



NASA Satellite Data Enable Research on the Impact of COVID-19 on World Air Quality

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NASA Earth Science Missions

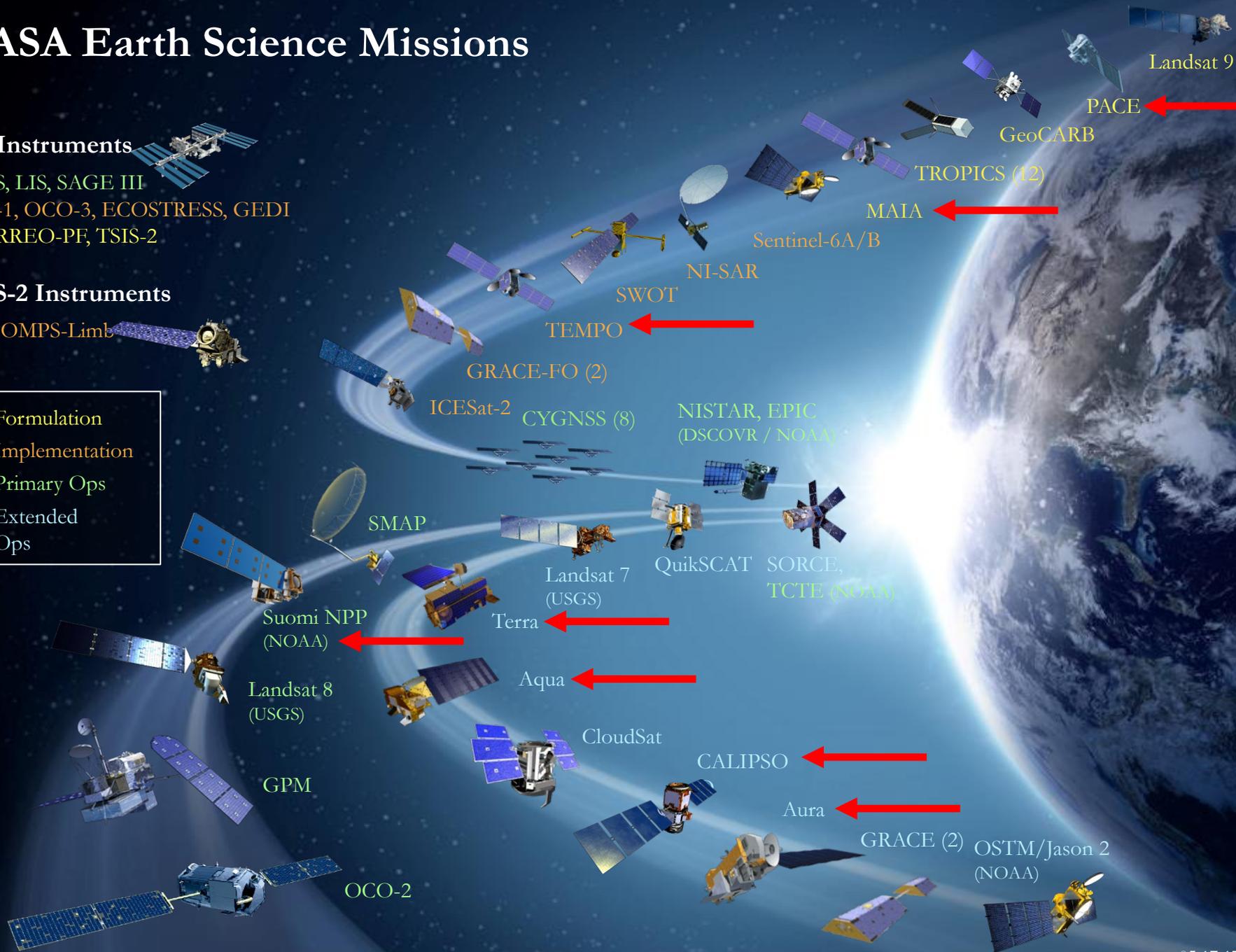
ISS Instruments

CATS, LIS, SAGE III
TSIS-1, OCO-3, ECOSTRESS, GEDI
CLARREO-PF, TSIS-2

JPSS-2 Instruments

RBI, OMPS-Limb

- Formulation
- Implementation
- Primary Ops
- Extended Ops



Aura Mission

Aura is an integrated observatory of atmospheric composition.



MLS

OMI

Microwave Limb Sounder (MLS)

Ozone Monitoring Instrument (OMI)

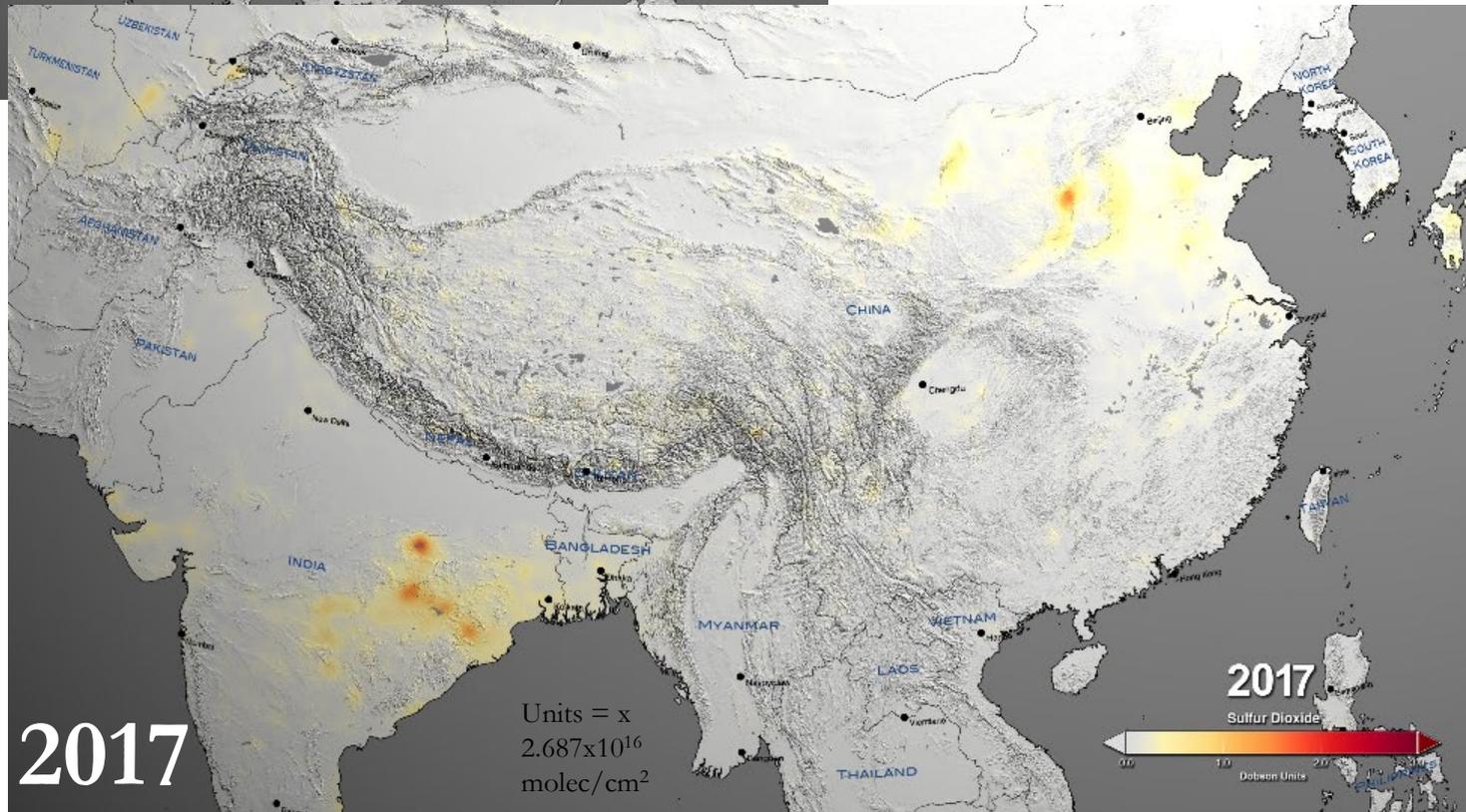
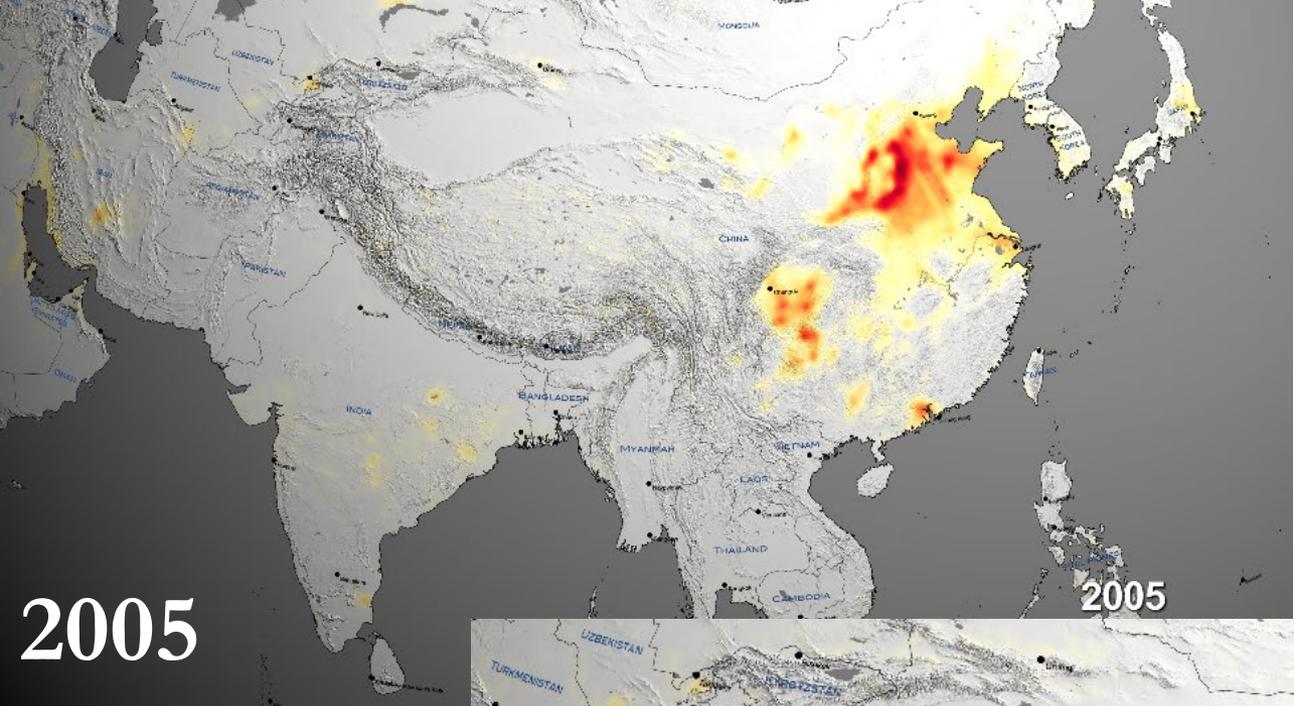
Ozone Layer

Air Quality

Climate

Some Historical Perspective

Sulfur Dioxide (SO₂)



SO₂ is released when coal is burned.

Figures Courtesy of NASA (<https://svs.gsfc.nasa.gov/4676>)

2017

Units = x 2.687x10¹⁶ molec/cm²



Nitrogen Dioxide (NO₂)

2005



NO₂ is released when coal & gasoline are burned, so it is an indicator of economic activity.

Satellite data indicate that NO₂ levels decreased from 2005 - 2018 by 20-60% in U.S. urban areas.

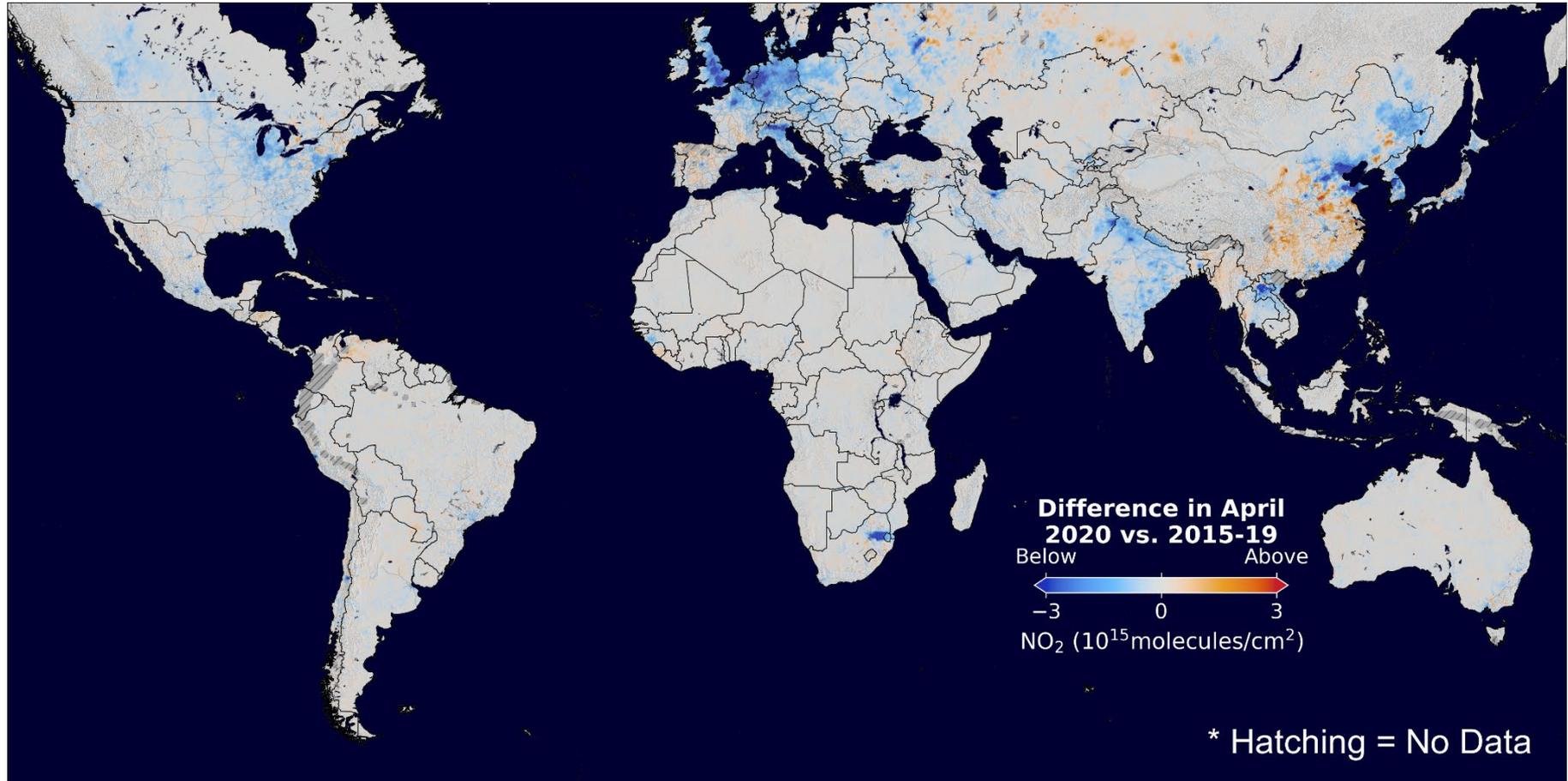
2018



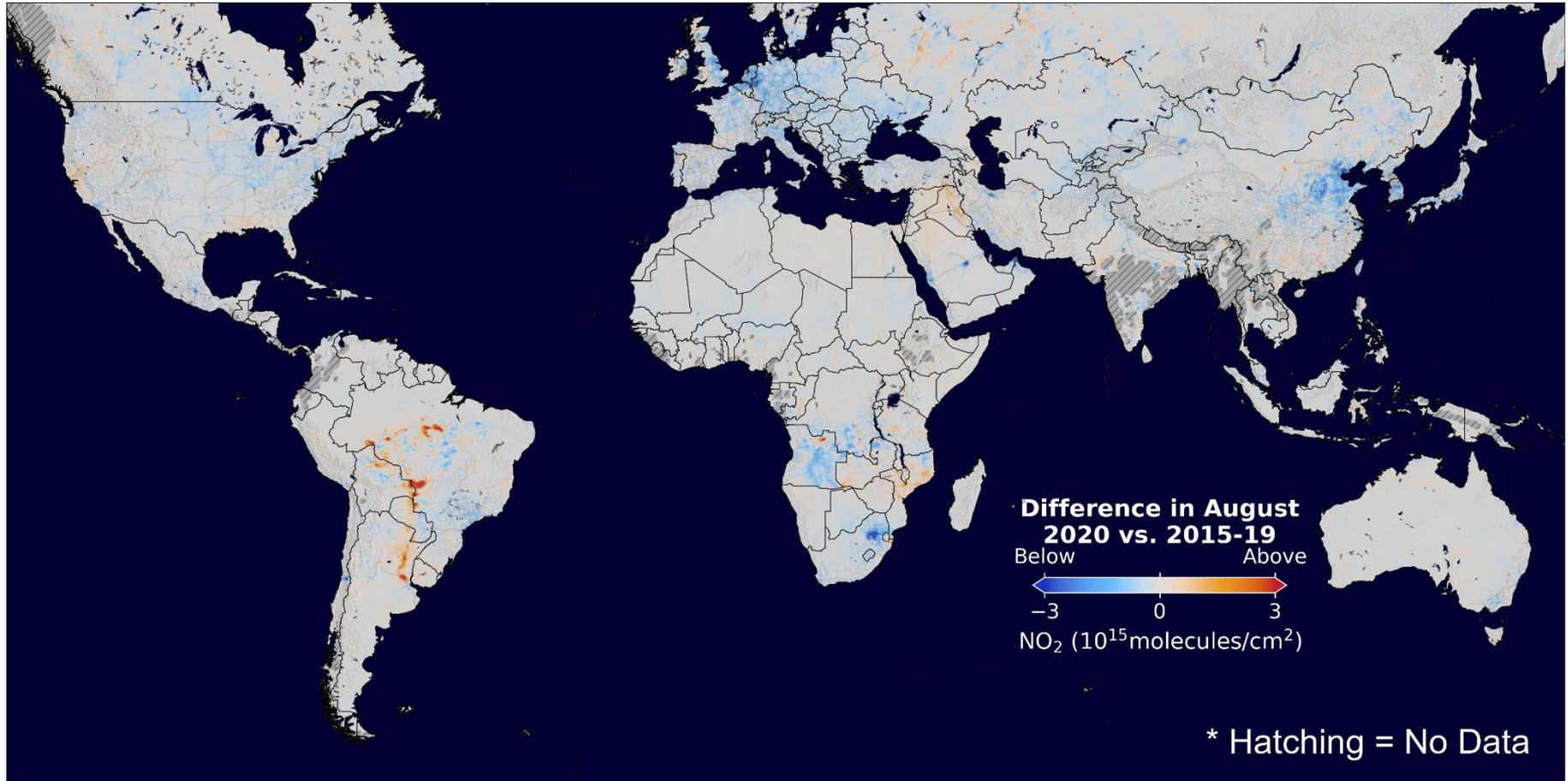
Impact of COVID-19

Tour of the World

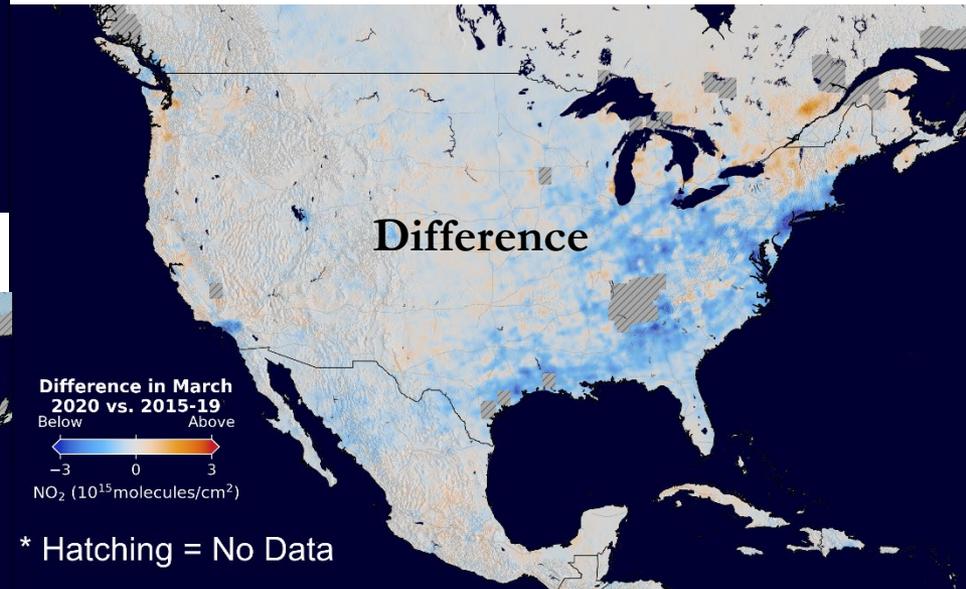
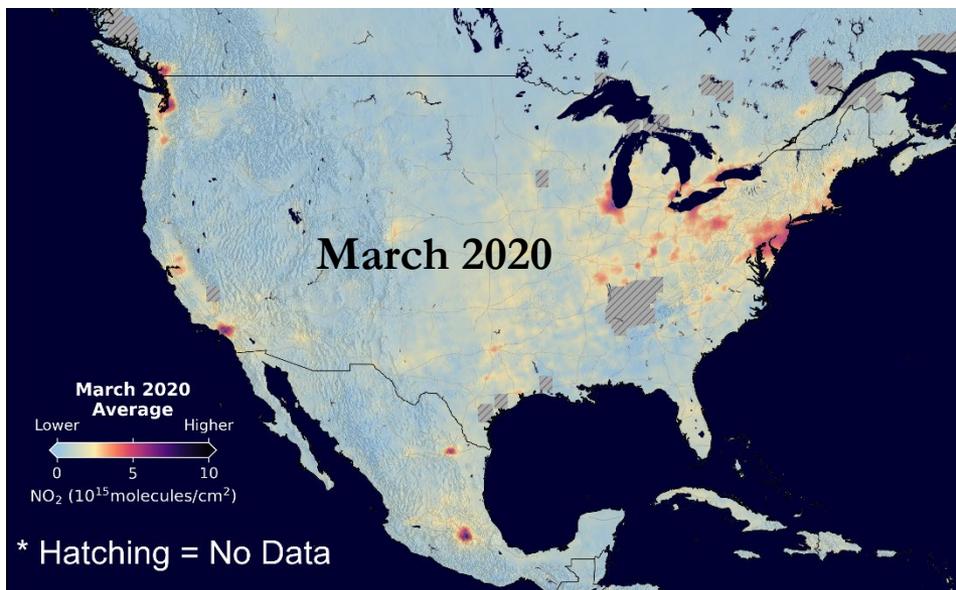
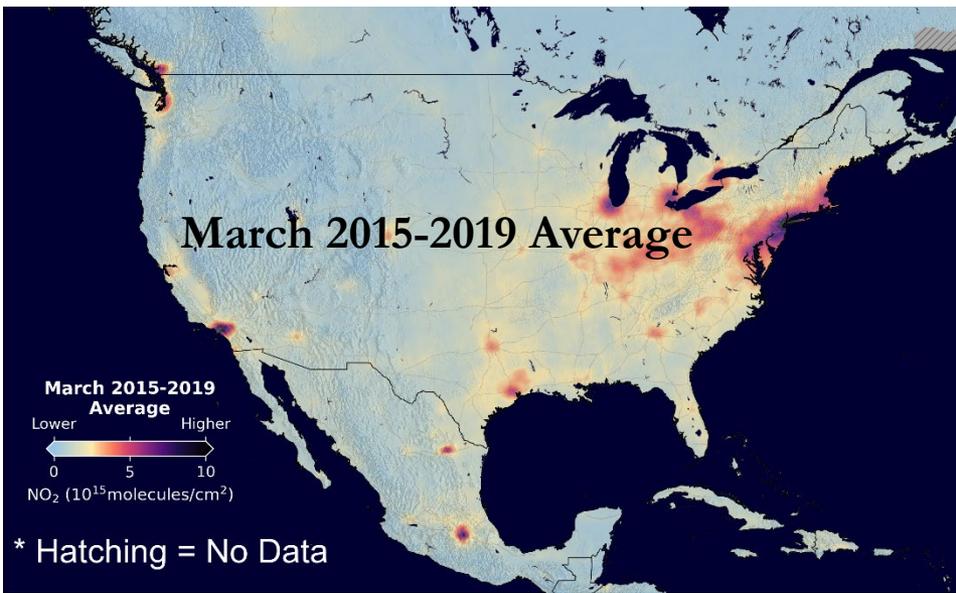
Global Changes in NO₂ Levels: April 2020 vs 5 Previous Years



Global Changes in NO₂ Levels: August 2020 vs 5 Previous Years

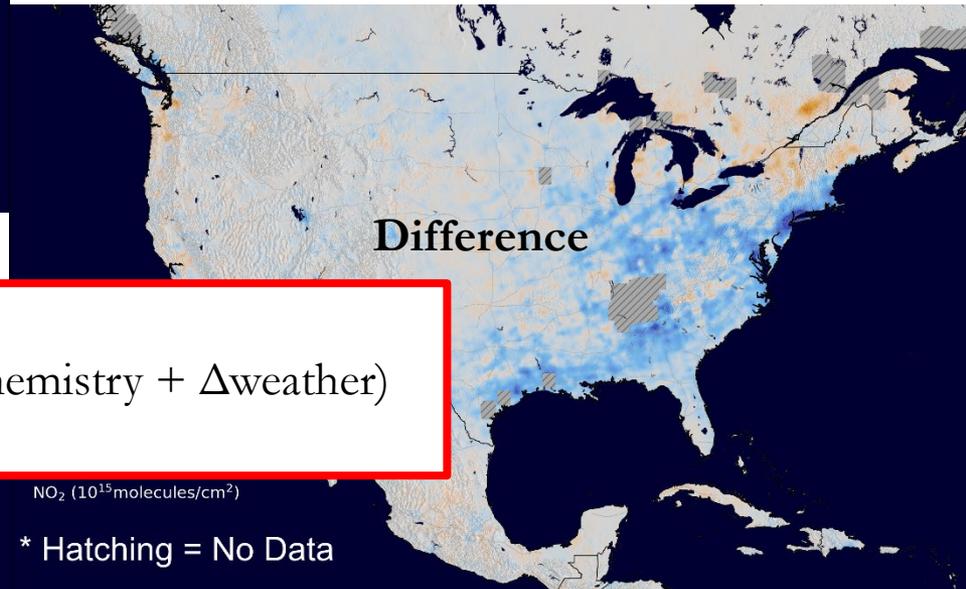
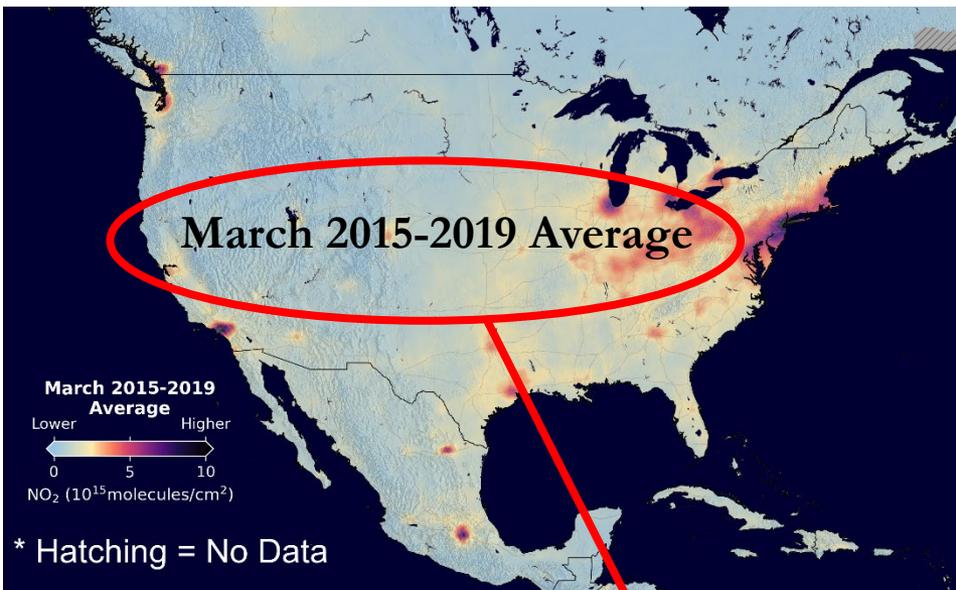


Nitrogen Dioxide (NO₂): *Impact of COVID-19*

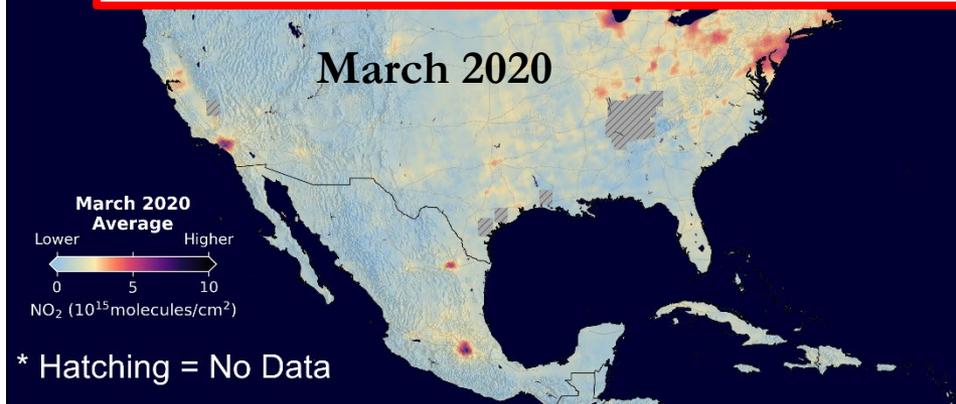


Satellite data indicate that NO₂ levels decreased by 30-40% in U.S. urban areas.

Nitrogen Dioxide (NO₂): *Impact of COVID-19*

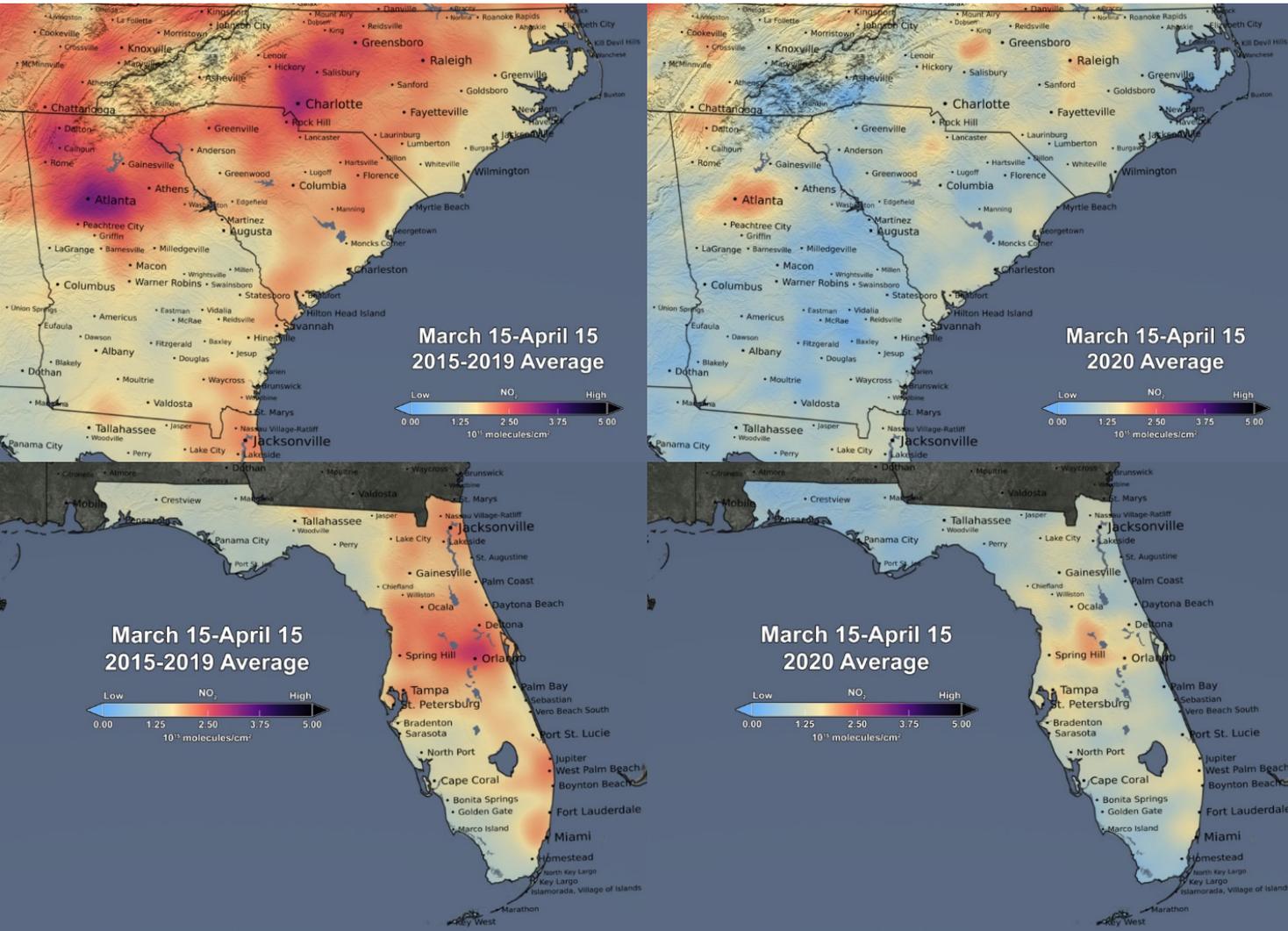


ΔNO_2 levels ($\Delta\text{emissions} + \Delta\text{atmospheric chemistry} + \Delta\text{weather}$)



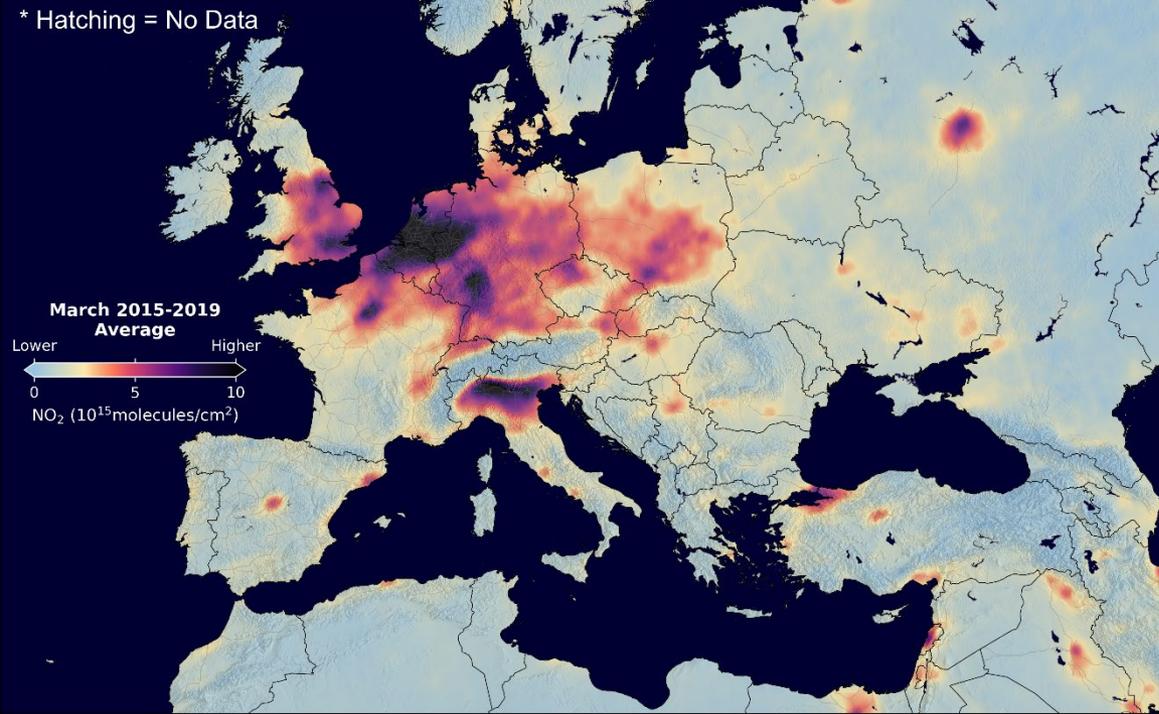
Satellite data indicate that NO₂ levels decreased by 30-40% in U.S. urban areas.

Changes in NO₂ Levels in Southeastern US



Most areas of the Eastern U.S. decreased by ~30-40% after stay-at-home orders came into effect.

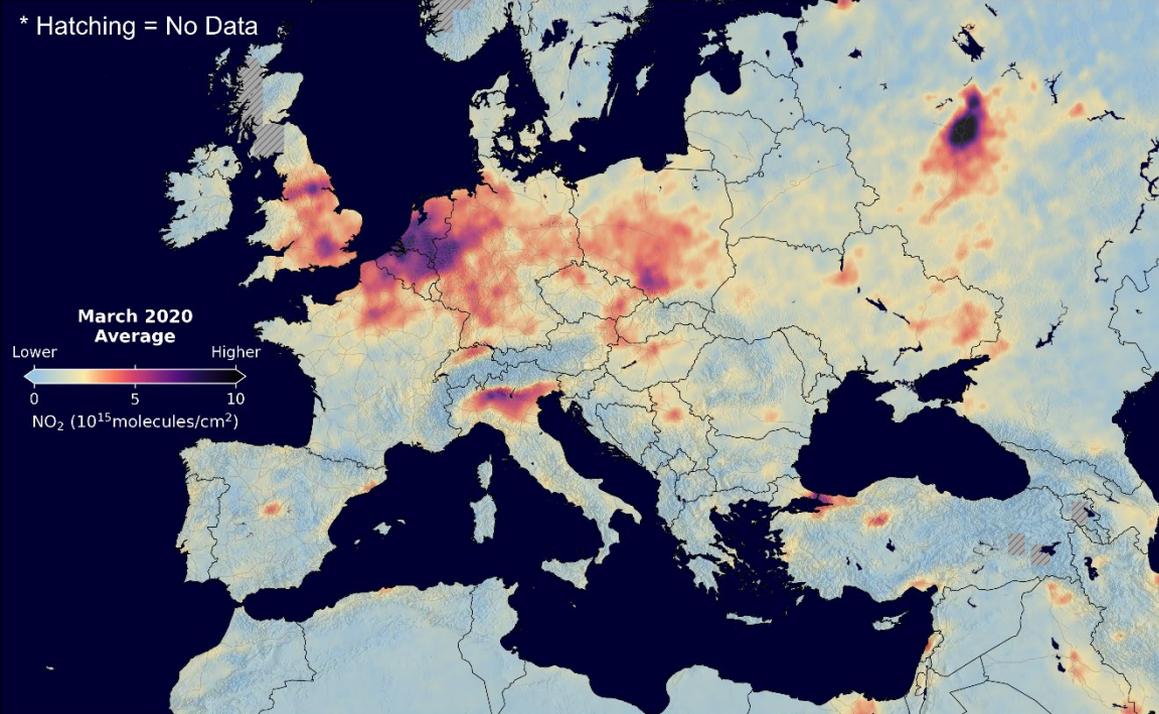
* Hatching = No Data



Nitrogen Dioxide (NO₂): *Impact of COVID-19*

March 2015-2019 Average

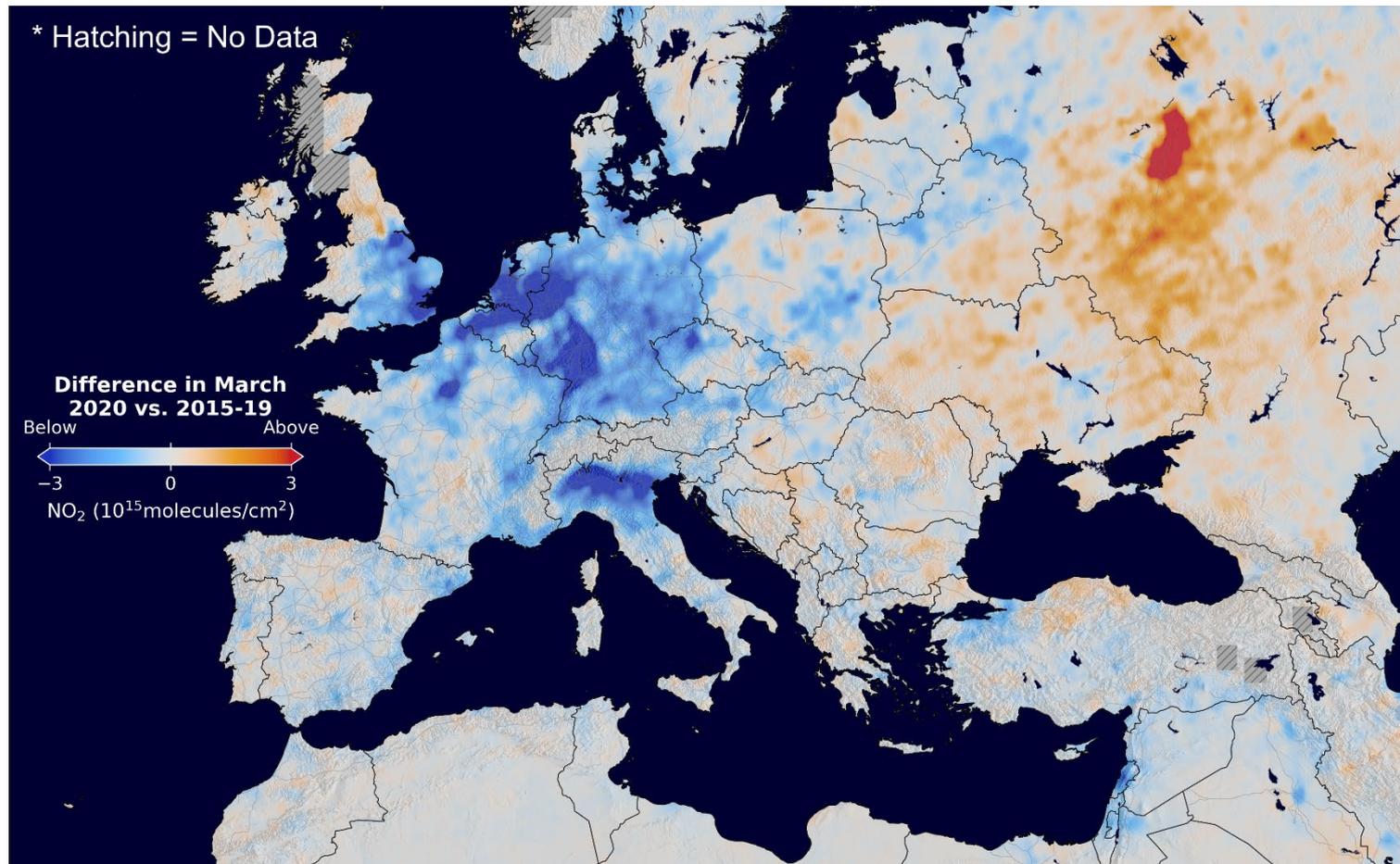
* Hatching = No Data



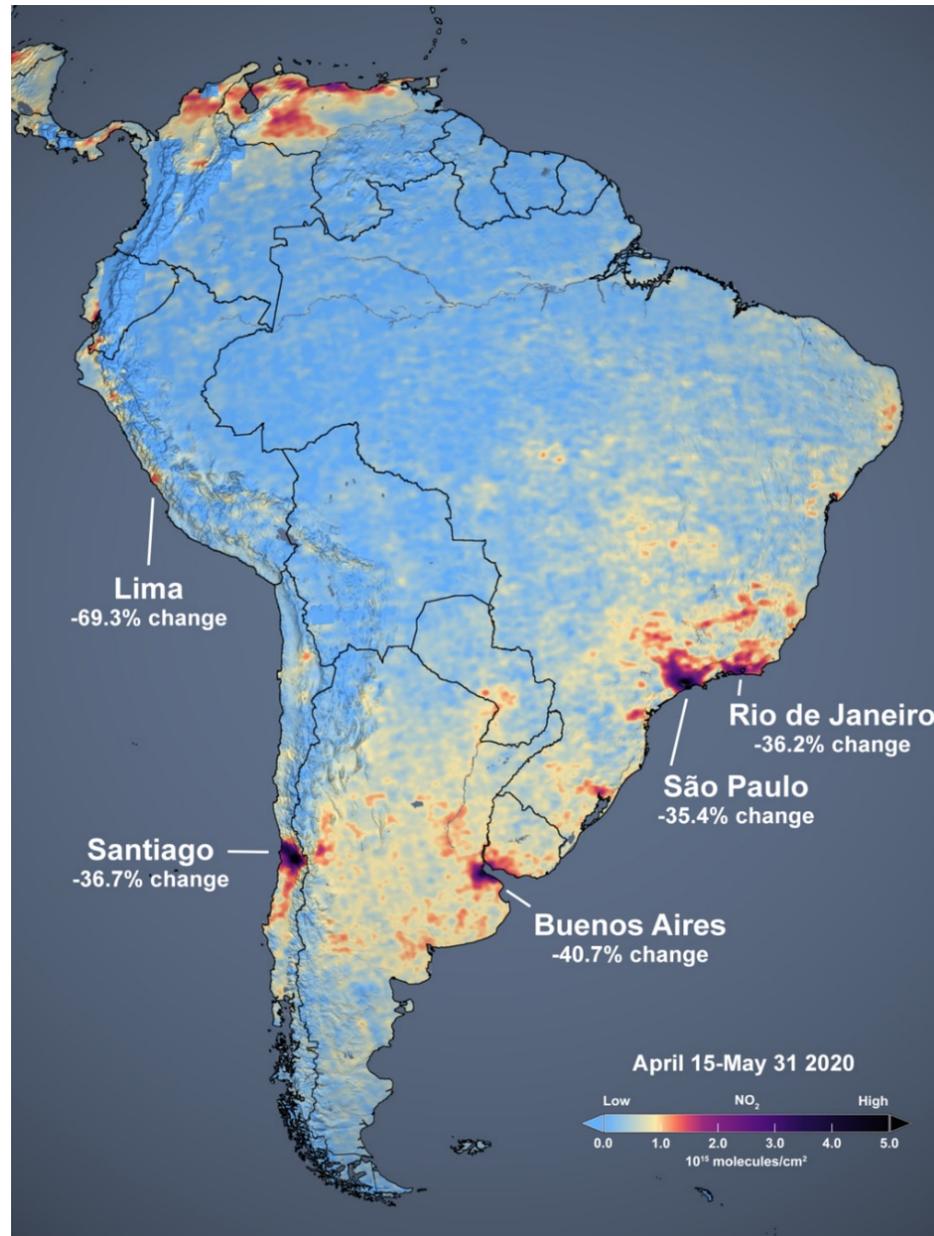
March 2020

Nitrogen Dioxide (NO₂): *Impact of COVID-19*

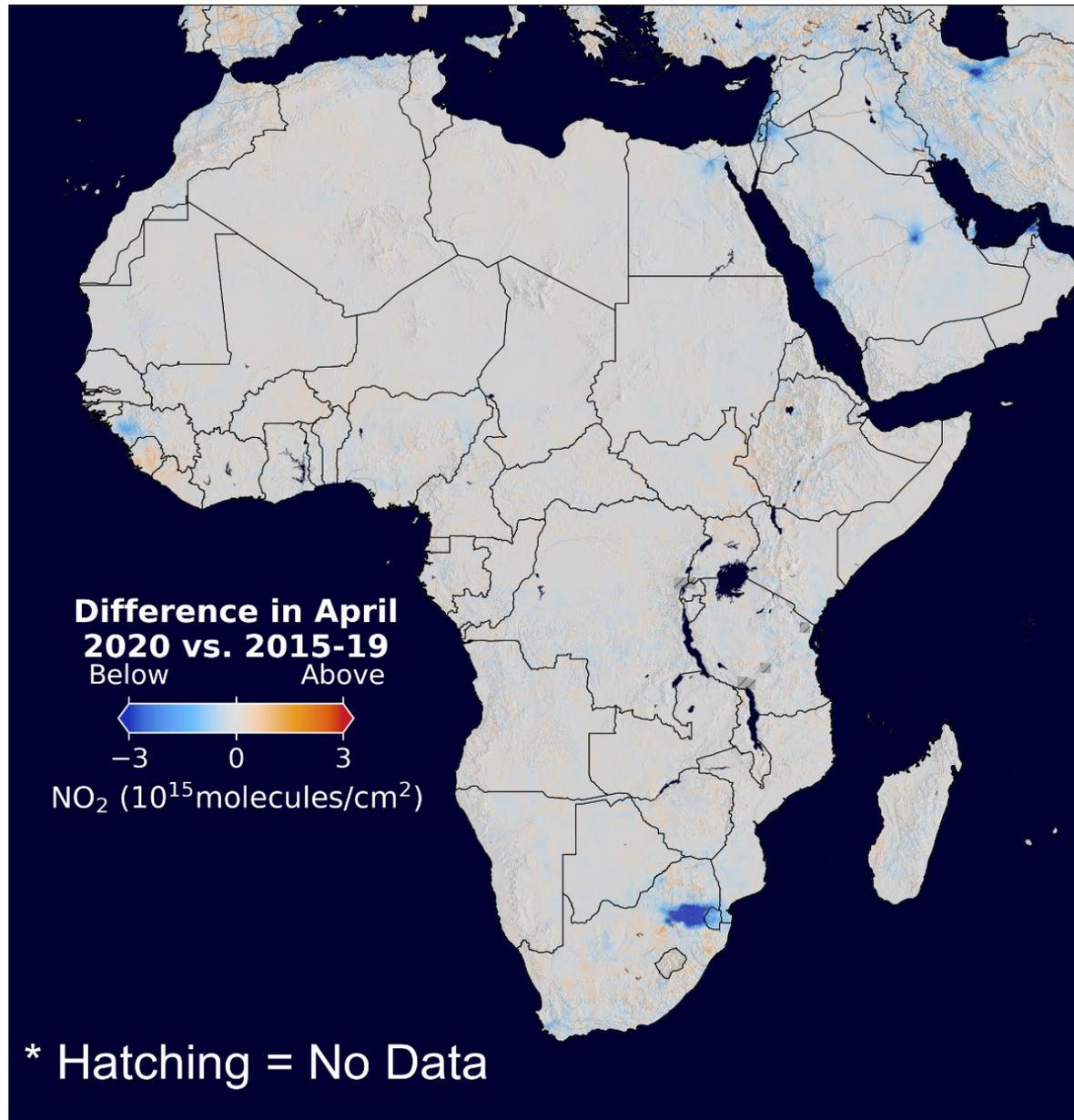
March 2020 - March 2015-2019 Average



Nitrogen Dioxide (NO_2): *Impact of COVID-19*



Nitrogen Dioxide (NO₂): *Impact of COVID-19*



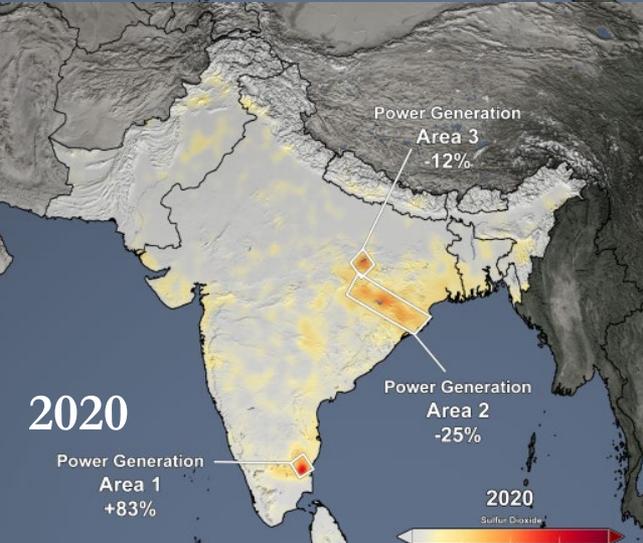
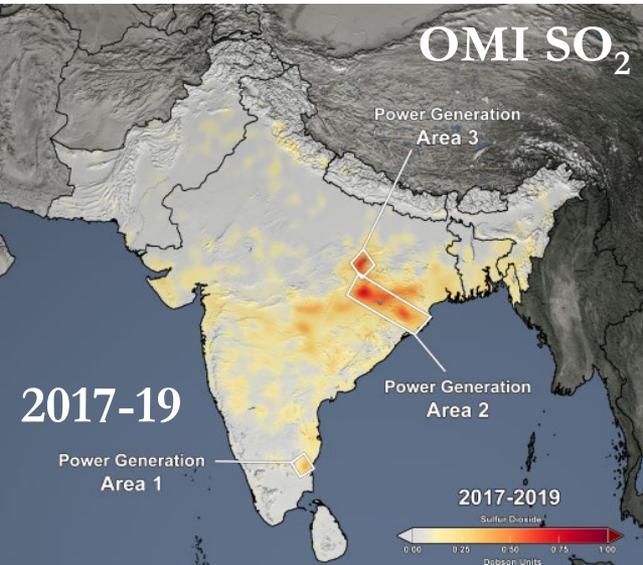


Aura Ozone Monitoring Instrument (OMI)

Reductions in Sulfur Dioxide & Nitrogen Dioxide Air Pollution over South Asia Associated with Efforts to Control the Spread of COVID-19



Can Li, Lok Lamsal, Yasuko Yoshida, Joanna Joiner, Bryan Duncan + GSFC Aura OMI Team

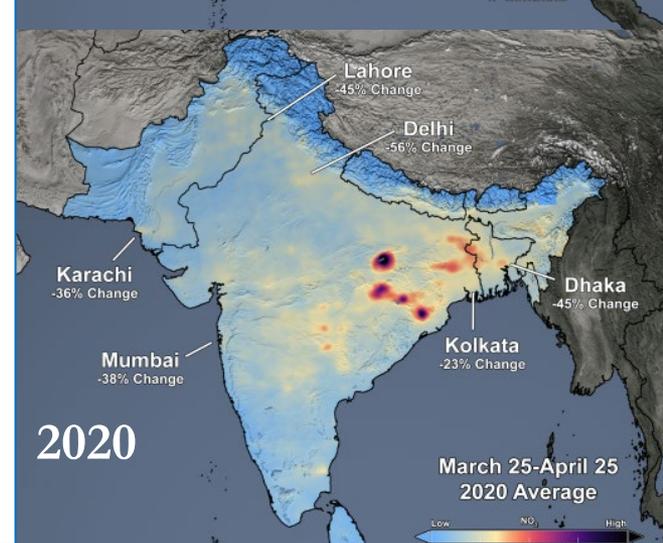
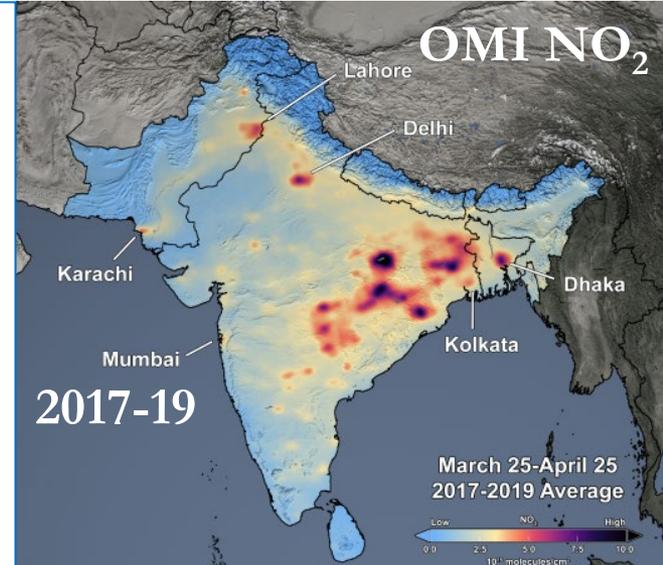


On March 24, 2020, Prime Minister Modi ordered a nationwide stay-at-home order for India's 1.3 billion citizens in an attempt to slow the spread of COVID-19.

The images show OMI data of SO₂ (left) and NO₂ (right) over South Asia as an average of March 25 – April 25. The **top images** show the means of the period in previous years, while the **bottom images** show the means for 2020.

The highest SO₂ levels are over eastern India and primarily associated with electricity generation; the coal burned has sulfur impurities. Independent estimates indicate that electricity generation for India was down about 10% and 25% in March and April 2020, respectively, as compared to March and April 2019. One exception is in southern India which could be related to increased thermal power generation that came on line before the stay-at-home order. However, there was not a similar increase in NO₂, so possibly coal with higher sulfur content was used in 2020 relative to 2019 without a significant increase in coal consumed.

NO₂ is primarily emitted from fossil fuel use. The images show that widespread decreases (~30-60%) in NO₂ levels have occurred over most of South Asia. The highest NO₂ levels are in eastern India and are primarily associated with electricity generation.





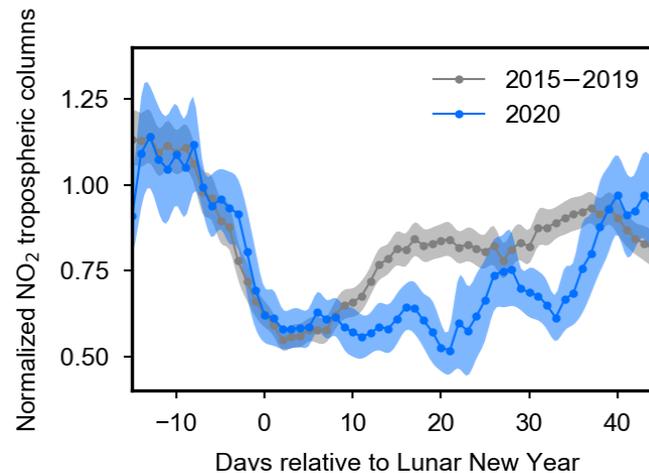
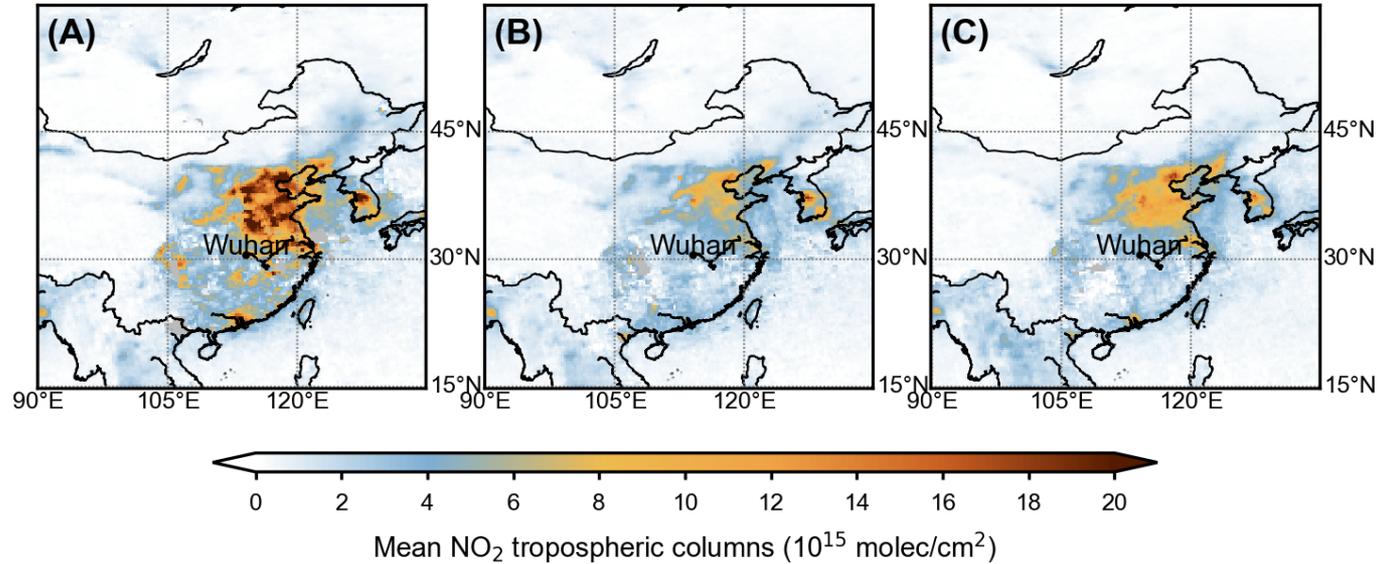
Abrupt decline in tropospheric nitrogen dioxide over China after the outbreak of COVID-19

Fei Liu (USRA/GSFC), Sarah A. Strode (USRA/GSFC), Yasuko Yoshida (SSAI/GSFC), Sungyeon Choi (SSAI/GSFC), Lok N. Lamsal (USRA/GSFC), Can Li (ESSIC/GSFC), Nickolay A. Krotkov (GSFC), Joanna Joiner (GSFC) and others

Tropospheric nitrogen dioxide (NO_2) indicates economic activities, as NO_2 is primarily emitted from fossil fuel consumption.

We evaluated the reduction in satellite measurements of NO_2 tropospheric vertical column densities (TVCD) before and after the Lunar New Year (LNY). The observed reduction in 2020 is $\sim 20\%$ larger than the typical holiday-related reduction.

We relate to this reduction to two of the government's actions: the announcement of the first report in each province and the date of a province's lockdown. Both actions are associated with nearly the same magnitude of reductions.



Top: Average OMI tropospheric NO_2 vertical column densities over China in 2020. (A) -20 to -1, (B) 0-19, and (C) 20-39 days relative to the 2020 Lunar New Year.

Bottom: Daily variations in 7-day moving averages of OMI NO_2 TVCDs over China. Shading shows standard error of the mean. Values are normalized to the mean of the period of -20 to -1 days relative to Lunar New Year.



OMI Data & OMI Team are Enabling
Research & Applications

The OMI NO₂ data can enable scientific and applied research.

- *Air Quality:* While air pollution is decreasing around the world due to lockdown orders, the US government has relaxed pollution emission restrictions on some industrial sectors (e.g., power plants). Therefore, the changes in air pollution associated with the pandemic will serve as a natural experiment in how the atmosphere responds to changes in pollutant emissions from various sources.
- *Climate:* Several recent studies by the proposers have shown that NO₂ emissions inferred from satellite data serve as an effective proxy for co-emitted CO₂ emissions from cities and power plants. Therefore, researchers may be able to assess the impact of the pandemic on climate gas emissions.
- *Economics:* Given that most world economies are driven by fossil fuels, economists may use NO₂ data, a non-traditional source of data for this community, to assess the impact of the pandemic on economic activity around the world, including in countries without reliable economic data.
- *Intelligence Agencies:* The global intelligence community will likely find interesting uses of the NO₂ data for assessing the impact of the pandemic on world countries, including with world governments that purposely misrepresent or withhold the true extent of the pandemic's impact.
- *Health Professionals:* The NO₂ data may be used to gauge the effectiveness (e.g., reduction in emissions from traffic and industry) of lockdown efforts to contain or slow the pandemic in a given area.



OMI Data Are Facilitating Scientific Research of the Impact of the Pandemic on Air Quality around the World



Zach Fasnacht (SSAI), Joanna Joiner (NASA) + GSFC Aura Ozone Monitoring Instrument (OMI) Team

Data from the Aura Ozone Monitoring Instrument (OMI) are facilitating scientific research on the impact of the COVID-19 pandemic on global air quality. As of early September 2020, the OMI Team has identified peer-reviewed manuscripts already published in the scientific literature since the start of the pandemic. Undoubtedly, there will be many more publications using OMI data of two major air pollutants:

- [Nitrogen dioxide](#) (NO₂) is primarily emitted from burning fossil fuels (diesel, gasoline, coal). If processed and interpreted carefully, NO₂ levels observed from space serve as an effective proxy for NO₂ levels at Earth's surface.
- [Sulfur dioxide](#) (SO₂) is emitted from anthropogenic activities that include electricity generation, oil and gas extraction, and metal smelting. SO₂ is emitted during electricity generation if the coal burned has sulfur impurities that are not removed (or not “scrubbed”) from the plant’s exhaust stacks

<https://acd-ext.gsfc.nasa.gov/Documents/Publications/covid/>



Publications

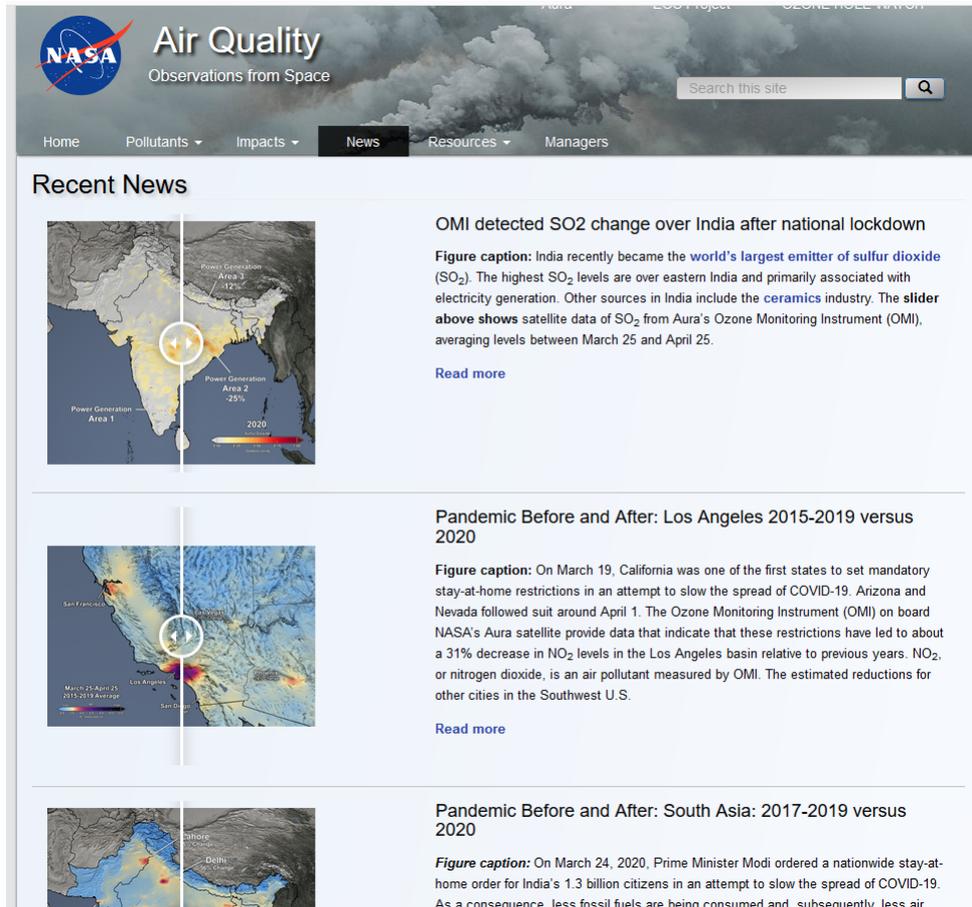
2020

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For More Information

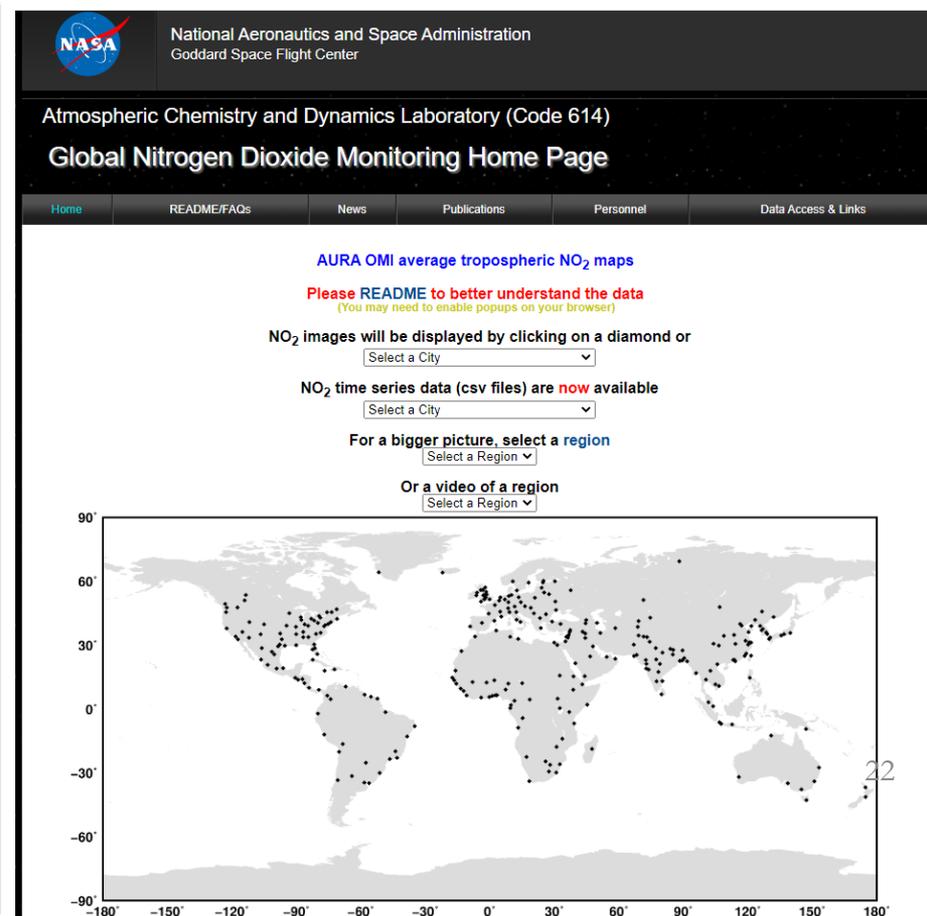
<https://airquality.gsfc.nasa.gov/>

https://so2.gsfc.nasa.gov/no2/no2_index.html



The screenshot shows the NASA Air Quality website. The header includes the NASA logo, the text "Air Quality Observations from Space", and a search bar. A navigation menu contains "Home", "Pollutants", "Impacts", "News", "Resources", and "Managers". The "News" section is active, displaying three articles:

- OMI detected SO₂ change over India after national lockdown**
Figure caption: India recently became the **world's largest emitter of sulfur dioxide (SO₂)**. The highest SO₂ levels are over eastern India and primarily associated with electricity generation. Other sources in India include the **ceramics industry**. The **slider above** shows satellite data of SO₂ from Aura's Ozone Monitoring Instrument (OMI), averaging levels between March 25 and April 25.
[Read more](#)
- Pandemic Before and After: Los Angeles 2015-2019 versus 2020**
Figure caption: On March 19, California was one of the first states to set mandatory stay-at-home restrictions in an attempt to slow the spread of COVID-19. Arizona and Nevada followed suit around April 1. The Ozone Monitoring Instrument (OMI) on board NASA's Aura satellite provide data that indicate that these restrictions have led to about a 31% decrease in NO₂ levels in the Los Angeles basin relative to previous years. NO₂, or nitrogen dioxide, is an air pollutant measured by OMI. The estimated reductions for other cities in the Southwest U.S.
[Read more](#)
- Pandemic Before and After: South Asia: 2017-2019 versus 2020**
Figure caption: On March 24, 2020, Prime Minister Modi ordered a nationwide stay-at-home order for India's 1.3 billion citizens in an attempt to slow the spread of COVID-19. As a consequence, less fossil fuels are being consumed and, subsequently, less air



The screenshot shows the NASA Atmospheric Chemistry and Dynamics Laboratory (Code 614) Global Nitrogen Dioxide Monitoring Home Page. The header includes the NASA logo, the text "National Aeronautics and Space Administration Goddard Space Flight Center", and the page title "Global Nitrogen Dioxide Monitoring Home Page". A navigation menu contains "Home", "README/FAQs", "News", "Publications", "Personnel", and "Data Access & Links". The main content area features:

- AURA OMI average tropospheric NO₂ maps**
Please README to better understand the data
(You may need to enable popups on your browser)
- NO₂ images will be displayed by clicking on a diamond or**
- NO₂ time series data (csv files) are now available**
- For a bigger picture, select a region**
- Or a video of a region**

Below the text is a world map showing the locations of OMI NO₂ measurements, with a diamond icon indicating a selected city. The map includes latitude and longitude coordinates.