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

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Project Goals

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- 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

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- 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

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- 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

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- 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

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- 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

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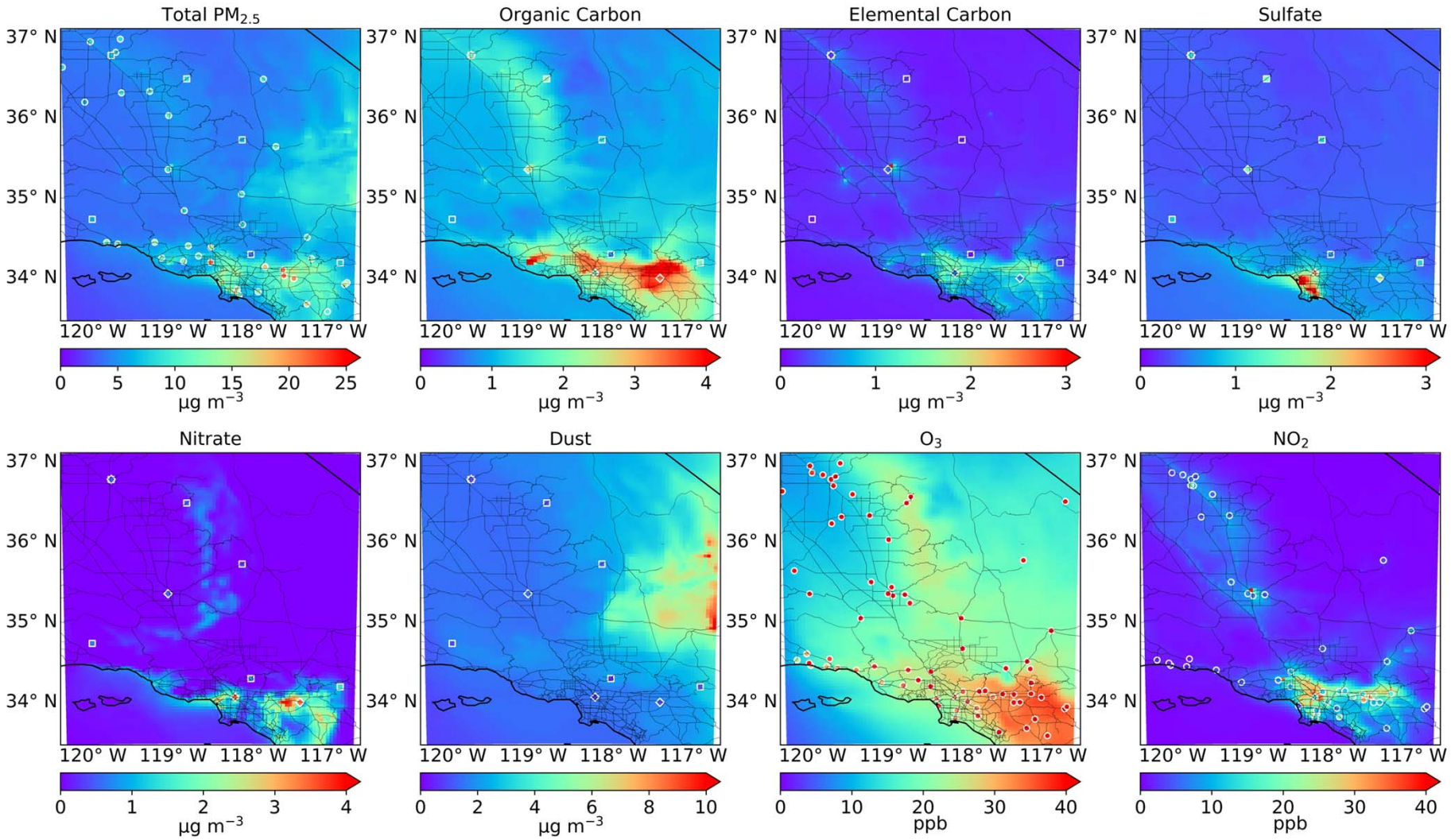

Boston + New York PTA: June 2018, 4 km resolution

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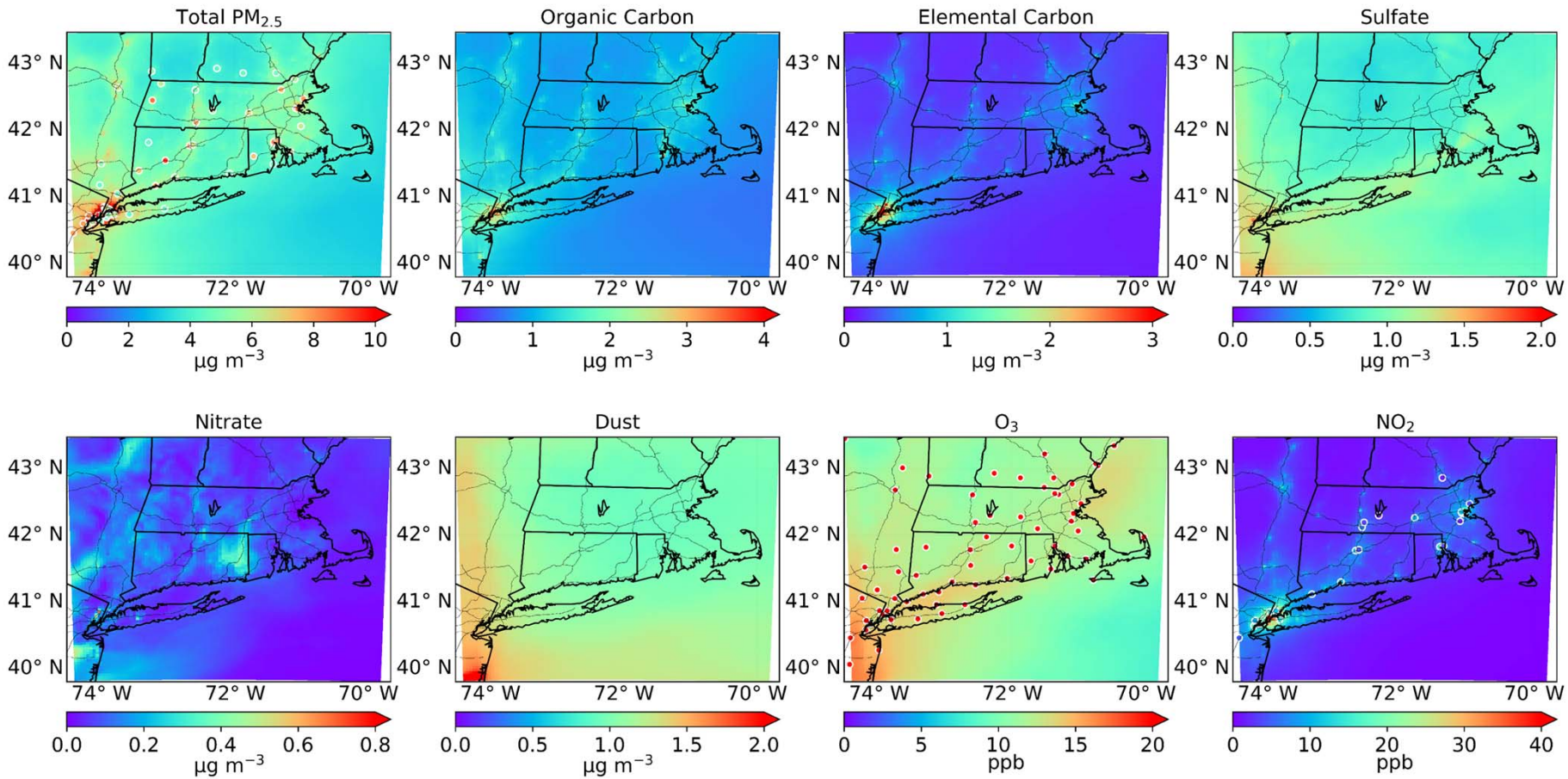

Measures to improve WRF-Chem

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- 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

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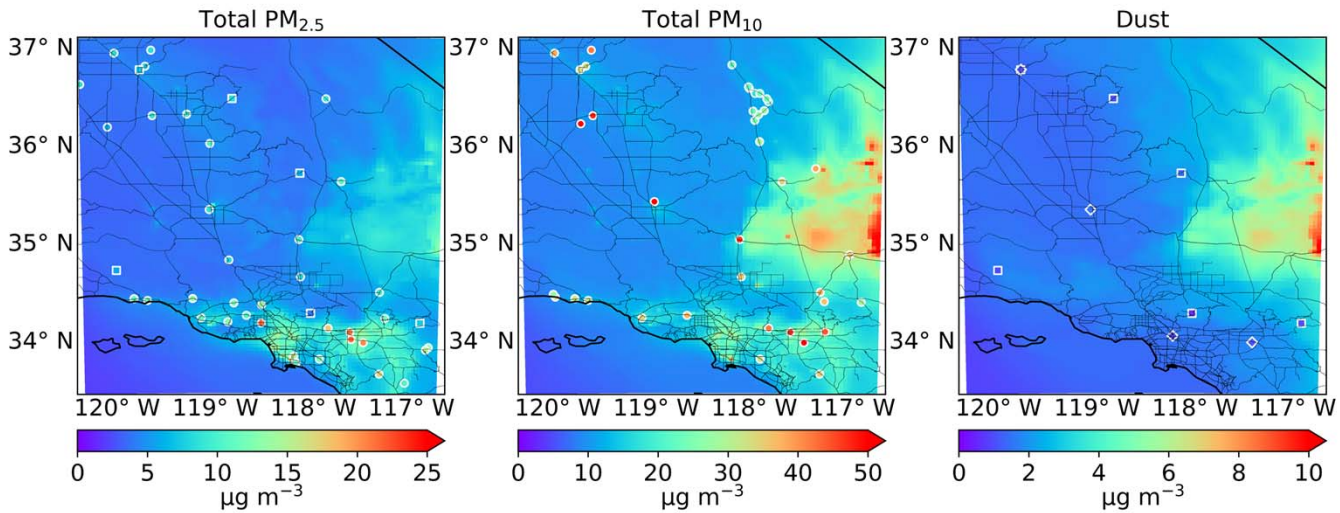

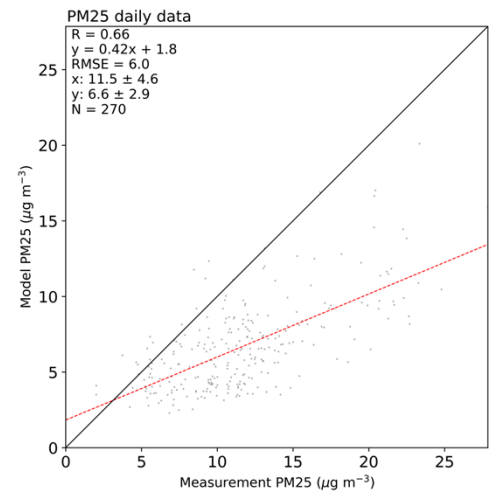

Model has been adjusted to lower the dust contribution from the Mojave Desert. Correlation with ground observations increased to 0.6.

Improvement of O_3 simulation

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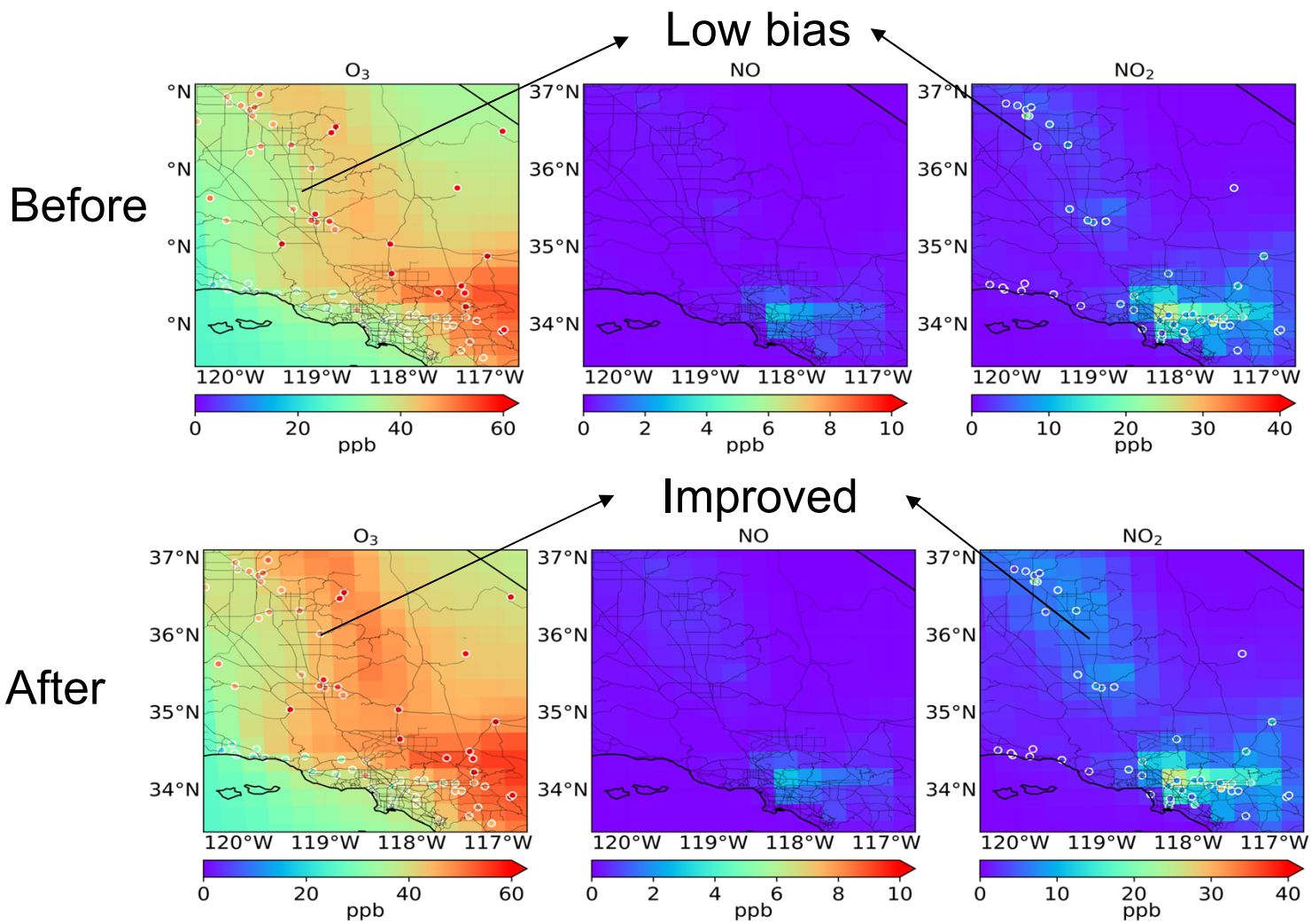


GOES16-Based Estimation of Hourly $PM_{2.5}$ Levels During the Camp Fire Episode in California

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

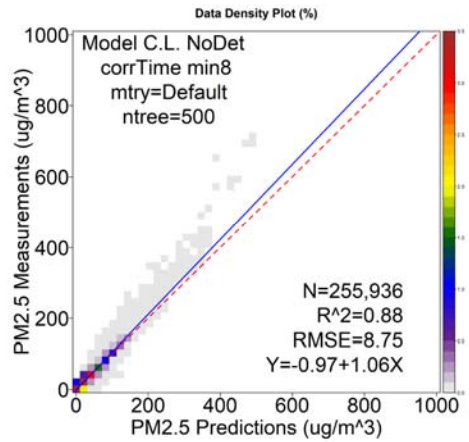
Highlight:

- 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.

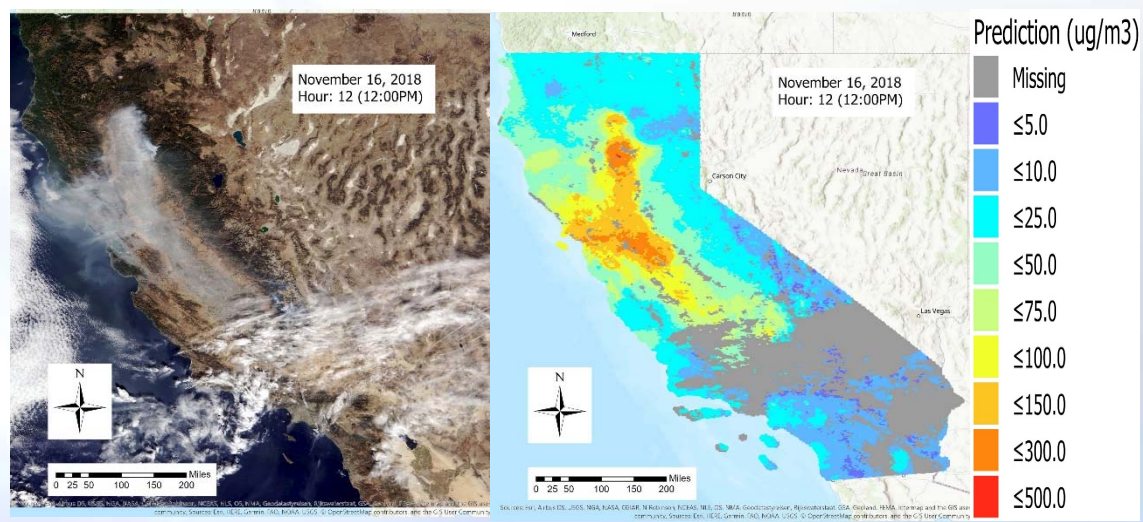


Figure 2: Hourly $PM_{2.5}$ prediction compared to True-Color Composite image from MODIS on November 16, 2018 at 12:00PM PST, the day with the highest measurement from the ground monitors.

MAIA L4 PM product file template

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Panoply: Panoply — Sources

File Edit View History Bookmarks Plot Window Help

Create Plot | Combine Plot | Open Dataset | Remove | Remove All | Hide Info

Datasets | Catalogs | Bookmarks

Name	Long Name	Type
l4_pm_product_example.nc	MAIA L4 Gap-Filled Particulate Matter Product	Local File
Albers_Equal_Area	Albers Equal Area Conic Projection	—
Geometric_Parameters	Geometric_Parameters	—
Latitude	Latitude	Geo2D
Longitude	Longitude	Geo2D
PM_10	PM_10	—
Total	Total	Geo2D
Total_Uncert	Total_Uncert	2D
PM_2.5	PM_2\.5	—
Black_Carbon	Black_Carbon	Geo2D
Black_Carbon_Uncert	Black_Carbon_Uncert	2D
Dust	Dust	Geo2D
Dust_Uncert	Dust_Uncert	2D
Elemental_Carbon	Elemental_Carbon	Geo2D
Elemental_Carbon_Uncert	Elemental_Carbon_Uncert	2D
Nitrate	Nitrate	Geo2D
Nitrate_Uncert	Nitrate_Uncert	2D
Organic_Carbon	Organic_Carbon	Geo2D
Organic_Carbon_Uncert	Organic_Carbon_Uncert	2D
Sulfate	Sulfate	Geo2D
Sulfate_Uncert	Sulfate_Uncert	2D
Total	Total	Geo2D
Total_Uncert	Total_Uncert	2D
X_Dim	Projection X Coordinate	1D
Y_Dim	Projection Y Coordinate	1D

Show: All variables

Group "PM_2.5"

In file "l4_pm_product_example.nc"

Group full name: PM_2\.5

```
variables:
  float Total(X_Dim=300, Y_Dim=400);
    :units = "µg / m^3";
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    :grid_mapping = "Albers_Equal_Area
    :_ChunkSizes = 1024U, 1024U; // ui

  float Total_Uncert(X_Dim=300, Y_Dim=
    :description = "Uncertainty for To
    :_ChunkSizes = 1024U, 1024U; // ui

  float Sulfate(X_Dim=300, Y_Dim=400);
    :units = "µg / m^3";
    :description = "Daily mean mass co
    :grid_mapping = "Albers_Equal_Area
    :_ChunkSizes = 1024U, 1024U; // ui

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    :description = "Uncertainty for Su
    :_ChunkSizes = 1024U, 1024U; // ui

  float Nitrate(X_Dim=300, Y_Dim=400);
```

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.

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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.

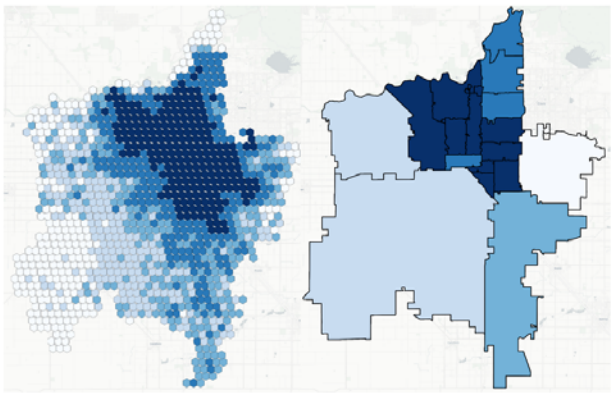

Figure 1. Maps of Fresno, CA showing a sample of $PM_{2.5}$ concentrations at A) 1 km^2 and B) ZIP-Code spatial resolutions.

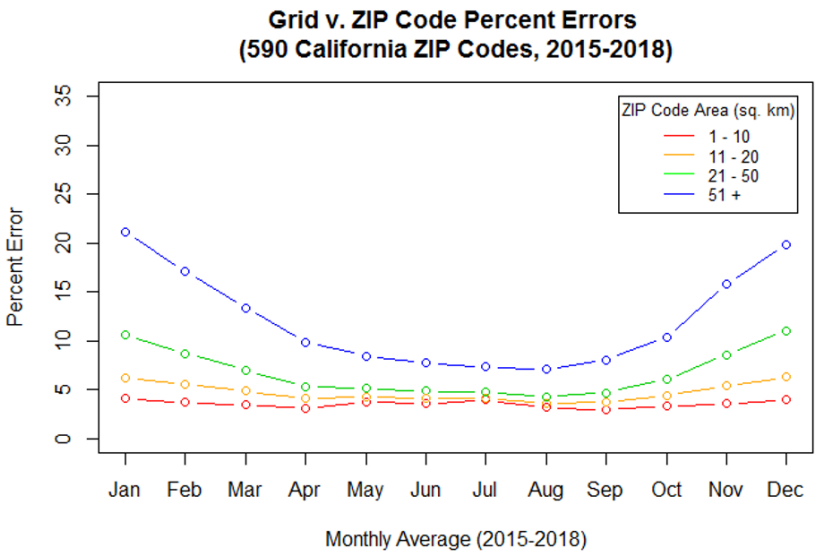

Figure 2. Plot of percent errors between 1 km^2 grids and their corresponding ZIP Codes by ZIP Code size.

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.

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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.

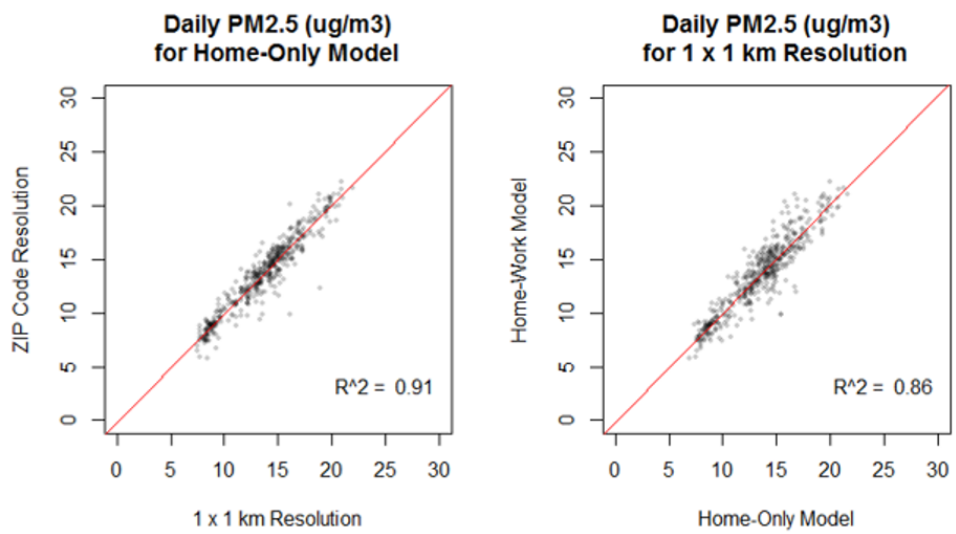

Figure 3. Comparison of exposure bias due to spatial differences in spatial resolution (1 km^2 vs. ZIP Code) and exposure misclassification due to assumptions of daily exposures based solely on home address location.

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.

Project Budget, Obligations & Costing Status

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- Provide the budget status for current year, prior FY, and project to date.

Current Year (FY20)					
Institution	**Budget**	**Obligated**	**Unobligated**	**Costed**	**Uncosted**
Emory	160079	160079	0	88888	71191
NYU	72775	72775	0	71186	1589
U. Iowa	77000	77000	0	15912	61088

Prior Year (FY19)					
Institution	**Budget**	**Obligated**	**Unobligated**	**Costed**	**Uncosted**
Emory	163903	113031	50872	113031	50872
NYU	71000	71000	0	71000	0
U. Iowa	75000	75000	0	2585	72415

Project to date (FY19 - 20)					
Institution	**Budget**	**Obligated**	**Unobligated**	**Costed**	**Uncosted**
Emory	323982	273110	50872	201919	122063
NYU	143775	143775	0	142186	1589
U. Iowa	152000	152000	0	18497	133503

Risks and Mitigation

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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.