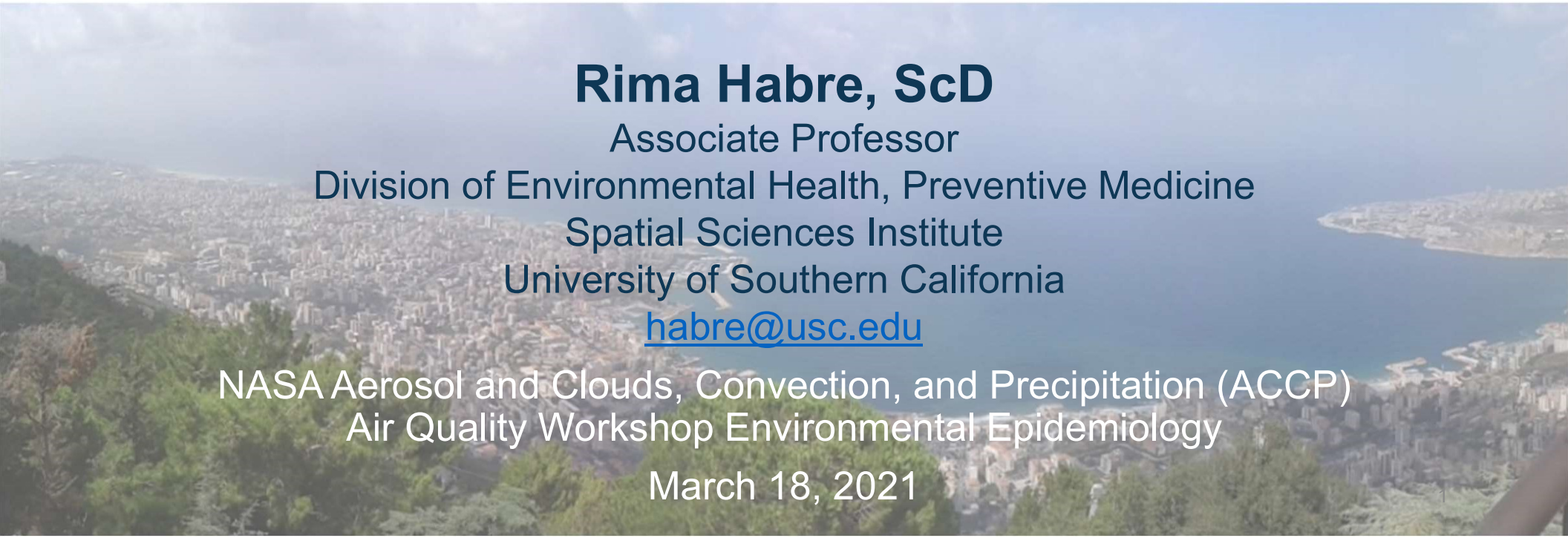
Air Pollution Exposure and Public Health

Needs and Opportunities for Remote Sensing Data Products



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NASA Aerosol and Clouds, Convection, and Precipitation (ACCP)
Air Quality Workshop Environmental Epidemiology

March 18, 2021

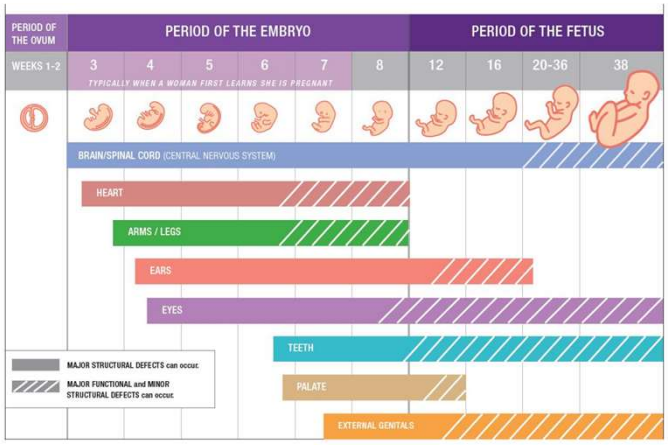
Introduction

- Air pollution is a public health concern
  - Multiple endpoints, acute and chronic
- Generally difficult to assess exposure accurately, efficiently, and at high spatiotemporal resolution in epidemiological studies
  - Air pollution is complex (chemistry/size, phases, sources, mixtures)
  - Humans are complex (mobility, time-activity, behaviors)
- Goal in health studies is to estimate “true, personal” exposure in breathing zone
  - f(outdoor concentrations, human time-activity/mobility, building/home characteristics and indoor sources)
  - Ideally ↓ exposure error to ↑ statistical power to detect true effects

Chronic Disease Conceptual Models

DOHaD HYPOTHESIS

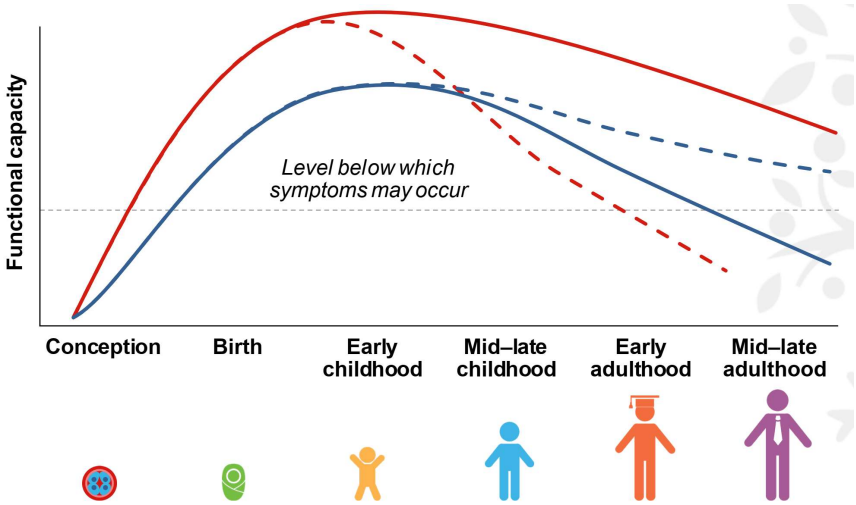
- Critical prenatal/early life developmental periods
- Order of days to weeks



https://mothertobaby.org/wp-content/uploads/2020/02/Adapted-from-Moore-1993-and-the-National-Organization-of-Fetal-Alcohol-Syndrome-NOFAS-2009.-3.png

LIFE COURSE FRAMEWORK

- Early environmental exposures can have a lifetime impact
- Order of months to years

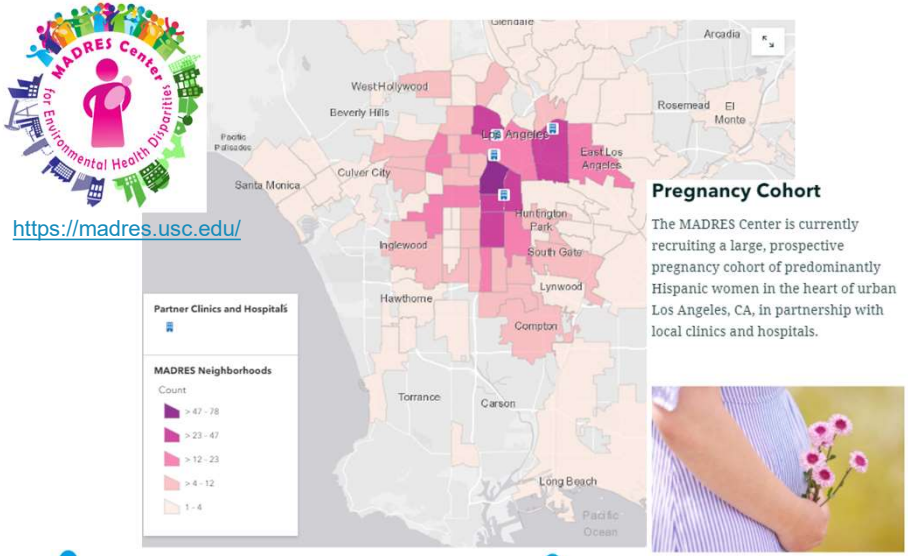


https://echochildren.org/wp-content/uploads/2019/03/ECHO_Overview-Slides_Final.pdf

MADRES and ECHO Cohort Studies

- Los Angeles pregnancy cohort, n~1,000, maternal and child health (2015-2025)

https://madres.usc.edu/

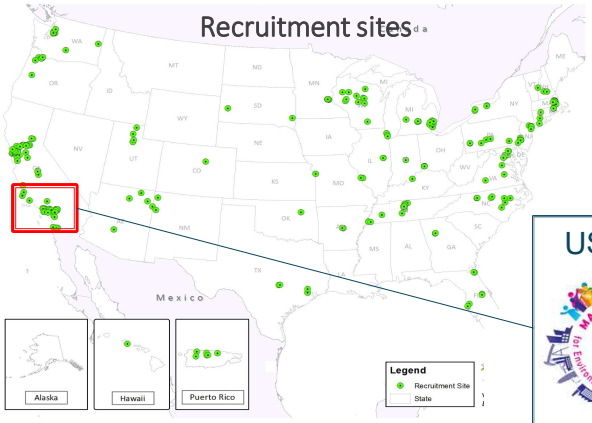


Pregnancy Cohort

The MADRES Center is currently recruiting a large, prospective pregnancy cohort of predominantly Hispanic women in the heart of urban Los Angeles, CA, in partnership with local clinics and hospitals.

Photo by Ashton Mullins on Unsplash

- Nationwide pediatric cohort, n~50,000, children's health (2016-2023)
- Habre, Co-Chair Geospatial WG

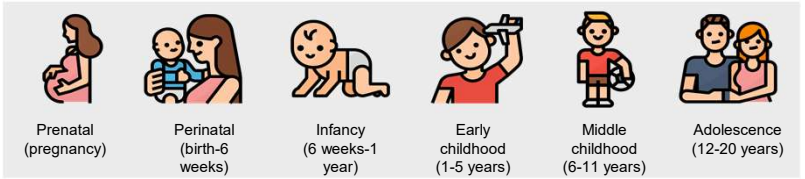


ECHO
Environmental influences on Child Health Outcomes
A program supported by the NIH

https://echochildren.org/

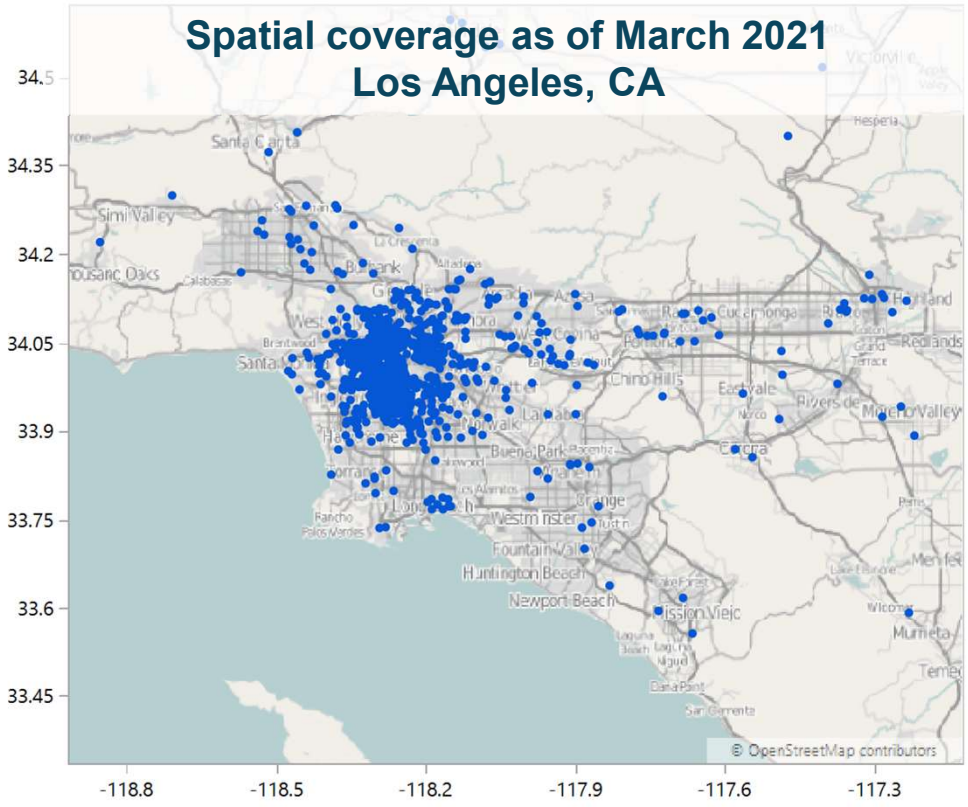
USC participating cohorts

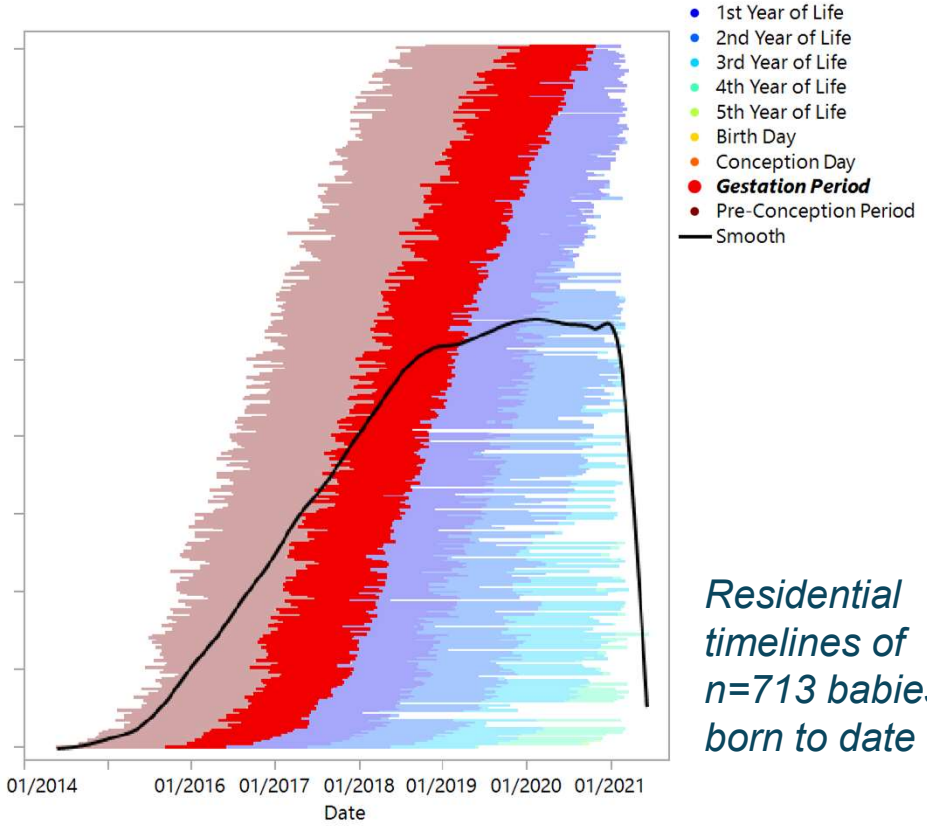
MADRES Center for Environmental Health Disparities + Children's Health Study



MADRES Pregnancy Cohort

Los Angeles, CA, more recent





Residential timelines of n=713 babies born to date

Motivation for California $PM_{2.5}$ Model

- To investigate $PM_{2.5}$ health effects (total and wildfire-related) in our MADRES and ECHO studies
- Wildfires increasingly frequent and widespread

Environment International 145 (2020) 106143

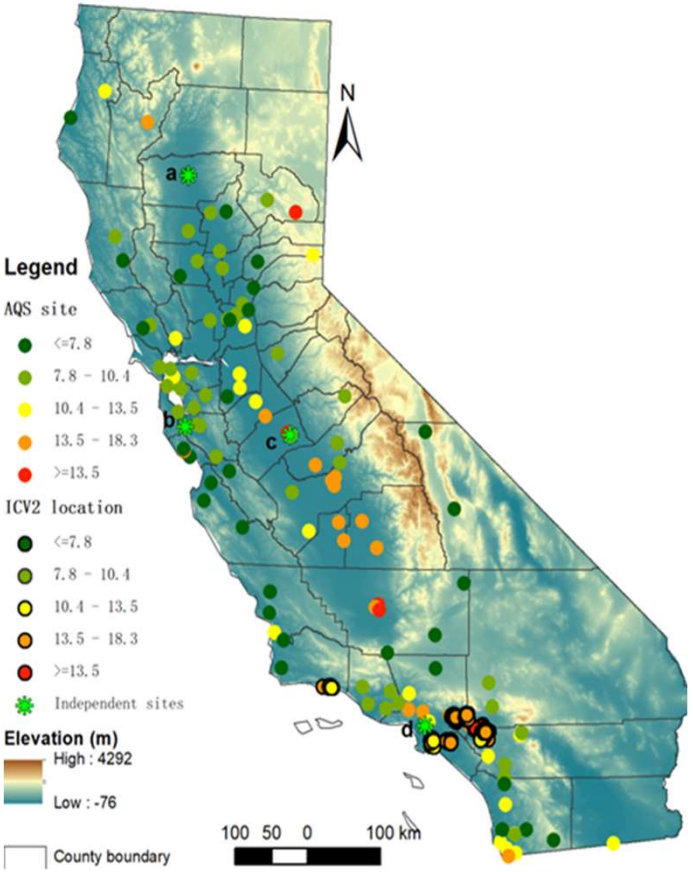
Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

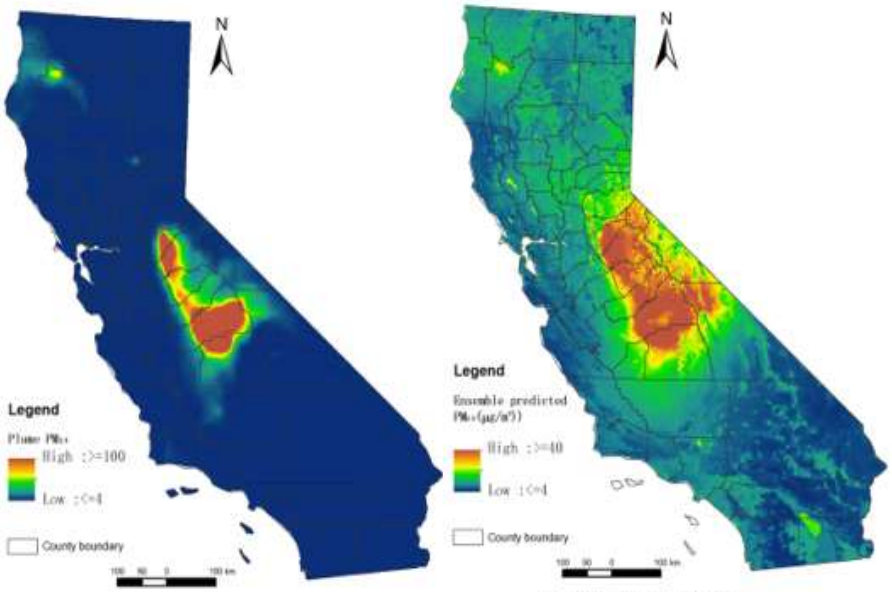
Ensemble-based deep learning for estimating $PM_{2.5}$ over California with multisource big data including wildfire smoke

Lianfa Li [a,b,*], Mariam Girguis [a], Frederick Lurmann [c], Nathan Pavlovic [c], Crystal McClure [c], Meredith Franklin [a], Jun Wu [d], Luke D. Oman [e], Carrie Breton [a], Frank Gilliland [a], Rima Habre [a,*]



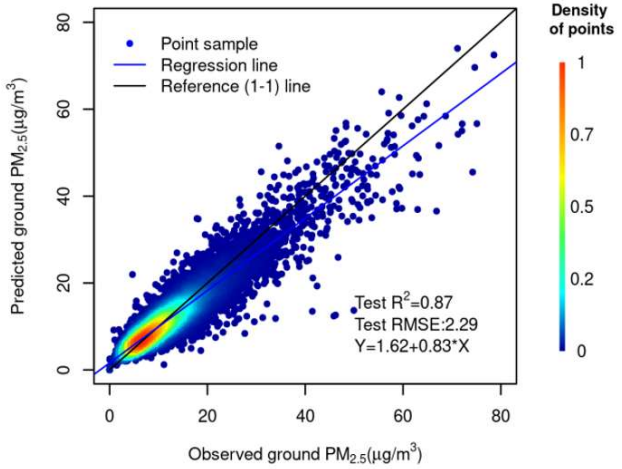
Model Overview

Weekly, 1KM^2 $PM_{2.5}$ Model, 2008-2017, incorporating Wildfire Smoke Plumes



e. Wildfire smoke $PM_{2.5}$ (0 - 857 μg/m^3))
for the autumn week of 2015 (Sep. 14 to 20)

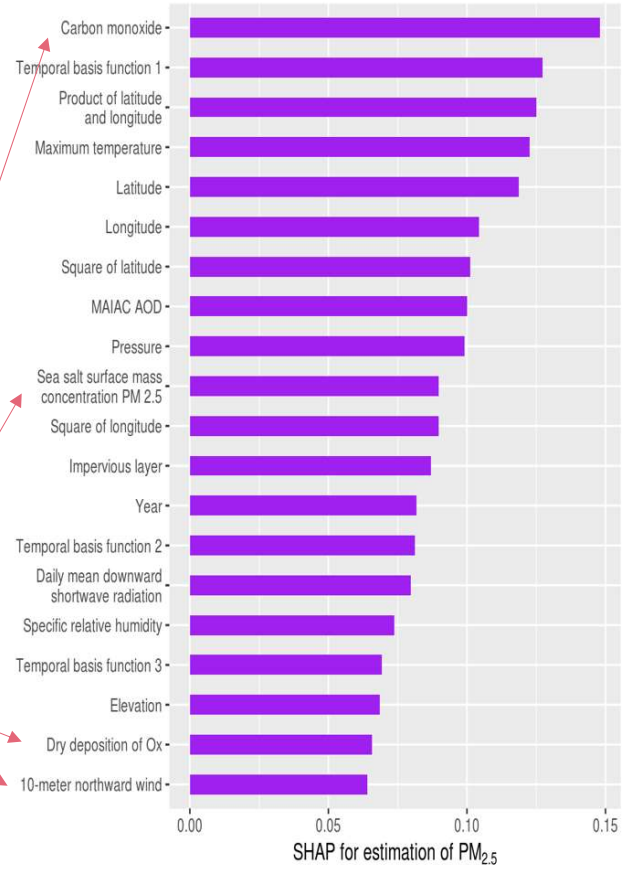
b. Ensemble predicted $PM_{2.5}$
for the autumn week of 2015 (Sep. 14 to 20)



- Residual autoencoder and ensemble learning
  - Test R^2 0.82, RMSE 2.70 μg/m^3
- Measurements, remote sensing, M2GMI, dispersion models of wildfire smoke

Key Contributions of NASA Remote Sensing and Hindcast Simulation Data

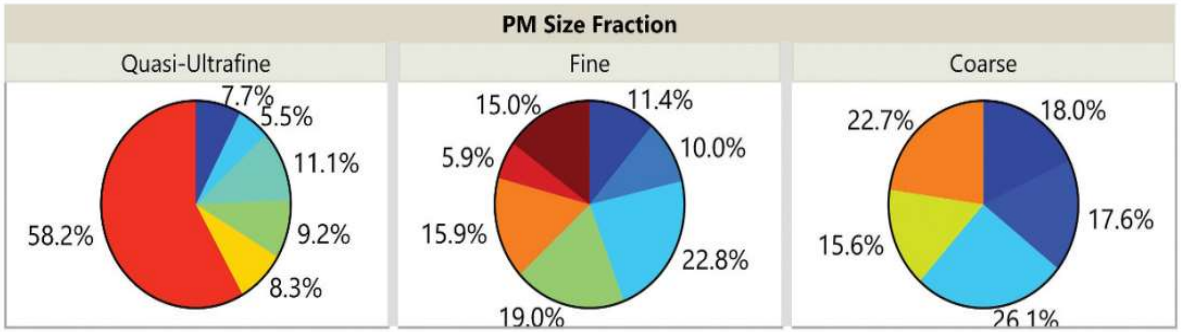
- MAIAC AOD (1km^2)
- M2GMI Replay Simulation
  - ~50km^2 AOD to impute missing MAIAC AOD
  - PBLH for AOD vertical adjustment
  - Wind speeds at 2m, 10m and 50m to calculate indicators of vertical stagnation and wind sheer/mechanical mixing
  - Gases and $PM_{2.5}$ aerosol types in surface layer, highly important features



Feature importance across 100 ensembles

PM Composition and Sources

- Drive toxicity and health effects
- Size distribution
- Urban sources
  - Tailpipe and non-tailpipe traffic
  - Airport-related UFPs



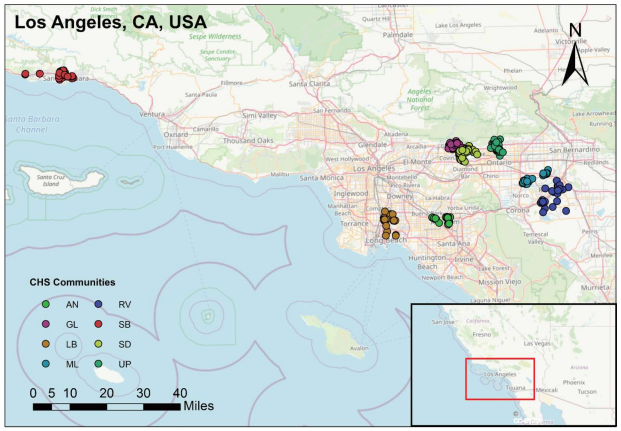


Figure 1. Map of CHS southern California communities participating in the ICV2 sampling campaign (AN = Anaheim, GL = Glendora, LB = Long Beach, ML = Mira Loma, RV = Riverside, SB = Santa Barbara, SD = San Dimas, UP = Upland).

JOURNAL OF THE AIR & WASTE MANAGEMENT ASSOCIATION
2021, VOL. 71, NO. 2, 209–230
https://doi.org/10.1080/10962247.2020.1826366

Taylor & Francis
Taylor & Francis Group

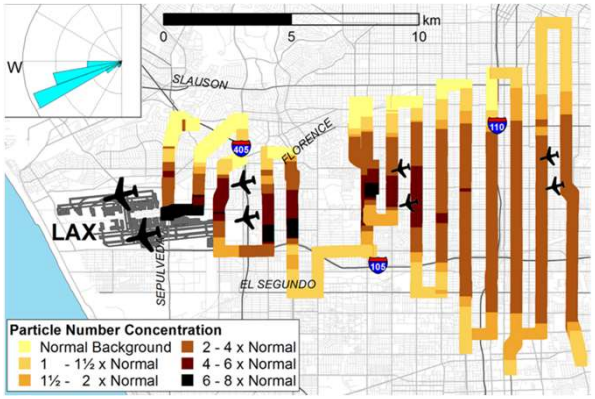
TECHNICAL PAPER

Check for updates

Contribution of tailpipe and non-tailpipe traffic sources to quasi-ultrafine, fine and coarse particulate matter in southern California

Rima Habre[a], Mariam Girguis[a], Robert Urman[a*], Scott Fruin[a], Fred Lurmann[b], Martin Shafer[c,d], Patrick Gorski[c], Meredith Franklin[a], Rob McConnell[a], Ed Avol[a], and Frank Gilliland[a]

Airport-related UFPs, Acute Effects



Hudda et al. (2014), *Environmental Science & Technology*, *48*(12), 6628–6635.

Environment International 118 (2018) 48–59

Contents lists available at ScienceDirect

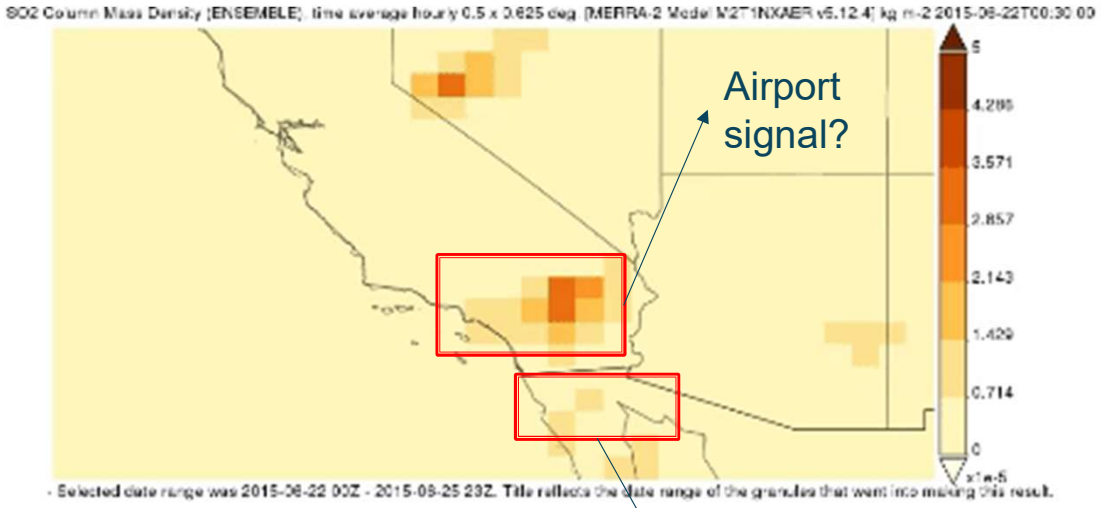
Environment International

journal homepage: www.elsevier.com/locate/envint

Short-term effects of airport-associated ultrafine particle exposure on lung function and inflammation in adults with asthma

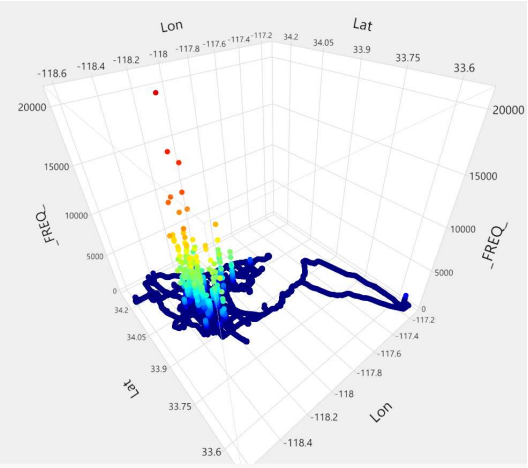
Rima Habre[a,*], Hui Zhou[a], Sandrah P. Eckel[b], Temuulen Enebish[a], Scott Fruin[a], Theresa Bastain[a], Edward Rappaport[a], Frank Gilliland[a]

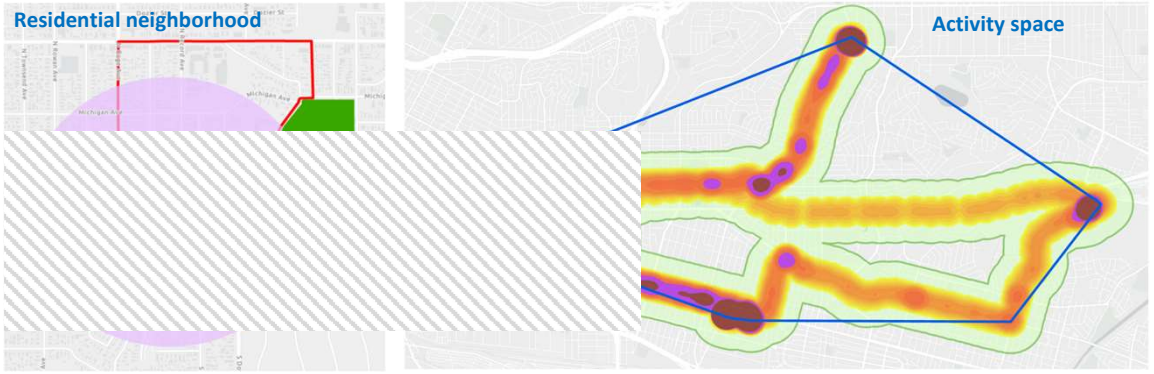
SO_2 column mass density from MERRA-2 over southern CA, few days in 2015

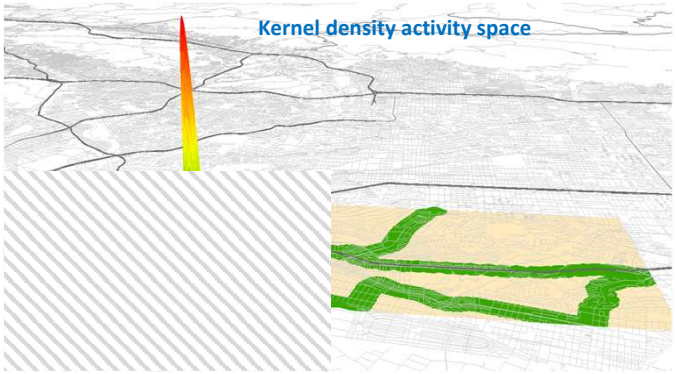


Future Directions…

- Incorporating mobility and activity spaces into air pollution exposure assessment







Yan Xu, PHP doctoral candidate

Paired with Personal $PM_{2.5}$ Monitoring

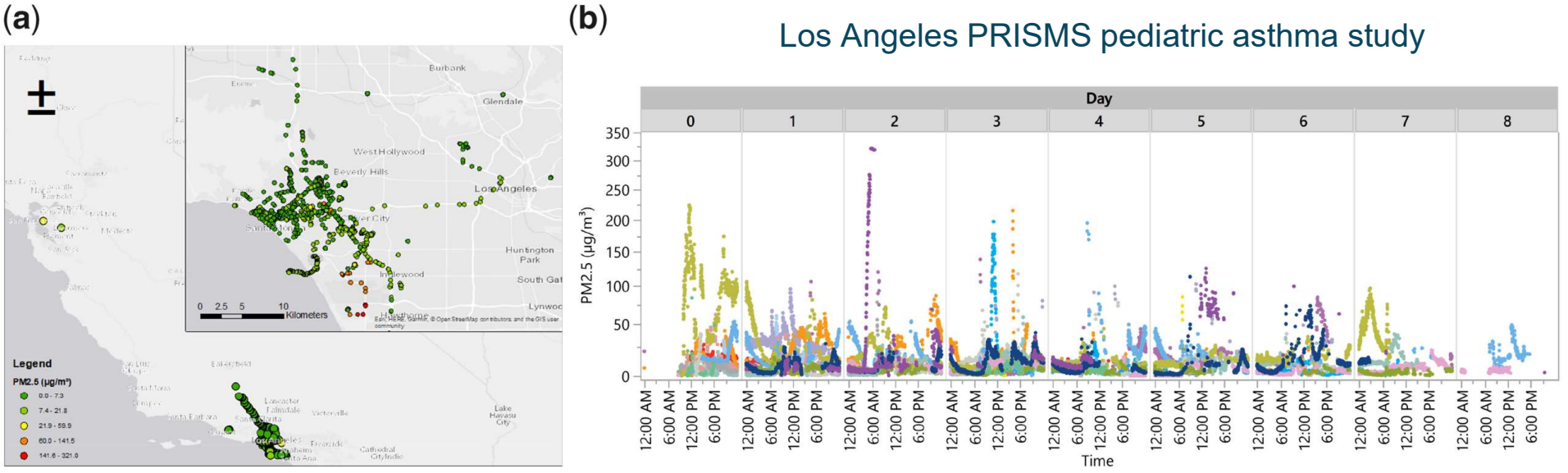


Figure 5. Examples of data collection from BREATHE. (A) Map of GPS trajectories across all subjects, correlated with 1-min $PM_{2.5}$ concentrations. (B) Temporal variation in personal $PM_{2.5}$ concentrations colored by subject. BREATHE: Biomedical REAl-Time Health Evaluation; GPS: global positioning system; PM: particulate matter.

Bui et al, *JAMIA Open*, 3(2), 2020

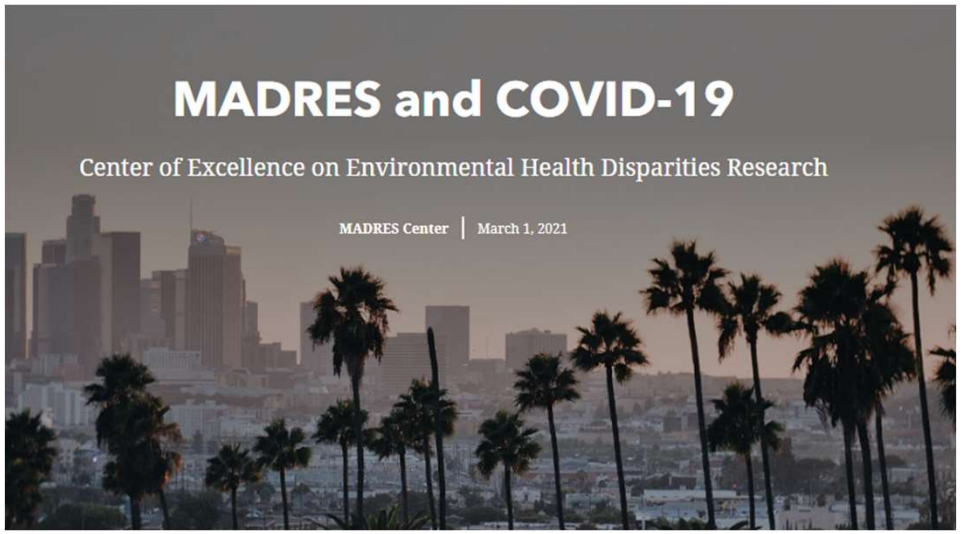
https://youtu.be/6y0tzsfApw4

Summary

- Air pollution exposure and health research needs
  - Composition, size distribution, mixtures!
  - Remote sensing data products, especially hindcast simulations (gas and aerosol), incredibly useful
    - Enhance/expedite exposure modeling work, minimize lag time
    - Spatiotemporal coverage key (simulations)
    - Spatiotemporal resolution
      - Daily to hourly temporal resolution important for understanding acute effects
      - Spatial resolution increasingly important considering human activity spaces
    - Vertical resolution

Thank You

- habre@usc.edu
- LA DREAMERs USC ECHO Center
  - MPIs Breton, Bastain, Farzan, Habre
  - NIH UH3OD023287
- MADRES Center
  - MPIs Breton and Bastain
  - NIMHD/NIEHS P50MD015705
- Los Angeles PRISMS Center
  - PI Bui
  - U54EB022002



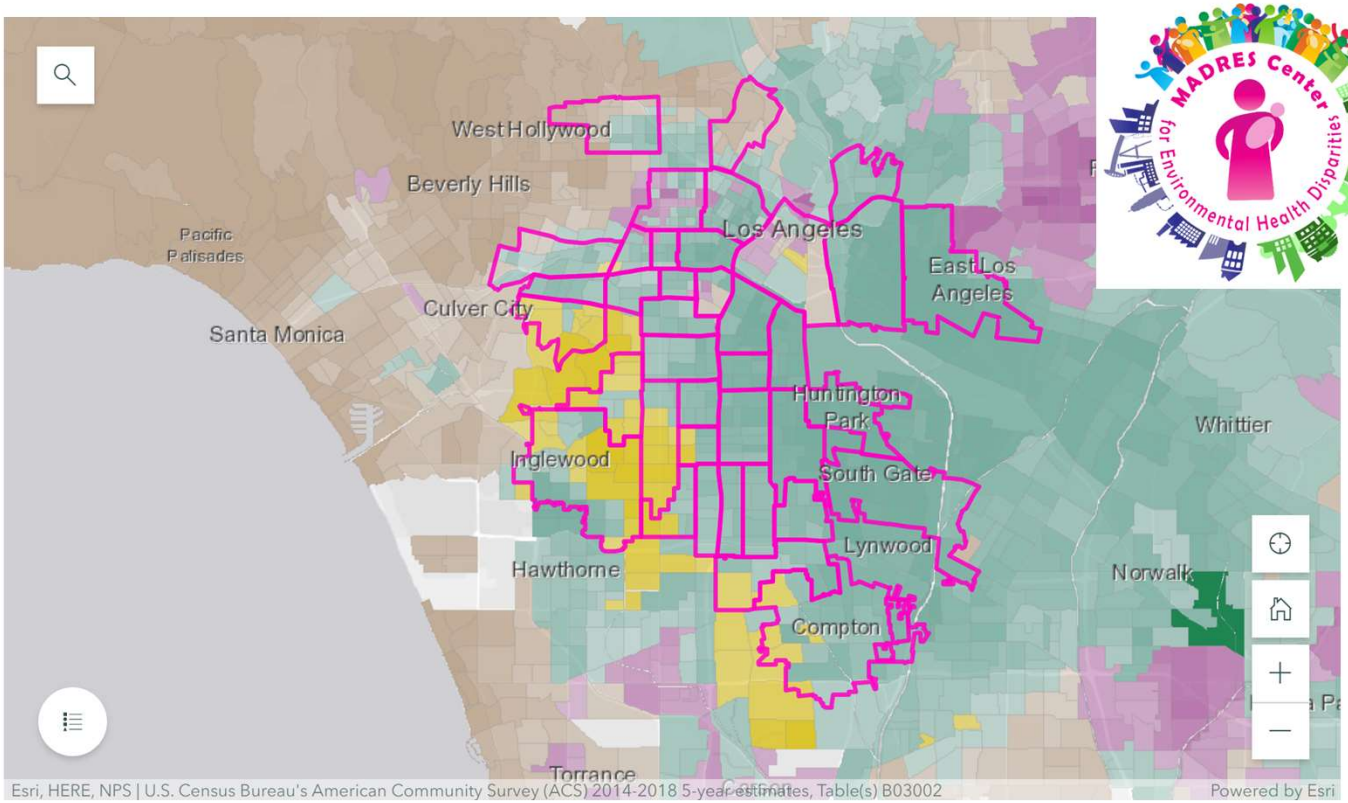
Visit our story map to learn more about MADRES!
https://arcg.is/1y8KHn

MADRES Center of Excellence on Environmental Health Disparities Research

MADRES Neighborhoods

MADRES participants live in predominantly Hispanic and African American communities in Los Angeles, CA.

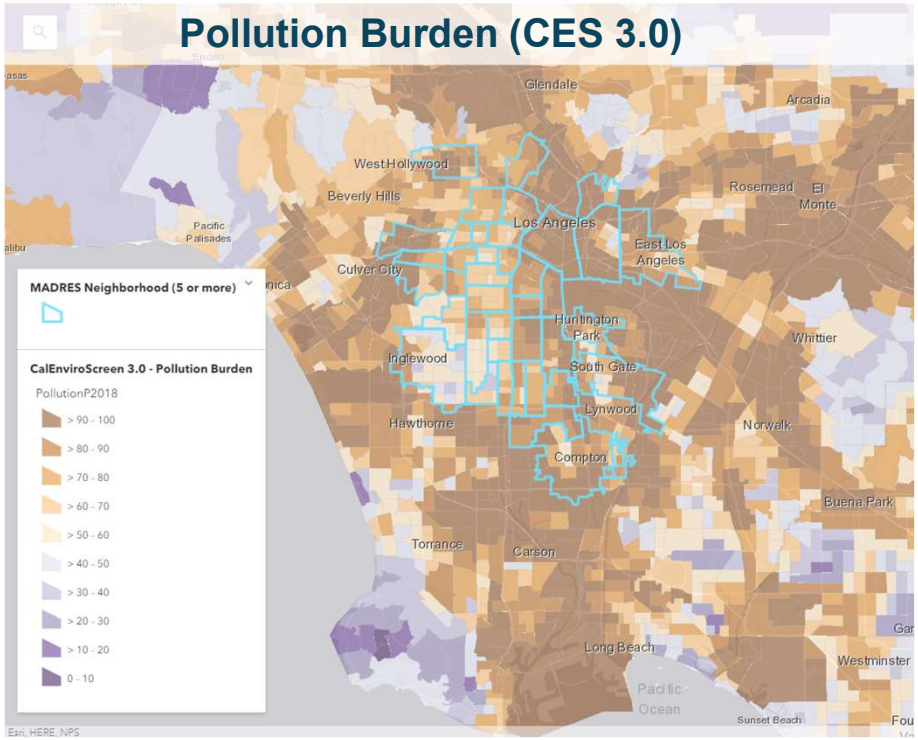
Photo by Viviana Rishe on Unsplash



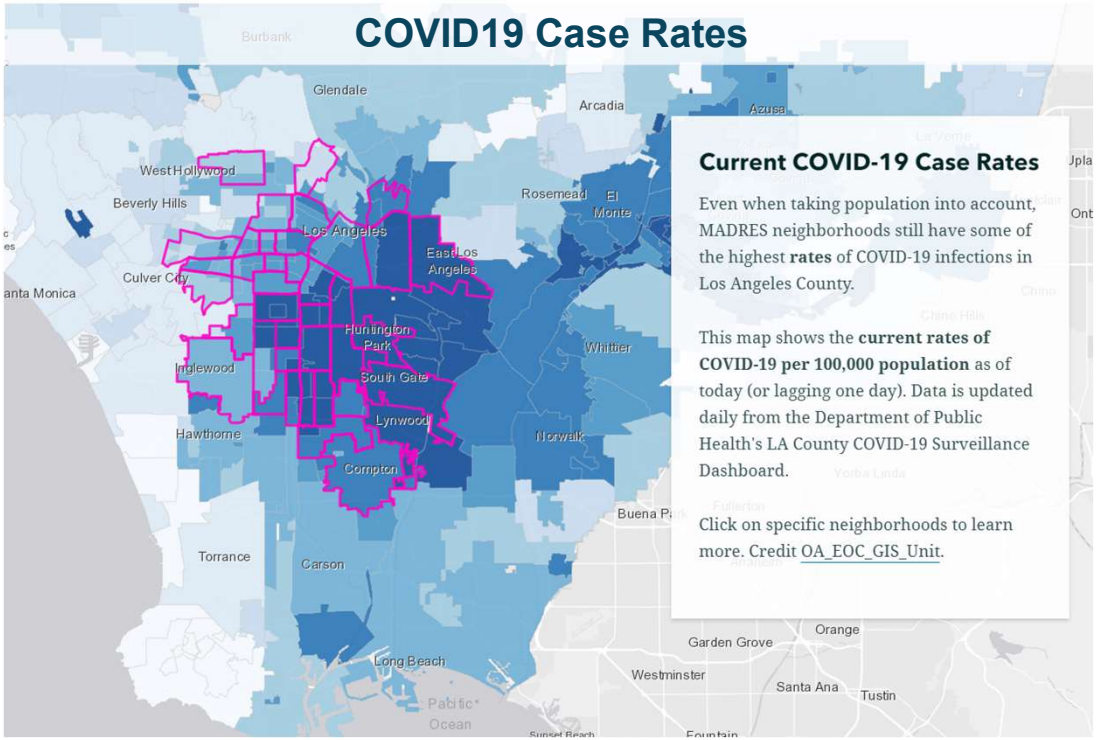
Visit this story map to learn more! → https://arcg.is/1y8KHn

Disproportionate Exposure to Pollution and Higher Susceptibility

Pollution Burden (CES 3.0)



COVID19 Case Rates



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