Nitrogen dioxide decline and rebound observed by GOME-2 and TROPOMI during COVID-19 pandemic

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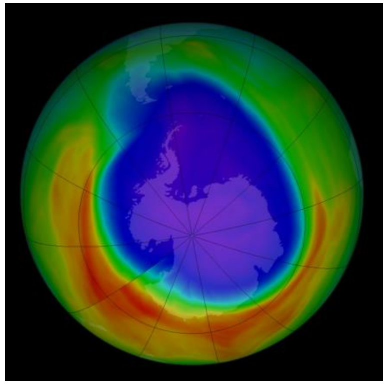
DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

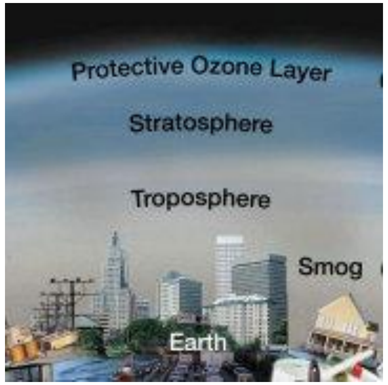
NO_2

- Chemistry

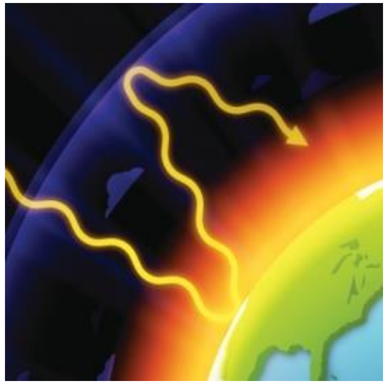
stratospheric ozone depletion



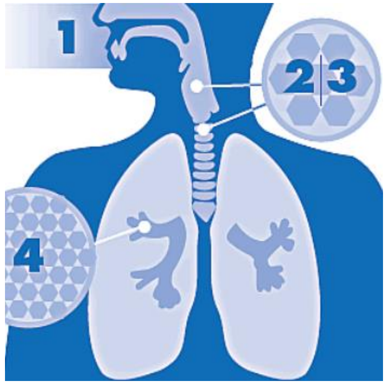
tropospheric ozone enhancement



climate change



air pollution



- Emission

natural

microbial activity

lightning

anthropogenic

air transport

surface transport

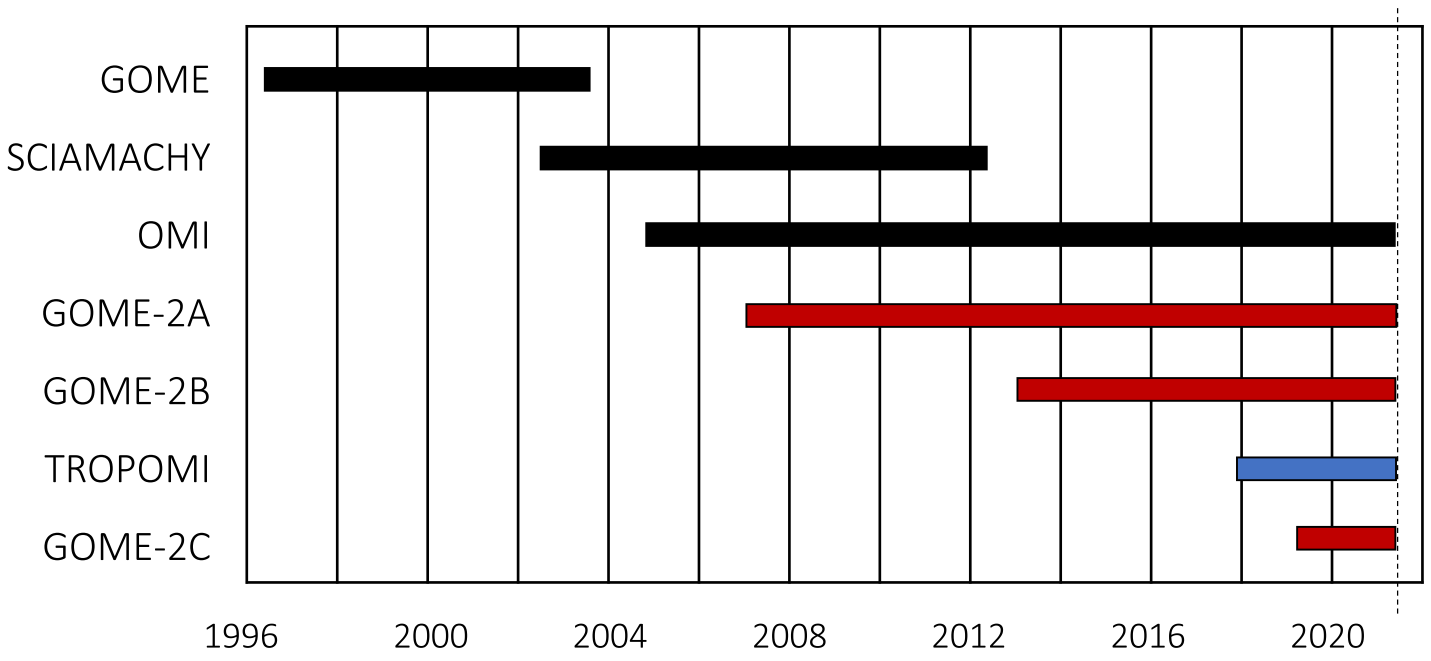
industrial process

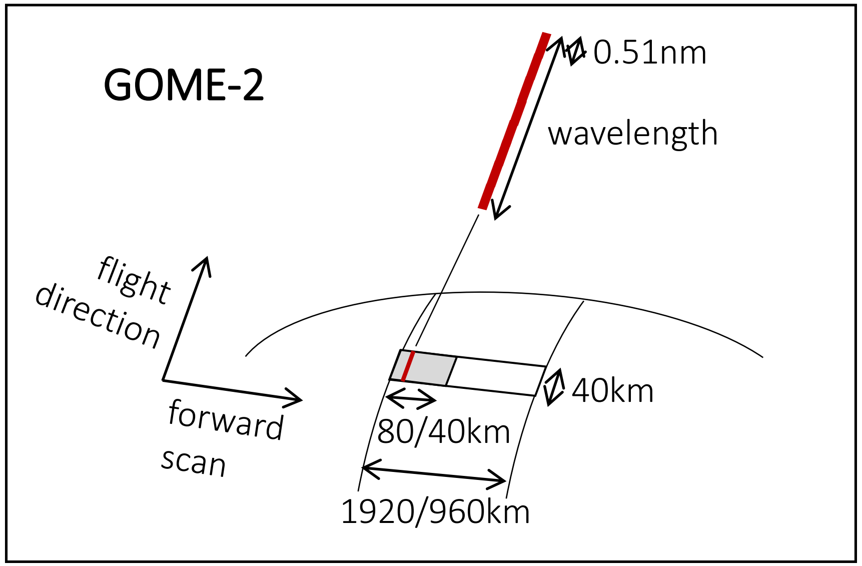
power generation

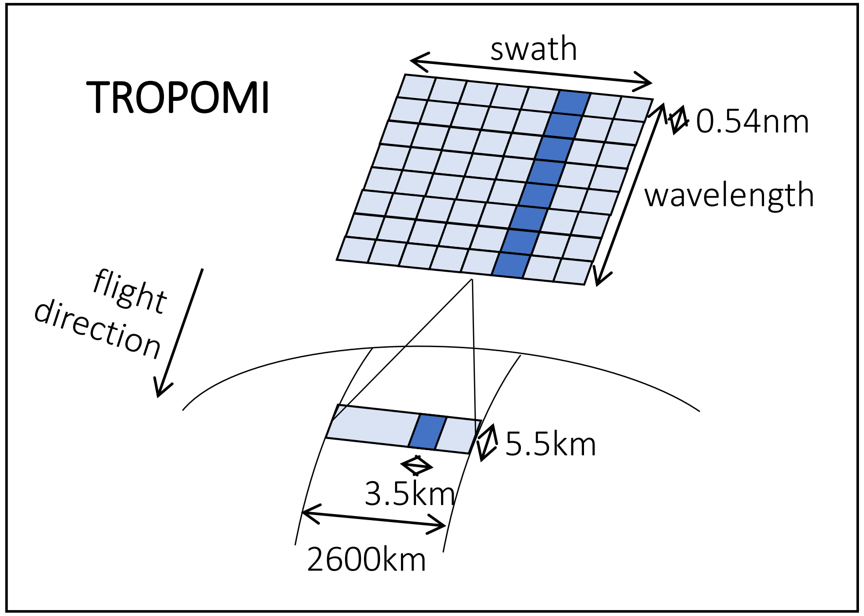
biomass burning

Spaceborne remote sensing

- Global coverage
- Long-term observations



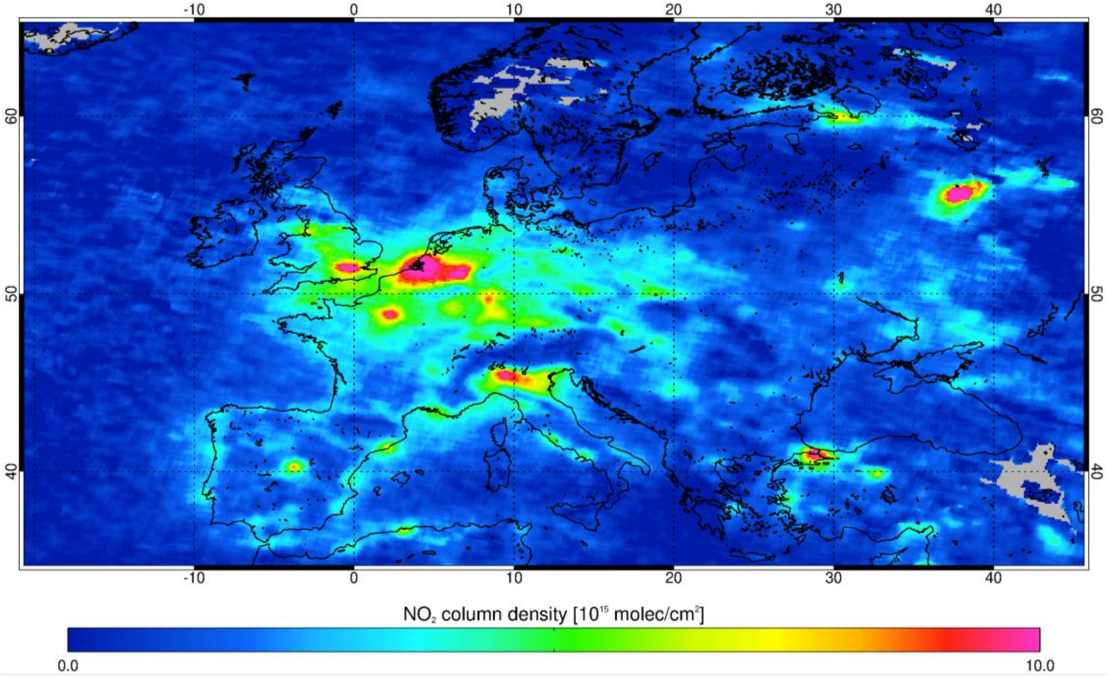




GOME-2 and TROPOMI measurements

- retrieved at DLR in a harmonized manner using
  - the DOAS technique for slant column calculation
  - a spatial filtering method to separate the stratospheric contribution (Valks et al., 2011; Beirle et al., 2016)
  - the OCRA/ROCINN cloud product in the AMF calculation
- corrected for
  - linear trend $f_{trend}(t_y, t_m)$
  - seasonal cycle $f_{season}(t_m)$
  - meteorological variation $f_{wind}(u(t), v(t))$

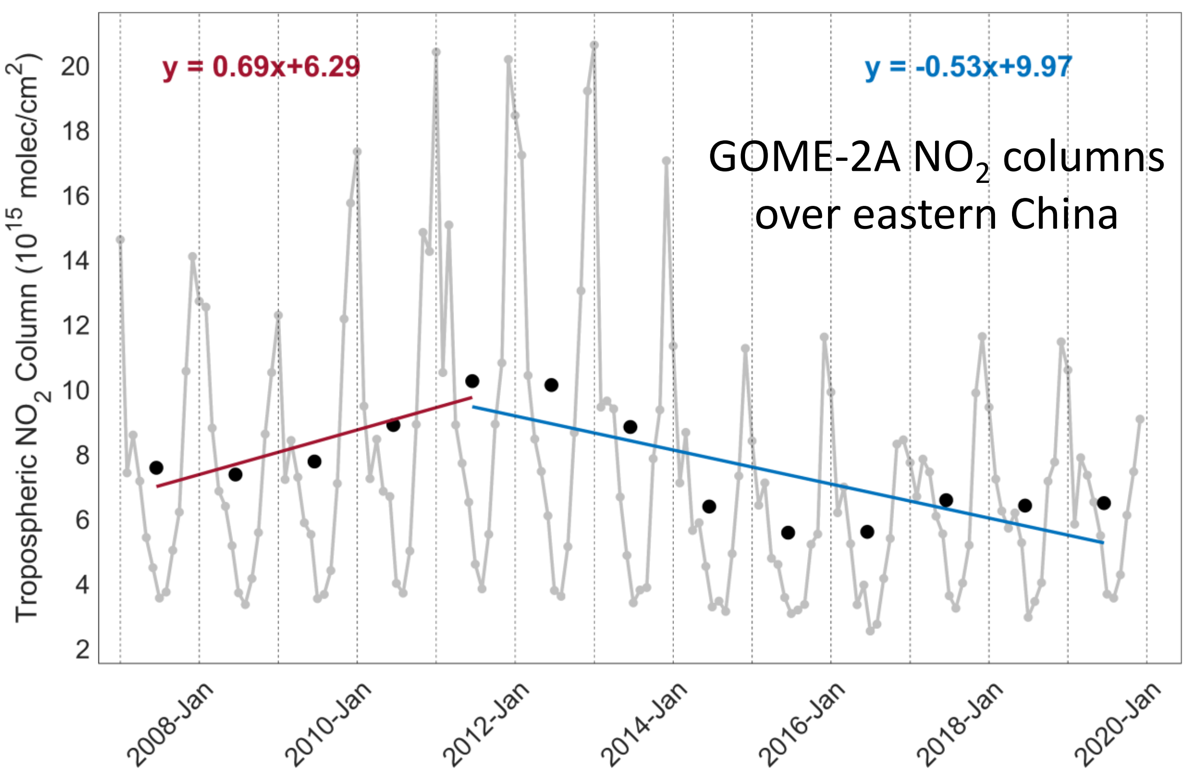
GOME-2A/B/C NO_2 columns (15 Mar – 15 Apr 2019)

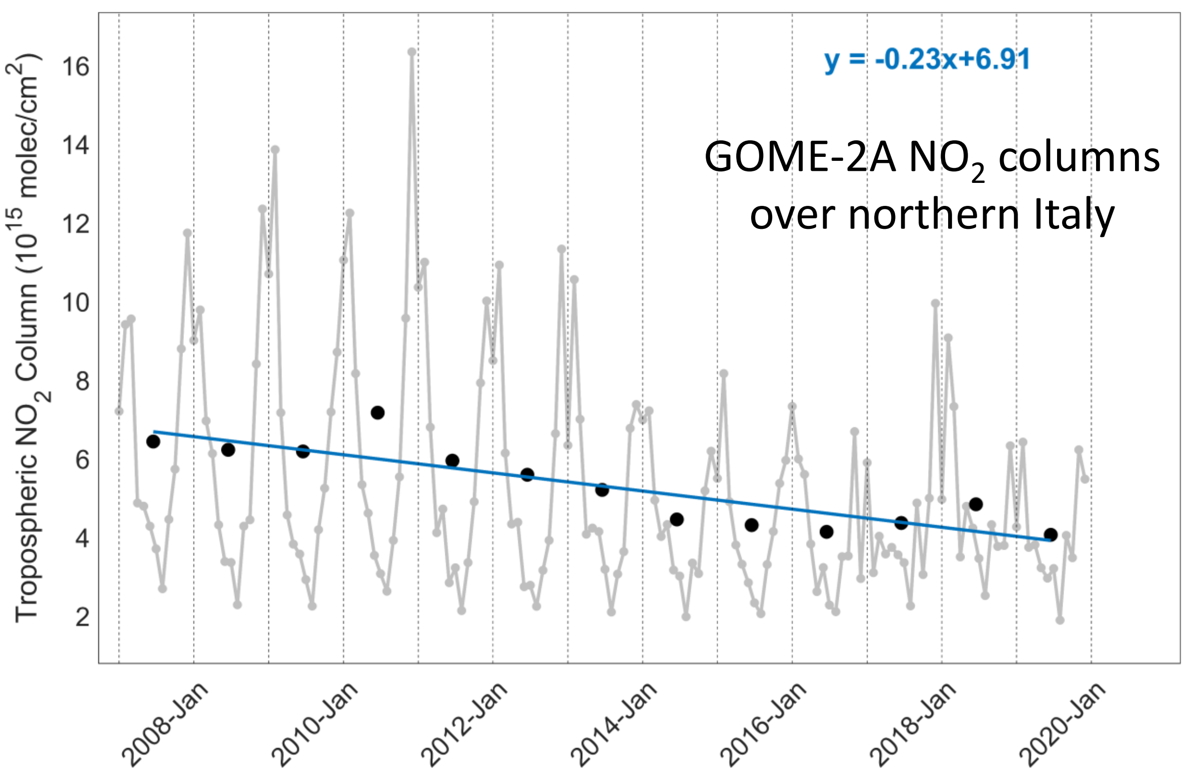


$$V_{corr} = \frac{V + f_{trend}(t_y, t_m)}{f_{season}(t_m) \times f_{wind}(u(t), v(t))}$$

Trend and season correction

- trend correction
  - Factors are calculated as slope of the linear regression line based on annual averages.
  - Trend reversals are detected statistically (Georgoulias et al., 2019).



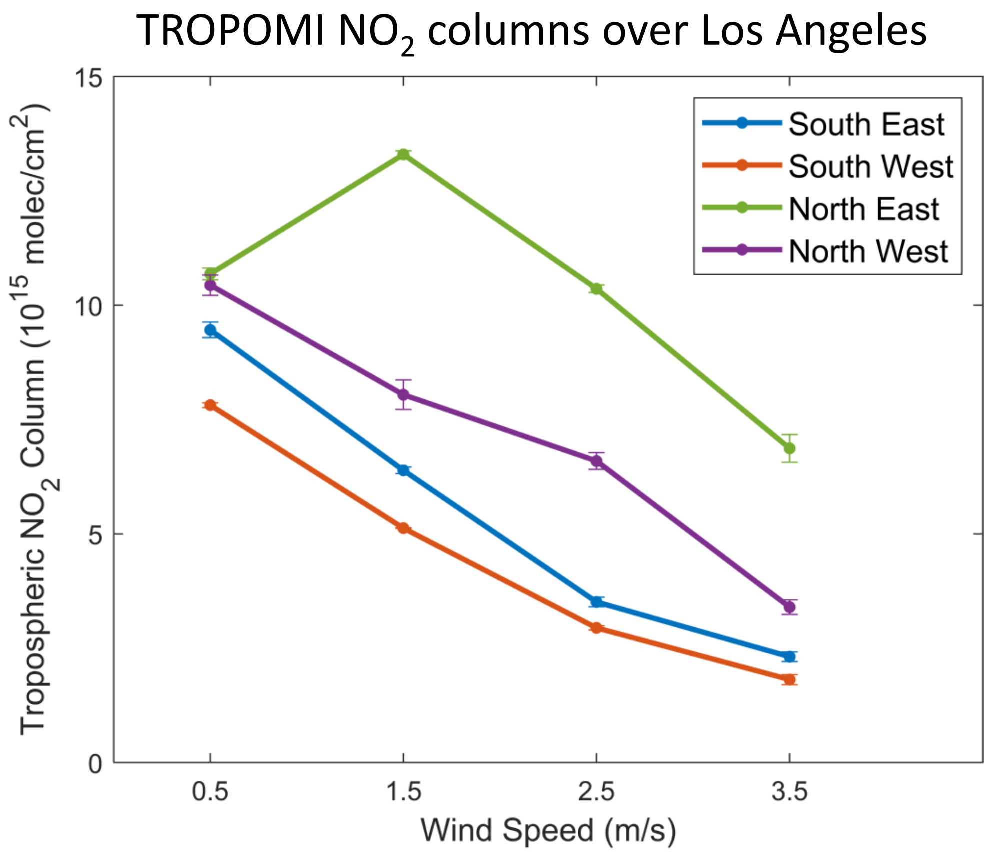


Trend and season correction

- trend correction
  - Factors are calculated as slope of the linear regression line based on annual averages.
  - Trend reversals are detected statistically (Georgoulias et al., 2019).
- season correction
  - Factors are calculated based on the climatological seasonal variability.

Wind correction

- Wind fields are described using the horizontal East-West and North-South wind components $u(t)$ and $v(t)$ from the ECMWF ERA5 dataset (https://cds.climate.copernicus.eu/).
- Correction factors are calculated by normalizing to a reference with an average wind speed (Goldberg et al., 2020).



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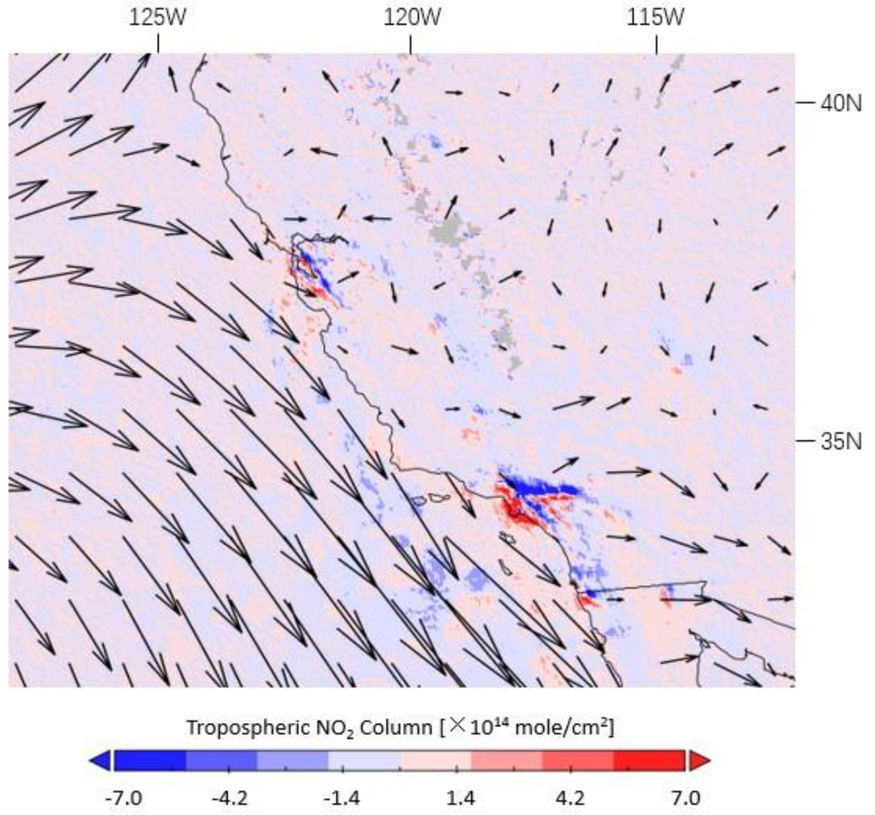
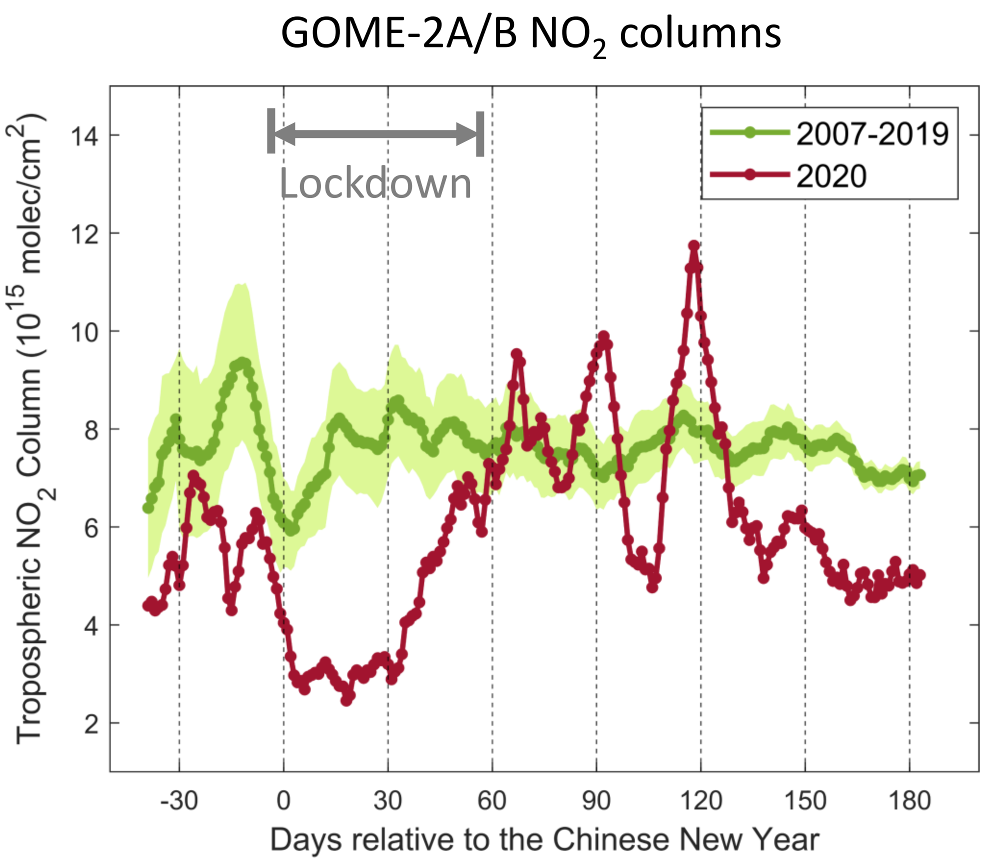
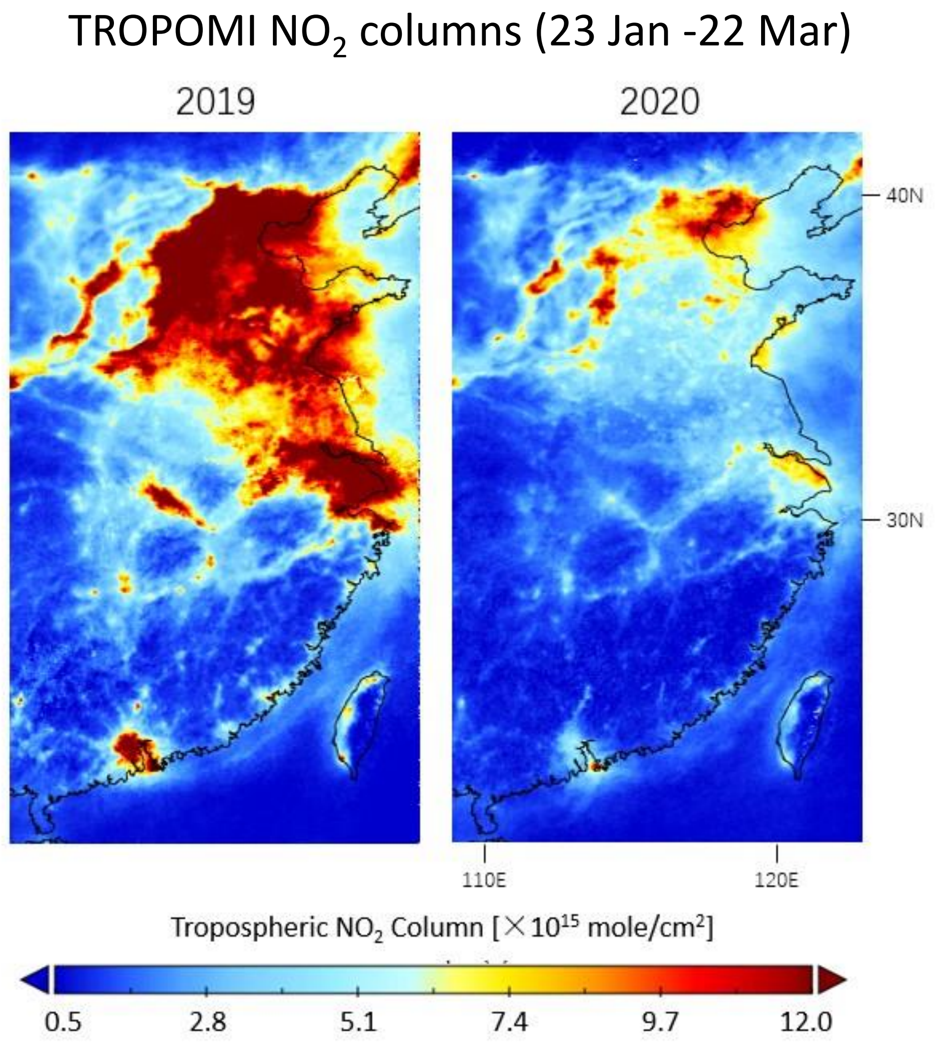
TROPOMI NO_2 column differences



COVID-19 impact on NO_2 pollution

- China

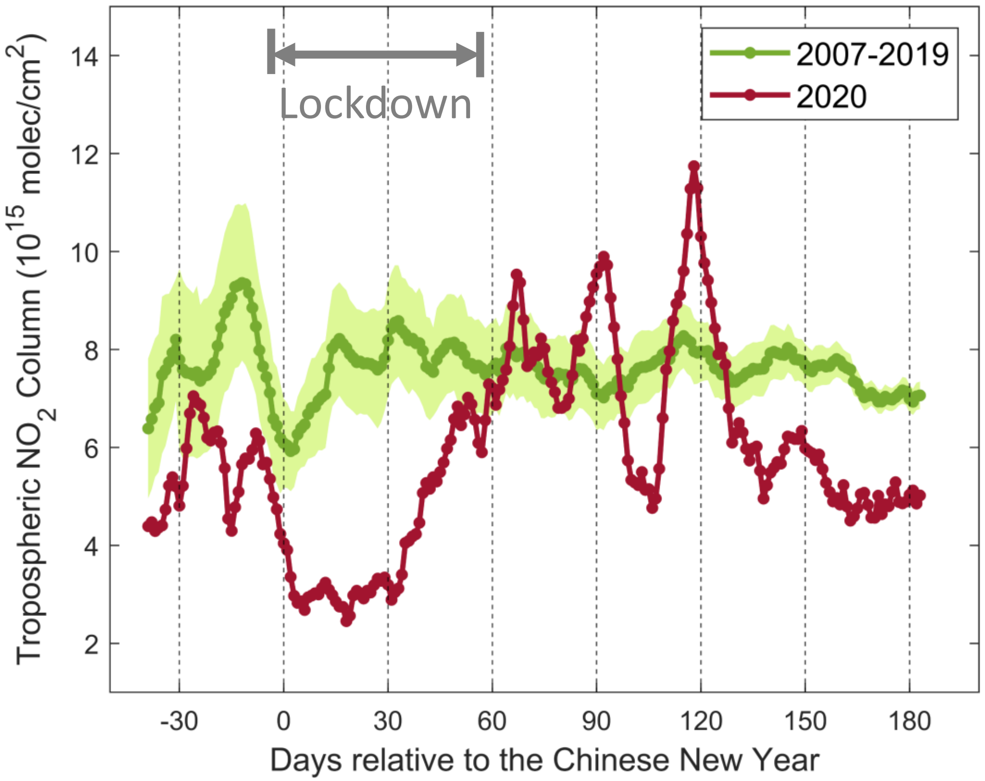




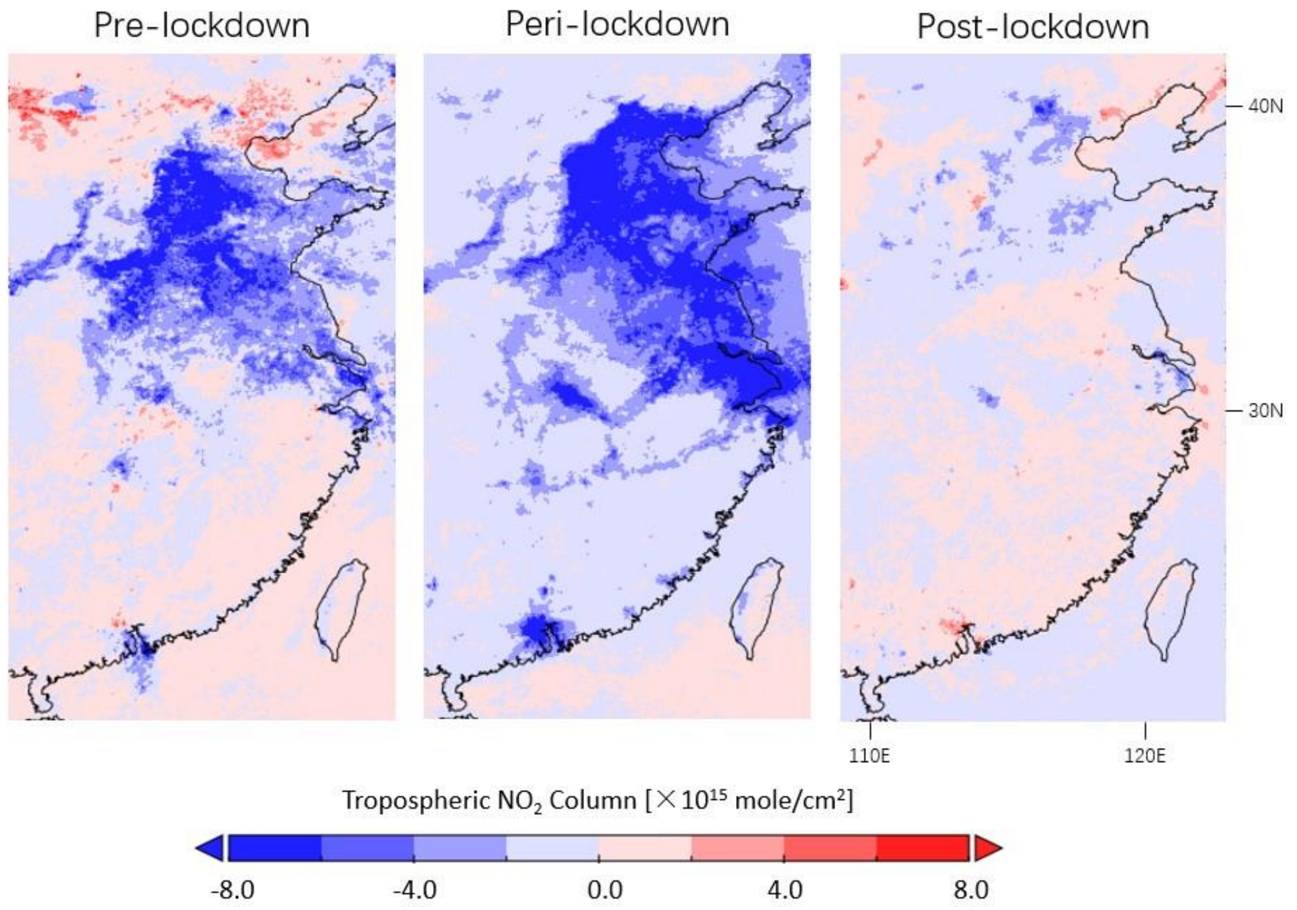
COVID-19 impact on NO_2 pollution

- China

GOME-2A/B NO_2 columns



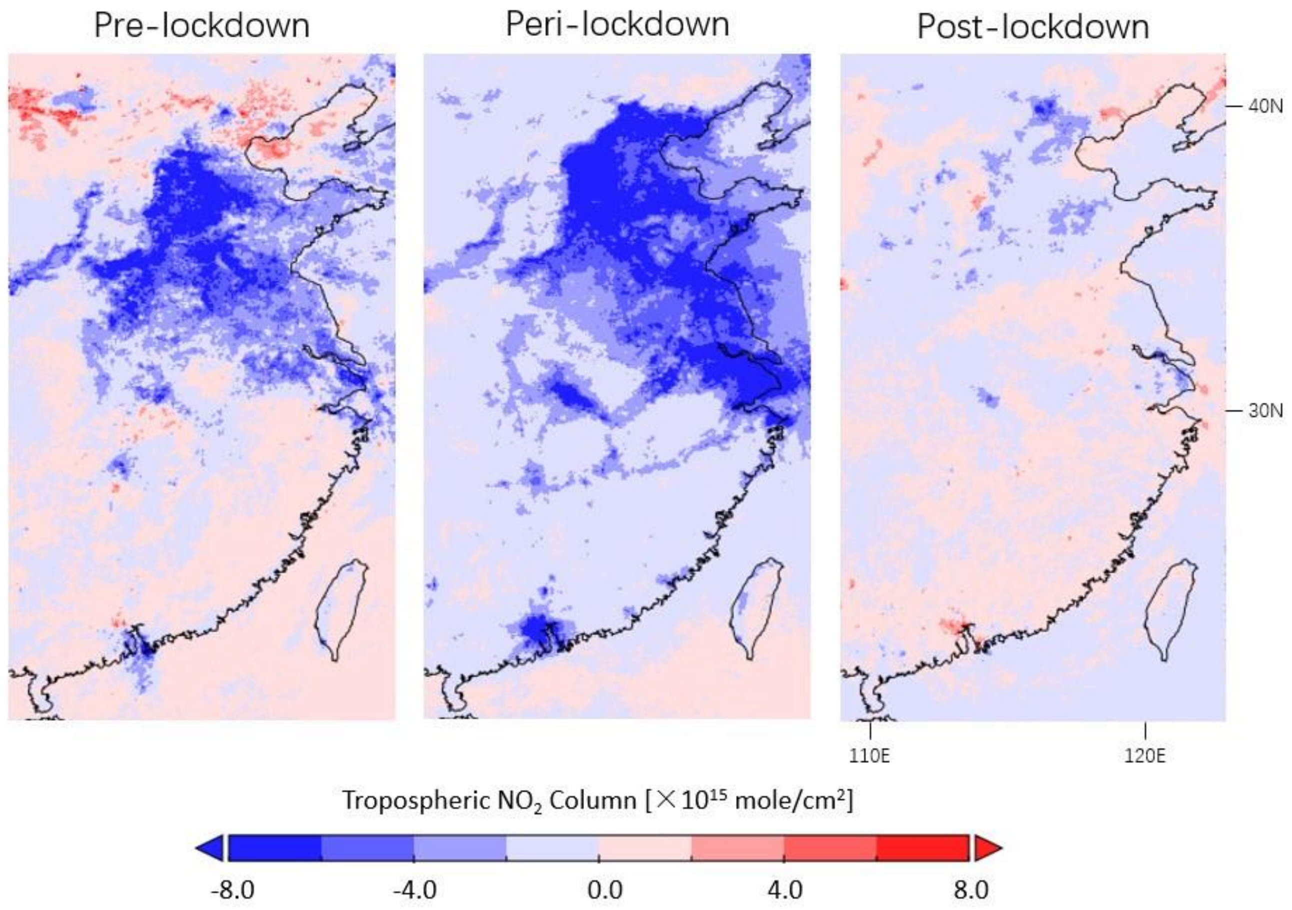
TROPOMI NO_2 column differences



COVID-19 impact on NO_2 pollution

- China
  - A 30% decline of NO_2 levels is due to the pollution control policies, and a further reduction of 30% is due to the COVID-19 containment measures.

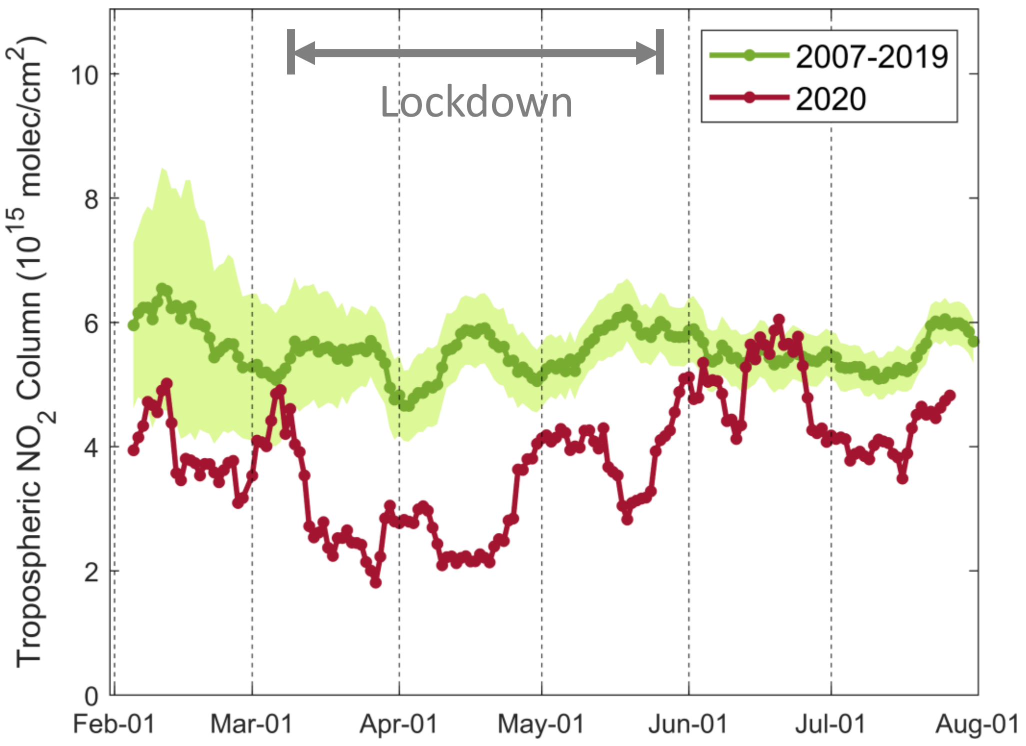
TROPOMI NO_2 column differences



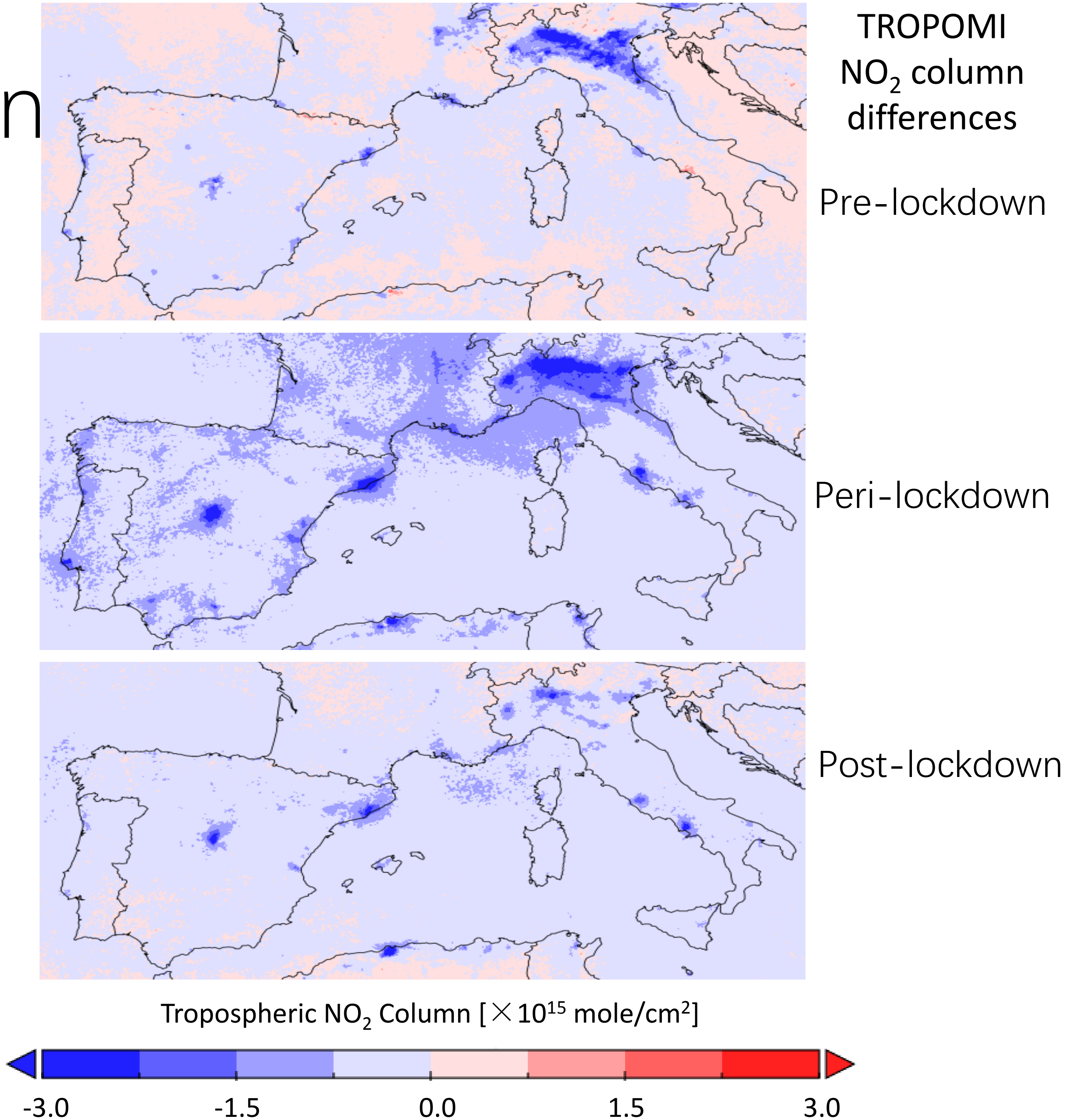
COVID-19 impact on

- Southern Europe

GOME-2A/B NO_2 columns over northern Italy

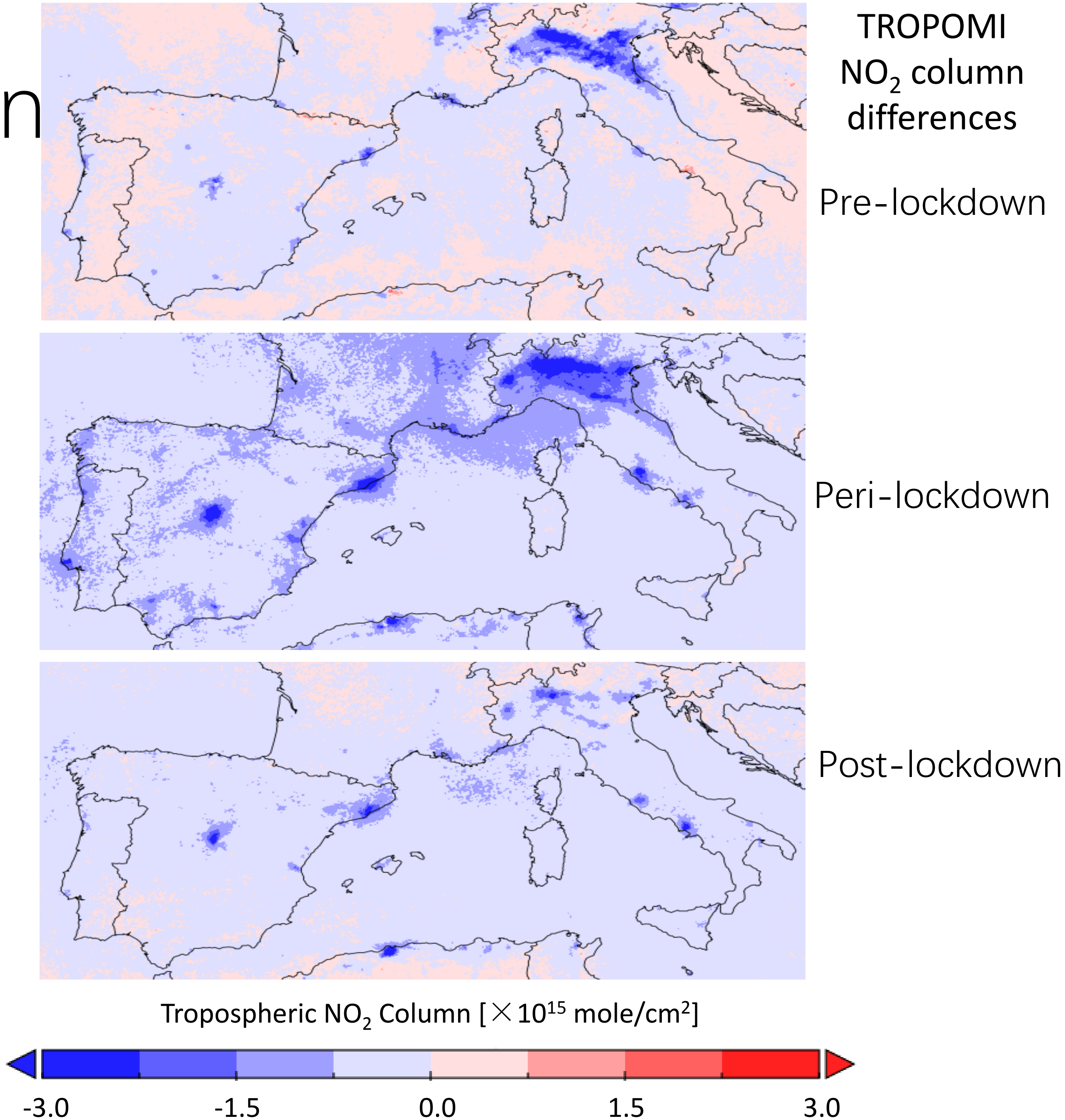


TROPOMI NO_2 column differences



COVID-19 impact on

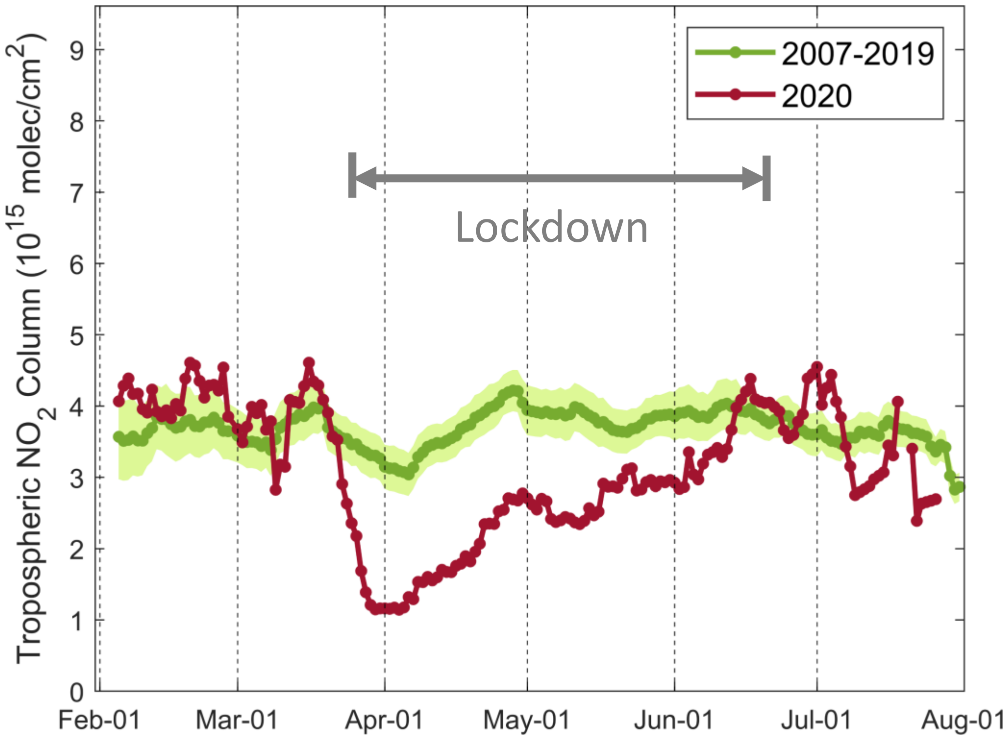
- Southern Europe
  - The observed NO_2 decline because of emission control is 20% and the lockdown-related drop is 30%.



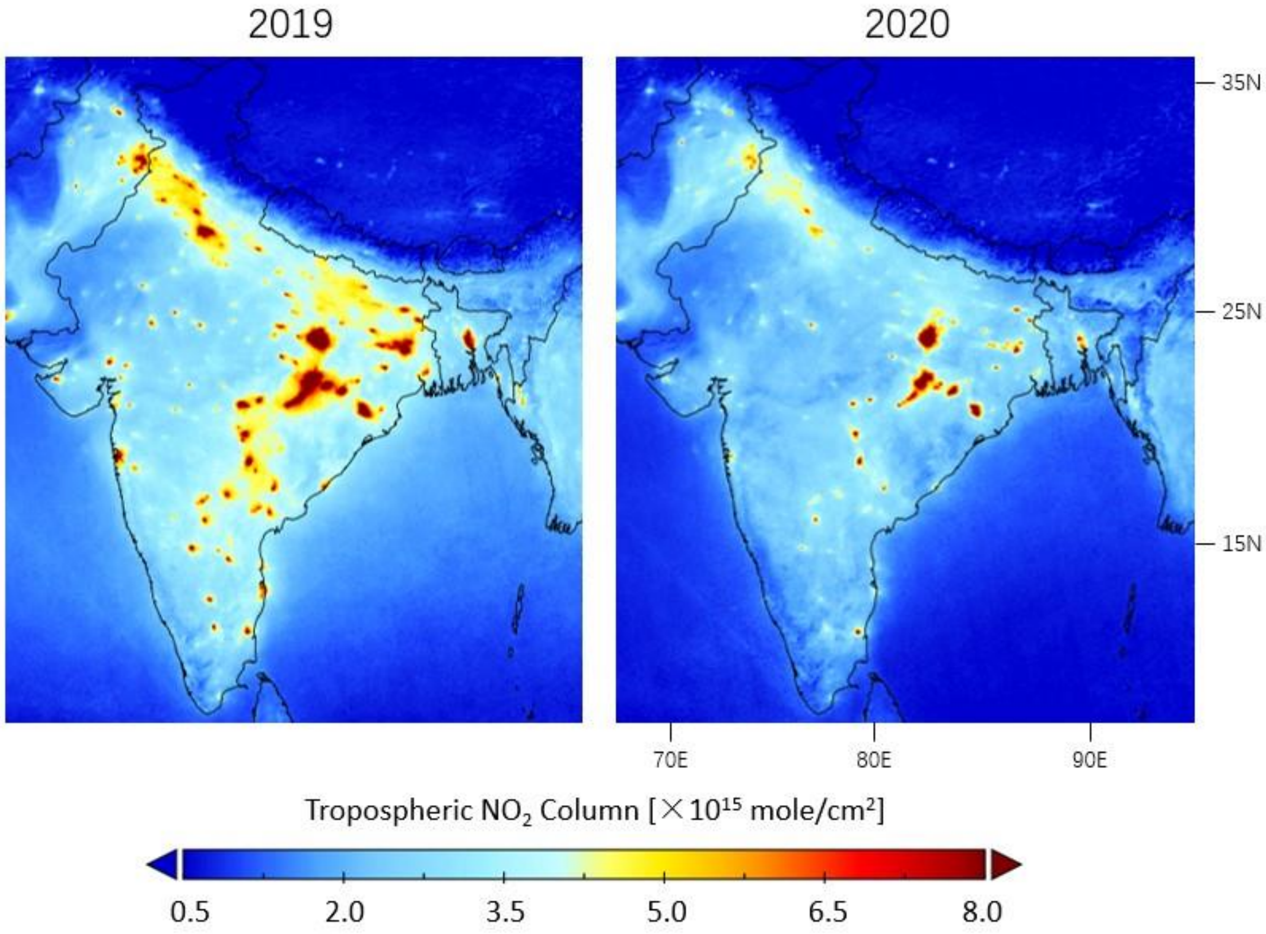
COVID-19 impact on NO_2 pollution

- India

GOME-2A/B NO_2 columns over New Delhi



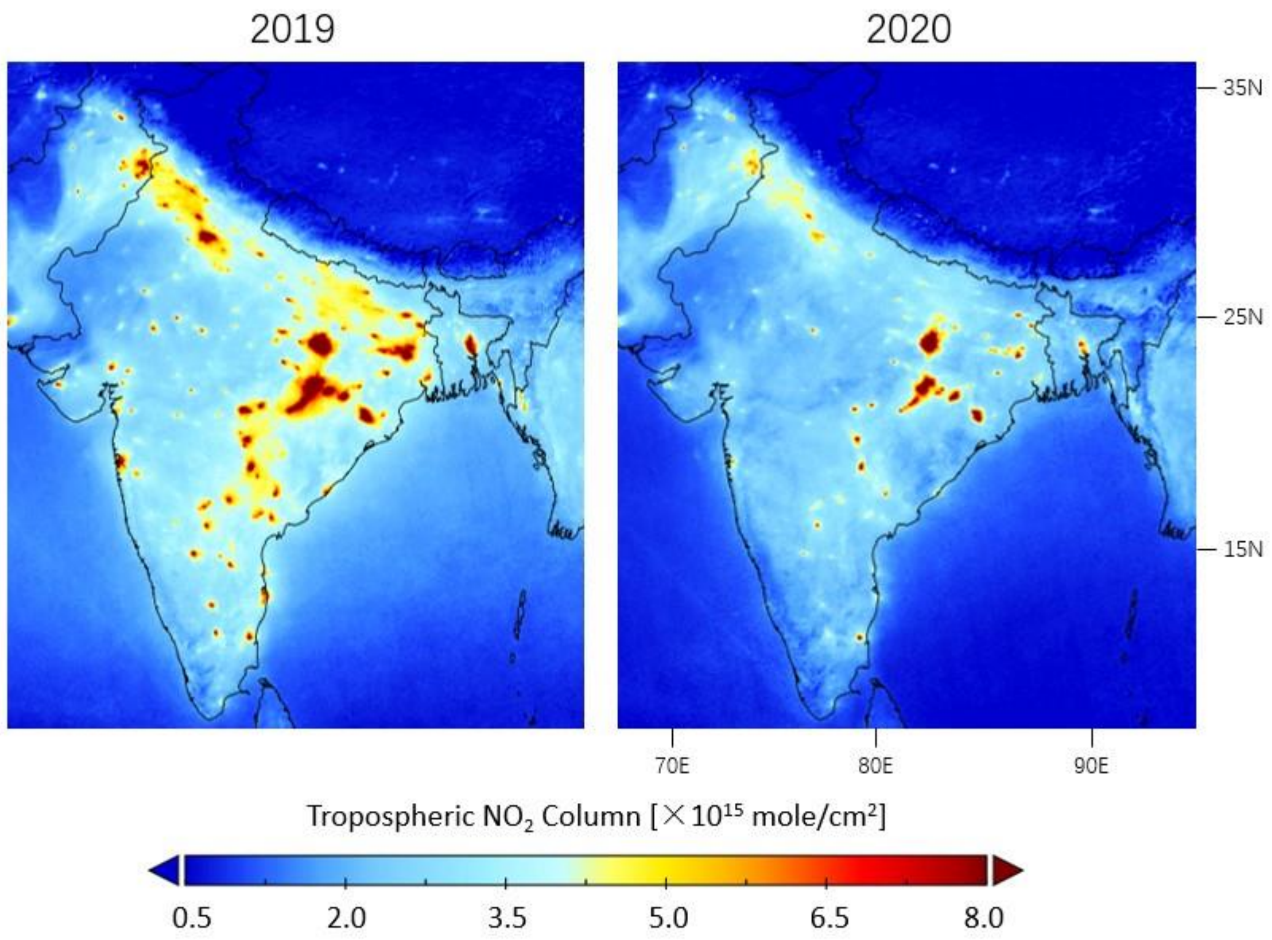
TROPOMI NO_2 columns (25 Mar -24 Jun)



COVID-19 impact on NO_2 pollution

- India
  - The NO_2 values decrease by 42% on average for populated cities for the lockdown period.
  - The lockdown drop is lower than 14% for particular power plant locations.

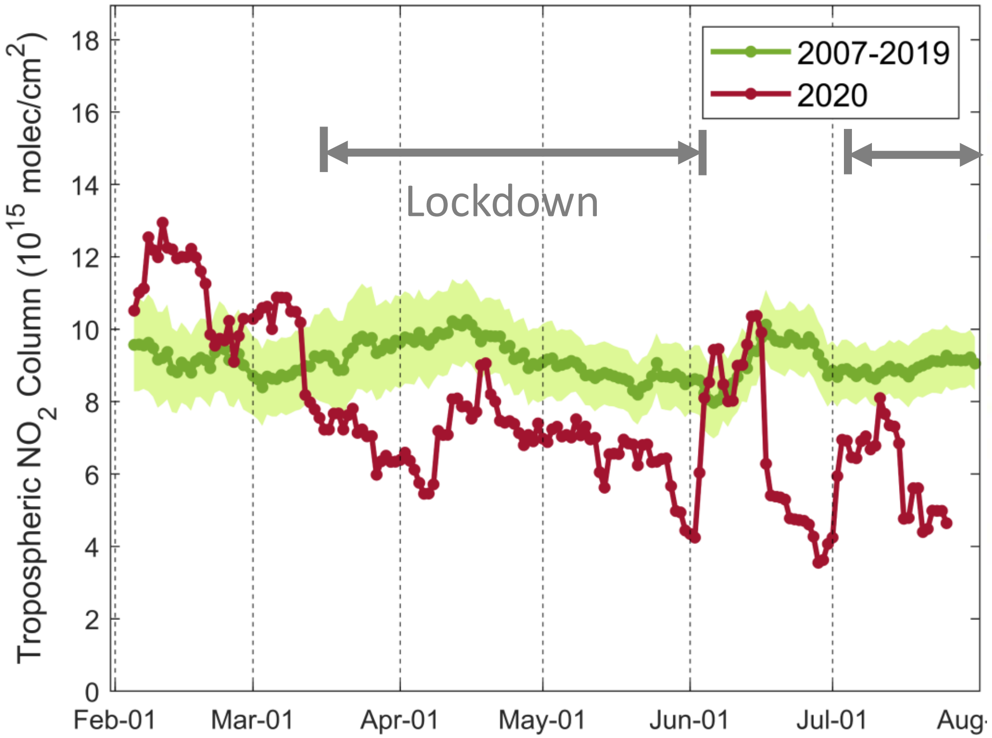
TROPOMI NO_2 columns (25 Mar -24 Jun)



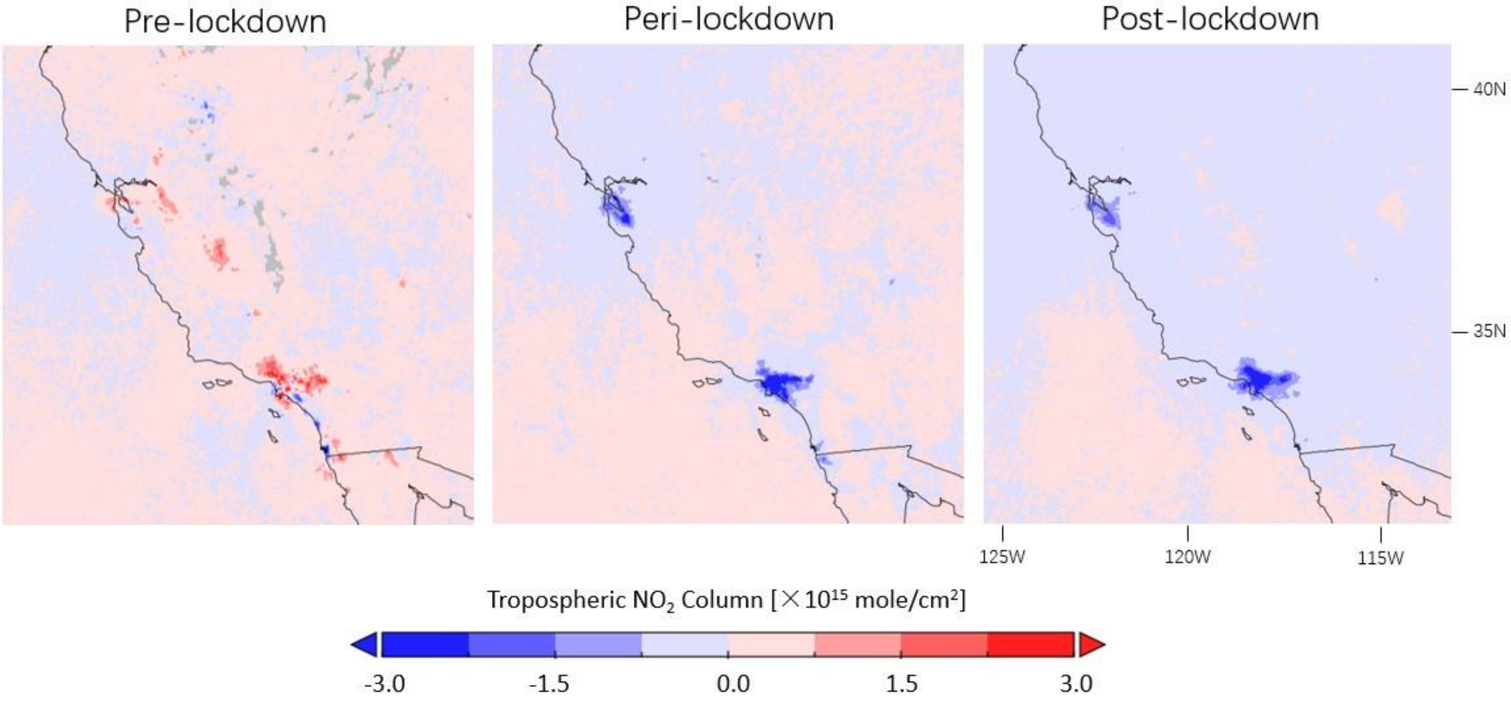
COVID-19 impact on NO_2 pollution

- The USA

GOME-2A/B NO_2 columns over Los Angeles



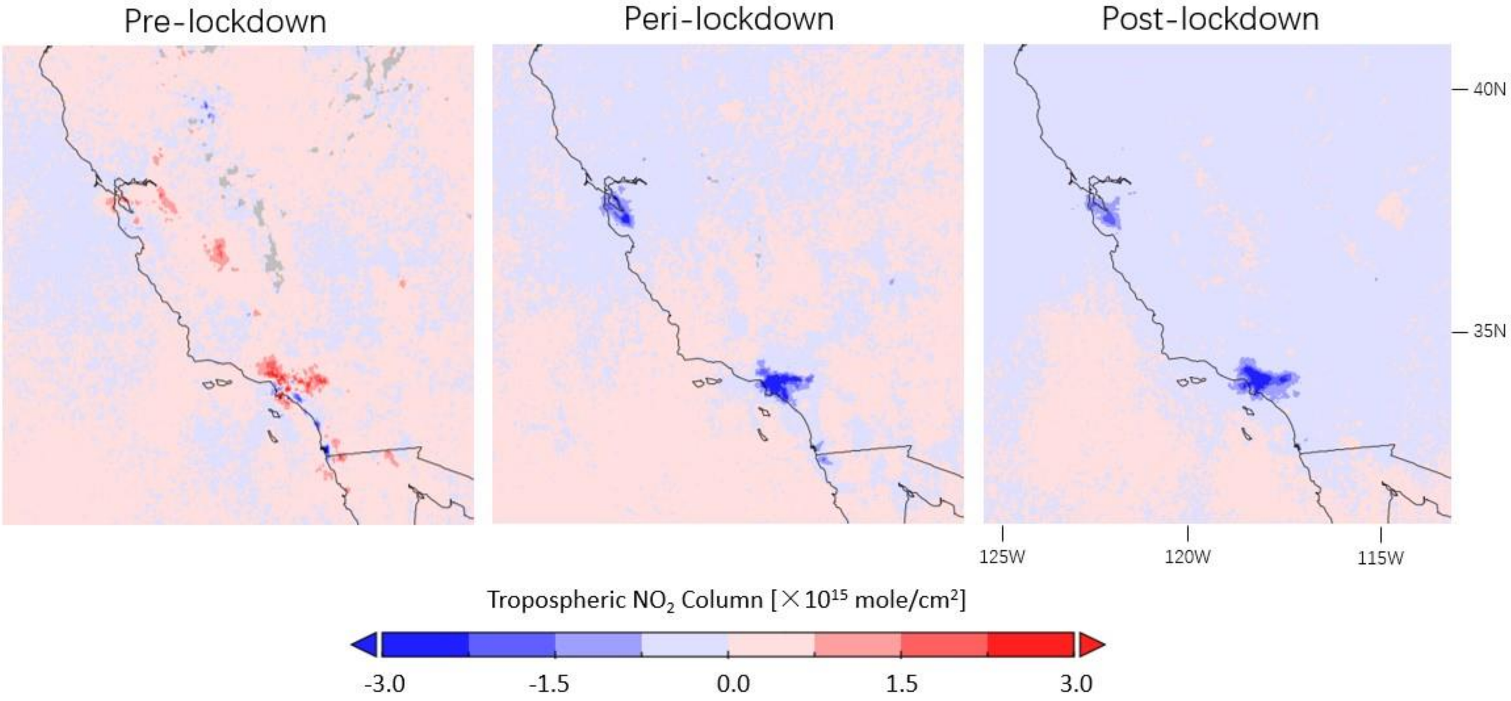
TROPOMI NO_2 column differences



COVID-19 impact on NO_2 pollution

- The USA
  - A lockdown-related NO_2 reduction of 35% is estimated for western regions such as California and 17% for eastern areas.

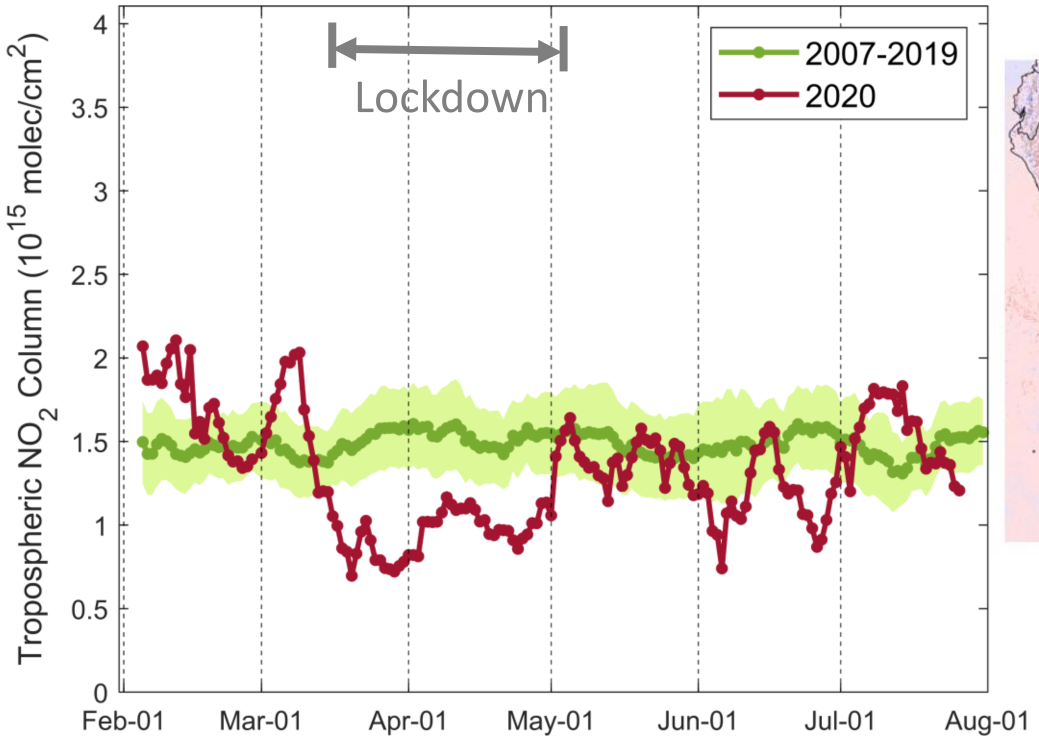
TROPOMI NO_2 column differences



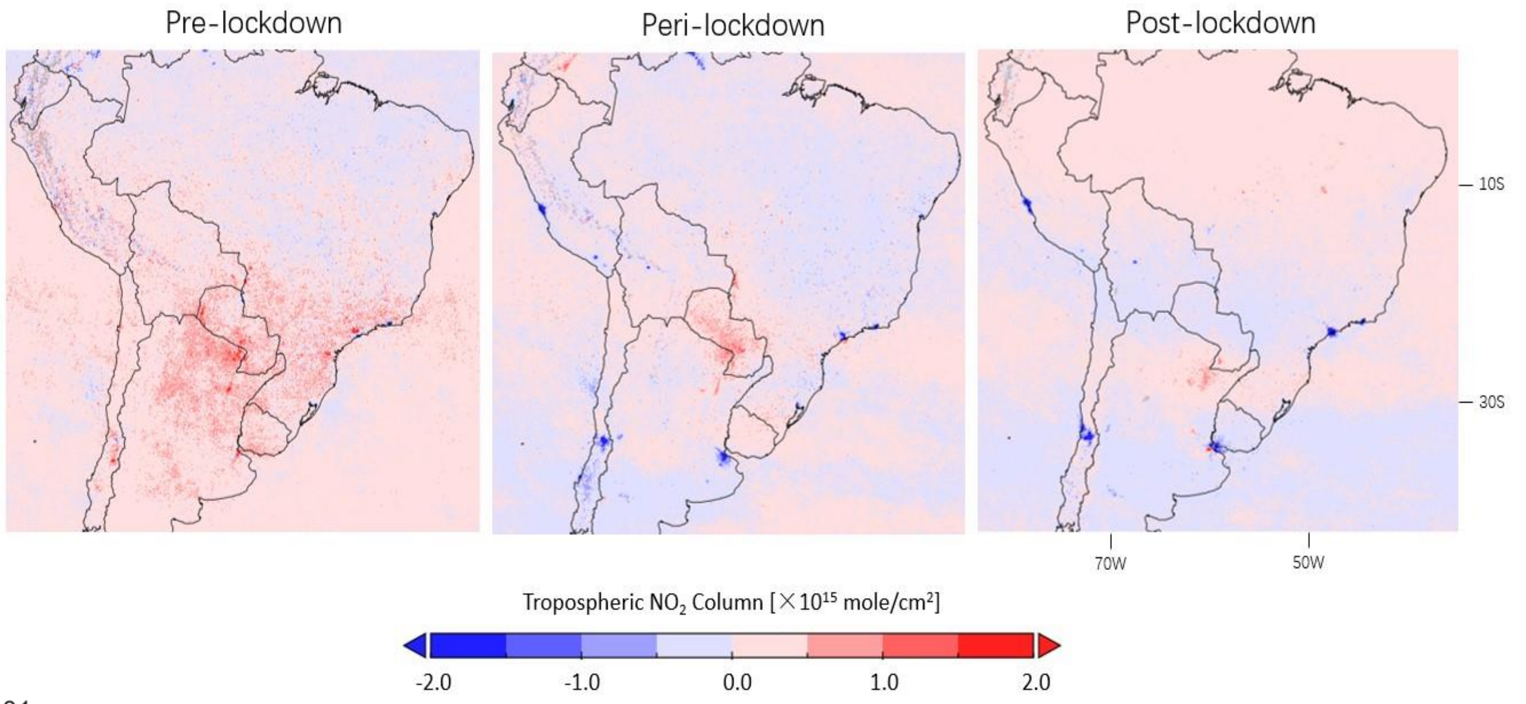
COVID-19 impact on NO_2 pollution

- South America

GOME-2A/B NO_2 columns over Lima



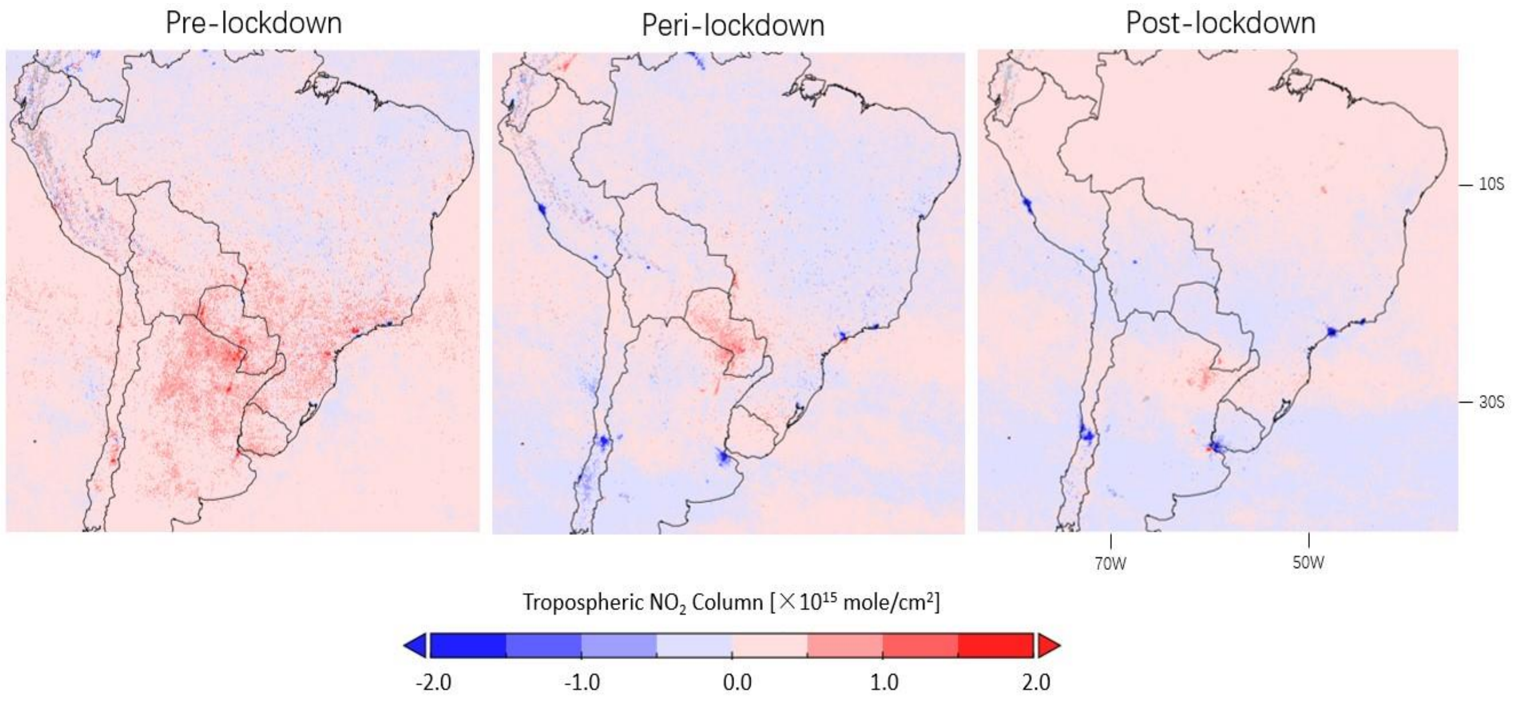
TROPOMI NO_2 column differences



COVID-19 impact on NO_2 pollution

- South America
  - An average NO_2 reduction of 48% is related to the lockdown.
  - Local changes can be attributed to active biomass burning.

TROPOMI NO_2 column differences



Summary

- The global variations of tropospheric NO_2 columns are analyzed based on the long-term dataset from GOME-2 and the high-resolution measurements from TROPOMI.
- The GOME-2 and TROPOMI NO_2 data are generated using harmonized retrieval algorithms and corrected for linear trend, seasonal cycle, and meteorological variation.
- With good consistency between GOME-2 and TROPOMI measurements, the NO_2 drop due to the lockdown restrictions is 30% on average for populated cities in China and southern Europe, 42% in India, 35% in the southwestern USA, and 48% in South America.
- Due to the recovery of social and economic activities, a gradual NO_2 rebounce is found for countries such as China, Italy, and India.

Thank you!

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