ATLANTIS PRESS

Advances in Engineering Research, volume 120

International Forum on Energy, Environment Science and Materials (IFEESM 2017)

Evaluation and analysis for Haze discrimination criteria in Jiangsu Province

Song Gao[1, a], Li Li[2,b], Yu Wang[3,c], Yanqing Zhang[4,d]

[1] Electric power research institute of Jiangsu electric power company, Nanjing 211103,China;

[2] Nanjing University of Information Science and Technology, Nanjing 210044,China;

[3]Nanjing University of Information Science and Technology, Nanjing 210044,China;

[4]Nanjing University of Information Science and Technology, Nanjing 210044,China;

[a]hvgaosong@qq.com, [b]summerlily@nuist.edu.cn,
[c]2429212196@qq.com,[d]20161212298@nuist.edu.cn

Keywords: Haze discrimination methods;Atmospheric pollutants;Typical city

Abstract This paper analyzes the distribution of haze under different conditions of winter in Jiangsu Province in 2014. Selected the city of Nanjing and Xuzhou as typical polluted cities, the analysis and comparison of different haze day's discrimination criteria are different. when the haze pollution is lighter, there are different methods, but when the haze pollution is relatively serious, the three methods of determine the haze day difference are almost same. The results showed that the concentration of pollution was higher in Nanjing and Xuzhou whose haze days were more.And the concentration of PM_{10} and $PM_{2.5}$ exceeded the national standard 38.9% and 42.2% respectively in the Nanjing , 51.1% and 55.6% respectively in Xuzhou. Nanjing and Xuzhou are affected by both local and external sources.

Introduction

With the rapid growth of the economy and the accelerating urbanization process, regional compound air pollution was more serious. The heavy haze phenomenon caused by secondary pollutants such as increasing fine particulate matter[1]. Zhang et al. [2] pointed out that people now see the fog and haze, is not a complete natural phenomenon, aerosol pollution is behind the main reason. Haze weather not only affect traffic safety, human health has also been a serious threat.

In different historical periods, WMO and other national meteorological agencies have given advice on distinguishing haze and fog [3], which also uses the relative humidity as a supplementary criterion. In the WMO 1984 report, it is recommended that the relative humidity of haze be less than 80% [4]. In recent years, there have been scholars identify the haze more concrete, there are two commonly used methods. One is the daily mean method, generally due to the relative humidity of less than 80% of the atmospheric turbidity caused by deterioration of visibility is caused by haze, relative humidity greater than 95% of the atmospheric turbidity caused by deterioration of visibility is caused by fog. When the relative humidity is between 80% and 95%, the deterioration of the visibility caused by atmospheric turbidity is caused by the combination of fog and haze [5]. Another is the use of 14:00 when the measured value method, when the data to meet the visibility is less than 10km, relative humidity less than 90%, recorded as a haze day [6]. When the relative humidity is less than 90%, the fog is more difficult to form. This method can misty haze isolated, but also can be false haze in the haze. In the "haze observation and rating criteria" [7]in the provisions of less than 10 km visibility, relative humidity less than 80% as haze. When the relative humidity is between 80% and 95%, it is necessary to further identify the atmospheric composition index ($PM_{2.5}$

concentration, PM_{10} concentration, aerosol scattering coefficient and absorption coefficient). But the "standard" provides that the indicator is for the daily average or hour value. Accurate haze of the basis of discrimination, still need to conduct different methods of comparative study.

In this paper, the temporal and spatial distribution of haze in Jiangsu Province under different discriminative criteria is analyzed according to the meteorological observation data and the air pollutant concentration data of Jiangsu Province in the winter of 2014.

Data

Site data

In this paper, the observation data of 72 basic weather stations and 63 national control environmental monitoring stations in Jiangsu Province from October 2014 to April 2015 were selected, the time resolution of conventional meteorological observation data is 10min, and the time resolution of air pollutant concentration data is 1h.

Distribution characteristics of haze in Jiangsu Province

Traditional haze day discrimination method and existing standard

Combined with the current domestic and foreign haze identification method of the status quo, the traditional haze day discrimination method to do a summary, see Table 1. Method 4 is based on the existing haze day discrimination criteria, the index value applied to the daily average method.

Table1 Fog and haze discriminant method summary

Solution1	Daily average visibility <10km, daily average relative humidity <80% [3]
Solution2	Daily average visibility <10km, daily average relative humidity <90%[4]
Solution3	14:00 measured data visibility <10km, relative humidity <90%, weather code 05 (haze), or when the weather code is recorded as 01 (exposed), 02 (frost), 03 (ice), 04 (smoke), 10 (light fog), still adjusted as a haze day [6]
Solution4	The daily average relative humidity <80%, daily average relative humidity of 80% ~ 95%, PM2.5 concentration> 75μg • m-3[7]

Distribution characteristics of haze in Jiangsu Province

Figure 1 shows the average haze distribution for individual sites in Jiangsu Province from October 2014 to April 2015, which are calculated by different methods. 86.1% of the site by the method 2 statistics out of the largest haze day, 13.9% of the site by the method 3 statistics of the haze more, method 1 statistics of the haze number of days is less than the method 2 statistics out, 50% of the site method 1 and method 3 statistics out of the haze day, 12.5% of the site method 2 and method 3 statistics of the haze number of days. But the haze more serious areas, these three methods of the haze count more daily, indicating that these three methods are easier to determine the haze day, and in the haze is not serious areas, different methods caused by the larger differences.

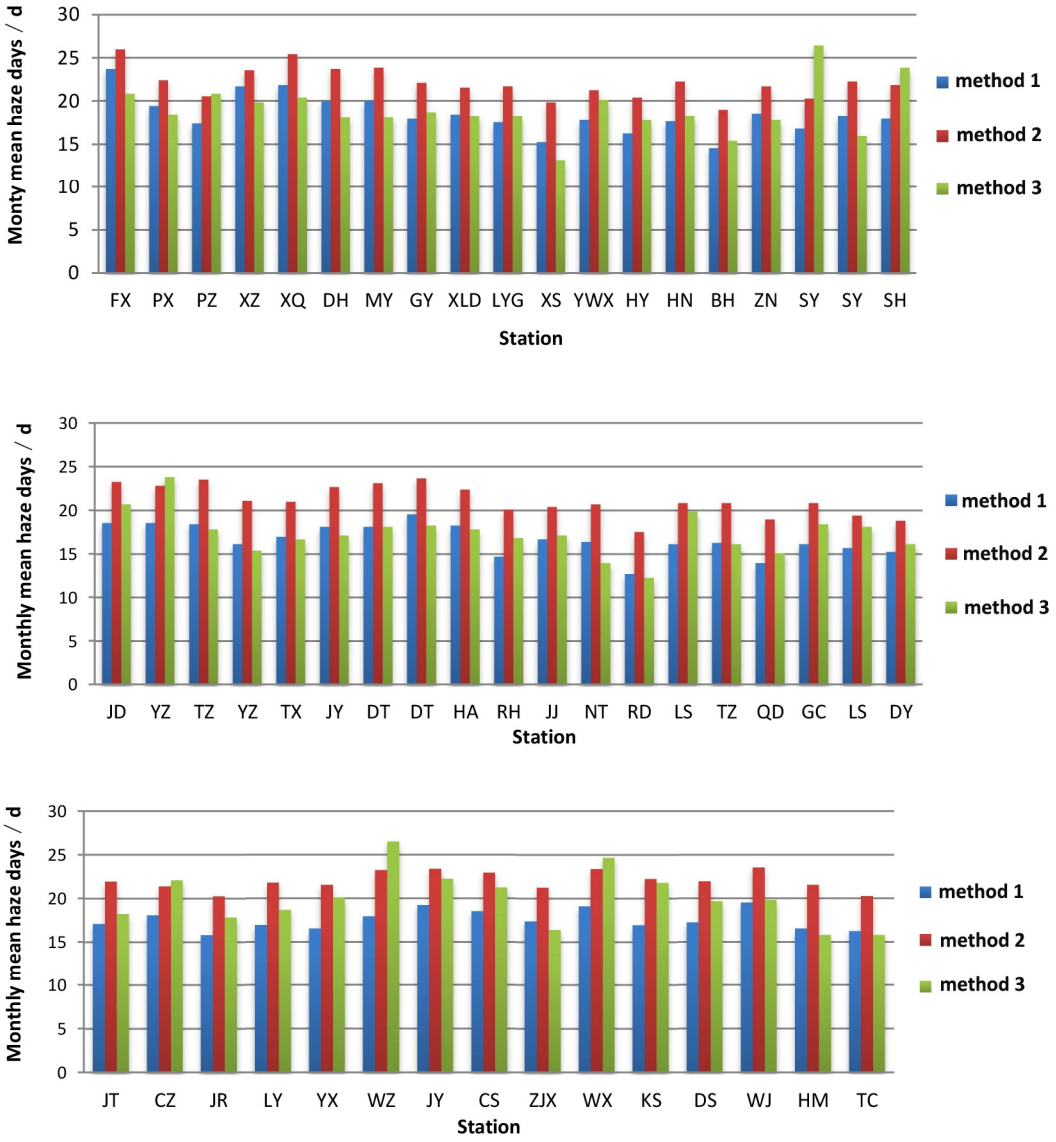

Fig.1 Monthly mean haze days distribution in different regions of Jiangsu from October 2014 to April 2015

The contrast between traditional distinguish methods and "standard" for haze

Figure 2 shows the number of haze days in different subcategories in the northern suburbs of Nanjing from October 2014 to April 2015. All four kinds of methods can reflect the development trend of the haze during the half year. Among them, the haze days of Oct, Nov, and Dec are the most, Jan is the least, followed by Feb, Mar , Apr. Indicating that the number of winter haze days is more than spring, when the number of haze days is more, these four methods are almost same. But the number counted by method 3 is the most during the slight haze days. And the number of haze counted by method 1 and method 4 (standard) is equivalent. It's indicated that when relative humidity between 80% - 95% , the case of $PM_{2.5}$ concentration greater than 75μg · m^{-3} is less. Secondly, the figure also shows that the northern suburbs of Nanjing has experienced a serious haze pollution process in December 2014.

Figure 3 shows the haze days distinguished by different methods in Xuzhou during October 2014 to April 2015. Similar to the northern suburbs of Nanjing, the number of winter haze days in

Xuzhou is more than spring. The difference is the number of haze days counted by method 4 (standard) are close to the method 1 during the heavy haze days, and the number of haze days counted by method 4 (standard) are close to the method 2 during the slight haze days. It's indicated that during the heavy haze days, the relative humidity between 80% - 95% , the case of $PM_{2.5}$ concentration under than 75μg · m^{-3} is less. During the slight haze days, the relative humidity between 80% - 95%, the case of $PM_{2.5}$ concentration under than 75μg · m^{-3} is more. Secondly, during the heavy haze days, the number of haze days distinguished by method 3 is far less than the other three methods, because the best visibility time of one day is 14:00, there's no haze pollution in this moment doesn't mean there's no haze pollution all day. But during the slight haze days, the number of haze days distinguished by method 3 is far more than the other three methods.

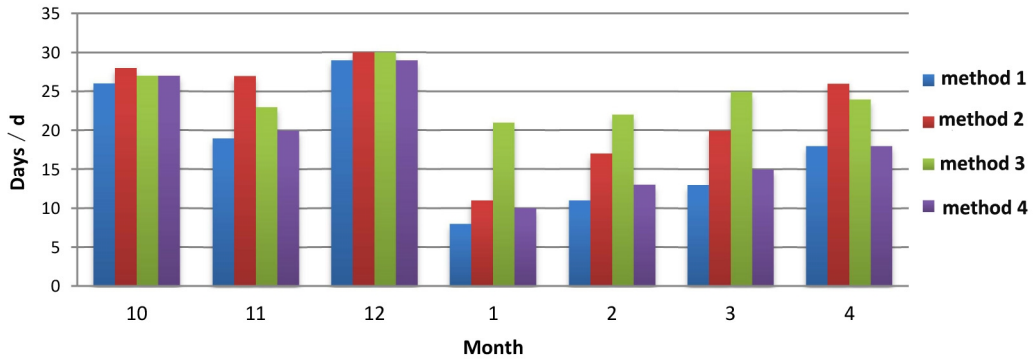

Fig.2 October 2014 - April 2015 haze days each month in northern suburbs of Nanjing

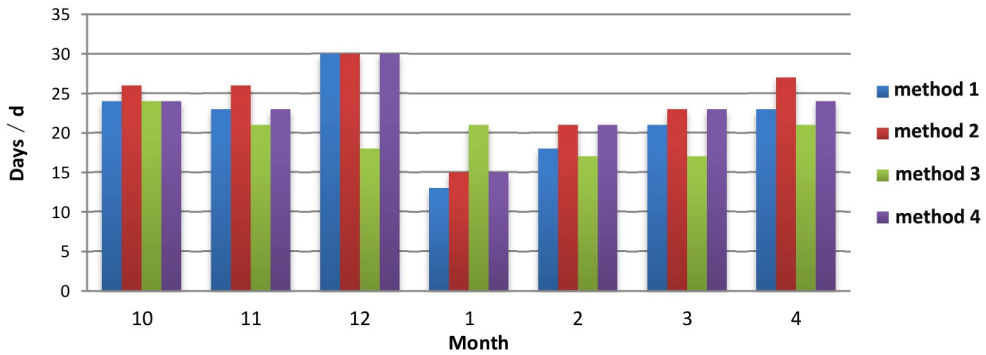

Fig.3 October 2014 - April 2015 haze days each month in Xuzhou

Table 2 shows the concentration of pollutant and exceeding standard rate in the cities of Jiangsu Province during October 2014 to April 2015, the maximum concentration of NO_2 appeared in the Suzhou, it's exceeding standard rate is 55.6%.The second concentration of NO_2 appeared in Nanjing, it's exceeding standard rate is 32.2%. There're higher concentration of O_3 appeared in Yangzhou and Yancheng. There're higher concentration of PM_{10} appeared in Nanjing and Xuzhou. Xuzhou whose average concentration of PM_{10} reached 160.8 μg·m^{-3} and exceeding standard rate reached 55.6% is the most serious. The exceeding standard rate of Nanjing reached 55.6%. The most concentration area of $PM_{2.5}$ appeared in Xuzhou, Huaian, Changzhou and Lianyungang. Among them, the maximum concentration of $PM_{2.5}$ is 90.9 μg·m^{-3},and the exceeding standard rate is 55.6％ appeared in Xuzhou. The most concentration area of $PM_{2.5}$ appeared in Xuzhou and Nanjing whose the value $PM_{2.5}/PM_{10}$ is lesser, it's indicated that coarse particle of PM_{10} accounted for a larger share in these two areas. The maximum concentration of SO_2 appeared in Xuzhou, and

there're maximum exceeding standard rate reached 56.7%. Among the whole province, there're minimum exceeding standard rate reached 2.2% in Nanjing and Suzhou, but the concentration of SO_2 of these two cities is exceed Huaian and Lianyungang. In addition, there're better correspondence between the haze distribution and pollutant concentration. More serious pollution, especially the more serious pollution of particulate matter appeared in Nanjing and Xuzhou. The haze day space map of Jiangsu Province shows that there're higher number of haze days in Nanjing and Xuzhou, it's indicated that the increase of concentration for pollutants, especially particulate matter is a key factor for the occurrence of haze. So the following, selecting in Nanjing and Xuzhou as the typical polluted cities, discussing the relationship between their pollutants and meteorological, the daily and monthly changes.

Table2 Pollutant concentration and exceeding rate in Jiangsu city on October 2014 -2015

City	SO_2(*10^{-9})		NO_2(*10^{-9})		O_3(*10^{-9})		PM_{10}(μg·m^{-3})		$PM_{2.5}$(μg·m^{-3})		$PM_{2.5}/PM_{10}$
	Average	Exceed	Average	Exceed	Average	Exceed	Average	Exceed	Average	Exceed	
Nanjing	33.6	2.2%	56.1	32.2%	62.3	7.8%	133.8	38.9%	77.2	42.2%	57.7%
Wuxi	36.8	14.4%	48.1	15.6%	67.0	1%	128.1	35.6%	85.1	58.9%	66.4%
Zhenjiang	31.3	6.7%	52.3	26.7%	70.7	4.4%	121.2	25.6%	75.0	42.2%	73.2%
Suzhou	32.1	2.2%	65.7	55.6%	67.4	8.9%	112.8	24.4%	82.6	51.1%	73.2%
Nantong	37.8	17.8%	44.2	18.9%	76.8	12.2%	121.0	27.8%	79.3	44.4%	65.5%
Yangzhou	31.4	4.4%	27.4	2.2%	82.3	21.1%	127.4	32.2%	67.1	36.7%	52.7%
Yancheng	32.5	11.1%	25.1	0	94.9	34.4%	118.5	21.1%	75.2	40%	63.5%
Xuzhou	60.6	56.7%	45.5	1%	70.6	6.7%	160.8	51.1%	90.9	55.6%	56.5%
Huaian	28.2	4.4%	28.1	0	67.3	2.2%	134.7	31.1%	89.1	57.8%	66.1%
Liangyungang	27.3	24.4%	41.4	8.8%	77.3	13.3%	134.2	30%	88.3	51.1%	65.8%
Changzhou	41.5	22.2%	48.8	22.2%	75.5	17.7%	130.0	37.8%	88.1	55.6%	67.8%
Taizhou	39.3	6.7%	31.9	2.2%	57.0	0	116.1	22.2%	80.3	53.3%	69.1%
Suqian	34.9	8.9%	45.3	13.3%	63.9	2.2%	136.2	31.1%	77.3	41.1%	56.8%

Conclusion

This paper uses data observed by the meteorological observation station and national control environment monitoring station, and makes a preliminary analysis about the haze days distribution and the pollution characteristics for typical urbans of Jiangsu Province during the winter of 2014. The following conclusions are obtained:

(1) The distribution of haze days distinguished by different method are almost same, The high number of haze days is mainly distributing in Nanjing and Xuzhou. During the slight haze days, there're difference among different method, the number of haze days counted by method 3 is always less than method 1 and method 2, because method 3 only considered the measured data at 14:00, the best visibility time of one day is 14:00, there's no haze pollution in this moment doesn't mean there's no haze pollution during other time. So the method 3 is not as reasonable as the

method 1 and the method 2, and the method 1 is similar with the existing criterion of haze days. But these three methods is almost same during the heavy haze days, it's indicated that the rationalization of three methods.

(2)There're different haze pollution levels distinguished by different haze identification method. The distribution of haze level distinguished by method 3 has great difference with the other three methods, there're moderate and heavy haze occurred in Oct, but the other three statistic result showed slight haze. The result obtained by method 1,2,4 is almost same during the heave haze days, but the result obtained by method 2,4 is almost same during the slight haze days. There's no moderate haze result obtained by method 1, it's indicated that no occurrence of less than 3km visibility, during the relative humidity less than 80% .

(3) The concentration of pollutants especially the pollution of particulate matter is serious in the areas during heavy haze days, such as Nanjing and Xuzhou area. The concentration of PM_{10} and $PM_{2.5}$ exceeded the national standard 38.9% and 42.2% respectively in the Nanjing , the concentration of PM_{10} and $PM_{2.5}$ exceeded the national standard 51.1% and 55.6% respectively in Xuzhou. The two cities were the most polluted in January. Overall, there're lighter pollution and lesser number of haze days in Taizhou and Yancheng.

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