Influences of cement production on atmospheric ^{13}C-CO_2 in the Yangtze River Delta

Reporter: Jiaping Xu

2014-01-10

Outline

- 1. Background
- 2. Objective
- 3. Preliminary results
  - 3.1 Cement and clinker production in YRD
  - 3.2 CO_2 emission from cement production
  - 3.3 Back trajectories
- 4. Conclusions
- 5. Next work

1. Background

- In 2011, cement production was about 2.1bt in China, which accounted for 61.47% in the whole world.

- Cement production has become the second biggest CO_2 emission source in China's manufacturing industry following coal-fired plants.

- During the process of burning, the raw material of cement and clink can release a rich ^{13}C signal ($\delta^{13}C$ =0) into atmosphere.

- YRD is an important area of concrete production base, with land area only of 4.57%, but raising over 15% of cement and clink.

The CO_2 emission from cement production

- 1. $CaCO_3 \rightarrow CaO + CO_2$ (65%) 510.710kgCO_2/ton
- 2. $MgCO_3 \rightarrow MgO + CO_2$ (1.5%) 16.5kgCO_2/tton
- 3. EF_{ckd} (3%) 1.3kgCO_2/tton
- 4. Organic carbon(0.2%) 11.5kgCO_2/ton
- 5. Diesel for process
- 6. Combustion of fossil fuel for power
- 7. Remained heat

Clinker (90%) + CaSO4 + industrial residue + industrial additive → Cement

2. Objective

Why atmospheric $\delta^{13}C$ in Nanjing was less negative in Beijing?

Whether cement production played an important role in atmospheric CO_2 of Nanjing?

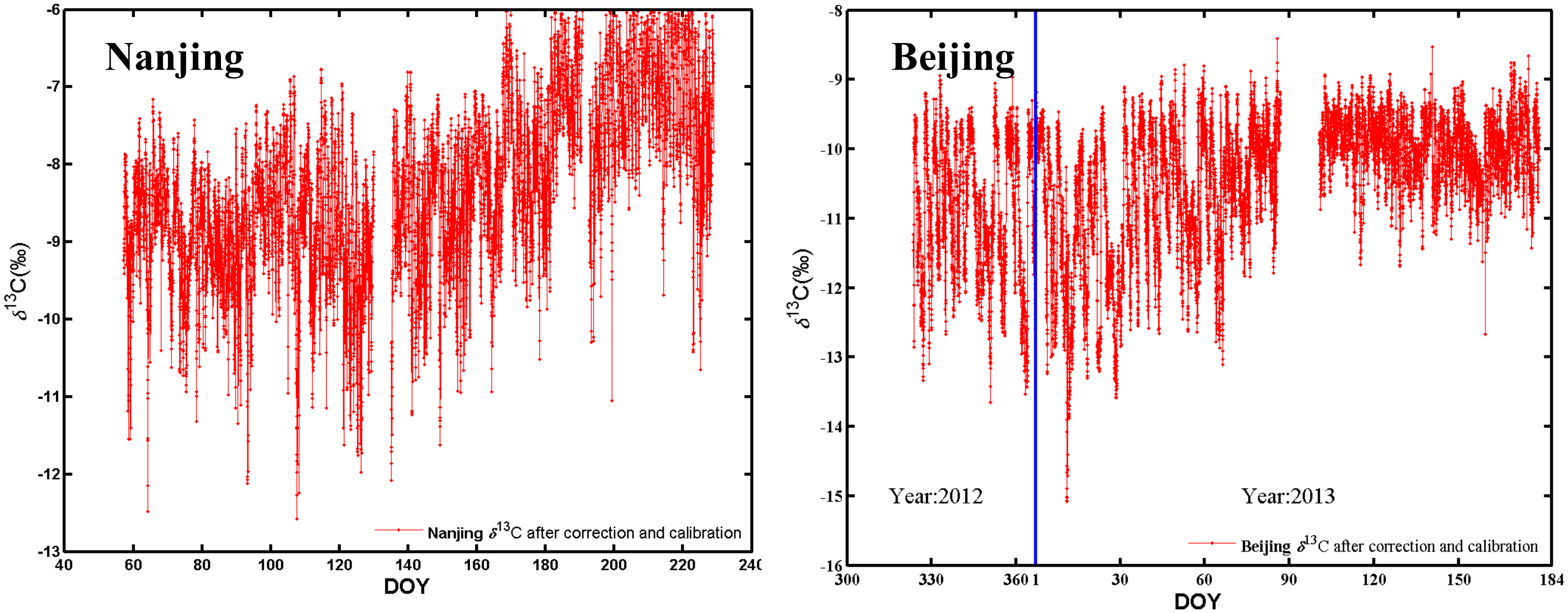

Fig. 1.The time series of $\delta^{13}C$ in Beijing and Nanjing.

Why $\delta^{13}C$ in Nanjing was such rich during summer?

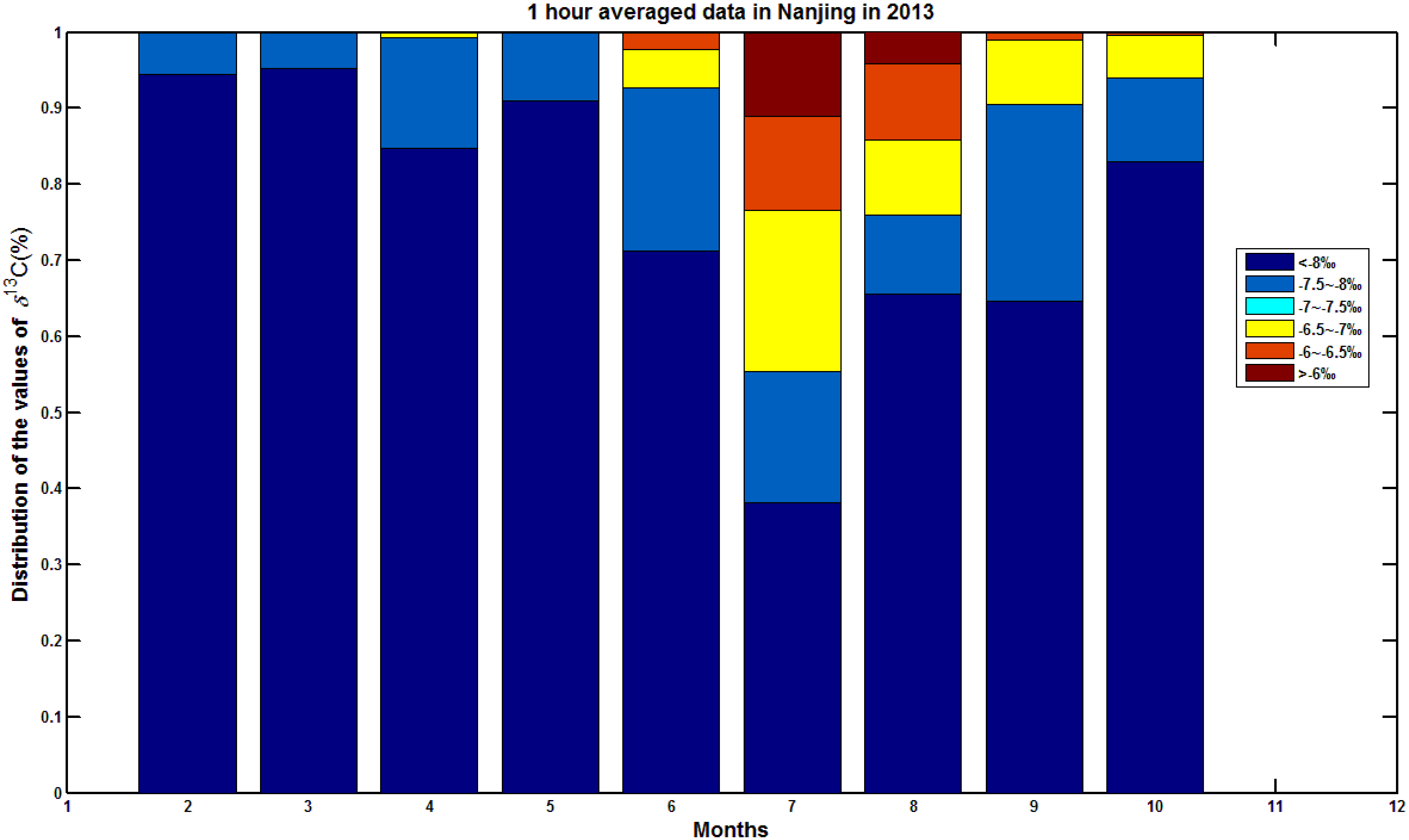

Fig.2 Distribution of the values of $\delta^{13}C$ in Nanjing in 2013.

- 1. To investigate the production of cement and clinker in YRD and its seasonal variation.

- 2. To calculate the CO_2 emission due to cement production in YRD.

- 3.To analyze back trajectories.

3. Preliminary results

- 3.1 Cement and clinker production in YRD
- 3.2 CO_2 emission from cement production
- 3.3 Back trajectories

3.1 Cement and clinker production in YRD

3.1.1 Material and Method

- 1.Yearbook of China cement
- 2.China Statistical Yearbook(2011-2013)
- 3.The monthly data were achieved from www.ccement.com

3.1.2 Cement and clinker production in YRD in 2013

Table.1 The number of cement plants in YRD

Areas	Clinker(10^6t)	Cement(10^6t)
Nanjing	9.27	10.30
Shanghai	0.0000437	7.95
Jiangsu	61.37	170.30
Zhejiang	56.70	115.40
Anhui	113.12	108.70
YRD	231.19	402.34

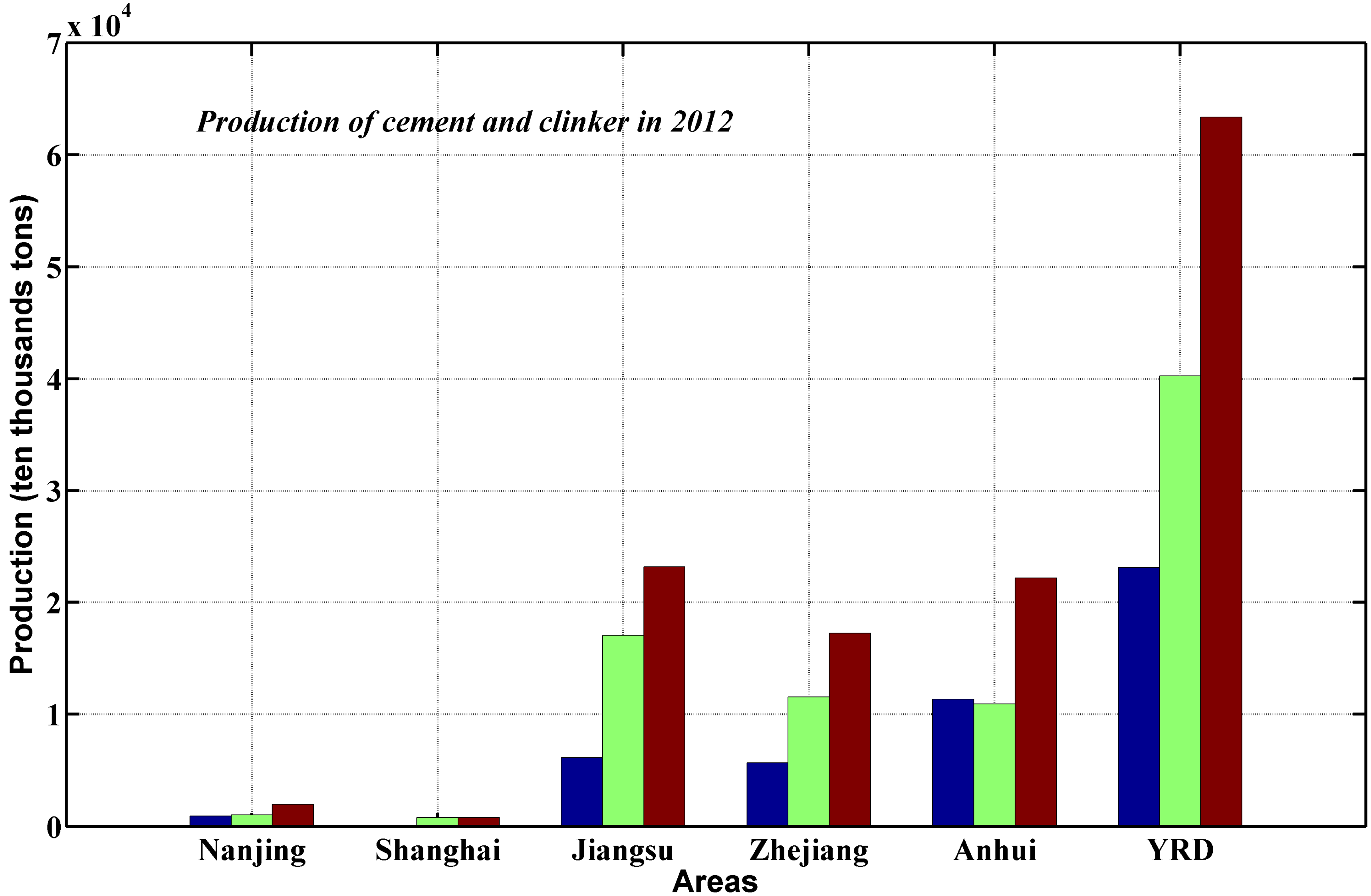

Fig.3 The cement production in YRD in 2012.

Table.1 The sum production of cement in Jan and Feb in YRD.

Province	Production (ten thousands tons)
Jiangsu	2246.87
Zhejiang	1149.71
Shanghai	82.13

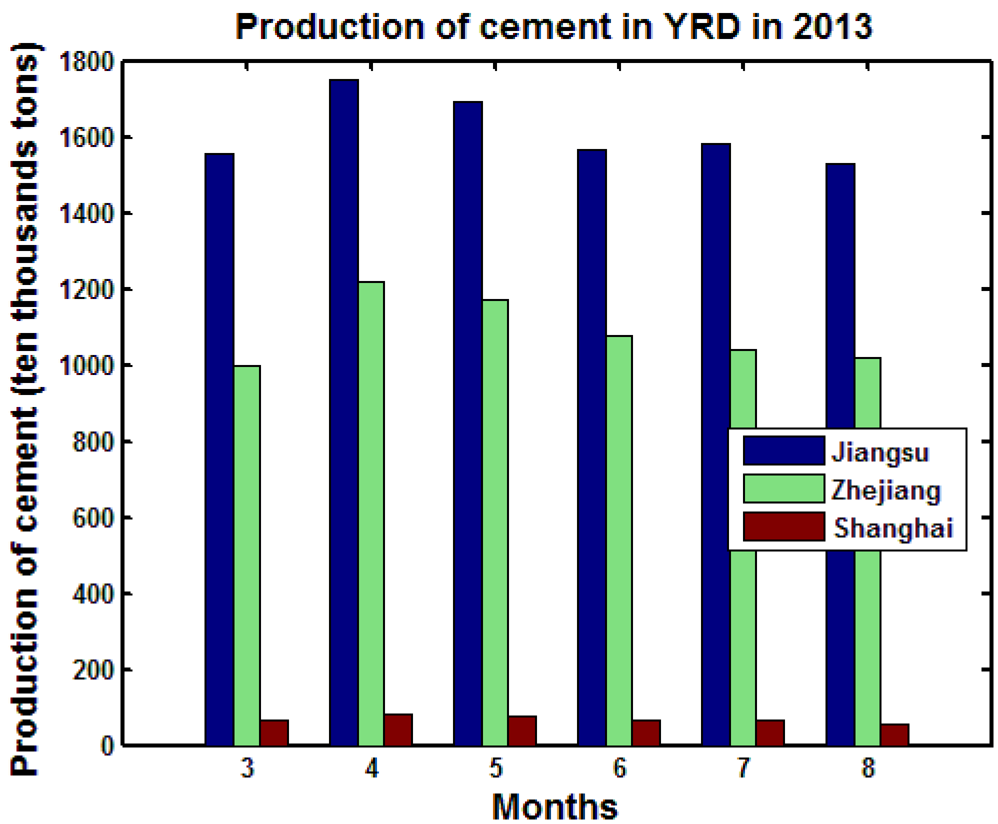

Fig.4 The time series of cement production in YRD in 2013.

Table.2 The sum production of clinker in Jan and Feb in YRD

Province	Production (tons)
Jiangsu	6019401.64
Zhejiang	5811159.25
Shanghai	52758

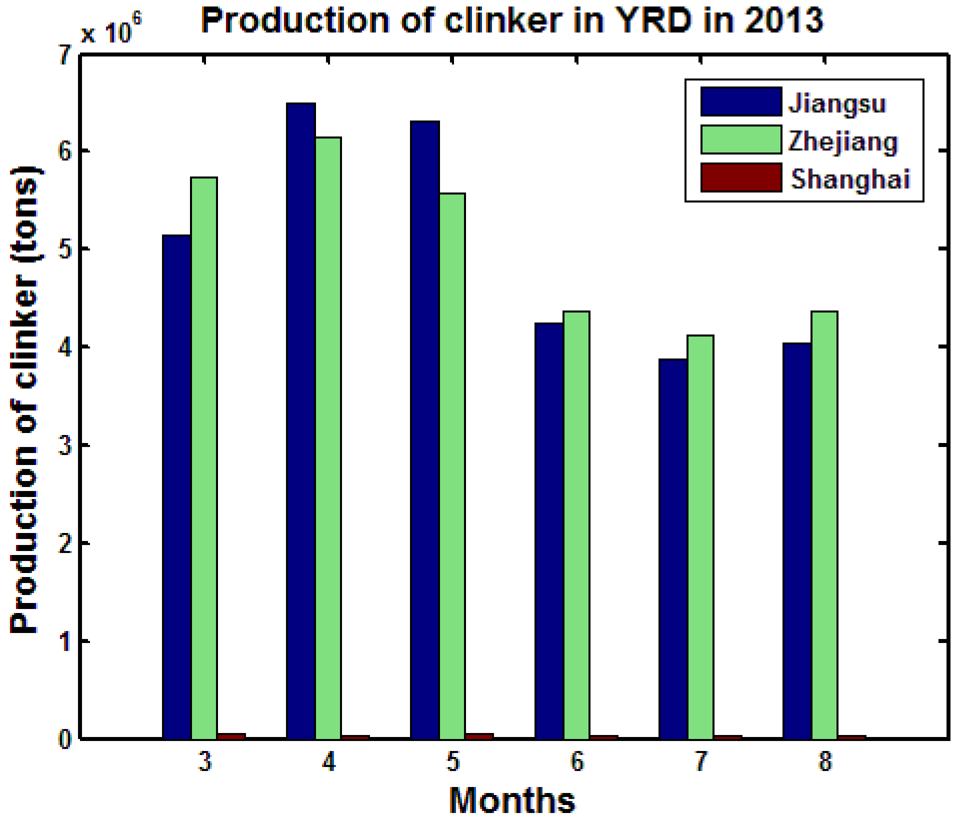

Fig.5 The time series of clinker production in YRD in 2013.

3.1.3 The cement plants in YRD

Table.2 The number of cement plants in YRD

Province	Production (ton/day)									
	All	>5000	5000	4000	3000	2500	2000	1500	1000	<1000
Jiangsu	259	0	12	0	0	9	0	1	0	237
Anhui	178	2	14	3	0	9	1	0	2	?
Zhejiang	?	0	3	0	0	14	2	4	1	?
Shanghai	10	0	0	0	0	0	0	0	0	10

Fig.6 The 1000T/d cement plants in YRD. Fig.7 The 1500T/d cement plants in YRD.

Fig.8 The 2000T/d cement plants in YRD.

Fig.9 The 2500T/d cement plants in YRD.

Fig.10 The 3000T/d cement plants in YRD.

Fig.11 The 4000T/d cement plants in YRD.

Fig.12 The 5000T/d cement plants in YRD.

Fig.13 The 6000T/d cement plants in YRD.

Fig.14 The 10000T/d cement plants in YRD.

3.1.4 Cement plants in Nanjing

Table.3 The main cement plants in Nanjing

Plants	Production (ton/day)
Nanjing Zhonglian(3 plants)	1000+1500+5000
China Hailuo(3 plants)	2000+2*5000
Lishui Hantian	5000
Jiangnan Xiaotanye	4000
Nanjing Ningxin	**5000**
Nanjing Hailuo	About 5500

Nanjing Ningxin is the nearest cement plant to our university which can produce 5000ton cement per day.

Fig.15 The location of Nanjing Ningxin.

3.2 CO_2 emission from cement production

3.2.1 Material and Method

- 1. China Statistical yearbook.
- 2. IPCC method based on the material balance.

Table.4 Industry energy consumption and products of related industrial processes.

	Nanjing	Shanghai	Jiangsu	Zhejiang	Anhui	YRD
Raw coal(10^7t)	2.86	0.73	28,29	12.90	15.62	57.55
Gasoline(10^4t)	2.89	31.31	38.37	31.16	4.07	104.91
Diesel oil(10^5t)	0.99	6.78	9.61	7.84	3.09	23.32
Fuel oil(10^5t)	0.84	4.02	7.02	20.24	0.64	31.92
Natural gas(10^9m^3)	2.37	5.01	5.71	3.94	0.75	15.40
Clinker(10^6t)	9.27	$4.37*10^{-5}$	61.37	56.70	113.12	231.19
Cement(10^6t)	10.30	7.95	170.30	115.40	108.70	402.34
Synthesis ammonia(10^5t)	2.53	0	34.27	5.77	29.44	69.47
Pig iron(10^6t)	12.14	18.00	58.72	10.06	19.27	106.05
Crude steel(10^6t)	12.26	19.710	74.20	13.05	21.47	128.43

Table.5 CO_2 emission parameters according IPCC.

Material	Emission parameter	Min	Max
Raw coal	1.98	1.83	2.11
Gasoline	2.98	2.91	3.14
Diesel oil	3.16	3.1	3.19
Fuel oil	3.24	3.16	3.3
Natural gas	2.19	2.12	2.28
Clinker	0.52	0.51	0.53
Cement	0.468	0.459	0.477
Synthesis ammonia	3.27	3.04	3.5
Pig iron	1.35	1.15	1.55
Crude steel	1.06	0.9	1.22

Table.6 CO_2 emission from different industrial processes.

	Nanjing	Shanghai	Jiangsu	Zhejiang	Anhui	YRD
Raw coal (ton)	5.67E+07	1.45E+07	5.60E+08	2.55E+08	3.09E+08	1.14E+09
Gasoline (ton)	8.61E+04	9.33E+05	1.14E+06	9.28E+05	1.21E+05	3.13E+06
Diesel oil (ton)	3.12E+05	2.14E+06	3.04E+06	2.48E+06	9.78E+05	8.63E+06
Fuel oil (ton)	2.71E+05	1.30E+06	2.27E+06	6.56E+06	2.07E+05	1.03E+07
Natural gas (ton)	5.18E+05	1.10E+06	1.25E+06	8.63E+05	1.63E+05	3.37E+06
Clinker (ton)	4.82E+06	2.27E+01	3.19E+07	2.95E+07	5.88E+07	1.20E+08
Cement (ton)	4.82E+06	3.72E+06	7.97E+07	5.40E+07	5.09E+07	1.88E+08
Synthesis ammonia (ton)	8.29E+05	0.00E+00	1.12E+07	1.89E+06	9.63E+06	2.27E+07
Pig iron (ton)	1.64E+07	2.43E+07	7.93E+07	1.36E+07	2.60E+07	1.43E+08
Crude steel (ton)	1.30E+07	2.09E+07	7.86E+07	1.38E+07	2.28E+07	1.36E+08
Total (ton)	9.77E+07	6.89E+07	8.49E+08	3.79E+08	4.79E+08	1.78E+09

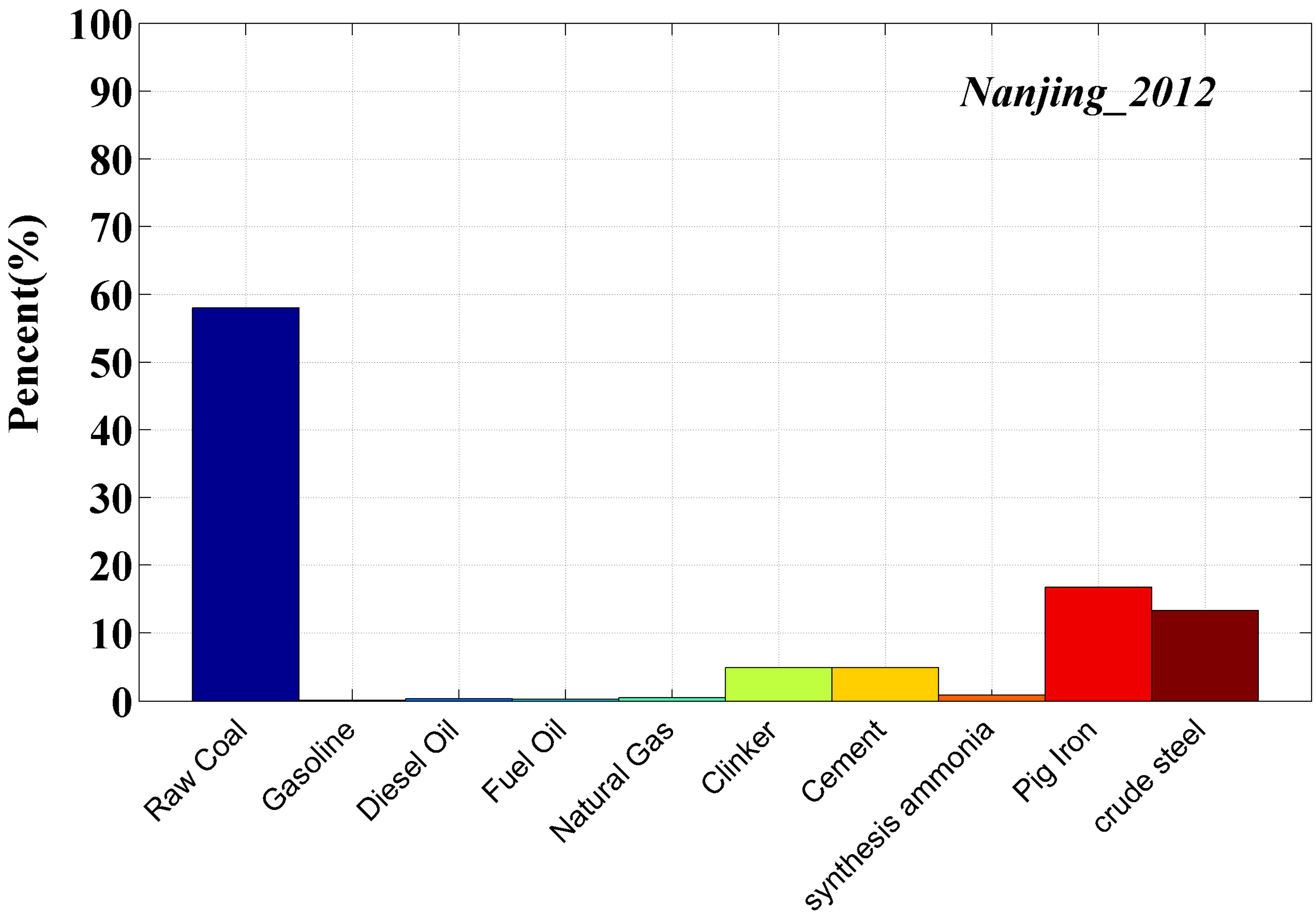

Fig.16 The different contributions of CO_2 emission among industrial processes in Nanjing.

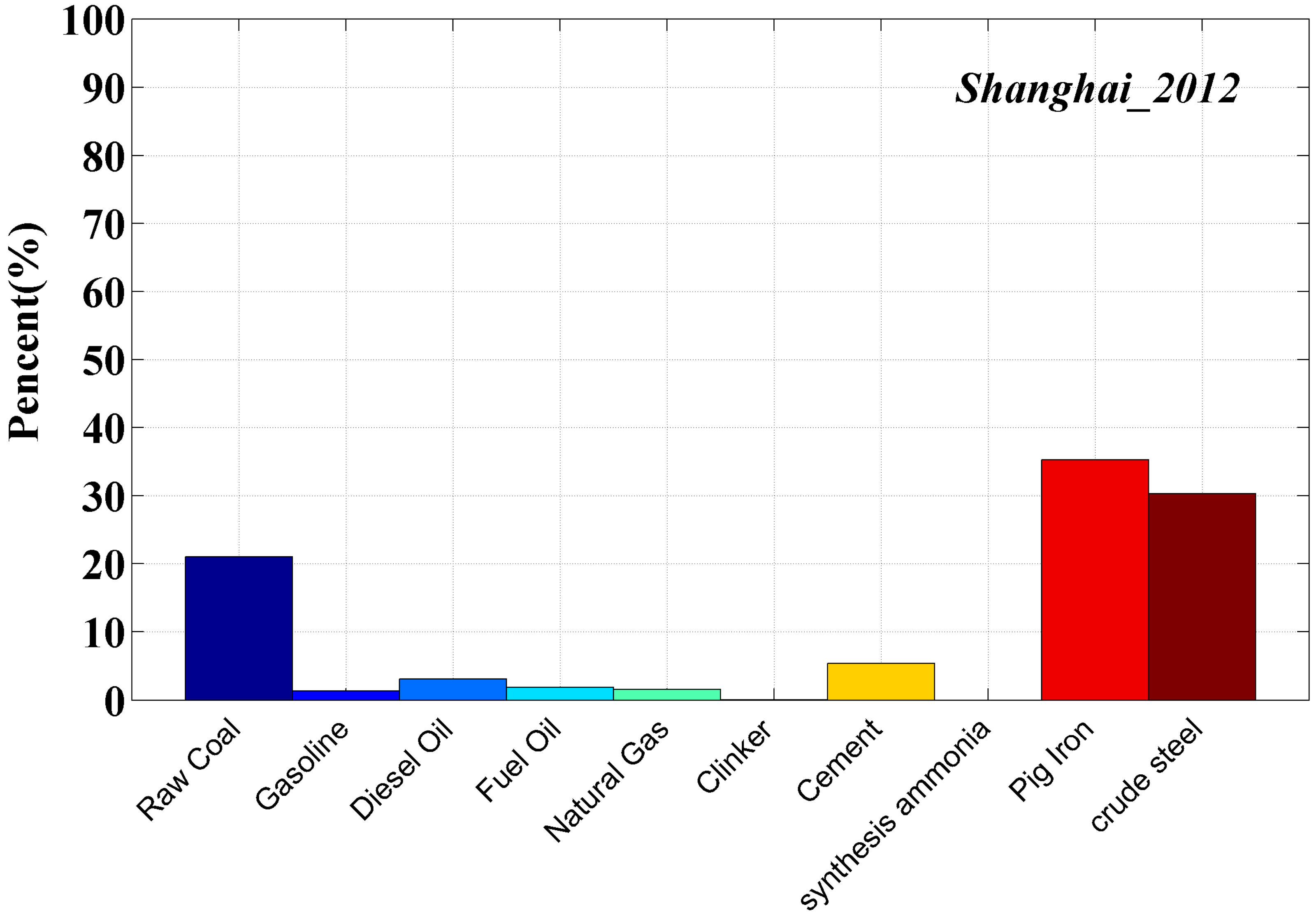

Fig.17 The different contributions of CO_2 emission among industrial processes in Shanghai.

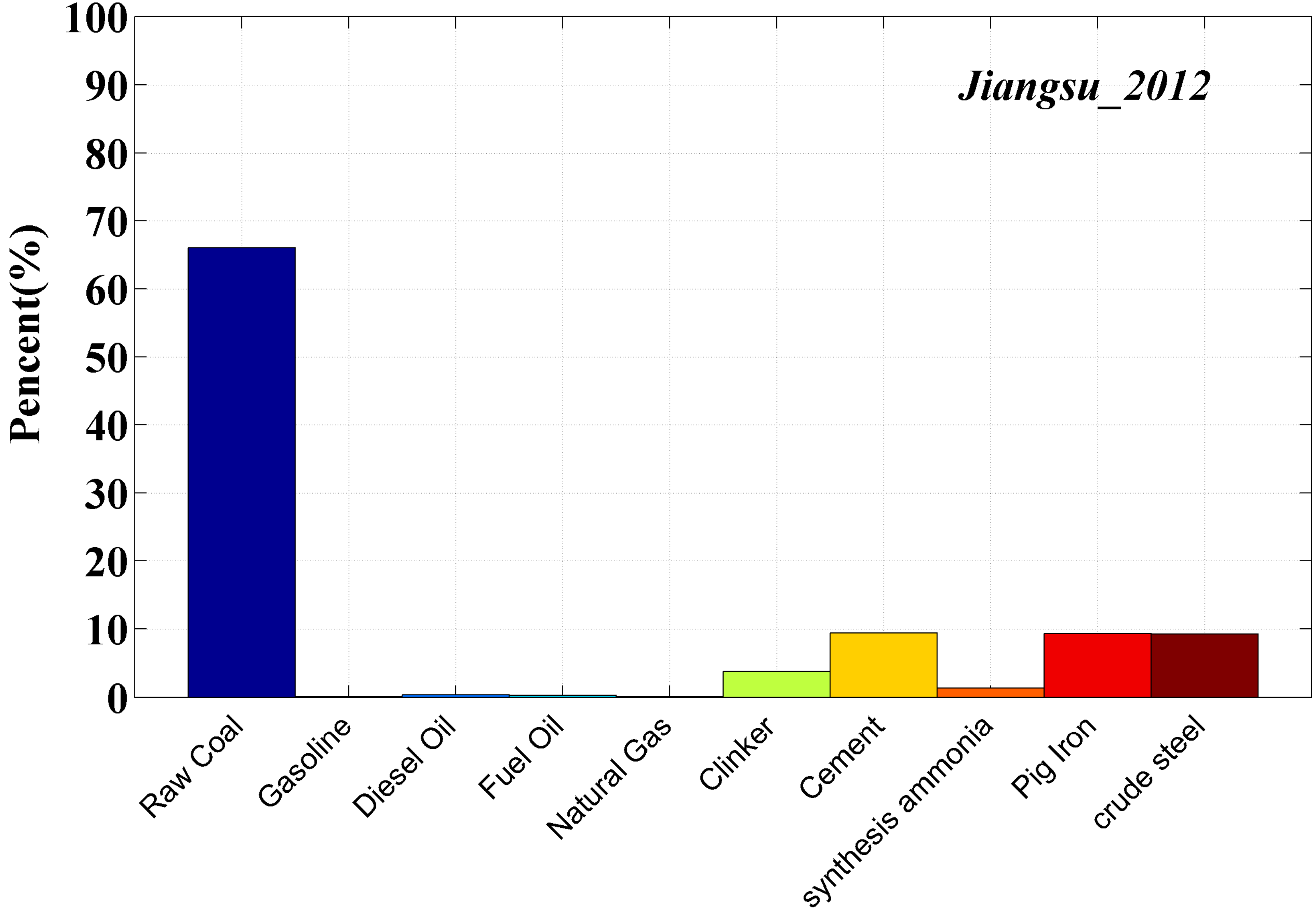

Fig.18 The different contributions of CO_2 emission among industrial processes in Jiangsu.

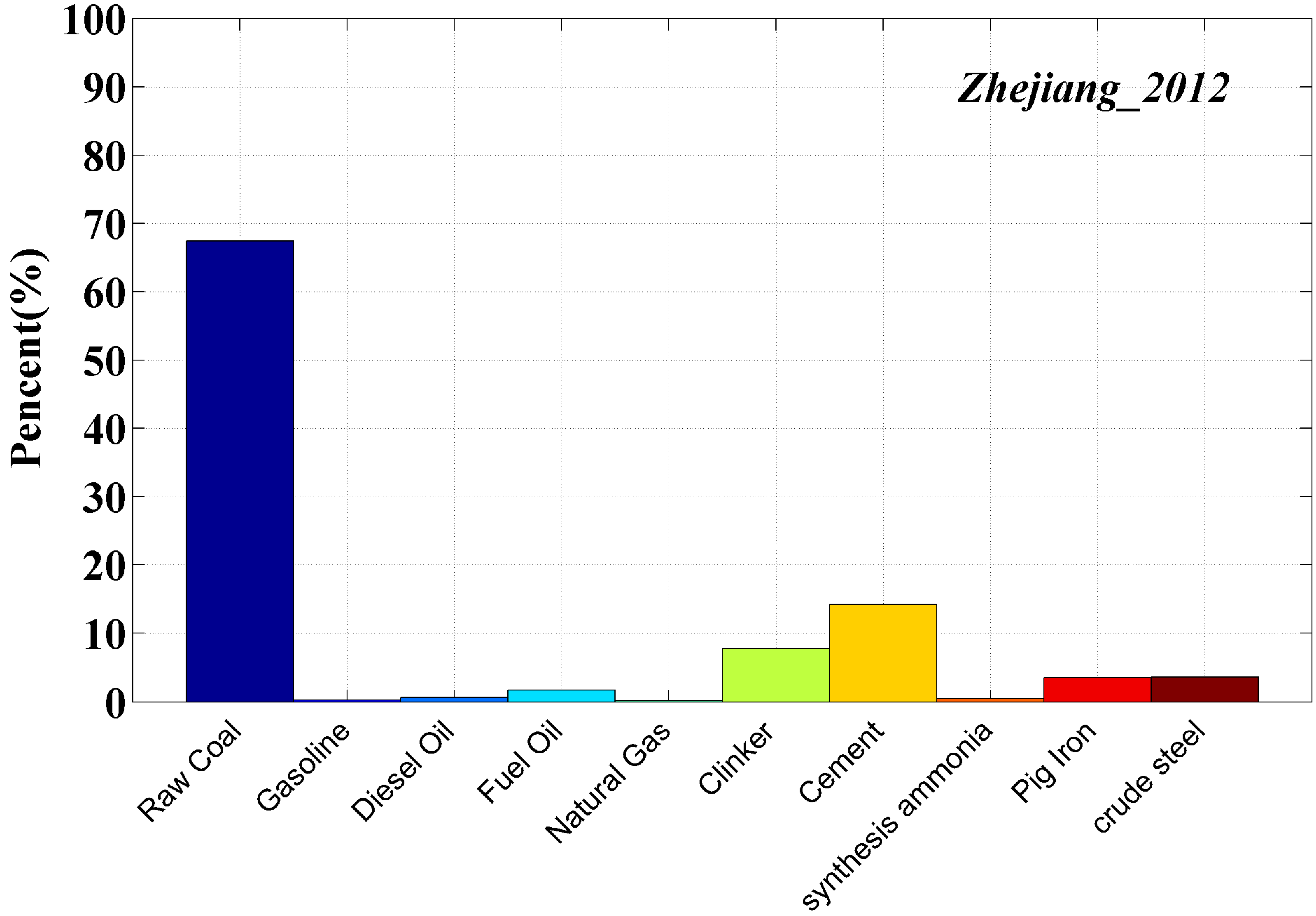

Fig.19 The different contributions of CO_2 emission among industrial processes in Zhejiang.

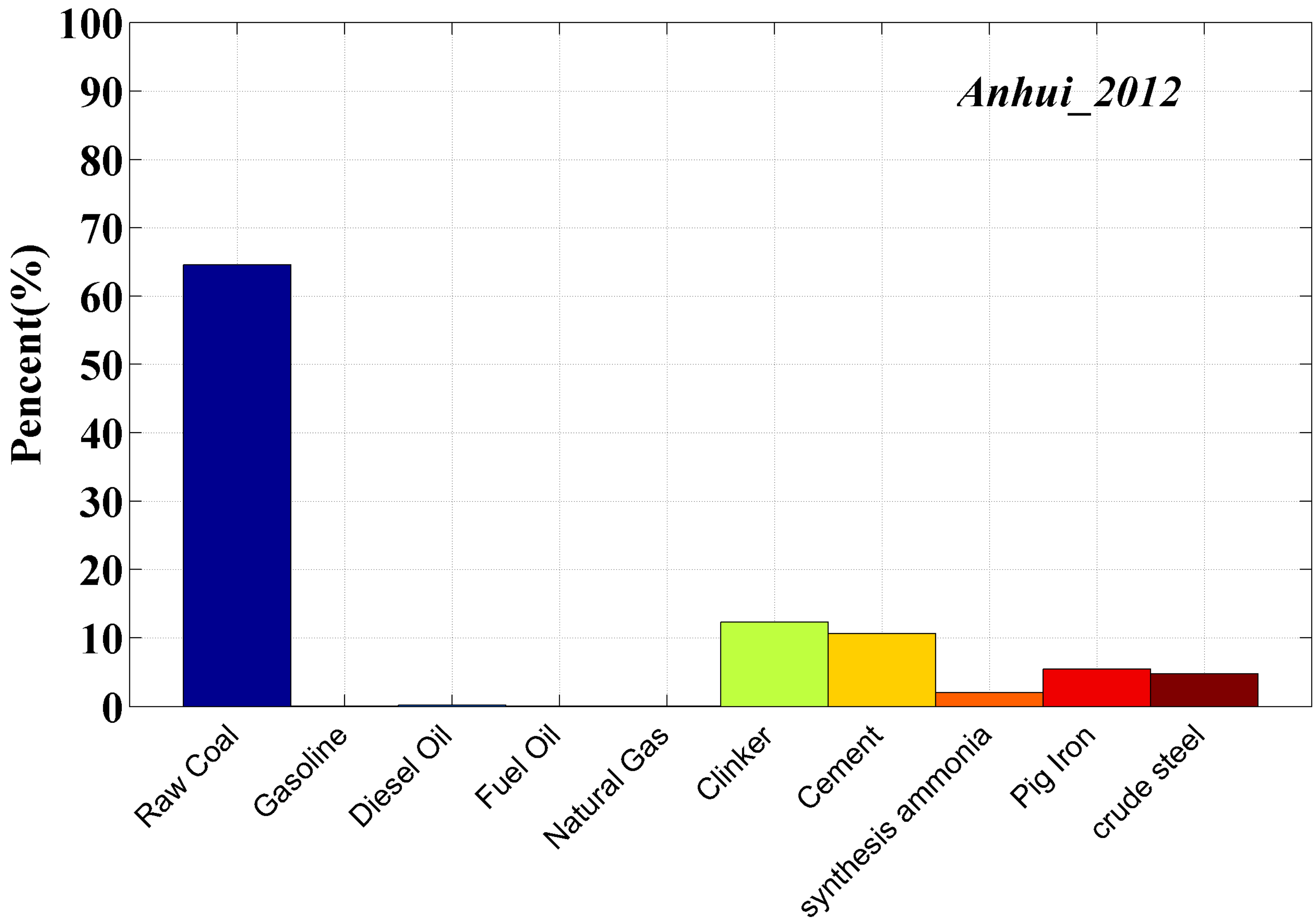

Fig.20 The different contributions of CO_2 emission among industrial processes in Anhui.

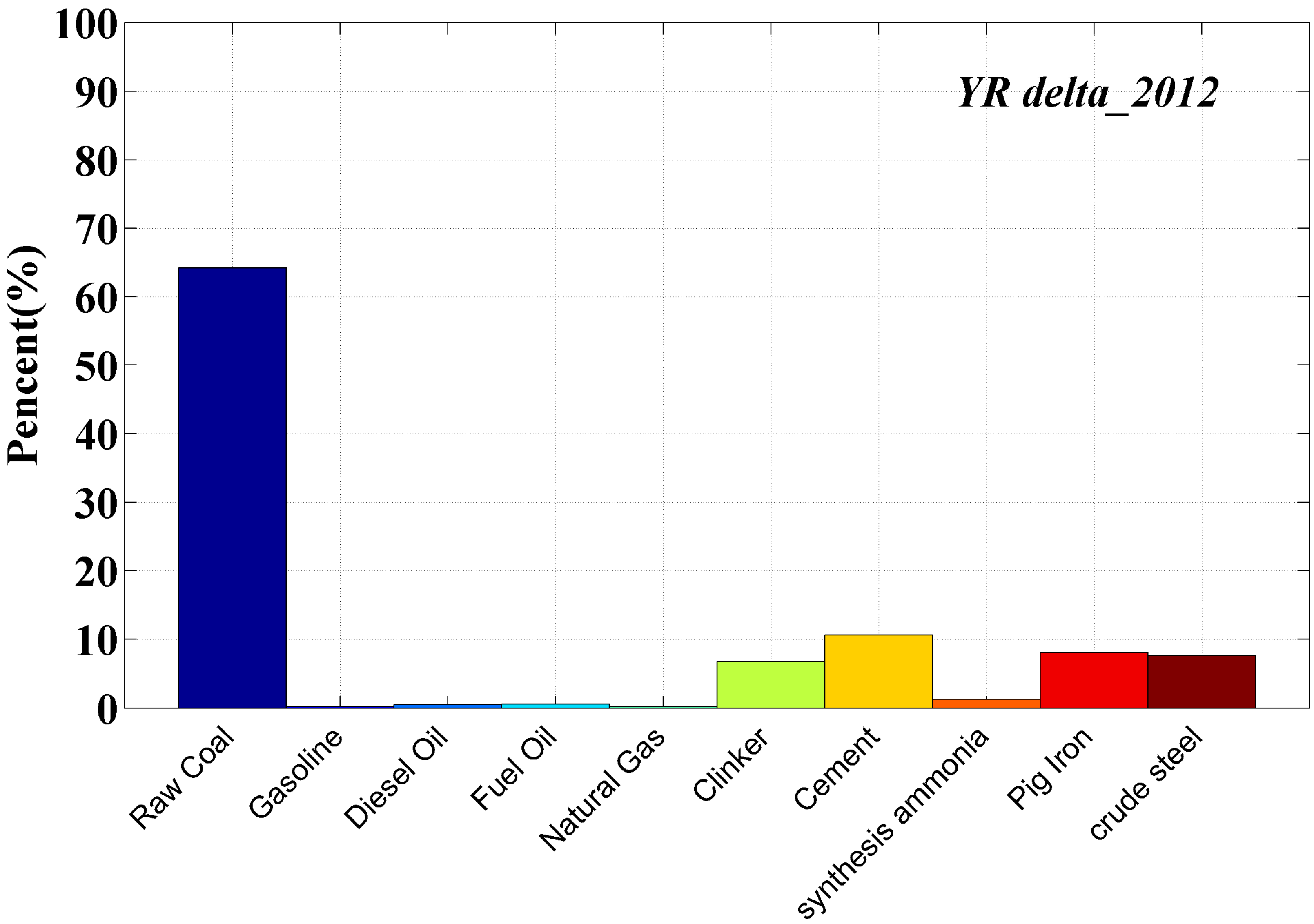

Fig.21 The different contributions of CO_2 emission among industrial processes in YRD.

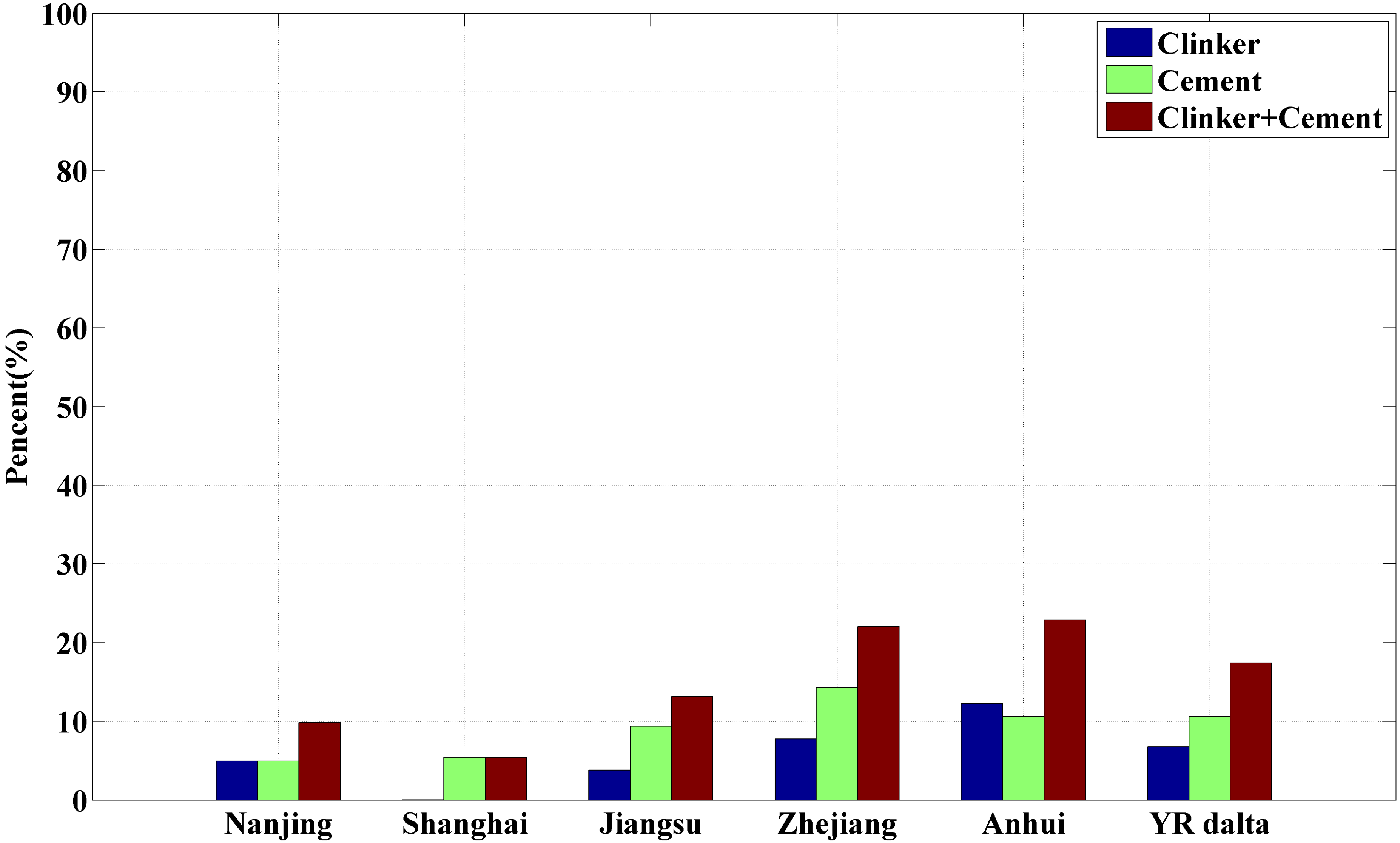

Fig.21 The percent of CO_2 emission contribution from cement production.

3.3 Back trajectories

3.3.1 Material and Method

- 1.Two 72-hour back trajectories every day (0 and 12 Beijing time) were calculated at 1000m AGL by using HSPLIT modeling.

- 2.All these back trajectories had been applied to make a clustering analysis which is embedded in the HSPILT software to find the main track of air mass in every month.

- NCEP GDAS data 1*1 degree.
- Location： Meteorology Building（32.207 118.717）
- Height:1000m

- In 2012, J.A. Adame found regular daily patterns of surface ozone, NO2 and SO2 in an industry area by using HSPLIT modeling and its cluster function.

- Somporn Chantara et.al (2012) reported that 3-day backward trajectories of air mass were analyzed and grouped by cluster analysis using HYSPLIT. They also defined the arriving level of air masses at 1000m above ground level (AGL) . I also did this. For the middle of troposphere in Nanjing area, it may be a good choice.

- F.Wang et.al (2010) selected a 24-h back trajectories to identify PM10 transport pathways in Beijing because they thought that it was sufficient to determine probable locations of regional emission sources and explain regional transport pathways at 300m height.

- M. Sadys et.al(2014) thought that a cluster methodology can reduce the uncertainty related to individual back trajectory.

- In addition, Mohd Talib Latif and Khan Alam's papers also gave the method of using HSPLIT to calculate back trajectories with different parameters according the various local conditions.

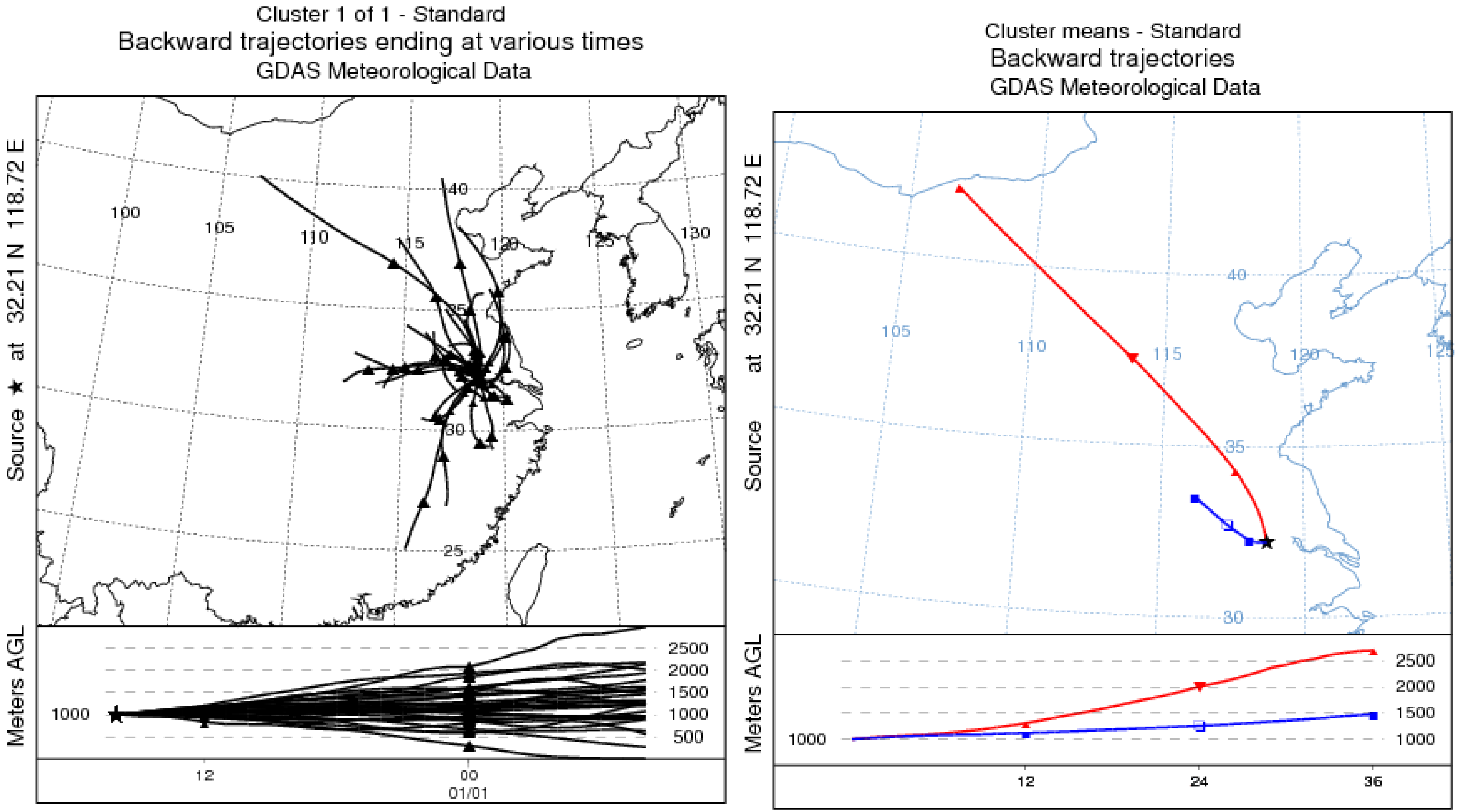

Fig.22 Daily back trajectories and clusters at Nanjing in Jan, 2013.

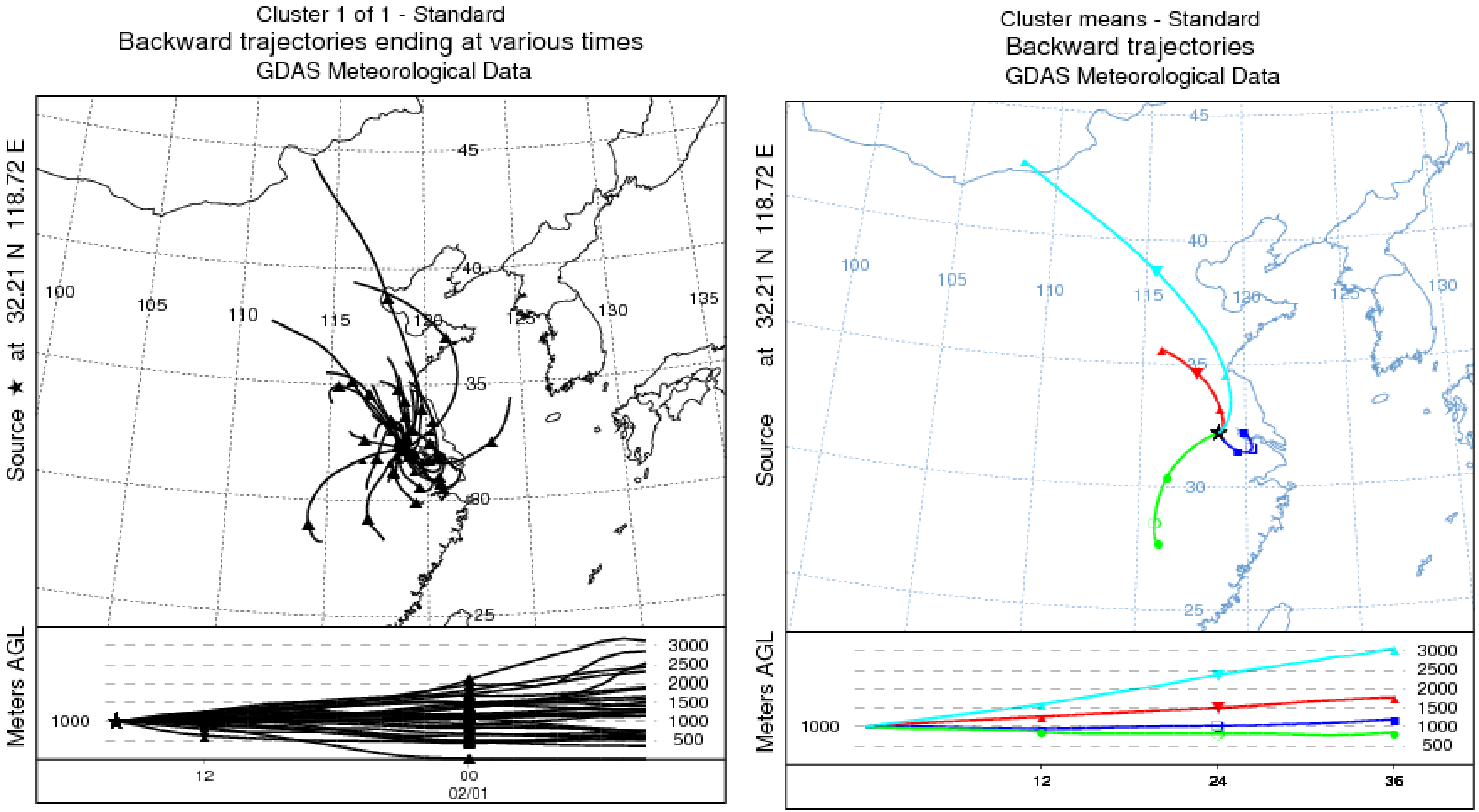

Fig.23 Daily back trajectories and clusters at Nanjing in Feb, 2013.

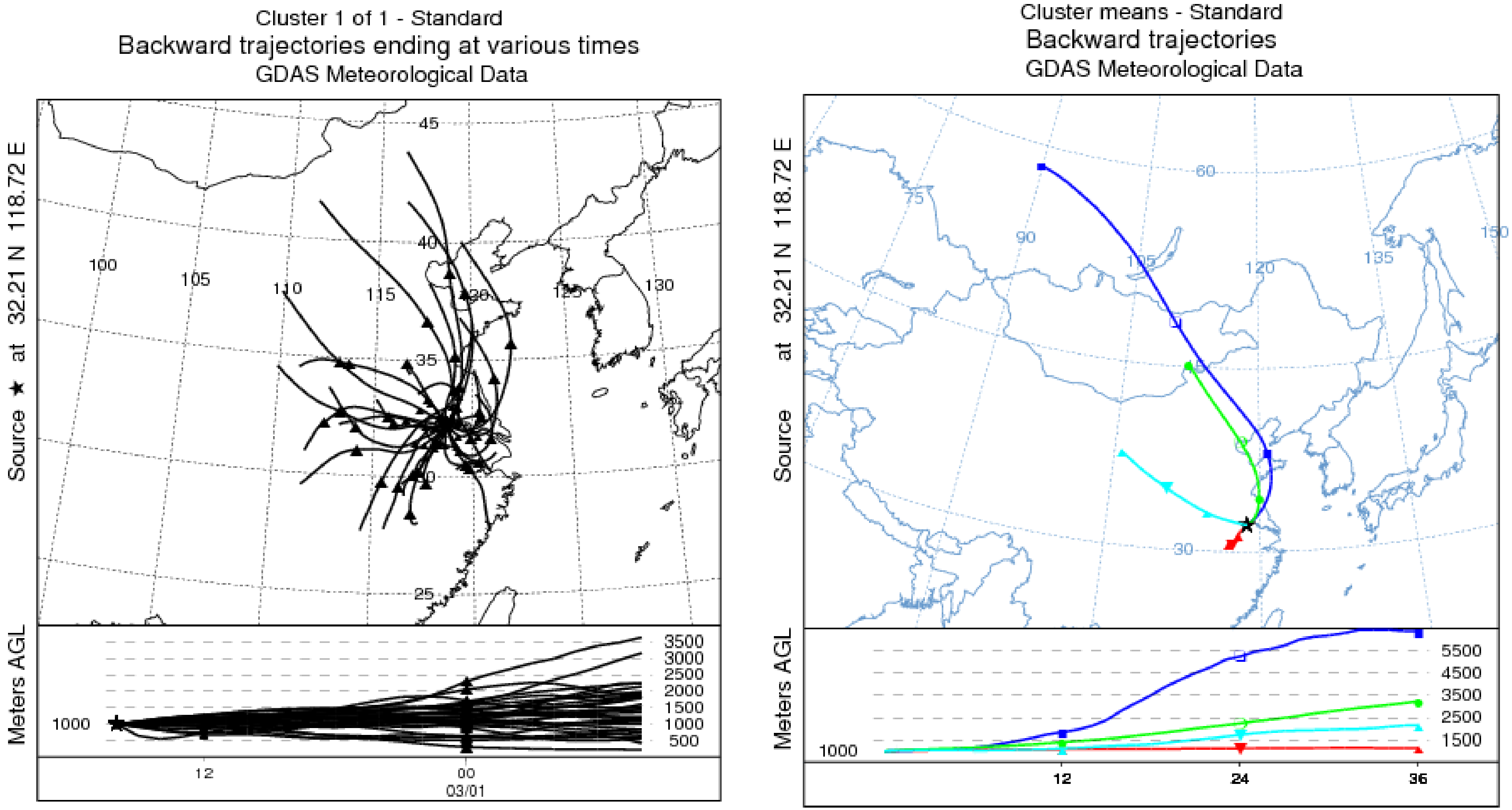

Fig.24 Daily back trajectories and clusters at Nanjing in Mar, 2013.

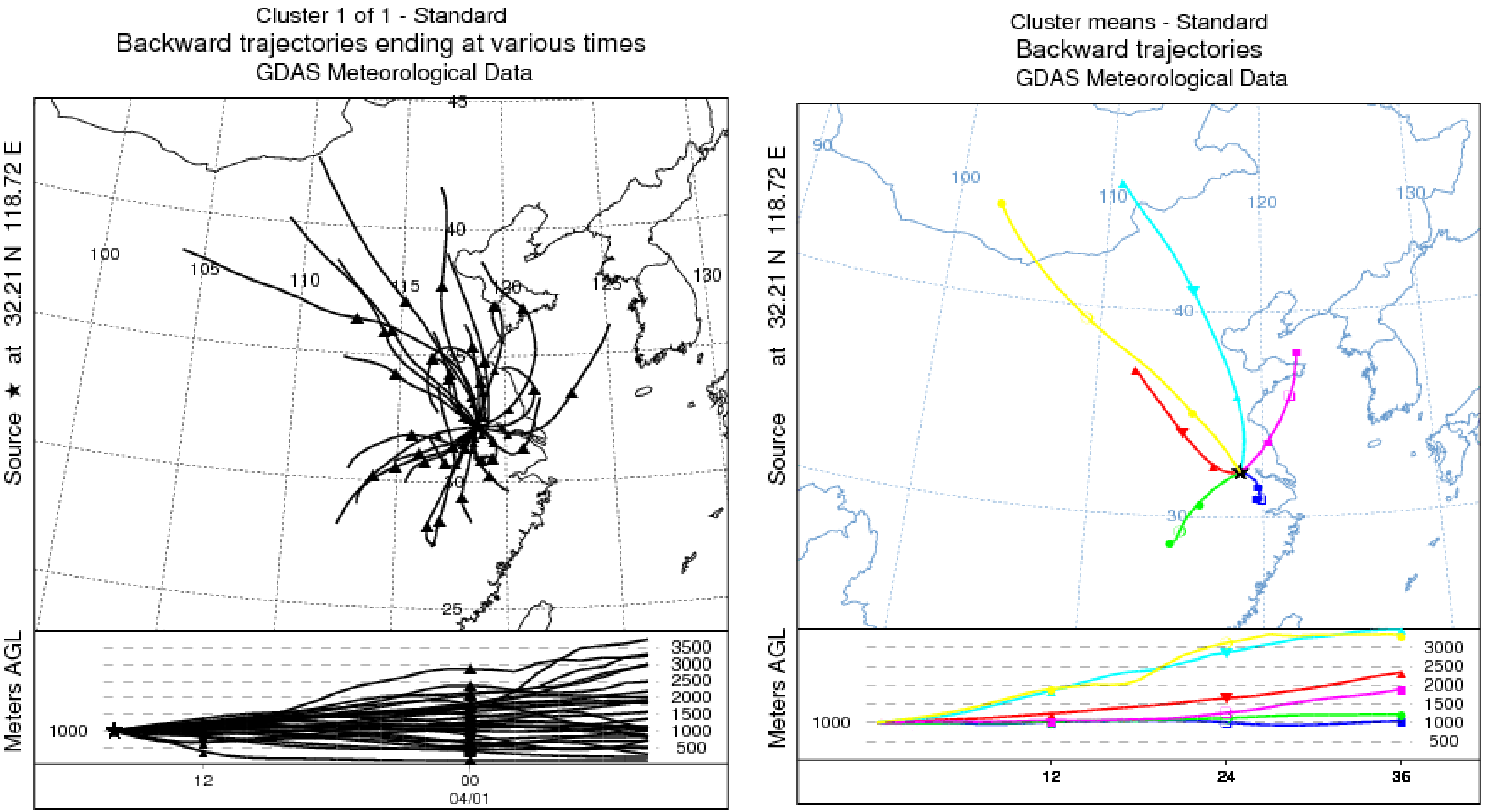

Fig.25 Daily back trajectories and clusters at Nanjing in Apr, 2013.

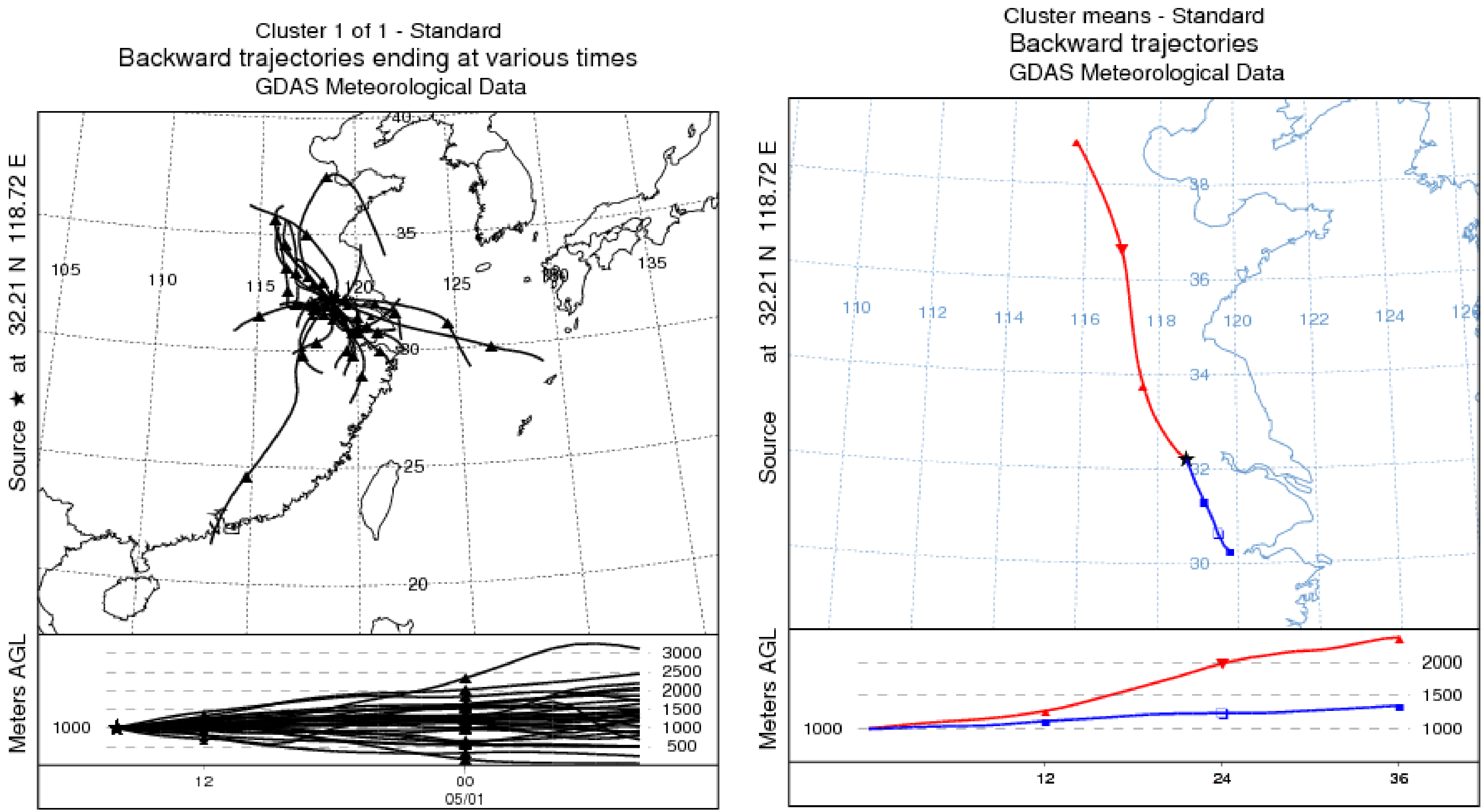

Fig.26 Daily back trajectories and clusters at Nanjing in May, 2013.

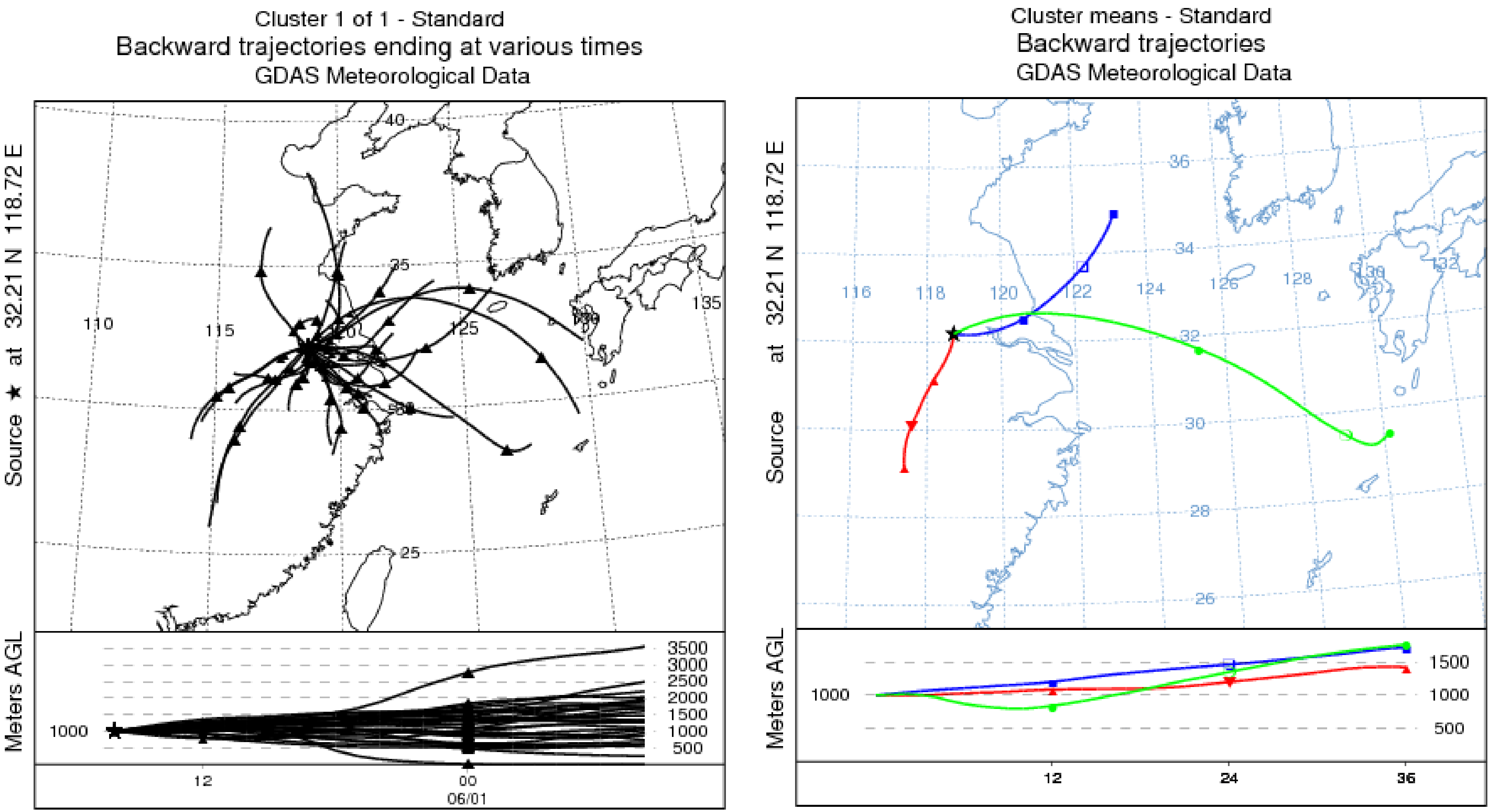

Fig.27 Daily back trajectories and clusters at Nanjing in Jun, 2013.

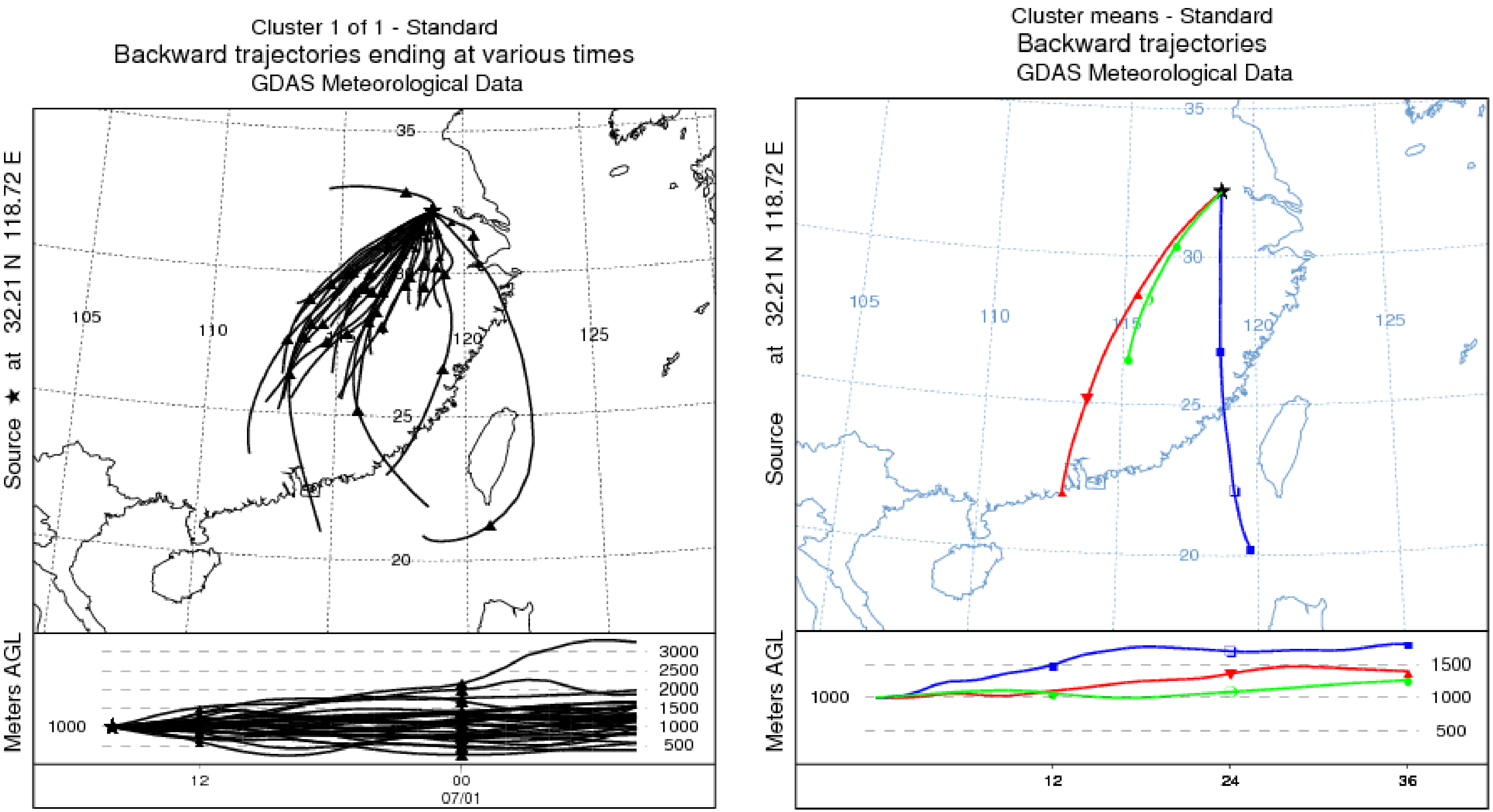

Fig.28 Daily back trajectories and clusters at Nanjing in Jul, 2013.

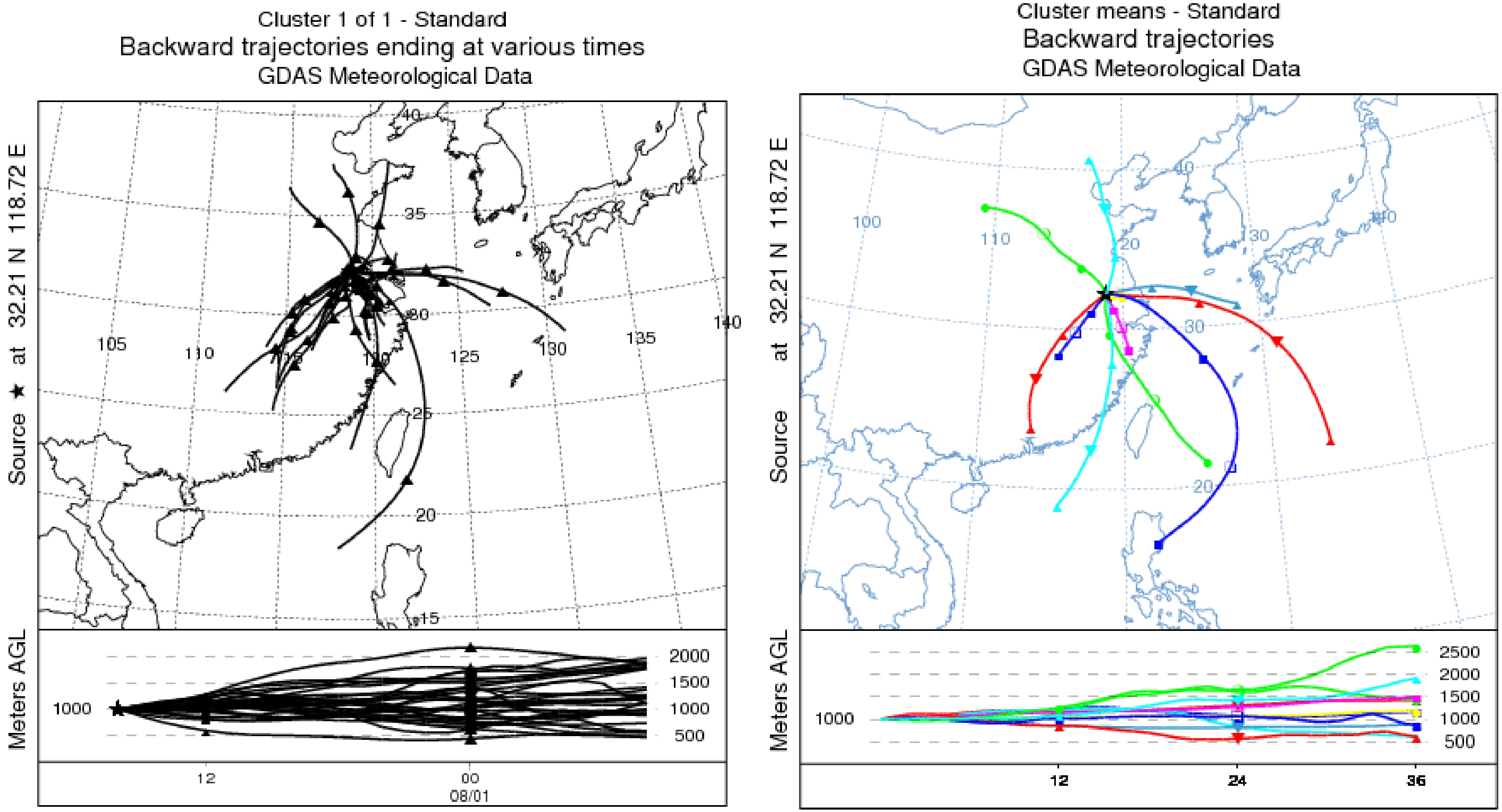

Fig.29 Daily back trajectories and clusters at Nanjing in Aug, 2013.

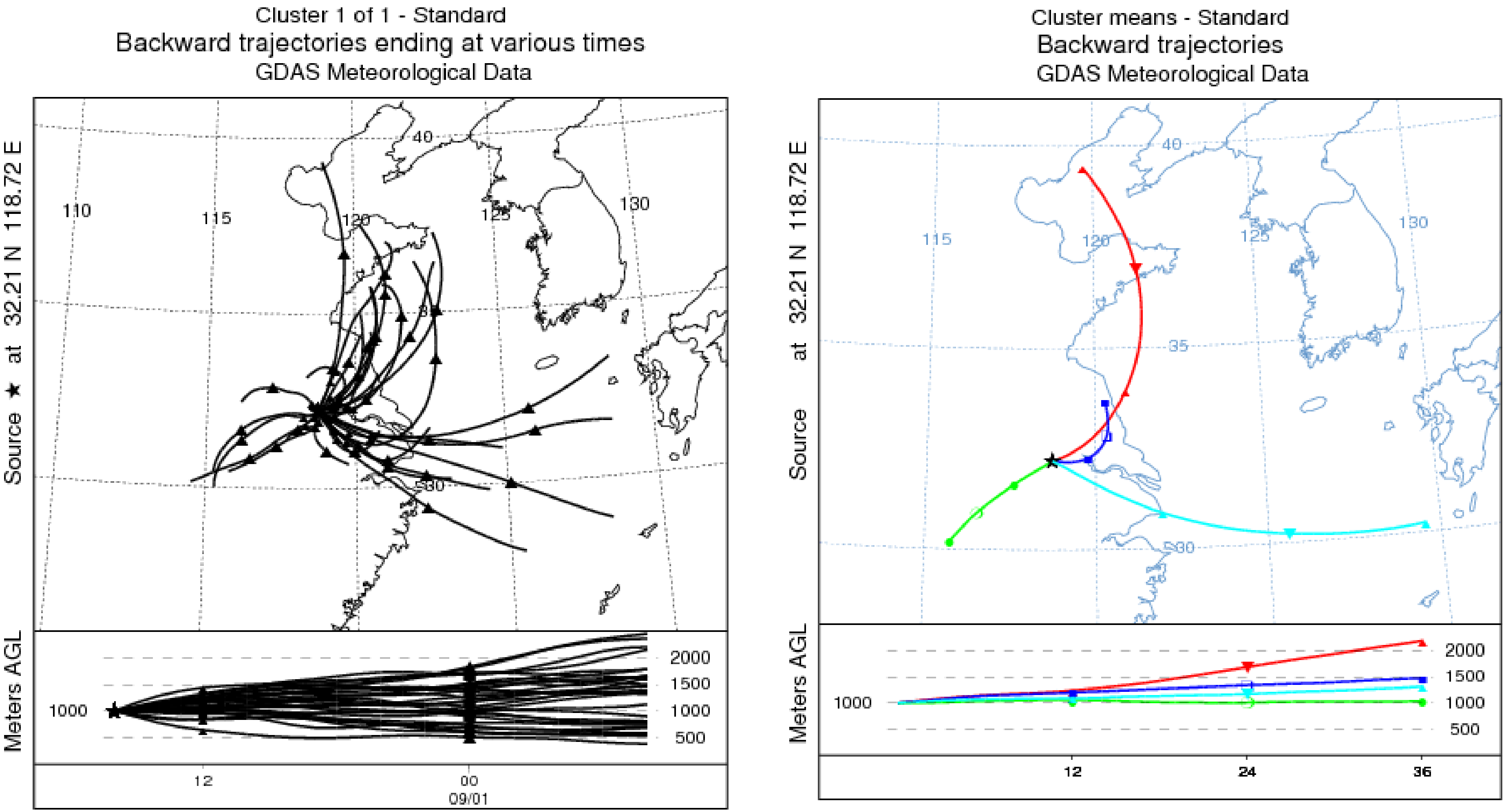

Fig.30 Daily back trajectories and clusters at Nanjing in Sep, 2013.

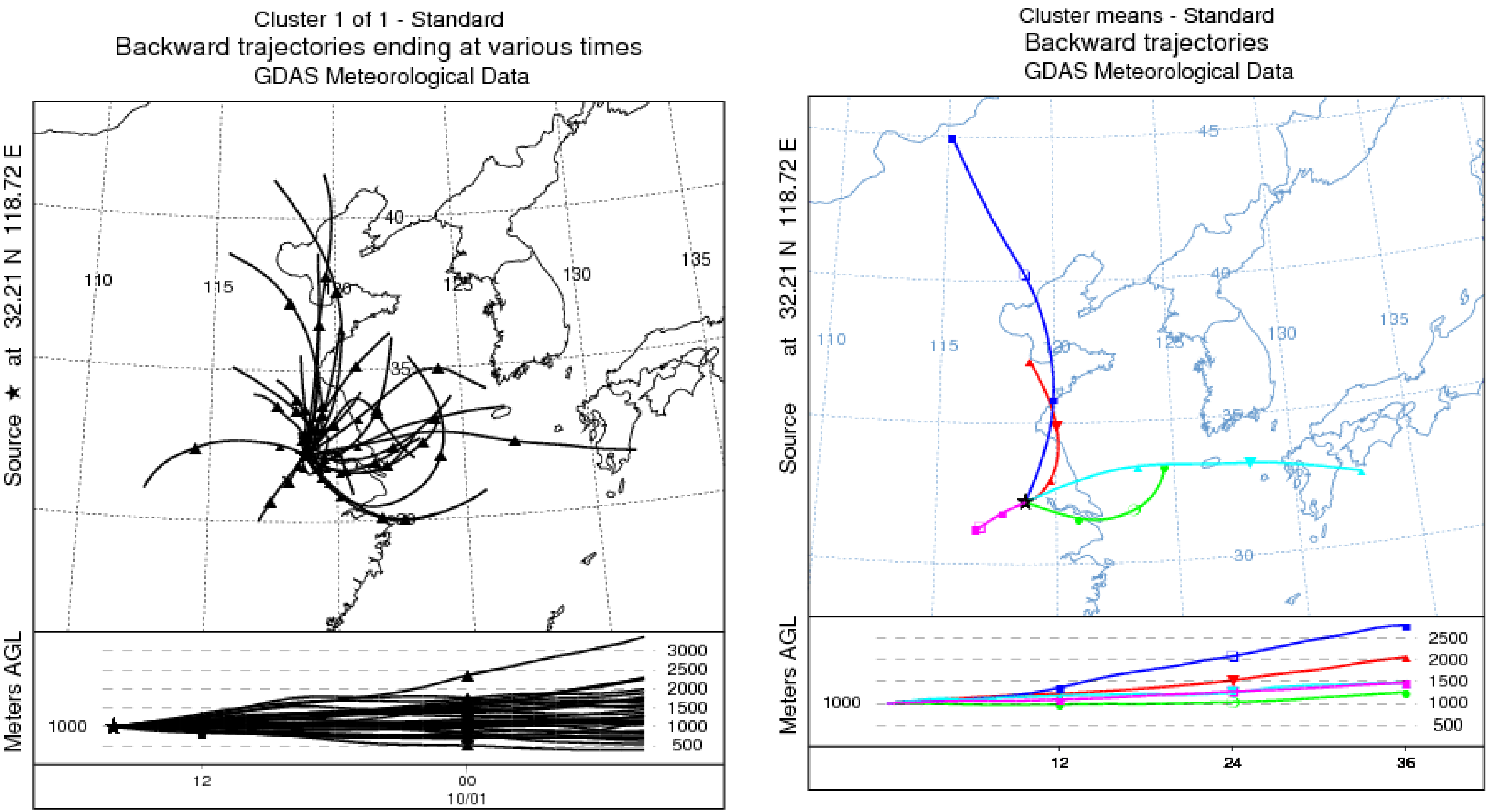

Fig.31 Daily back trajectories and clusters at Nanjing in Oct, 2013.

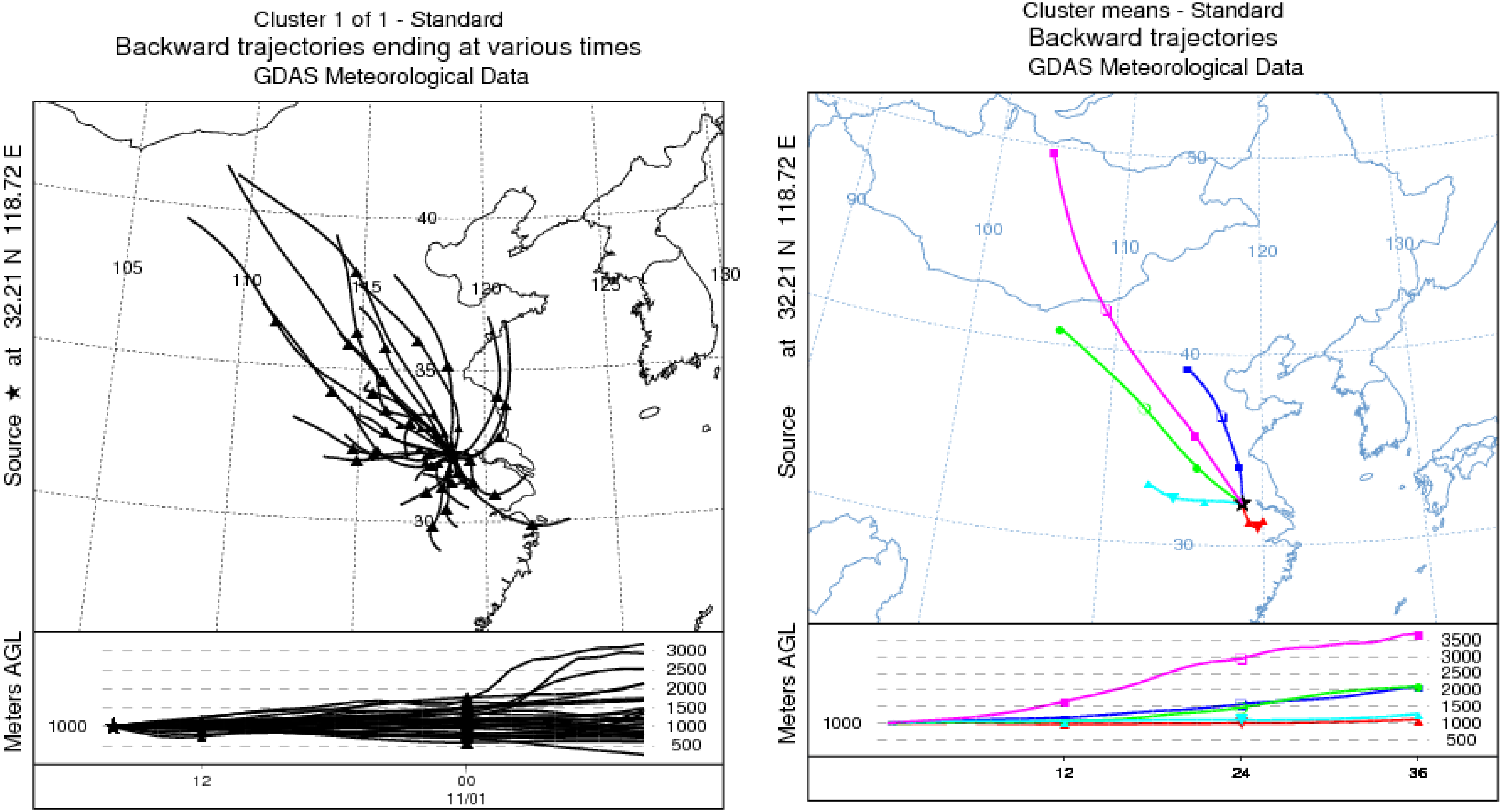

Fig.32 Daily back trajectories and clusters at Nanjing in Nov, 2013.

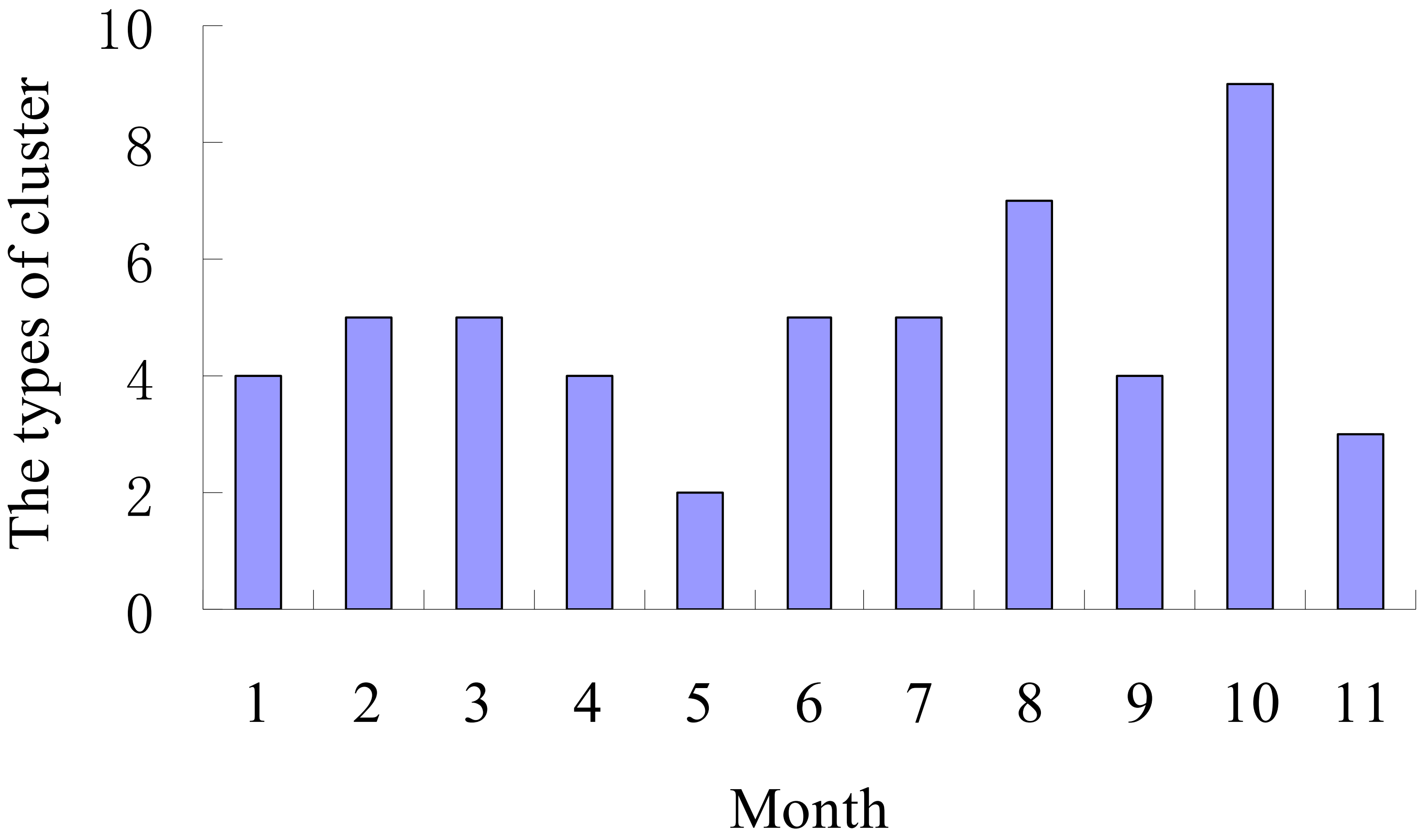

Fig.33 The types of trajectory cluster in 2013.

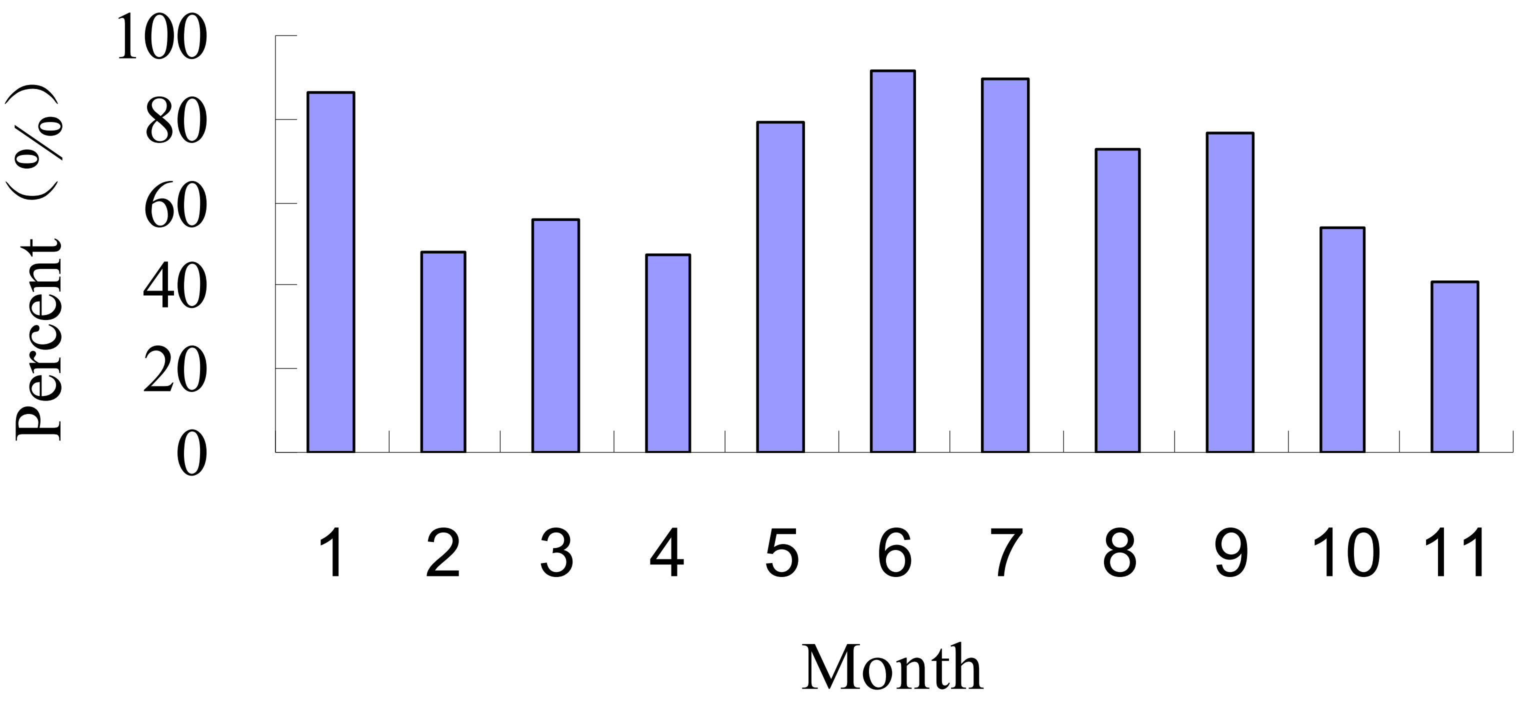

Fig.34 The percent of 24-hour back trajectories in YRD

4. Conclusion

- Except Jan and Feb, there is no obvious monthly variation of cement production in one year.

- The cement production can contribute 17.38% CO_2 emission in industrial processes in YRD, with 9.67% in Nanjing and 13.15% in Jiangsu.

- The reason why the value of $\delta^{13}C$ in Nanjing was less negative in Beijing is that the CO_2 emission from cement production released more CO_2 with rich ^{13}C signal in Nanjing.

- When it showed a high percentage of air mass coming from YRD, the less negative $\delta^{13}C$ were measured in Nanjing.

Thank You!