Diverse response of surface ozone to COVID-19 lockdown in China

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Observed changes in O$_3$ during the COVID-19 lockdown

Modeling the causes of O$_3$ changes (Meteorology and Emission)
Primary pollutants has decreased except $O_3$ in northern China after lockdown.

Shi et al., 2020 @ GRL
Three typical regions:
- North China (NC)
  North China Plain, 184 sites
- Central China (CC)
  Hubei province, 108 sites
- South China (SC)
  Pearl River Delta, 77 sites

Two period:
- Pre-COVID-19 lockdown (pre-CLD) period: Jan 2-22, 2020
- COVID-19 lockdown (CLD) period: Jan 23-Feb 12, 2020
$O_3$ decreased in SC but increase in most other regions.
Possible reasons for the changes in $O_3$

- Improper emission reductions of $O_3$ precursors (NOx, VOC, CO);
- Decrease in aerosol effects through altering photolysis rates and heterogeneous reactions.
- Changes in meteorological conditions (temperature, wind field, humidity, precipitation, etc.)
Reproduce $O_3$ changes using the WRF-CMAQ model

Model setting
- Model: WRF-CMAQ
- Resolution: 36km $\times$ 36km
- Period: 2 Jan-12 Feb 2020
- Mechanism: SAPRC07TIC, AERO6i, heterogeneous uptake of NO$_2$, N$_2$O$_5$, NO$_3$, HO$_2$, OH, O$_3$, H$_2$O$_2$ and updated HONO sources
- Anthropogenic emissions: MEIC
- Biogenic emission: MEGAN v2.1

Estimated changes in anthropogenic emission during lockdown
- -70% in transportation emission
- -40% in industry emission
- -30% in power emission
- +10% in residential emission

Literature:
- Huang et al., 2020 @ NSR
- Wang et al., 2020 @ RCR
- Doumbia et al., 2021 @ ESSD
Meteorology and emission exert diverse effects in different regions

Liu et al., 2021 @ STOTEN
**O₃ changes mainly depend on reductions of NOx and VOCs**

- The changes of NOx and VOCs emissions have the highest contributions to O₃ changes.
- In NOx-saturated NC, the reduction in NOx >> VOC contributed to the O₃ increase;
- For SC, the comparably large decreases in NOx and VOC contributed to the O₃ decrease.

Liu et al., 2021 @ STOTEN
Residential sources contribute more VOC in northern China

Anthropogenic pollutant emissions in winter

- Attention should be paid to control the residential emission in winter.

Data from MEIC (http://meicmodel.org)
Conclusion

- **Observational evidence**: We find that $O_3$ decreased in the subtropical south, in contrast to increases in most other regions.

- **Meteorology**: Meteorological changes played an important role in short-term $O_3$ variability. It contributed to the $O_3$ increase in NC & CC but the $O_3$ decrease in SC.

- **Emissions**: The larger reduction in NO$_x$ than VOCs induced $O_3$ increases in the NO$_x$-saturated north, whereas the comparably large decreases in both precursors resulted in $O_3$ declines in the south.

- **Implications**: Control in residential emission is strongly suggested in winter to reduce the atmospheric oxidation capacity in North China.
Thank you!

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For more information:
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