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November 12th, 2020: Potomac Geophysical Society (Virtual)
Aura Mission

Aura is an integrated observatory of atmospheric composition.

Microwave Limb Sounder (MLS)
Ozone Monitoring Instrument (OMI)

Ozone Layer
Air Quality
Climate
Some Historical Perspective
SO$_2$ is released when coal is burned.

Figures Courtesy of NASA (https://svs.gsfc.nasa.gov/4676)
Nitrogen Dioxide (NO$_2$)

NO$_2$ is released when coal & gasoline are burned, so it is an indicator of economic activity.

Satellite data indicate that NO$_2$ levels decreased from 2005 - 2018 by 20-60% in U.S. urban areas.

Images courtesy of NASA.
Impact of COVID-19

Tour of the World
Global Changes in NO$_2$ Levels: April 2020 vs 5 Previous Years

Difference in April 2020 vs. 2015-19
Below Above
-3 0 3
NO$_2$ (10$^{15}$ molecules/cm$^2$)

* Hatching = No Data

Images courtesy of Zach Fasnacht (OMI Team)
Global Changes in NO$_2$ Levels:
August 2020 vs 5 Previous Years

Images courtesy of Zach Fasnacht (OMI Team)
Nitrogen Dioxide (NO₂): Impact of COVID-19

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

Images courtesy of Zach Fasnacht (OMI Team)
Nitrogen Dioxide (NO$_2$): Impact of COVID-19

March 2015-2019 Average

ΔNO$_2$ levels (Δemissions + Δatmospheric chemistry + Δweather)

March 2020

Satellite data indicate that NO$_2$ levels decreased by 30-40% in U.S. urban areas.

Images courtesy of Zach Fasnacht (OMI Team)
Most areas of the Eastern U.S. decreased by ~30-40% after stay-at-home orders came into effect.

The images were released in April and May and are available at [https://svs.gsfc.nasa.gov/4810](https://svs.gsfc.nasa.gov/4810).
More details may be found at [https://airquality.gsfc.nasa.gov](https://airquality.gsfc.nasa.gov).
Nitrogen Dioxide (NO₂): 
Impact of COVID-19

March 2015-2019 Average

March 2020

Images courtesy of Zach Fasnacht (OMI Team)
Nitrogen Dioxide (NO₂): Impact of COVID-19

March 2020 - March 2015-2019 Average

Images courtesy of Zach Fasnacht (OMI Team)
Nitrogen Dioxide (NO$_2$): *Impact of COVID-19*

Figure Courtesy of NASA (https://svs.gsfc.nasa.gov/4810 & https://so2.gsfc.nasa.gov/no2/no2_index.html)
Nitrogen Dioxide (NO$_2$): *Impact of COVID-19*

*Hatching = No Data*

Images courtesy of Zach Fasnacht (OMI Team)
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.
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 ~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 NO$_2$ 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 NO$_2$ emissions inferred from satellite data serve as an effective proxy for co-emitted CO$_2$ 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 NO$_2$ 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 NO$_2$ 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 NO$_2$ 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 if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities that if the coal burned has sulfur impurities. If the coal burned has sulfur impurities.

https://acd-ext.gsfc.nasa.gov/Documents/Publications/covid/
For More Information

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

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