Air Pollution Exposure Assessment for Epidemiological Health Studies

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NASA Heath and Air Quality Applied Sciences Team Meeting, Jul 16, 2018

LA DREAMERs, USC ECHO Center

Santa Barbara

"**L**ifecourse **A**pproach to **D**evelopmental **R**epercussions of Environmental **A**gents on **Me**tabolic and **R**espiratory health"

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

Director of Exposure Assessment, LA DREAMERs (PIs Breton and Gilliland)

Co-Chair Air Pollution Subcommittee, NIH ECHO Program

USC and partner institutions awarded $6 million children's environmental health grant from NIH

Posted on Wednesday, September 21, 2016 by Scehsc UscEdu

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Research to look at prenatal and early life environmental influences on lifetime health related to asthma and obesity

Staff Report

Media Coverage: Press Enterprise, Daily News, The Washington Times, Redding.com, Daily Breeze, Pasadena Star News

LOS ANGELES – September 21, 2016 – Researchers at the Keck School of Medicine of USC have been awarded a 2 year $6 million grant, as the first phase of a large seven-year National Institutes of Health, Environmental Influences on Child Health Outcomes (ECHO) initiative involving more than 30 research entities. The USC based research team will investigate health issues related to asthma and obesity.

MADRES Center for Environmental Health Disparities

Pregnancy cohort study

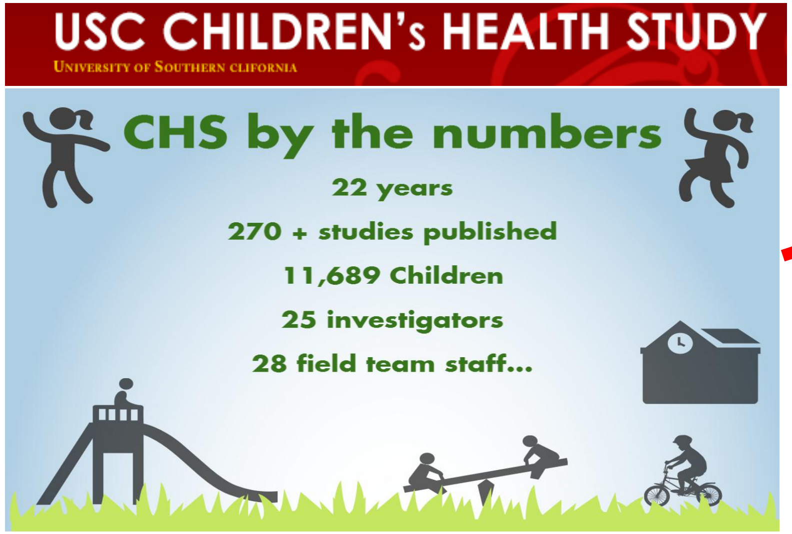
Children's cohort study

USC CHILDREN's HEALTH STUDY
UNIVERSITY OF SOUTHERN CLIFORNIA

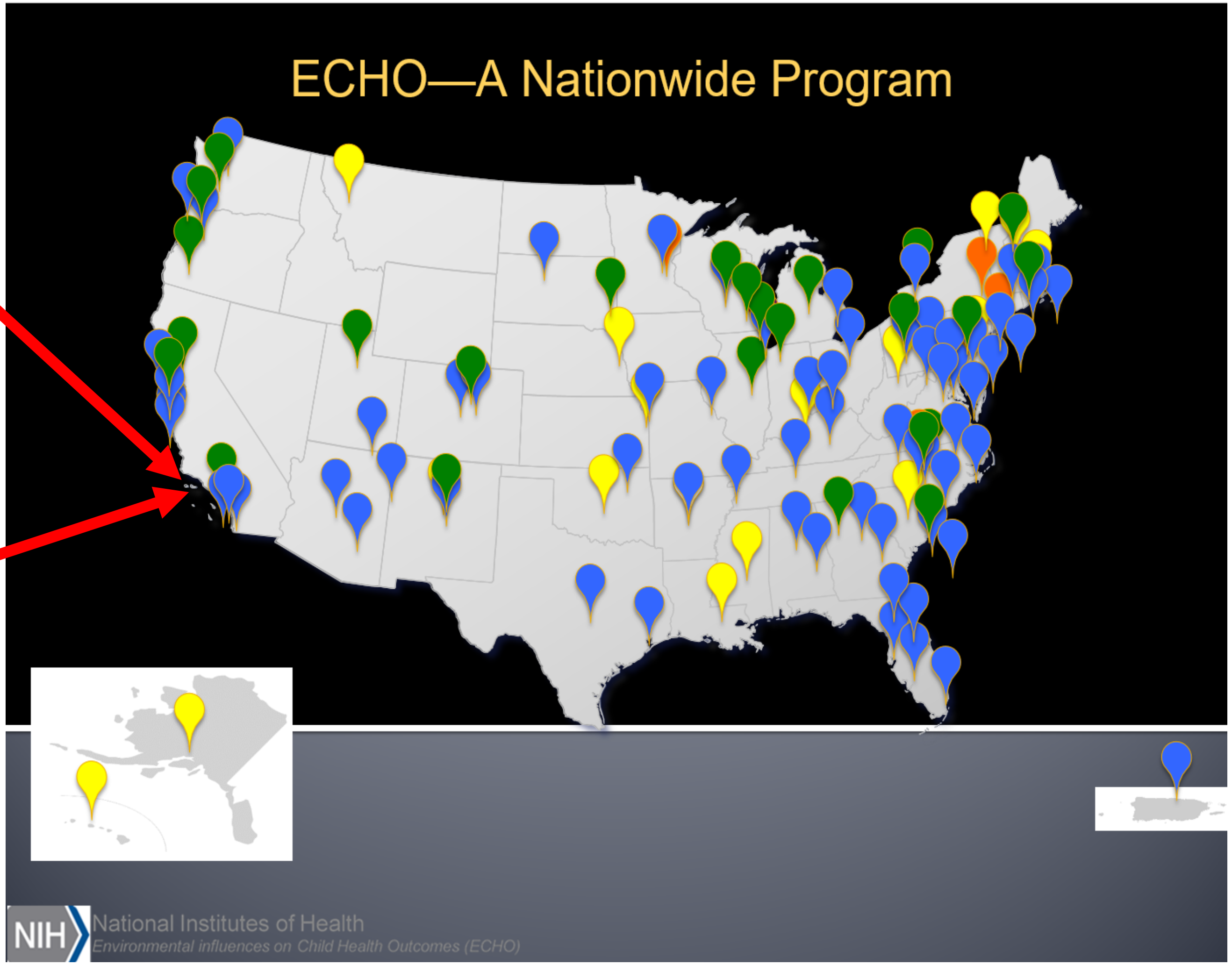
MADRES Center for Environmental Health Disparities

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

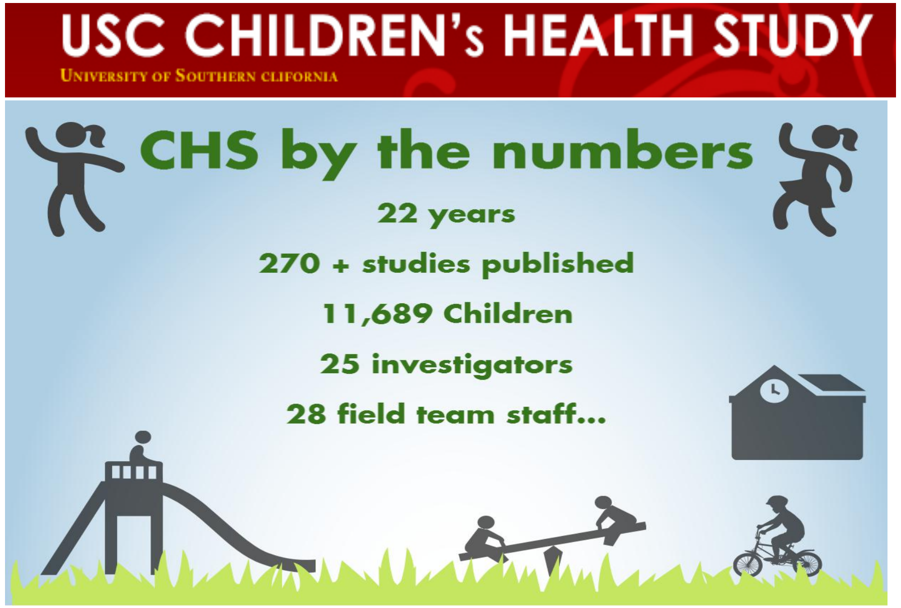
LA DREAMERs
USC ECHO
Cohorts



https://healthstudy.usc.edu/

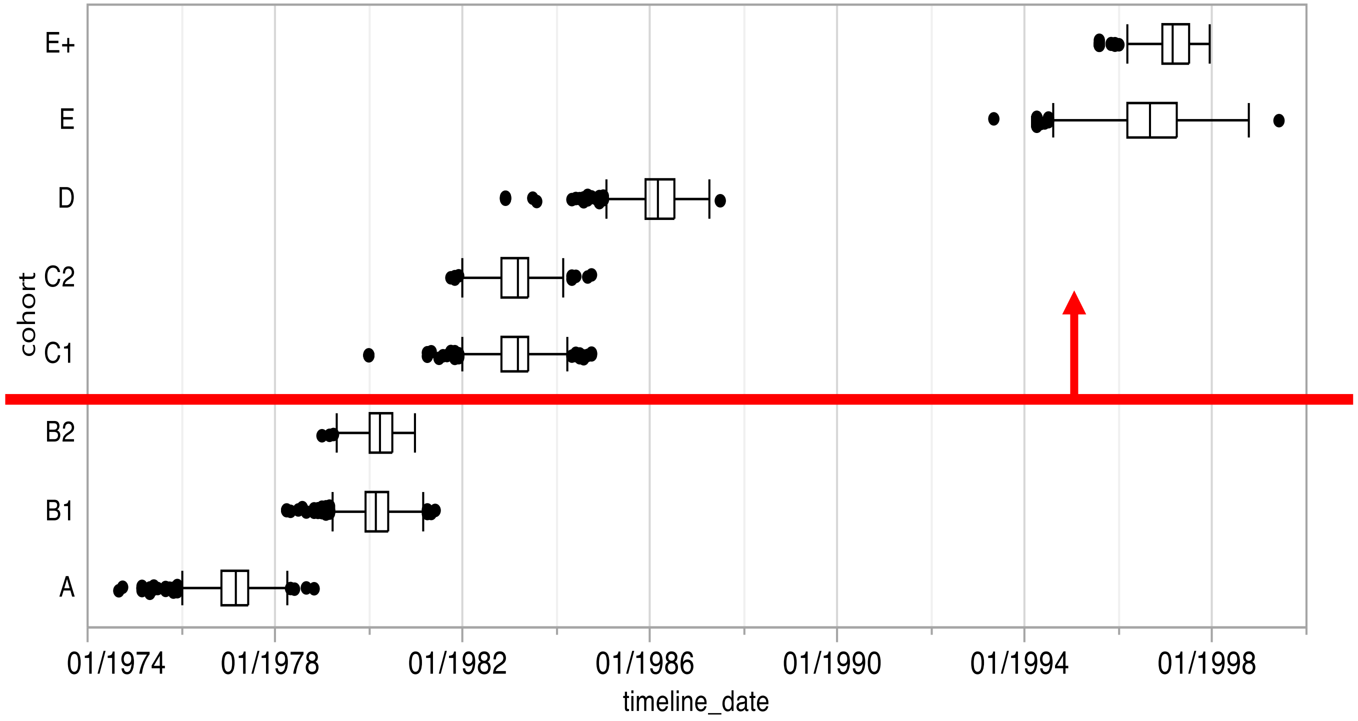


CHS Cohort(s), ~12,000 children

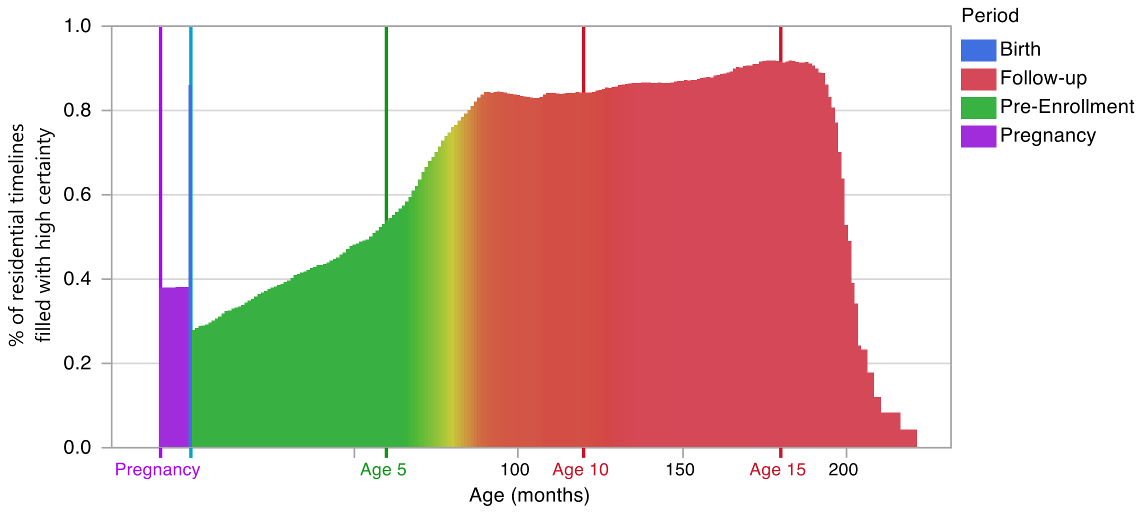


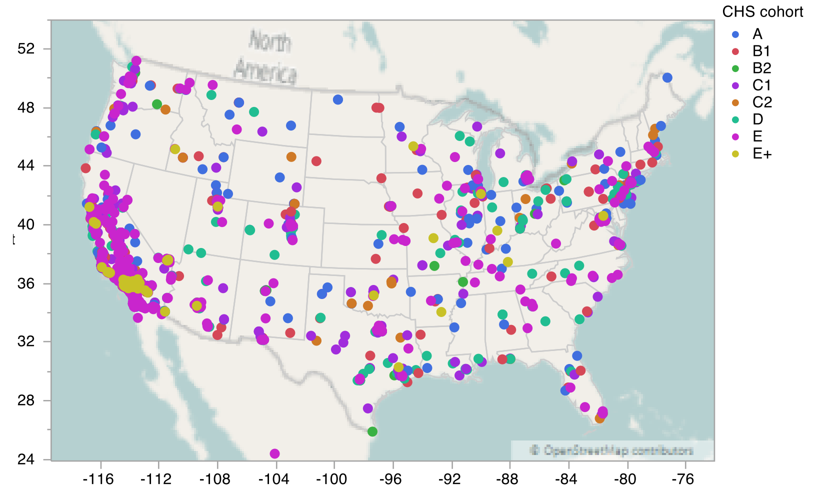
https://healthstudy.usc.edu/

Pregnancy Periods in CHS Cohorts A-E

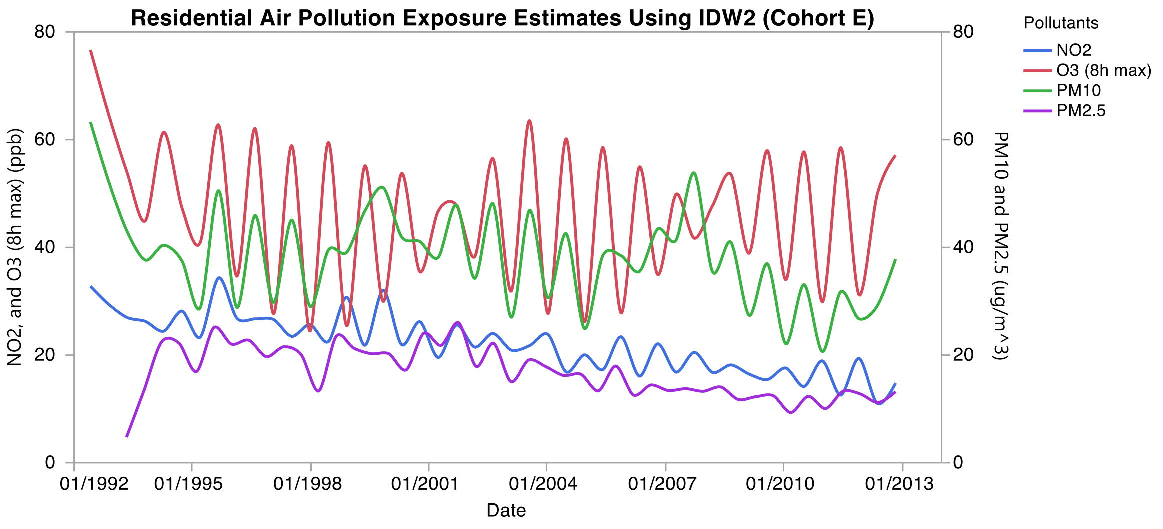


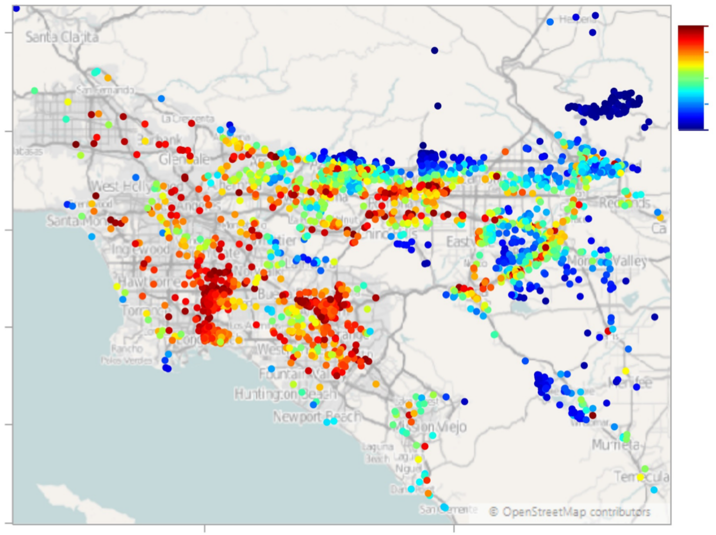
1) Lifetime residential histories assembled and geocoded in the Children's Health Study





2) Residential air pollution exposure estimated (regional lifetime estimates, left; traffic-related pregnancy estimates, right)





NO_2/NO_x Models

- Novel, three-stage spatiotemporal modeling framework to estimate short-term (two-week average) NO_2/NO_x concentrations and uncertainties in their prediction over 22 years (1992-2013)
- SoCal model CV R^2: NO2 0.85 and NOx 0.86 (Li et al. 2017)
- California model CV R^2: NO2 0.88 and NOx 0.88 (Li et al. 2018, in submission)

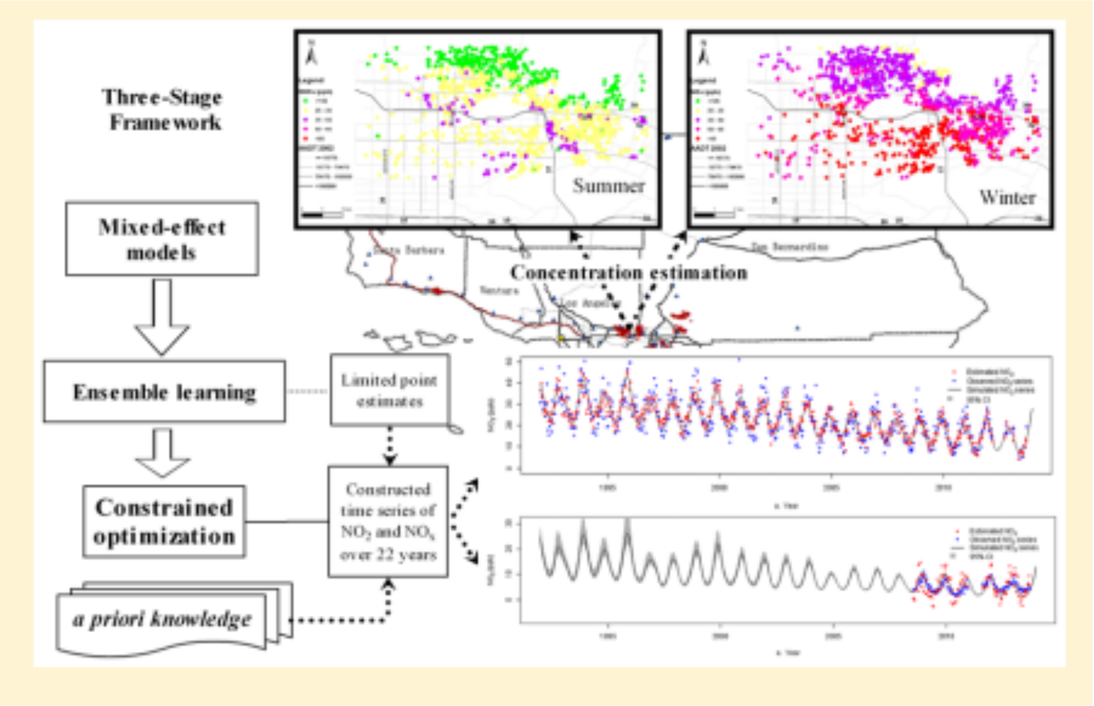
Environmental Science & Technology

Article

pubs.acs.org/est

Constrained Mixed-Effect Models with Ensemble Learning for Prediction of Nitrogen Oxides Concentrations at High Spatiotemporal Resolution

Lianfa Li,[*,†,‡] Fred Lurmann,[§] Rima Habre,[*,†] Robert Urman,[†] Edward Rappaport,[†] Beate Ritz,[∥] Jiu-Chiuan Chen,[†] Frank D. Gilliland,[†] and Jun Wu[*,⊥]



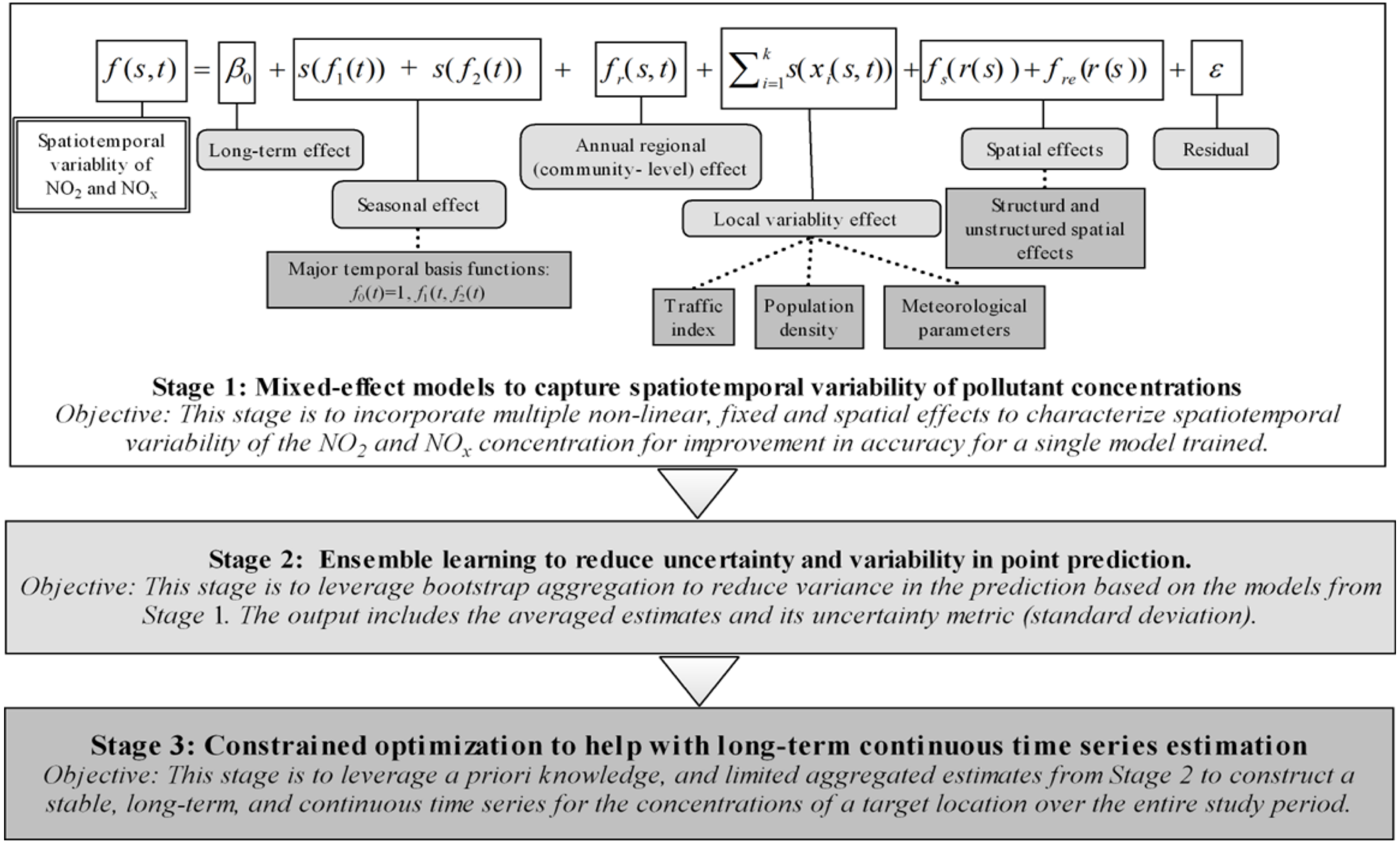
Li L, Lurmann F, Habre R et al. Constrained mixed-effect models with ensemble learning for prediction of nitrogen oxides concentrations at high spatiotemporal resolution, Environ Sci Technol., 2017, 5:9920-9929

Model Framework

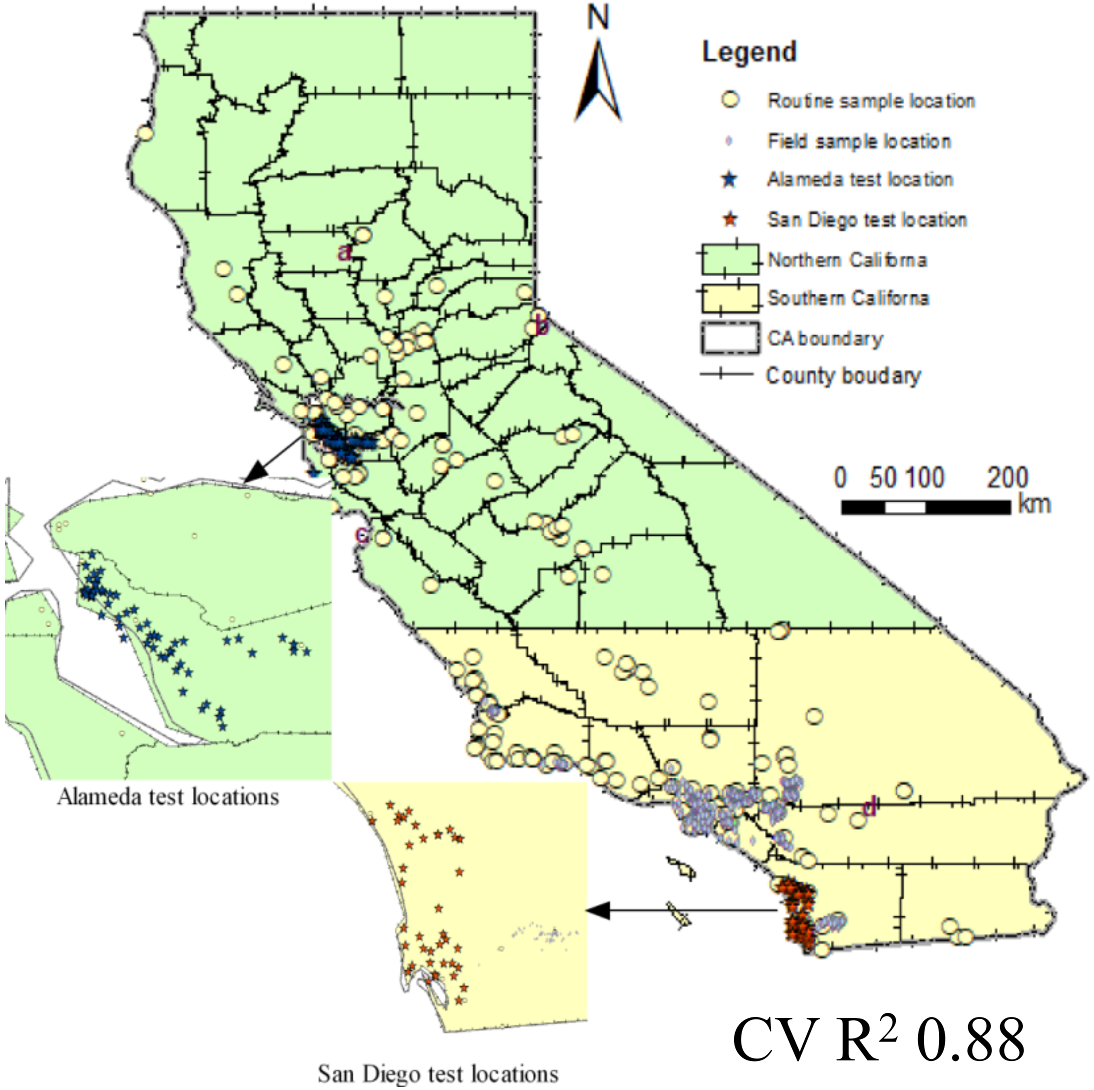
Stage 1

Stage 2

Stage 3

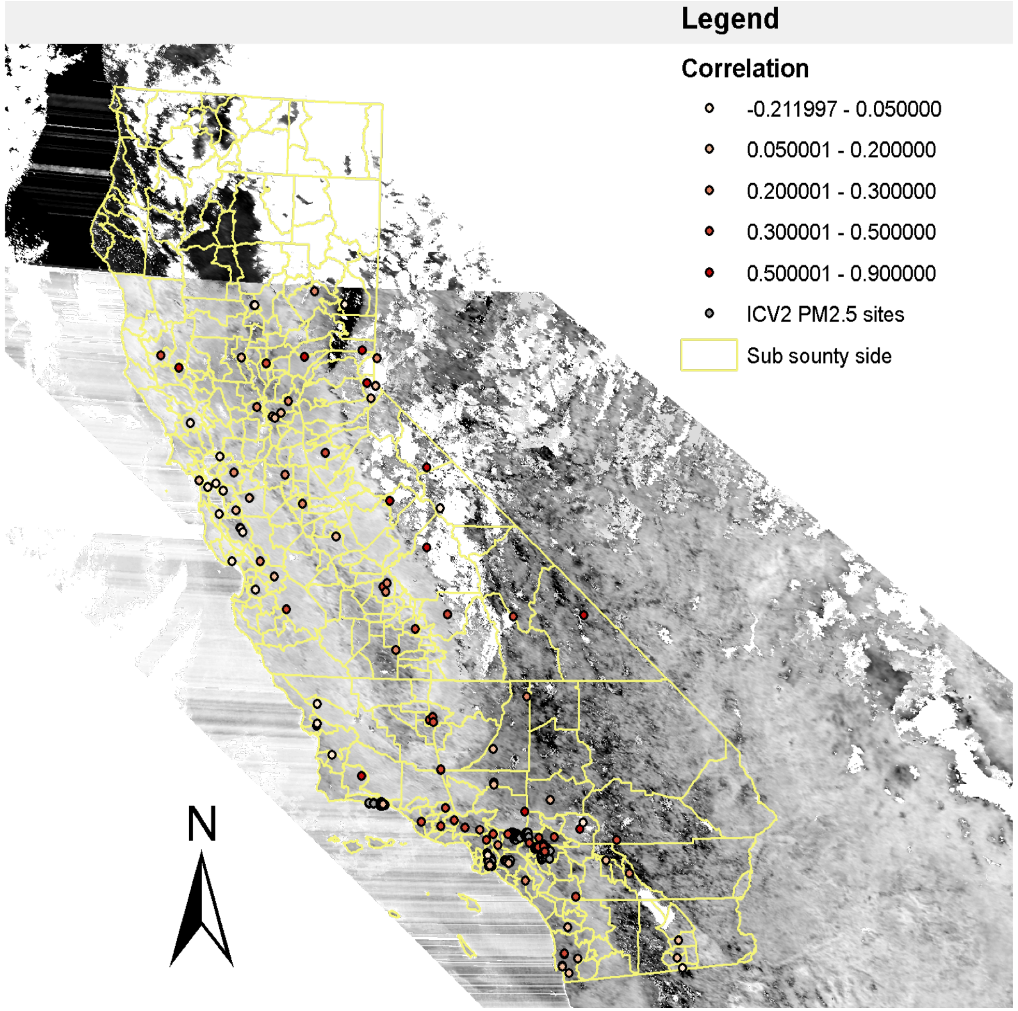


Li et. Al (2018, *in submission*) California Spatiotemporal NO_x Model



CV R^2 0.88

Li et. Al (2018, *in progress*) California Spatiotemporal $PM_{2.5}$ Model

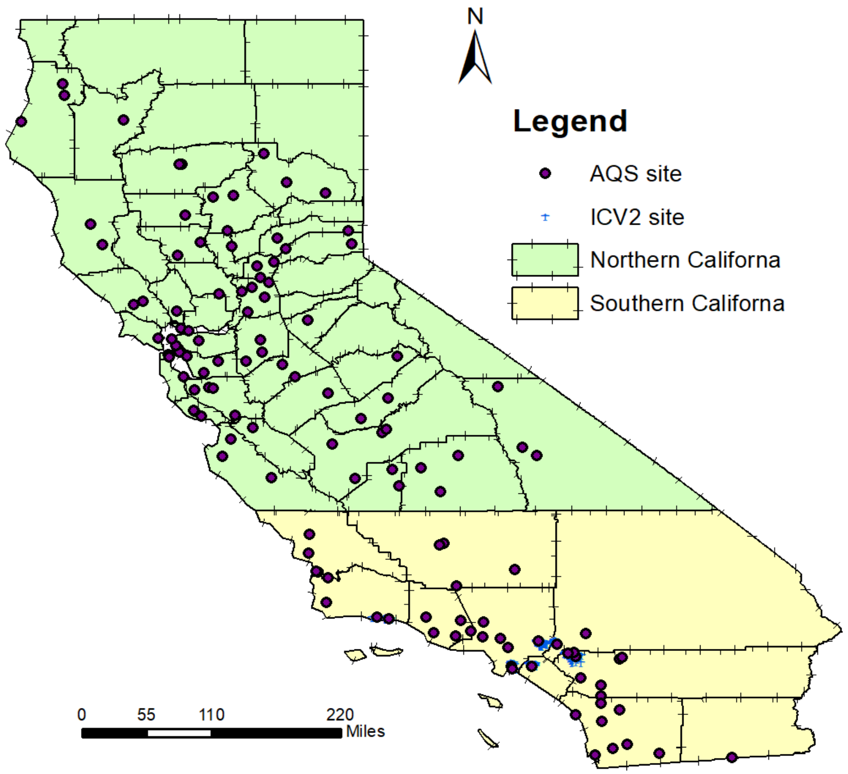


Li et. Al (2018, *in progress*) California Spatiotemporal $PM_{2.5}$ Model

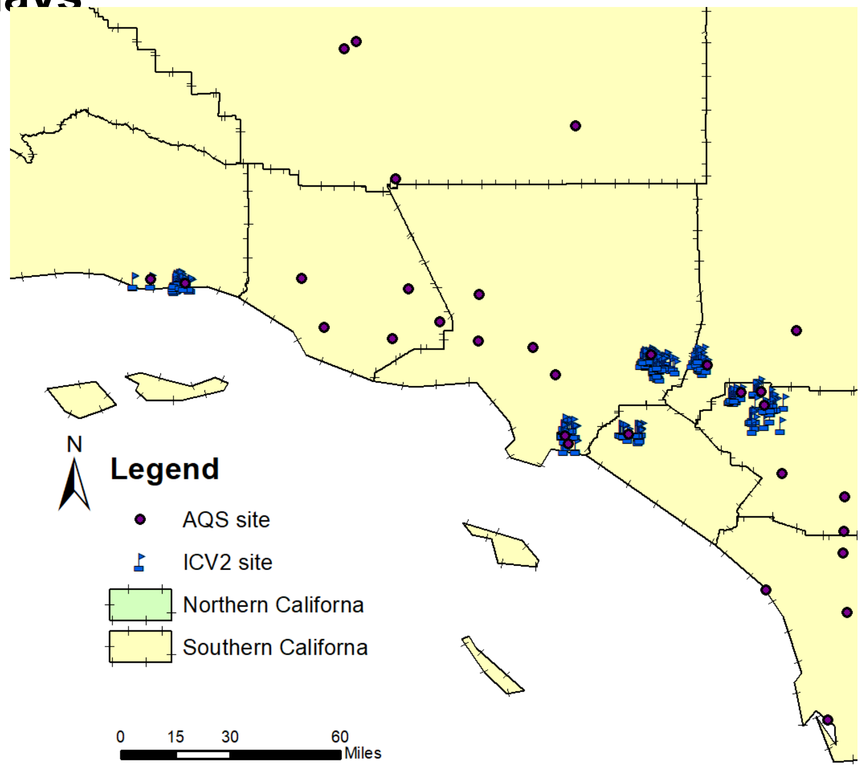
- Building two $PM_{2.5}$ models, weekly
  - ~2000 onwards using MAIAC 1km x 1km data
  - ~1980 onwards using MERRA-2 50km x 50km data
- Fitting temporal basis functions to 50km x 50km MERRA-2 grid cells to reconstruct long term time series (1980's onwards)
- Using MERRA-2 AOD to help interpolate missing MAIAC AOD using machine learning approaches
- Incorporating MERRA-2 GMI Replay Simulation AOD/surface-level $PM_{2.5}$

PM2.5 Measurements (2000+ model)

127 monitoring AQS stations for California with 160,652 daily averages



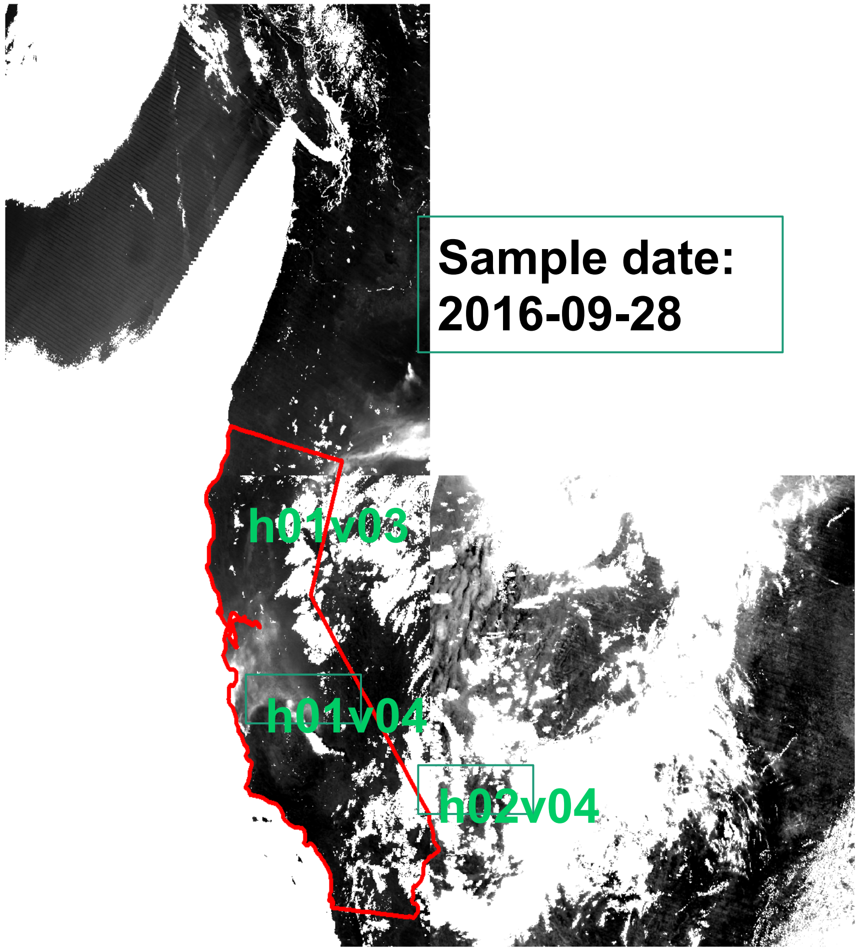
278 sampling locations for USC ICV2 with 937 measurements of 12 to 16 days



MAIAC AOD, 1km x 1km

MAIAC 2000-2016 CA Tiles

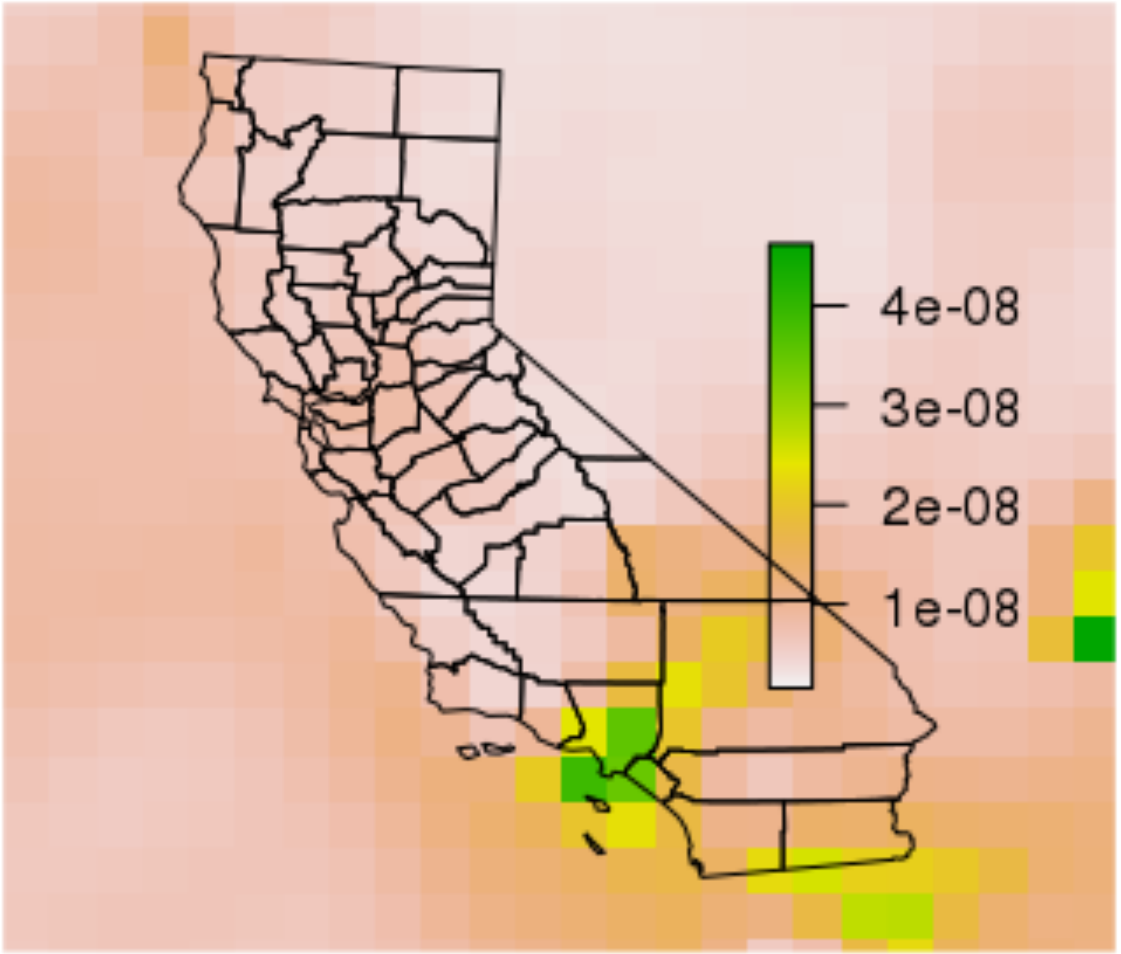
- **H01V03** small northern region of CA
- **H01V04** large area of CA (southern CA)
- **H02V04** covering a small corner of CA



MERRA-2 GMI Replay Simulation

Surface-level $PM_{2.5}$

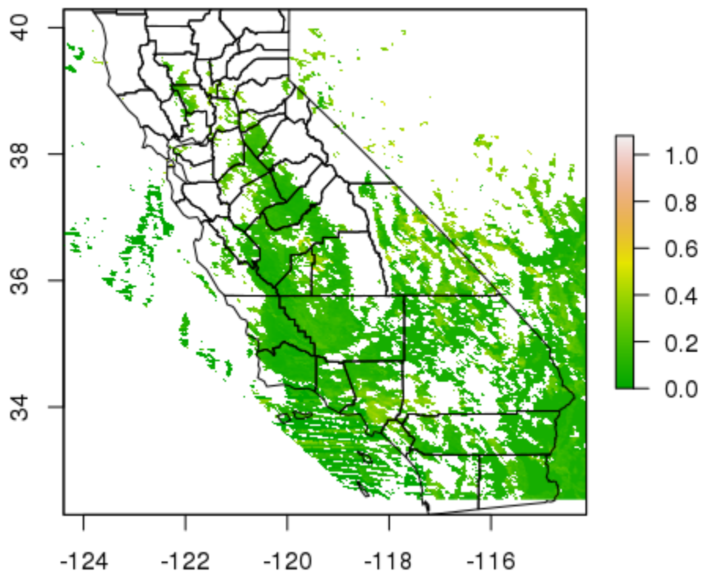
- 57 km x 57 km spatial
- Hourly temporal



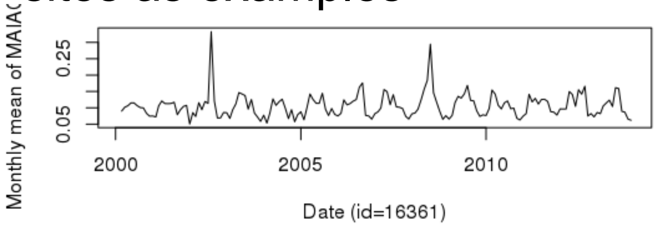
- Sample date 2006-06-07
- $PM_{2.5}$_BOT (kg/m^3): Total reconstructed $PM_{2.5}$

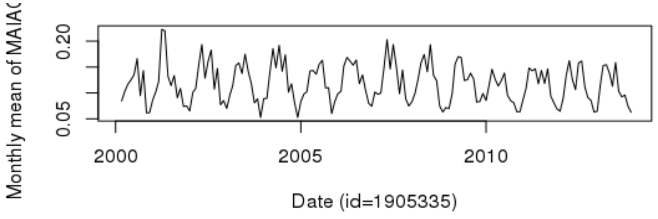
Using monthly mean MAIAC AOD, construct temporal basis functions

February 2000

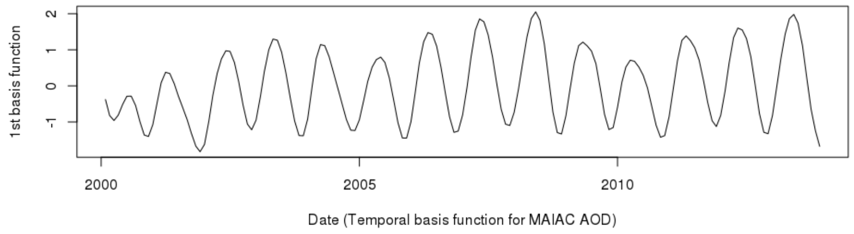


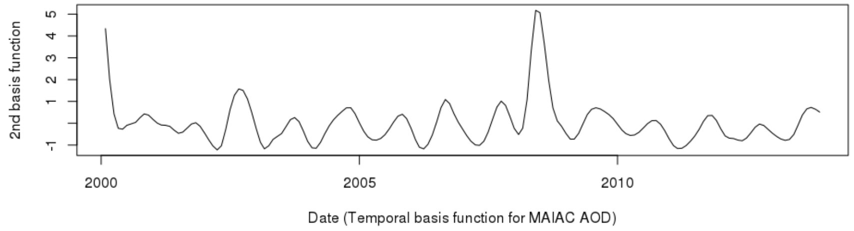
Monthly means at different sites as examples





Temporal basis functions generated from random sample (n=10,000), reflect regional long-term temporal variation, we expect regional differences





Imputation of missing daily MAIAC AOD

- Currently using coordinates (space), elevation, air temperature, wind speed, specific humidity, surface shortwave radiation flux, MERRA-2 daily AOD, and monthly MAIAC AOD, day of week index

$$
\begin{aligned}
AOD_{jt} = {} & s(X_j) + s(Y_j) + s(X_j^2) + s(Y_j^2) + s(X_j \times Y_j) + \beta_1 CF \\
& + \beta_2 CMTAOD_{jt} + \beta_3 + Temp_{jt} + \beta_4 RH_{jt} + \beta_5 SH_{jt} \\
& + \beta_6 Ele_j + D_t + \varepsilon_{jt}
\end{aligned}
$$

Coordinates: x, y, x^2, y^2 and x*y to capture spatial autocorrelation;

Air temperature: min and max air temperature, difference between minimum and maximum temperatures;

Specific humidity;

Surface downwelling shortwave flux in air;

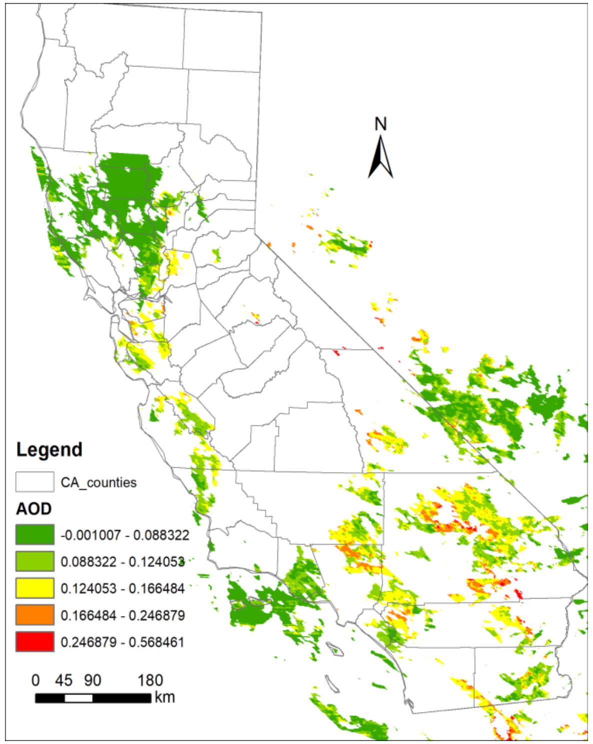
Elevation;

MERRA2 reanalysis AOD: background AOD predictor ;

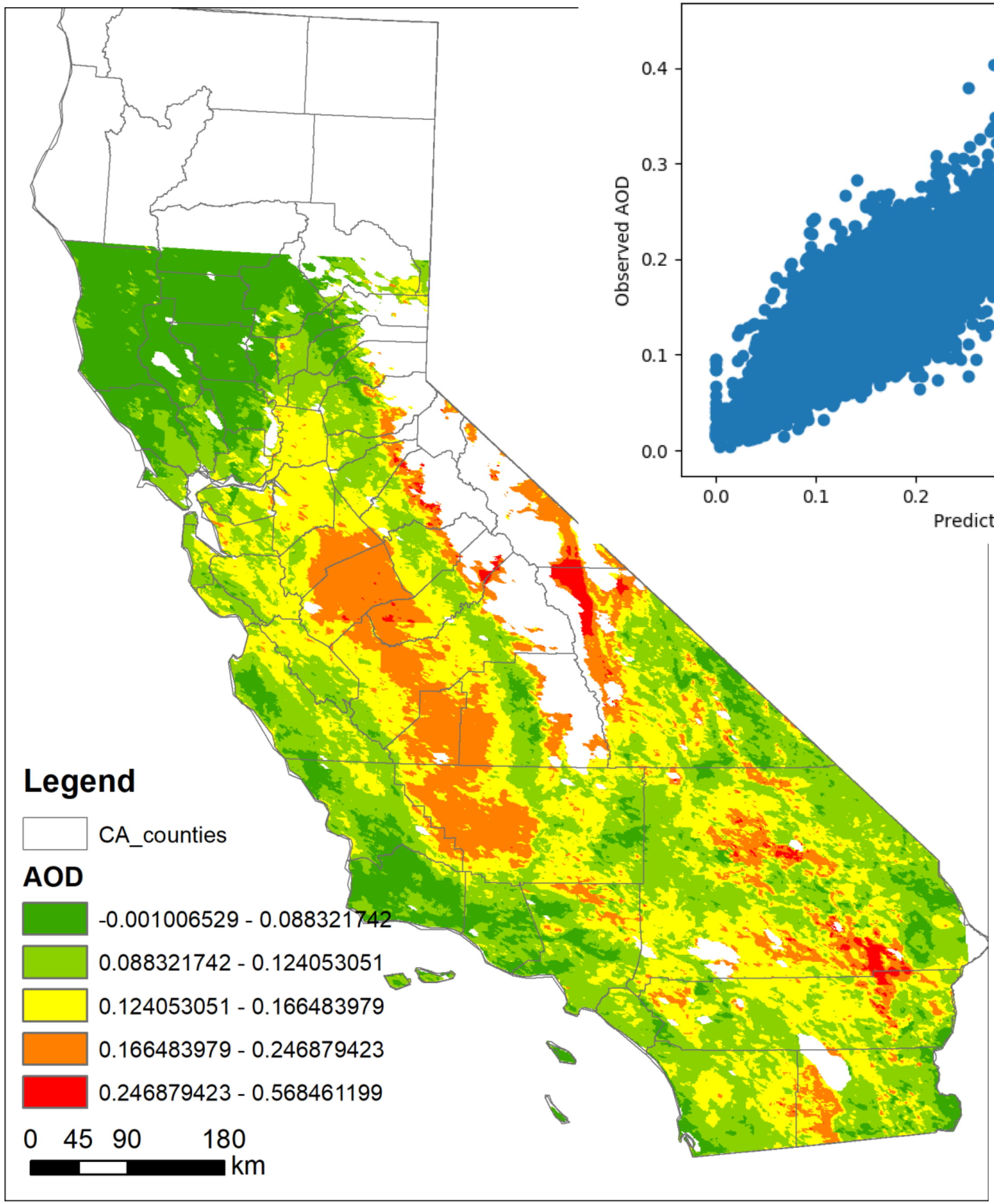
Monthly mean AOD: to capture temporal trend and spatial difference;

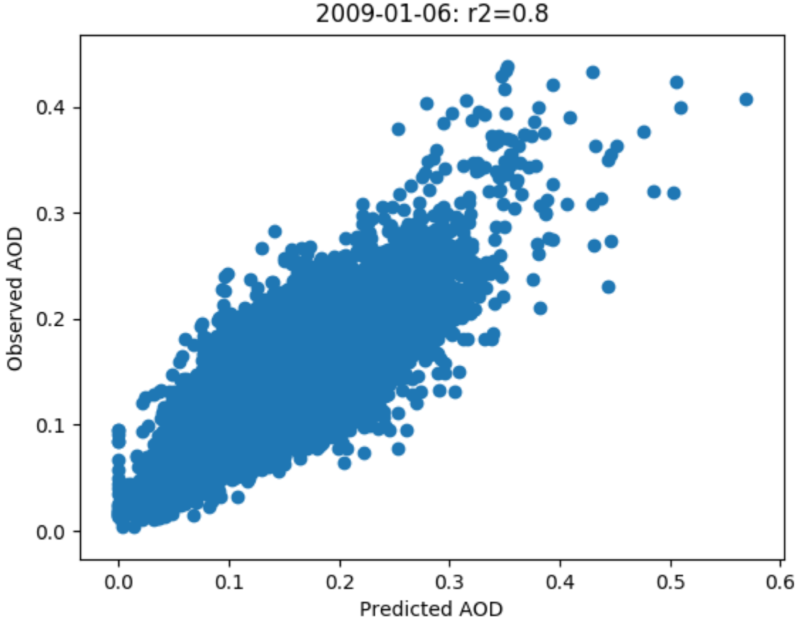
Day index: dummy variable for day index (1-7)

Preliminary findings, please do not cite or circulate.



Original image (2009-01-06)





Imputed image: Several places still not imputed due to snow or water

Preliminary findings, please do not cite or circulate.

Thank You

- Lianfa Li, postdoctoral research associate
- Mariam Girguis, postdoctoral research associate
- ECHO exposure assessment team
  - Fred Lurmann, Jun Wu, Meredith Franklin, Nathan Pavlovic
- LA DREAMERs PIs
  - Carrie Breton and Frank Gilliland