NOAA's Response to the Science Advisory Board Climate Working Group's Letter,

Opportunity for COVID-19-related Earth System monitoring and prediction efforts as a result of worldwide shelter in place/ stay at home policies.

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27 April 2022

Outline

- Review SAB Climate Working Group (CWG) recommendations to NOAA
- Discuss NOAA's response to SAB CWG

Purpose

- **8 April 2020:** SAB CWG recommended that NOAA take advantage of the *opportunity for COVID-19-related Earth System monitoring and prediction efforts as a result of worldwide shelter in place/ stay at home policies.*
- **March - April 2022:** NOAA drafted a response to the SAB CWG letter documenting its research efforts to address the CWG's recommendations.
- **27 April 2022:** NOAA's efforts summarized and discussed.

SAB CWG Recommendations to NOAA

Actions

1. *"What can NOAA do?"*
2. *"What can NOAA organize?"*
3. *"How can NOAA help?"*

Objectives

1. *Observe and quantify atmospheric composition and radiation responses* to the pandemic's economic downturn.
2. *Model the Earth system impacts* of these changes.
3. *Collaborate with public health agencies to assess prediction capability* for vector-borne diseases.

NOAA's Response to the SAB CWG

NOAA has crafted a response to the CWG's recommendations:

- Introduction with CWG recommendations
- Summary of NOAA efforts addressing Objectives 1-3
- Supporting Material with detailed reports on each research study

The detailed NOAA response document is available in the materials for this meeting. Today's presentation will provide an overview of the document and highlight NOAA's efforts.

Summary of Efforts by NOAA and Partners

Objective 1

- Led intensive field campaigns on the ground and in the air
- Increased sampling at long-term monitoring sites
- Supported field sampling by academic partners
- Analyzed satellite observations
- Produced data archive
- Organized teleconferences and meeting sessions
- Reviewed hundreds of related papers from across the globe

Objective 2

- Produced near-real-time emissions inventories
- Quantified the pandemic's perturbations of air pollutants and greenhouse gases
- Modeled impacts of pandemic emission perturbations on air quality
- Modeled impacts of atmospheric composition changes on Earth's radiative balance

Objective 3

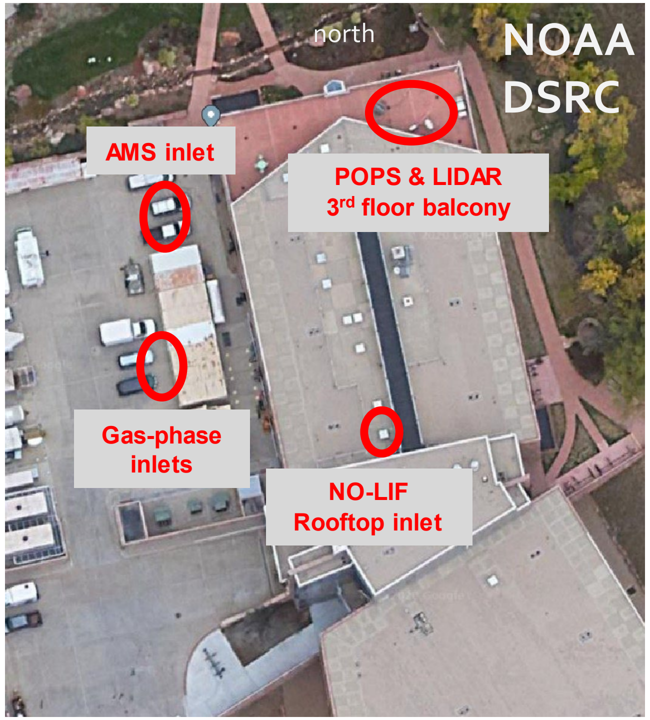
- Modeled scenarios to predict vector-borne virus responses to weather variations
- Assess weather/climate prediction skill at predicting vector-borne virus incidence
- Develop statistical model for vector-borne disease outbreaks

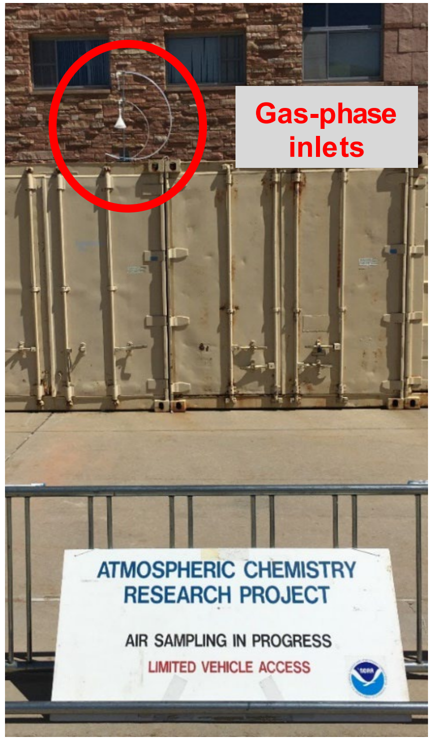
Results of this research are in preparation or published in numerous papers in scientific journals

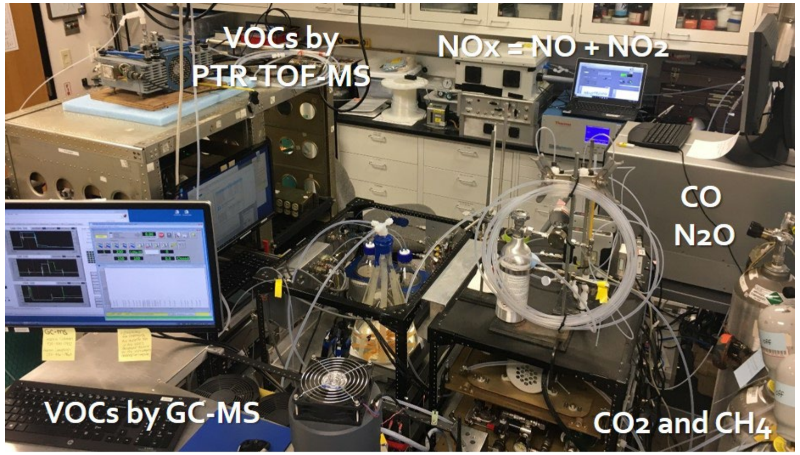
Detailed reports and participants

Authors	Title	Participating Institutions
Brown et al.	Research Activities in Response to Emissions Reductions Following the Onset of the COVID-19 Pandemic	OAR CSL, CIRES, US universities, international research centers
Ren and Luke	NOAA/ARL's Measurements and Data Analyses during the COVID-19 Pandemic	OAR ARL, OAR GML, OAR CSL, NESDIS, UMD, NIST, MDE, Stony Brook U
Lopez-Coto et al.	East Coast Outflow – COVID (ECO-COVID) Aircraft Campaign	OAR GML, OAR ARL, CIRES, NIST
Chang et al.	NOAA CSL/GML/CIRES Research on COVD-19 Impacts on Tropospheric Ozone	OAR CSL, OAR GML, CIRES
Langford et al.	Analysis of surface ozone changes in the Denver-Boulder area during the COVID-19 lockdown	OAR CSL, CIRES
Kopacz	AC4 input on COVID-related research	OAR CPO, various US universities
Kondragunta et al.	Markers of Economic Activity in Satellite Data: COVID-19 Lockdown Impact on Air Quality	NESDIS, UMD, CIRA, CIMMS, OAR CSL
Campbell	Impacts of the COVID-19 economic slowdown on ozone pollution in the U.S.	OAR ARL, CISESS, George Mason U
Schnell et al.	Modeling studies of emissions and air quality forecasts during the pandemic period and comparisons to business-as-usual conditions	OAR GSL, OAR CSL, CIRES
Ming et al.	Assessing the influence of COVID-19 on Earth's radiative balance	OAR GFDL, NASA, CalTech, UMBC, U Reading (UK)
Baker et al.	Susceptible Supply Limits the Role of Climate in the Early SARS-CoV-2/COVID-19 Pandemic	Princeton U, OAR GFDL, NIH
Holcomb et al.	Investigating the Predictability of West Nile Virus Disease from Using Climate Data	OAR GSL, CDC, OAR CPO

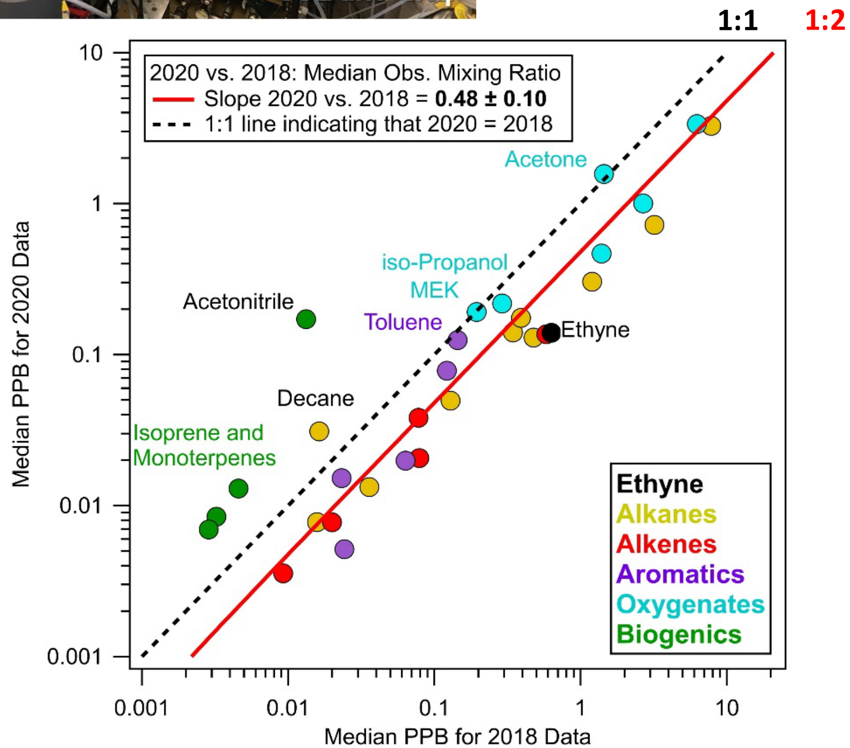
COVID-AQS, NOAA's ground-based field study of pandemic air quality





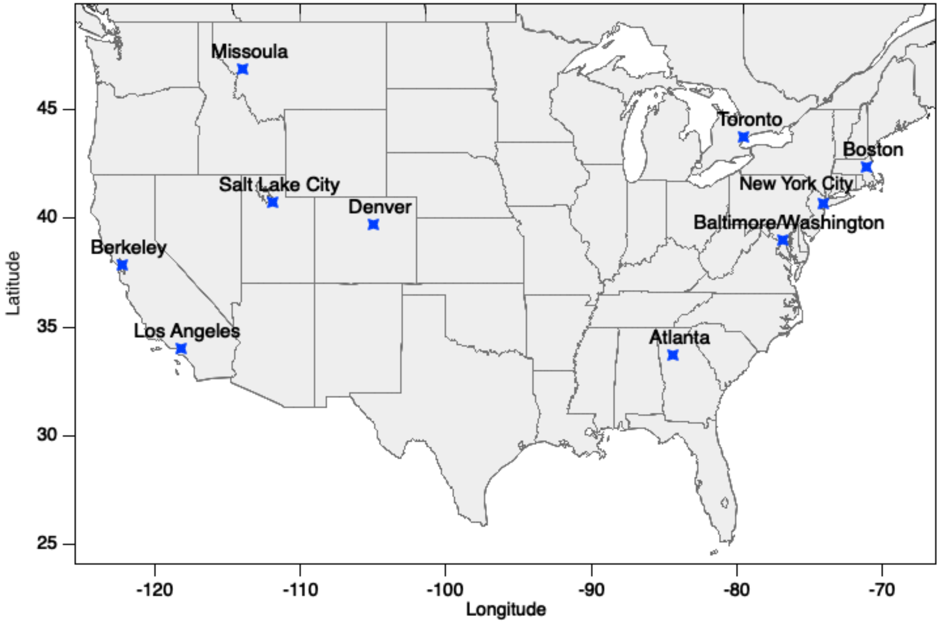


Two COVID Air Quality Study field campaigns in Boulder, Colorado, organized by OAR's Chemical Sciences Laboratory (CSL), quantified the levels of a large number of reactive air pollutants, greenhouse gases, aerosols, and meteorological variables during the spring and summer of 2020. Analysis of COVID-AQS is providing information about emissions, detailed assessment of satellite observations, and evaluation of NOAA's air quality models.



Collaborative research by NOAA's university partners during the pandemic

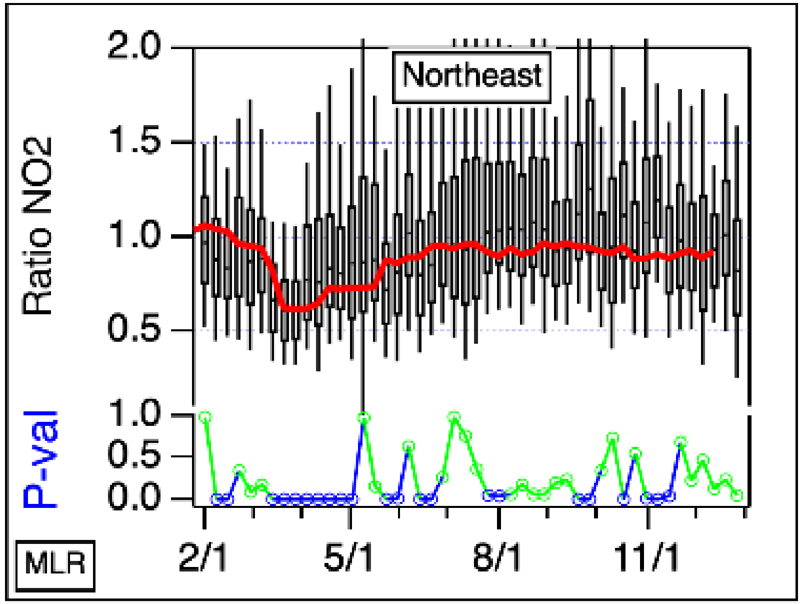
In collaboration with COVID-AQS, the Atmospheric Chemistry, Carbon Cycle and Climate (AC4) Program in OAR's Climate Program Office funded 8 projects to measure and analyze data across the country. The measurements included NOx, ozone, VOCs, aerosols and greenhouse gases from ground sites, mostly in urban areas. Overall, all investigators found a profound decrease in emissions during April and May, which often persisted through the summer and beyond. Analysis of subsequent months (Fall 2021 and later) is ongoing.

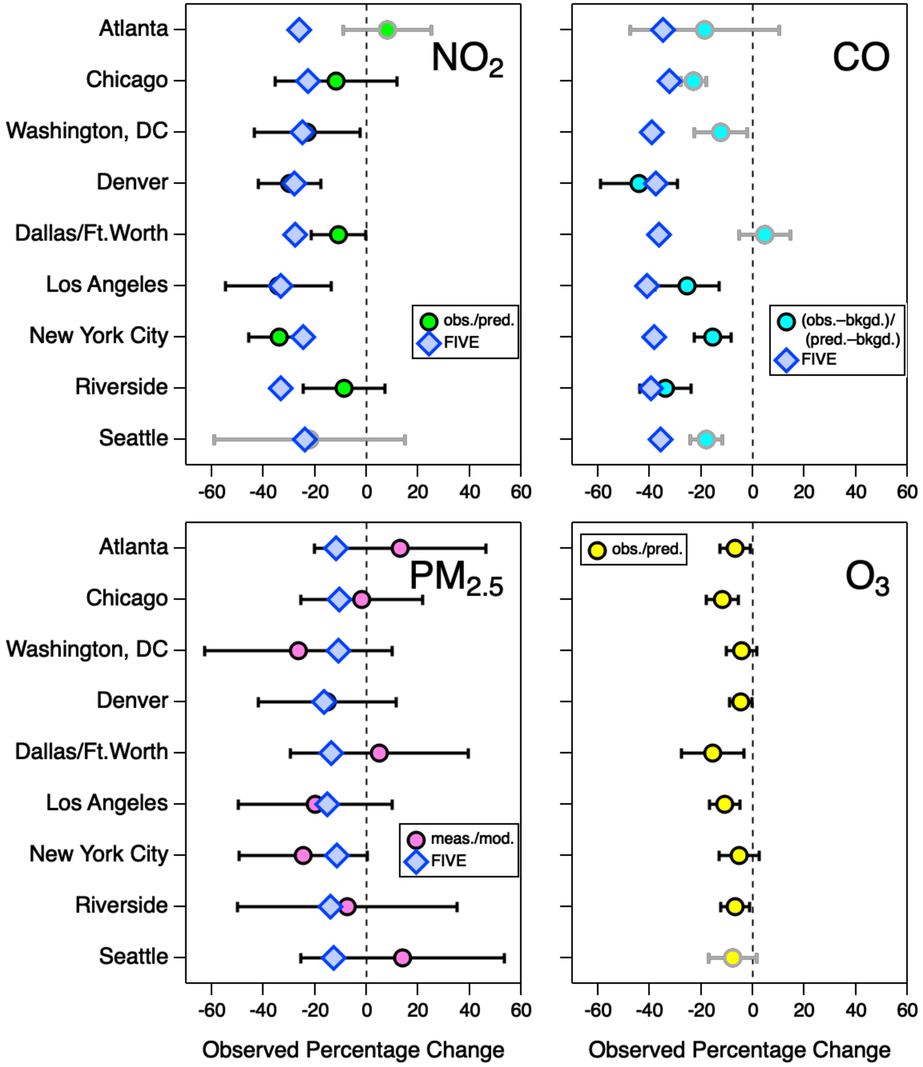


#	Investigators	Project title	Institution(s)
1	Baek, Bok Haeng; Yang, Kai	Developing an enhanced bottom-up and top-down emissions inventories over the U.S. during the pandemic outbreaks by satellite data and chemical transport model	George Mason University, University of Maryland
2	Barsanti, Kelley; Blake, Donald	Using Observations of Gaseous Compounds in the LA Basin during COVID-19 to Elucidate Sources and Atmospheric Processes Affecting Urban Air Quality	UC Riverside, UC Irvine
3	Commane, Roisin; Hutyra, Lucy; Wofsy, Steve	Understanding methane changes in cities affected by COVID-19 shutdowns	Columbia U, Boston U, Harvard U
4	Davis, Kenneth; Turnbull, Jocelyn; Weiss, Ray; Lin, John; Gurney, Kevin	COVID impact on urban GHG emissions: A multi-city investigation	Penn State U; U of Colorado; UC San Diego; U of Utah, Northern Arizona U
5	Hu, Lei; Miller, Scot	Quantifying the impacts of COVID-19 on U.S. national and regional non-CO2 greenhouse gas emissions from atmospheric observations	U of Colorado; Johns Hopkins U
6	Mitchell, Logan	Tracking impacts of COVID-19 lockdowns & recovery on urban atmospheric composition at neighborhood scales with public-transit based measurements	U of Utah
7	Ng, Nga Lee (Sally)	Changes in Aerosol Loading and Composition in Atlanta Driven by Changes in Anthropogenic Emissions during the COVID-19 Pandemic	Georgia Tech
8	Wennberg, Paul	Changes in Air Quality in Los Angeles Associated with COVID-19 'Safer-at-Home' Traffic Reductions	CalTech

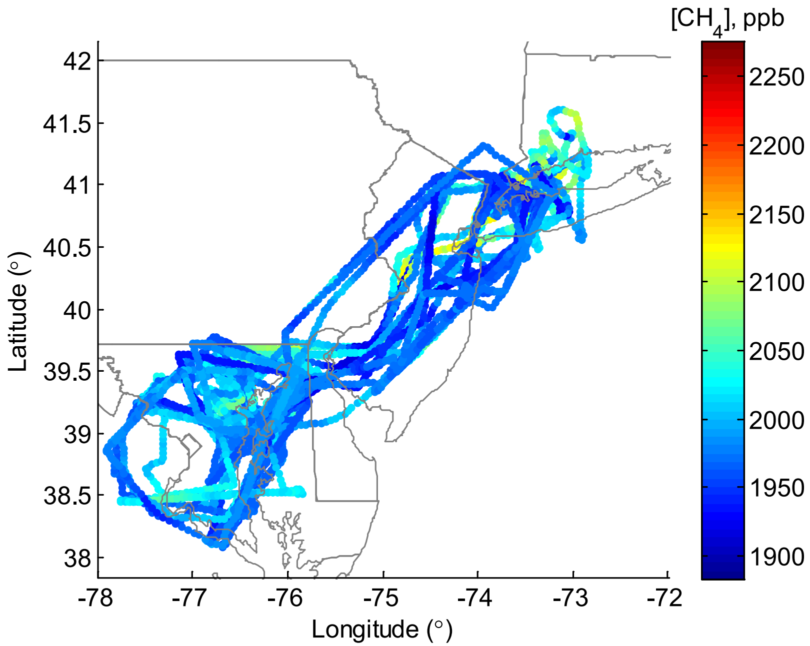
Analysis of routine monitors to understand air quality changes during the pandemic

OAR CSL compiled an archive of regulatory air quality monitoring data throughout 2020 of four major pollutants from the U.S. air quality monitoring network, including NO_2, CO, O_3 and $PM_{2.5}$. The 2020 data were compared to historical data spanning either 5 or 10 years (i.e., 2010-2019 or 2015-2019). These data and the subsequent analysis were shared with collaborators from the nationwide network of NOAA partners.





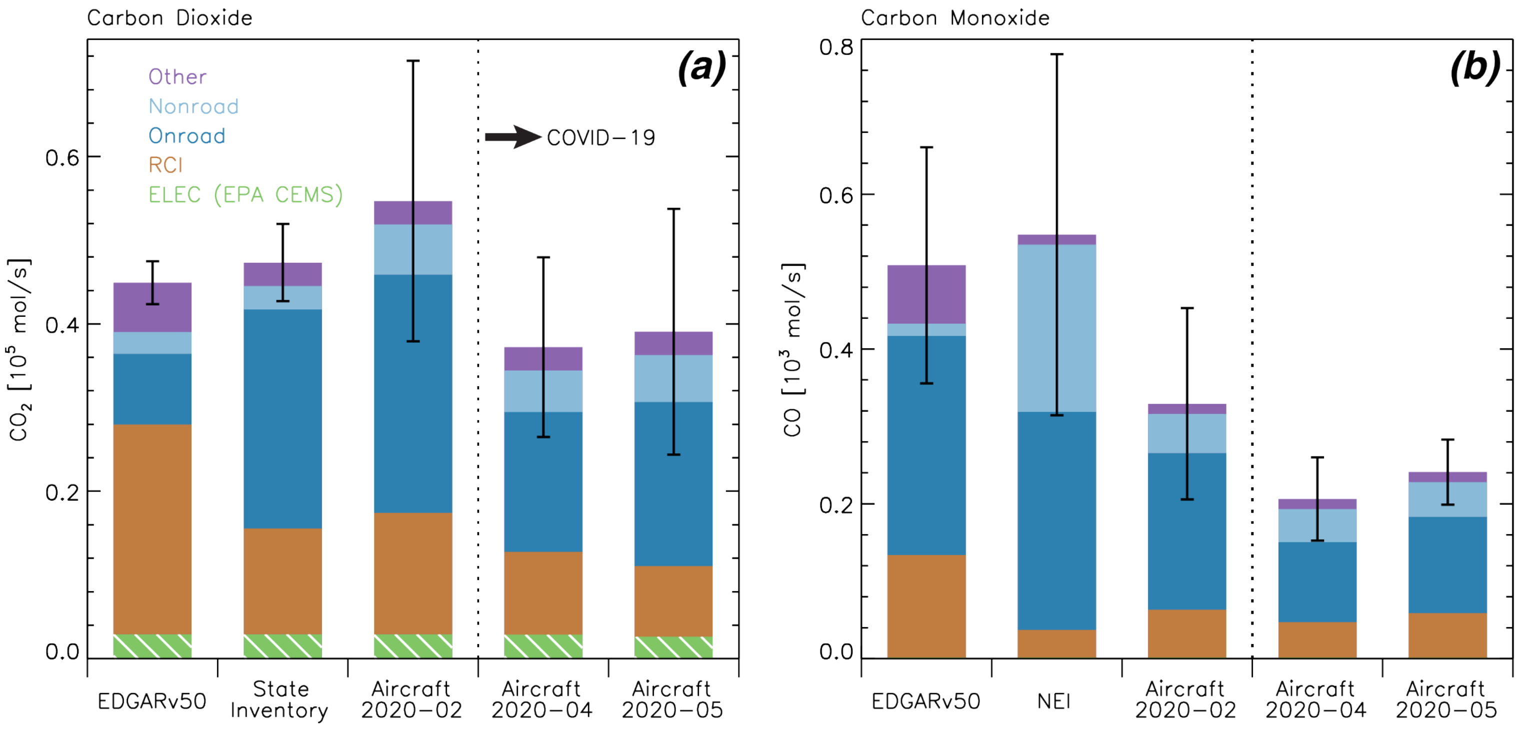
Analysis of aircraft field measurements to understand pandemic emissions changes



ARL quantified the reductions in the emissions of carbon dioxide (CO_2) and carbon monoxide (CO) over the Baltimore-Washington area during the COVID-19 pandemic by analyzing their aircraft observations with a mass balance approach.

They found that CO_2 and CO emission rates declined by about 30% and 34%, respectively, in April - May 2020, relative to the February mean. On-road transportation was the largest contributor to the pandemic declines.

OAR's Air Resources Laboratory (ARL) carried out aircraft and ground-based measurements of reactive air pollutants and greenhouse gases in the Baltimore-Washington and New York City metropolitan areas during the spring and summer of 2020.



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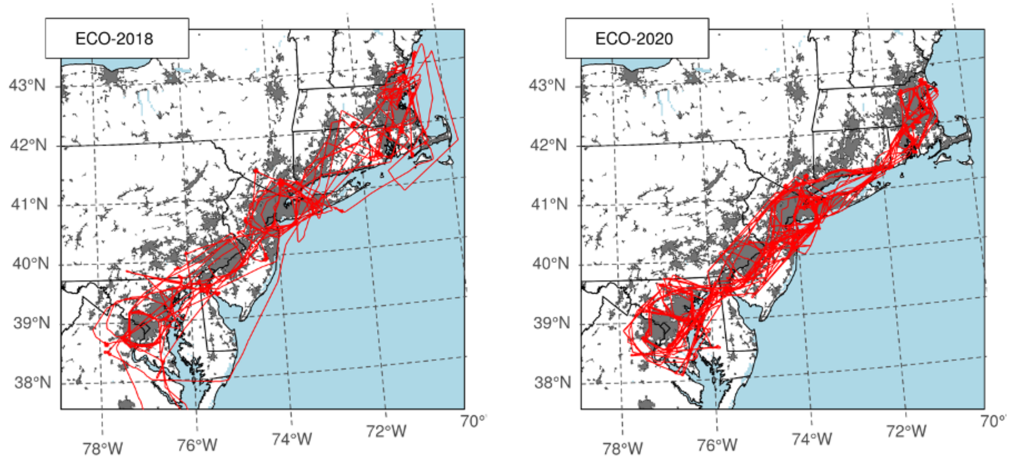
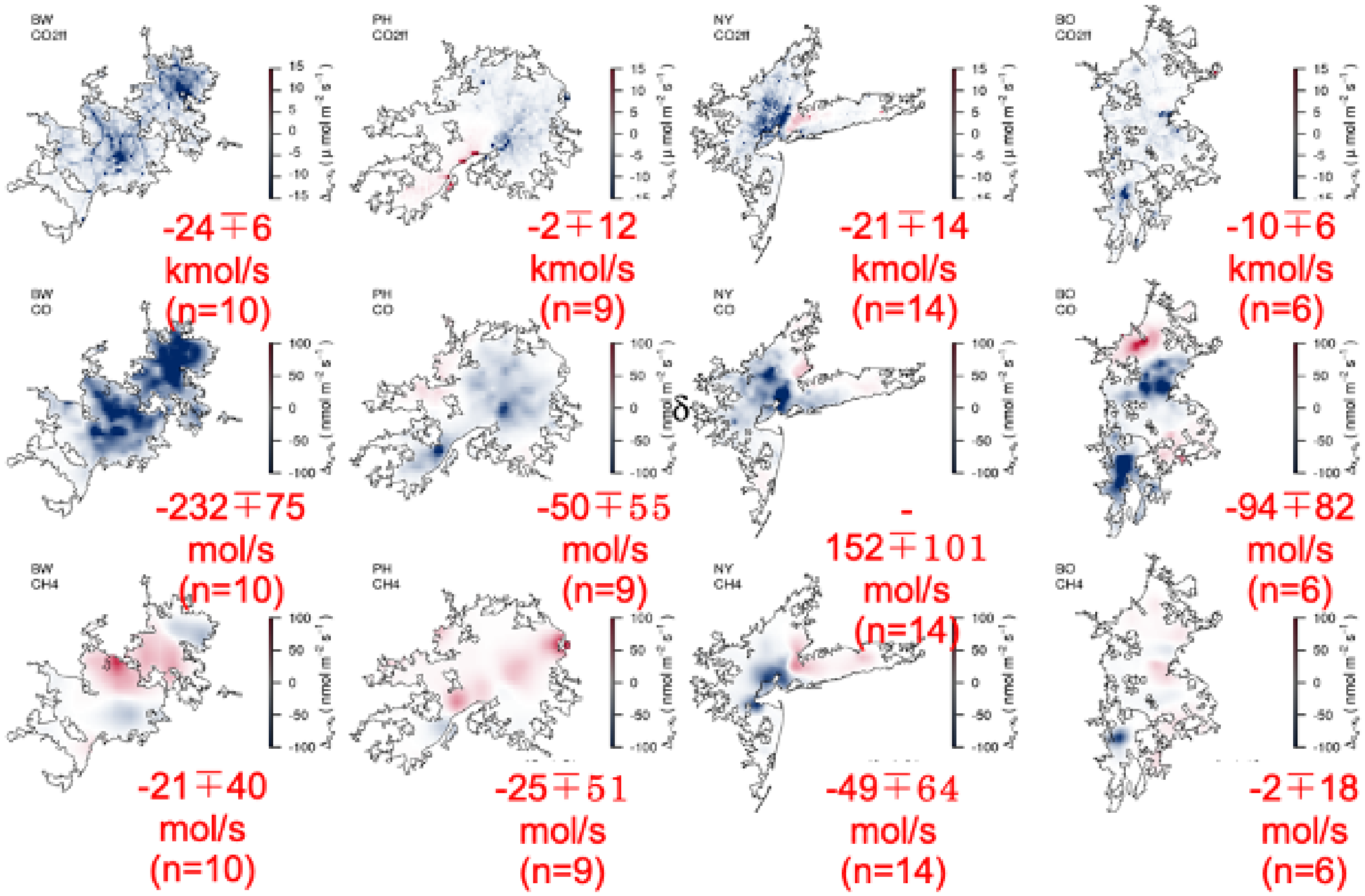
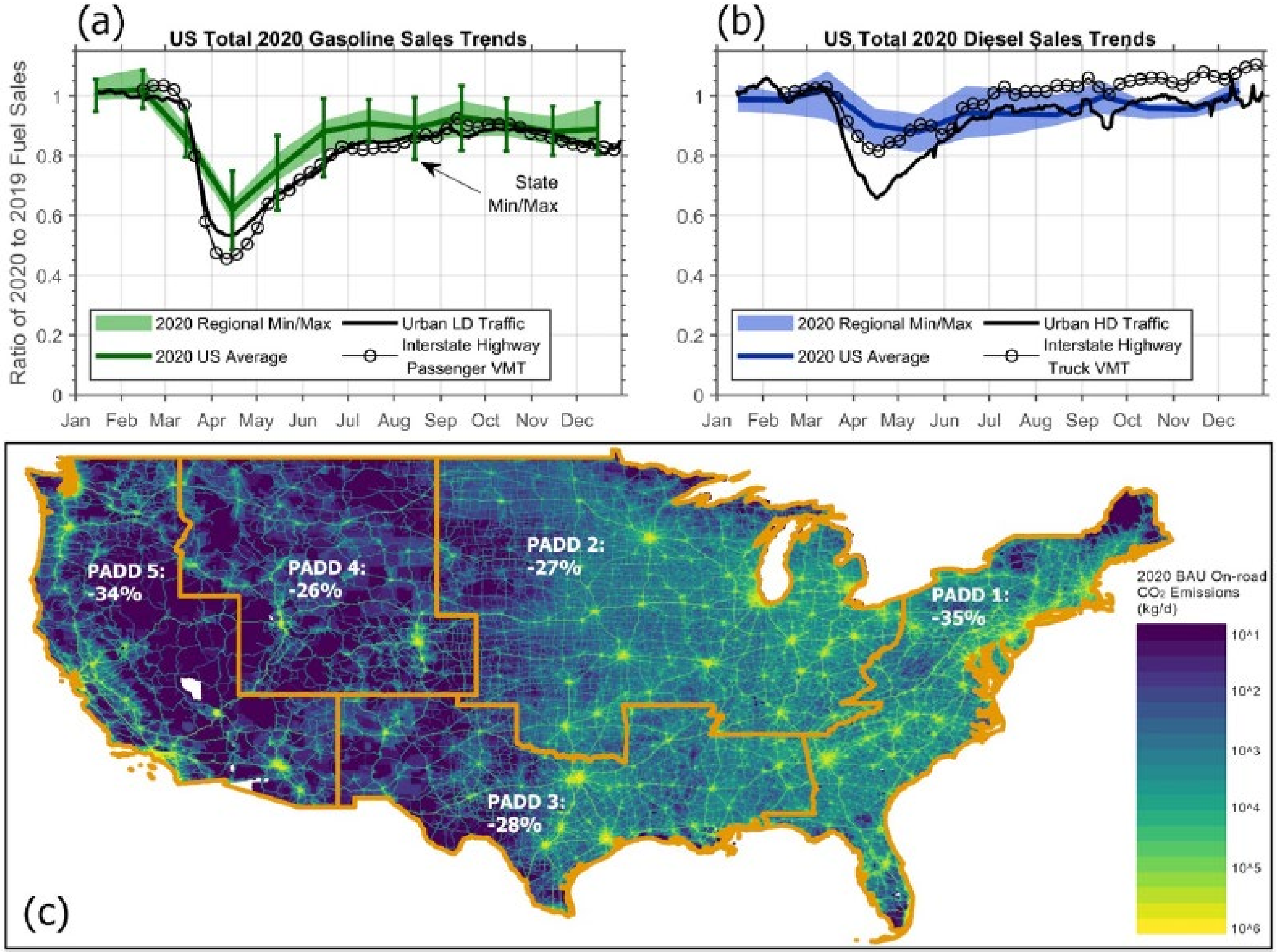




OAR's Global Monitoring Laboratory (GML) led aircraft field sampling of carbon dioxide (CO_2), carbon monoxide (CO), and methane (CH_4) over the New York City, Boston, Philadelphia, and the Baltimore-Washington metro areas during spring of 2020 and compared these observations with similar aircraft sampling carried out in 2018.

GML incorporated their aircraft observations into ARL's HYSPLIT inverse modeling system to calculate emissions in these 4 urban areas. They found systematic reductions in all of these cities' CO_2 and CO emissions in April 2020 relative to April 2018, partial recovery of emissions in May 2020, and established that CO_2 emissions declines were consistent with reduced traffic. In contrast, CH_4 emissions in these cities were not significantly different in 2020 and 2018.

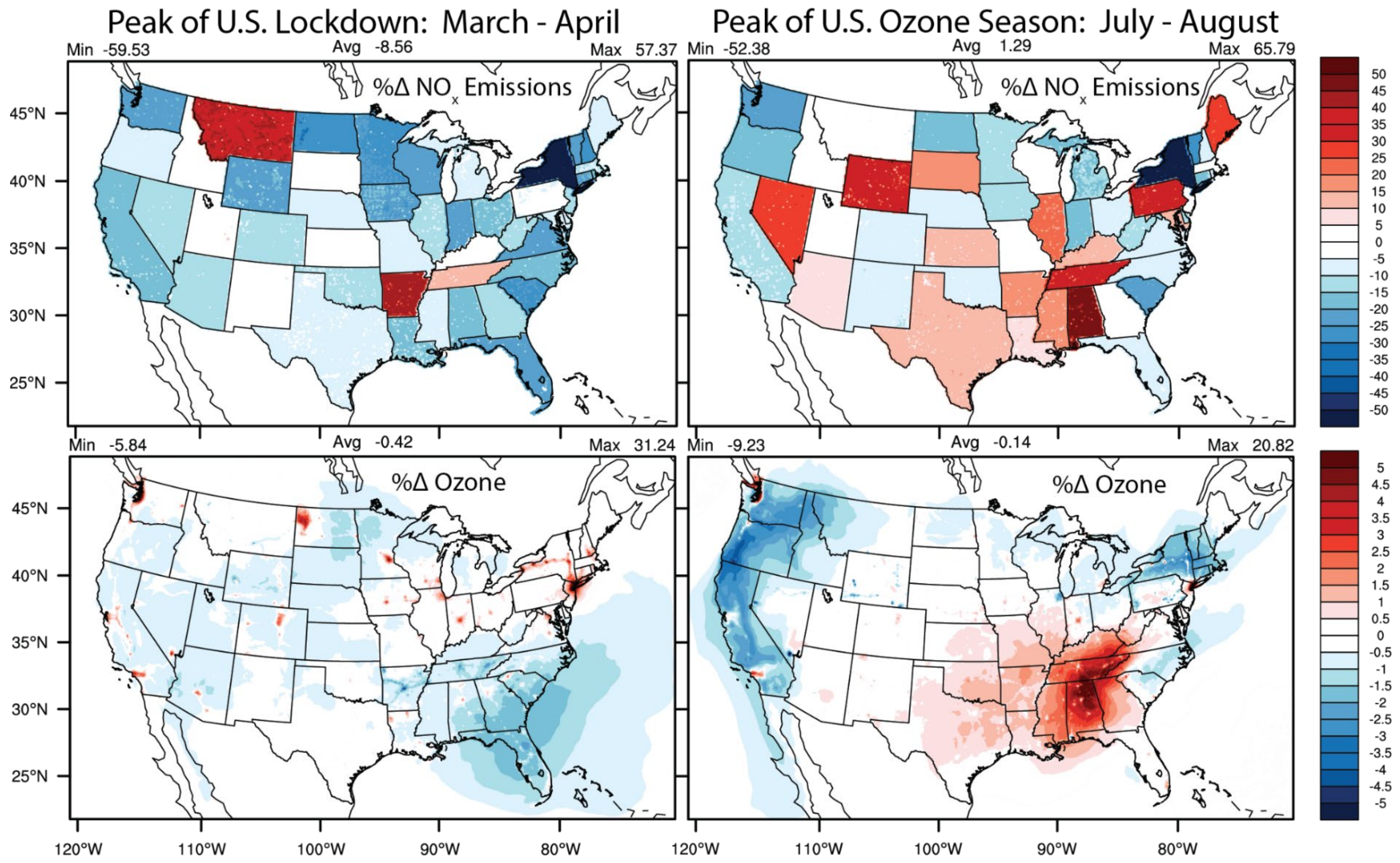
Quantifying pandemic emissions changes using bottom-up approaches



OAR's CSL developed a bottom-up inventory for US traffic emissions, the Fuel-Based Inventory of Vehicle Emissions (FIVE). Fuel-based methodologies are well-suited to capture rapid variations in their respective sectors as these data are publicly available from the US Department of Energy on a near real-time basis. CSL combined this information on fuel activity with co-emitted air pollutant emission factors to develop near-real-time gridded emission inventories for air quality models. CSL's near-real-time FIVE inventory captured pandemic changes that were not captured in the available inventories from the nation's regulatory agencies, which were several years out of date. FIVE was subsequently used in a number of NOAA air quality modeling and satellite analysis studies.

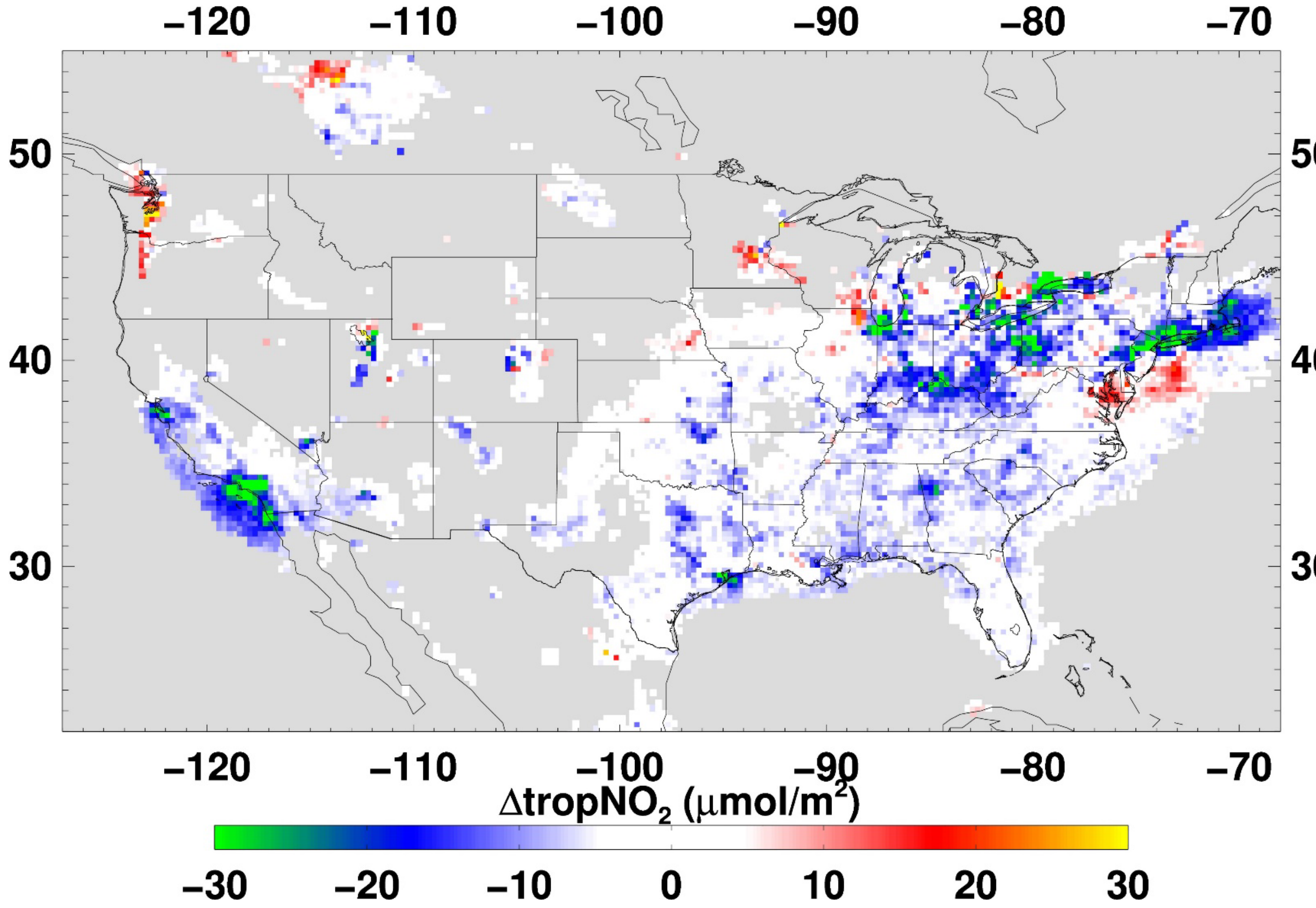
Modeling air quality impacts during the pandemic

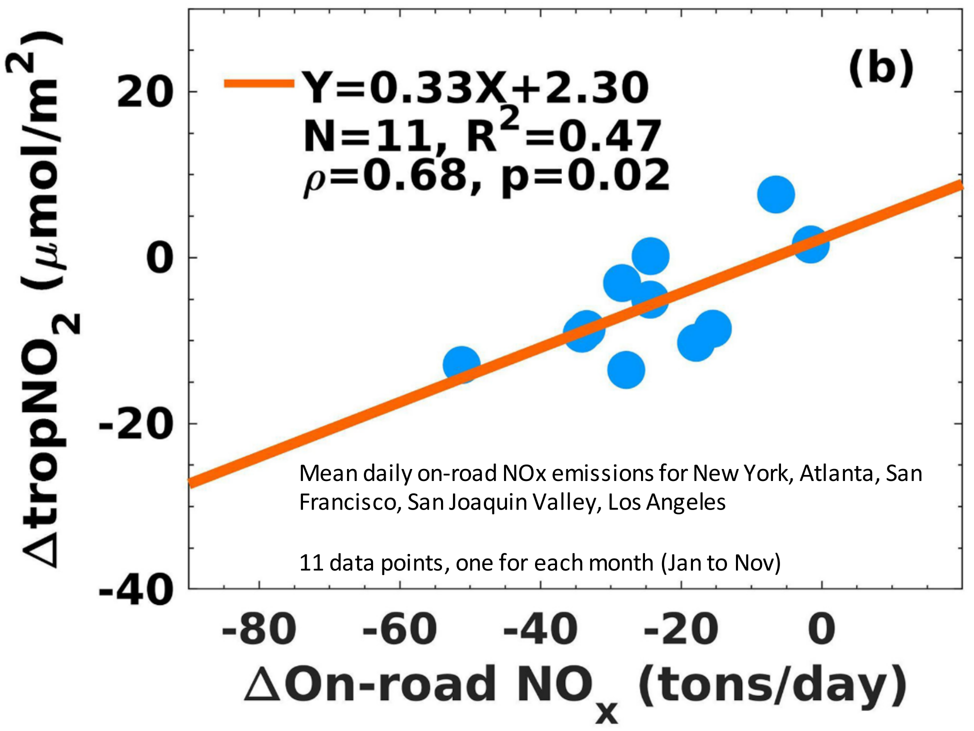
OAR ARL investigated the regional differences in the impact of pandemic lockdowns on near-surface ozone (O_3) formation across the U.S., combining both ground and satellite-based observations of NO_2 to infer changes in precursor emissions due to the COVID-19 economic slowdown. ARL used CSL's FIVE emissions as input to an air quality model quite similar to NOAA's operational daily forecast to quantify the related changes in O_3 between spring and summer 2020. While reduced emissions decreased springtime O_3 in some areas, there were also notable increases in many areas. By summer, relaxed mobility restrictions, shifts in vehicle fleets and increased wildfires led to widespread O_3 increases.



NOAA analysis of satellite observations to understand pandemic related emissions changes

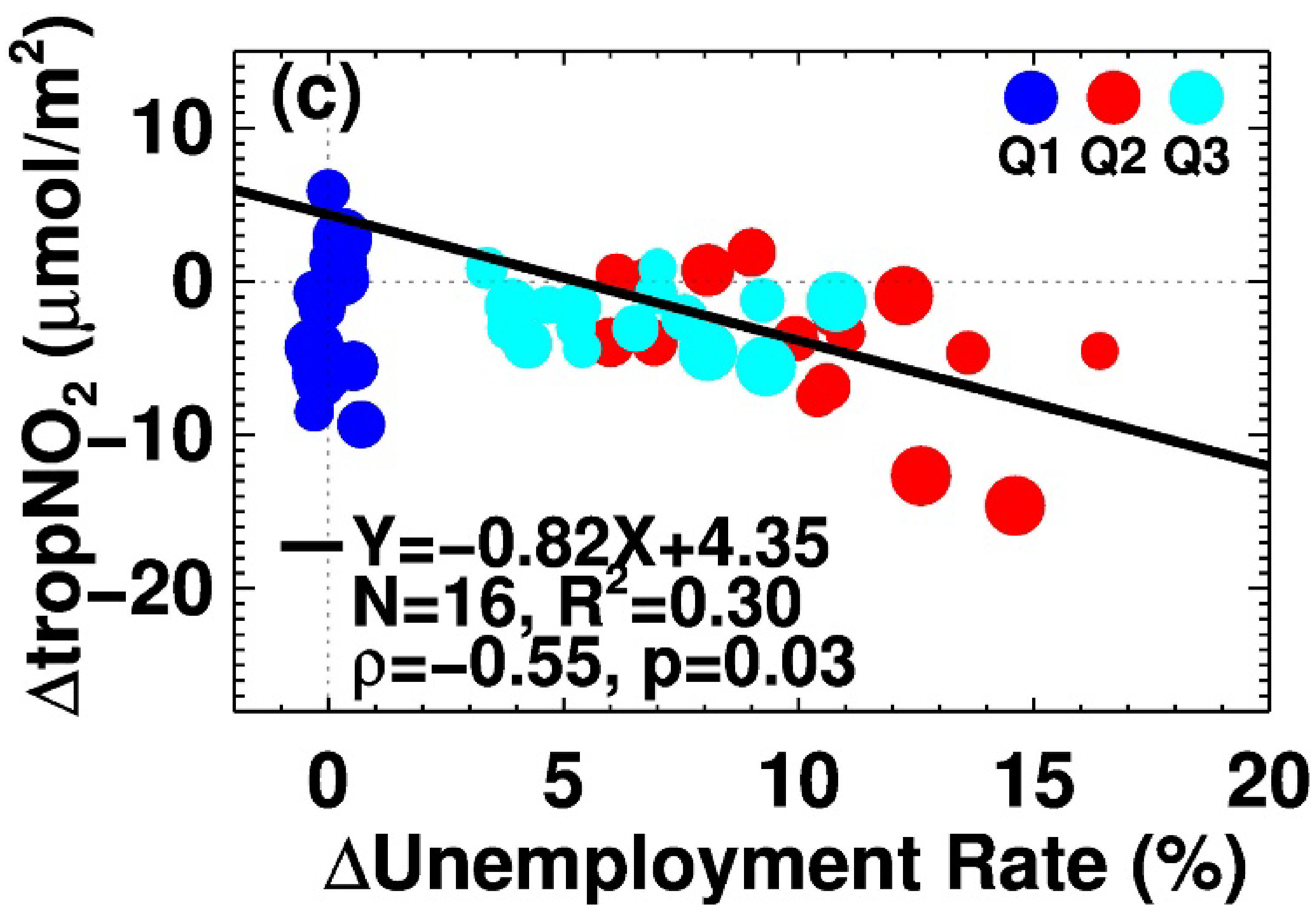
A NESDIS-OAR joint study was the first to correlate pandemic related lockdown changes in on-road NO_x emissions to reported changes observed in satellite NO_2 data.





S. Kondragunta, Z. Wei, B. McDonald, D. Goldberg, D. Tong, Fingerprints of a new normal urban air quality in the United States, JGR-Atmospheres, 2021

NOAA analysis of satellite observations to understand pandemic related emissions changes



- Found a negative linear correlation between the unemployment rate during the height of the pandemic-related lockdown in Quarter 2 (red circles) and the observed tropospheric column of nitrogen dioxide (tropNO_2).

- Demonstrated that tropNO_2 detected from satellites can serve as an indicator of changes in human activity (e.g., shifts from internal combustion to electric vehicles, remote work, etc.).

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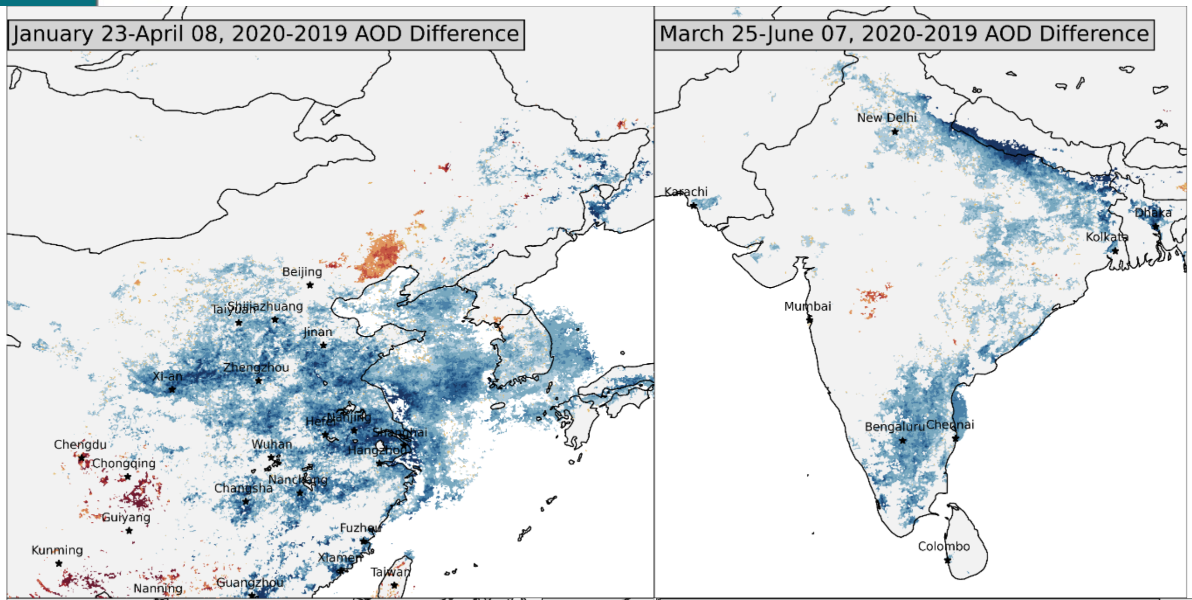
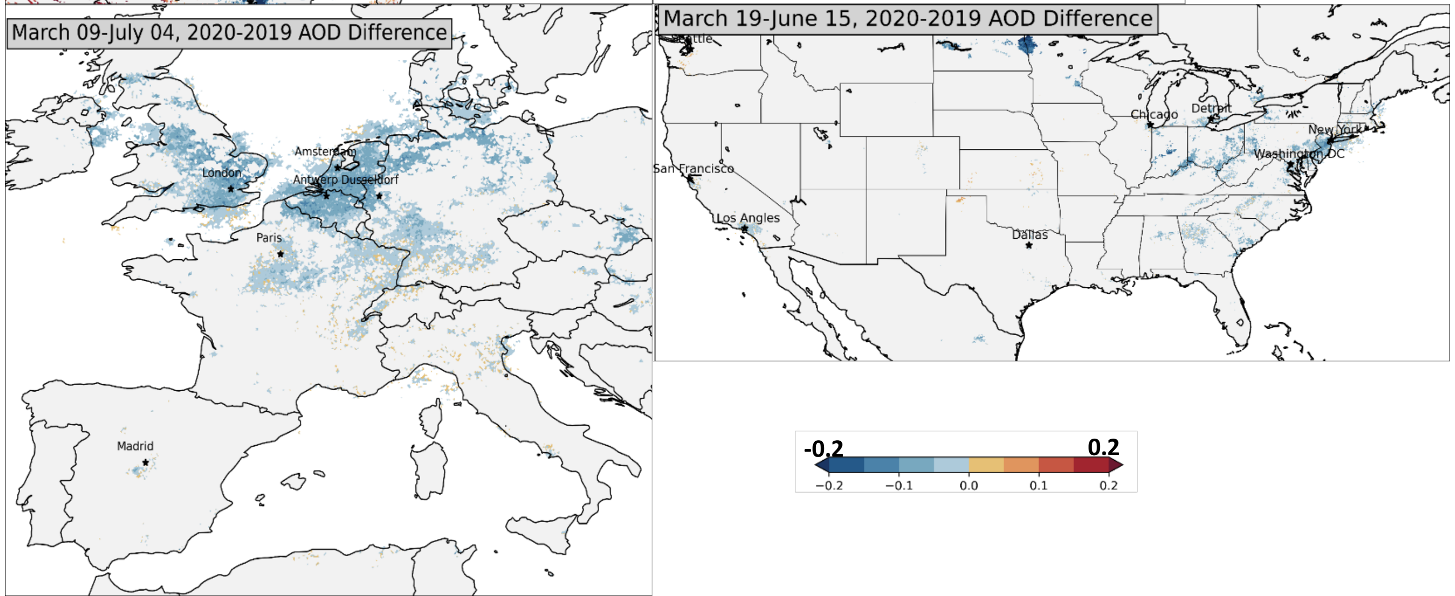


- COVID-19 project provided support to reprocess Suomi NPP Visible Infrared Imaging Radiometer Suit (VIIRS) aerosol optical depth data record on Amazon Web Services Cloud

- Reprocessing was important to generate reference data for interpreting lockdown related changes in aerosol optical depth

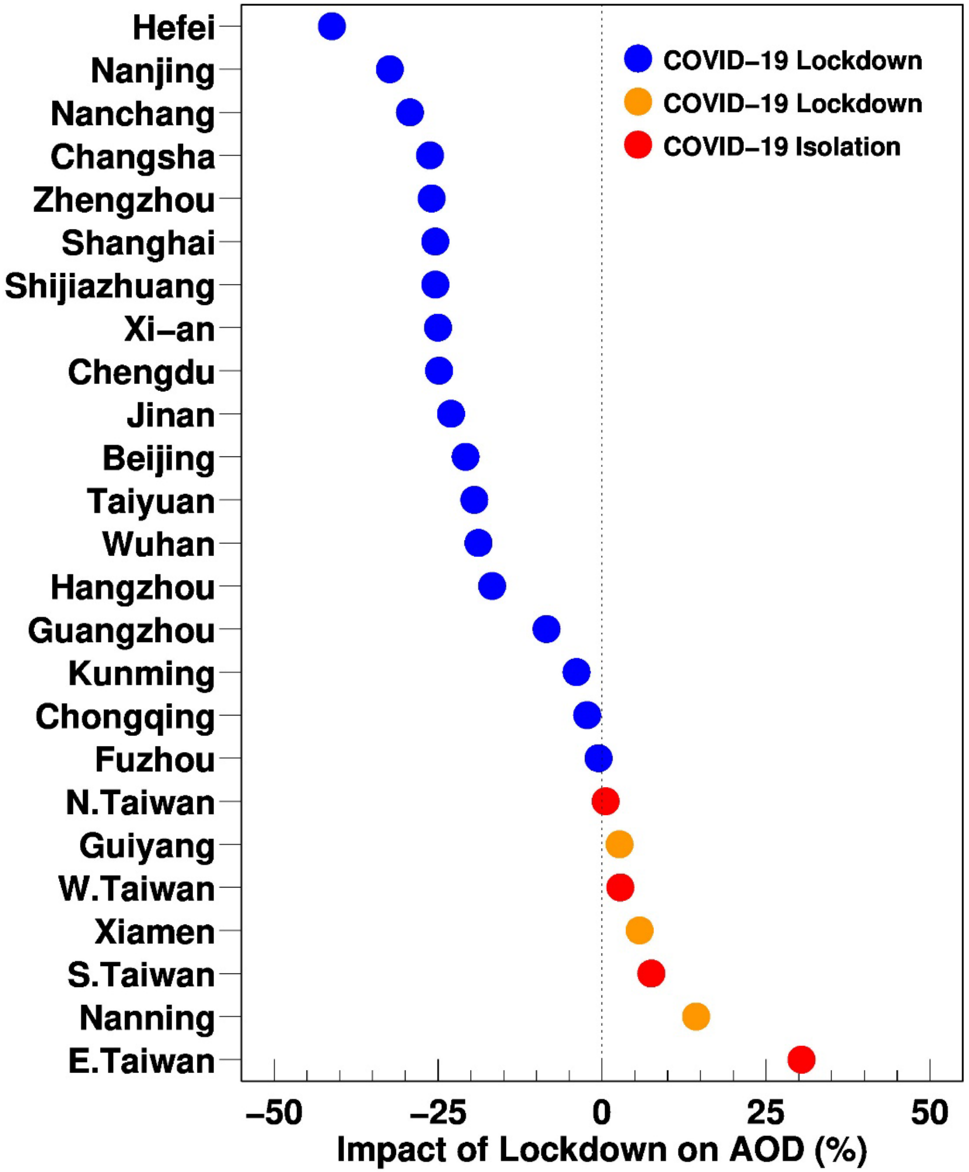


- Changes in aerosol optical depth due to lockdown in different parts of the world. Blue color indicates improved air quality (low aerosol optical depth) in 2020 compared to 2019; red color indicates deteriorated air quality due to smoke from fires.

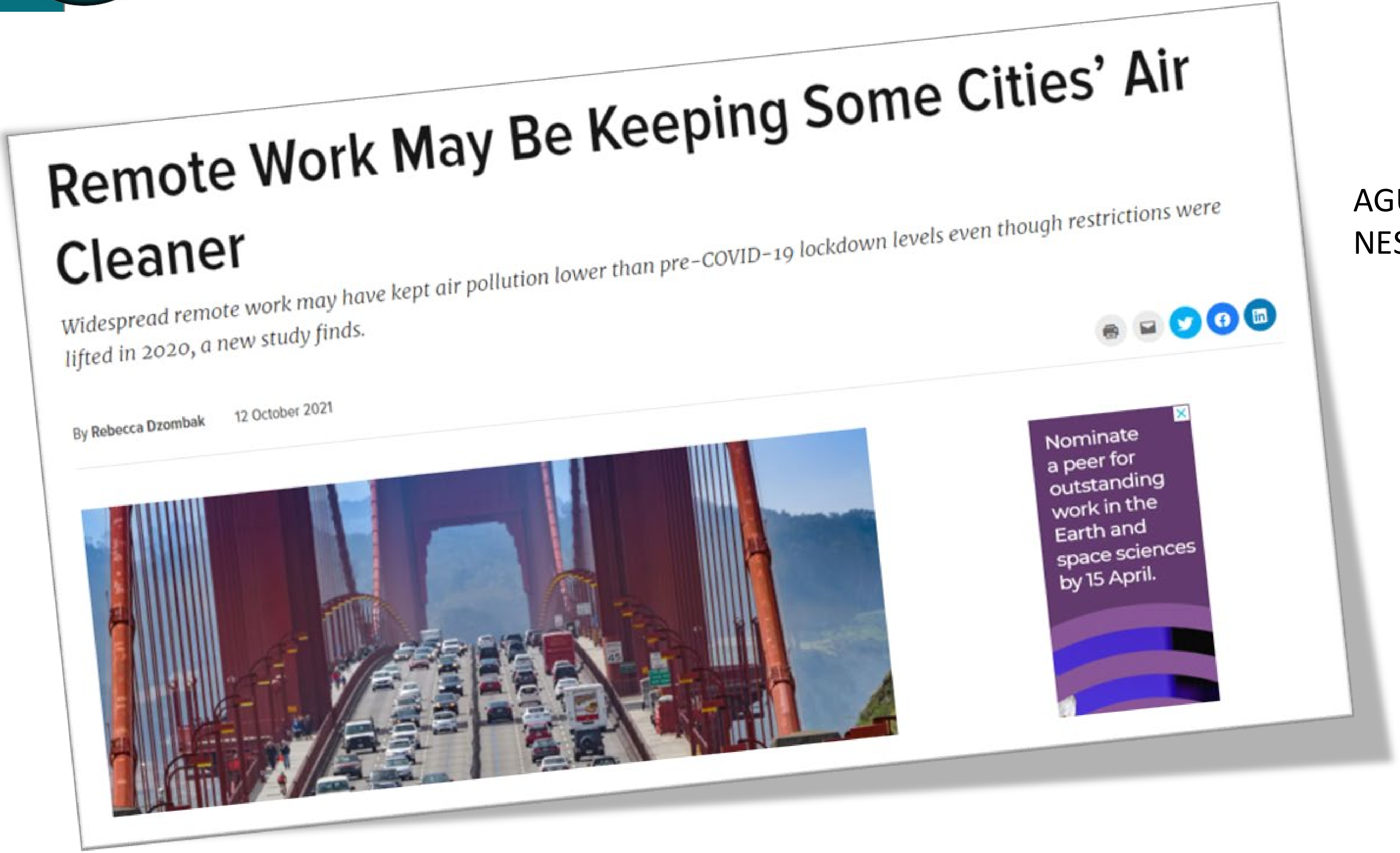
- Changes in US smaller compared to China because ***pollution in US is four times lower than in China.***

NOAA analysis of satellite observations to understand pandemic related emissions changes

- After accounting for long-term trend in aerosol optical depth (AOD) data, differences in AOD between 2020 and 2019 were computed for major urban/industrial areas where transportation sources dominate.
- Most cities show decreased AODs due to decrease in traffic except cities closer to smoke influence.
- Taiwan did not see any benefits in pollution because it did not implement any lockdown measures.



NOAA analysis of satellite observations to understand pandemic related emissions changes

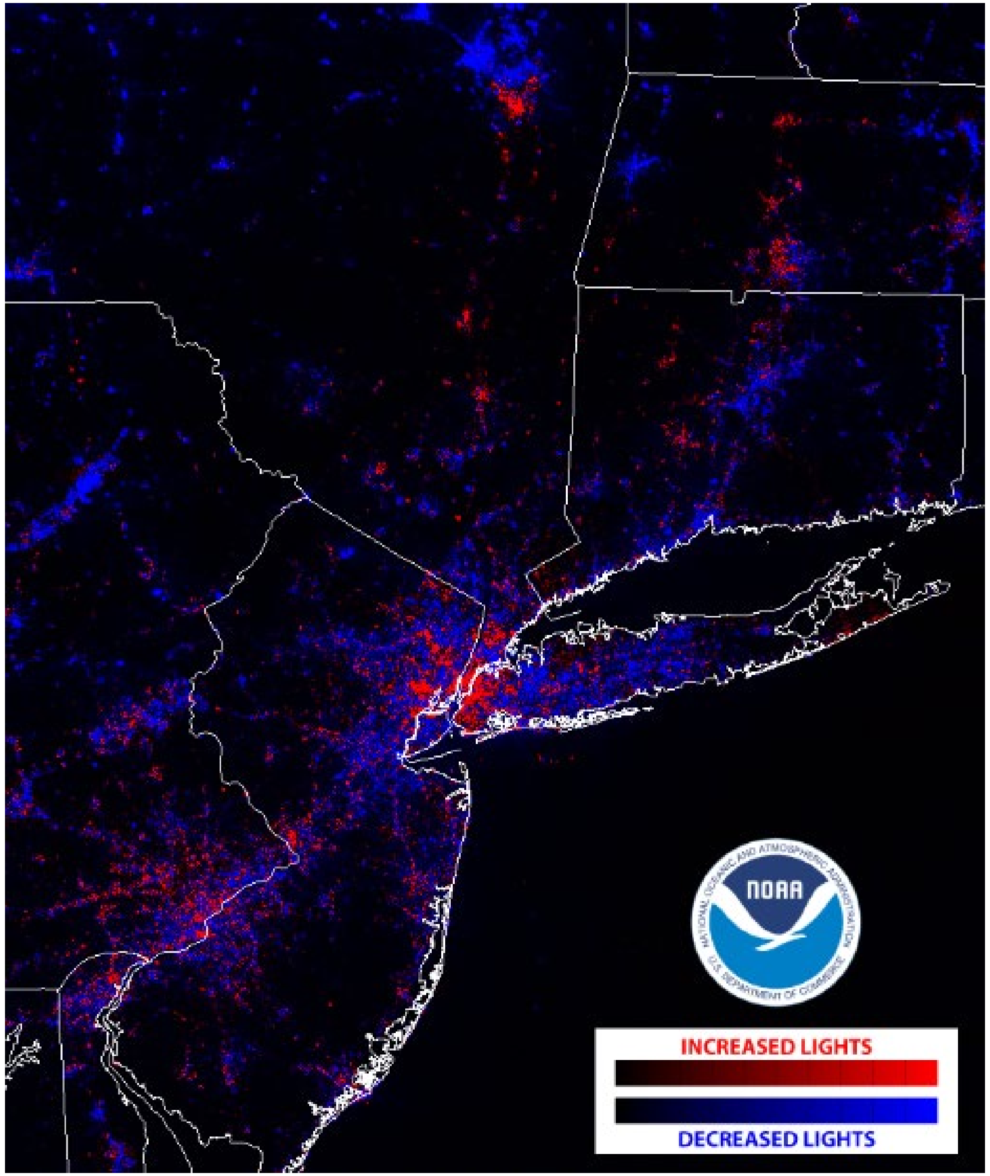

Remote Work May Be Keeping Some Cities' Air Cleaner

Widespread remote work may have kept air pollution lower than pre-COVID-19 lockdown levels even though restrictions were lifted in 2020, a new study finds.

By Rebecca Dzombak 12 October 2021

AGU press release based on NESDIS-OAR study

NOAA analysis of satellite observations to understand pandemic related emissions changes

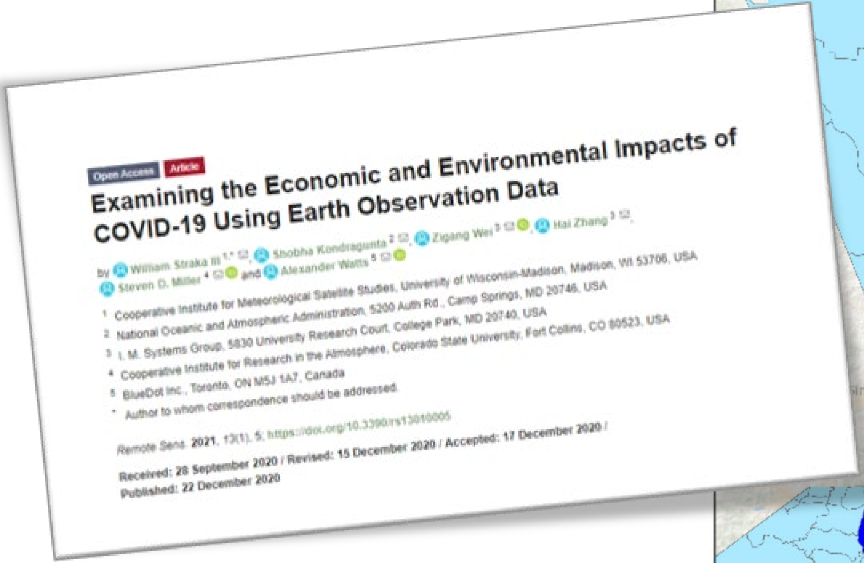


From WeatherNationTV.com (May 2020)

Tapping into data from the NOAA/NASA Suomi NPP satellite's Day/Night Band (DNB), NOAA's Joint Polar Satellite System (JPSS) colleagues at the Cooperative Institute for Research in the Atmosphere (CIRA), Cooperative Institute for Meteorological Satellite Studies (CIMSS), and the Colorado School of Mines (CSM) examined the difference in illumination of urban and suburban lights between February 2020 and March 2020. By doing so, the scientists were able to detect areas of dimming (blue), and in some cases brightening (red), of nighttime lights from the Mid-Atlantic to New England.

In explaining the slight uptick in illumination on the Hampton shores of Long Island, CIRA Senior Research Scientist Steve Miller speculates that these, "may be cases of people who usually live in NYC in the winter months having relocated to their summertime residences early, due to the slowdown."

NOAA analysis of satellite observations to understand pandemic related emissions changes



Open Access Article

Examining the Economic and Environmental Impacts of COVID-19 Using Earth Observation Data

by William Straka III [1,*], Shobha Kondragunta [2], Zigang Wei [3], Hai Zhang [3], Steven D. Miller [4] and Alexander Watts [5]

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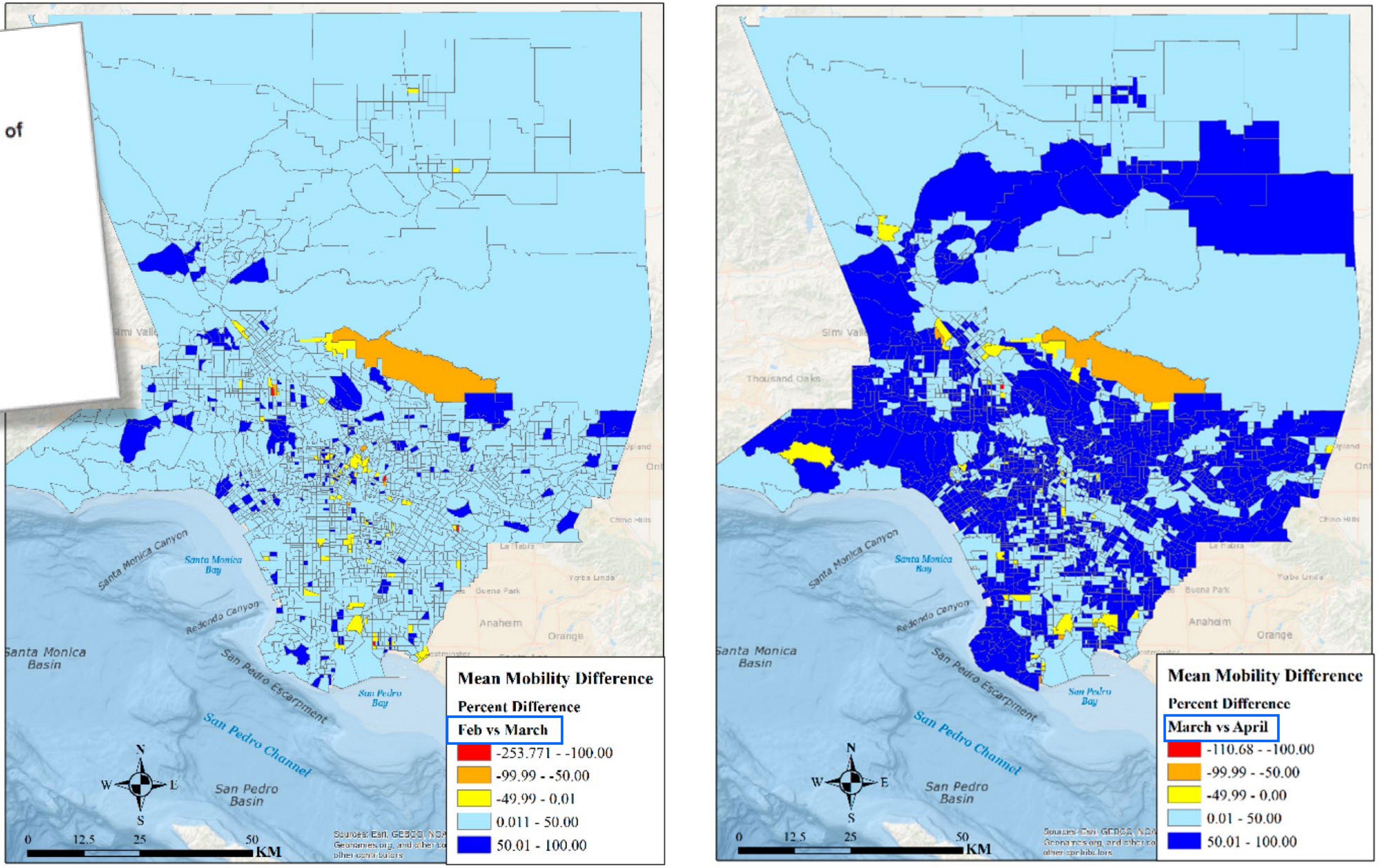


(a) (b)

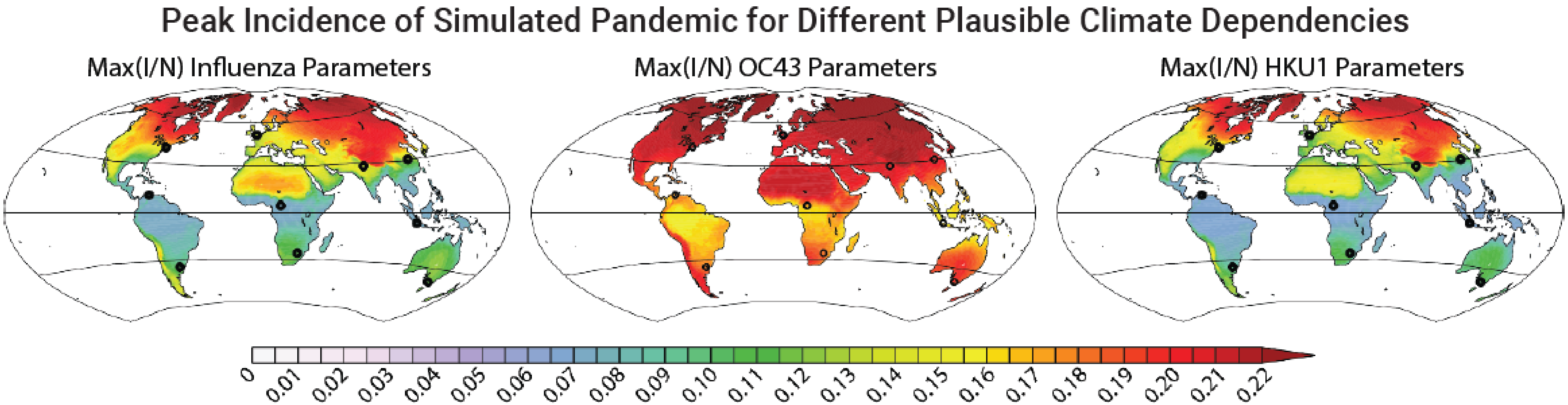
Areas in yellow-gold-red indicate decreased mobility at census tract level in Los Angeles due to lockdown

Predictability of COVID-19 and related viral illnesses

A team from Princeton University (funded through NOAA GFDL's cooperative agreement) and the National Institutes of Health used a climate-dependent epidemic model to simulate the COVID-19 pandemic, probing different scenarios based on what is known about the role seasonal variations have on the occurrence of similar viruses.

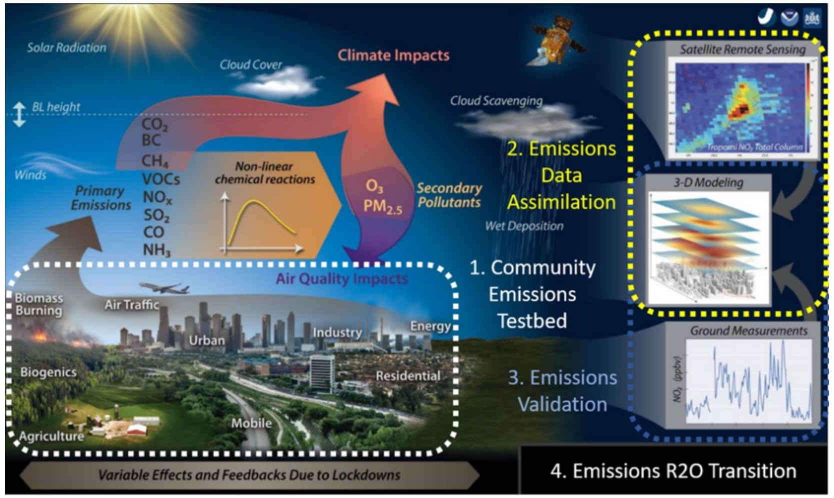
Findings:

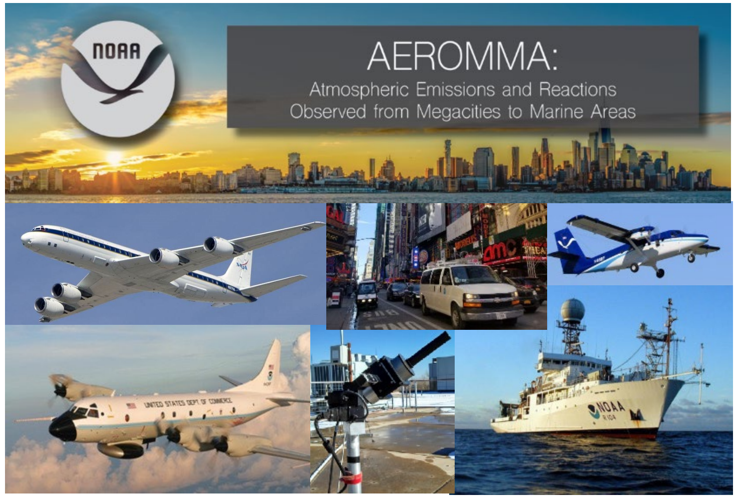
- Without a vaccine or other control measures, COVID-19 will likely only be responsive to seasonal changes after the supply of unexposed hosts is reduced.
- A simulation that accounted for the impact of control measures, such as social distancing, suggested that the longer these measures are in place and slow the transmission of COVID-19, the more sensitive the virus becomes to warmer weather.



Future Directions

- Continued, stronger NOAA partnerships
- New NOAA research efforts
- Next-generation NOAA satellite missions
- Innovative NOAA applications
- Improved NOAA forecasting tools
- Better information for NOAA stakeholders
- Preparation for the next pandemic event





Summary

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If you have questions about the detailed report, please contact:
Greg Frost (gregory.j.frost@noaa.gov) or
Shobha Kondragunta (shobha.kondragunta@noaa.gov)