Assessing MAIAC AOD High Resolution PM Patterns During Windblown Dust Events
(Imperial Valley, CA)

Project Work: NASA Health and Air Quality Applied Science Team (https://haqast.org/)

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Collaborators: Ana Rivera (SJSU), Akula Venkatram (University California Riverside)

Presentation: Public Health Institute @ California Department of Public Health
November 2, 2018

Background: Imperial Valley

High particulate air pollution

- Non-attainment area, among the highest asthma rates in country
- Socio-economically disadvantaged community

Imperial County

Ihttps://en.wikipedia.org/wiki/Imperial_County,_California)

Among main sources

- Agricultural
- Vehicle, truck traffic
- **Wind-blown dust**
- Cross-boundary transport from Mexico
- Often unfavorable meteorological conditions (winter inversions & high-wind events)

Imperial Valley

Recently deployed low-cost sensor network

- Imperial Valley Air Network (IVAN, https://ivan-imperial.org/))
- 40 sensors deployed since 2016
- https://www.tandfonline.com/doi/full/10.1080/10962247.2017.1369471
- https://ehp.niehs.nih.gov/doi/full/10.1289/EHP1772

HAQAST High-Resolution Tiger Team: Imperial Valley
(Investigation topics)

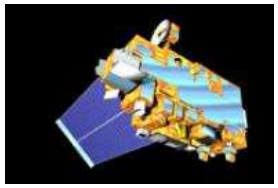
1. MAIAC AOD spatial patterns for high-wind, high PM cases (F. Freedman)
2. Assessing particulate sources using IVAN w dispersion models (A. Venkatram)
3. Contribution of IVAN monitors to Random Forest PM2.5 prediction model (Yang Liu)

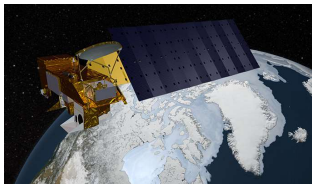
http://sites.bu.edu/haqast-highrestt/research/aim-3/

HAQAST

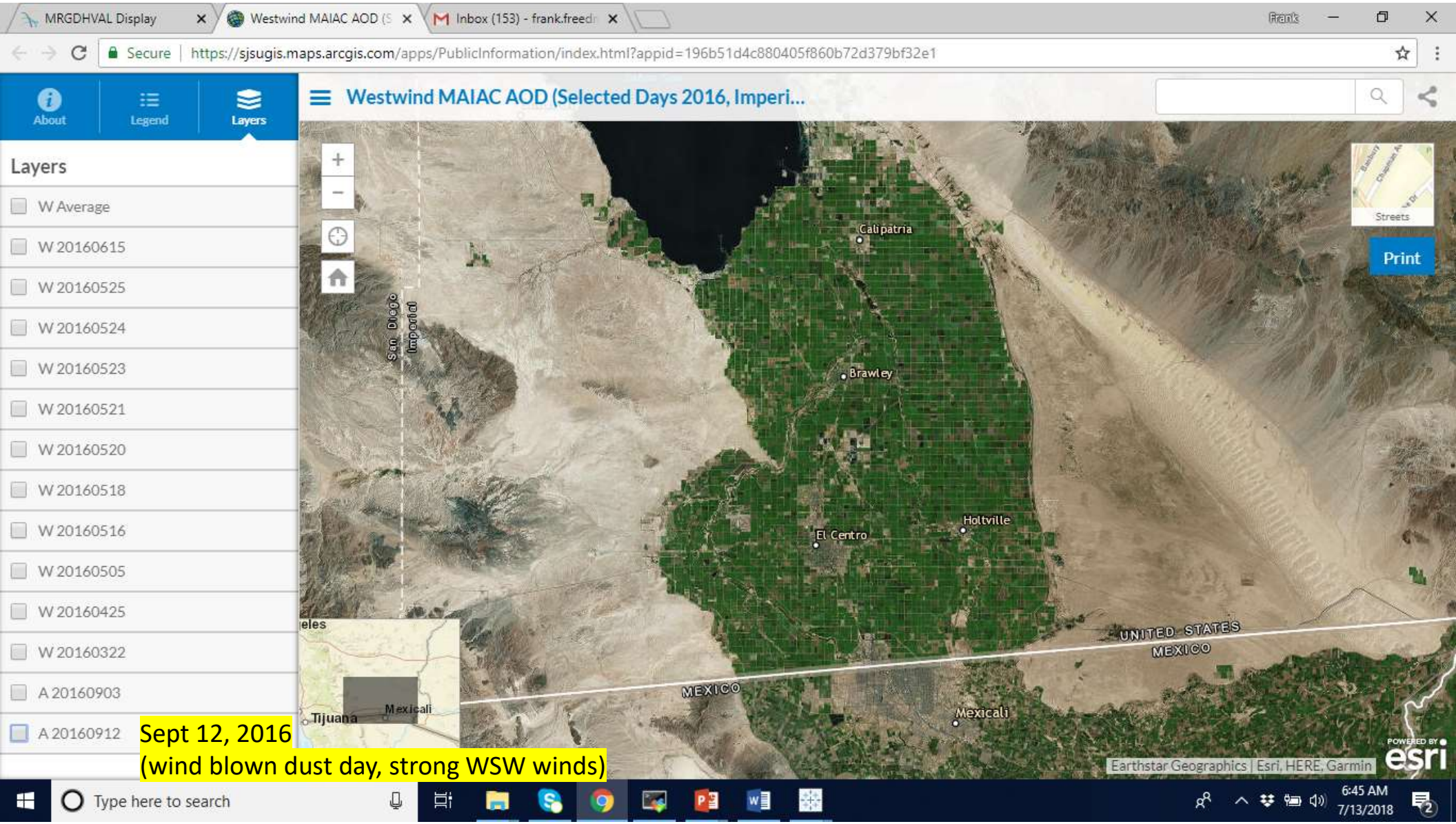
MAIAC Aerosol Optical Depth

- **MAIAC**: Multiangle Implementation of Atmospheric Correction
- 1-km horizontal resolution (highest available)
- NASA gridded product for **Aerosol Optical Depth (AOD)**
- **AOD**: an index for column integrated aerosol mass, derived from MODIS TERRA and AQUA top-of-atmosphere radiances
- Five minute daily snapshots at around 1030 (TERRA) and 1330 (AQUA) LST
- Main challenge: Relating column particulate indicator to ground-level PM mass concentrations
- https://www.atmos-meas-tech-discuss.net/amt-2018-141/
- https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/products/maiac/

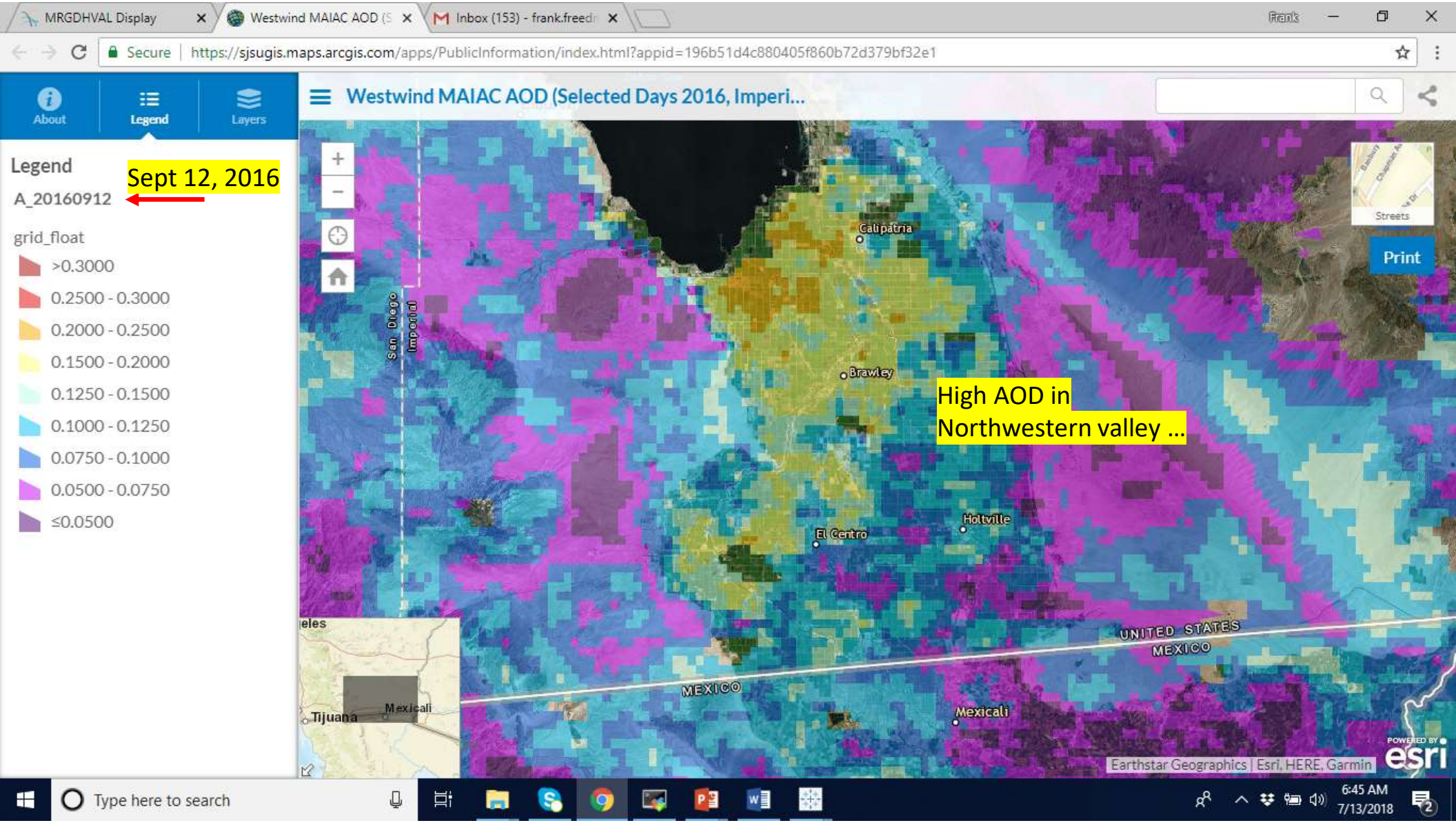




https://terra.nasa.gov/about/terra-instruments/modis
https://aqua.nasa.gov/modis



Sept 12, 2016
(wind blown dust day, strong WSW winds)


MRGDHVAL Display
Westwind MAIAC AOD
Inbox (153) - frank.freed
Secure
https://sjsugis.maps.arcgis.com/apps/PublicInformation/index.html?appid=196b51d4c880405f860b72d379bf32e1
About
Legend
Layers
Westwind MAIAC AOD (Selected Days 2016, Imperi...
Legend
Sept 12, 2016
A_20160912
grid_float
>0.3000
0.2500 - 0.3000
0.2000 - 0.2500
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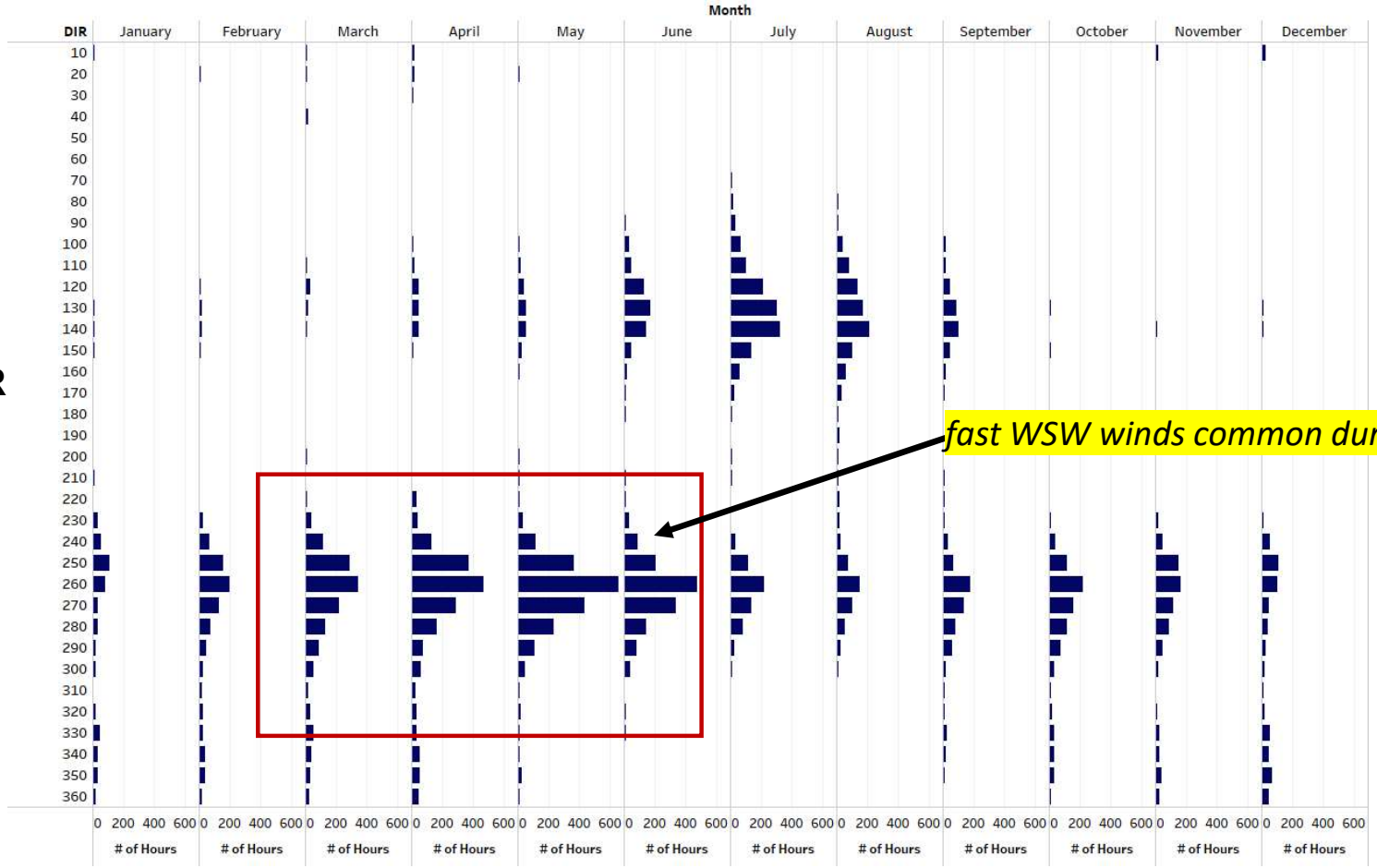
0.0500 - 0.0750
≤0.0500
Calipatria
Brawley
El Centro
Holtville
Mexicali
San Diego
Imperial
High AOD in
Northwestern valley …
UNITED STATES
MEXICO
MEXICO
Tijuana
Mexicali
Streets
Print
Earthstar Geographics | Esri, HERE, Garmin
Type here to search
6:45 AM
7/13/2018

Histograms: Hours of High Wind Speeds in Imperial Valley

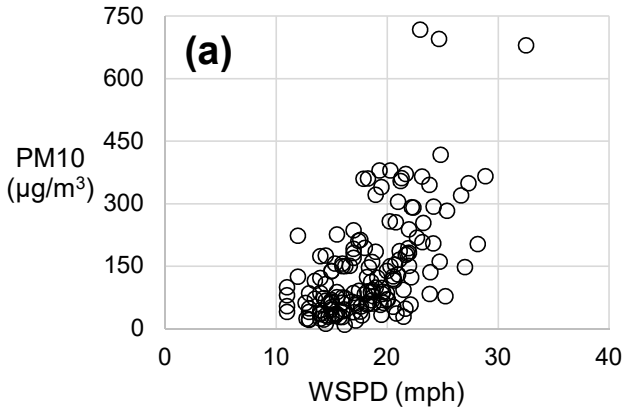
WDIR



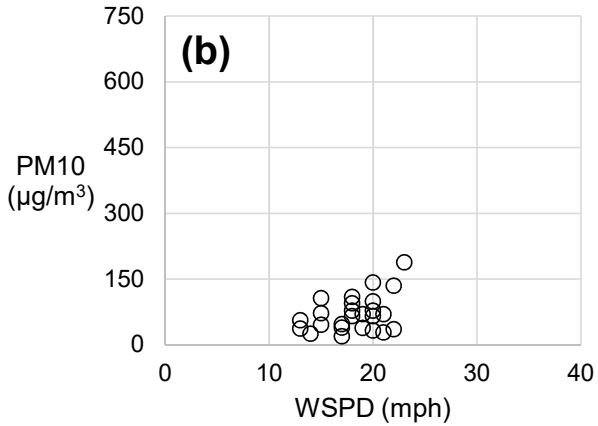
Histograms of hours when WSPD > 10 mph @ Imperial County Airport. Main wind direction of occurrence from WSW. Large percentage of hours during spring, especially during April and May. Associated with high windblown PM.

High PM Concentrations During high-speed WSW Wind Conditions

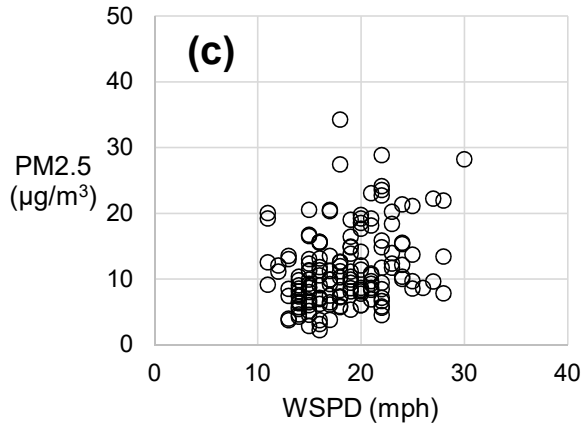
PM10 from hourly monitors
(1200 – 1800 LST averages)



PM10 from daily monitors
(daily averages)



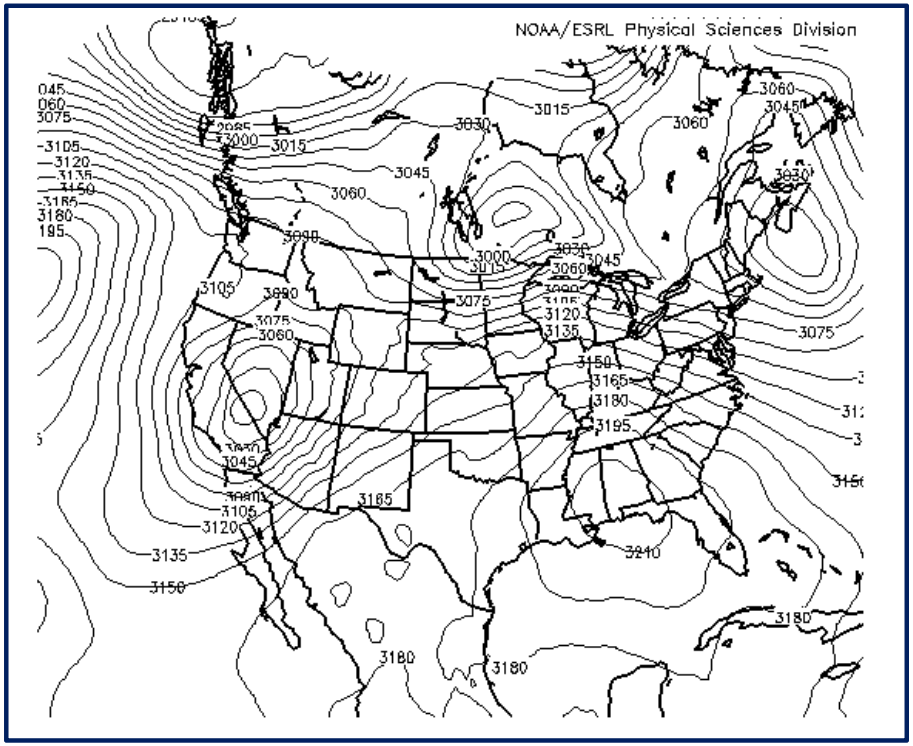
PM2.5 from daily monitors
(daily averages)



less data points than (a) since data are one-in-six days

PM10 & PM2.5 concentrations vs. WSPD @ Imperial County Airport for high-speed springtime WSW wind direction days during 2014 – 2017. Plotted PM data are averages over routine state monitoring sites reporting data during selected days.Horizontal axis is WSPD averaged over 1200 – 1800 LST. PM values strongly increase with WSPD, typical of windblown dust. PM levels are beyond or approaching ambient air standards.

20140521 00Z: Sample WSW high wind event (afternoon of May 20 2014)



IMPERIAL COUNTY
AIR POLLUTION CONTROL DISTRICT

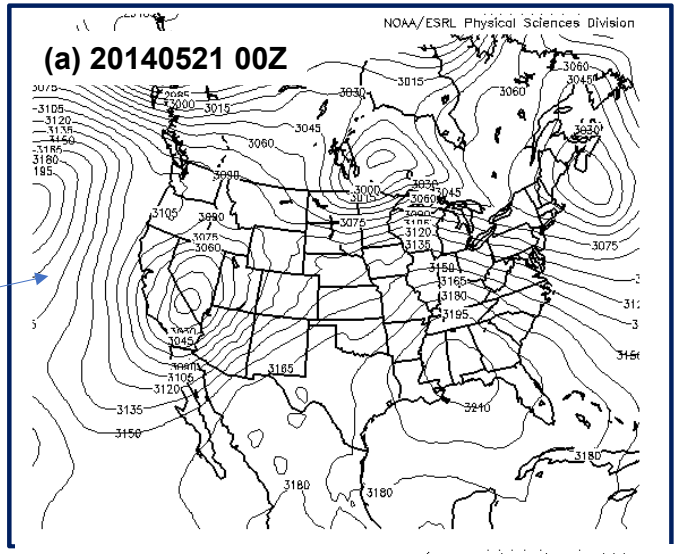
https://www.power-technology.com/projects/mount-signal-solar-power-plant-imperial-county-california/

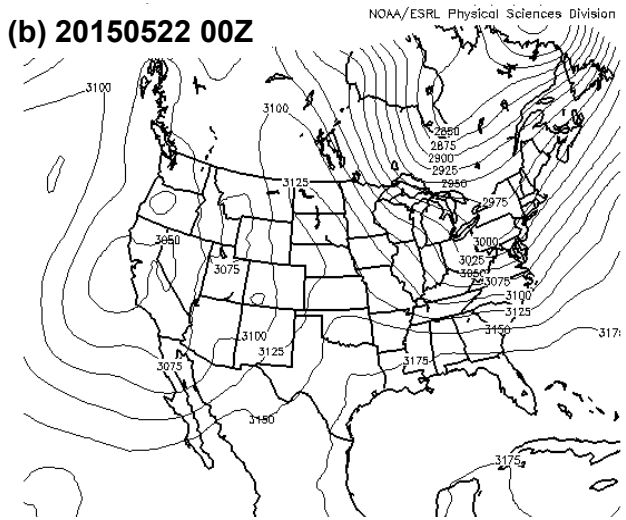
May 20, 2014
Exceptional Event Documentation
For the Imperial County PM_{10} Nonattainment Area

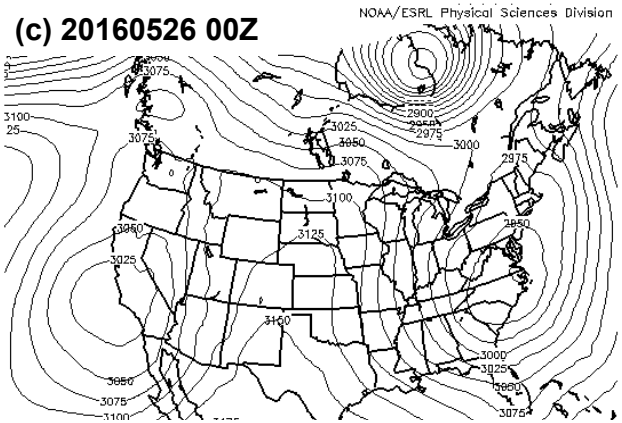
DRAFT REPORT
January 31, 2018

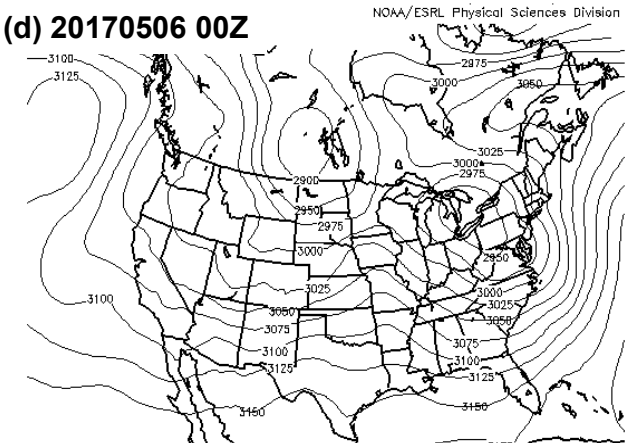
http://www.co.imperial.ca.us/AirPollution/PublicNotices/PDFs/ExceptionalEvents/20180302VariousEEs/00EEDemoMay202014.pdf

exceptional event





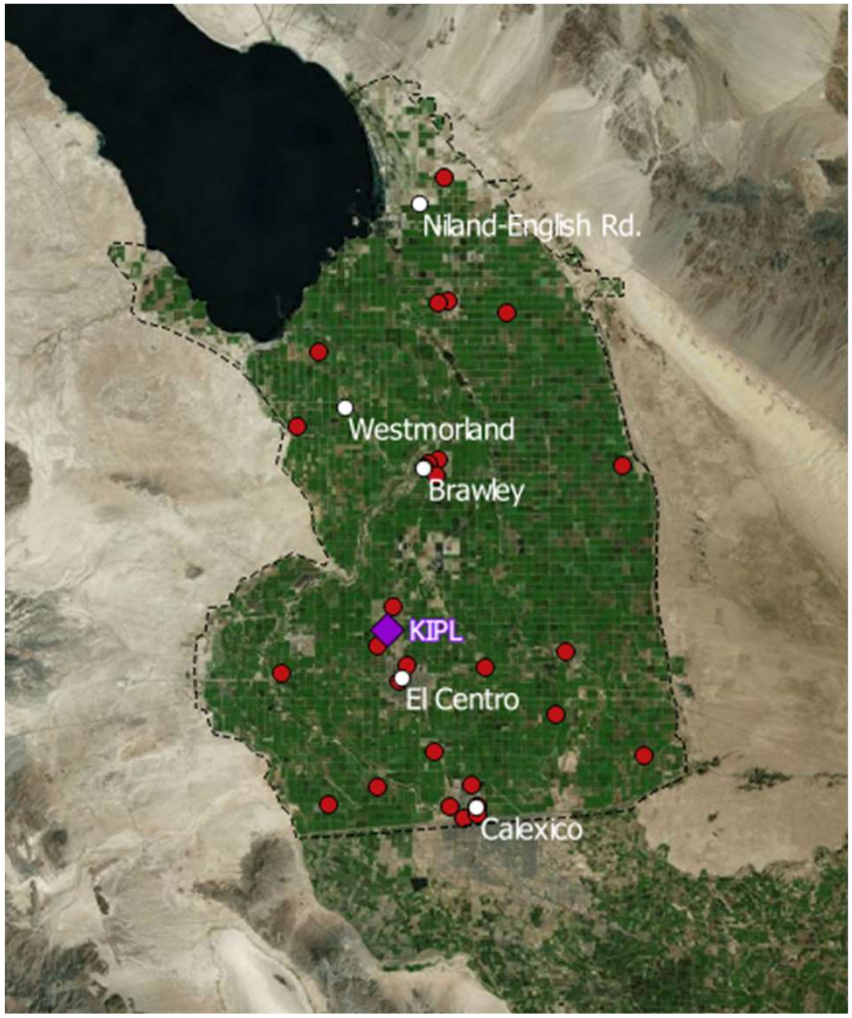




Other examples of WSW wind events: 700-mb geopotential height charts for four springtime high-speed WSW wind situations associated with high windblown PM in Imperial Valley. Note common low-pressure systems centered over California. Upper left panel (boxed) is subject to “Exceptional Event’ determination for exceedance daily PM10 standard. Plots from NARR plotting page (https://www.esrl.noaa.gov/psd/cgi-bin/data/narr/plothour.pl).

Study Synopsis

- Goal: Investigate MAIAC AOD ability to distinguish spatial details of PM patterns during WSW high PM wind events in Imperial Valley.
- Cases of Interest: Springtime high wind speed days out of west-southwest (WSW) direction. Investigate cases over 2014 – 2017. Utilize MAIAC images from AQUA polar orbiting satellite (overpass time around 1330 LST).
- Approach
  - WSW Days (n = 31 days): "Experimental" (high windblown PM)
  - SE Days (n = 47 days): "Control". Southeasterly wind direction days of low to moderate speed (representative of lower PM, more typical conditions)
- Compare w ground level monitors
  - Routine state monitors (PM10 & PM2.5 hourly)
  - Imperial Valley Air Network (IVAN) community run monitors (PM2.5 hourly)
  - Extract PM measurements at hour of satellite overpass to compare w AOD.



Routine Agency PM Sites
(PM10 & PM2.5)

IVAN Sites
(PM2.5)

Imperial County Airport (KIPL)
(WSPD & WDIR)

Site locations from where surface data are utilized.

MAIAC AOD Image Selection Procedure

- AQUA overpasses (between 1200 - 1400 LST depending on day)
- Identify those with high AOD coverage
- Utilize only QA = 1 pixels (highest quality flagged data)
- Mask with shapefile to only include pixels within valley (surrounding desert areas less reliable for AOD retrievals)
- Results in n = 31 WSW days between 2014 – 2017.
- Results in n = 47 SE days between 2014 – 2017.

Table 2: Summary Statistics; WSW & SE Cases*

WSW

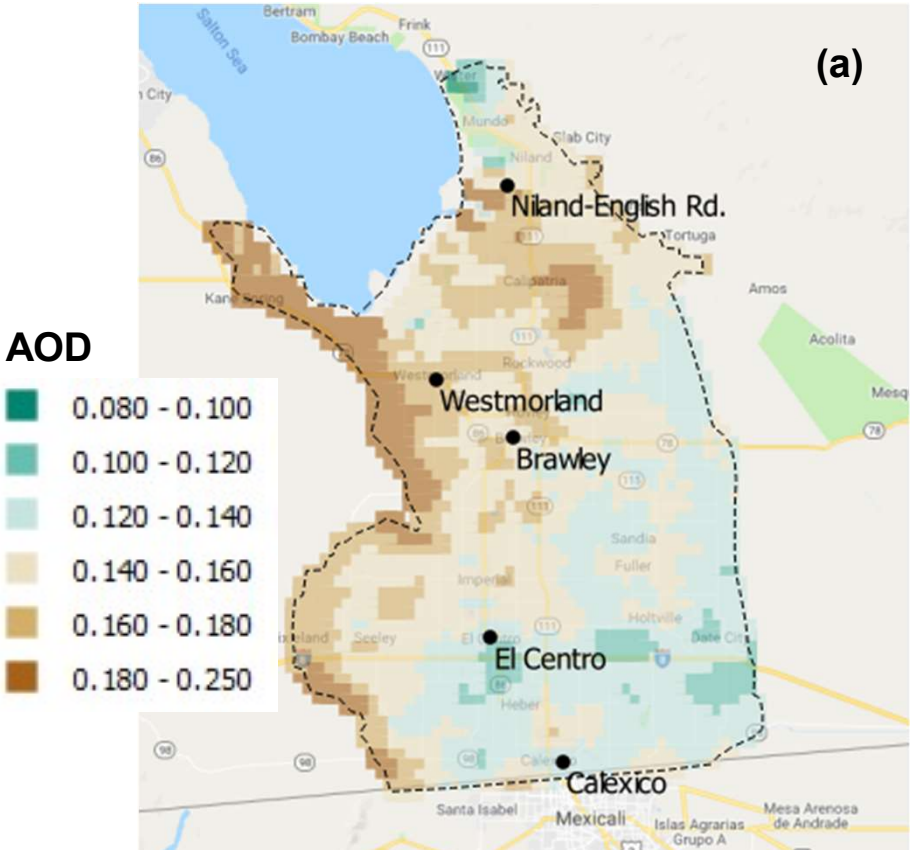
Year	# of Days	WSPD (mph)	WDIR (deg)	PM10 (µg/m^3)	# of paired obs. (AOD w IVAN PM2.5)	# of paired obs. (AOD w routine PM10)
2014	11	18	234	92	-	19 over 2 sites
2015	2	21	265	227	-	2 over 1 site
2016	11	17	248	102	99 over 14 sites	46 over 5 sites
2017	7	18	259	74	149 over 30 sites	32 over 5 sites
Total/Avg	**31**	**18**	**247**	**96**	**248 over 30 sites**	**99 over 5 sites**

SE

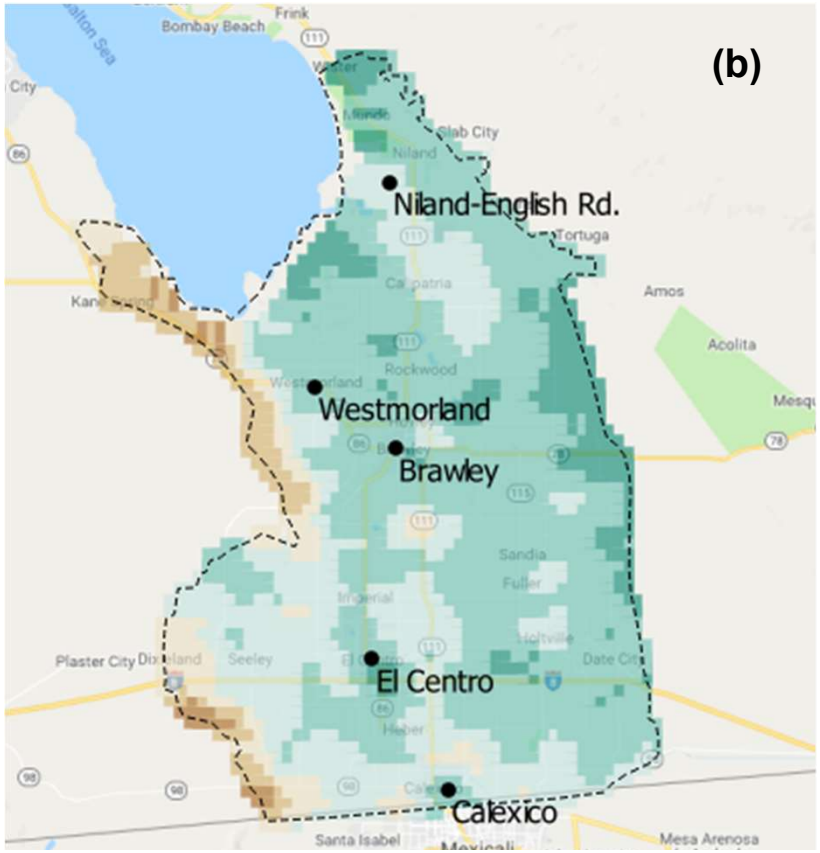
Year	# of Days	WSPD (mph)	WDIR (deg)	PM10 (µg/m^3)	# of paired obs. (AOD w IVAN PM2.5)	# of paired obs. (AOD w routine PM10)
2014	13	6	125	37	-	20 over 2 sites
2015	12	7	100	24	-	16 over 2 sites
2016	12	7	104	34	108 over 14 sites	55 over 5 sites
2017	10	8	106	33	240 over 30 sites	49 over 5 sites
Total/Avg.	**47**	**7**	**108**	**33**	**348 over 30 sites**	**140 over 5 sites**

*WSPD, WDIR and PM10 are averages computed over the hourly measurements closest to AQUA satellite overpass hours associated with each selected day. WSPD and WDIR averages are from KIPL measurements; PM10 averages are over all routine hourly sites reporting measurements.

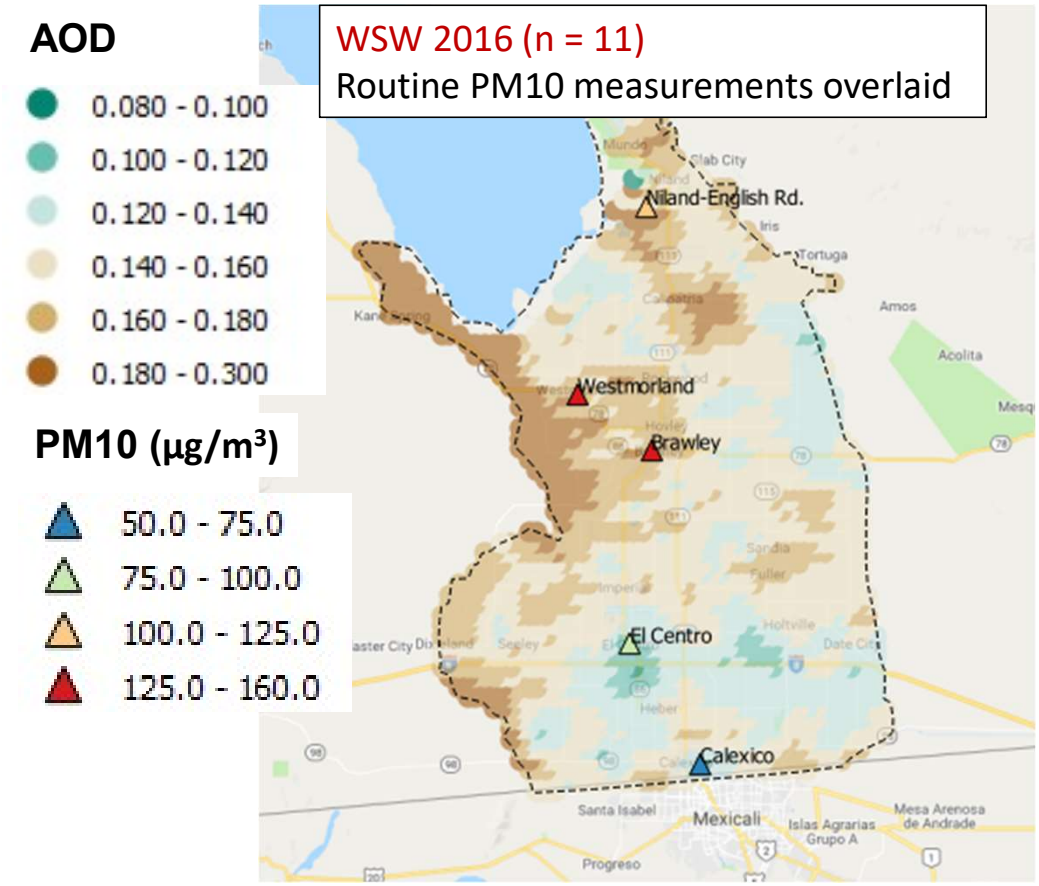
Aggregate MAIAC AQUA AOD for WSW cases
(2014 – 2017; n = 31 days)

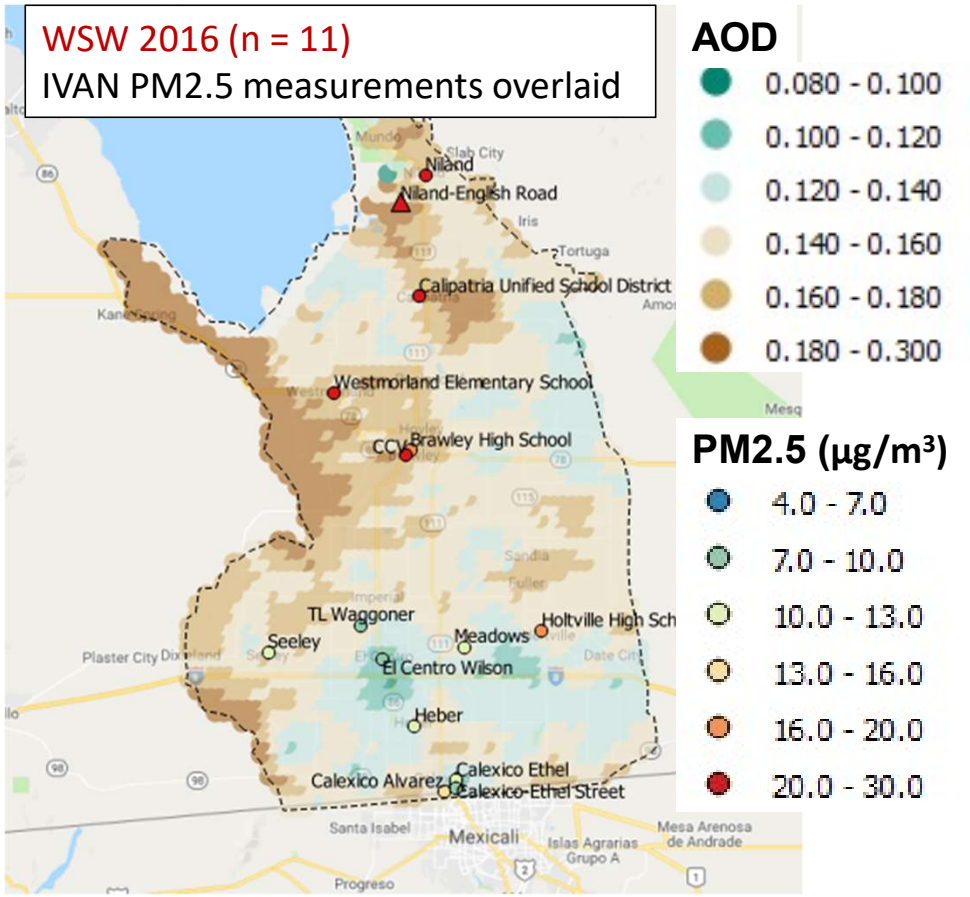


Aggregate MAIAC AQUA AOD for SE cases
(2014 – 2017; n = 47 days)

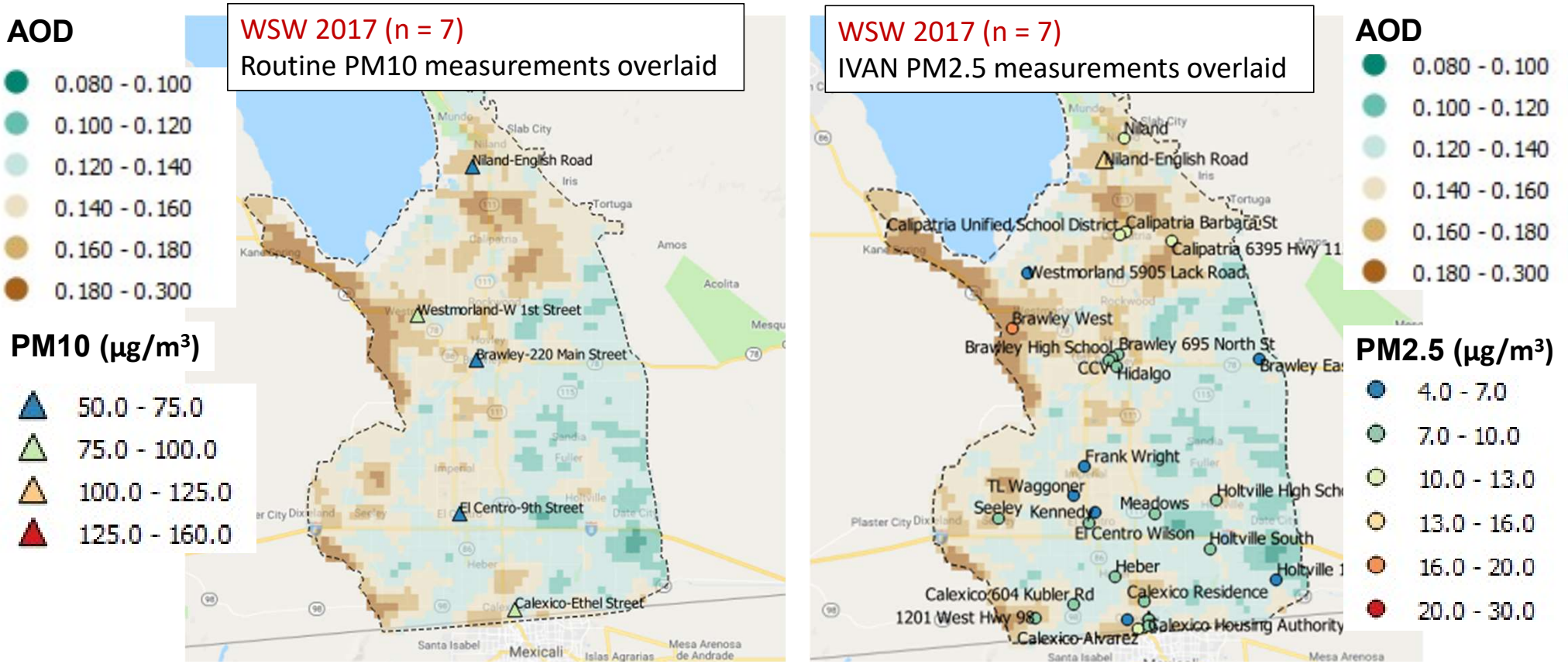


Aggregate MAIAC AOD from AQUA over selected overpasses for WSW days of high windblown dust (left panel, n = 31 days) versus control SE wind days (right panel, n = 47 days). Note higher overall AOD for WSW cases, especially in northwest valley. Also note areas of relatively high AOD common in both sets (e.g. Niland area, western rim of valley, just east of El Centro). Black dots are locations of routine PM monitor sites.

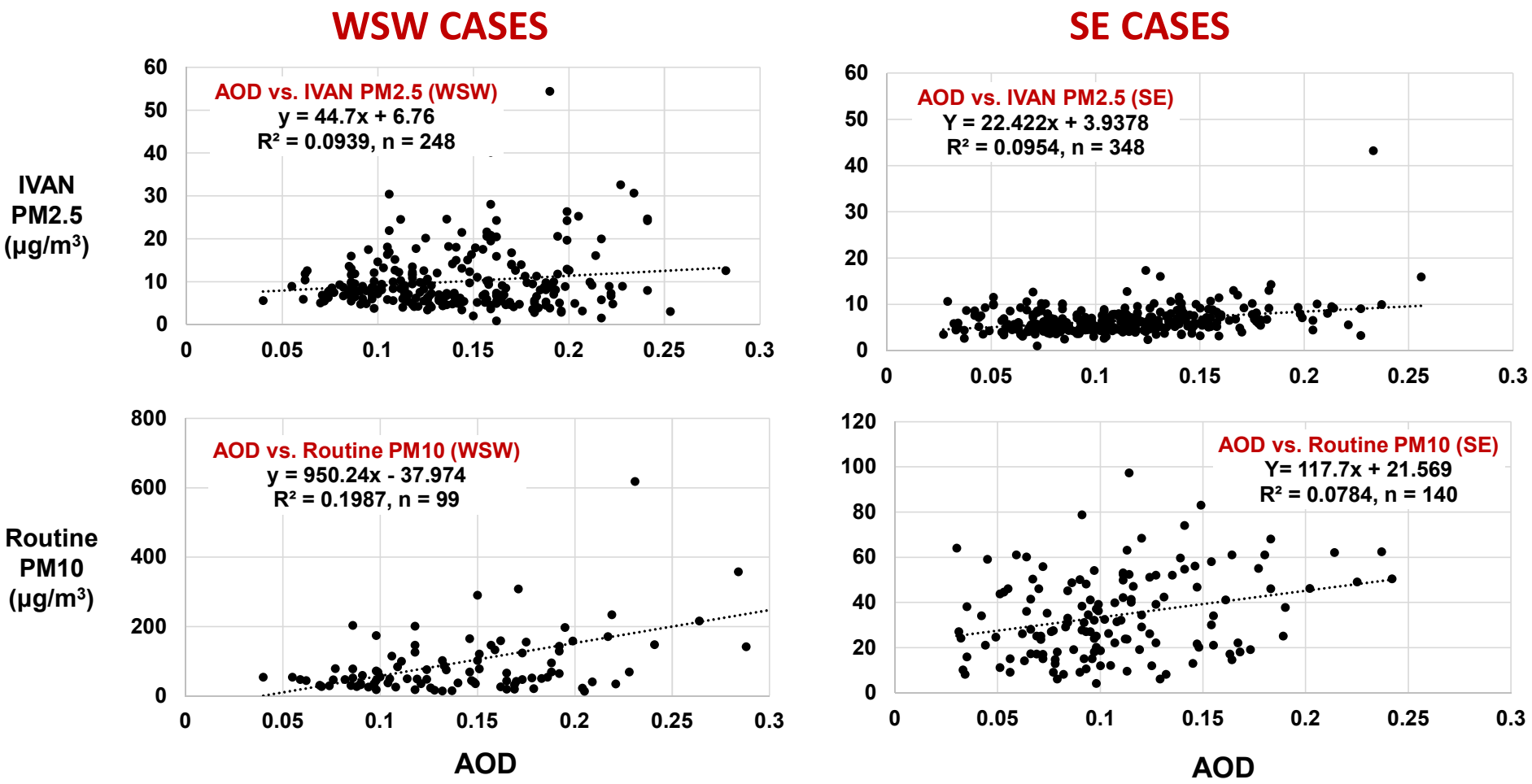




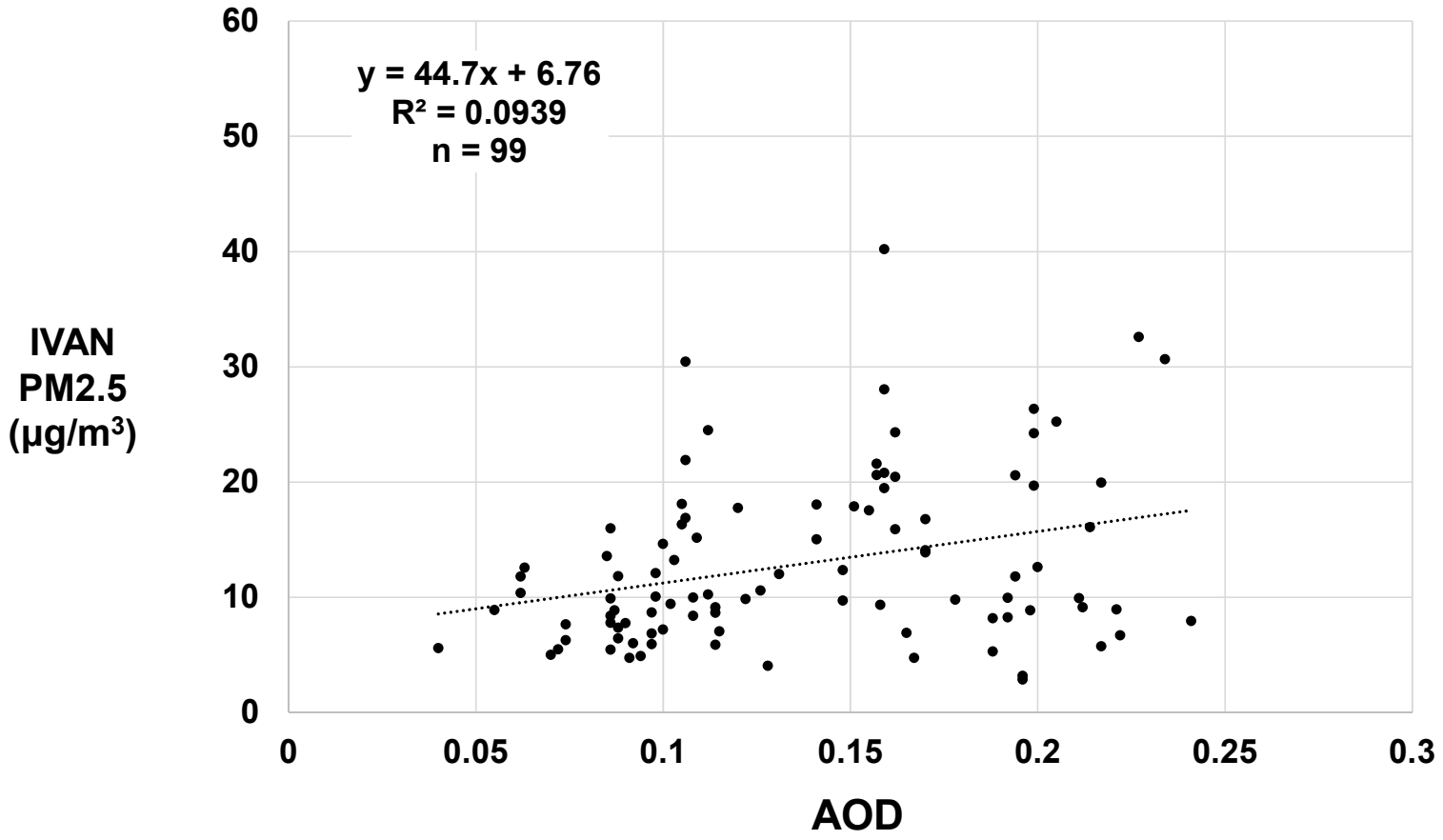
WSW 2016: MAIAC AQUA AOD fields for WSW cases during 2016 (n = 11 days). Left panel is with PM10 at routine sites averaged over the period overlaid. Right panel is with PM2.5 at IVAN sites averaged over period overlaid. Also plotted on right panel is average PM2.5 at Niland-English Rd. routine site (triangle) All plotted PM measurements are at nearest hour to satellite overpass, and averages are over available days of measurements within period. Note strong correspondence of AOD within measurements.



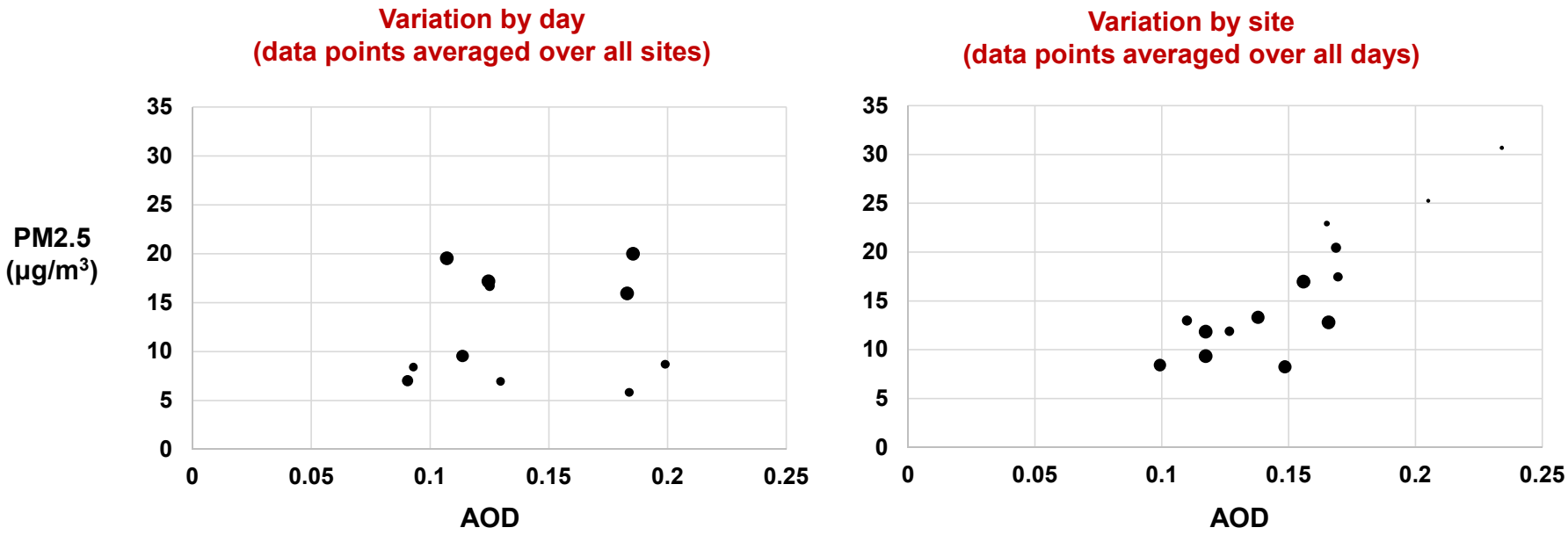
WSW 2017: MAIAC AQUA AOD fields for WSW cases during 2017 (n = 7 days). Left panel is with PM10 at routine sites averaged over the period overlaid. Right panel is with PM2.5 at IVAN sites averaged over period overlaid. Also plotted on right panel is average PM2.5 at Niland-English Rd. routine site (triangle) All plotted PM measurements are at nearest hour to satellite overpass, and averages are over available days of measurements within period. Lower AOD and PM, and correspondence of AOD and PM patterns less strong compared with 2016.



MAIAC AQUA AOD versus ground-level PM data for WSW and SE cases. Data pairs formulated by identifying AOD pixel closest to monitor location at hour closest to AQUA satellite overpass hour for the day. Positive correlation in all cases. However, note points of high AOD but low PM in WSW cases.

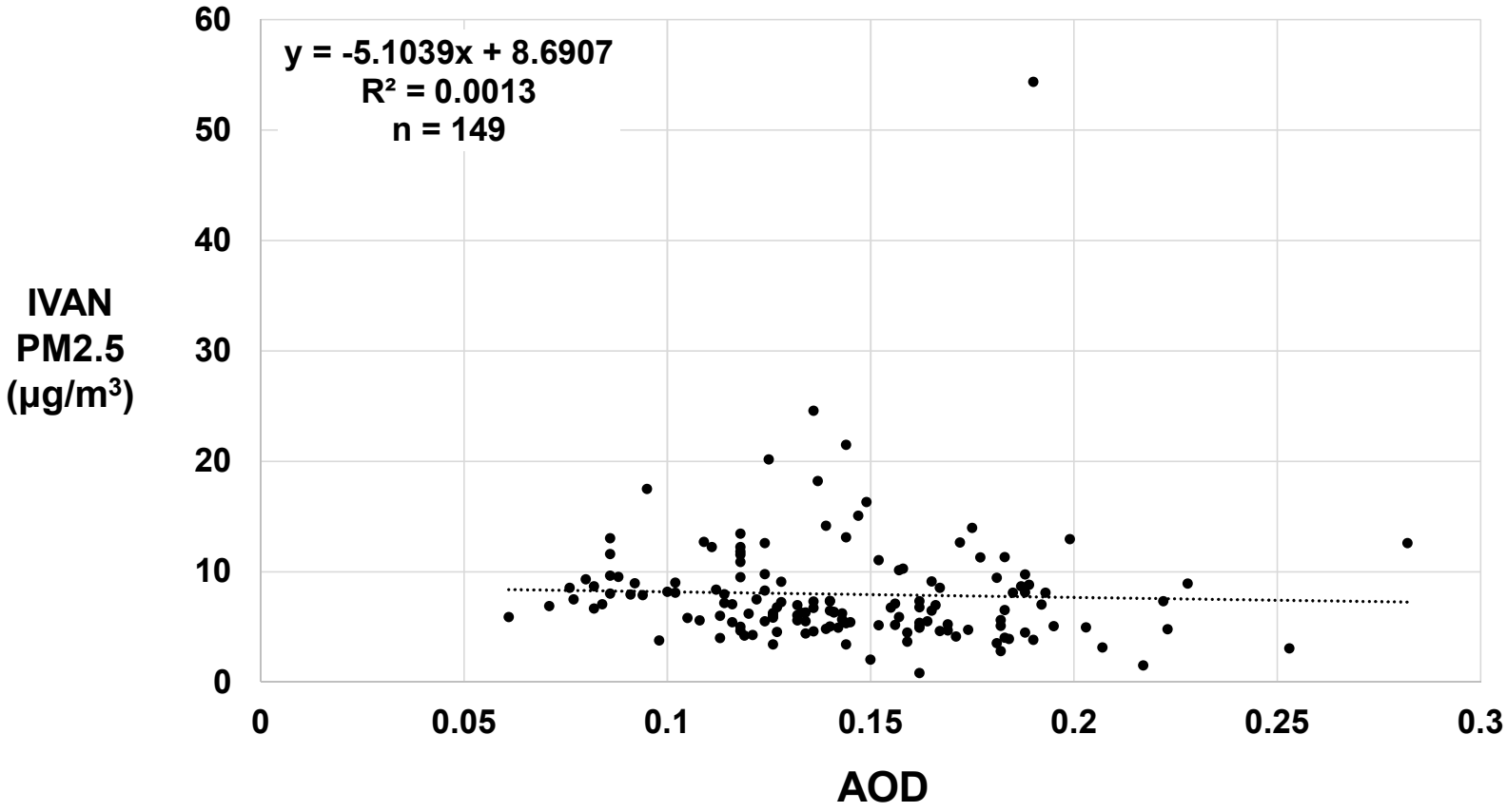


MAIAC AQUA AOD versus ground-level IVAN PM2.5 data for WSW cases during **2016**. Data pairs formulated by identifying AOD pixel closest to monitor location at hour closest to AQUA satellite overpass hour.



AOD vs IVAN PM2.5 for WSW cases during **2016**. Left panel is AOD and PM2.5 averaged over all sites to highlight variation by day (temporal variation). Right panel is AOD and PM2.5 averaged over all days to highlight variation by site (spatial variation). Size of dots indicates number of pairs AOD-PM2.5 are available, ranging from 6 to 14 sites (left panel) and 1 to 11 days (right panel).

Strong positive relationship seen on right panel, which indicates that spatial variation is mainly driving the overall positive correlation between AOD and PM2.5 in this case seen in the previous chart.



MAIAC AQUA AOD versus ground-level IVAN PM2.5 data for WSW cases during **2017**. Data pairs formulated by identifying AOD pixel closest to monitor location at hour closest to AQUA satellite overpass hour.

Conclusions
(Synopsis)

1. MAIAC AOD appears to be capturing an area of high PM due to windblown dust in the northwestern Imperial Valley over an area covering the towns of Brawley and Westmorland during springtime high-speed WSW wind days. AOD and PM corroborate over this area.
2. Other high AOD areas apparent in MAIAC fields over the valley have low/inconclusive corroboration with available ground level PM measurements. These high AOD areas also appear in SE control.
3. Low AOD compared w other locations (e.g. eastern U.S., India, China). Signal on order or noise in AOD. How to best utilize AOD in these situations???