Analysis of air quality trends in 2017

This briefing was edited on 12 Jan 2018 to update province-level PM2.5 numbers in the industrial output chart on page 5.

After the launch of China's "war on pollution" and the National Air Quality Action Plan in 2013, eastern China has seen a dramatic improvement in air quality, driven above all by reductions in coal use and emissions of power plants and heavy industry factories. From 2013 to 2017, average PM2.5 levels fell 35% in the 74 cities across China for which data is available. Nationwide, about 160,000 premature deaths were avoided in 2017 due to the reduction in pollution.

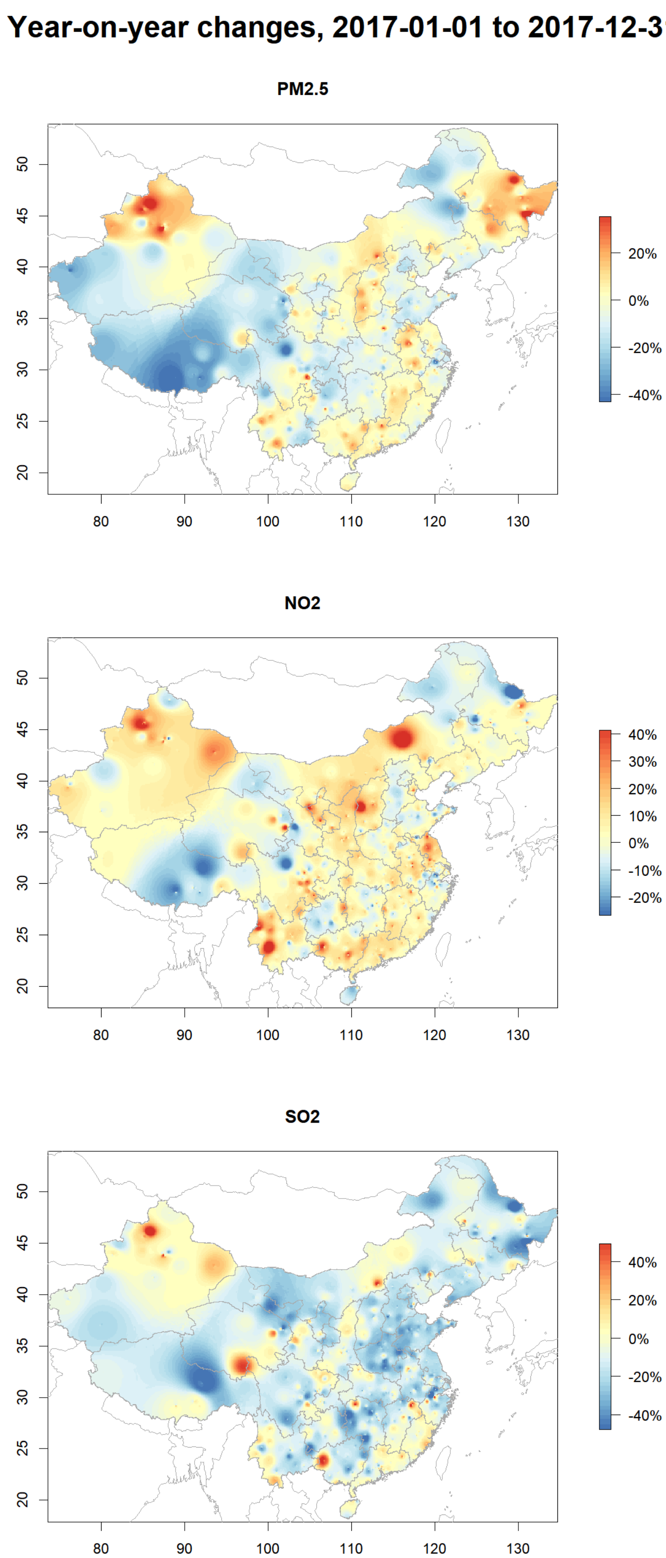
However, coal use rebounded from 2016 until late 2017 due to government stimulus policies and overheating of the real estate market. This saw air quality gains slow down significantly and threatened the attainment of Beijing's air quality target for 2017, the target year of the national action plan. As a result, while Beijing posted record air quality gains, the country as a whole saw the smallest yearly improvement since the start of the national action plan, with PM2.5 levels falling by only 4.5%.

Record gains around Beijing

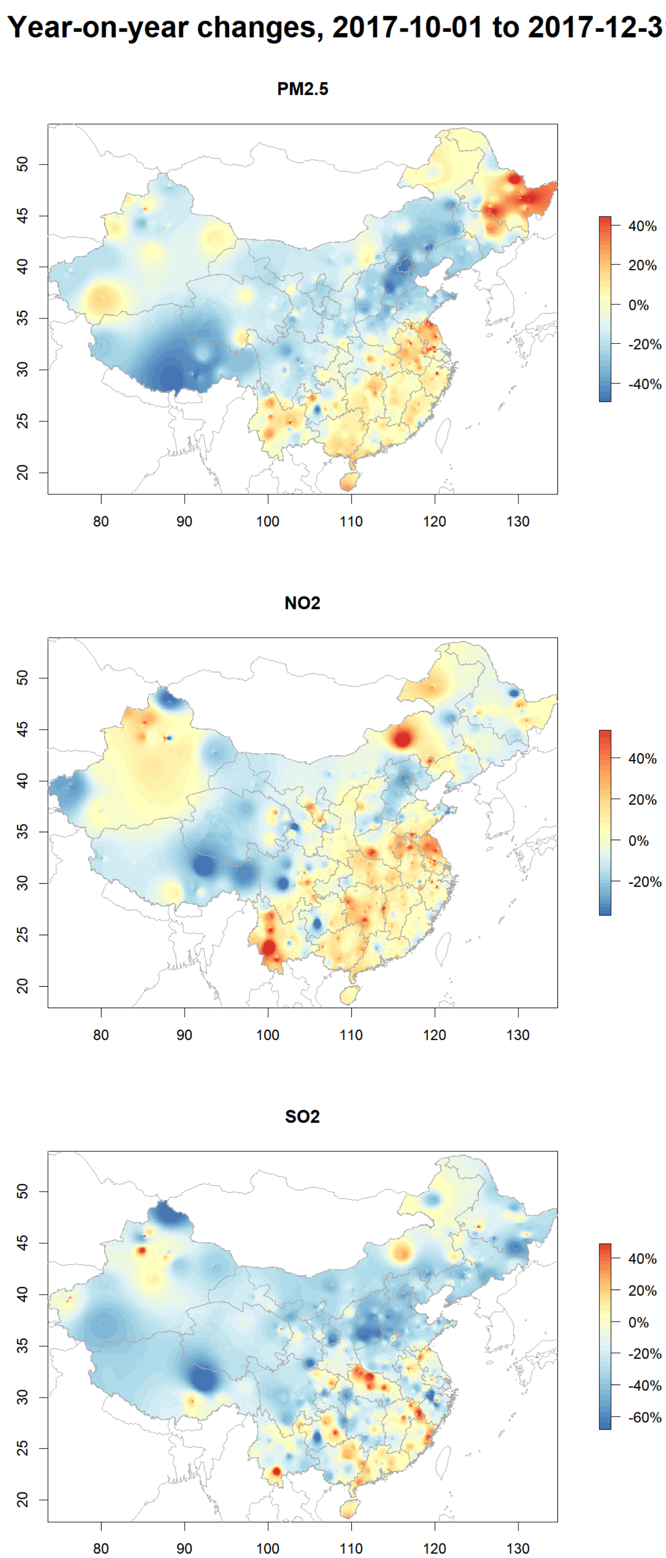
At the end of 2017, the 'winter action plan', targeting Beijing, Tianjin and 26 surrounding cities (so-called "2+26 cities"), resulted in dramatic falls in pollution in the area, with industrial output being curtailed, inspections of polluting factories ramped up and small-scale coal burning being banned. PM2.5 levels across the 28 cities fell by 33% in the last quarter of 2017, and Beijing levels fell by a whopping 54%. The coal ban was poorly implemented and caused hundreds of thousands of households to go without proper heating for weeks. Nevertheless, the air quality gains show the urgent need to reduce coal burning while at the same time ensuring everyone has access to adequate heating.

Spillover

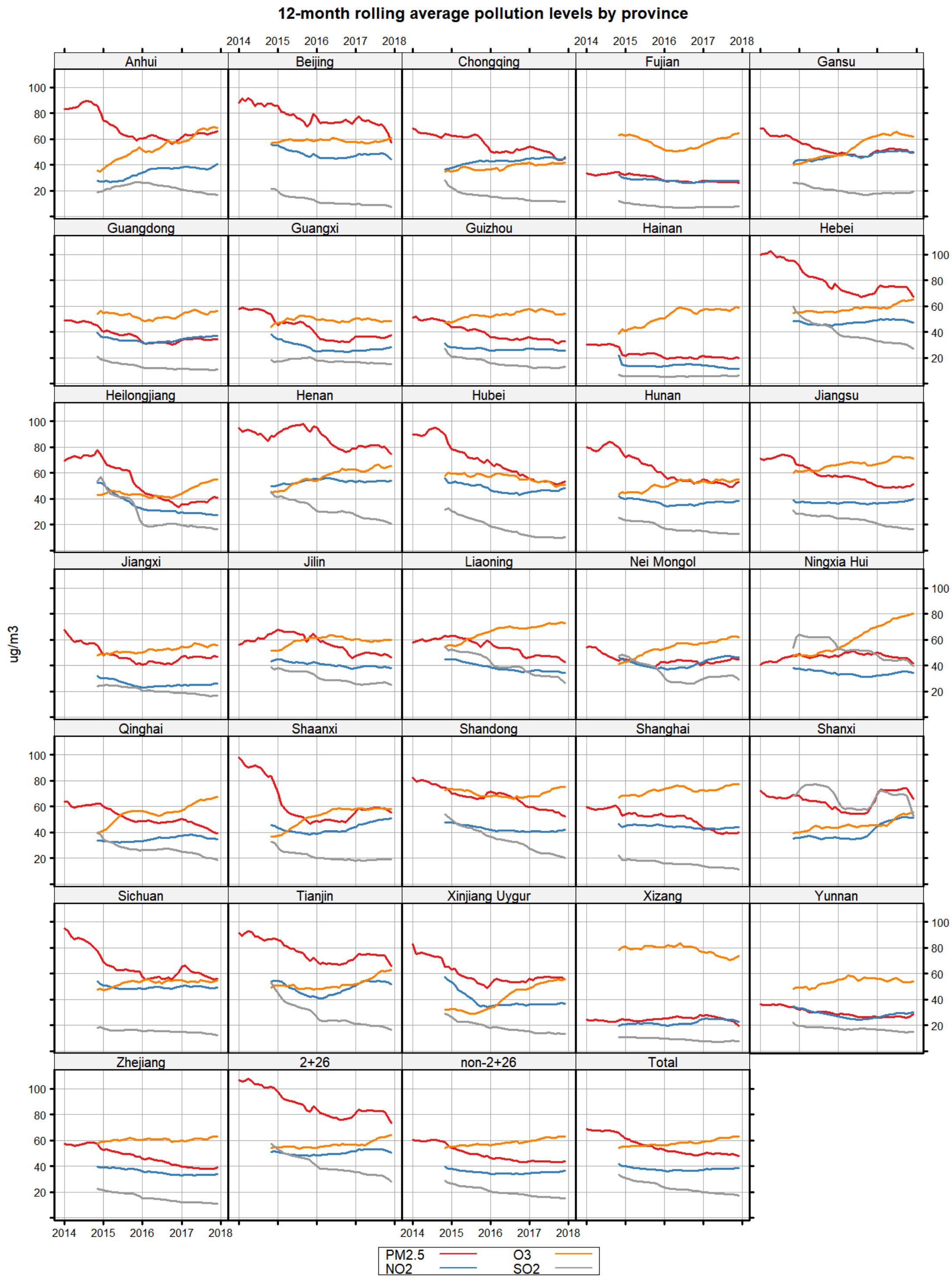
The curbs to industrial output have resulted in 'emission spillover', with factories in Hebei increasing output in the summer, contributing to record ozone levels, and with factories provinces not affected by the curbs increasing output in the last quarter of the year. PM2.5 levels in Heilongjiang, Anhui and Jiangsu, in particular, jumped in the last quarter, with Guangdong, Shanxi and Ningxia also registering substantial increases for the whole year. These provinces had double digit increases in steel output, coal-fired power generation and/or production of other metals.



Pollution levels fell significantly in Beijing and surrounding areas while increasing in many industrial areas and coal power bases in northern, northeastern, central and southern China.



Air quality gains are very dramatic in Beijing-Tianjin-Hebei-Shanxi in the last quarter, while the rebound in central and southern China becomes more pronounced.



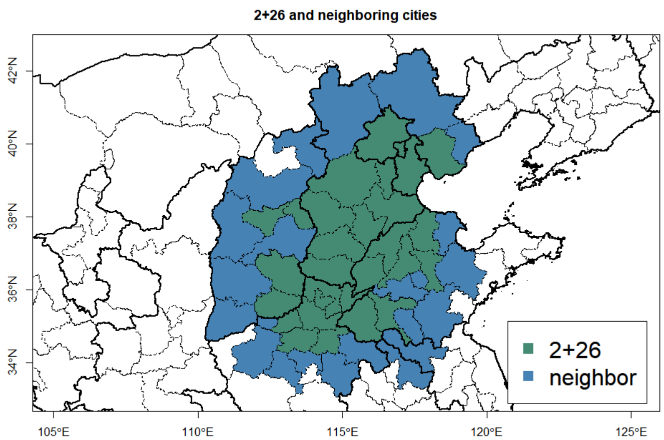
After dramatic gains in 2014-2015, national-level average PM2.5 levels started stagnating and NO2 levels started increasing as coal consumption rebounded. Air pollution levels increased in many provinces that are highly dependent on heavy industry, most notably Hebei, Shanxi and Sha'anxi. Beijing's PM2.5 levels stopped falling in early 2016, until the winter action plan went into effect in the last quarter of 2017. Ozone levels kept shooting up throughout the 2014-2017 period.

Year-on-year changes in industrial output and PM2.5 levels

Province	Cement	Coke	Crude Steels	Non-ferrous Metals	Thermal Power	PM2.5
Heilongjiang	-14%	13%	29%		-1%	10.4%
Anhui	9%	10%	8%	31%	10%	7.4%
Guangdong	10%	20%	31%	5%	13%	5.3%
Guangxi	3%	3%	7%	34%	5%	4.5%
Jiangxi	2%	-4%	7%	17%	11%	4.0%
Shanxi	-1%	1%	10%	4%	12%	4.0%
Jilin	-10%	-2%	9%		4%	1.3%
Hainan	1%				-2%	0.8%
Fujian	3%	21%	23%	-1%	20%	-0.8%
Shaanxi	1%	1%	28%	1%	1%	-1.0%
Hunan	0%	-5%	11%	-7%	6%	-2.9%
Jiangsu	1%	-20%	0%	23%	0%	-3.1%
Zhejiang	6%	2%	-8%	7%	7%	-3.6%
Inner Mongolia	-27%	17%	6%	3%	12%	-4.4%
Hubei	1%	-1%	1%	8%	1%	-4.5%
Yunnan	1%	-13%	9%	4%	-12%	-5.0%
Liaoning	-16%	4%	7%	5%	1%	-5.2%
Ningxia	14%	-3%	36%	9%	25%	-5.3%
Gansu	-13%	-11%	-14%	4%	0%	-5.6%
Hebei	-9%	-10%	-1%	-48%	4%	-6.7%
Guizhou	5%	-18%	-14%	23%	3%	-7.7%
Henan	4%	-20%	8%	1%	4%	-8.1%
Xinjiang	11%	2%	22%	1%	4%	-9.4%
Tianjin	-26%	-12%	12%	26%	-2%	-9.5%
Sichuan	-3%	-2%	17%	20%	2%	-9.8%
Shandong	-3%	-13%	3%	-17%	-6%	-11.8%
Shanghai	2%	3%	-5%		3%	-13.7%
Chongqing	-4%	32%	6%	8%	10%	-16.3%
Qinghai	-15%	-1%	8%	2%	33%	-18.5%
Beijing	-27%				-12%	-20.8%
Tibet	-2%				22%	-30.5%

Provinces with increases in PM2.5 levels generally saw large jumps in polluting industry output. Provinces with large air quality gains but large relative increases in industrial output are generally not significant producers. Source: China National Statistics Bureau via Wind Information; PM2.5 data from MEP

Wasn’t it just the weather?

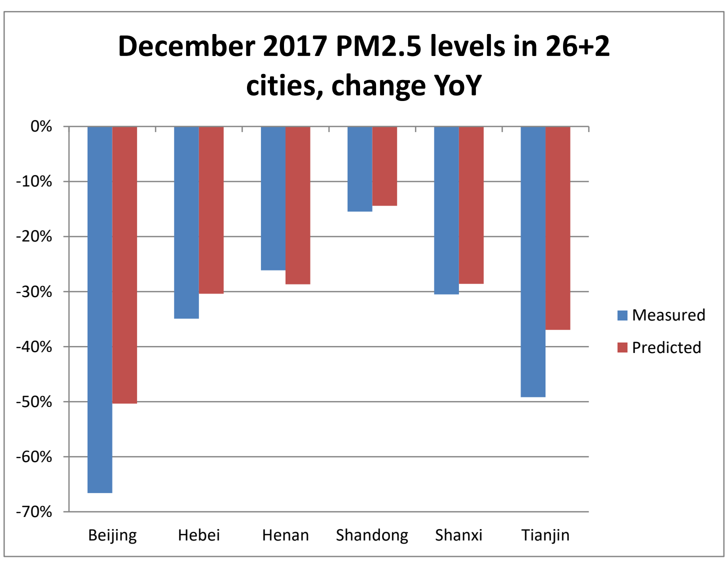


The air quality improvements around Beijing in November-December were aided by exceptionally favorable weather. PM2.5 levels in December would have been expected to fall by 30% on year even without any action, based on a statistical model of air quality and observed weather conditions. Actual levels fell by 40%, indicating that the winter action plan made a significant difference as well.

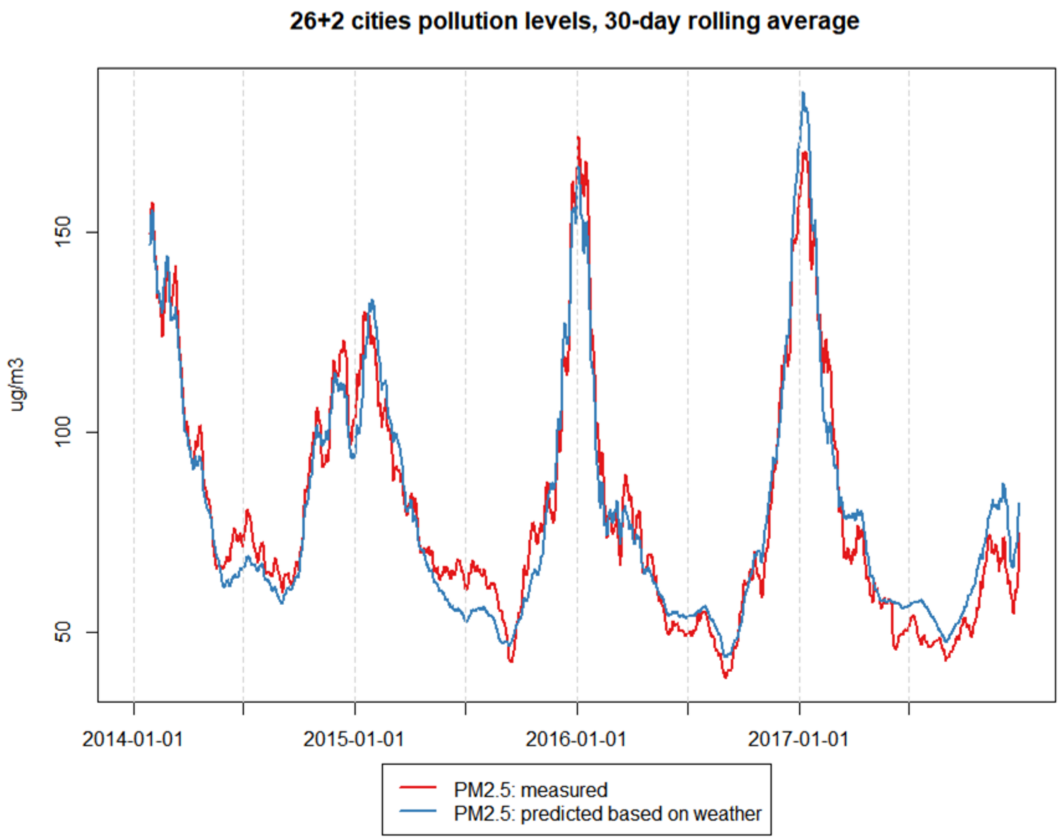
Another way to gauge the influence of weather on air quality during this winter period is to compare air quality in the 2+26 region and the immediately surrounding cities, where meteorological conditions are quite similar. This comparison shows that PM2.5 levels fell by 40% year-on-year in the 2+26 cities during the heating season, and by 23% in the surrounding cities. This implies that both the winter action plan and favorable atmospheric conditions played a significant role, with almost half of the reductions attributable to the action plan measures.

Satellite-based measurements also show a 50% fall in SO2 emissions in the region year-on-year, centered in heavy industry clusters and in the areas where a lot of residential coal-burning took place in previous years.

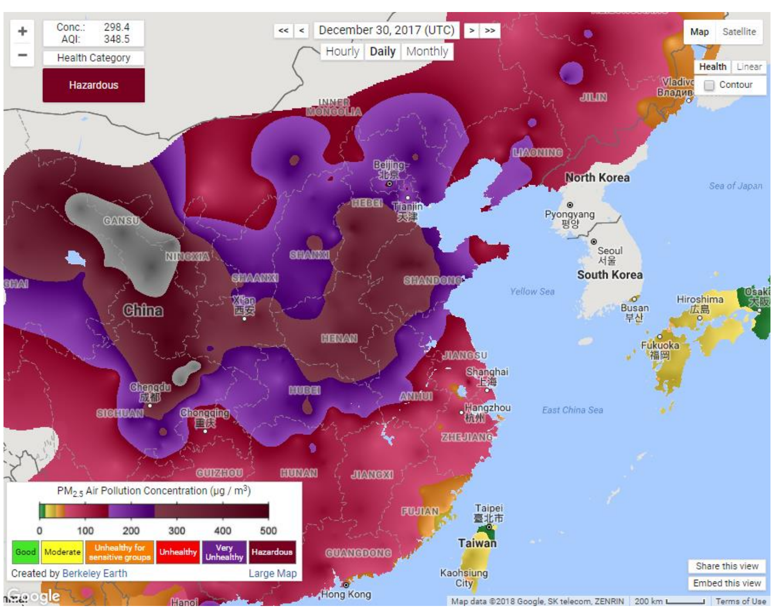
However, the air pollution episode in Dec 28-30, when much of the region saw ‘hazardous’ levels and Beijing experienced ‘very unhealthy’ levels showed that air pollutant emissions remain high enough to cause severe episodes, even after the measures.



About three fourths of the gains in air quality in December can be accounted for by weather conditions.



Measured air pollution levels match closely with predictions from a statistical model, but a gap opens up in the last months of 2017, showing the effect of the winter action plan. However, the region has not experienced the extremely smog-prone conditions seen in past winters yet.

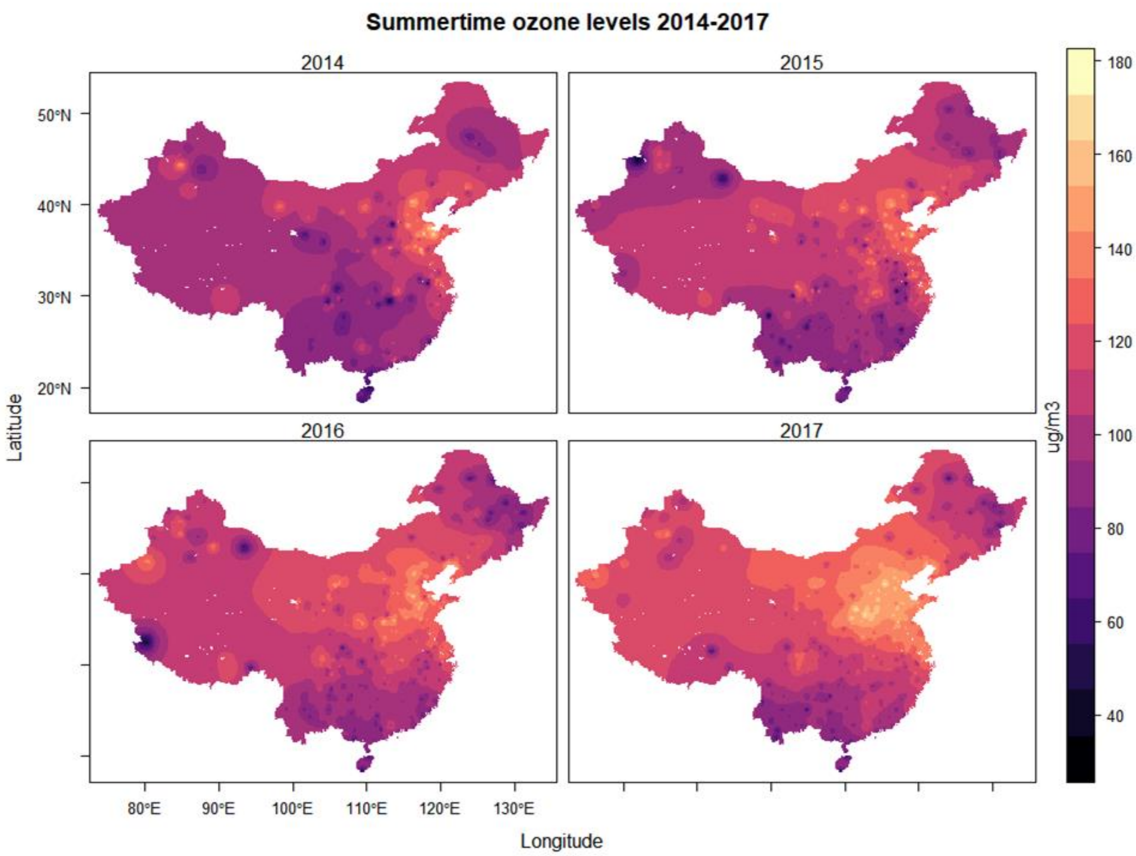


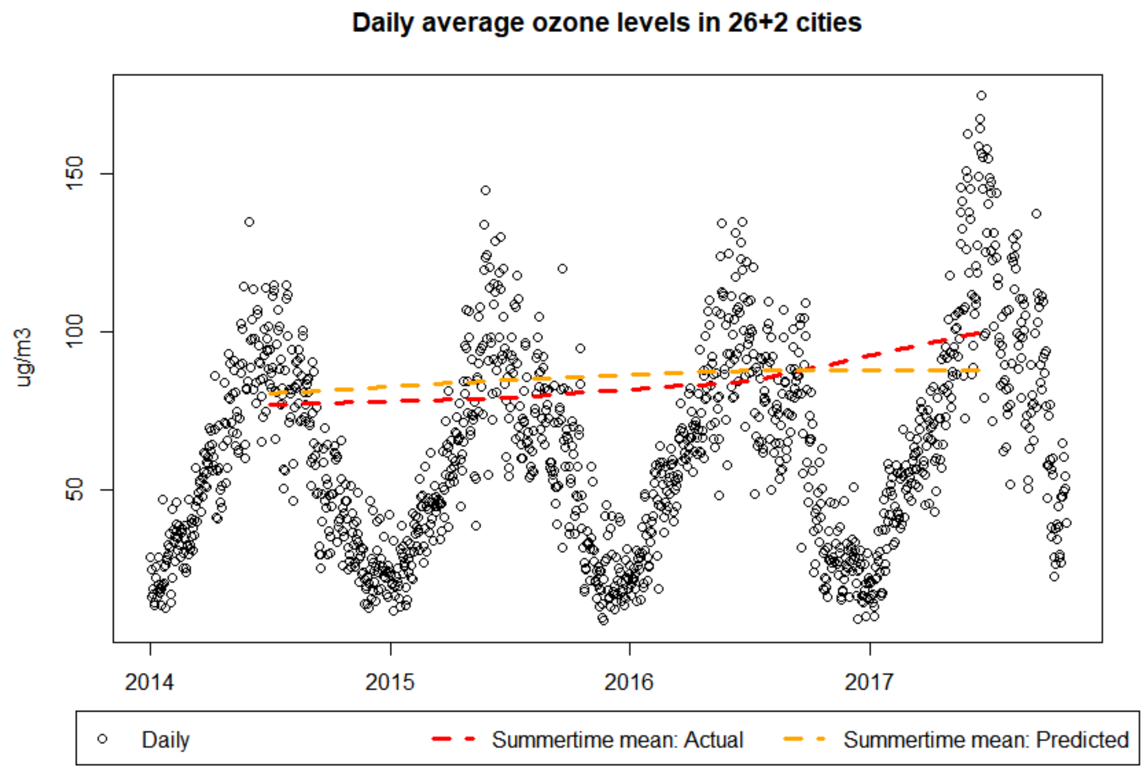
PM2.5 concentration reached ‘hazardous’ levels in the Beijing region in Dec 28-30.

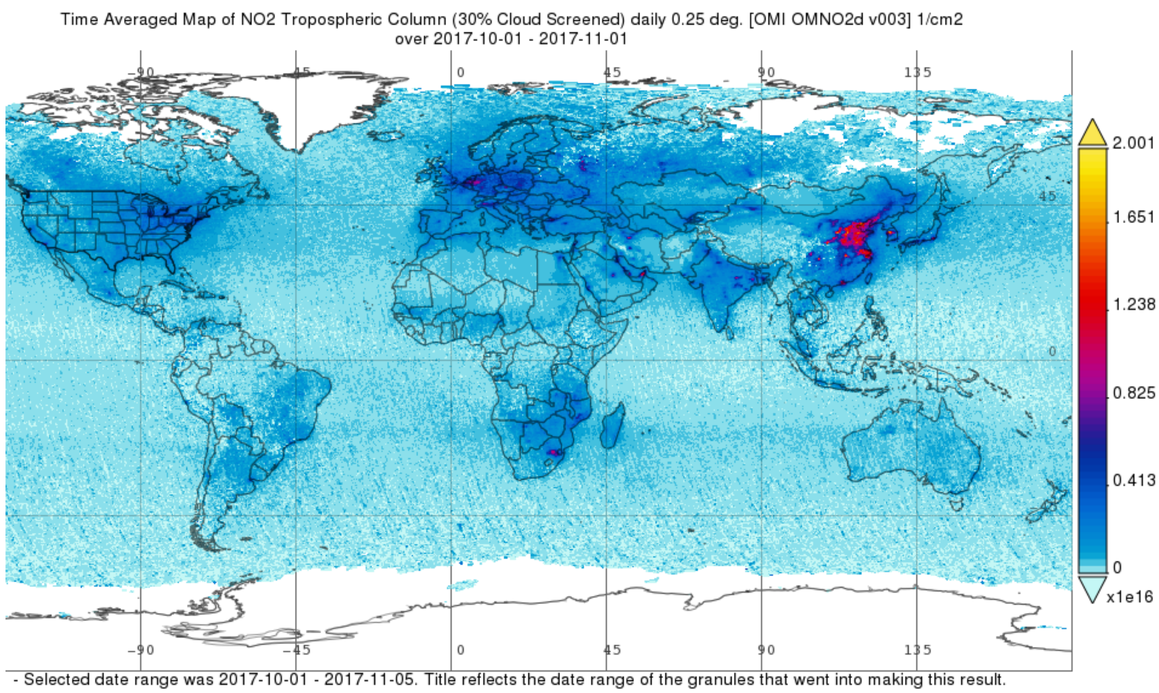
Ozone surging to record levels

Summertime (May-Aug) ozone levels increased 10% year-on-year nationwide and 25% in the 28 cities surrounding Beijing. Reasons for the increase in ozone include record industry output, partially driven by preparation for the restrictions during the winter, increasing oil consumption in chemical industry and transport, hot weather and the reduction in particle pollution levels which allows more sunlight to penetrate.

Ozone exposure was responsible for approximately 72,000 premature deaths in China in 2015 (according to Global Burden of Disease). Average exposure in the entire country increased 17% from 2014-2017, implying an increase of 12,000 premature deaths per year (compared with ozone staying at 2014 level).







The industrial rustbelt surrounding Beijing from three sides remains the largest hotspot of industrial pollution in the world. October 2017 average NO2 levels measured from NASA satellites. (Source: NASA Giovanni.)

Year-on-year changes in pollution levels by province

Province	PM2.5
Tibet	-30.5%
Beijing	-20.8%
Qinghai	-18.5%
Chongqing	-16.3%
Shanghai	-13.7%
Shandong	-11.8%
Sichuan	-9.8%
Tianjin	-9.5%
Xinjiang	-9.4%
Henan	-8.1%
Guizhou	-7.7%
Hebei	-6.7%
Gansu	-5.6%
Ningxia	-5.3%
Liaoning	-5.2%
Yunnan	-5.0%
Hubei	-4.5%
Inner Mongolia	-4.4%
Zhejiang	-3.6%
Jiangsu	-3.1%
Hunan	-2.9%
Shaanxi	-1.0%
Fujian	-0.8%
Hainan	0.8%
Jilin	1.3%
Jiangxi	4.0%
Shanxi	4.0%
Guangxi	4.5%
Guangdong	5.3%
Anhui	7.4%
Heilongjiang	10.4%

Province	NO2
Hainan	-17%
Tibet	-9%
Qinghai	-6%
Guizhou	-5%
Beijing	-5%
Hebei	-4%
Gansu	-4%
Henan	-2%
Heilongjiang	-1%
Shandong	0%
Chongqing	0%
Zhejiang	0%
Jilin	0%
Liaoning	1%
Hunan	1%
Tianjin	2%
Shanghai	3%
Xinjiang	4%
Fujian	4%
Sichuan	5%
Anhui	7%
Inner Mongolia	7%
Jiangsu	7%
Guangdong	7%
Hubei	8%
Jiangxi	8%
Guangxi	10%
Shaanxi	11%
Shanxi	12%
Yunnan	13%
Ningxia	17%

Province	O3[1]
Chongqing	-12%
Guizhou	-3%
Hubei	-2%
Inner Mongolia	-1%
Jiangsu	0%
Yunnan	0%
Qinghai	0%
Jilin	1%
Shaanxi	1%
Sichuan	1%
Ningxia	3%
Henan	4%
Guangxi	4%
Beijing	4%
Hunan	4%
Hainan	5%
Tibet	5%
Liaoning	5%
Gansu	6%
Zhejiang	7%
Xinjiang	7%
Shanghai	9%
Hebei	10%
Shandong	10%
Jiangxi	10%
Guangdong	12%
Heilongjiang	13%
Tianjin	13%
Anhui	19%
Shanxi	23%
Fujian	26%

[1] 90th percentile of 8-hour maximum values