

The Complex Chemical Effects of COVID-19 Shutdowns on Air Quality

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*AMIGO/IGAC COVID workshop
November 3, 2020*

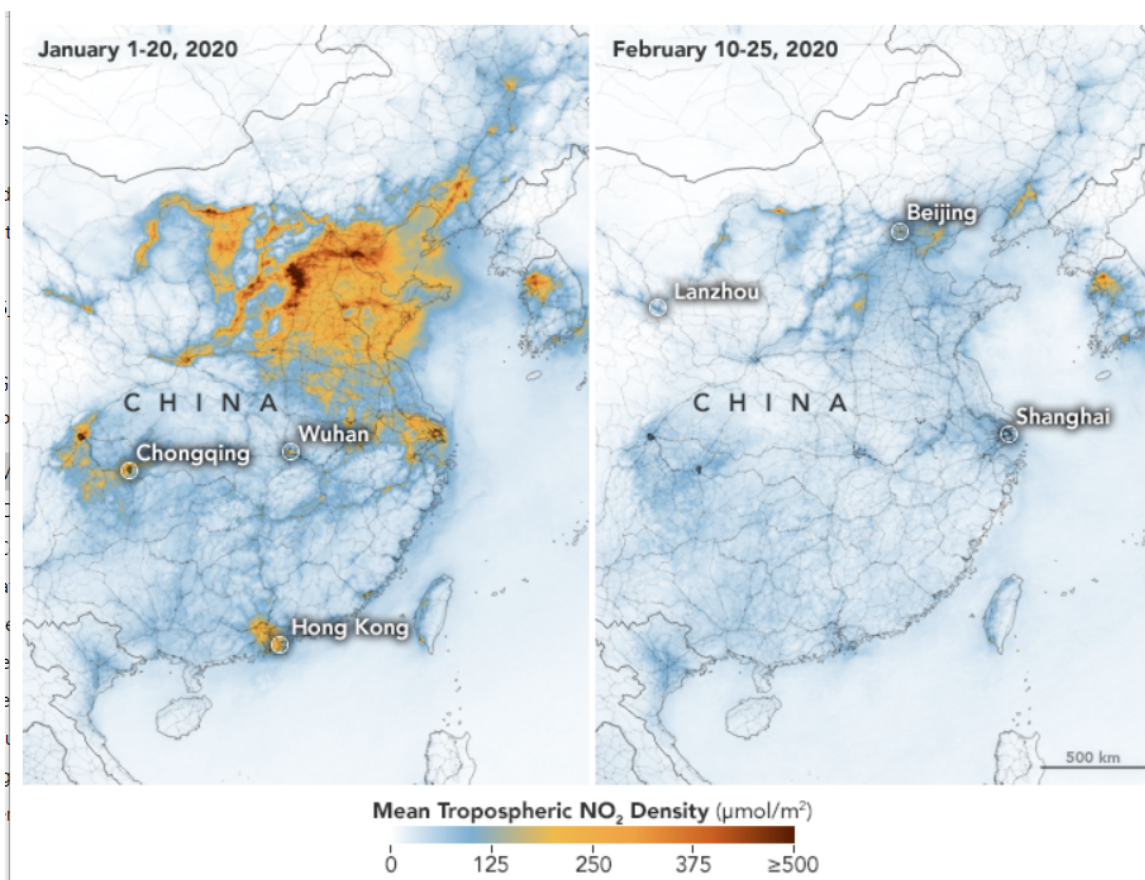
Lockdowns Led to a Decrease in Vehicle Usage and Satellite Images Confirm Decrease in NO₂



Airborne Nitrogen Dioxide Plummet Over China

Image of the Day for March 2, 2020

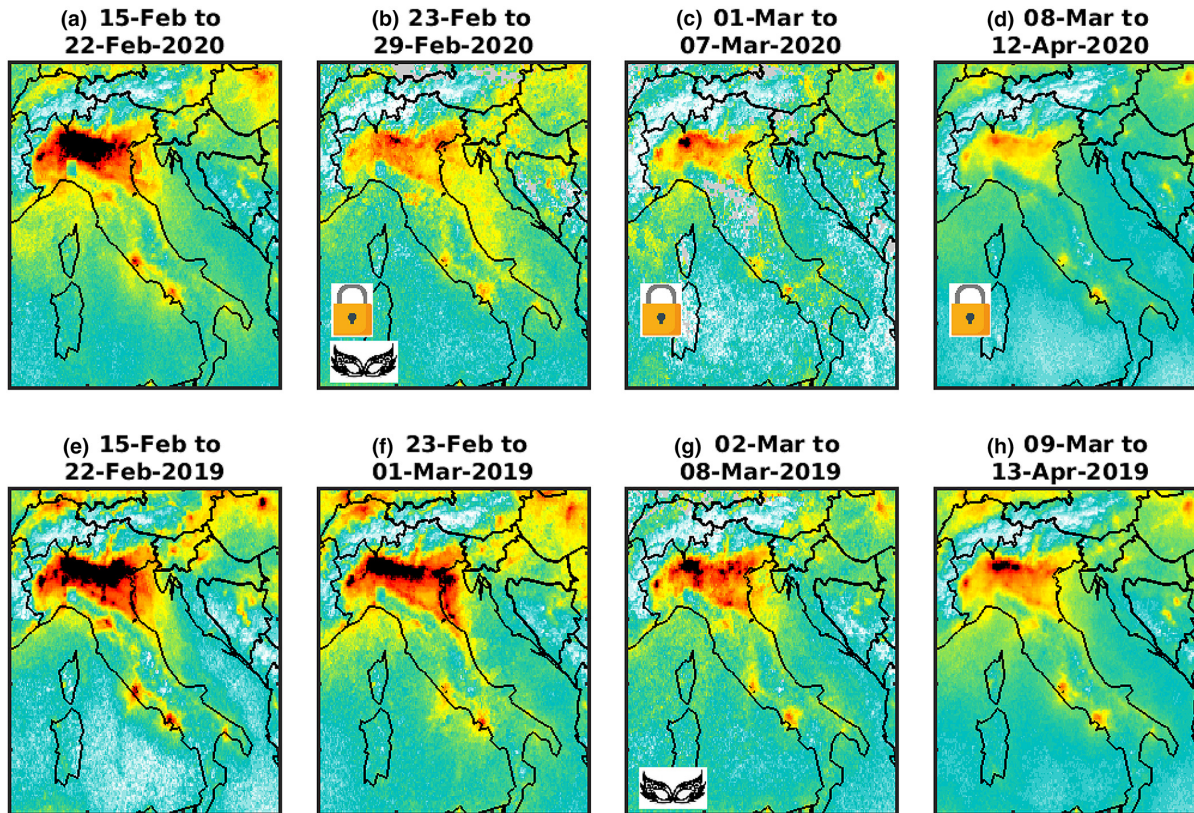
Instrument:
Sentinel-5P



Very Quickly, Publications Appear

Impact of Coronavirus Outbreak on NO₂ Pollution Assessed Using TROPOMI and OMI Observations

M. Bauwens, S. Compernelle, T. Stavrou, J.-F. Müller, J. van Gent, H. Eskes, P. F. Levelt, R. van der A, J. P. Veefkind, J. Vlietinck, H. Yu, C. Zehner



TROPOMI NO₂ (10^{15} molec. cm⁻²)



[Bauwens et al., GRL, 2020]

Generalization to “Pollution” in the Press

The New York Times

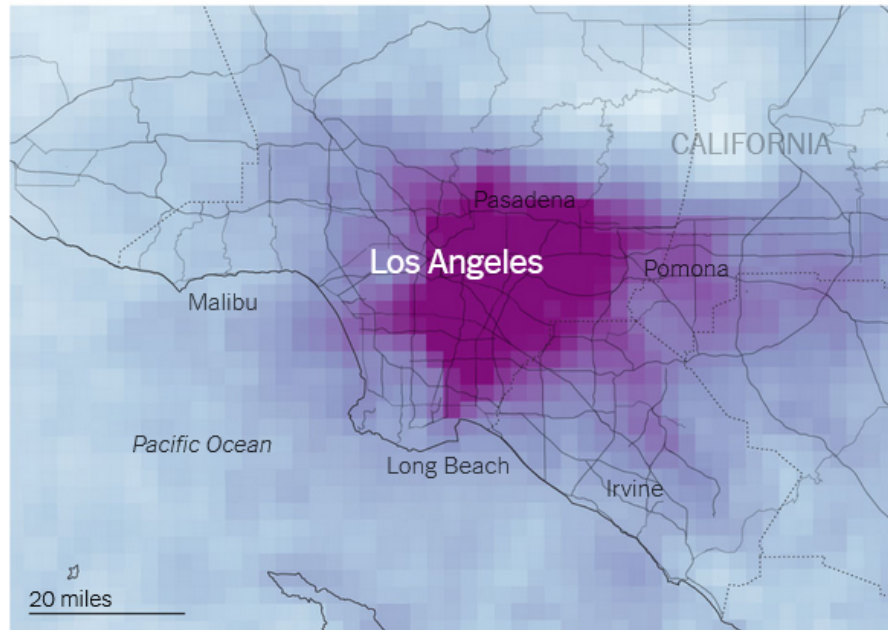
Traffic and Pollution Plummet as U.S. Cities Shut Down for Coronavirus

By [Brad Plumer](#) and [Nadja Popovich](#) March 22, 2020

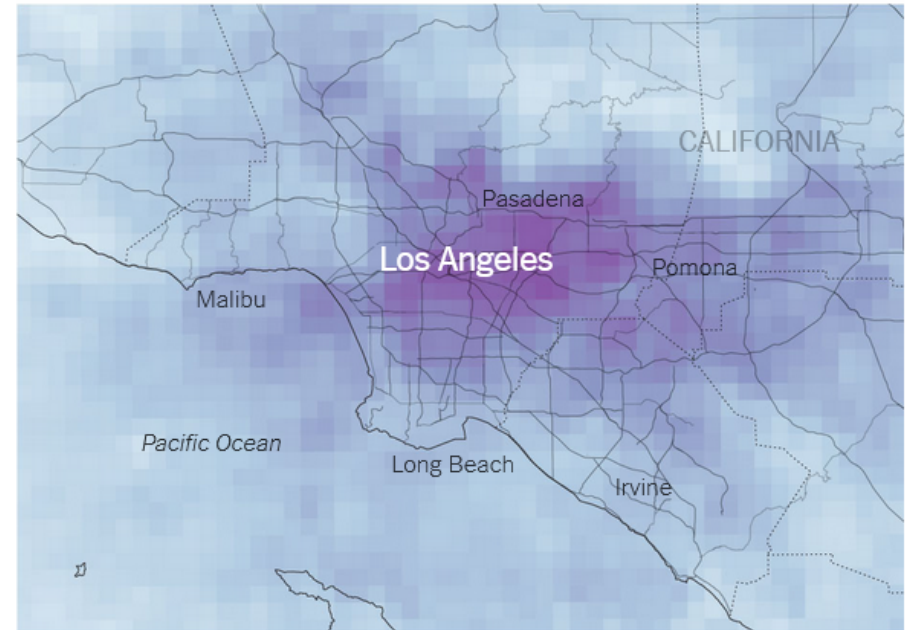
More NO₂ emissions →



2019 March 1 to March 19

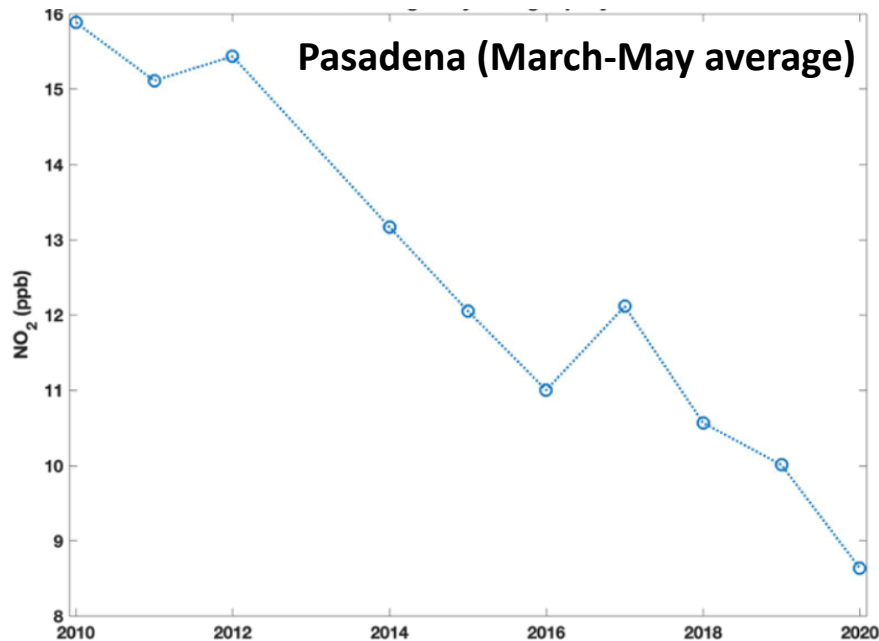


2020 March 1 to March 19

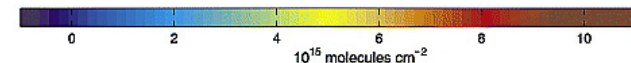
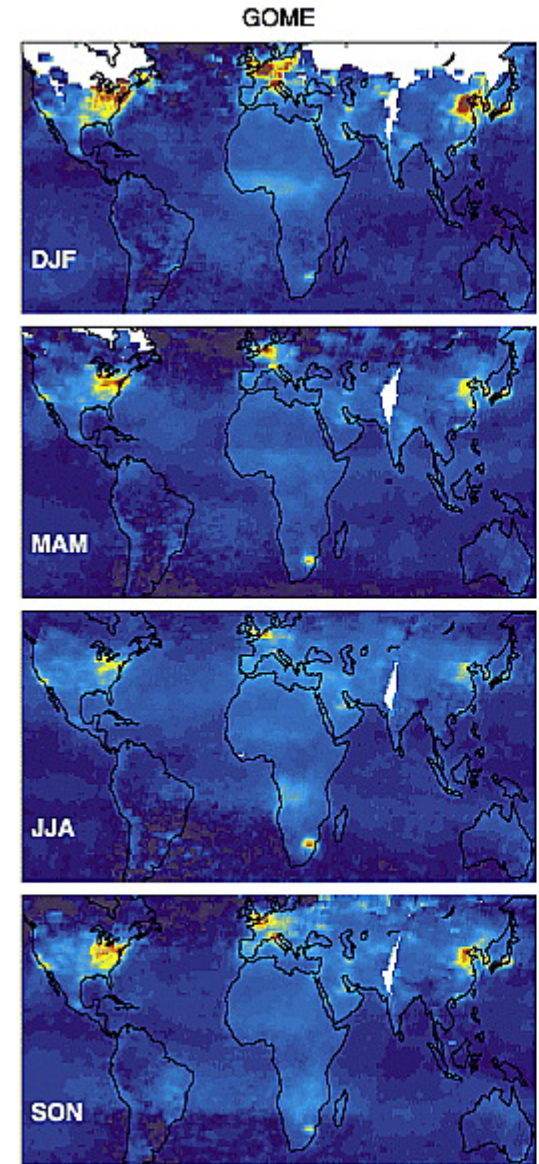


Considerations Beyond NO_x Emissions

- 1) Seasonality & Meteorology
- 2) Longer-term trends
- 3) Non-vehicle pollution
- 4) Role of chemical transformations

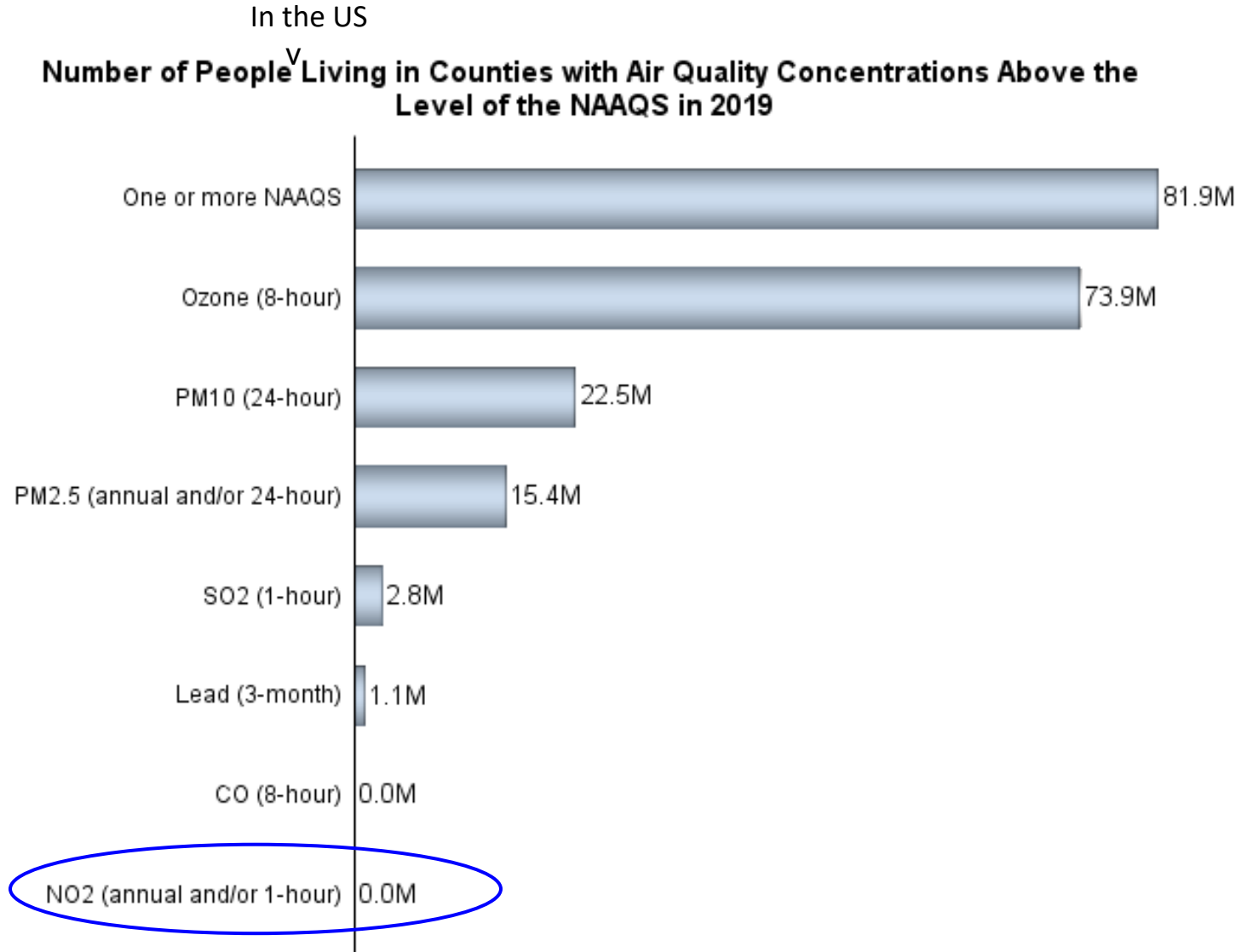


 Paul Wennberg (May 14, 2020)

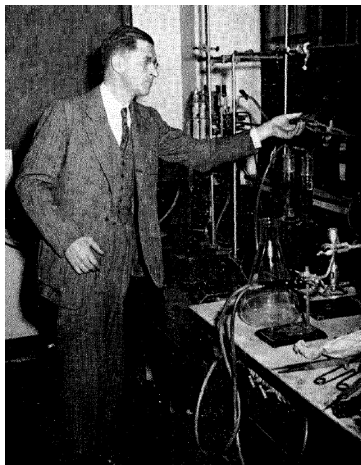


[Martin et al., 2003]

Which “Pollutants” Are a Concern?



Chemical Transformations of Pollutants



Chemistry and Physiology of Los Angeles Smog

A. J. HAAGEN-SMIT

*California Institute of Technology, Pasadena, Calif., and
Los Angeles County Air Pollution Control District, Los Angeles, Calif.*

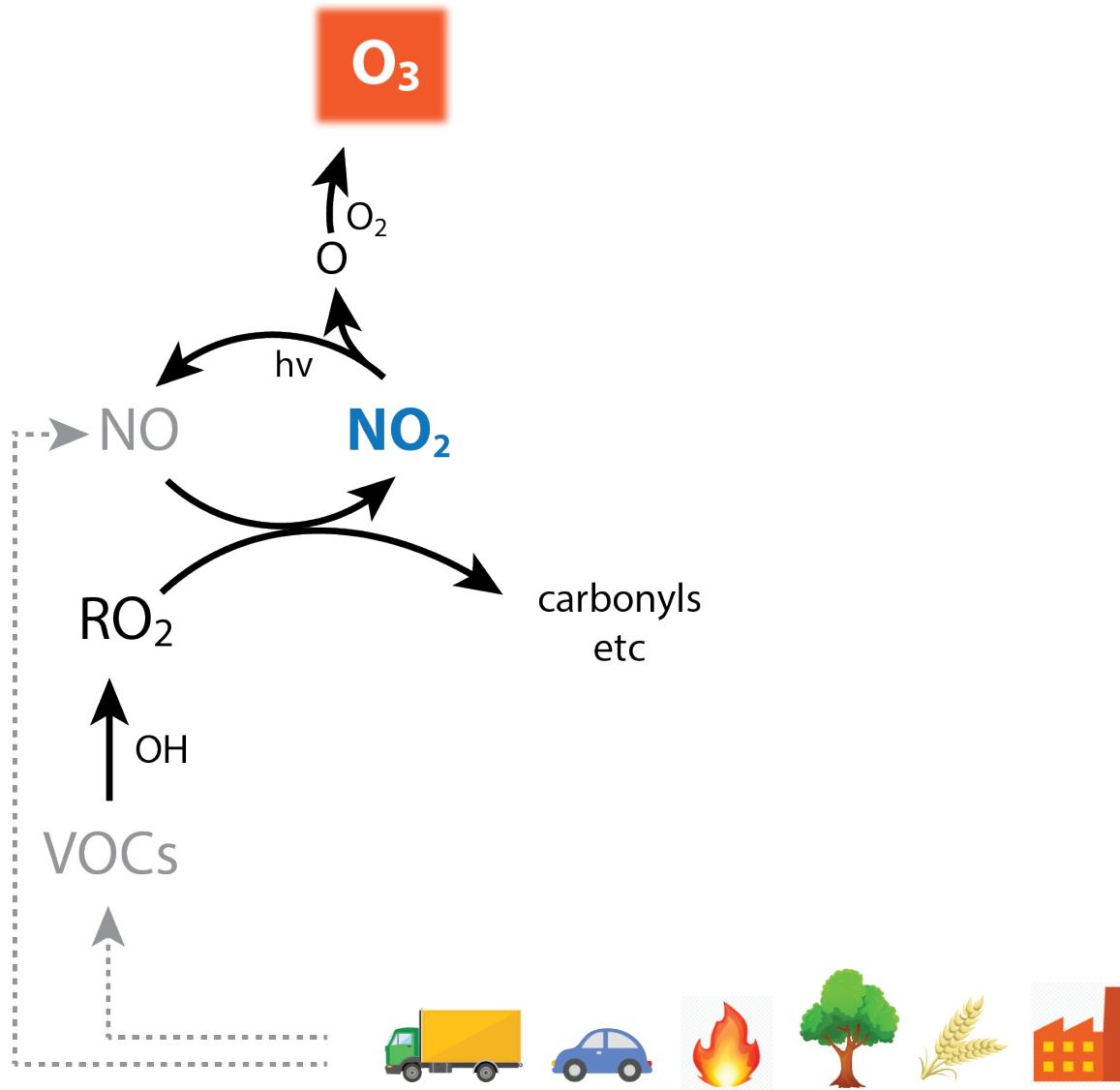
Ind. Eng. Chem. 44:1342 (1952)

Ind. Eng. Chem. 45:2086 (1953)

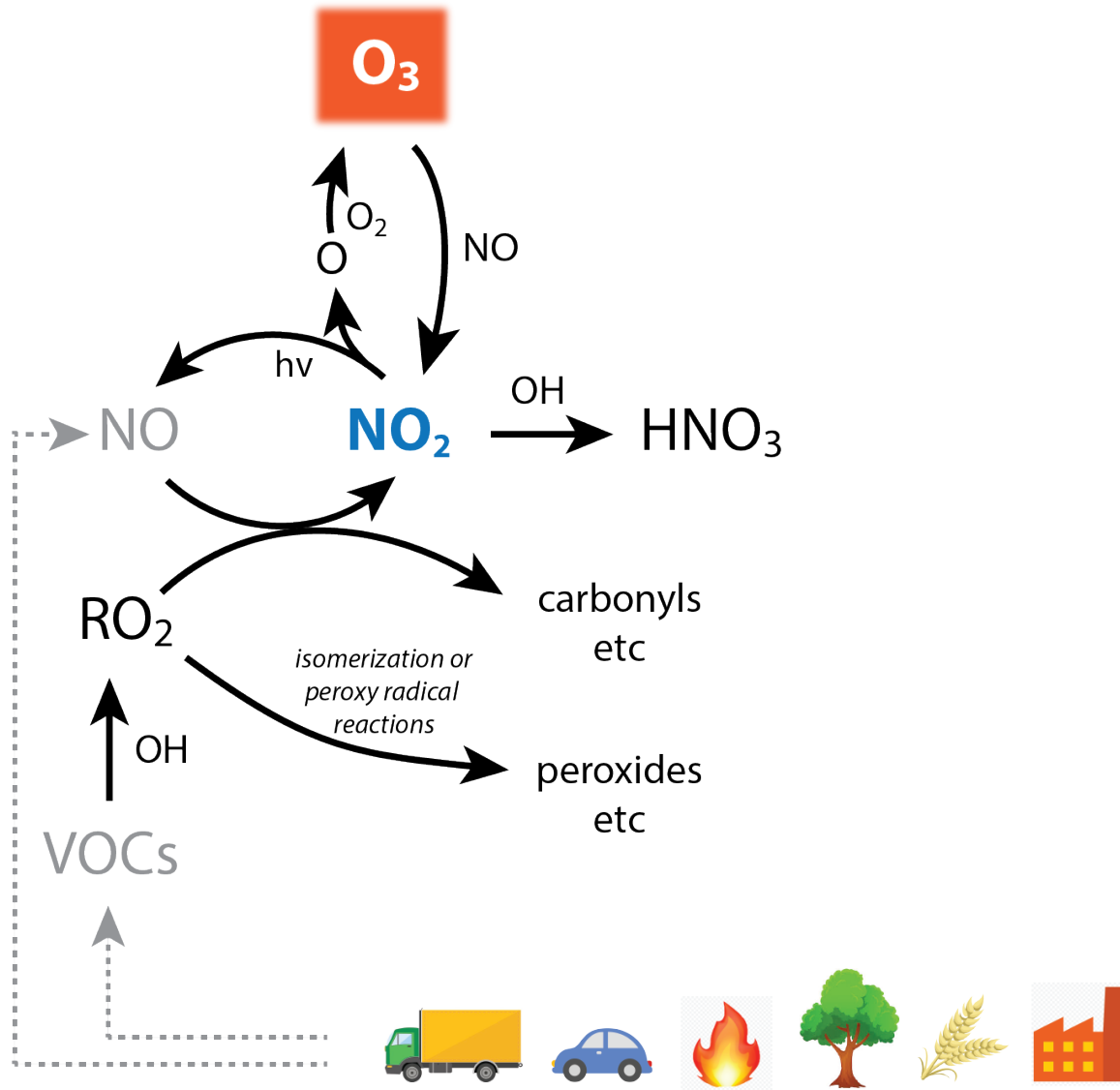
Identified ozone and particulate matter as primary components of smog

Showed they were “secondary pollutants”, formed photochemically from organic compounds + nitrogen oxides

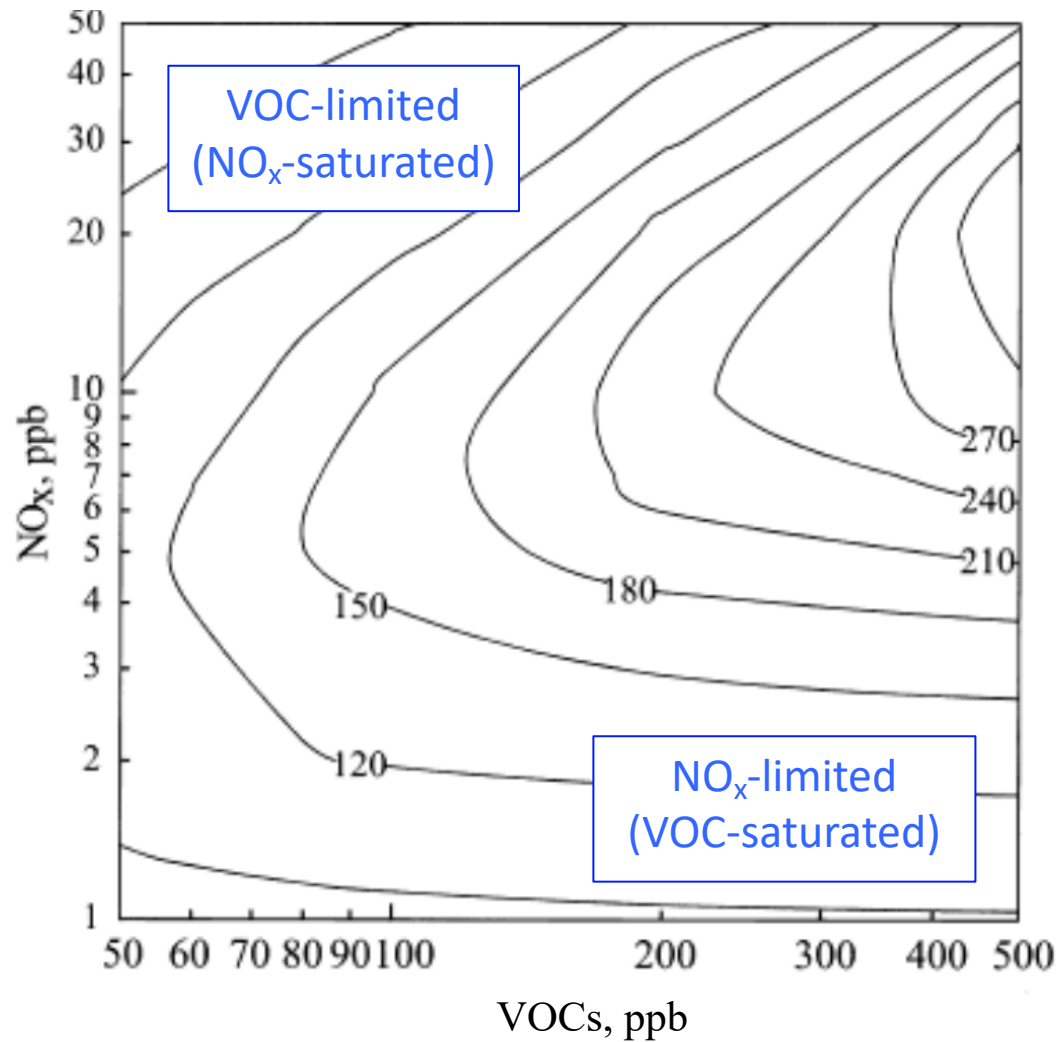
Formation of Secondary Pollutants (O₃ and PM)



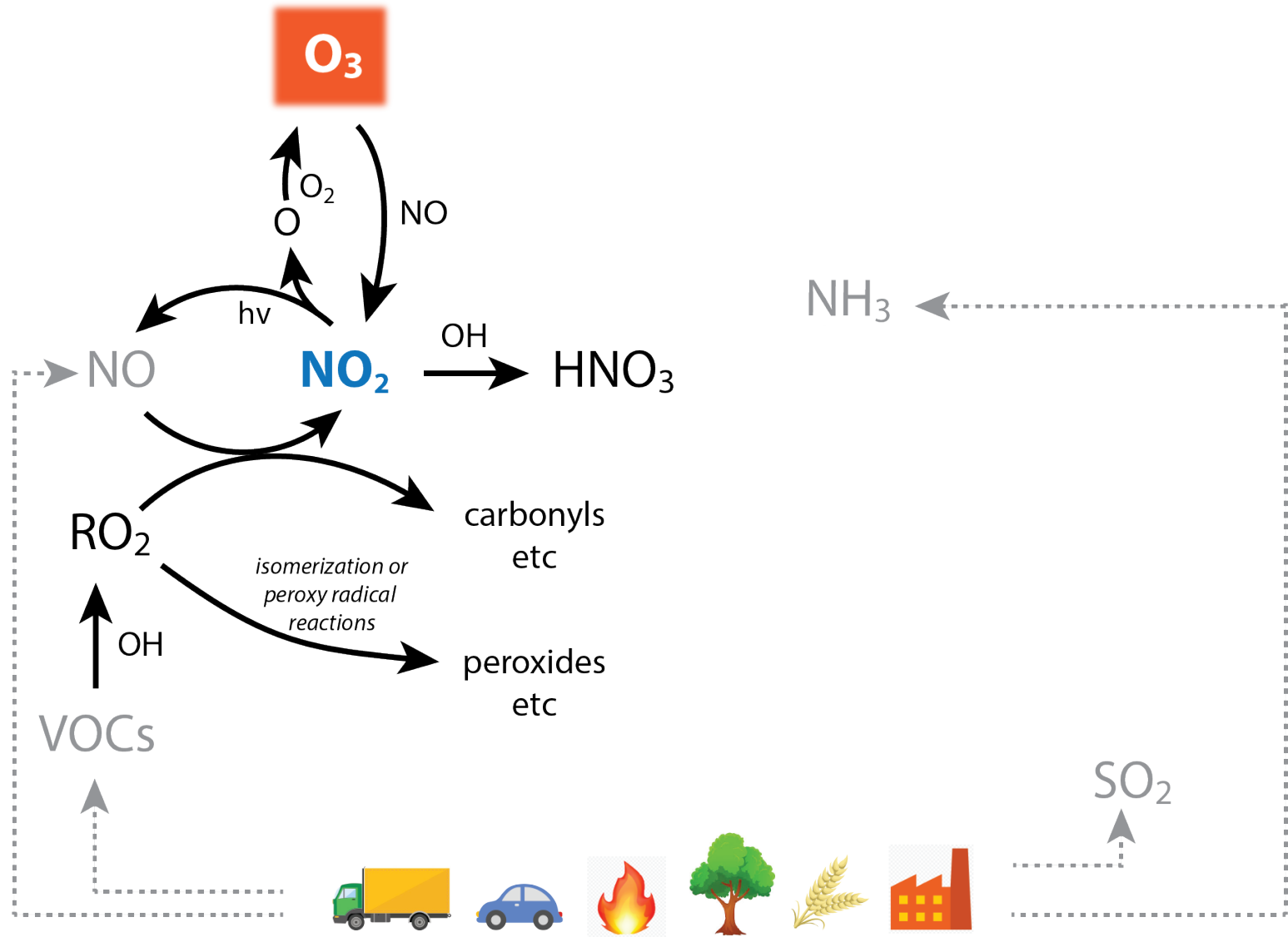
Formation of Secondary Pollutants (O₃ and PM)



O₃ Formation: Dependence on VOCs and NO_x

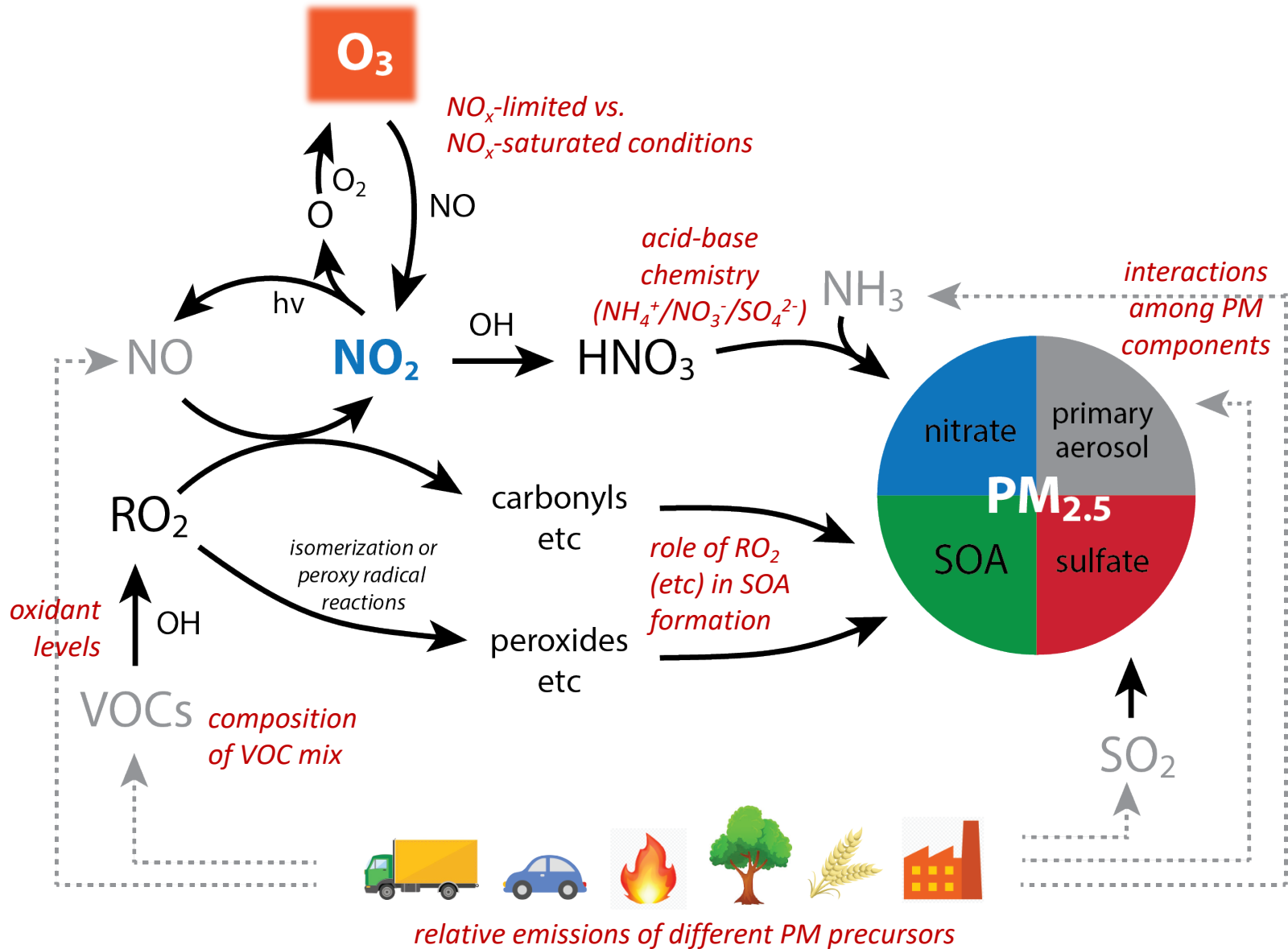


Formation of Secondary Pollutants (O₃ and PM)



Formation of Secondary Pollutants (O_3 and PM)

major nonlinearities/uncertainties



COVID-19 Shutdowns as Chemical Perturbations and an Opportunity

These nonlinearities and interdependencies are challenging to disentangle (and establish causality) from most ambient measurements

COVID-19 shutdowns serve as (un-)natural experiments to examine these, because of the large step-changes in emissions, and provide a glimpse into a future atmosphere with lower emissions

Opportunity to learn more about:

- The role of specific emissions in controlling local air quality
- Local chemical regimes
- Chemical processing in the atmosphere
- Interactions between local emissions and regional/global atmospheric composition and climate