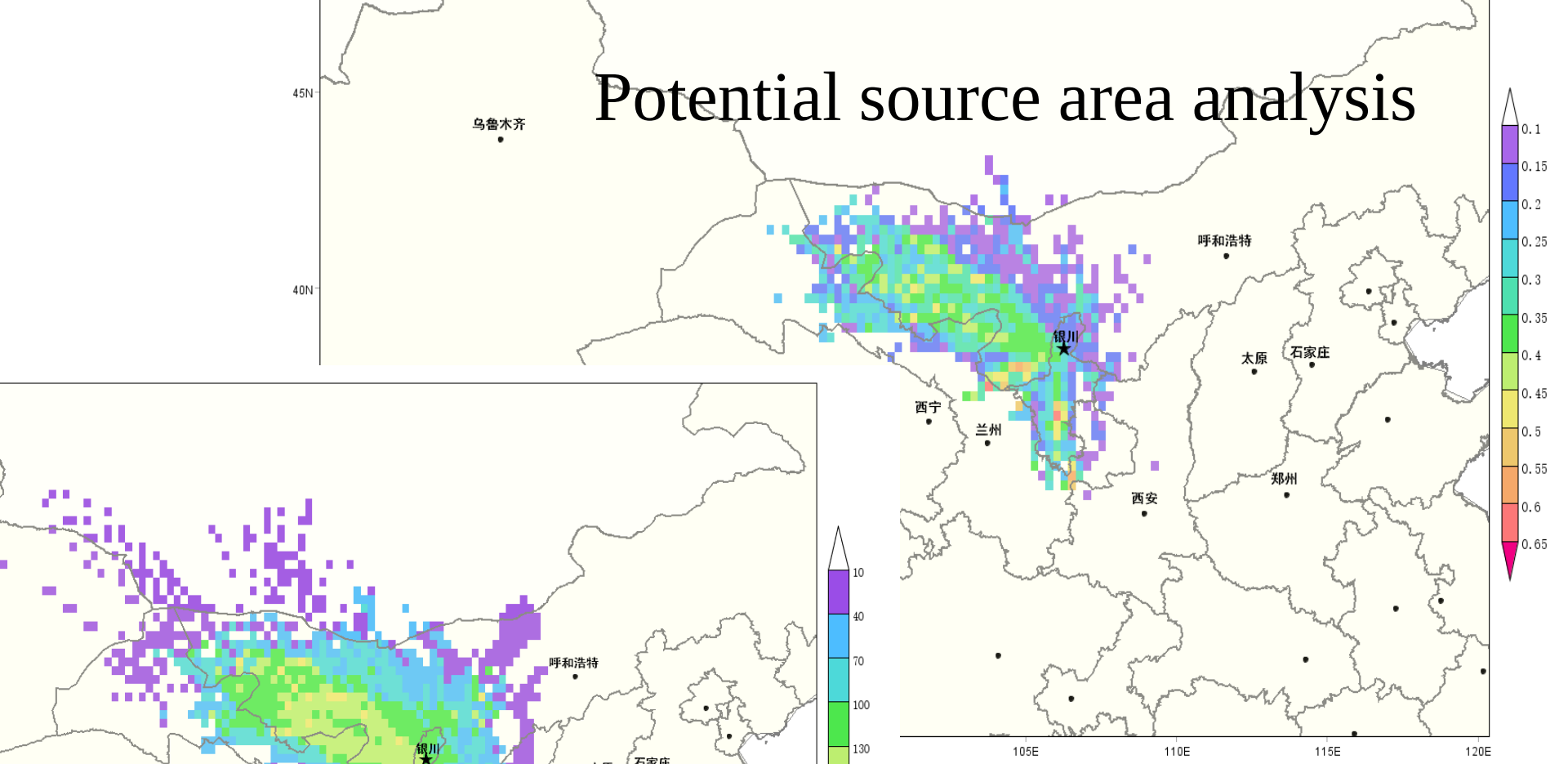
19 air quality monitoring sites(2015 Jan-Jun)

- Hourly PM_{10} and $PM_{2.5}$ concentration data in Ningxia
- Monitoring reports on dust events process in Ningxia

- 0.25°x 0.25° ERA-Interim reanalyze data of European Centre for Medium-Range Weather Forecasts



Potential source area analysis

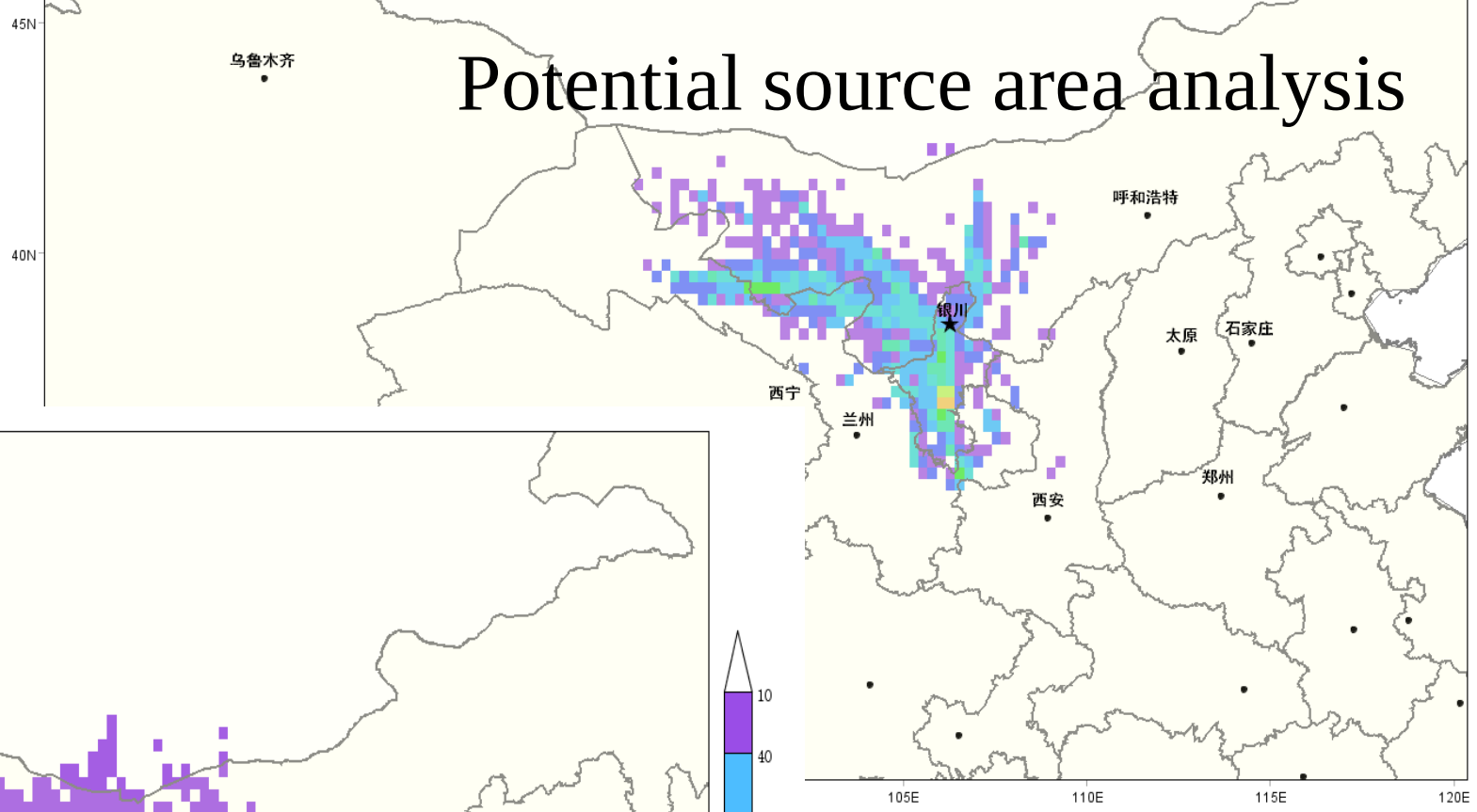


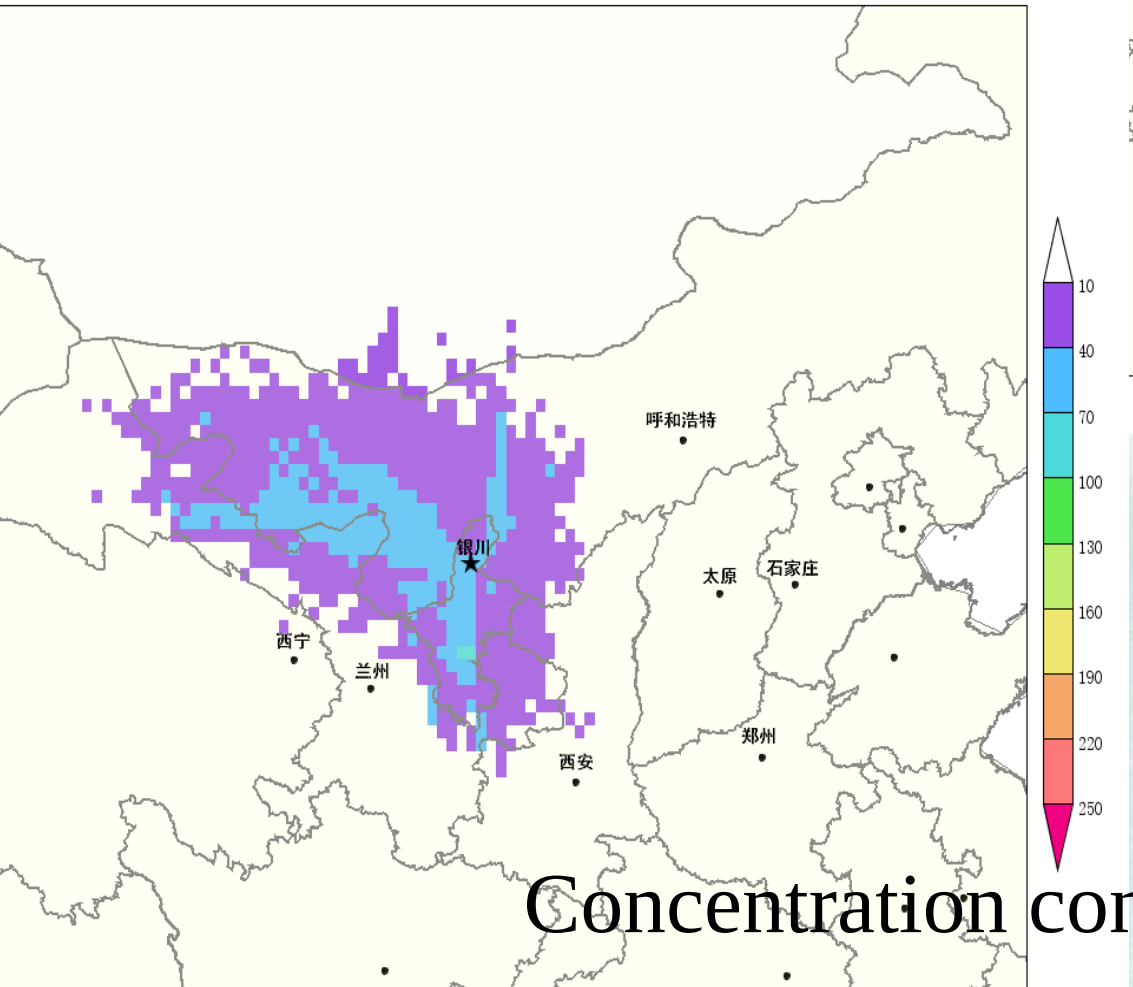
Yinchuan

PM_{10}

Concentration contribution analysis

Potential source area analysis





Yinchuan

$PM_{2.5}$

Concentration contribution analysis

PM_{10} and $PM_{2.5}$ dust release fluxes of different surface open sources

Material and methods

Methods：

Soil wind erosion model

Cultivated field

$$Q_{fa} = 10 * \hat{C} * (1-W) * \sum_{j=1} \left\langle T_j * \exp\left\{ a_1 + b_1 / z_0 + c_1 * \left[\left(A * U_j \right)^{0.5} \right] \right\} \right\rangle$$

Forest、grassland、bare soil

$$Q_{fg} = 10 * \hat{C} * (1-W) * \sum_{j=1} \left\langle T_j * \exp\left\{ a_2 + b_2 * VC^2 + c_2 / \left[\left(A * U_j \right) \right] \right\} \right\rangle$$

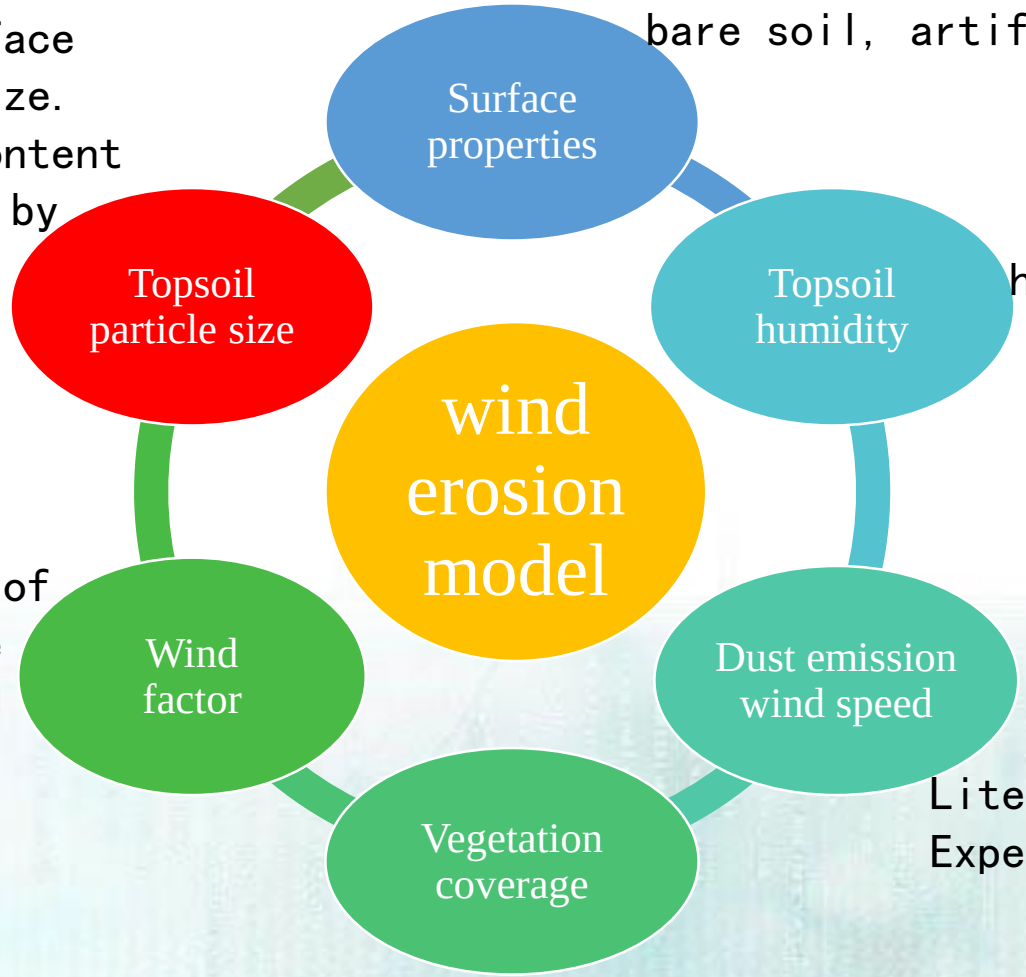
sand

$$Q_{fs} = 10 * \hat{C} * (1-W) * \sum_{j=1} \left\{ T_j * \exp\left[a_3 + b_3 * VC + c_3 * In\left(A * U_j \right) / \left(A * U_j \right) \right] \right\}$$

Grid resolution: 250m
Simulation time:2015 JAN-JUN

Land use data, repartition to sand, forest, grassland, cultivated field, bare soil, artificial surface

Analysis of surface soil particle size. Determine the content of PM_{10} and $PM_{2.5}$ by field sampling



http://data.cma.cn/

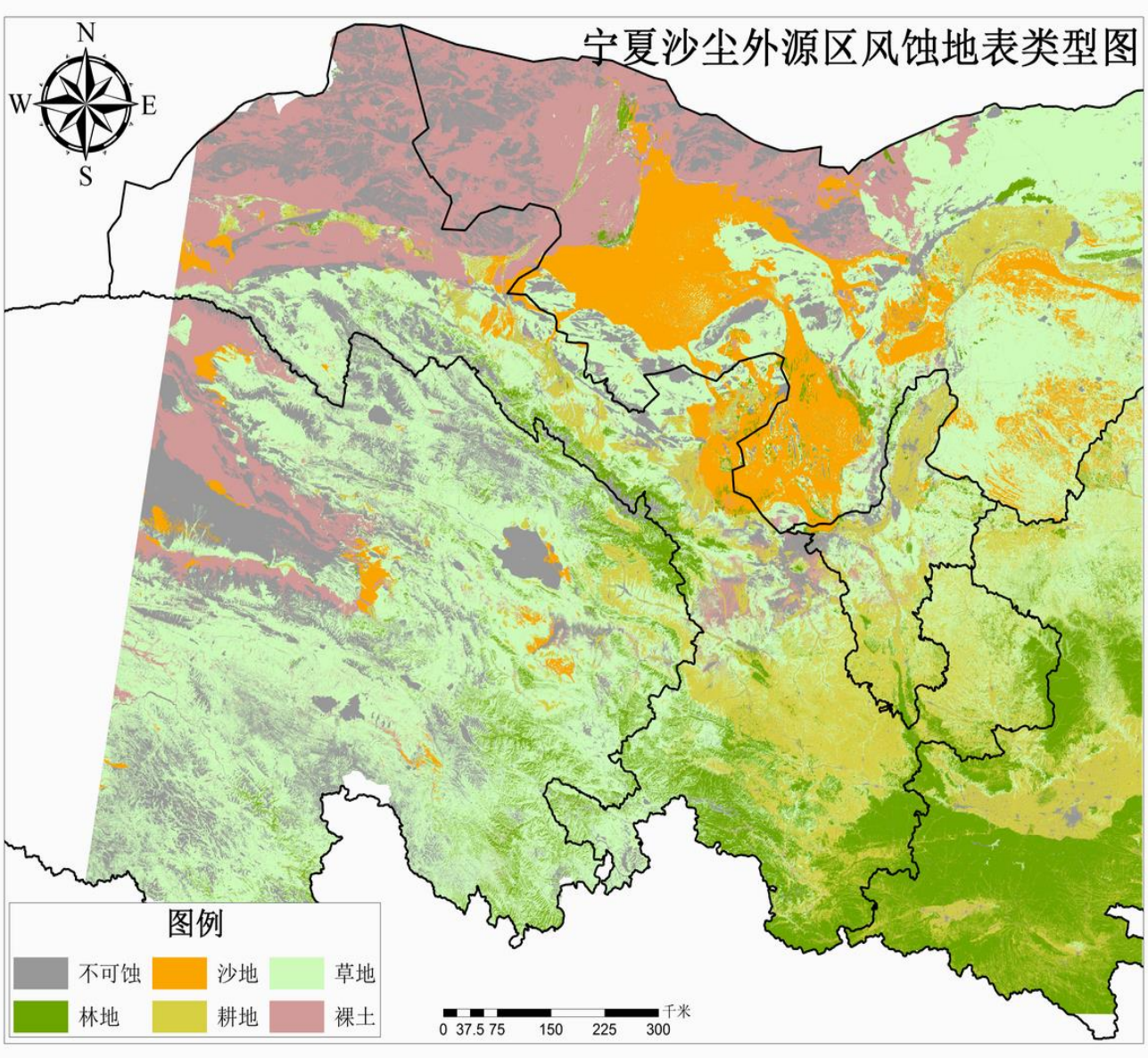
Accumulated time of wind speeds above the critical wind speed

Literature research
Experimental test

Data from MOD13Q1.005 of the US National Aeronautics and Space Administration (NASA) (250 meter resolution vegetation index 16 day synthetic product)

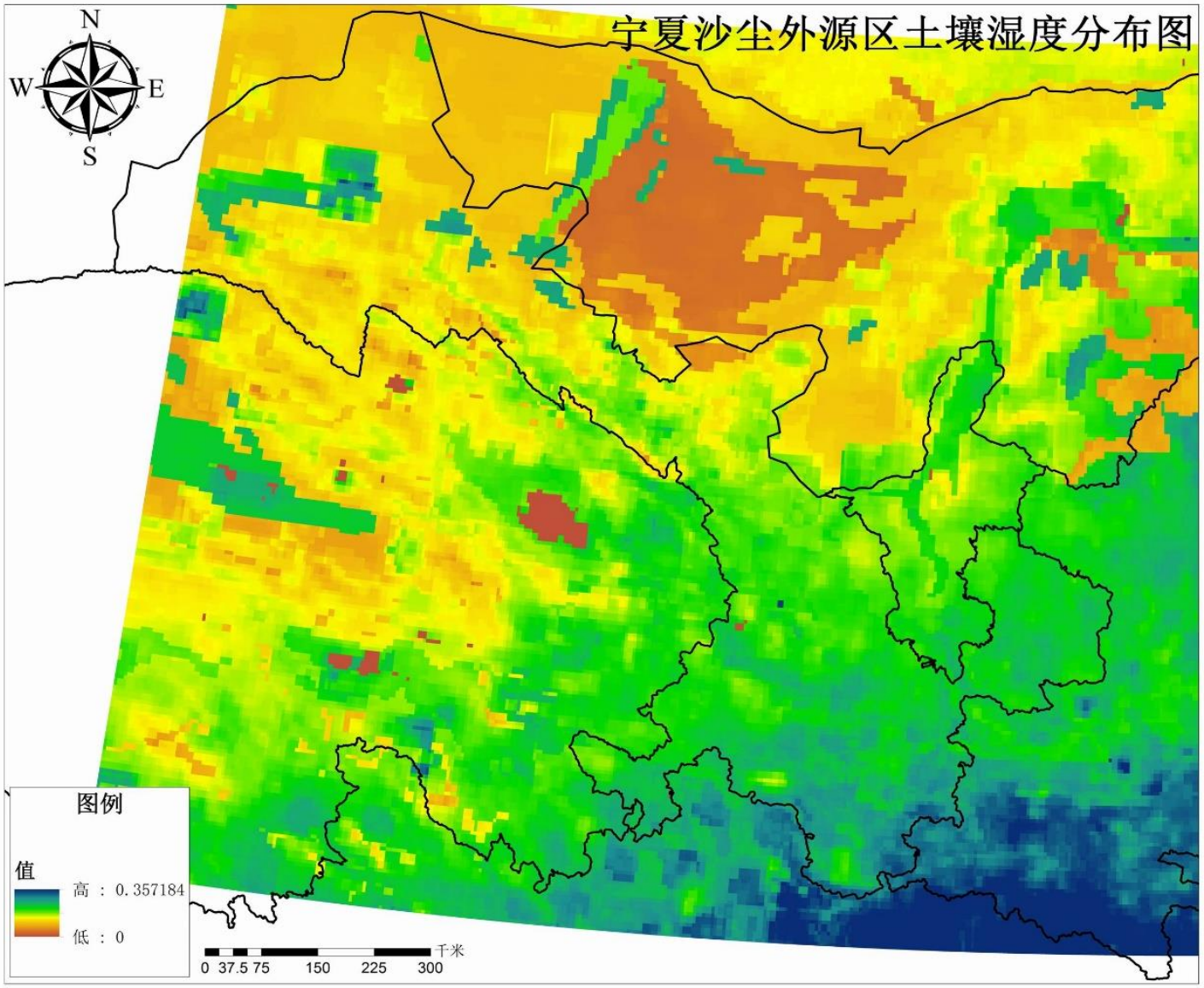
Research area 90°E~110°E，31°N~43°N

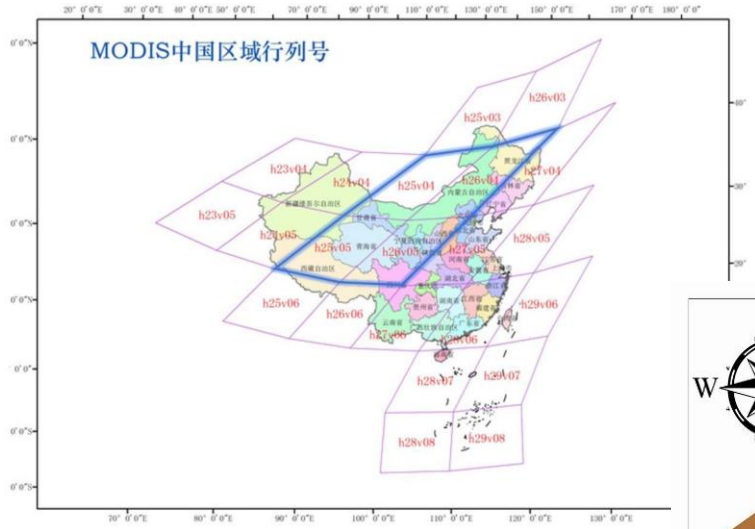
Surface properties



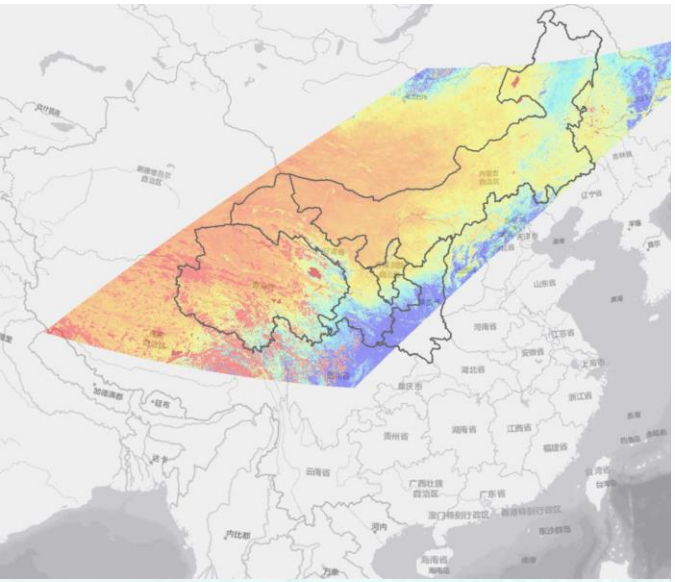
repartition to
sand
forest
Grassland
cultivated field
bare soil
artificial surface

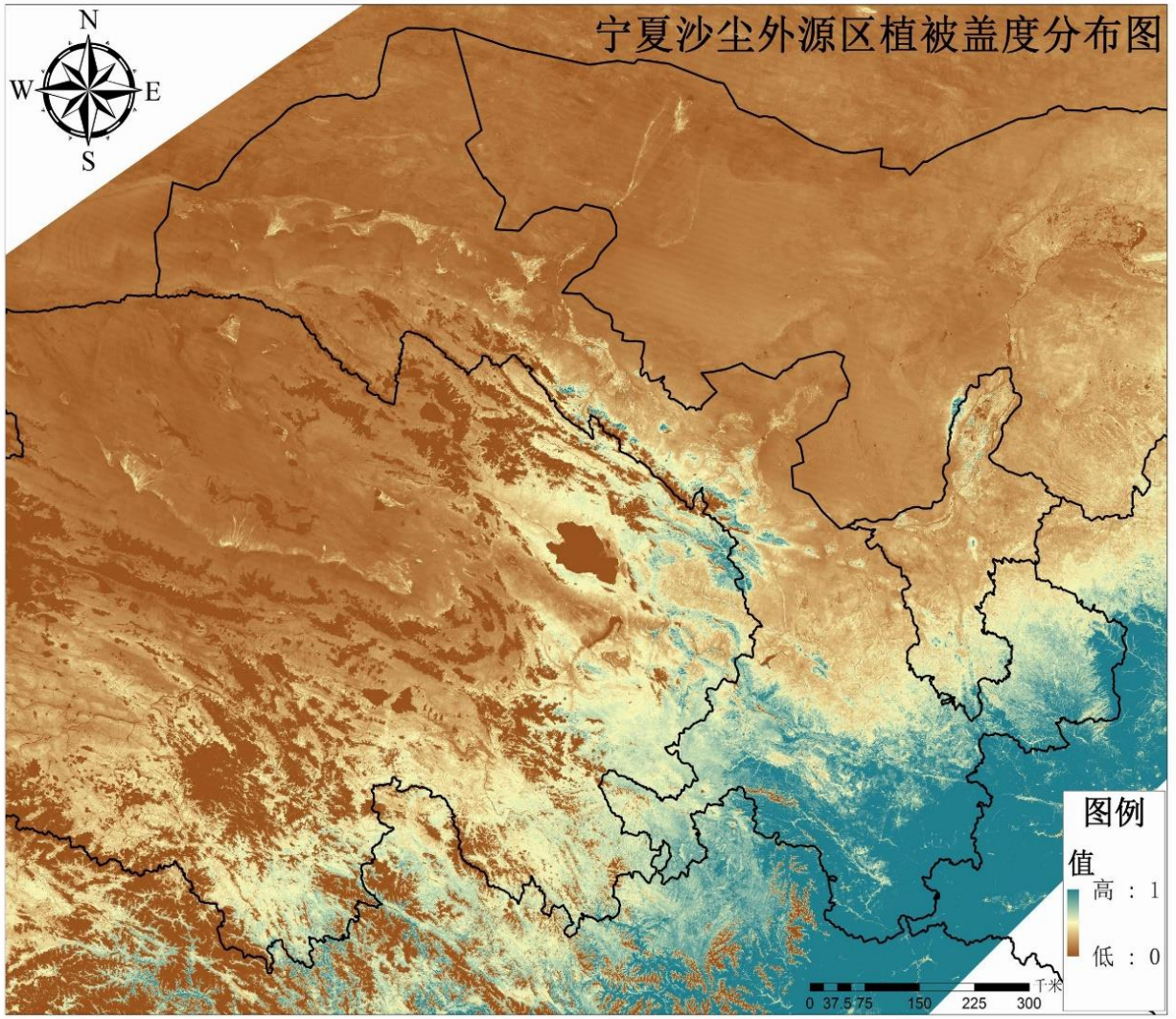
Topsoil humidity





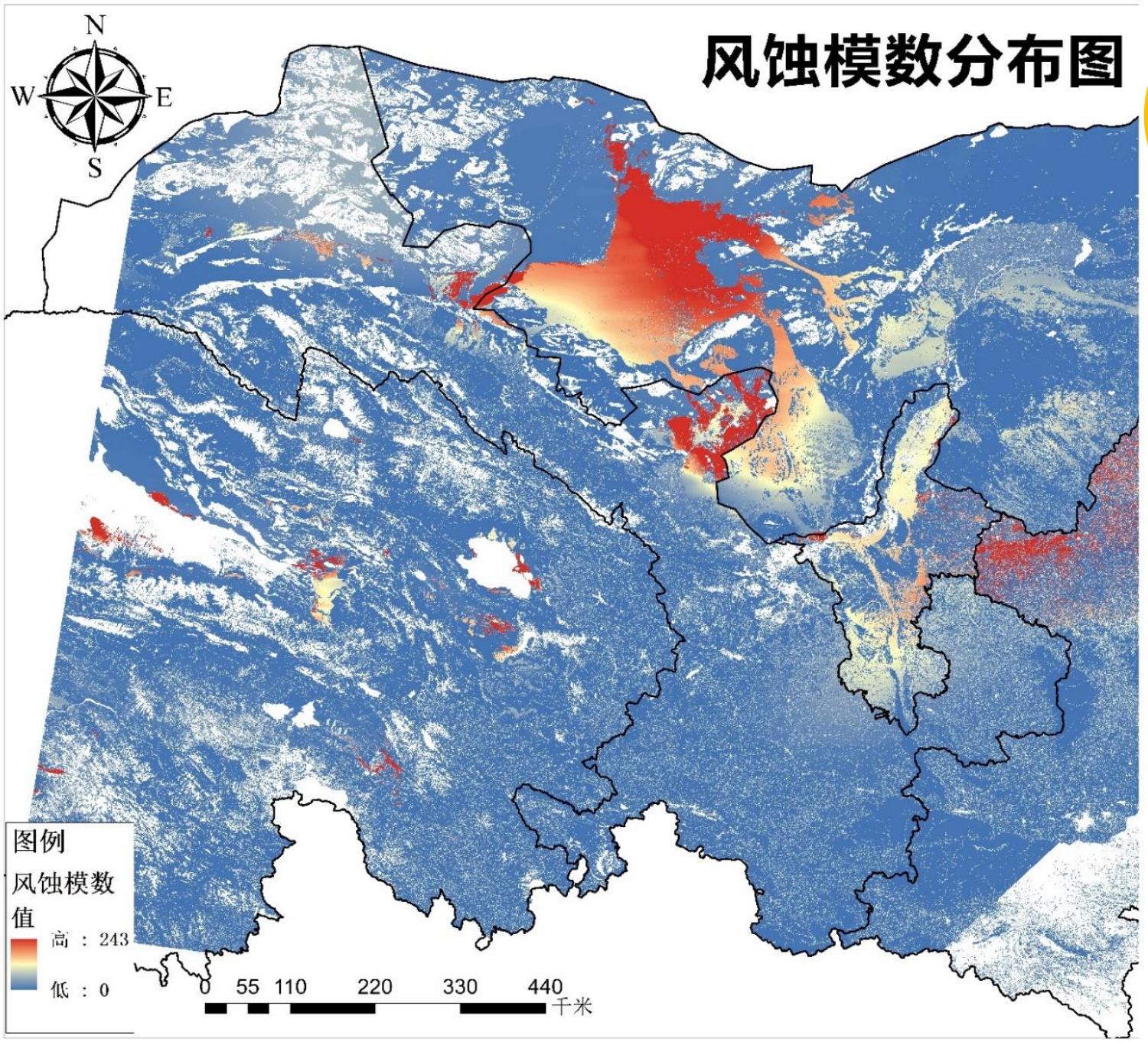
Vegetation coverage



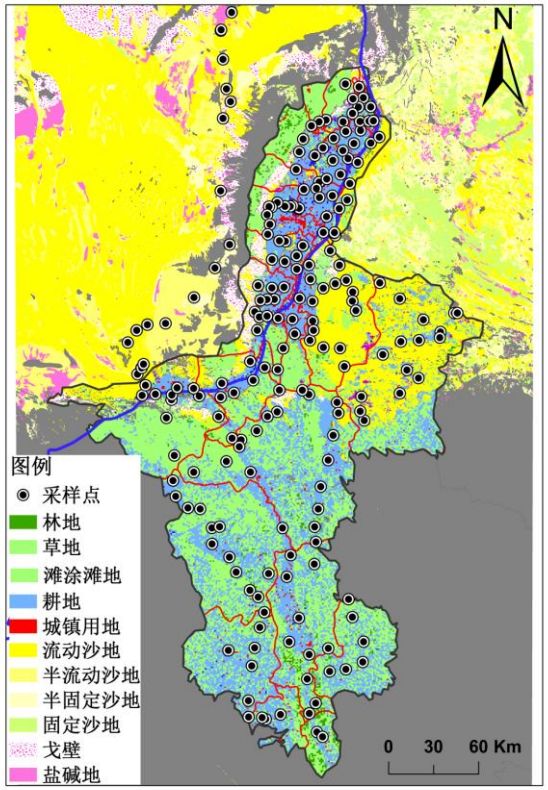


Wind factor

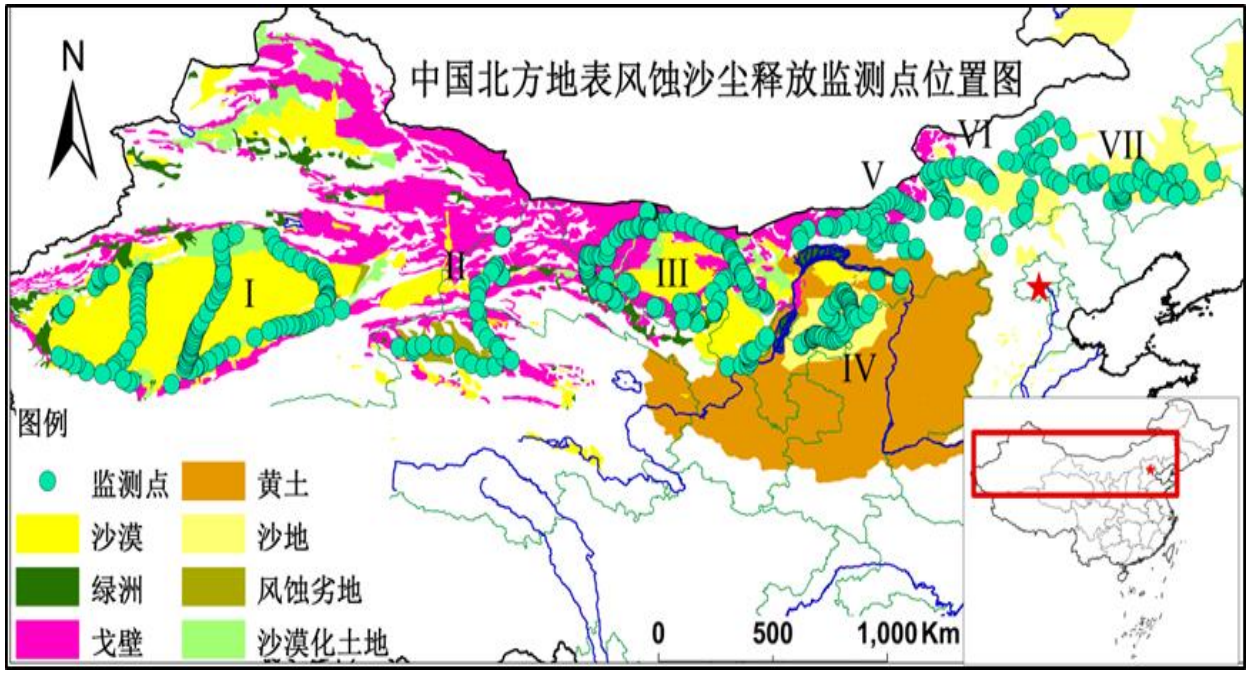
风速/(m/s)	外源各省			
	甘肃	内蒙古	陕西	青海
1-2	31680	15840	60480	30240
2-3	105120	54720	115200	82080
3-4	67680	66240	50400	69120
4-5	31680	53280	20160	41760
5-6	14400	34560	8640	23040
6-7	7200	21600	4320	10080
7-8	2880	10080	2880	4320
8-9	1440	4320	0	1440
9-10	1440	1440	0	0
10-11	0	1440	0	0
11-12	0	1440	0	0
12-13	0	1440	0	0
13-14	0	0	0	0



wind erosion modulus



field sampling points



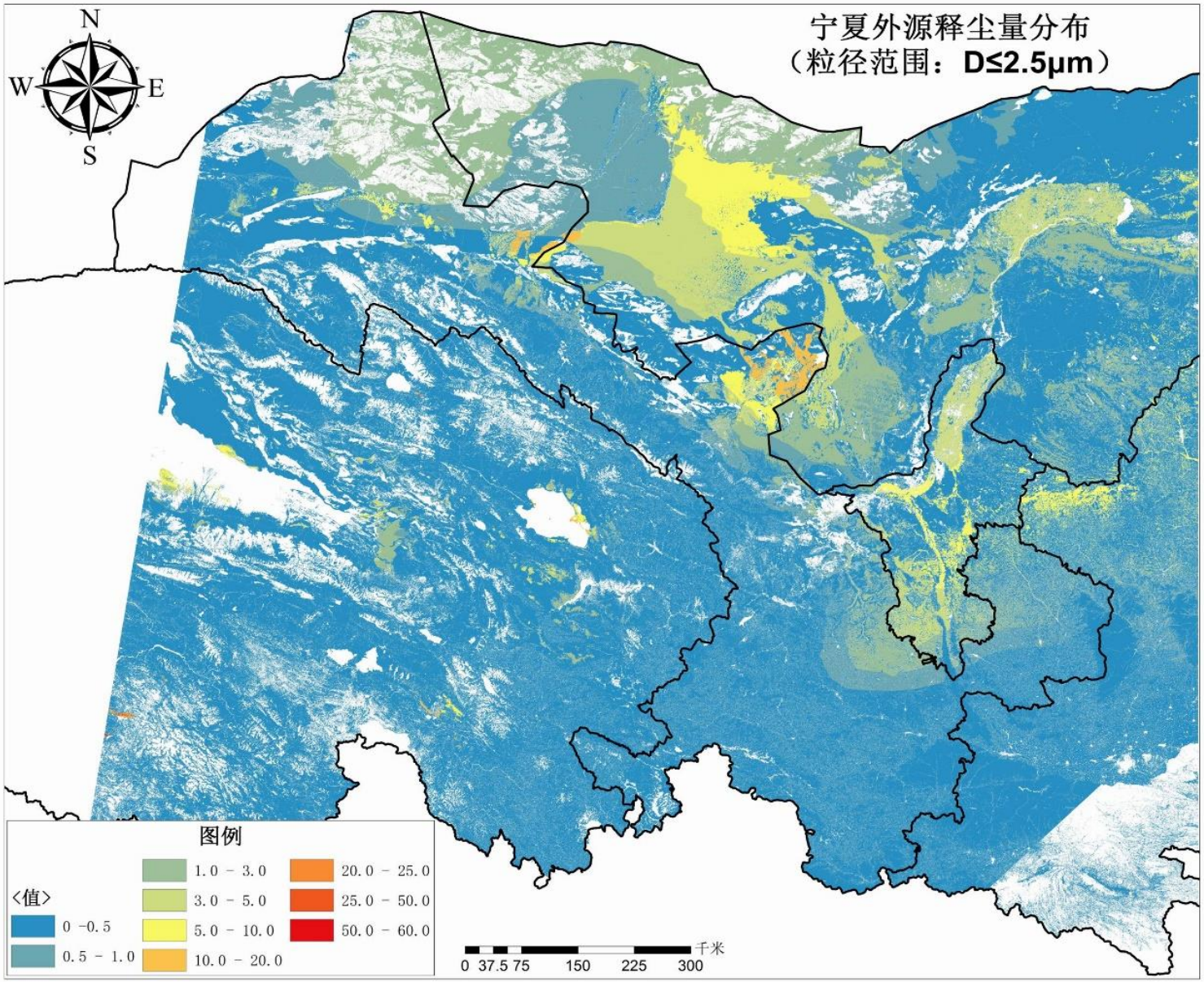
观测点位置（I：塔克拉玛干沙漠；II：青海盆地和敦煌区域戈壁；III：河西、阿拉善区域戈壁；IV：毛乌素沙地；V：阴山北部戈壁、沙地；VI：浑善达克沙地及周边草地；VII：科尔沁沙地）

The average content of dust particles in different types of land surface

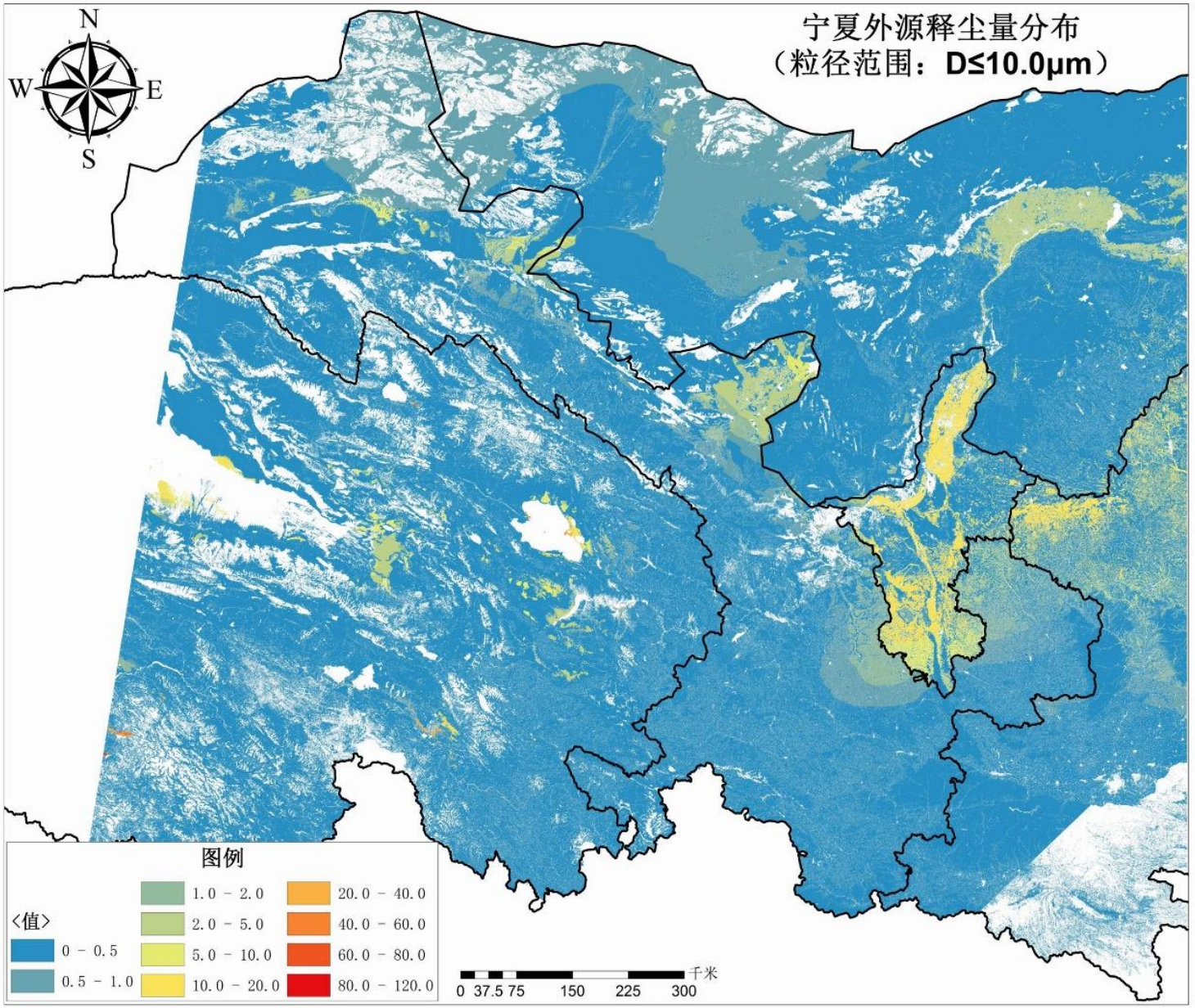
Topsoil particle size

地区	粒径范围/μm	草地	耕地	林地	沙地
甘肃	< 2.5	3.85	5.67	3.96	2.84
	(2.5，10)	3.99	7.06	5.70	3.13
	(10，20)	2.38	4.98	4.66	2.36
	(20，50)	18.57	17.24	37.18	5.24
	> 50	71.21	65.05	48.49	86.43
内蒙古	< 2.5	3.6	5.53	—	0.79
	(2.5，10)	5.33	6.17	—	1.17
	(10，20)	3.90	4.13	—	0.74
	(20，50)	6.79	31.95	—	0.70
	> 50	80.37	52.22	—	96.58
陕西	< 2.5	7.72	5.75	11.23	—
	(2.5，10)	10.20	6.07	14.24	—
	(10，20)	7.57	2.94	9.51	—
	(20，50)	26.69	22.61	23.77	—
	> 50	47.67	62.62	41.25	—
青海	< 2.5	2.78	9.97	—	—
	(2.5，10)	2.9	12.83	—	—
	(10，20)	1.63	9.61	—	—
	(20，50)	17.38	24.13	—	—
	> 50	75.27	43.47	—	—

$PM_{2.5}$ dust release fluxes of different surface open sources



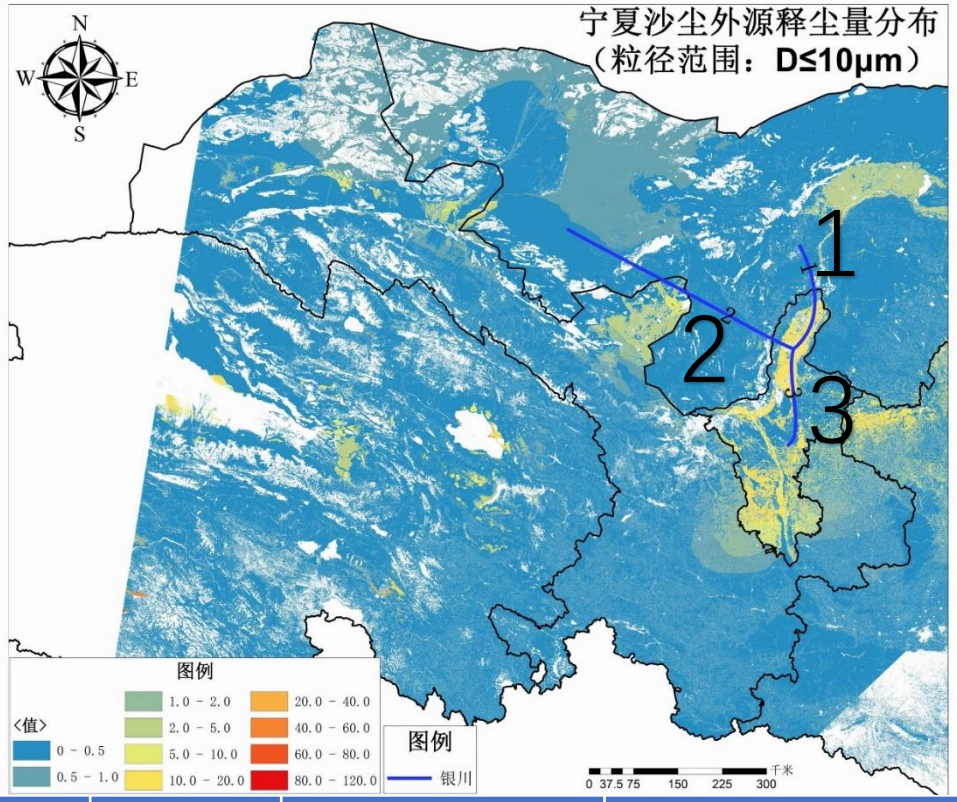
PM_{10} dust release fluxes of different surface open sources

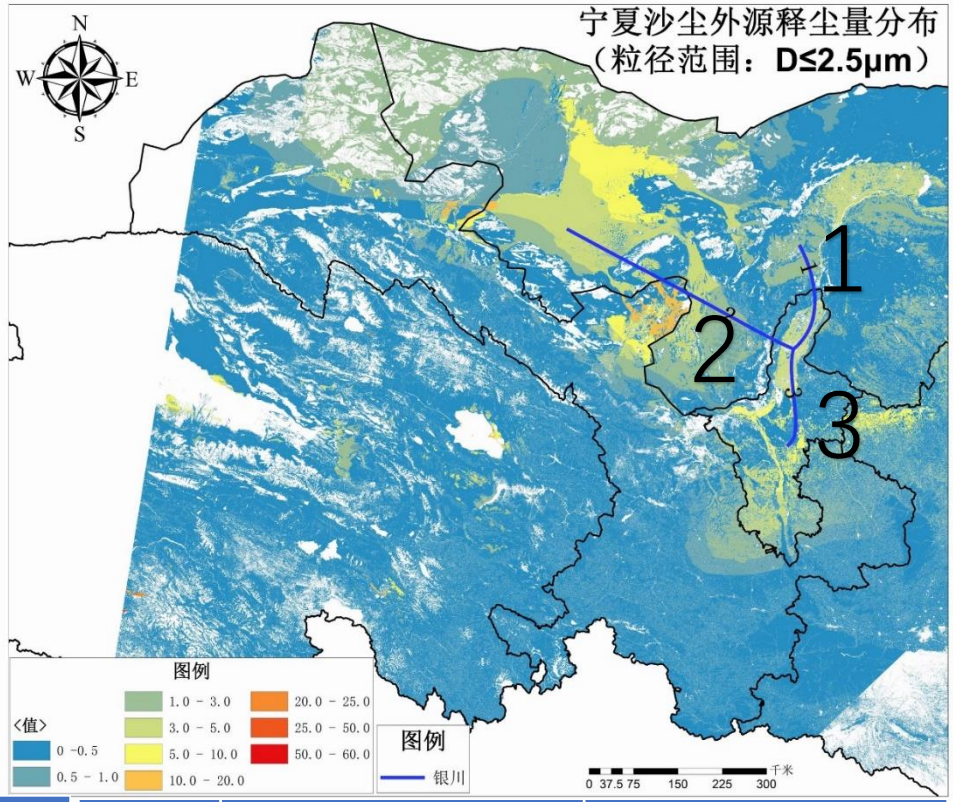


Dust release fluxes of different surface open sources

省市	土地利用类型	面积(公顷)	风蚀模数（吨/公顷·年）	$PM_{2.5}$释尘模数（吨/公顷·年）	$PM_{2.5}$释尘量（吨）	PM_{10}释尘模数（吨/公顷·年）	PM_{10}释尘量（吨）
甘肃	草地	12053329	0.1339	0.0008	9322.2320	0.0016	18983.4543
	林地	5530876	0.0321	0.0002	1053.6366	0.0005	2570.2346
	耕地	1857410	2.3340	0.1323	245801.8442	0.2971	551861.9889
	沙地	1524666	32.7090	0.9289	1416317.2537	1.9527	2977258.4523
	裸土	7445095	2.3262	0.0872	649465.2786	0.1924	1432287.4277
内蒙古	草地	4748011	0.8755	0.0047	22446.3110	0.0117	55679.3213
	林地	796311	0.9507	0.0051	4087.9742	0.0127	10140.4472
	耕地	1454018	11.6352	0.6434	935549.9450	1.3613	1979373.3013
	沙地	9338429	64.1831	0.5070	4735016.9109	1.2580	11747636.8928
	裸土	261	4.1546	0.1558	40.6265	0.3436	89.5949
陕西	草地	981252	0.1012	0.0012	1150.0203	0.0027	2669.4772
	林地	8038846	0.0086	0.0000	393.9035	0.0001	861.2240
	耕地	2903351	2.3408	0.2334	677566.3577	0.5337	1549499.7949
	沙地	173658	13.6762	0.5129	89061.9945	1.1310	196411.3853
	裸土	28014	0.3683	0.0138	386.8628	0.0305	853.1615
青海	草地	27399846	0.0716	0.0003	8179.3910	0.0006	16711.8493
	林地	2869733	0.0065	0.0000	77.7105	0.0001	158.7754
	耕地	880119	1.2196	0.1216	107016.5171	0.2781	244731.8545
	沙地	656845	15.7539	0.5908	388045.9451	1.3028	855770.6576
	裸土	3205474	0.2916	0.0109	35049.6673	0.0241	77296.1996

Cluster Analysis Comparison Results





轨迹类别	占总轨迹数的比例/%	污染轨迹出现的频率		输送类型/地区
		PM10	PM2.5	
1	21.99%	17.53%	15.16%	阿拉善左旗、贺兰县、平罗县、乌海市
2	60.17%	23.87%	23.24%	阿拉善左旗、民勤县、阿拉善右旗
3	17.85%	34.46%	19.93%	同心县、灵武县、永宁县

轨迹类别	所有轨迹对应的ρ平均值/(μg/m3)		污染轨迹对应的ρ平均值/(μg/m3)	
	PM10	PM2.5	PM10	PM2.5
1	108.01	38.15	244.66	110.55
2	139.71	46.87	234.42	121.4
3	117.37	45.02	223.08	114.39

Conclusions

- The maximum contribution rate of dust weather to the atmospheric environment quality of five cities in Ningxia occurred in March, and the average contribution rate was 17.02%.
- The average daily concentration of PM_{10} in Yinchuan is less than 190 $\mu g/m^3$ in potential source areas; For most potential source areas, the average daily concentration of $PM_{2.5}$ in Yinchuan is generally less than 70 $\mu g/m^3$.
- The main transmission path affecting PM_{10} concentration in Yinchuan is Alashan Left Banner-Helan-Pingluo-Wuhai. The main transmission path affecting $PM_{2.5}$ concentration in Yinchuan is Alashan Left Banner-Minqin-Alashan right flag.

Thank you ！