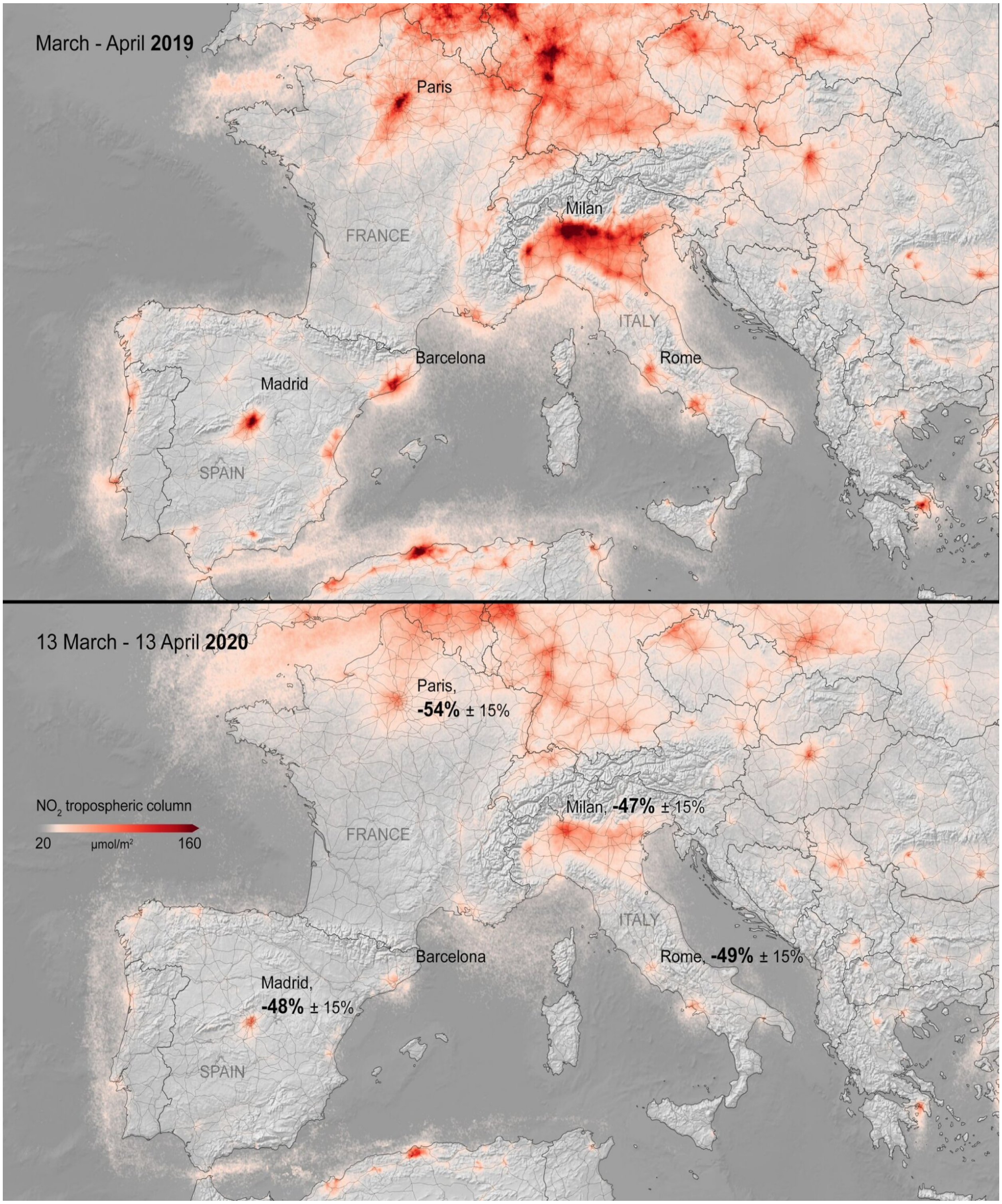
Air quality

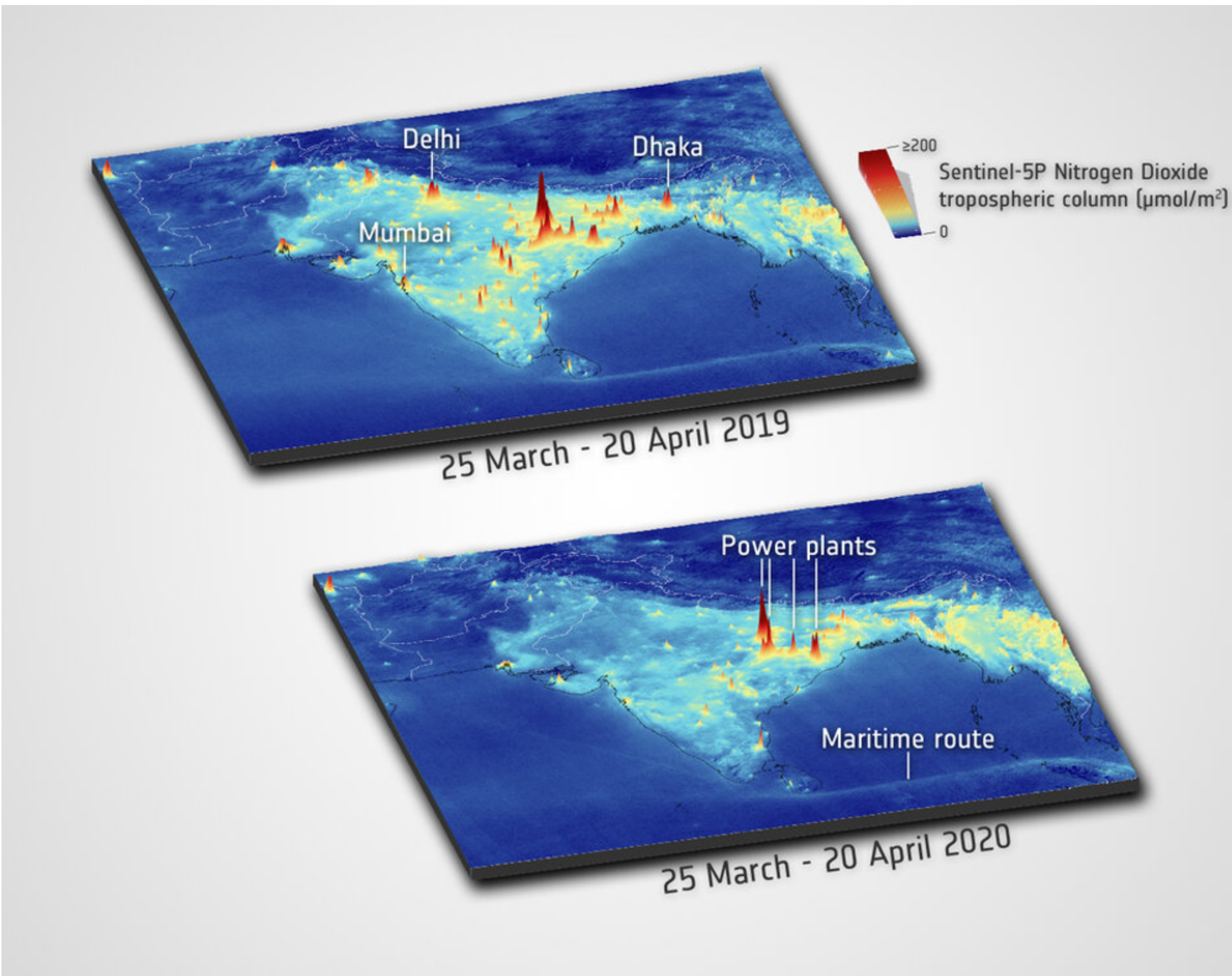
Effects of NO_2

As human behavior has changed during the pandemic, ongoing measurements from Earth observing instruments have detected concurrent changes in environmental factors, such as a drop in the air pollutant nitrogen dioxide (NO_2).

Data shown from the Tropospheric Monitoring Instrument (TROPOMI jointly developed by The Netherlands and ESA) on the European Space Agency's (ESA) Copernicus Sentinel-5P satellite satellite and the Netherlands-Finnish instrument Ozone Monitoring Instrument (OMI) on the Aura satellite, show significant drops in regional nitrogen dioxide (NO_2) levels that coincide with reduced traffic and industrial activity.The measurements presented here combine and average nitrogen dioxide data to account for variations in NO_2 caused by weather, such as clouds and wind. This provides a clearer picture of the impact of human activity on NO_2 levels. In Madrid, Milan, Rome, and Paris, for example, TROPOMI data show about a 50% reduction in NO_2 from March 13-April 13, 2020 compared to the same months the year before. These reductions coincide with implementation of strict quarantine measures across Europe.

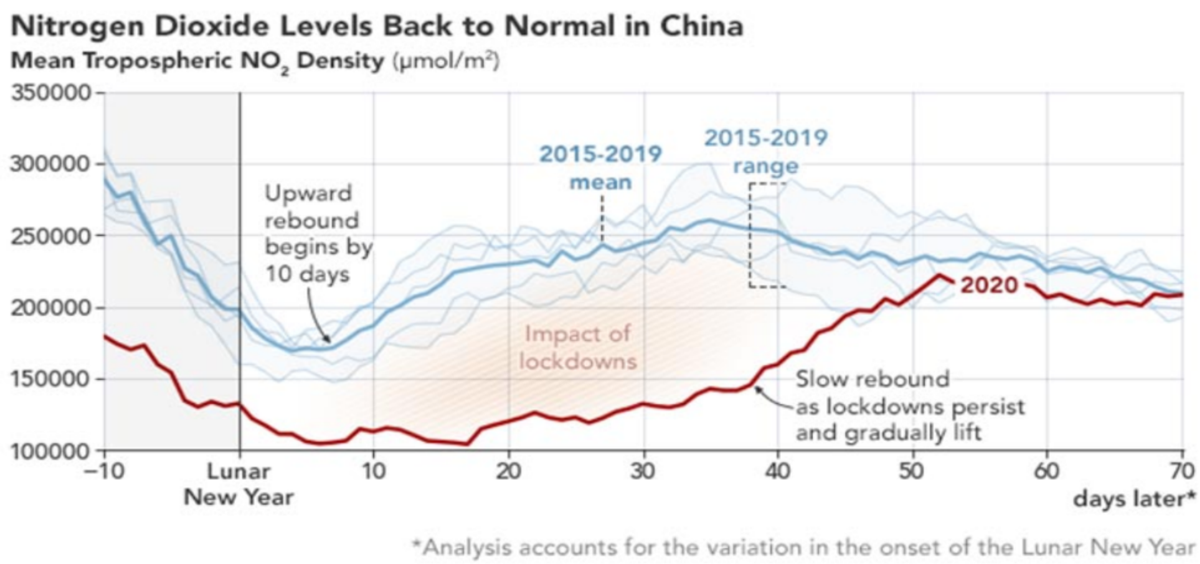

March - April **2019**
Paris
Milan
FRANCE
ITALY
Barcelona
Rome
Madrid
SPAIN
13 March - 13 April **2020**
Paris,
-54% ± 15%
NO2 tropospheric column
20 µmol/m² 160
Milan, **-47%** ± 15%
FRANCE
ITALY
Barcelona
Rome, **-49%** ± 15%
Madrid,
-48% ± 15%
SPAIN

TROPOMI observations over India also showed less air pollution during lockdowns in selected cities, such as New Delhi and Mumbai. Comparing the same time frames in 2019, averaged NO2 concentrations from the first day of the lockdown on March 25-April 20, 2020 data show reductions of about 40-50% of air pollution. However, reductions in nitrogen dioxide were not consistent throughout India. Northeast India showed nearly constant values of NO2 levels due to ongoing operations at coal-based power plants, which did not reduce electric power generation significantly during the lockdown.



Sentinel-5P/TROPOMI Nitrogen Dioxide concentration measurements over India. Image Credit: ESA

Similarly, as stay-at-home and other lockdown restrictions begin to ease, OMI and TROPOMI are observing rebounds in nitrogen dioxide levels.



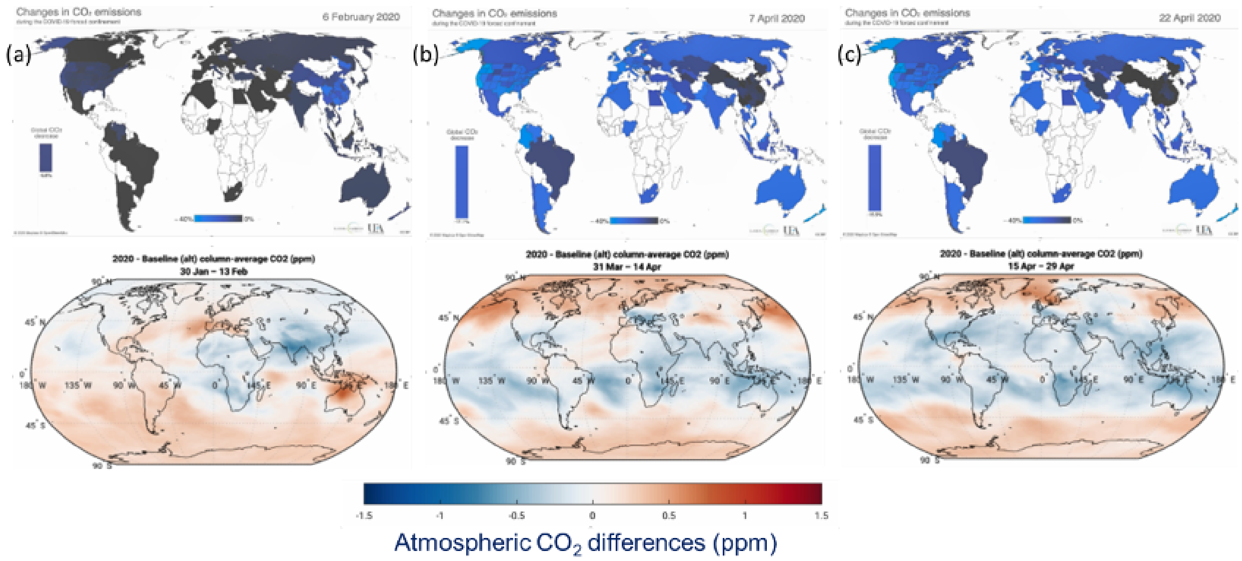
[The mean column density of nitrogen dioxide (NO2) over China as measured by the OMI satellite in 2020 (red line) and the average from 2015-2019 (blue lines). Time is measured in days before and after the Lunar New Year began. (In 2020, it started on Jan.25)] Image Credit: NASA Earth Observatory

Green house gases- CO2

Lockdowns and other social distancing measures implemented in response to the COVID-19 pandemic have led to temporary reductions in carbon dioxide (CO_2) emissions from fossil fuel combustion and other human activities. Initial studies suggest that although COVID-19-related CO_2 emission reductions are expected to slow the speed at which CO_2 accumulates in the atmosphere, they will not reduce the overall atmospheric concentration of CO_2. CO_2 emission reductions have been accompanied by comparable, or even greater, reductions in emissions of short-lived air pollutants, such as [nitrogen dioxide (NO2)]. While fossil fuel combustion emits far more CO_2 than NO_2, much smaller relative changes are expected for atmospheric CO_2 because it has a much longer atmospheric lifetime and there is much more CO_2 in the atmosphere than NO_2. Therefore, time-dependent, regional-scale changes in CO_2 concentrations are expected to be no larger than 1 part per million (ppm), out of the normal 415 ppm CO_2 background – a change of only 0.25%. To track atmospheric CO_2 changes resulting from the lockdowns, observations collected by the NASA Orbiting Carbon Observatory-2 (OCO-2) satellite and Japan's Greenhouse gases Observing SATellite (GOSAT) during the first few months of 2020 were compared to results collected in previous years. The OCO-2 results were used to search for changes on regional scales over the globe. Targeted observations from GOSAT were used to track changes in large urban areas, such as Beijing, Tokyo, Mumbai, and New York. Both types of observations yielded key insights into the CO_2 changes accompanying the economic disruptions caused by the COVID-19 pandemic.

REGIONAL STATE CHANGES IN CO2 AROUND THE GLOBE

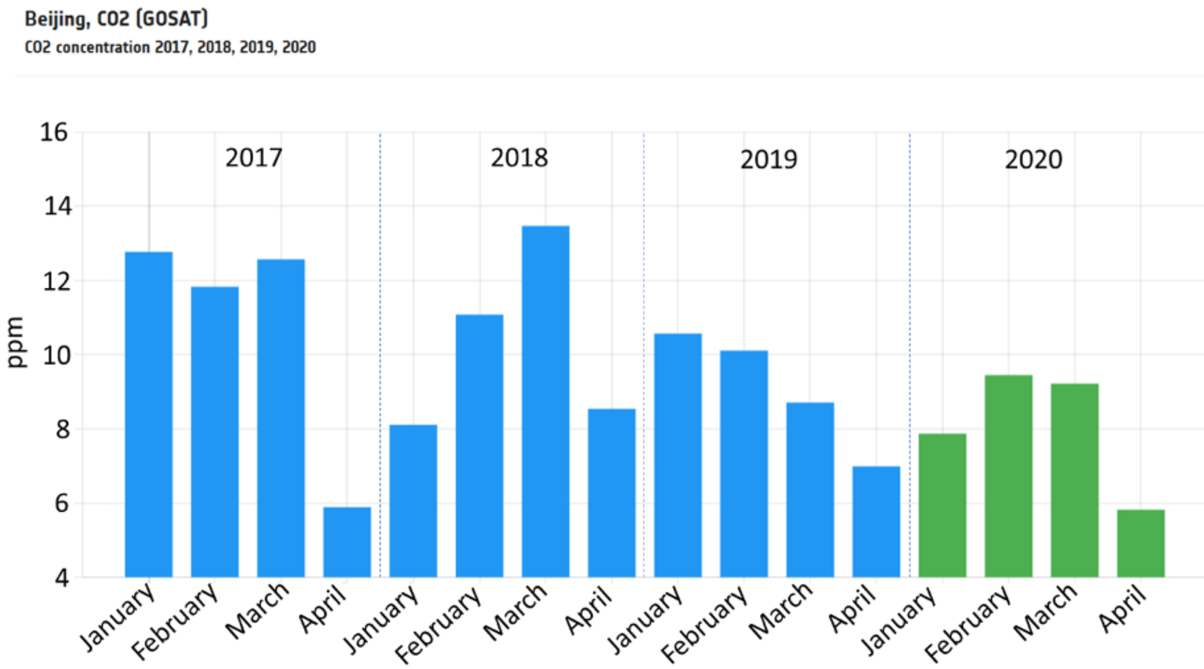
The maps below show these comparisons for the peak periods of the lockdowns in China (early February), southern Europe (early April) and the eastern U.S. (late April). The results show small (about 0.5 parts per million, or 0.125%) reductions in CO_2 over each region at times that are well aligned with the largest CO_2 emissions reductions in those regions reported by the Global Carbon Project. The CO_2 map for late April (panel c) also appears to show a rebound in CO_2 levels over East Asia and northern Pacific Ocean in late April, as China began to emerge from its coronavirus lockdowns. Many features are not likely to be associated with the lockdowns. The enhanced CO_2 values in the southern hemisphere are probably due in part to the large wildfires over Australia in late December 2019, while the enhanced values in central Asia in April include contributions from wildfires in Siberia.



Top row: Reported country-by-country reductions in fossil fuel use during the most intense periods of the COVID-19 lockdowns in a.) China (early February), b.) Europe (early April) and c.) Northeast U.S. (late April). Brighter blue colors indicate greater reductions. Bottom row: observed changes in atmospheric CO2 concentration differences derived from OCO-2 measurements. Blue shades indicate reductions in CO2, while red shades indicate increases relative to the baseline CO2 climatology. Image Credit: (Top) Global Carbon Project (Bottom) NASA

<u>CO2 CHANGES OVER LARGE URBAN AREAS</u>

GOSAT observations were analyzed to reveal CO2 concentration enhancements, such as fossil fuel emissions that contribute to higher levels of CO2 lower down in the atmosphere over cities, relative to the CO2 concentrations at higher altitudes, which are less affected by city emissions. The figure below shows the CO2 concentration enhancements over Beijing, China, derived from GOSAT observations collected in January through April of each year from 2017 to 2020. The results from earlier years illustrate the amount of month-to-month variability in the observed CO2 enhancements that is typical during this season. However, while the CO2 concentration enhancements vary substantially from month-to-month, they are generally much lower in 2020 than in earlier years.



Monthly time series of lower atmospheric CO2 enhancements over Beijing, China for January 2017 through April 2020 derived from GOSAT data. The results for January through April of prior years are shown in blue, while those for 2020 are shown in green. Image Credit: ESA/JAXA

Further inspection of the Beijing results reveals that all months in 2020 have smaller CO2 enhancements relative to prior years. While this behavior is consistent with reported COVID-19-related reductions in fossil fuel emissions from Beijing, it is important to remember that these results include variations in CO2 concentrations not only from COVID-19 shutdowns, but also from other processes such as photosynthesis and respiration by plants and transport by passing weather systems.

Similar results were derived for the other cities. Shanghai shows reduced CO2 enhancements from February through April 2020. For New York, CO2 values were higher in January 2020, close to normal for February, and lower in March, as lockdowns were imposed. There is no data for New York in April due to cloud cover. In New Delhi, Mumbai and Dhaka, the story is somewhat more mixed. The CO2 enhancements are smaller or almost the same in February, reflecting the large role of natural processes, such as year-to-year differences in CO2 uptake and release by forests and crops. In March 2020, CO2 enhancements are higher than in earlier years in New Delhi, and lower in Mumbai and Dhaka. The CO2 enhancements decrease across all three cities in April, as lockdowns are implemented. However, these changes are very difficult to attribute to the pandemic because of the large-scale natural CO_2 changes seen across India during this season.