Using satellite-derived $PM_{2.5}$ dataset to assist air pollution management in California

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Cynthia Garcia (California Air Resource Board)
Sang-Mi Lee (South Coast Air Quality Management District)

Collaborators: Meytar Sorek-Hamer & Robert Chatfield (NASA ARC)

Some of the highlights

A review paper in preparation for $PM_{2.5}$ exposure estimates

Methods, availability, and applications of $PM_{2.5}$ exposure estimates derived from ground measurements, models, and satellite datasets

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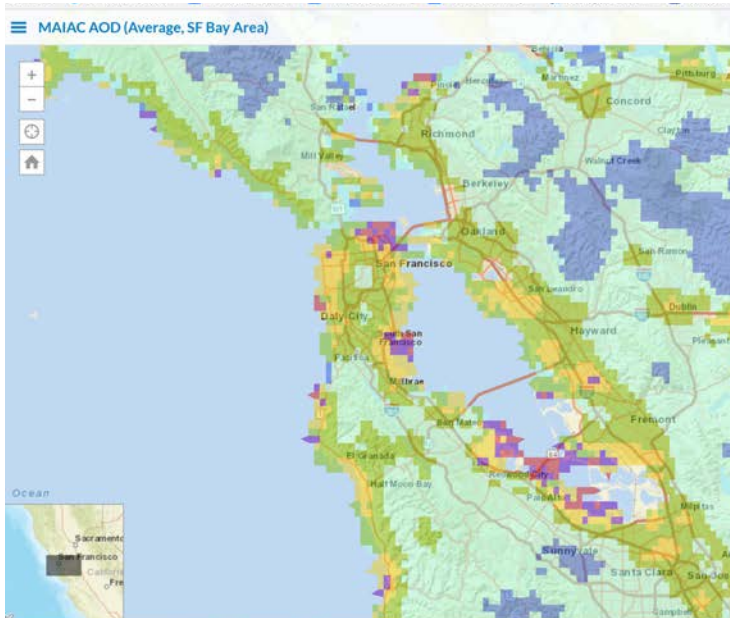
A visualization website of satellite AOD using ArcGIS interface



https://arcg.is/1XbzCy

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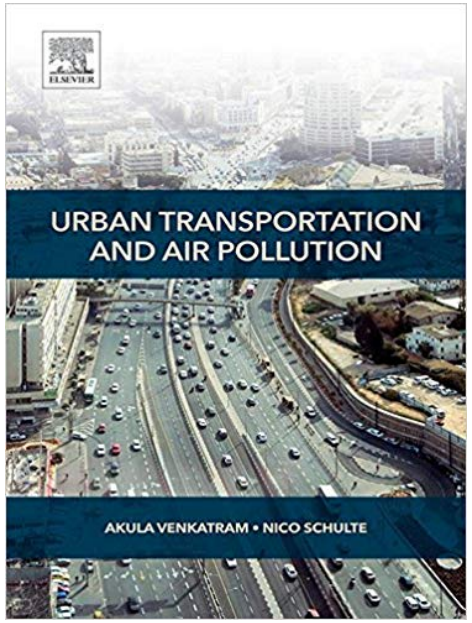
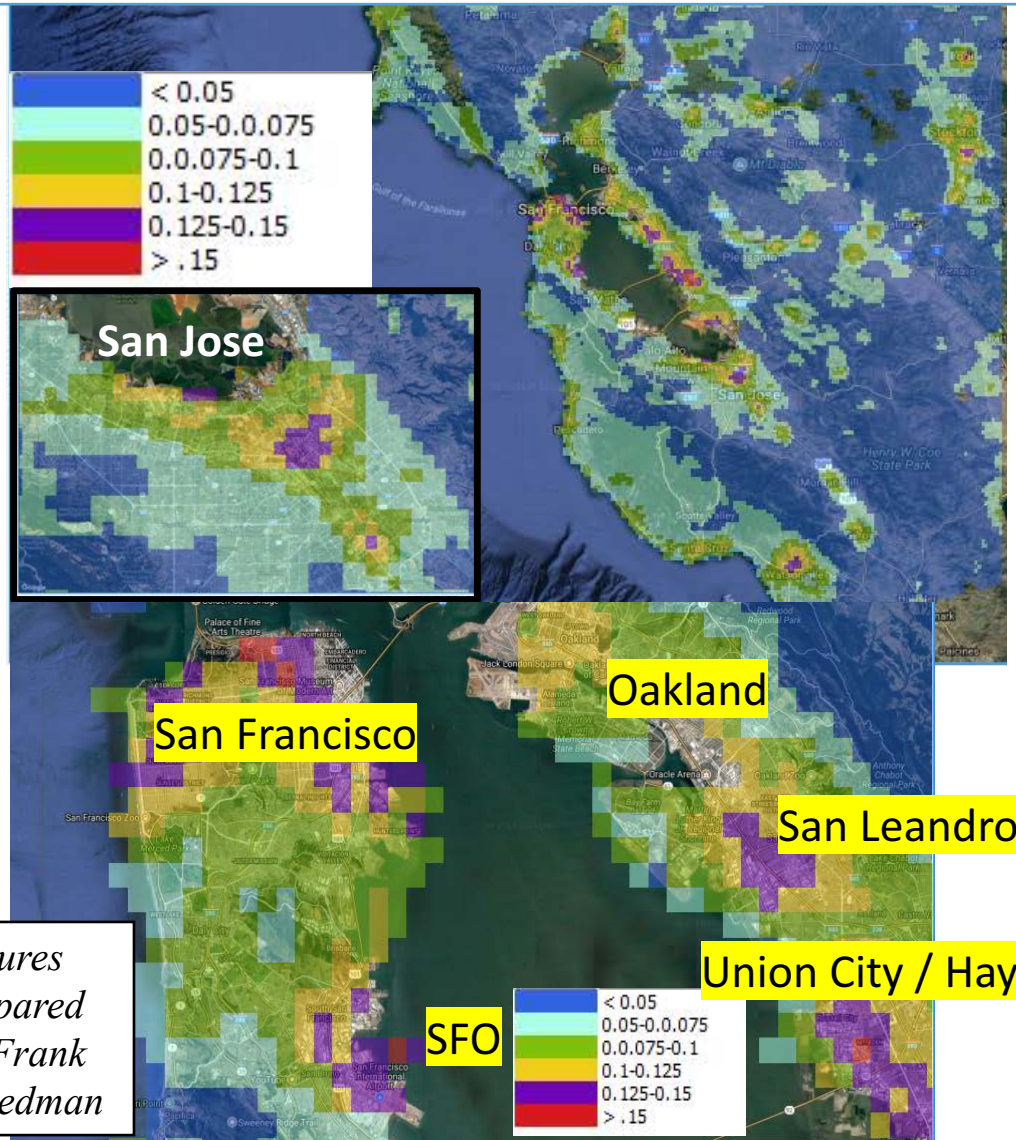


San Francisco Bay Area average of AOD ArcGIS visualization

Test of individual days in the winter of 2016

November 2 2016 AQUA 2:30PM: http://arcg.is/zGbTm

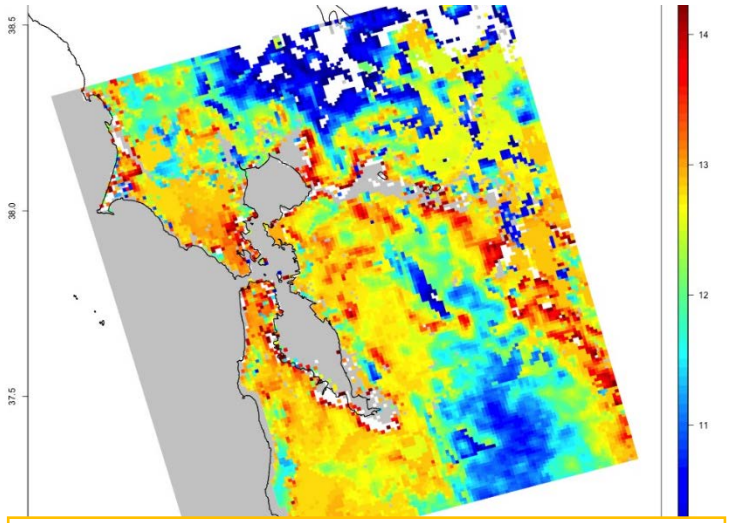


Figures prepared by Frank Freedman

A composite analyses of 14 days in 2016 winter

San Francisco Bay Area Average of AOD:
https://arcg.is/1XbzCy

- Average of MAIAC Aqua AOD fields
- Number of Days: 14 (Jan 27, Feb 13, Feb 22, Feb 24, Feb 25, Feb 29, Mar 16, Nov 2, Nov 4, Nov 8, Nov 9, Nov 13, Dec 20, Dec 29).
- No HRRR winds, only average AOD image.



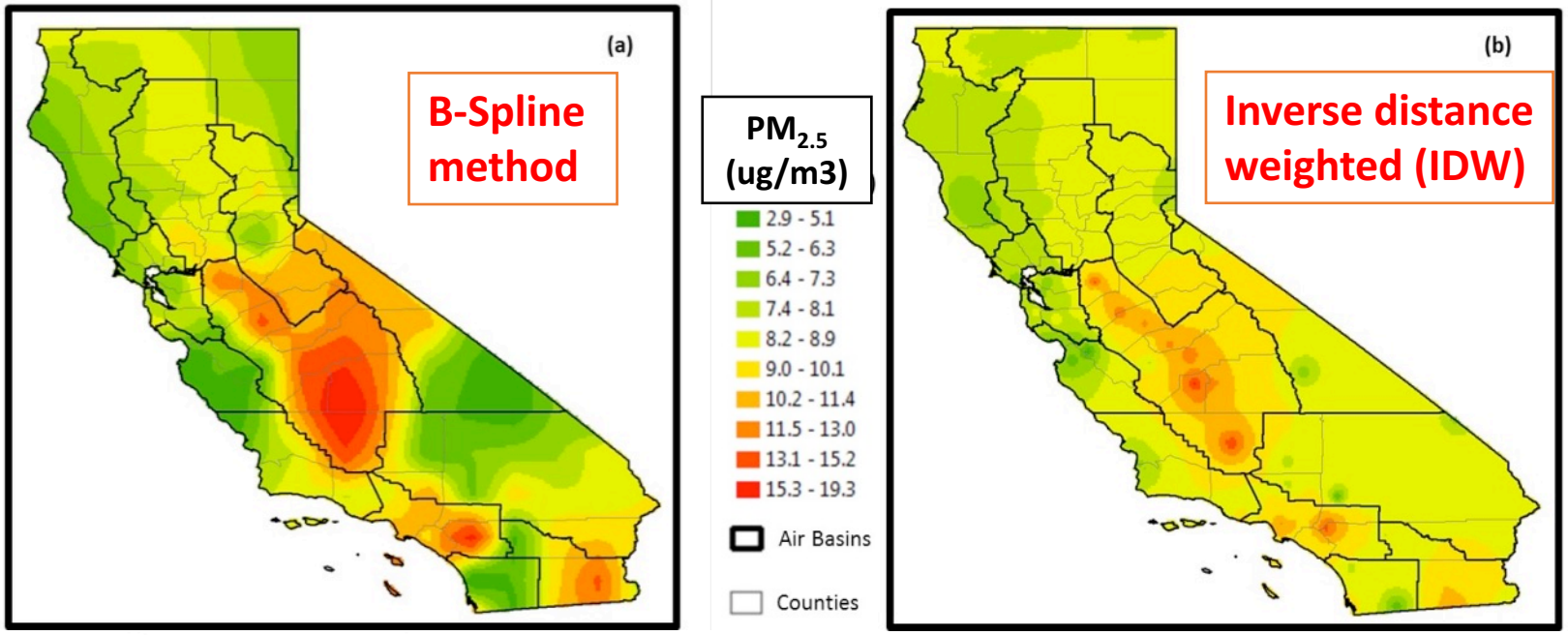
Predicted $PM_{2.5}$ Quantile 0.9 over 23 days *(prepared by Robert Chatfield and Meytar Sorek-Hamer)*

Selection criteria:
(1) clear skies,
(2) good AOD coverage
(3) 500 mb geopotential height ≥ 576 decameters

A two-page proposal submitted to California Air Resource Board for AB617 legislation

Sensitivity tests to surfacing algorithms

(1) Two methods for $PM_{2.5}$ 3-km Surfaces Annual Mean Composite in 2016



(2) Comparisons of two methods

Validation statistics based on 44 non-FRM monitors in different locations throughout California

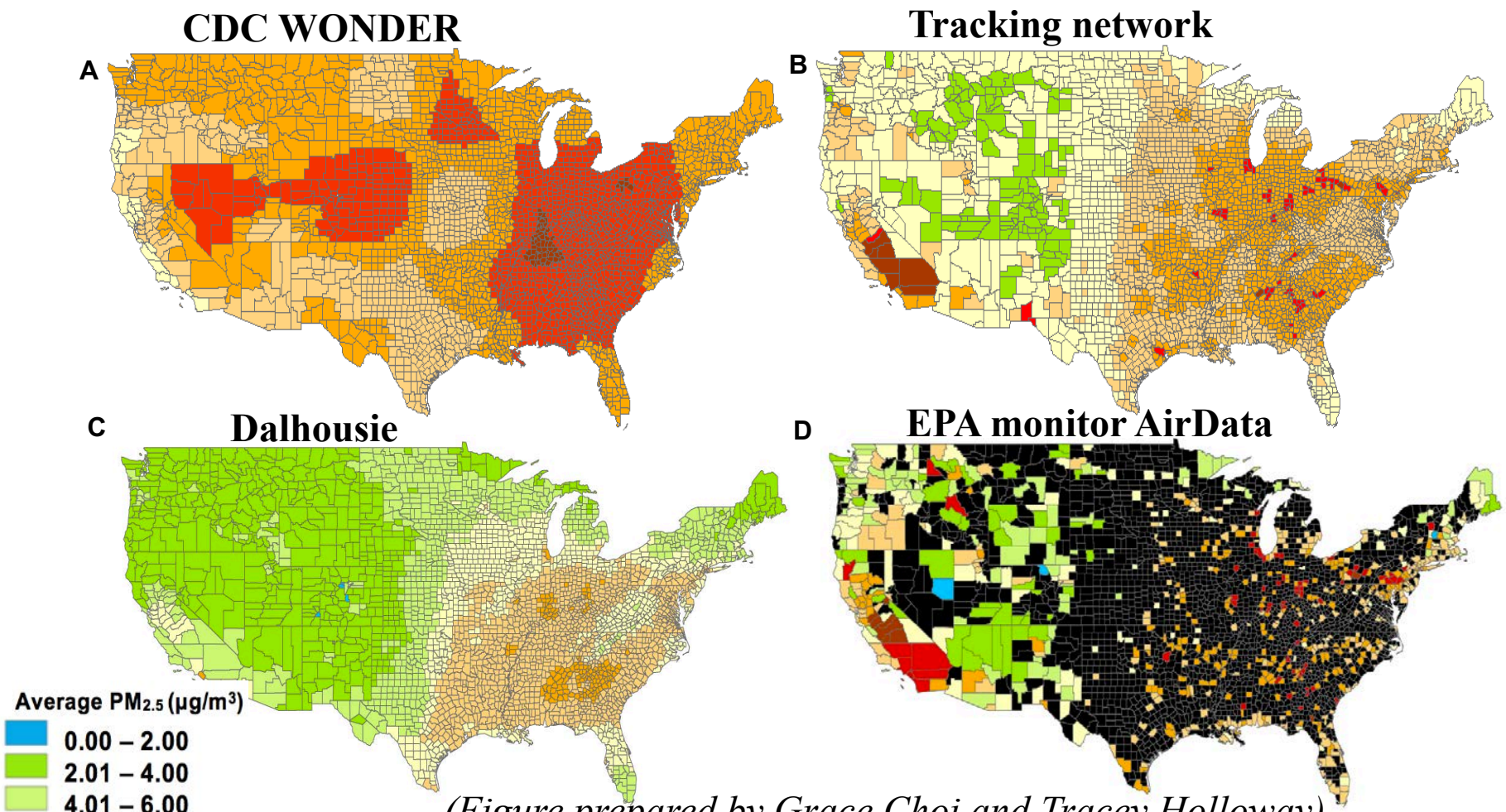
Correlation Coefficient (R), Root Mean Square Error (RMSE), Mean Error (ME) (Bias), and Mean Absolute Error (MAE).

Surfacing Technique	Data Source	R	RMSE	MAE	ME
IDW	AQS Only	0.68	4.59	3.45	0.71
IDW	Merged AQS/MODIS	0.76	4.14	3.15	0.84
B-Spline	AQS Only	0.742	4.714	3.505	0.06
B-Spline	Merged AQS/MODIS	0.737	4.713	3.501	-0.02

Prepared By:
Dr. Mohammad Al-Hamdan
USRA at NASA/MSFC
April 30, 2018

Details about the surfacing methods used can be found at Al-Hamdan et al. (2009, JAWMA; 2014, Geocarto)

Comparisons of three commonly-used publicly available $PM_{2.5}$ datasets in the contiguous U.S.



(Figure prepared by Grace Choi and Tracey Holloway)

ArcGIS-generated county-level maps of $PM_{2.5}$ in 2011

(1) CDC WONDER exhibits higher $PM_{2.5}$ and a large regional maximum over the central U.S.

(2) For Southern California, EPHTN shows the highest $PM_{2.5}$ (over 14 µg/m3)

(3) Dalhousie exhibits lower $PM_{2.5}$ overall, and is more spatially homogeneous over the western U.S.

Diao M., T. Holloway, S. Choi, S.M. O'Neill, M.Z. Al-Hamdan, A.van Donkelaar, R.V. Martin, X. Jin, A.M. Fiore, D.K. Henze, F. Lacey, P.L. Kinney, F. Freedman, N.K. Larkin, Y. Zou, A. Vaidyanathan Methods, availability, and applications of $PM_{2.5}$ exposure estimates derived from ground measurements, models, and satellite datasets, in preparation.

Statistical distributions of three $PM_{2.5}$ datasets in the contiguous US in 2011

(1) CDC WONDER: overall higher values

(2) Dalhousie: the lowest mean values of $PM_{2.5}$ overall, and the largest standard deviation

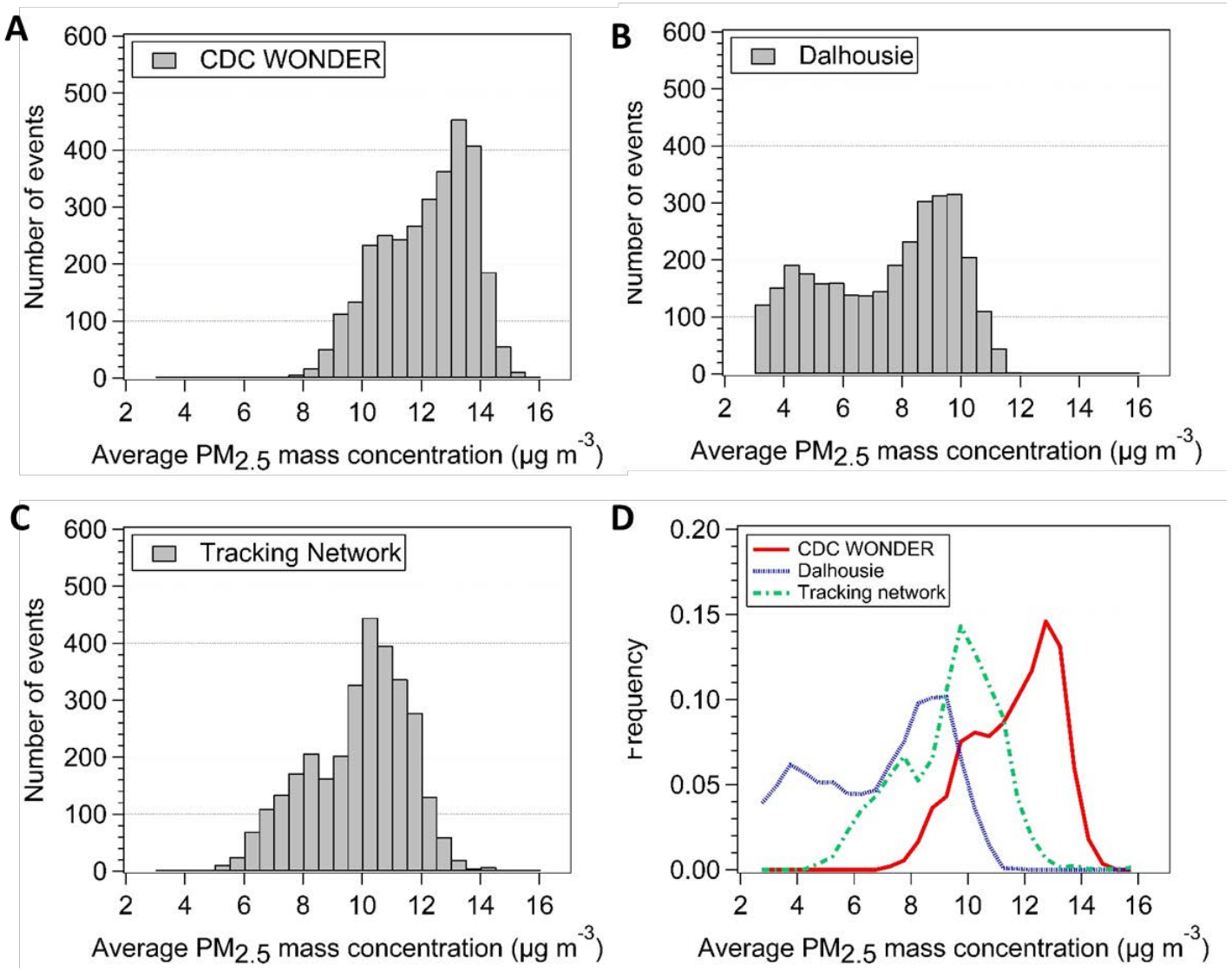


Figure prepared by Minghui Diao, Grace Choi and Tracey Holloway

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Year 2 Progress Update, PI Diao

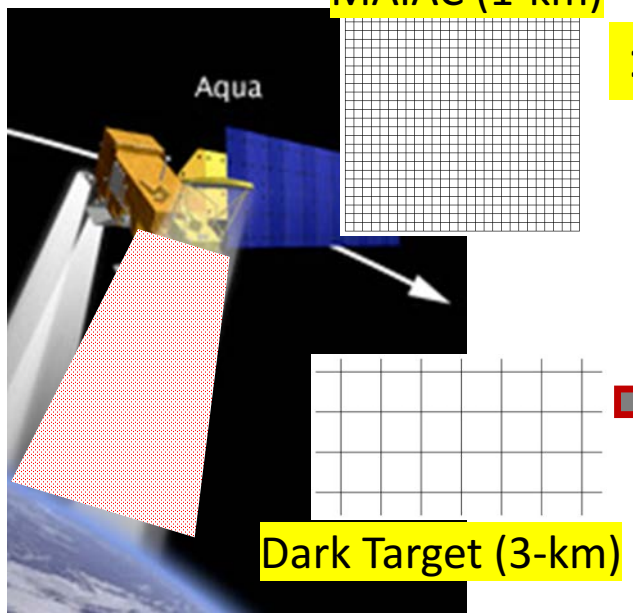
Integrating Satellites into Health and Air Quality Management

- 1. Satellite-derived $PM_{2.5}$ grids
  - Develop, apply and evaluate regression model for California;
  - Construct AOD-$PM_{2.5}$ surfaces for California for 2016 and 2017;
  - Preparation of ***a review paper*** on $PM_{2.5}$ data availability, method and analyses, led by Minghui Diao
- 2. Visualization of satellite-derived $PM_{2.5}$ grids (mostly finished)
  - Develop visualization of MAIAC AOD and derived $PM_{2.5}$ on selected days (LA, Bay Area, Imperial Valley);
  - Analysis and incorporation of HRRR wind fields.
- 3. Dispersion model simulation
  - Development and evaluation of the dispersion model simulations

Tiger Team Participation

- TT#1 led by Patrick Kinney
  - Developed in a GIS at 1-km modeling grid that overlaps the MATES-IV modeling grid; Processed the remotely-sensed data of 2012, integrated into 1-km modeling grid;
  - Deploy low-cost sensors in three Bay Area sites;
  - MAIAC AOD and dispersion modeling analysis of PM_{10} and $PM_{2.5}$ fields across Imperial Valley.
- TT#2 led by Susan O'Neill. Our group will contribute to the $PM_{2.5}$ data derived from satellite data and use downscaling model to provide higher resolution data.
- 8+ academic talks; 5 stakeholders; research website on HAQAST project at SJSU:
  - www.cloud-research.org

Project Overview



MAIAC (1-km)

Dark Target (3-km)

1. $PM_{2.5}$ Regression & Surfacing

Regression & Surfacing Model
Regional $PM_{2.5}$ = f(x,y) daily

$PM_{2.5}$ Monitors (Daily EPA FRM)

Meteorology (NLDAS – 12km)

4. Visualization of the satellite-based $PM_{2.5}$ and AOD

Regional $PM_{2.5}$(x,y) (Daily)

3. Blend fields

$PM_{2.5}$(x,y,t)

Daily average time series

HRRR Model (NOAA – 3km)

Meteorological & Emission Inputs

CALTRANS / EMFAC / other

2. Dispersion Modeling System

Fine Scale Model
Local $PM_{2.5}$ = f(x,y) hourly

Daily average hourly results

Local $PM_{2.5}$(x,y) (Daily)