SPATIO-TEMPORAL CHANGE AND INFLUENCING FACTORS OF TROPOSPHERIC NO2 COLUMN DENSITY OF BEIJING-TIANJIN-HEBEI REGION IN THE DECADE BASED OMI PRODUCT

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ABSTRACT

Based on satellite derived NO_2 column data from OMI, we analysed the characteristics of spatio-temporal distribution of tropospheric NO_2 column density and its impact factors over Beijing-Tianjin-Hebei Region for 2005-2014.

KEYWORDS: Tropospheric NO_2 column density; OMI; satellite remote sensing; spatial-temporal change; influencing factors

1. INTRODUCTION

NOx causes a wide variety of health and environmental problems. In recent years, industrialization and urbanization of China lead to the fossil energy consumption and large motor vehicle usage, and bring about the serious environmental problems. Beijing-Tianjin-Hebei Region includes Beijing, Tianjin and Hebei province. Beijing-Tianjin-Hebei Region has a high population density, and the land area is 21.7 square kilometers, accounting for 2.25% of the nation's total, and the resident population is 104.405 million people, accounting for 7.79% of the total permanent population. Beijing-Tianjin-Hebei Region is the major high-tech and heavy industry base of China, and the regional GDP accounts for about 9.7% of the gross domestic product. Beijing-Tianjin-Hebei Region has very important strategic status in China.

2. METHODOLOGY

DOMINO version 2.0 OMI tropospheric NO_2 vertical column concentration product provided by TEMIS [1] is used in this paper. The product has the spatial resolution of 0.125 ° x 0.125 ° [2], and is validated to be reliable for application [3-4]. Varieties of statistics are used to analyze the influencing factors, including: DEM, precipitation and GDP. The purpose of this paper is as follows: 1) to discuss spatial and temporal change of the NO_2 column density over Beijing-Tianjin-Hebei Region in recent 10 years; 2) to find the natural and anthropogenic factors behind the environmental changes.

3. RESULTS AND DISCUSSION

3.1 Spatio-temporal change of tropospheric NO_2 column density

Tropospheric NO_2 column density had a large fluctuation on the temporal scale, increased at the annual rate of 3.35%.The lowest density was 807.75×10^{13} mole/cm^2 in 2005, and the highest value was 1303.36×10^{13} mole/cm^2 in 2011.NO_2 was rising during 2005 to 2011 ignoring the change of 2008，and was gradually reducing during 2012 to 2014(Fig.1).

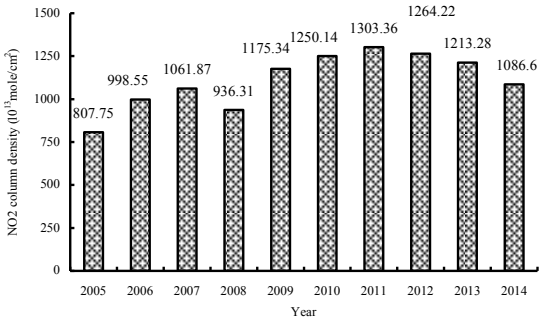


Fig.1 Annual average NO_2 column density change over Beijing-Tianjin-Hebei Region during 2005 to 2014

The spatial distribution of tropospheric NO_2 column density also had significant changes, and showed low in the northwest and high in the southeast. Tropospheric NO_2 column density over Zhangjiakou and Chengde in the north of Beijing-Tianjin-Hebei Region was low, and there were two highest value regions located in the Beijing-Tianjin-Tangshan and Shijiazhuang-Xingtai-Handan(Fig.2).

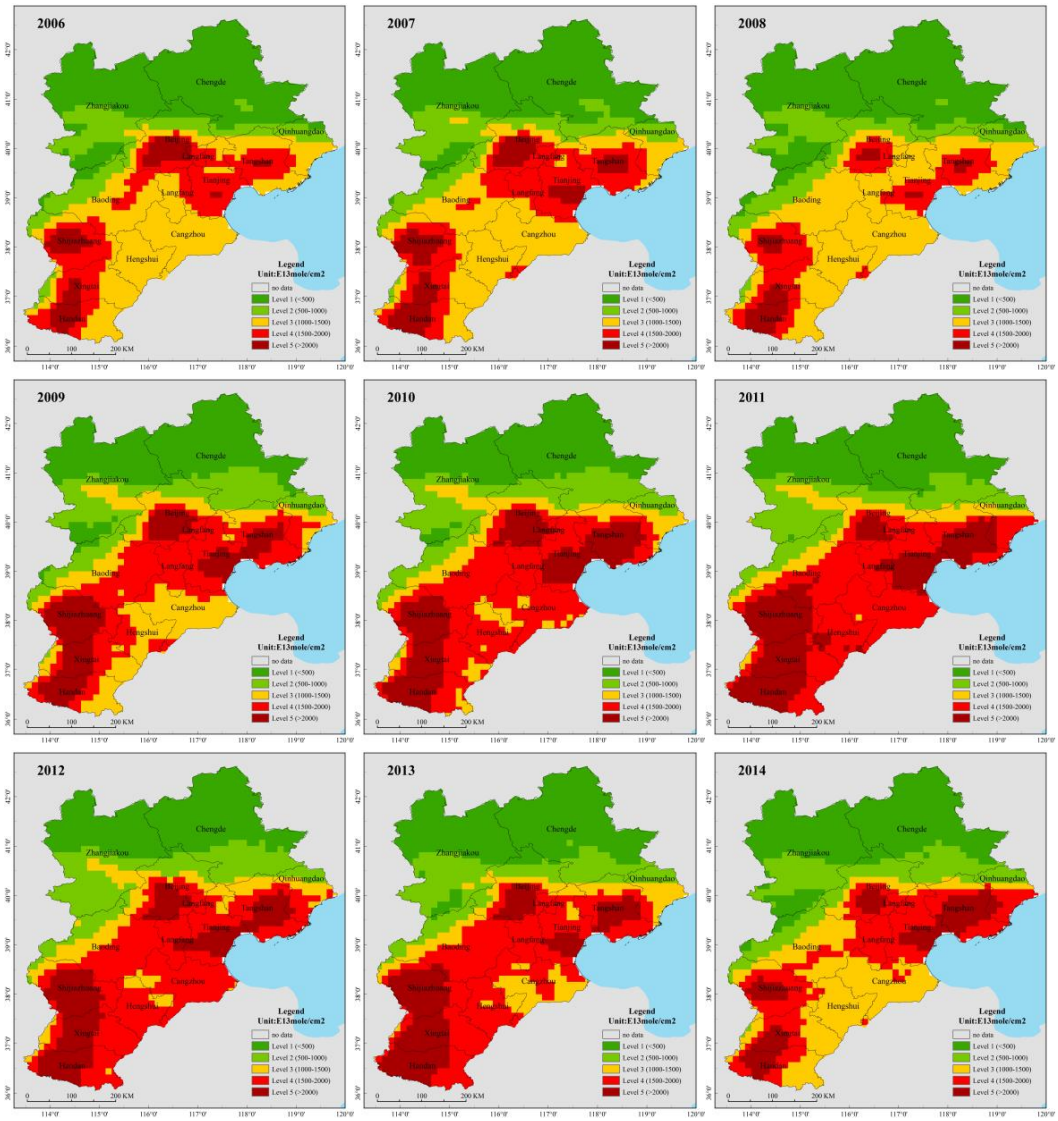


Fig.2 Annual average NO_2 column density distribution during 2006 to 2014 over Beijing-Tianjin-Hebei Region

Tab.1 Coal consumption of Beijing-Tianjin-Hebei Region during 2004 to 2012 (ten thousand tons)

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Beijing	2939.41	3068.97	3055.67	2984.67	2747.73	2664.70	2634.62	2366	2270
Tianjin	3508.57	3801.45	3809.31	3926.70	3972.77	4119.65	4806.79	5262	5298
Hebei	17073.96	20542.39	21345.42	24548.51	24418.62	26515.81	27464.72	30792	31359
Beijing-Tianjin -Hebei Region	23521.94	27412.81	28210.40	31459.88	31139.12	33300.16	34906.13	38420	38927
China	224926.00	263864.85	291869.73	319156.12	334806.44	351182.33	381413.30	429000	436454

3.2 Influencing factors of tropospheric NO_2 column density

Beijing-Tianjin-Hebei is surrounded on three sides by mountains in the north (Fig.3). This terrain is not helpful to the spread of NO_2.

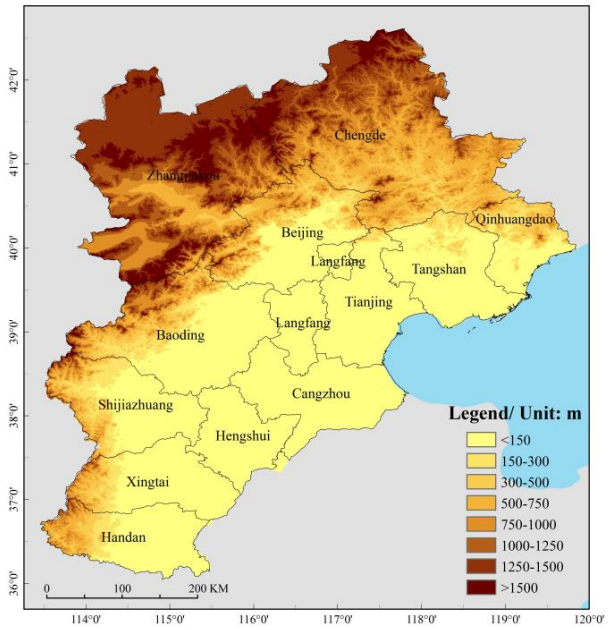


Fig.3 DEM of Beijing-Tianjin-Hebei Region

Precipitation of Beijing-Tianjin-Hebei Region is extremely uneven in four seasons, and is a little and about 2% of annual rainfall in winter, and is a lot and about 66% of annual rainfall in summer (Fig.4). There was a high negative correlation between precipitation and tropospheric NO_2 density, up to -81% in 2005, the lowest value is -61% in 2009.Precipitation had a certain negative effects on the NO_2 concentration for the reason of atmospheric wet deposition, so tropospheric NO_2 vertical column density decreased significantly over Beijing-Tianjin-Hebei Region in the rainy summer.

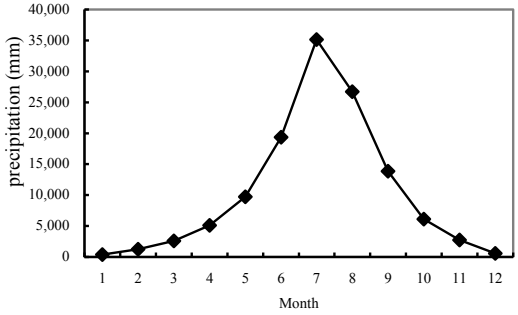
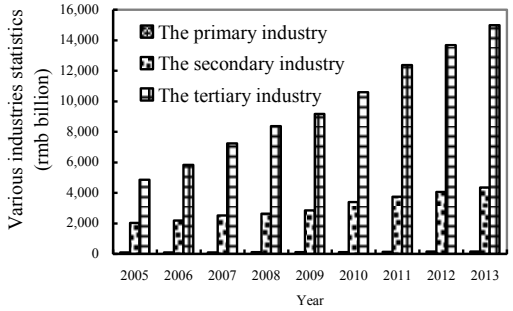
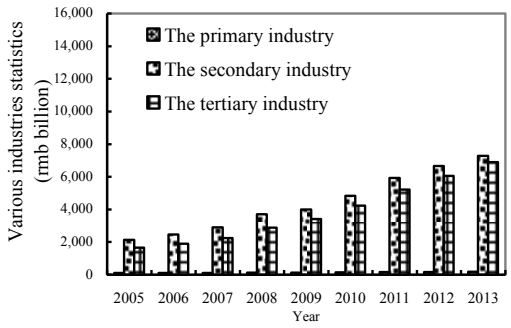


Fig.4 Monthly precipitation statistics of Beijing-Tianjin-Hebei Region during 2005 to 2013

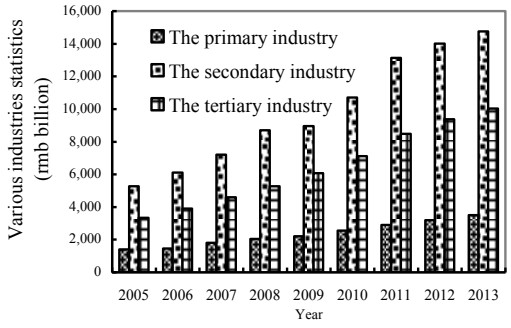
GDP is the important indicators of economic development. The GDP of Beijing-Tianjin-Hebei Region during 2005 to 2013 increased year by year, and the second industry product which is the largest contribution to the column density of NO_2 was also increasing year by year (Fig.5).The second industry has the highest energy consumption among the three industries. In 2012, coal consumption of the Beijing-Tianjin-Hebei Region accounted for 8.9% of the national consumption, and Hebei province consumes 80.6% of the Beijing-Tianjin-Hebei Region (Tab.1). So economic of Hebei province always rely on high energy consumption, and then bring about high emissions and heavy atmospheric pollution. The correlation coefficient is as high as 0.84 between the second industry GDP and tropospheric NO_2 concentration column in the Beijing-Tianjin-Hebei Region during 2005 to 2013



(a)



(b)



(c)

Fig.5 Various industries statistics of Beijing-Tianjin-Hebei Region during 2005 to 2013

(a)Beijing (b)Tianjin (c)Hebei

4. CONCLUSION

Results demonstrate:

1) Tropospheric NO_2 column density had a large fluctuation on the temporal scale, increased at the rate of 3.35%, with the highest column density in the year 2011; NO_2 was rising during 2005 to 2011 ignoring the change of 2008，and was gradually reducing during 2012 to 2014.

2) The spatial distribution of tropospheric NO_2 column density also had significant changes, and showed low in the northwest and high in the southeast. Tropospheric NO_2 column density over Zhangjiakou and Chengde in the north of Beijing-Tianjin-Hebei Region was low, and there were two highest value areas located in the Beijing-Tianjin-Tangshan and Shijiazhuang-Xingtai-Handan.

3) Beijing-Tianjin-Hebei is surrounded on three sides by mountains in the north. This terrain is not helpful to the spread of NO_2. Precipitation had a highly negative correlation with NO_2 concentrations, for the reason of atmospheric wet deposition.

4) Pollution sources are determined by the industrial and energy structure to a large extent. The third industry of Beijing was in a dominant and increasing steadily, and coal consumption was low, but car ownership increased 1.5 times, so the main source of NO_2 in Beijing were the motor vehicle exhaust emissions; The second industry product of Tianjin was higher than the third industry slightly, and coal consumption was double more than that of Beijing, but car ownership was only half of Beijing, so the industrial emissions and motor vehicles were the main sources of NO_2 in Tianjin; There was a high proportion of secondary industry in Hebei, and coal consumption accounted for 80.6% of the Beijing-Tianjin-Hebei Region, so Hebei industrial emission was the main source of NO_2, but vehicle emissions shared rate to be reckoned with as a surge in its ownership in recent years.

5. REFERENCES

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