Global Chemical Impacts of the COVID-19 Lockdown

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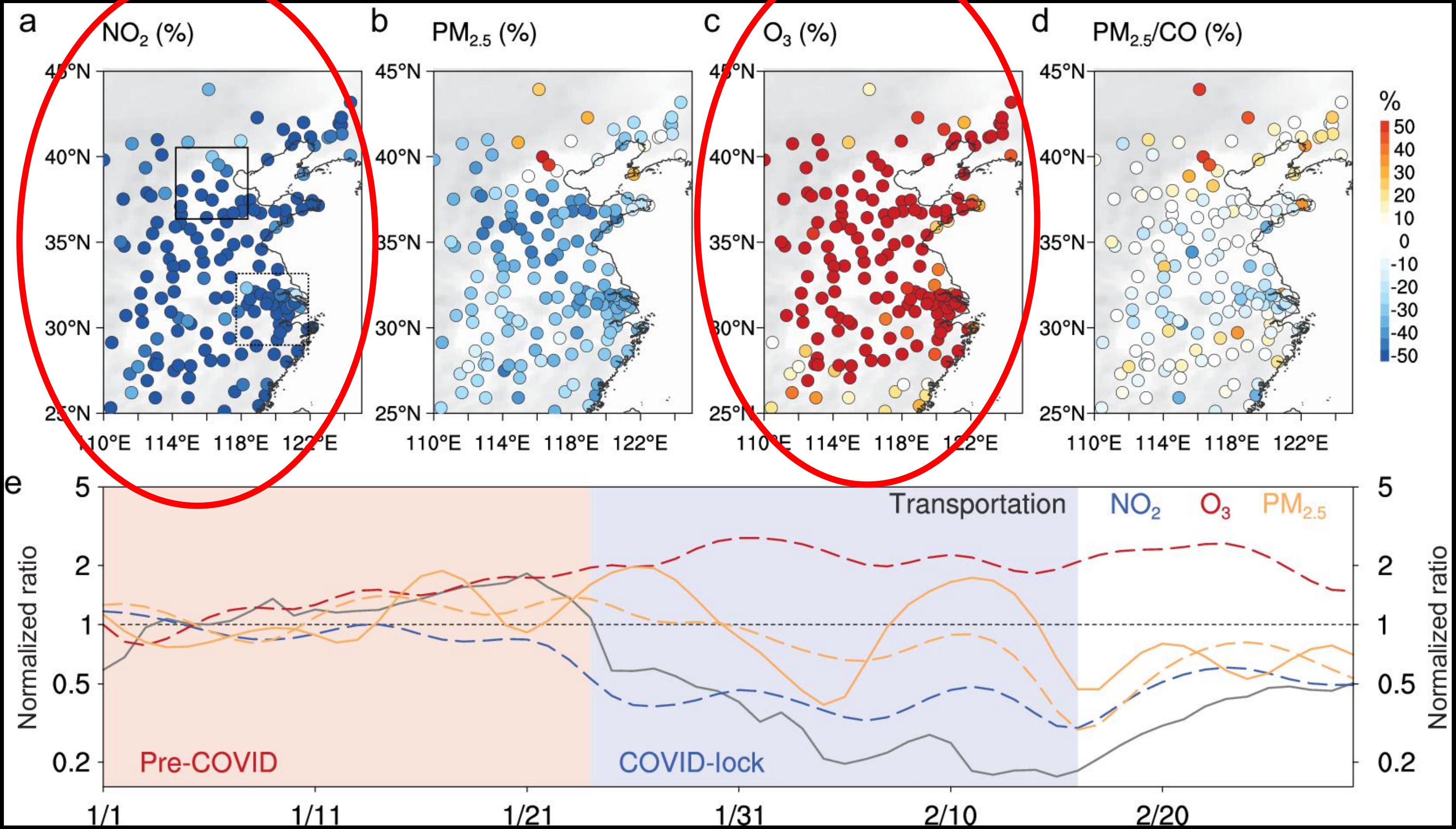
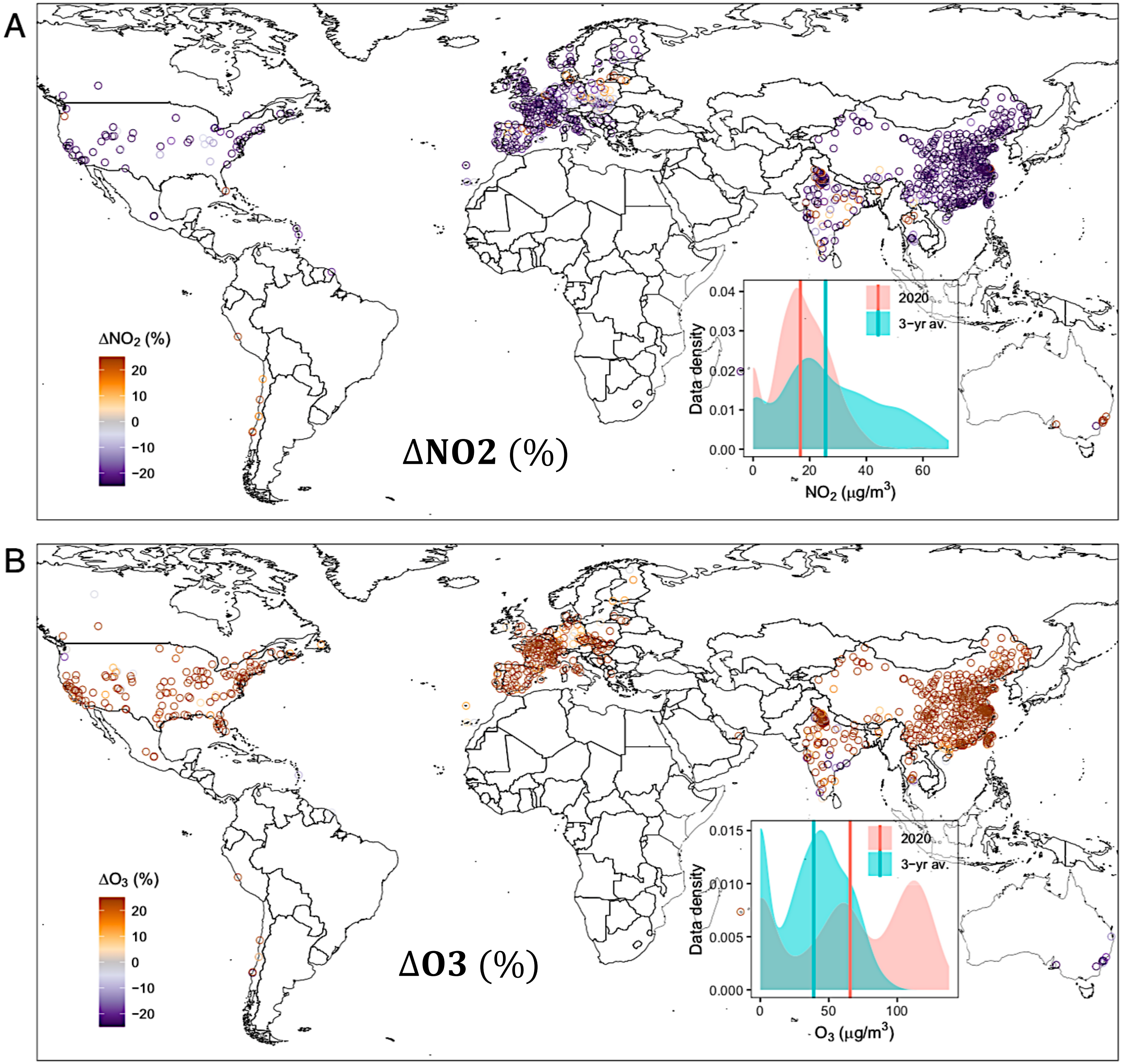
Changes in air quality before and during the COVID-19 lockdown in eastern China



Xin Huang et al., Natl Sci Rev, nwaa137, 2020



Global Response to Covid-19

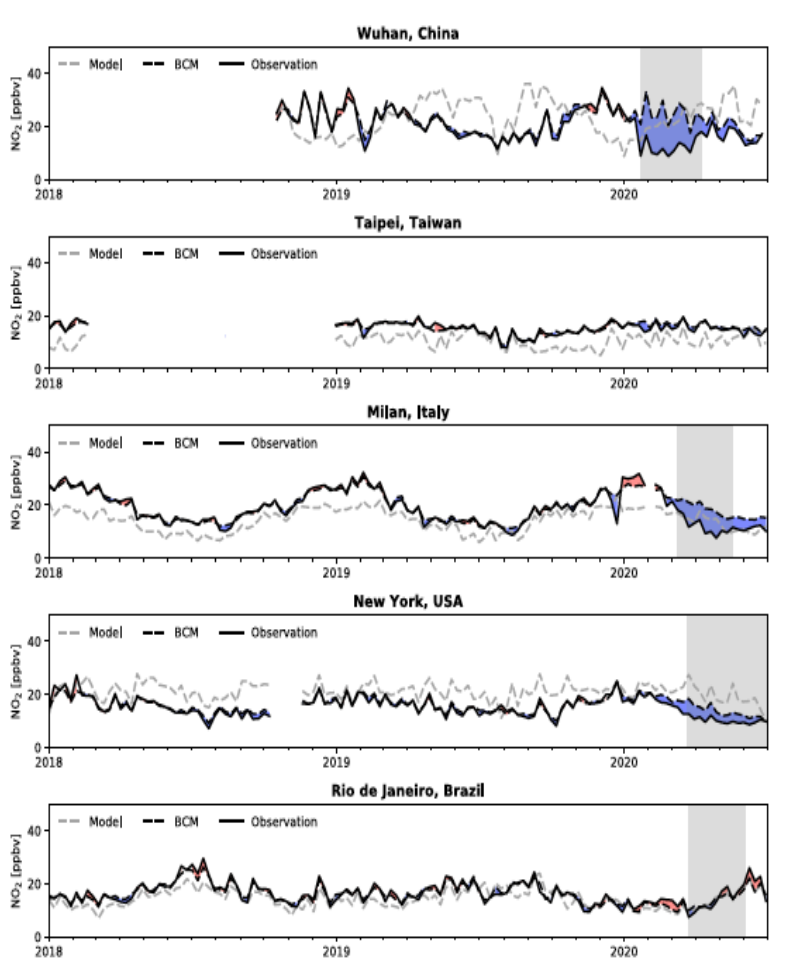
- From a network of 10,000 stations in 34 countries and after accounting for the effects of meteorological variability, Vender et al. report declines in NOx and PM concentrations with marginal increases in ozone.

Keller et al. use a machine learning algorithm driven by the NASA GEOS-CF model to assess the response of NOx and ozone, using 5,756 observation sites in 46 countries

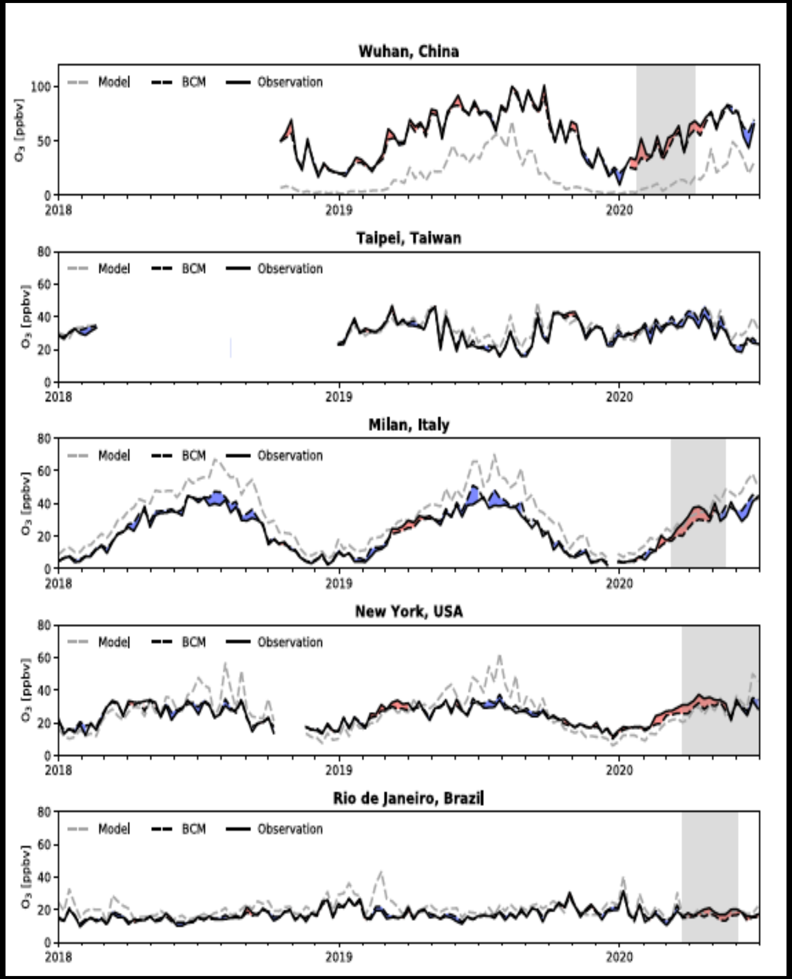
Keller et al. (2020) estimate an NOx emission reduction during the first 6 months of 2020 of 5.1% of the annual anthropogenic total.

Surface ozone increased by up to 50% at some locations, but overall the impact was small.

NO_2

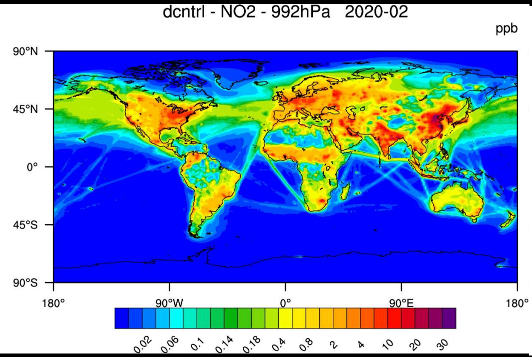


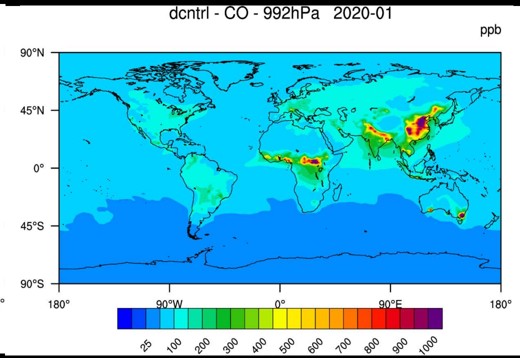
Ozone

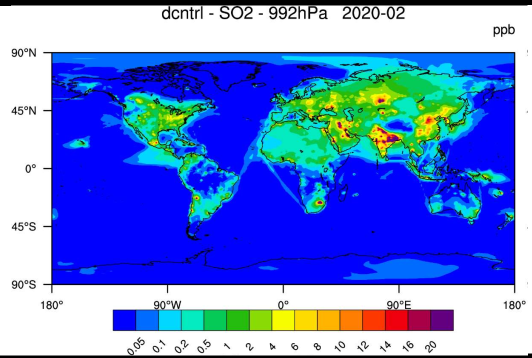


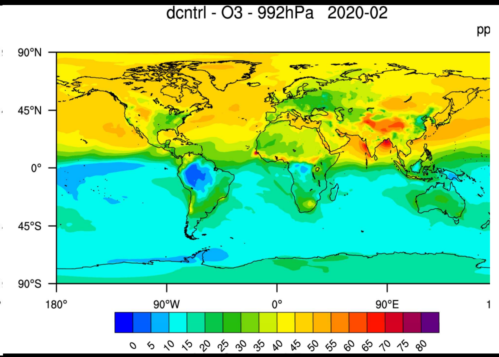
Community Earth System Model v. 2.2 (NCAR)

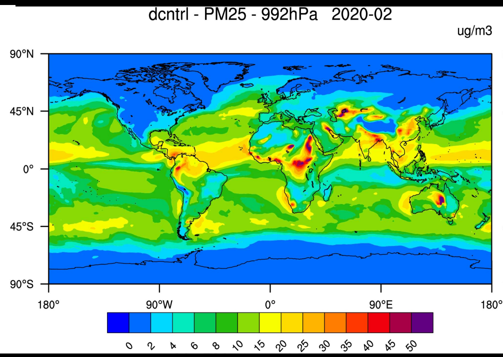
- Atmospheric component (CAMS-Chem) with TS1 chemical mechanism
  - Horizontal resolution 100 km (1.25 in longitude and 0.95 in latitude)
  - 32 vertical levels up to 3.6 hPa
  - Calculated dynamics, but nudged to GEOS-FP meteorological analysis
  - 221 chemical species, 528 chemical reactions.
  - Four mode Modal Aerosol Model and VBS approach for SOA formation
  - CAMS GLOB-ANT-v4.2-R1.1 surface emissions
  - Emissions adjustments during the pandemic according to Doumbia et al. 2020.



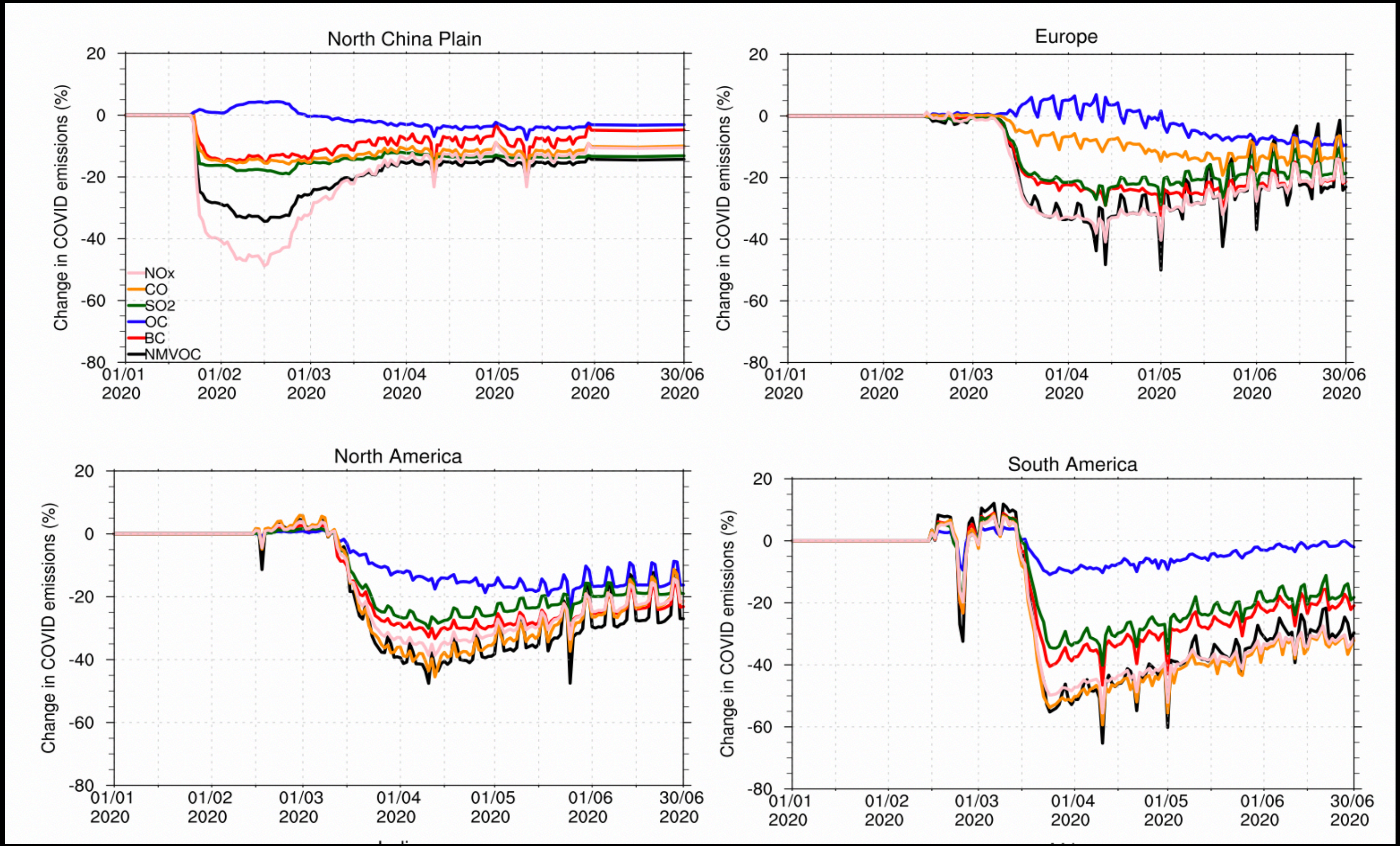








Adjustment of the emissions during the pandemic in different regions of the world

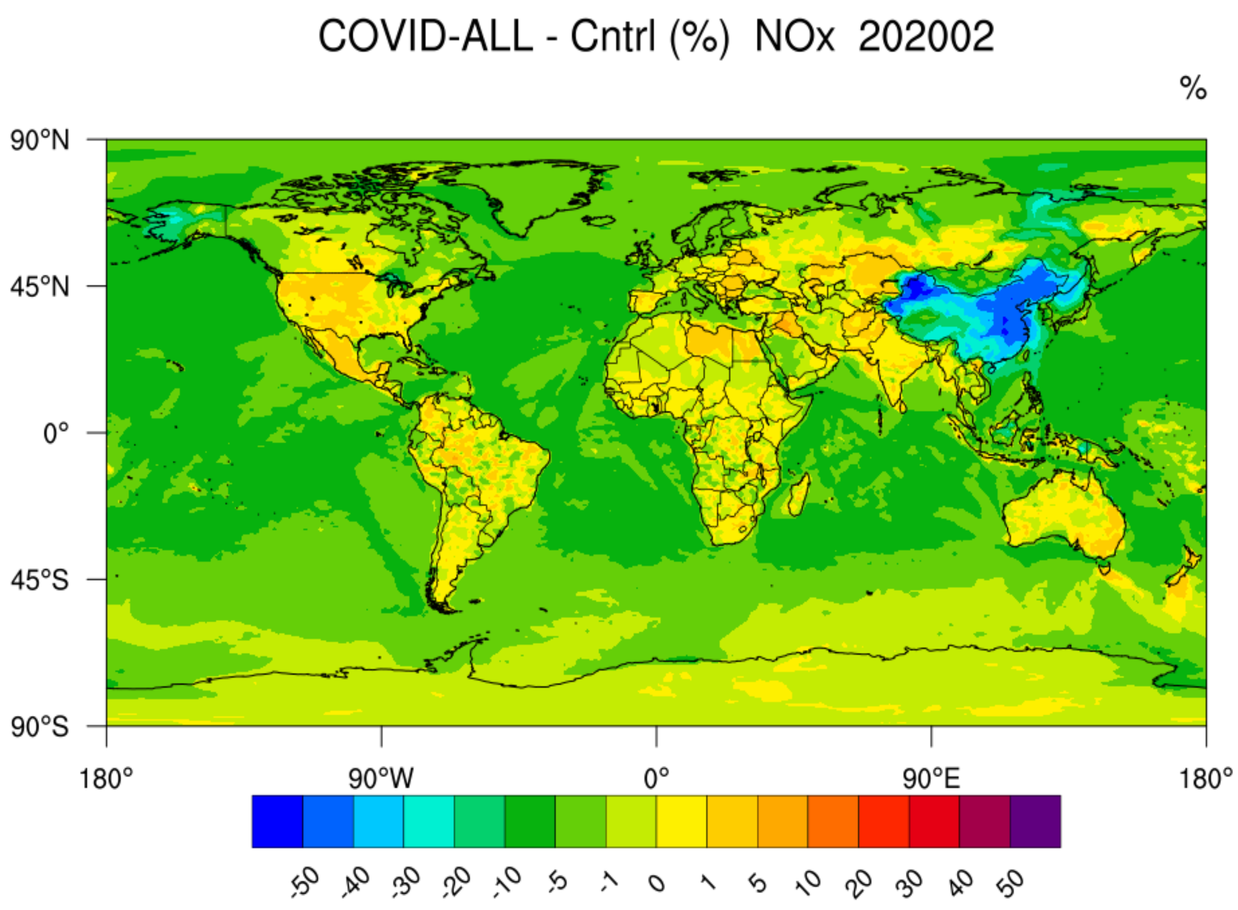


- China: Reduction starts in February 2020 (40% for NOx, 25% for VOCs)
- Rest of the world: Reduction is highest on March-April 2020.

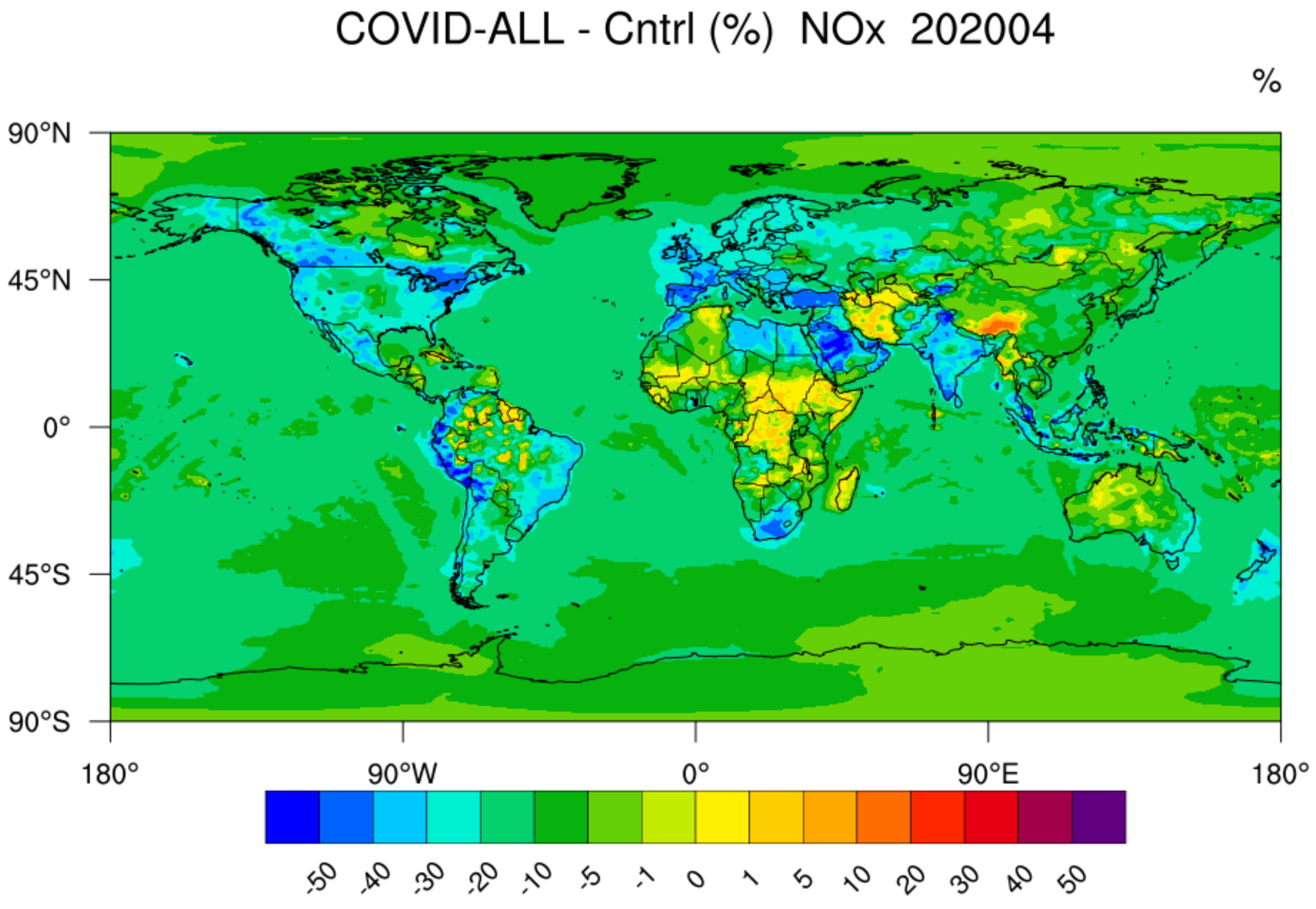
Based on Doumbia et al. 2020

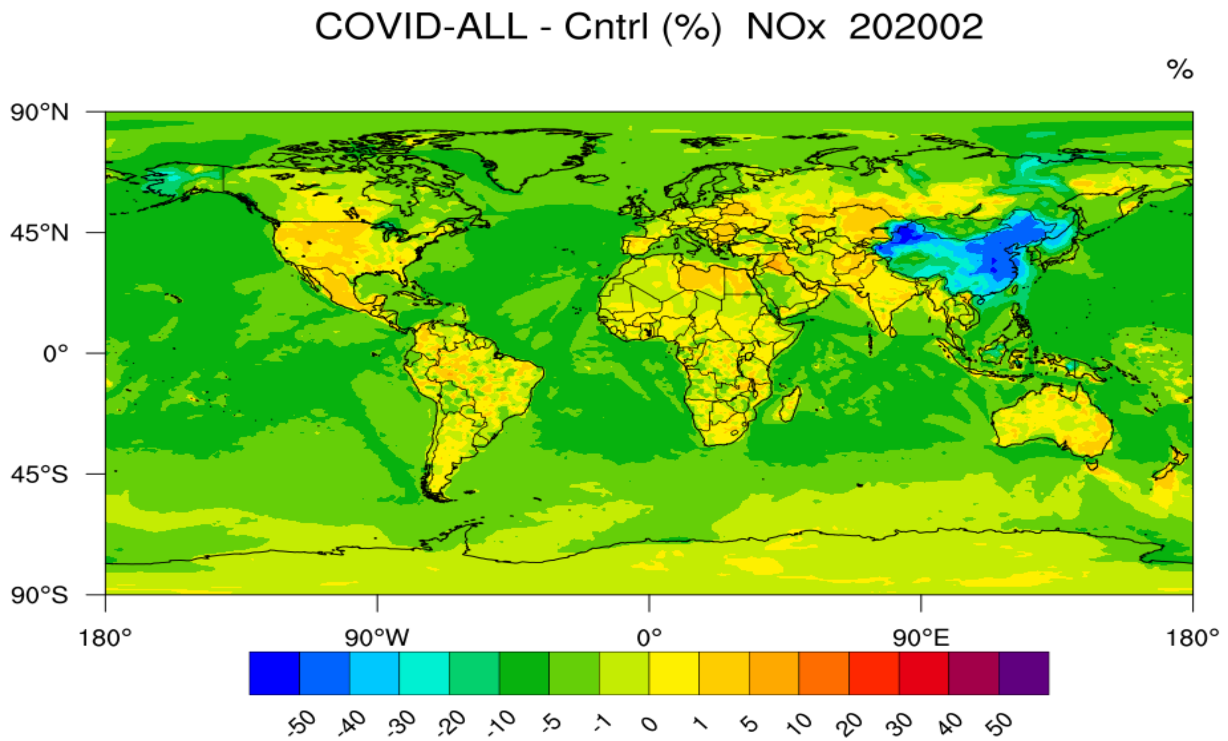
Reduction in NO_2: From China in February to the rest of the world in April 2020

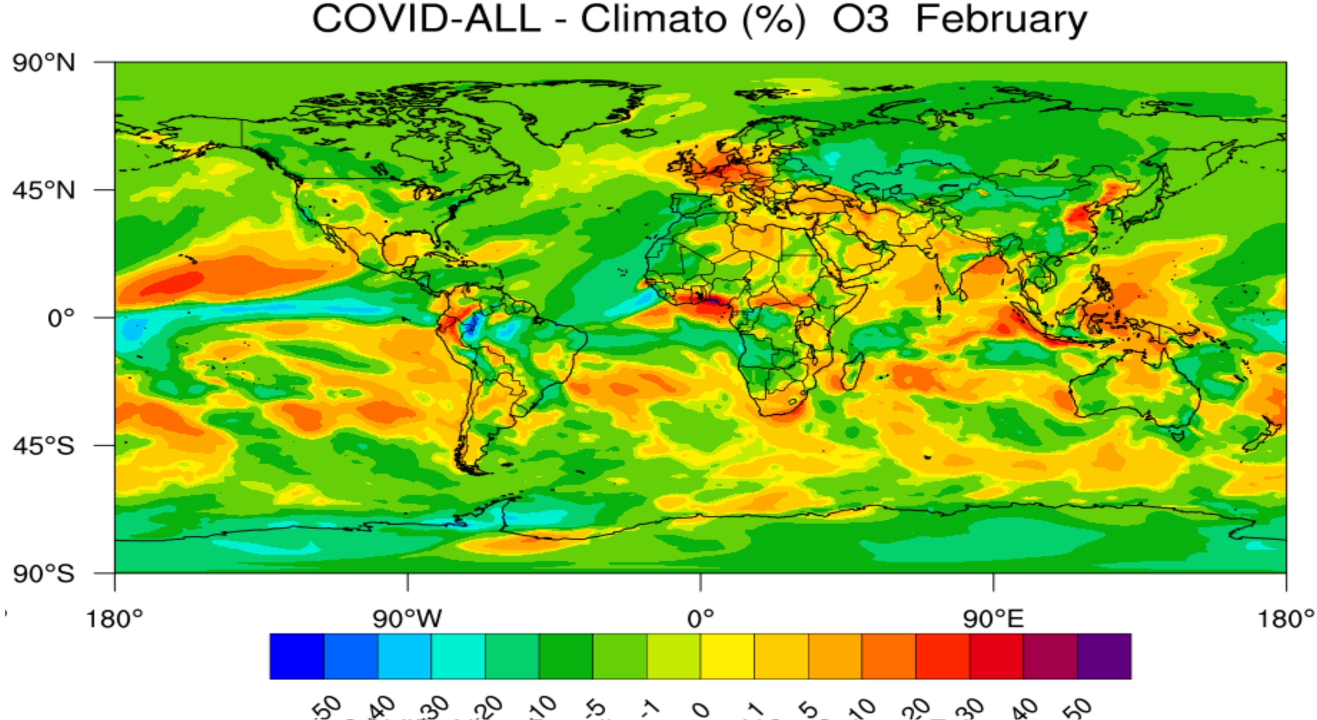
February

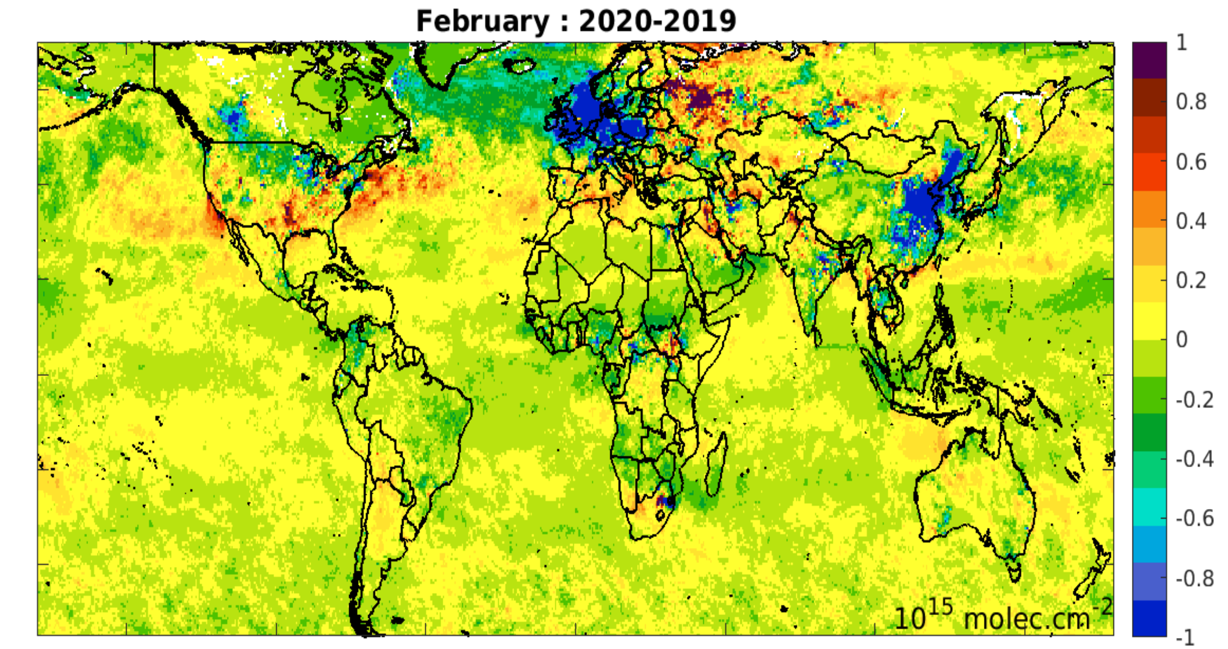


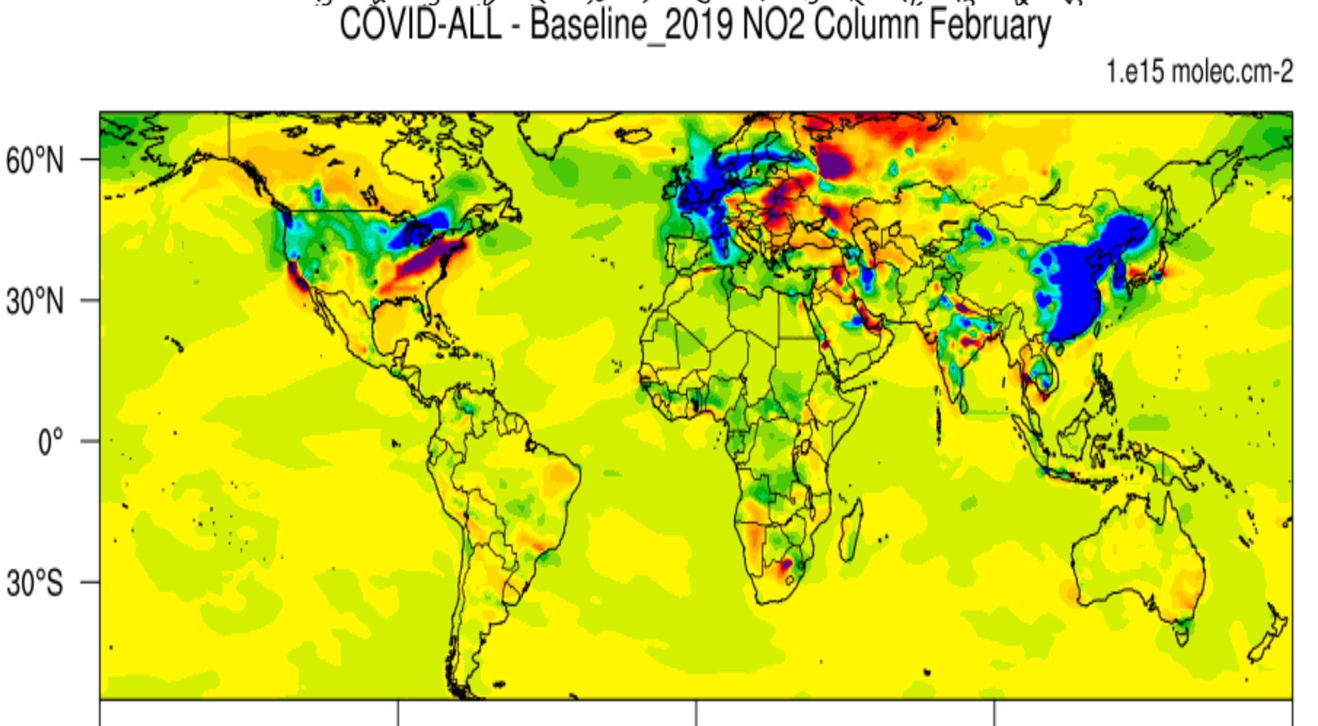
April



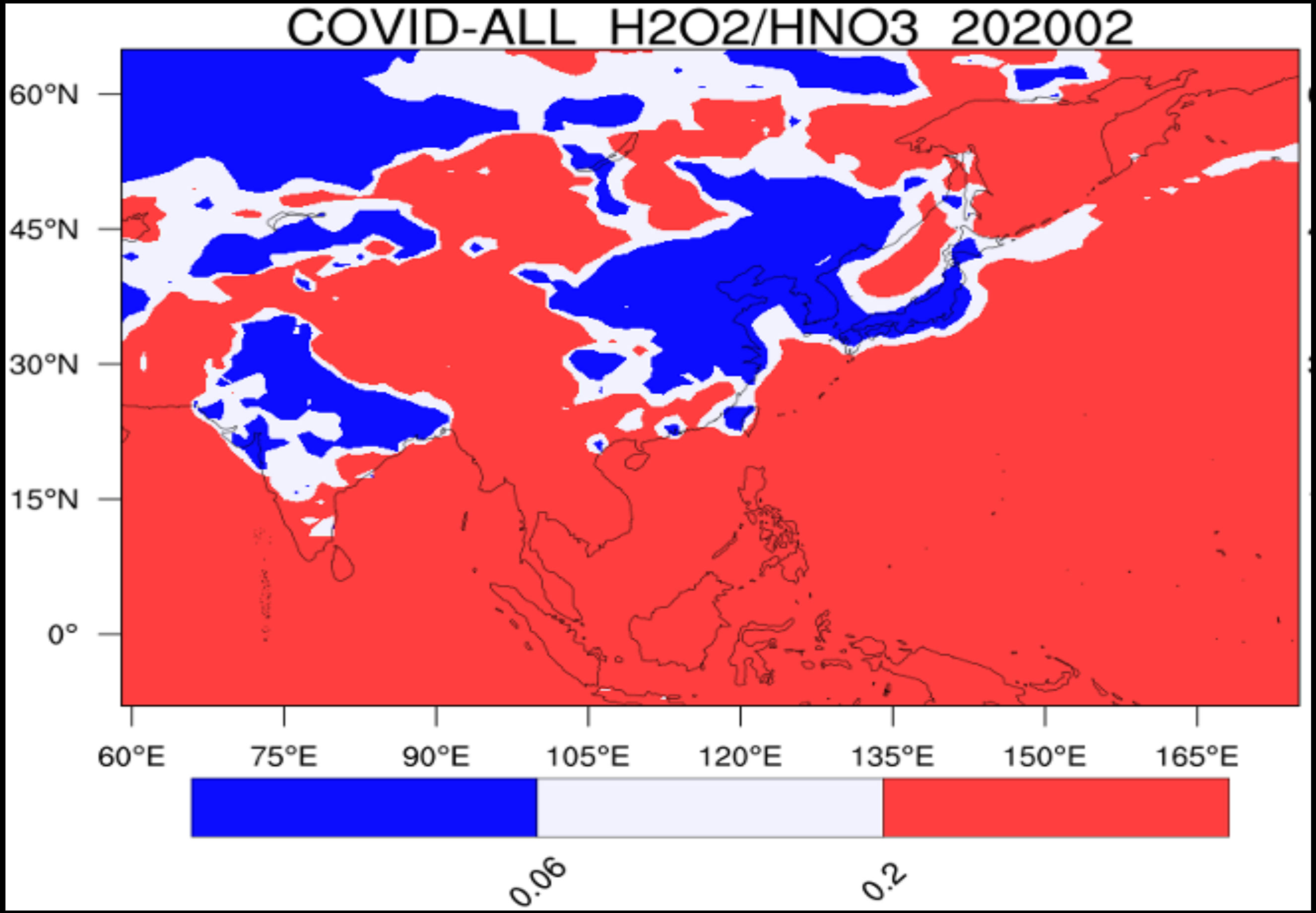

COVID-ALL - Cntrl (%) NOx 202002
%
90°N
45°N
0°
45°S
90°S
180°
90°W
0°
90°E
180°
-50 -40 -30 -20 -10 -5 -1 0 1 5 10 20 30 40 50


COVID-ALL - Climato (%) O3 February
90°N
45°N
0°
45°S
90°S
180°
90°W
0°
90°E
180°
-50 -40 -30 -20 -10 -5 -1 0 1 5 10 20 30 40 50


February : 2020-2019
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
10^15 molec.cm^-2

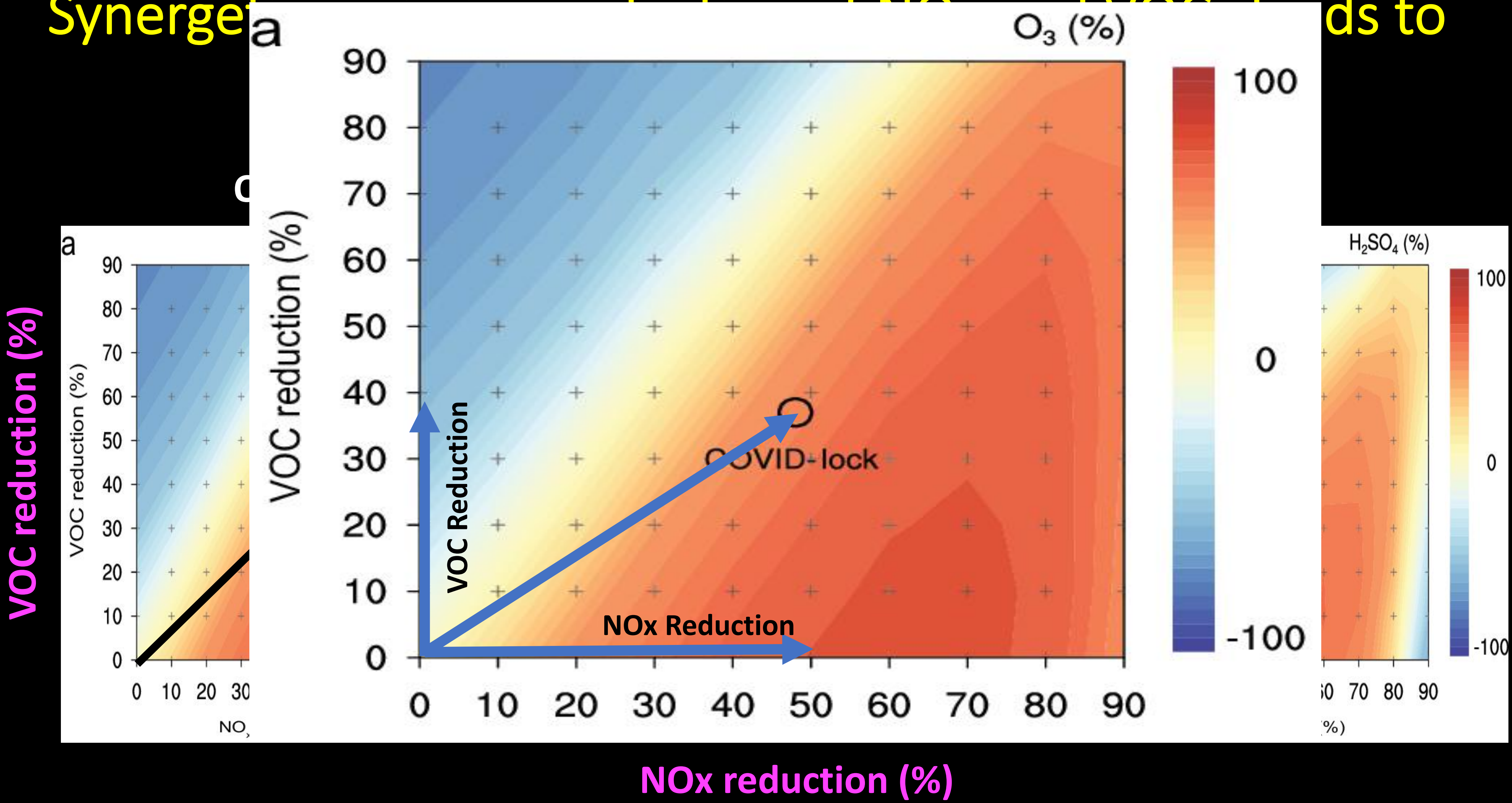

COVID-ALL - Baseline_2019 NO2 Column February
1.e15 molec.cm-2
60°N
30°N
0°
30°S

Photochemical Regimes in Asia (February)



- Blue: Values less than 0.06: NOx-saturated, VOC-limited
- Red: Values larger than 0.2: NOx-limited
- White: Intermediate area.

Synerget… ds to



Xin Huang et al., Natl Sci Rev, nwaa137, 2020

North China Plain

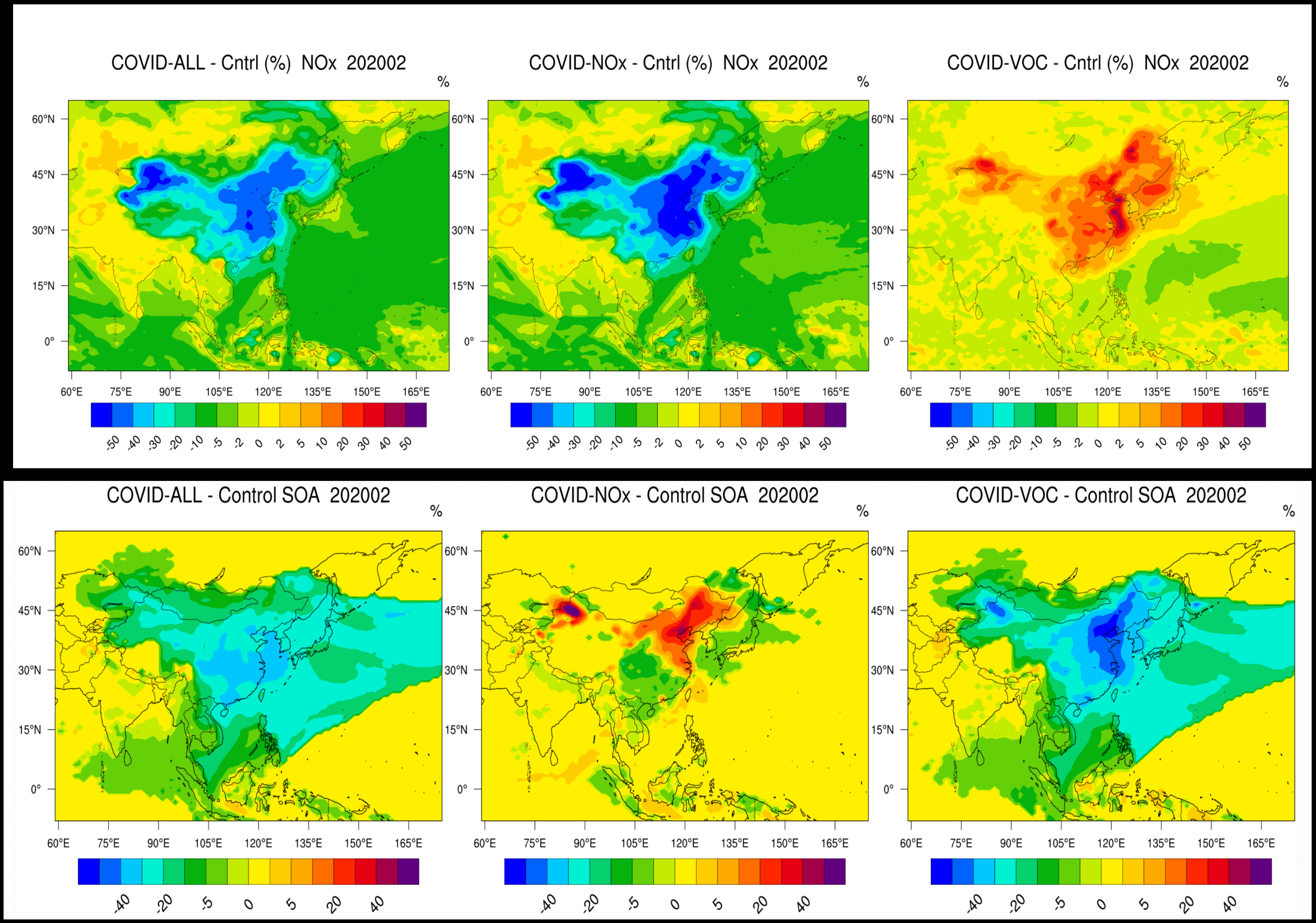
In China:

Reduction in: **All emissions.** **NOx emissions.** **VOC and CO emissions**

The response of NO_2 and secondary pollutants to reduced emissions during February 2020

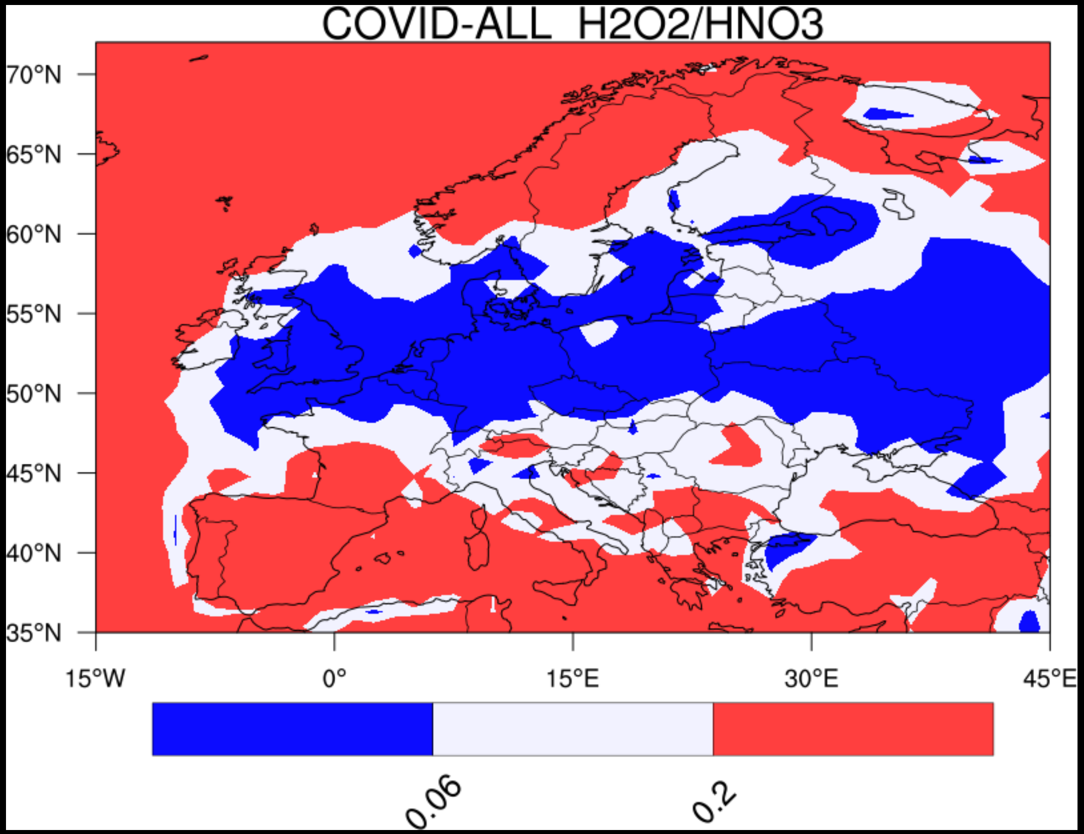
NO_2

SOA



During the pandemic: Reduction in ozone titration in northern China (NOx saturated)

Photochemical Regimes in Europe (March-April)



- Blue: Values less than 0.06: NOx-saturated, VOC-limited
- Red: Values larger than 0.2: NOx-limited
- White: Intermediate area.

In Europe:

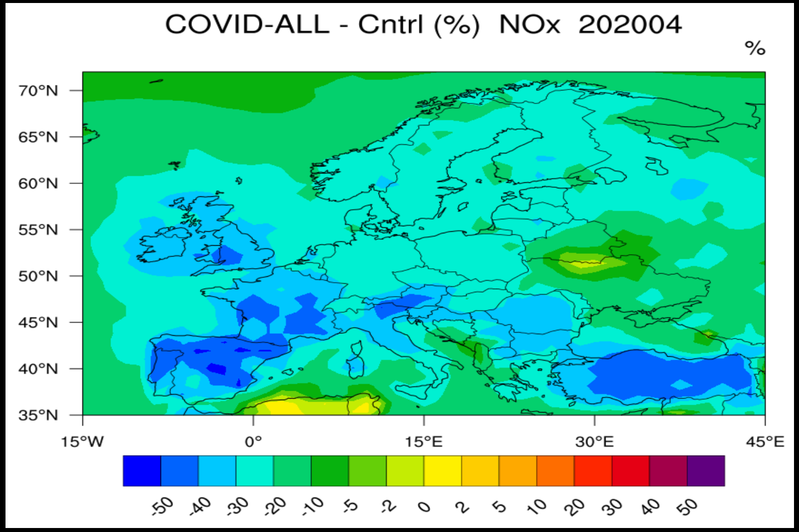
The response of NO_2 and ozone in reduced emissions during April 2020. Importance of weather anomalies

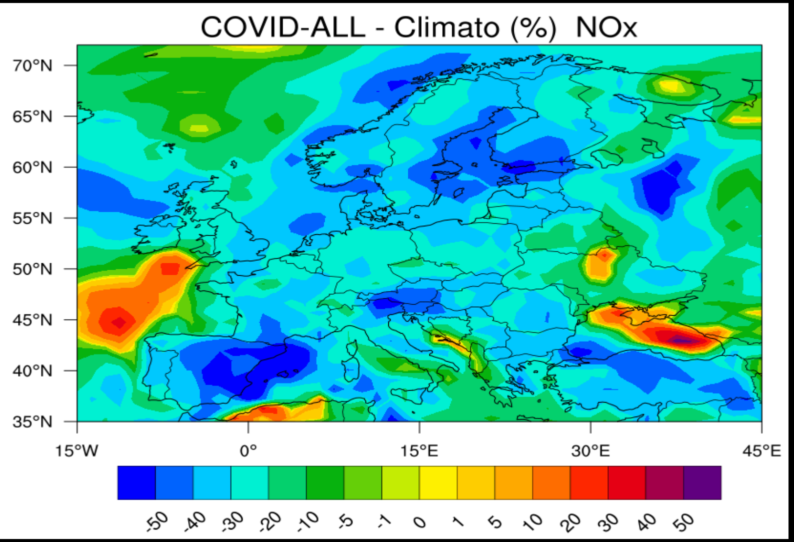
During the pandemic: most of the ozone increase is attributed to weather anomaly (except in the UK, Benelux, Germany)

Emissions reduction only
No meteorological effect

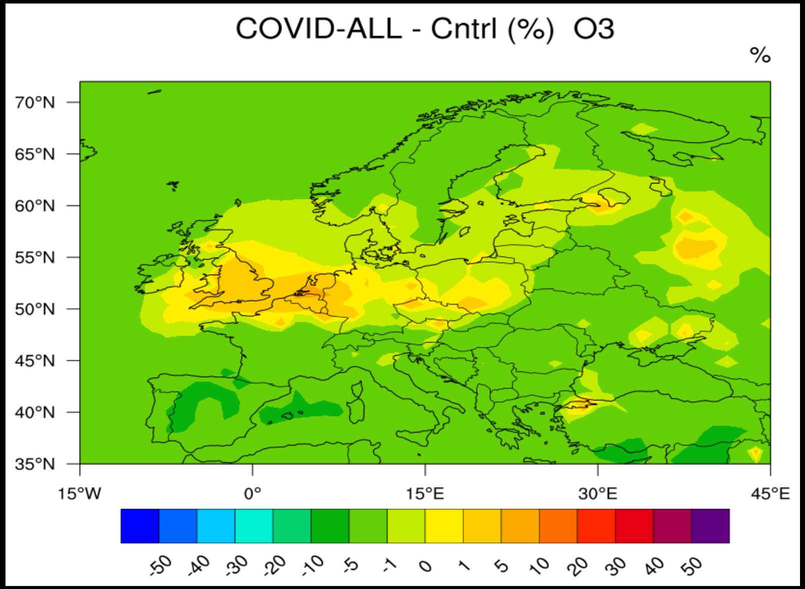
Emissions reduction
With meteorological effects

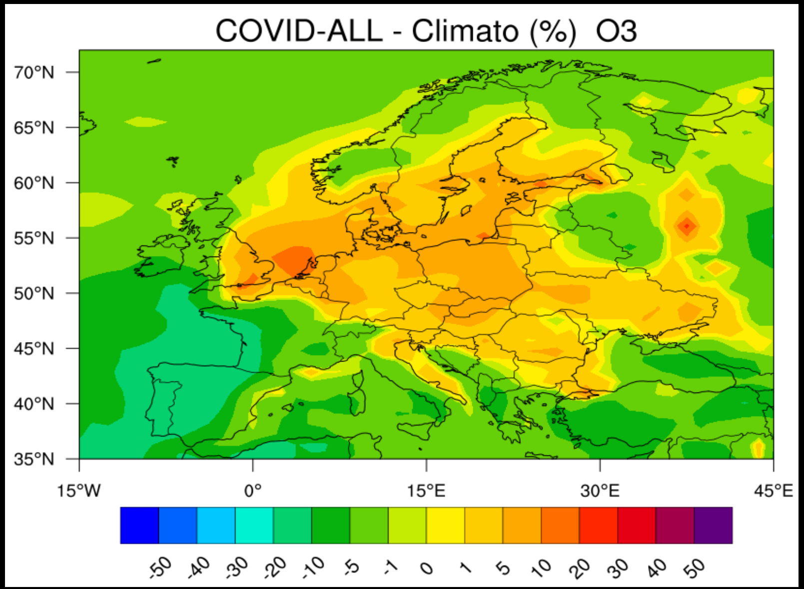
NO_2





O_3





Summary

- The response of secondary pollutants (ozone, SOA) during COVID-19 depends on the relative reduction of NOx and VOC emissions, which affect photo-oxidants (OH, HO_2, NO_3) in opposite ways.
- Ozone increase occurred in NOx-saturated areas (VOC control) and were substantial in winter and in urban areas.
- Meteorological anomalies complicate the analysis of the observed changes; these effects can be as large or larger than the effects of emission reductions during the pandemic.
- The gigantic chemical experiment associated with the pandemic confirms our (limited) understanding of atmospheric photochemistry and allows us to make progress on unresolved questions related to a complex nonlinear system: chemical regimes, partitioning in VOCs, formation mechanisms of SOA, chemical partitioning among aerosols, etc..

Thank You

NCAR

MAP-AQ

AMIGO

Analysis of eMIssions usinG Observations