Preparing Key State and Local Health and Air Quality Agencies for Upcoming Earth Observations

Yang Liu, Jun Wang, Kevin Cromar

September 15, 2020

ROLLINS
SCHOOL OF
PUBLIC
HEALTH

EMORY

Project Goals

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

- Prepare air quality and public health stakeholders for data from the next-generation satellite instruments such as MAIA, TEMPO, and GOES-R series

- Use actual or synthetic data of these instruments to demonstrate how the new information can enhance stakeholders' decision support activities

Decision Support Systems and Needs

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

- GA EPD - Air Quality Exceedance Report System - helps the EPD better understand the complex conditions leading to exceedances and develop effective emission control strategies (if warranted) to prevent future exceedances

- Proposed enhancement: (1) upgrade GA EPD's O3 and NO2 modeling analysis with synthetic TEMPO O3 and NO2; and (2) introduce $PM_{2.5}$ mapping capabilities using GOES-16 AOD.

Decision Support Systems and Needs

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

- NYC - (1) Community Air Survey (NYCCAS) - to evaluate how air quality differs across New York City, (2) Syndromic Surveillance of ED visits for emergency response and situational awareness

- Proposed enhancement: (1) upgrade NYC's $PM_{2.5}$ LUR model with synthetic MAIA SO4 and NO3, and (2) develop daily $PM_{2.5}$ model with GOES-R AOD

Decision Support Systems and Needs

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

- CARB - Community Air Pollution Monitoring Networks to reduce exposure in communities most impacted by air pollution

- Proposed enhancement: (1) a statewide $PM_{2.5}$ screening tool using GOES-16 AOD data to prioritize monitoring locations, (2) a seasonal $PM_{2.5}$ NO3 and SO4 model in Southern California using synthetic MAIA SO4 and NO3, GOES-R AOD

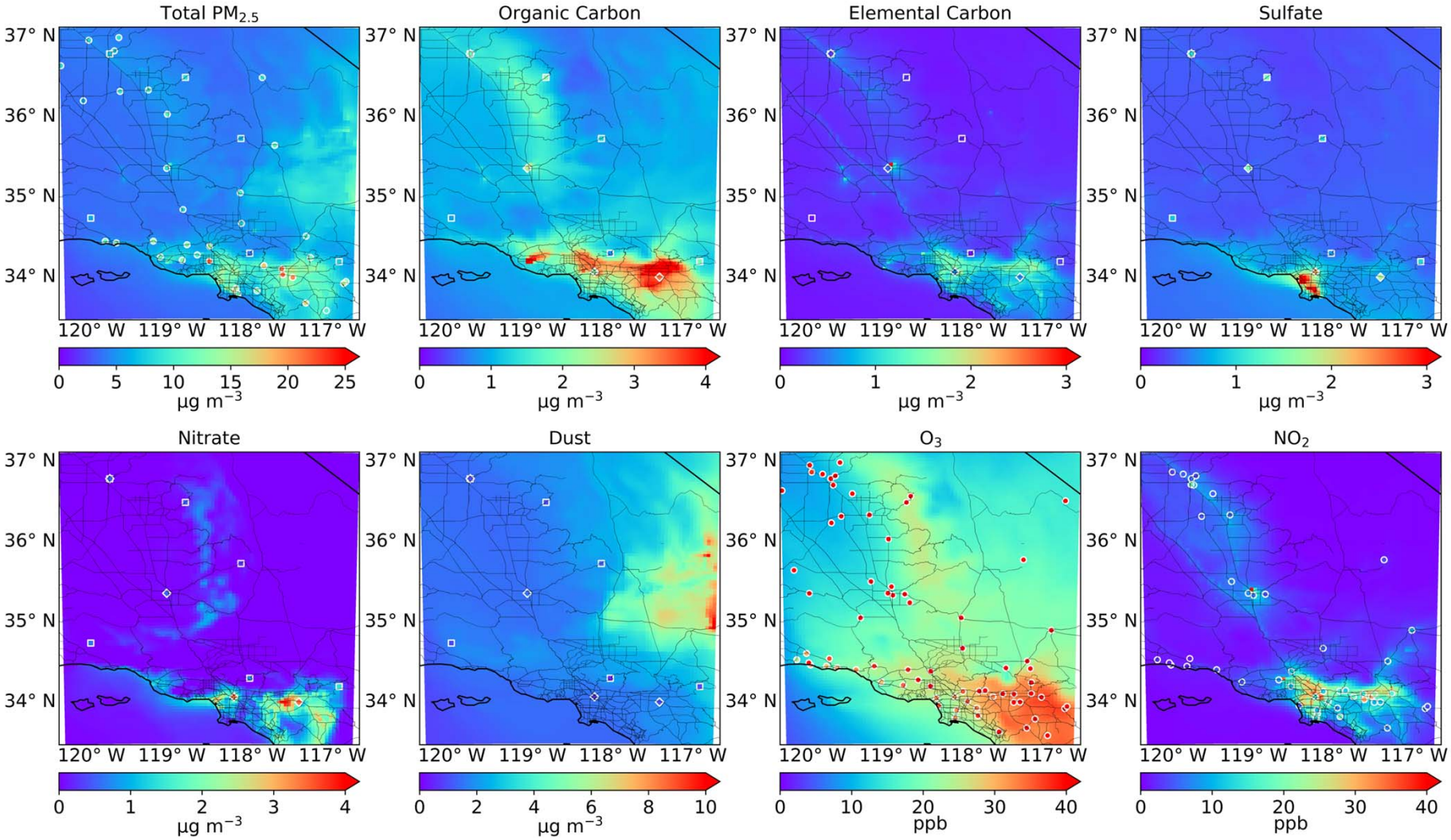
WRF-Chem run to generate TEMPO & MAIA synthetic data

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

- WRF-Chem simulation are conducted at 4 km resolution for three MAIA PTAs in U.S.
- Output parameter list was finalized and initial model runs conducted for a month in 2018 in all three study regions.
- Early results showed significant low bias of O_3 and too much dust in the simulation, especially at the Los Angels PTA.

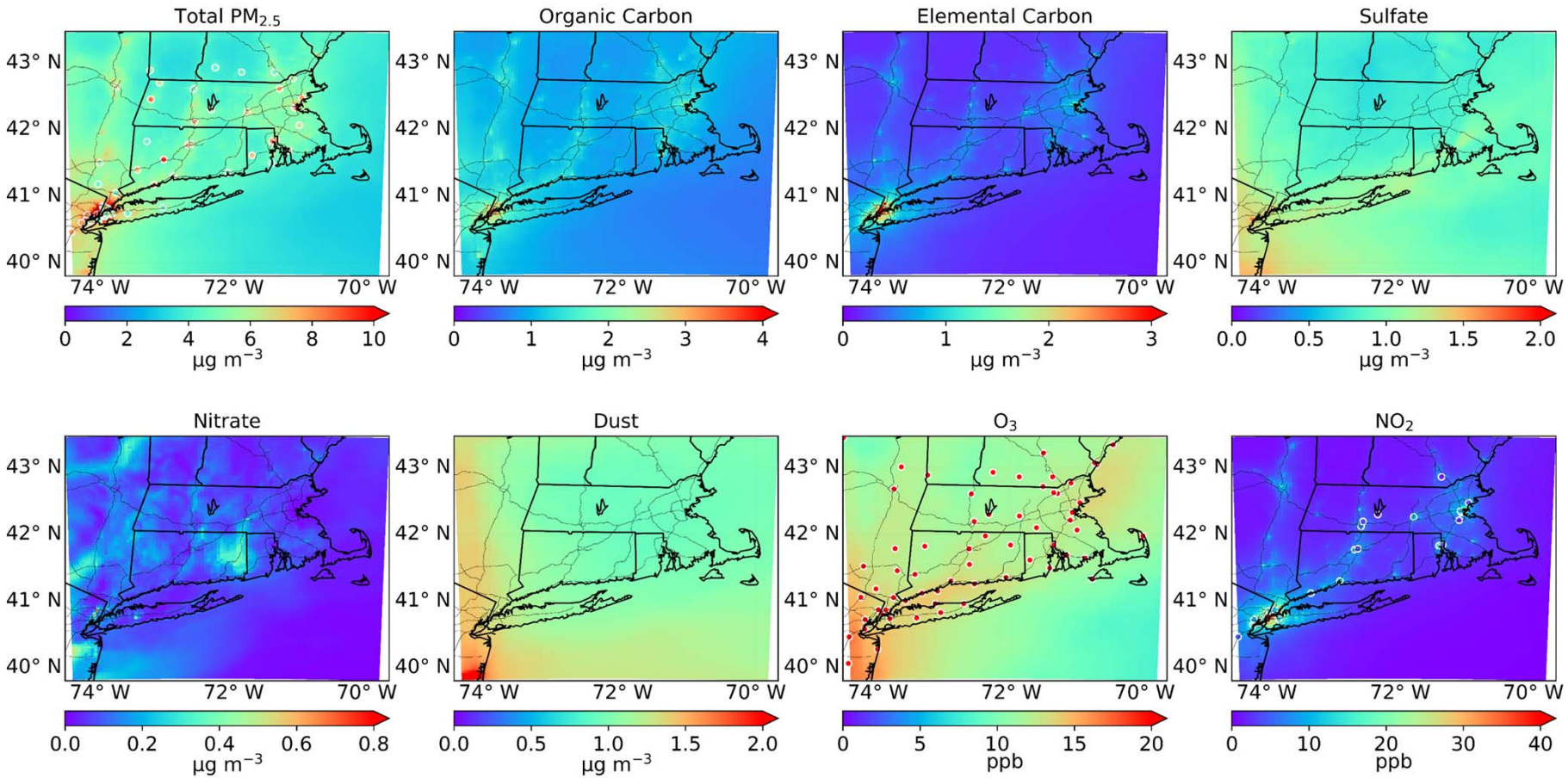
LA PTA: June 8-14, 2018, 4 km resolution

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY



Boston + New York PTA: June 2018, 4 km resolution

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY



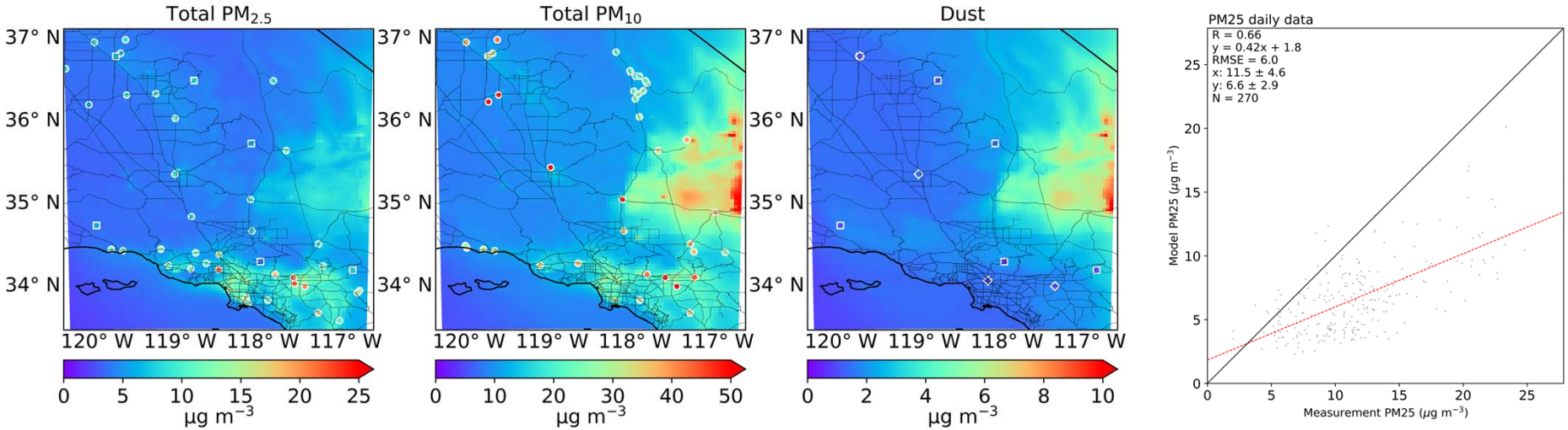
Measures to improve WRF-Chem

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

- A series of modifications were made to improve
  - Diurnal variation of NOx emission
  - VOC emissions
  - Soil NOx emissions
  - Dust emissions
  - Representation of land use and land change
- The most recent results show better agreement with observations.

Improvement on PM simulation
LA PTA: June 8-14, 2018, 4 km resolution

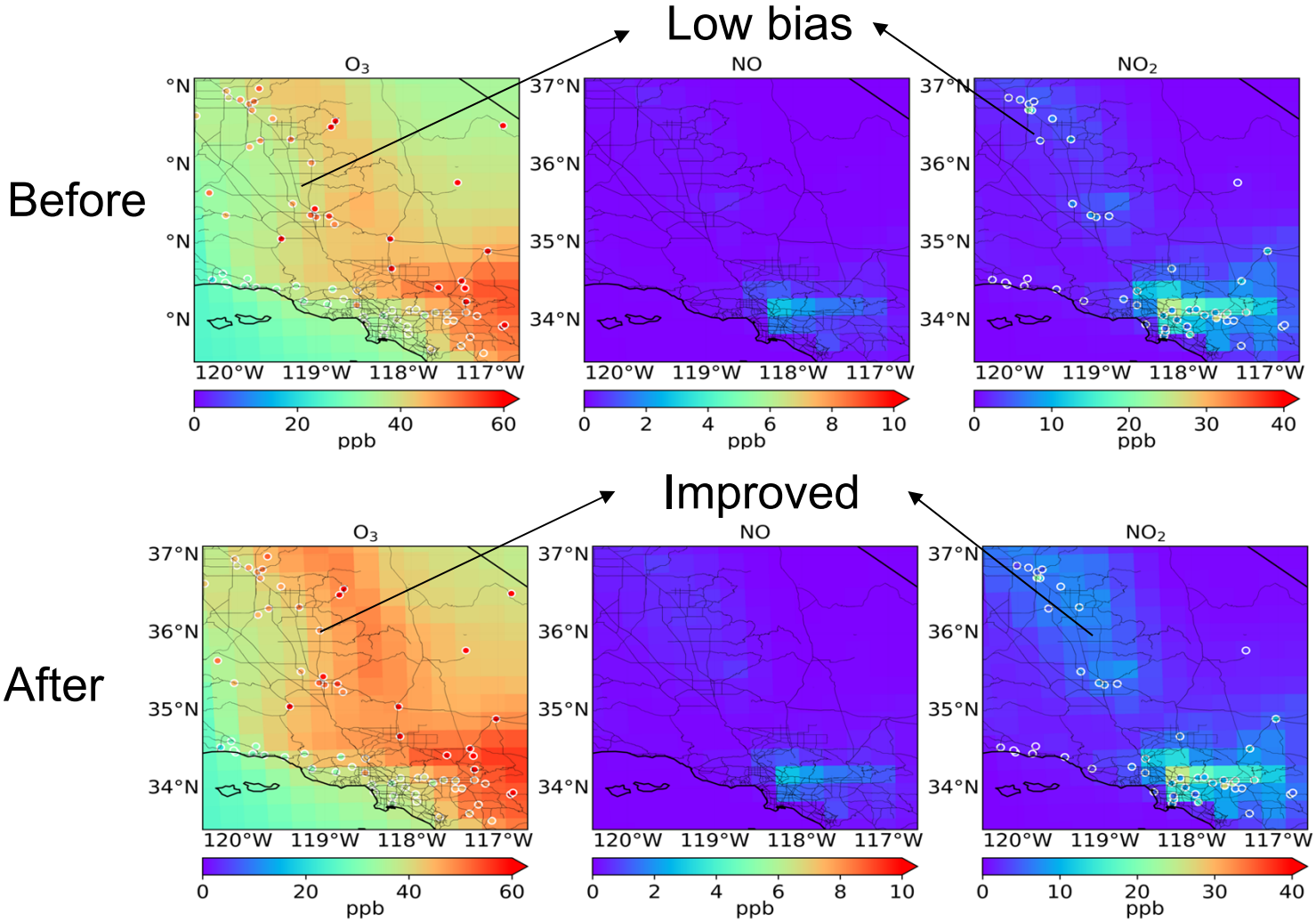
ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY



Model has been adjusted to lower the dust contribution from the Mojave Desert. Correlation with ground observations increased to 0.6.

Improvement of O_3 simulation

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY



GOES16-Based Estimation of Hourly $PM_{2.5}$ Levels During the Camp Fire Episode in California

Bryan Vu, Jianzhao Bi, Amy Huff, Shobha Kondragunta, Yang Liu

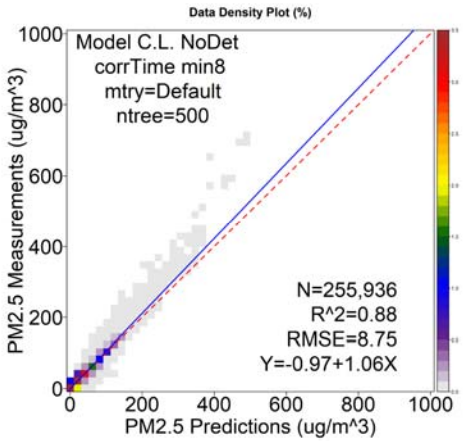
Highlight:

- We conducted a RF model with both AQS and PA measurements to evaluate the effectiveness of GOES16 data in predicting wildfire $PM_{2.5}$
- Our model achieved an out of bag (OOB) R^2 of 0.88 with a relatively small RMSE of 8.8 μg/m^3
- Hourly GOES-16 AOD performed among the top 5 predictors and is able to tract not only the temporal but also the spatial trend of $PM_{2.5}$

Relevance:

- Wildfire events release vast amounts of $PM_{2.5}$ into the atmosphere, which may be transported via smoke plumes and traverse tens to thousands of kilometers in distance and result in excess mortality and morbidity
- GOES-16's fine temporal resolution allows for reconstruction of $PM_{2.5}$ levels that will aid in health studies investigating very acute air pollution exposures

A)



B)

Variable	Importance
Convol_Layer	89.568
GOES16 AOD	37.589
per_Herb	36.925
per_Forest	35.829
HPBL	35.220

Figure 1: A) Density plot of ground observations versus model predictions. B) Top 5 predictors of RF model.

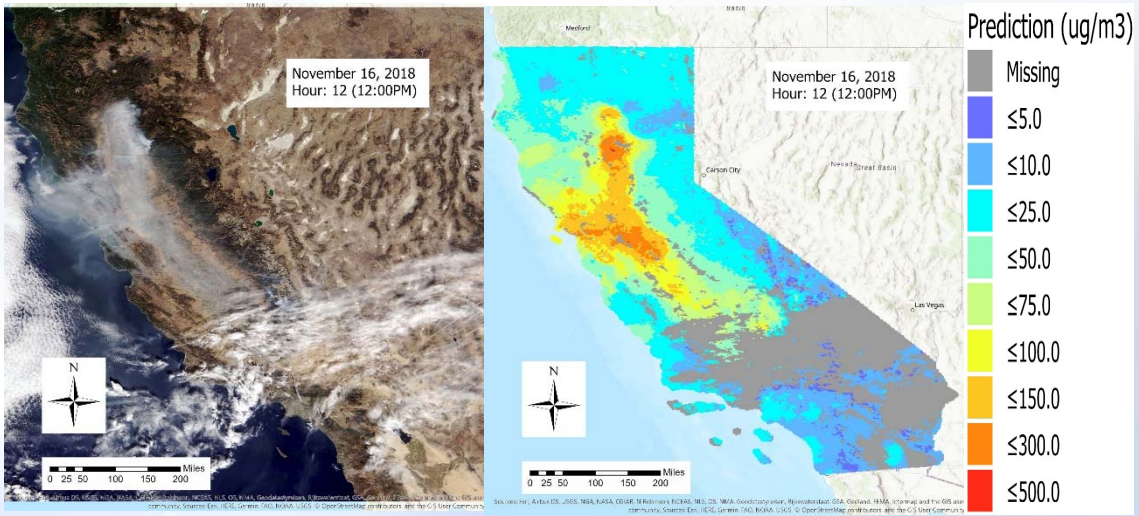
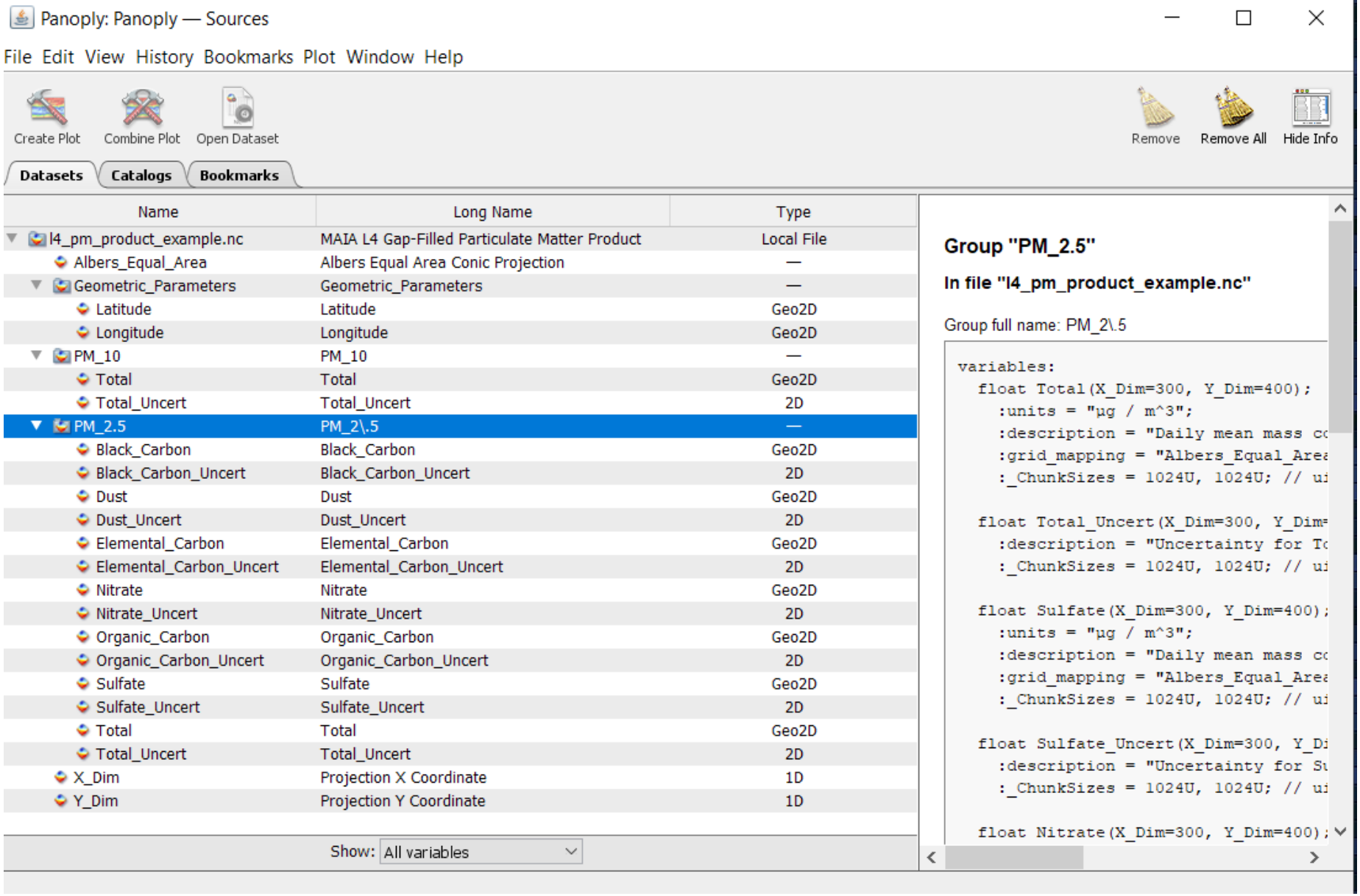


Figure 2: Hourly $PM_{2.5}$ prediction compared to True-Color Composite image from MODIS on November 16, 2018 at 12:00PM PST, the day with the highest measurement from the ground monitors.

MAIA L4 PM product file template

ROLLINS SCHOOL OF PUBLIC



Evaluating the utility of high-resolution air pollution data: Comparing the importance of temporal and spatial variability in estimating local air pollution exposures in California from 2015-2018.

Cromar et. al., 2020. International Society of Environmental Epidemiology.

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

Highlight:

- Daily PM2.5 estimates at a 1 km^2 resolution, derived from MAIAC AOD, from 2015-2018 were linked to ZIP Codes in California.
- For 92 cities, comparisons were made between variations within- and between-ZIP Codes, and among relative variances within ZIP Codes.
- Variation of $PM_{2.5}$ concentrations within ZIP Codes is negligible (except for very large ZIP Codes > 50 km^2), with much greater variation observed between ZIP Codes in the same city. The amount of information lost varies by season.
- In all cases, day-to-day temporal variability was much greater than the spatial variability at the suburban spatial resolutions included in this study.

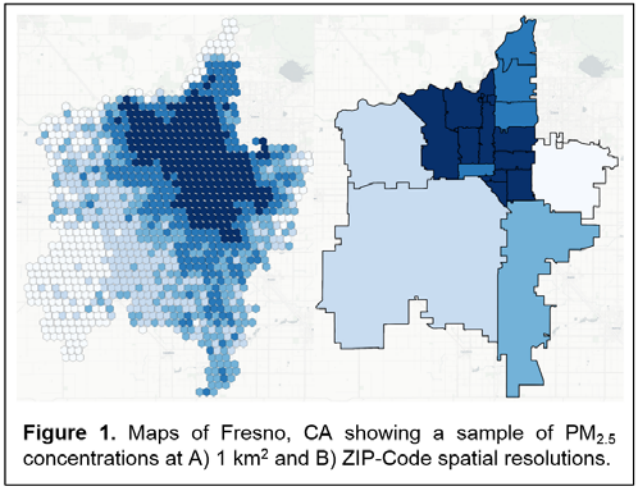


Figure 1. Maps of Fresno, CA showing a sample of $PM_{2.5}$ concentrations at A) 1 km^2 and B) ZIP-Code spatial resolutions.

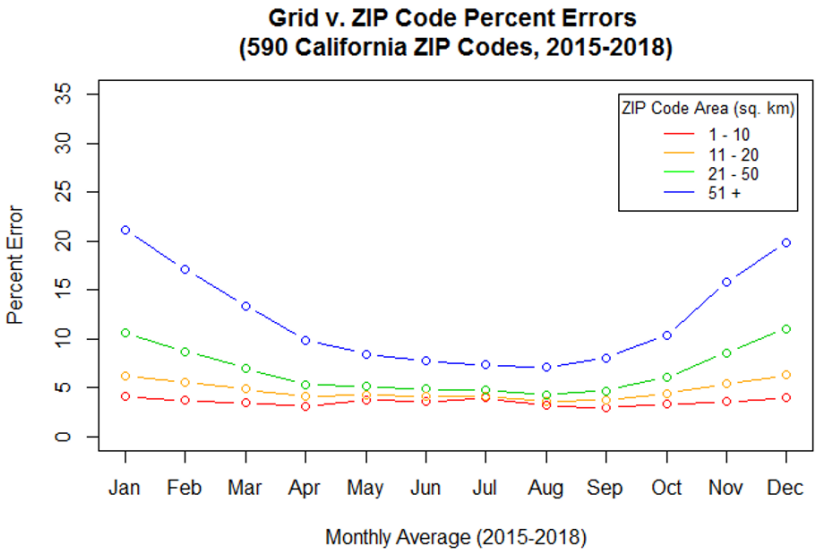


Figure 2. Plot of percent errors between 1 km^2 grids and their corresponding ZIP Codes by ZIP Code size.

Evaluating the utility of high-resolution air pollution data: Comparing the importance of temporal and spatial variability in estimating local air pollution exposures in California from 2015-2018.

Cromar et. al., 2020. International Society of Environmental Epidemiology.

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

Motivation:

- Exposure misclassification, due to assignment of exposures based on home address, results in larger bias in assigned exposures than use of coarser ZIP-Code level pollution estimates.

Relevance:

- For health research, it is often easier to compile necessary data (health statistics, predicting variables, confounding variables, etc.) for analysis at ZIP code level rather than at finer spatial resolutions.

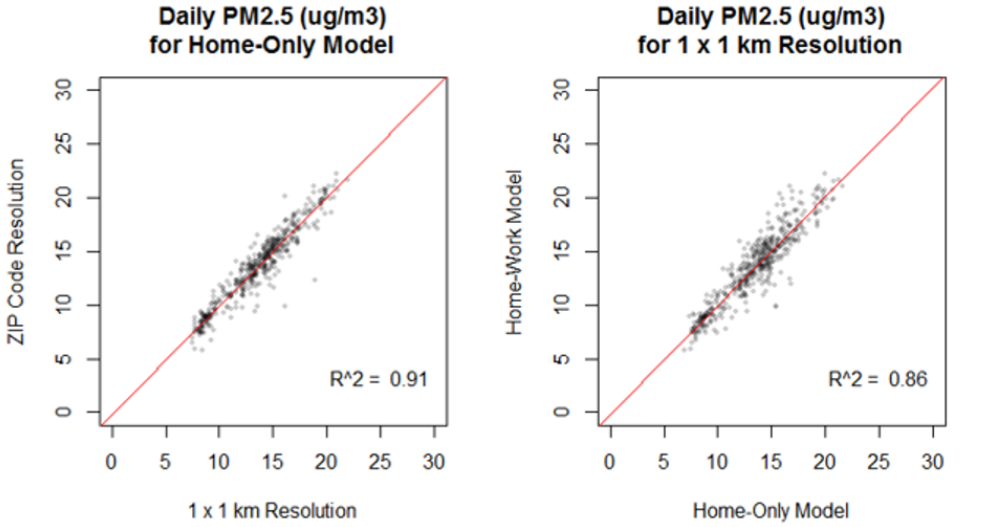


Figure 3. Comparison of exposure bias due to spatial differences in spatial resolution (1 km^2 vs. ZIP Code) and exposure misclassification due to assumptions of daily exposures based solely on home address location.

Exposure misclassification due to assignment of pollution exposures based on home address resulted in greater bias than use of zip-code estimates of $PM_{2.5}$. Without accompanying time-varying location data for study subjects, the need for finer resolution spatial estimates for $PM_{2.5}$ may be limited for use in health research.

Risks and Mitigation

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

ARL goal: 7 for MAIA and TEMPO, 8 for GOES-R. Current ARL: 4

Rank	Type*	Risk	Mitigation Action
1	Technical challenges	Limited access to workstations/clusters and high-speed internet, and reduced team productivity due to COVID-19. WRF-Chem performance issues.	Focus our WRF-Chem run on 2018 only. Will not affect fusion effort with TROPOMI. WRF-Chem performance has been improved.
2	Budget challenges	Emory billing has mostly caught up. U. Iowa billing will speed up in the fall.	No action needed.
3	Management challenges	CARB has not been responsive due to COVID-19 emergency response	Continue to try communicating with CARB.