China's air pollution overshoots pre-crisis levels for the first time

Levels of health-harming air pollutants in China have exceeded concentrations at the same time last year in the past 30 days, for the first time since the start of the COVID-19 crisis. This includes PM2.5, NO_2, SO_2 and ozone. Air pollutant levels plummeted during the national lockdown in February, bottomed out in early March and have now overshot their pre-crisis levels.

The rebound appears to be driven by industrial emissions, as the pollution levels in the largest cities, Beijing and Shanghai, are still trailing below last year. More broadly, pollution levels tended to increase more in areas where coal-burning is a larger source of pollution. Ozone levels are close to the record level of 2018.

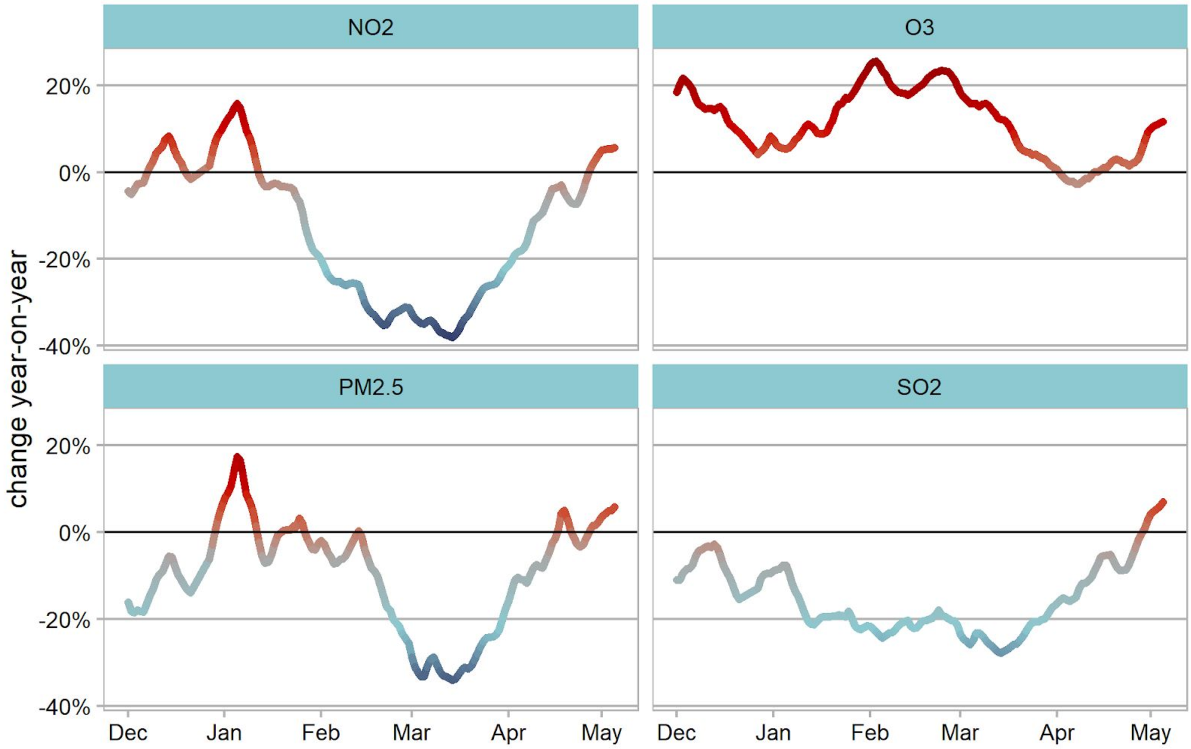
Rebounding air pollutant levels are a demonstration of the importance of prioritizing green economy and clean energy in the recovery from the COVID-19 crisis. All eyes are on China, as the first major economy to return to work after a lockdown. China's previous economic recoveries, including the aftermath of the Global Financial Crisis in 2008 and the SARS epidemic of 2003, have been associated with surges in air pollution and CO_2 emissions.

CREA's new Air Pollution Rebound Tracker can be used to track this development in real time.

Controlling for meteorological conditions, national average PM2.5, SO_2 and ozone concentrations in the past 30 days were above their pre-crisis levels, while NO_2 concentrations were at the same levels as before the crisis, showing that the rebound cannot be accounted for by weather factors.

National average pollutant levels

30-day running average, compared with last year



Source: CREA analysis of MEE real-time air quality monitoring data

Impact of the lockdown on air quality

The COVID-19 lockdowns had a dramatic impact on China's fossil fuel consumption and air quality - in the 30 days after the Chinese New Year holiday was originally scheduled to end, on February 3, national average PM2.5 levels fell by 33% while NO2 levels dropped by 40%, compared to the same post-holiday period in 2019. CO2 emissions fell by an estimated 25%, with coal-fired power generation, cement manufacturing and oil consumption all plummeting.

Changes in pollutant levels

30-day averages, year-on-year

	NO2		O3		PM2.5		SO2	
	during lockdown	now	during lockdown	now	during lockdown	now	during lockdown	now
Anhui	-42%	12%	-9%	18%	-45%	-9%	-30%	9%
Beijing	-48%	-24%	-9%	21%	-45%	-15%	-42%	-3%
Chongqing	-42%	27%	-36%	-3%	-39%	12%	-27%	15%
Fujian	-48%	-3%	-18%	21%	-30%	-3%	-24%	-3%
Gansu	-24%	15%	-9%	0%	-21%	30%	-24%	6%
Guangdong	-45%	6%	-12%	36%	-36%	24%	-24%	30%
Guangxi	-39%	30%	-9%	18%	-39%	18%	-30%	12%
Guizhou	-42%	6%	-12%	0%	-30%	3%	-27%	21%
Hainan	-42%	-15%	3%	33%	-39%	0%	-33%	-12%
Hebei	-42%	-9%	-9%	12%	-48%	-18%	-42%	-12%
Heilongjiang	-42%	15%	-3%	0%	-51%	108%	-12%	36%
Henan	-48%	3%	-12%	15%	-54%	-21%	-42%	12%
Hubei	-57%	-3%	6%	18%	-42%	-9%	-30%	15%
Hunan	-48%	9%	-6%	24%	-45%	3%	-42%	18%
Jiangsu	-48%	3%	-3%	18%	-45%	6%	-36%	-6%
Jiangxi	-51%	18%	-9%	45%	-36%	6%	-36%	15%
Jilin	-39%	24%	-6%	-3%	-48%	129%	-24%	45%
Liaoning	-45%	3%	-3%	6%	-51%	24%	-45%	0%
Inner Mongolia	-42%	-3%	-3%	-3%	-30%	-6%	-24%	-3%
Ningxia Hui	-39%	9%	-6%	-3%	-24%	-12%	-36%	6%
Qinghai	-27%	3%	-6%	-6%	-27%	-6%	-21%	-9%
Shaanxi	-39%	21%	-12%	6%	-39%	-9%	-36%	30%
Shandong	-51%	-3%	-9%	12%	-51%	-6%	-51%	0%
Shanghai	-42%	-6%	-6%	15%	-45%	-6%	-30%	15%
Shanxi	-30%	9%	-12%	9%	-42%	-15%	-42%	6%
Sichuan	-42%	12%	-9%	9%	-33%	6%	-24%	-3%
Tianjin	-39%	-9%	-6%	12%	-42%	-9%	-48%	-15%
Xinjiang	-45%	0%	-3%	0%	-33%	45%	-12%	0%
Tibet	-30%	3%	-9%	-9%	-30%	-12%	12%	42%
Yunnan	-42%	-6%	-15%	-15%	-21%	-21%	-30%	-21%
Zhejiang	-54%	3%	-9%	21%	-39%	3%	-27%	0%
National	-39%	6%	-3%	12%	-33%	6%	-27%	6%

"During lockdown" refers to the 30-day period with the largest year-on-year reduction in each province, between the start of the lockdowns and now. "Now" refers to the year-on-year change in the 30 days up to May 8. Source: CREA analysis of MEE real-time air quality monitoring data.

The rebound

It's obvious that once the economy starts to recover and production and transport to resume, much of the air pollution would return. What's not obvious is whether air pollution will overshoot pre-crisis levels, especially when many economic sectors are still reeling. Such an overshoot would signify a "dirty" recovery in which the more highly polluting sectors are leading.

Due to emphasis on GDP targets and on construction and manufacturing projects to hit those targets, China's recoveries have tended to be "dirty", with negative economic shocks followed by surges in fossil fuel consumption, air pollution and CO2 emissions - the most well-known example is the 2008 stimulus package that ushered in an unprecedented wave of construction projects and record levels of coal, cement and steel consumption. The stimulus programme culminated in the horrendous air pollution episodes of the winter 2012-13, commonly known as the "airpocalypse", around Beijing. Another worrying parallel to the current situation is the "SARS investment boom" started by the government in 2003 to offset the negative economic impacts of the SARS epidemic and resulting in a surge in pollution in the region surrounding Beijing.

In contrast, the rapid increase in output from energy-intensive industries and coal-fired power generation from 2017 to 2019 was offset by sweeping air quality efforts, including switching thousands of industrial boilers and millions of households from coal to gas and electricity, and massive investments in end-of-pipe emissions controls at power plants and factories. As a result, air quality gains slowed down but didn't reverse.

Now there are early warning signs that China's recovery from the COVID-19 crisis is reversing air quality gains, with national average PM2.5, NO2, SO2 and ozone levels catching up to and exceeding the levels at the same time last year in the past 30 days.

All four pollutants have severe health impacts, and their concentrations in China remain far above safe levels despite air quality gains made since the "airpocalypse" in 2013.

The reasons for the rebound are clear: emissions from power plants, industry and transport have all been increasing. Coal consumption at 5 major power generating companies in eastern China rose above 2019 levels for the first time in early May; thermal power generation already increased 1% in April year-on-year, after falling 8% in March. Cement and metals manufacturing has also been rebounding: already in April, cement output increased 4% year-on-year, after falling 18% in March; non-ferrous metals output increased 4% and steel output returned to growth after falling in March.

Heavy industry appears to be leading the rebound, while retail sales remained 8% below last year's level in April and consumer-facing manufacturing such as textiles and mobile phones recorded double digit falls on year.

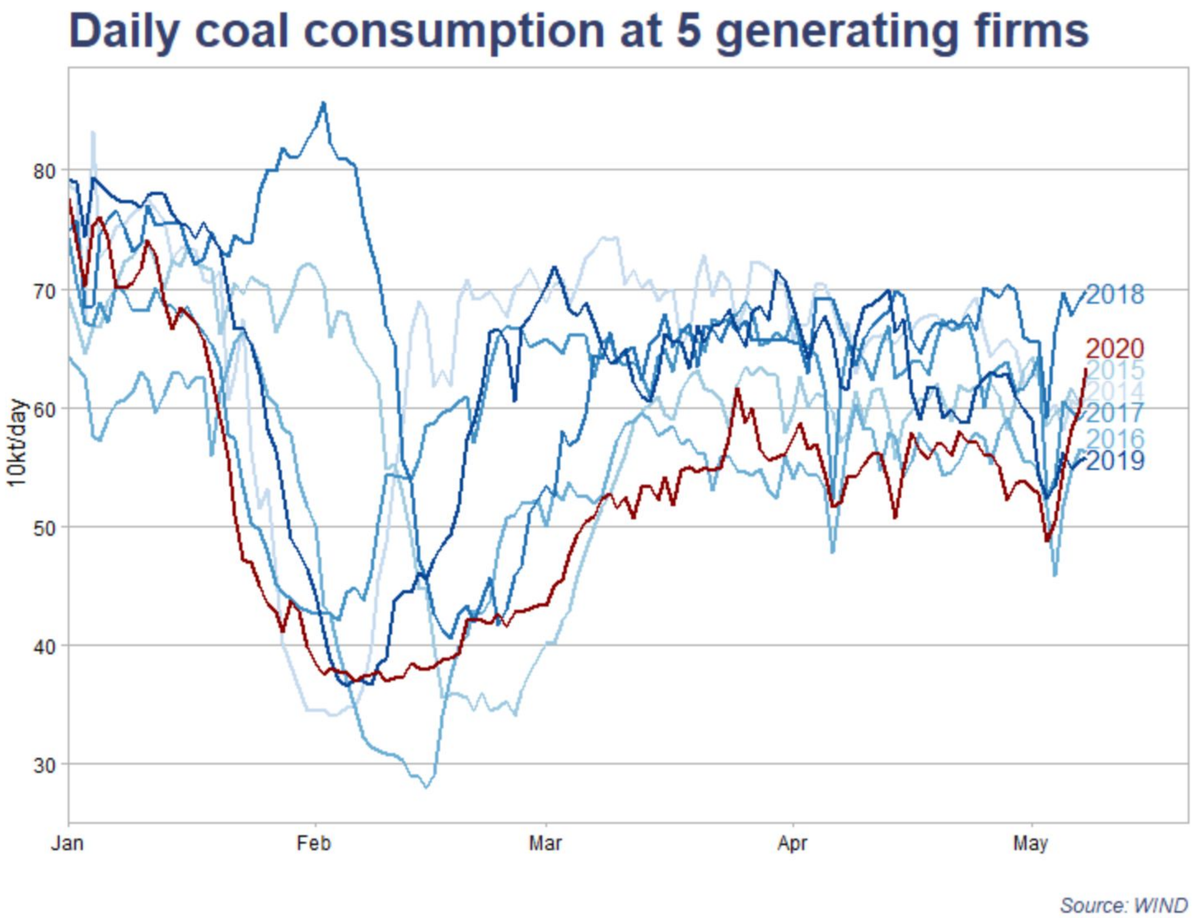
Overall mobility (passenger transport volume) is still below last year's levels but there has been a shift from public transport to private cars and return of congestion in urban areas due to worries about infection risk, which is not helping.

Two key findings from statistical analysis suggest an industrial emissions rebound:

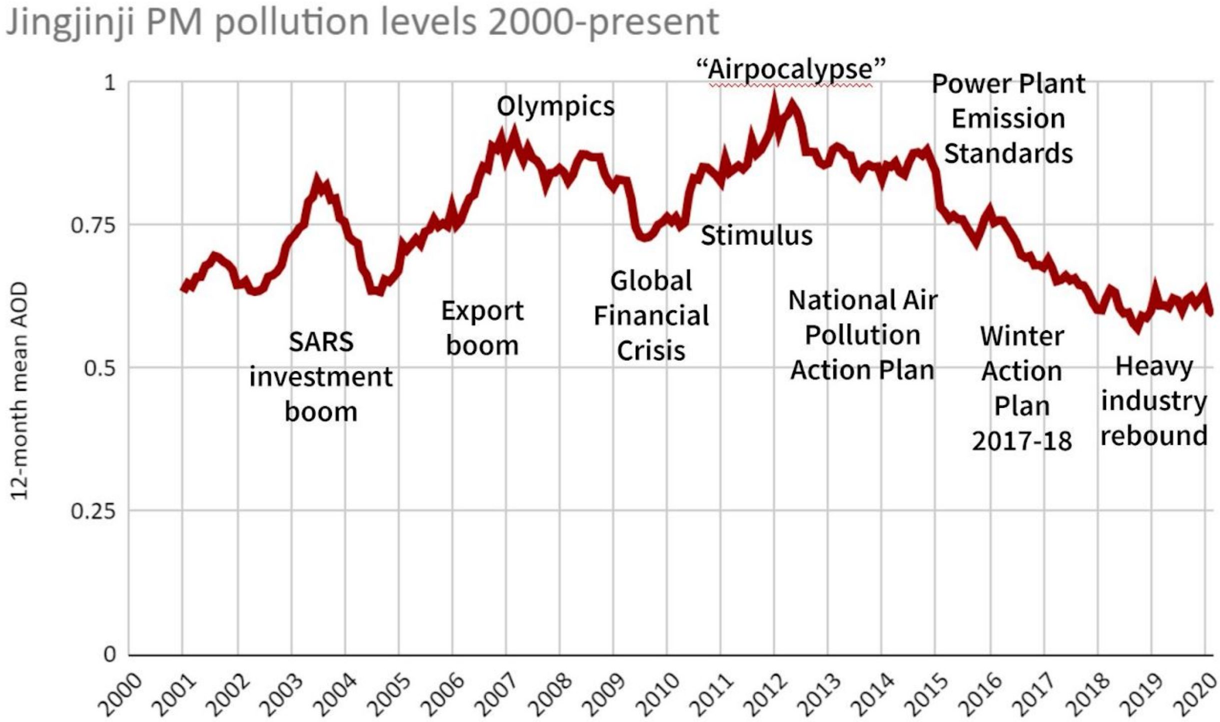
- NO2 increased less in densely populated urban areas than in the rest of the country, indicating that places where transport is the key source had a smaller increase (negative correlation between NO2 increase year-on-year and population density)
- PM2.5 and NO2 increased more in locations with higher SO2 levels, indicating that places where coal-burning is an important source had a larger increase (positive correlation between NO2 increase year-on-year and ratio of SO2:NO2 in April)

The province breakdown with places like Shanxi, Shaanxi, Ningxia, Inner Mongolia standing out also suggests industrial emissions rebound.

In terms of sources, SO2 is related to coal-burning. PM2.5, NO2 and ozone are related to power plants, industry and transport. Heating and agricultural burning are not significant contributors in April-May in most of the country.

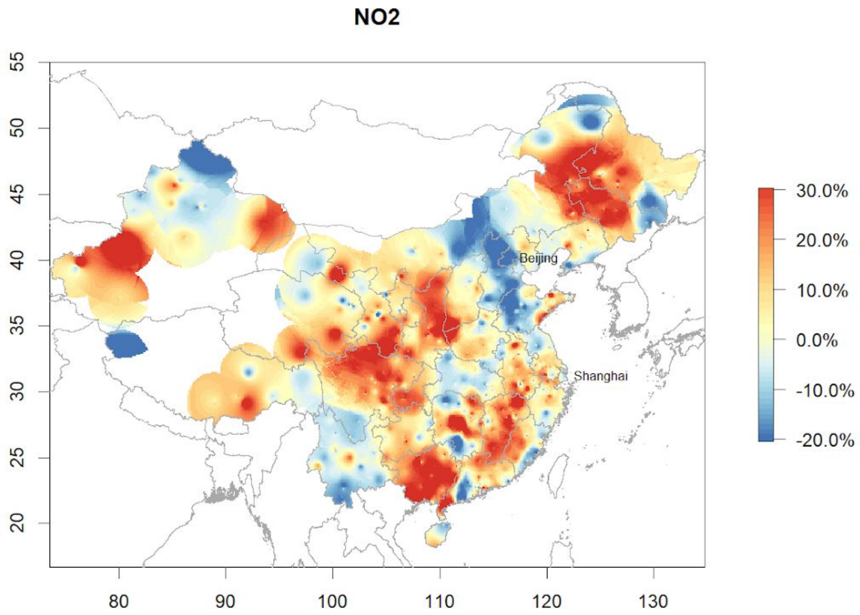


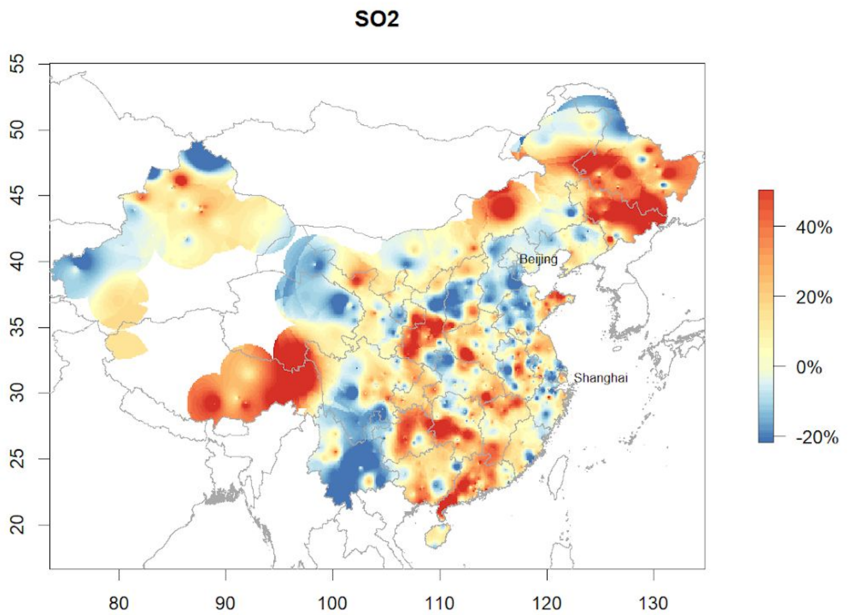
The long view of particle pollution in Jingjinji shows how stimulus has driven surges in pollution in 2003-2004 and 2008-2012:



Source: CREA analysis of NASA MODIS data

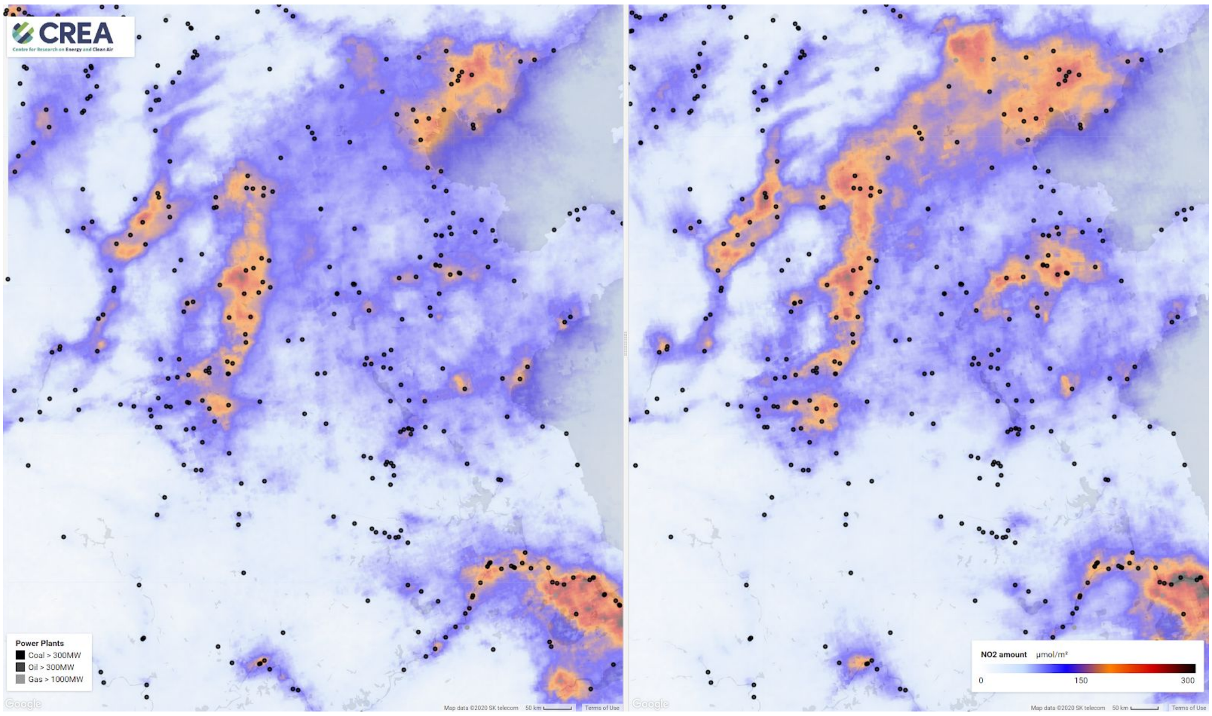
Year-on-year changes in pollution levels in the 30 days to May 8



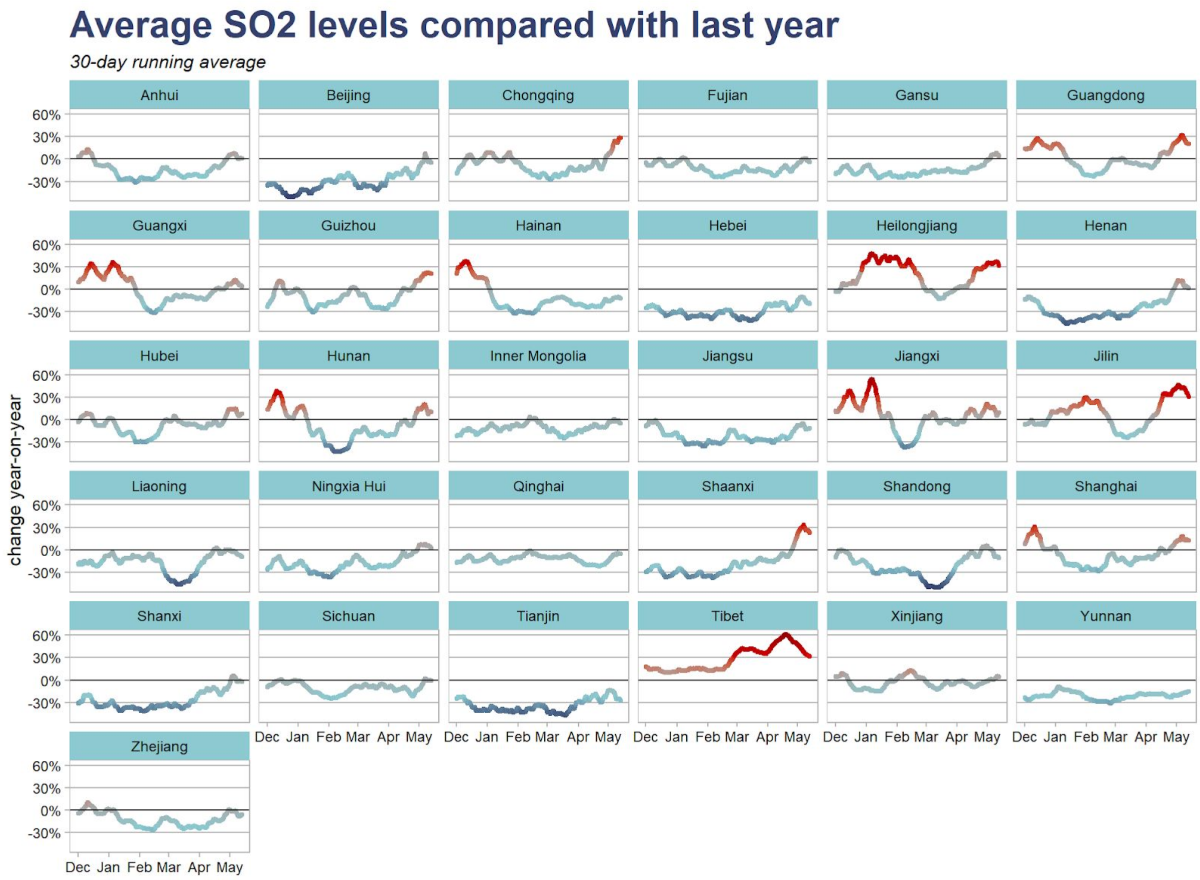


Source: CREA analysis of MEE real-time air quality monitoring data

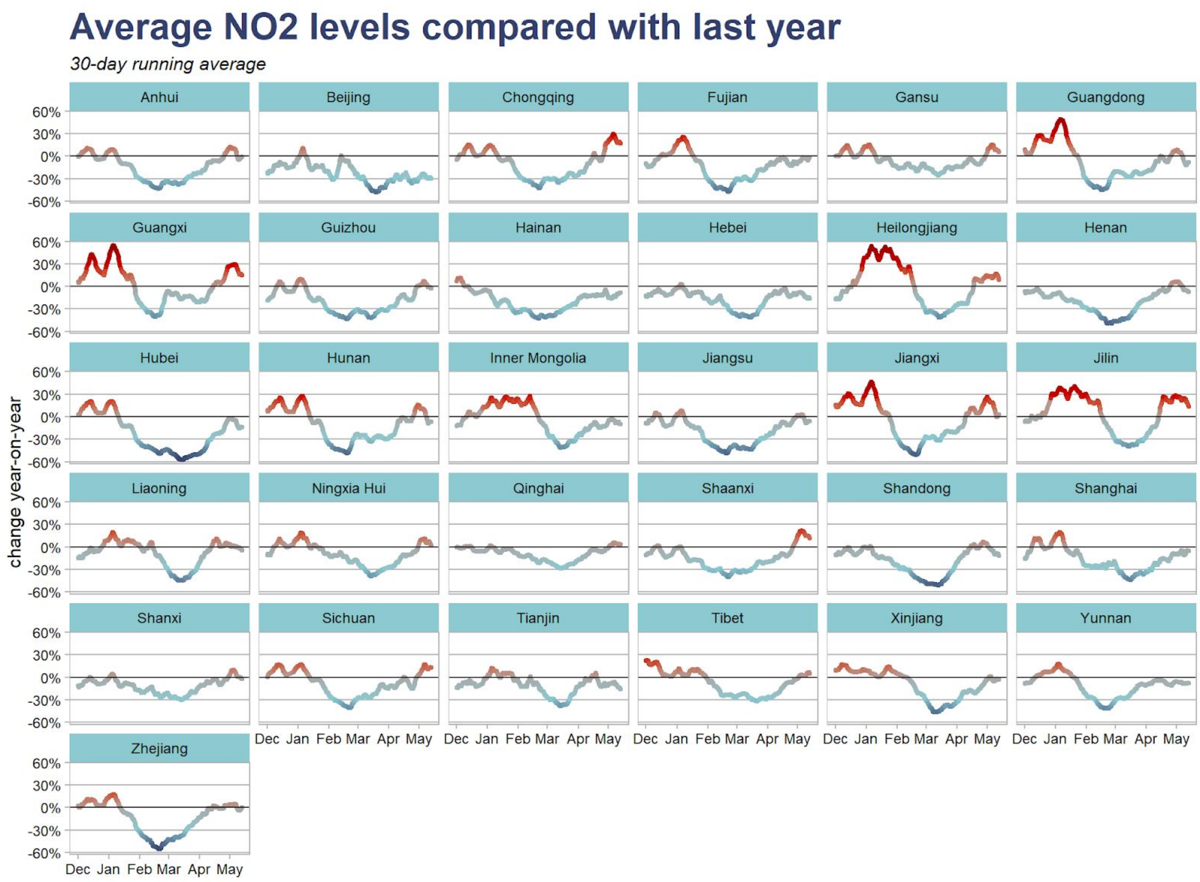
Satellite-based NO2 levels also show that Beijing&Baoding local emissions are still very low, Tangshan, south Hebei, Shanxi are back to last year's levels:



April 1 - May 5, NO2 from TROPOMI. 2020 on left, 2019 on right. Source: ESA Sentinel 5P satellite data analysed by CREA.



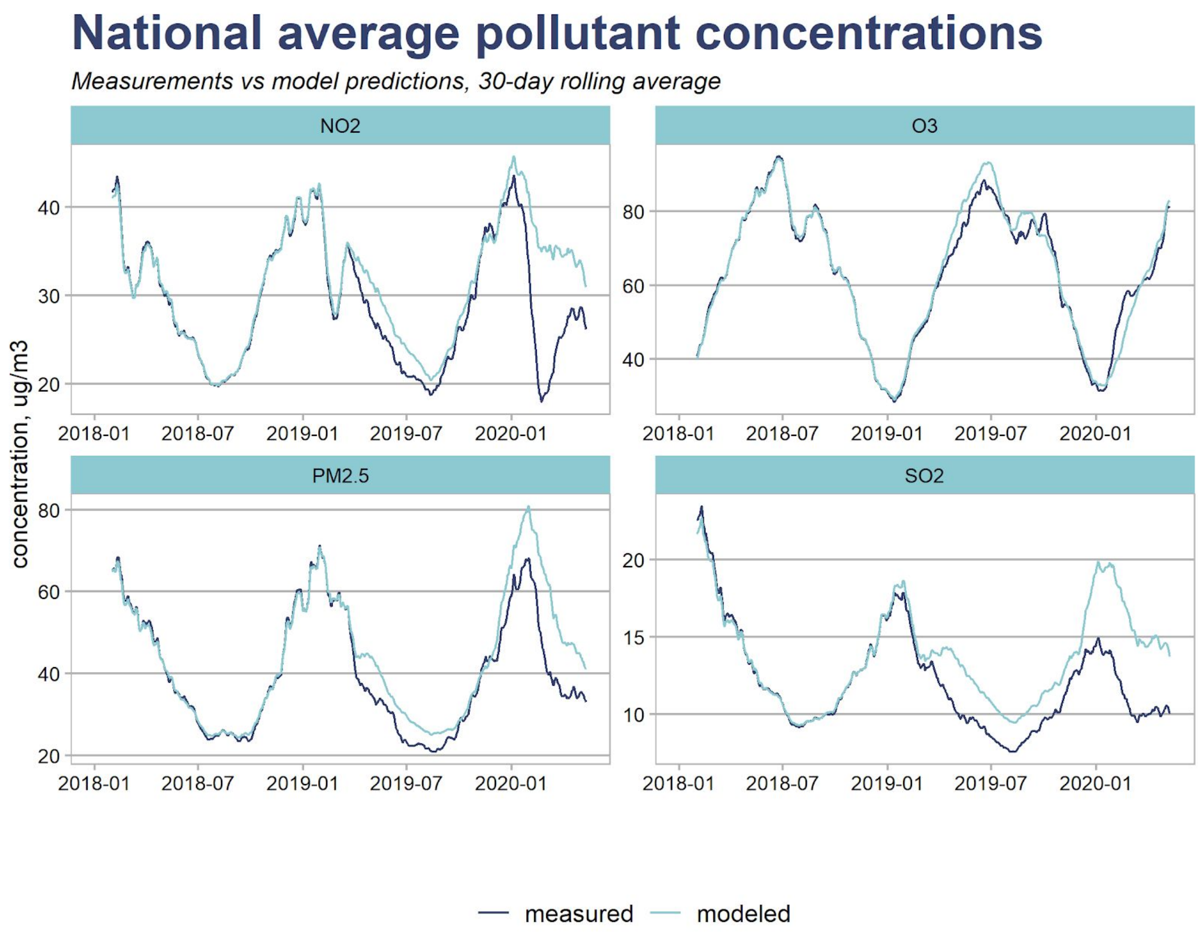
Average SO2 levels compared with last year
30-day running average
Anhui
Beijing
Chongqing
Fujian
Gansu
Guangdong
Guangxi
Guizhou
Hainan
Hebei
Heilongjiang
Henan
Hubei
Hunan
Inner Mongolia
Jiangsu
Jiangxi
Jilin
Liaoning
Ningxia Hui
Qinghai
Shaanxi
Shandong
Shanghai
Shanxi
Sichuan
Tianjin
Tibet
Xinjiang
Yunnan
Zhejiang
change year-on-year
60%
30%
0%
-30%
Dec Jan Feb Mar Apr May



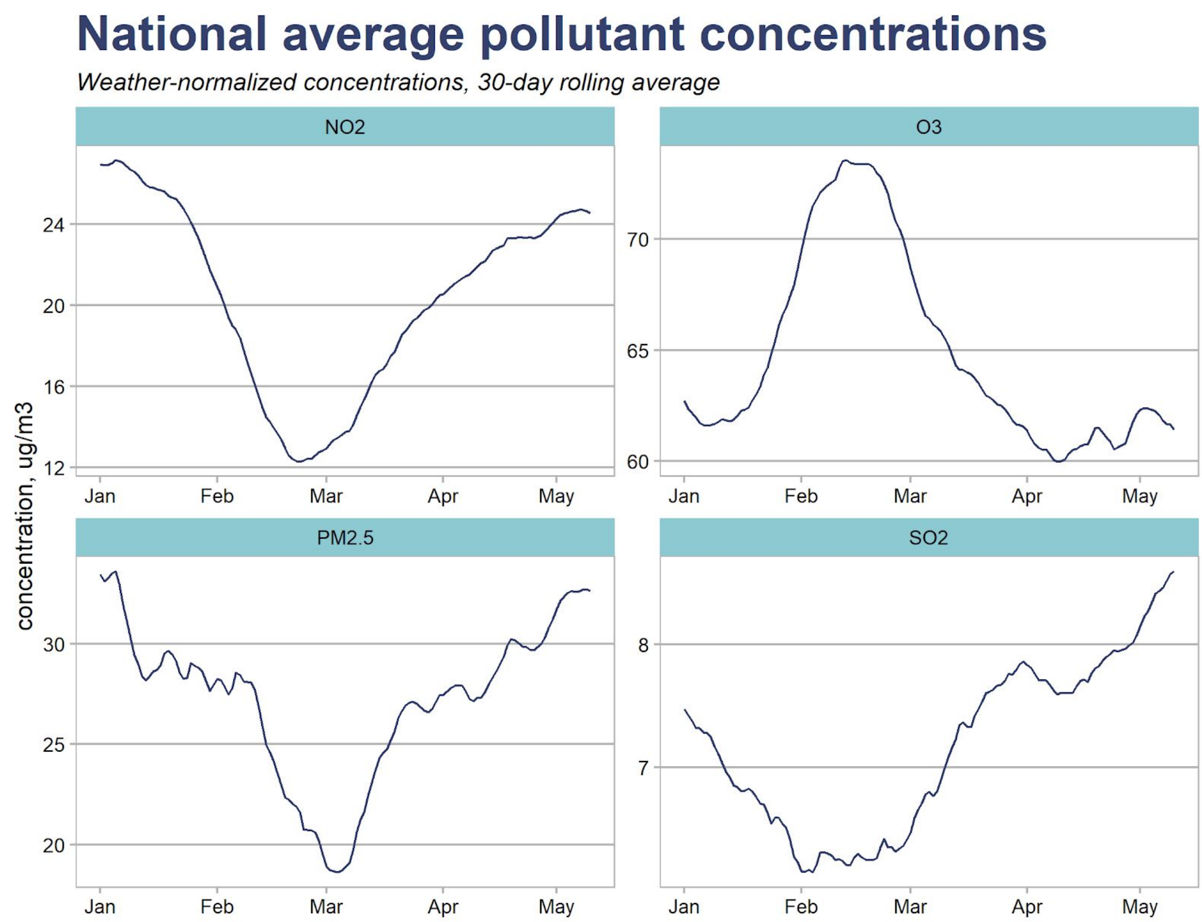
Controlling for weather variability

The analysis is based on hourly air quality data from 1,500 official stations monitoring air pollutant concentrations. For each air quality station, data from the closest meteorological observation station was downloaded from the NOAA ISD database. Planetary boundary layer height, a key meteorological parameter affecting air quality was obtained from UNCAR daily global meteorological model runs. Other meteorological variables included wind speed, direction, humidity, temperature and solar radiation, with one day lags or daily minimum/maximum values where these were found to improve model performance. A Gradient Boosting Model, a standard machine-learning approach was trained for average daily meteorology and air quality in each city, using data from 2018-2019, and used to forecast daily air quality under “normal” emissions levels. This follows the meteorological normalization technique described in Grange & Carslaw (2019).

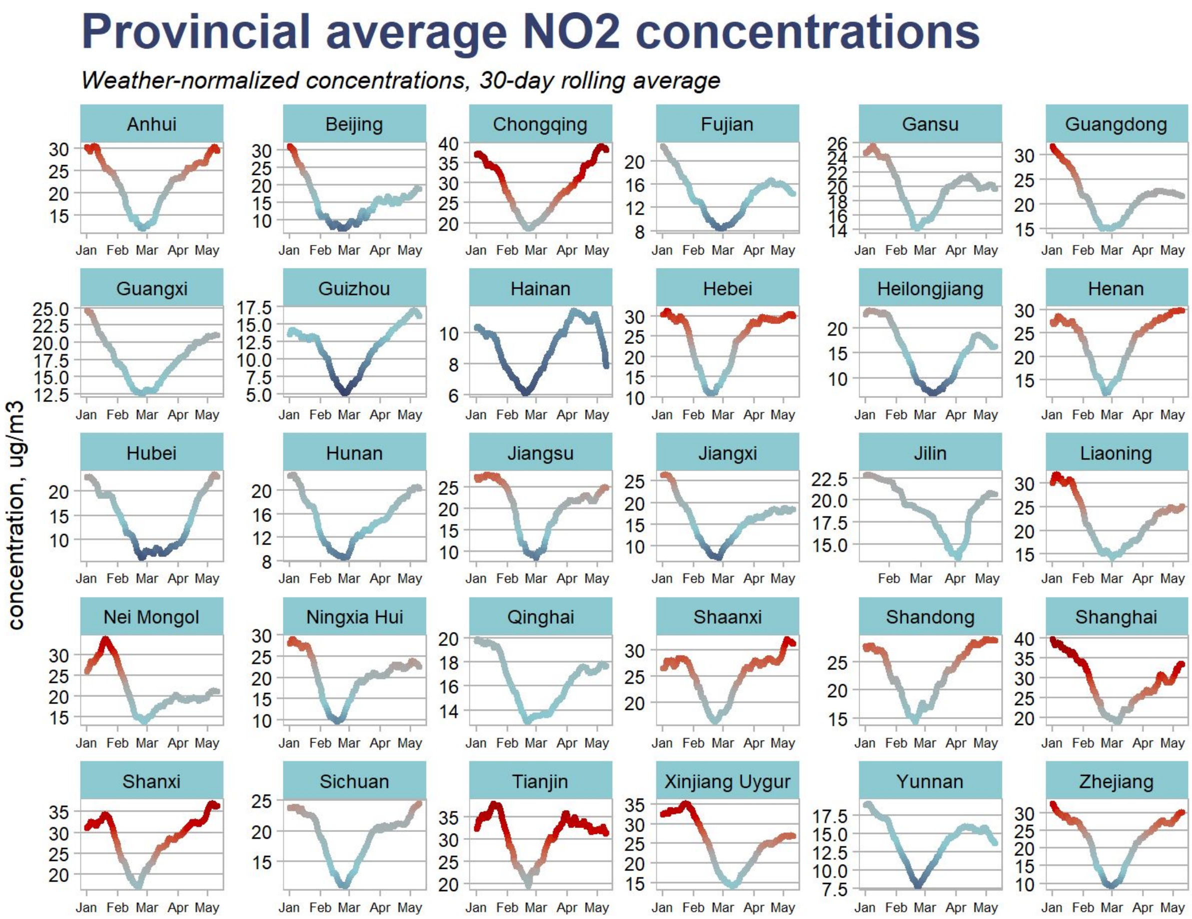
The graph below shows nationally averaged pollutant concentrations as actual observed values and model-predicted values. The measured values for pollutants other than ozone gradually move below the model-predicted values as air quality improves, but the short-term variation of the two lines follows each other closely. In 2020, after the lockdowns, SO2, NO2 and PM2.5 fall steeply below the predicted values as emissions are reduced. The effect on ozone is much more complex, as NOx emissions can inhibit ozone formation.



The model-predicted values show the part of the variation in air quality that is attributable to weather. When that variation is removed, the weather-controlled trend shows the effect of changes in emissions:



Weather-normalized PM2.5 and SO2 concentrations have exceeded their pre-crisis levels in early January, while NO2 has returned to pre-crisis levels. Ozone concentrations initially spiked under the lockdowns due the effects of reduced emissions of other pollutants. They then fell and are now increasing, rising above last year's levels. On the provincial level, the next graph shows post-lockdown increases in NO2 pollution levels after lockdowns were lifted.



About CREA

Centre for Research on Energy and Clean Air (CREA) is a new independent research organisation focused on revealing the trends, causes, and health impacts, as well as the solutions to air pollution. CREA uses scientific data, research and evidence to support the efforts of governments, companies and campaigning organizations worldwide in their efforts to move towards clean energy and clean air, believing that effective research and communication are the key to successful policies, investment decisions and advocacy efforts. CREA was founded in December 2019 in Helsinki and has staff in several Asian and European countries.