Decadal Evaluation of a Regional Air Quality Forecast System in the Pacific Northwest from 2009-2018 and an Assessment of Air Quality Health Impacts

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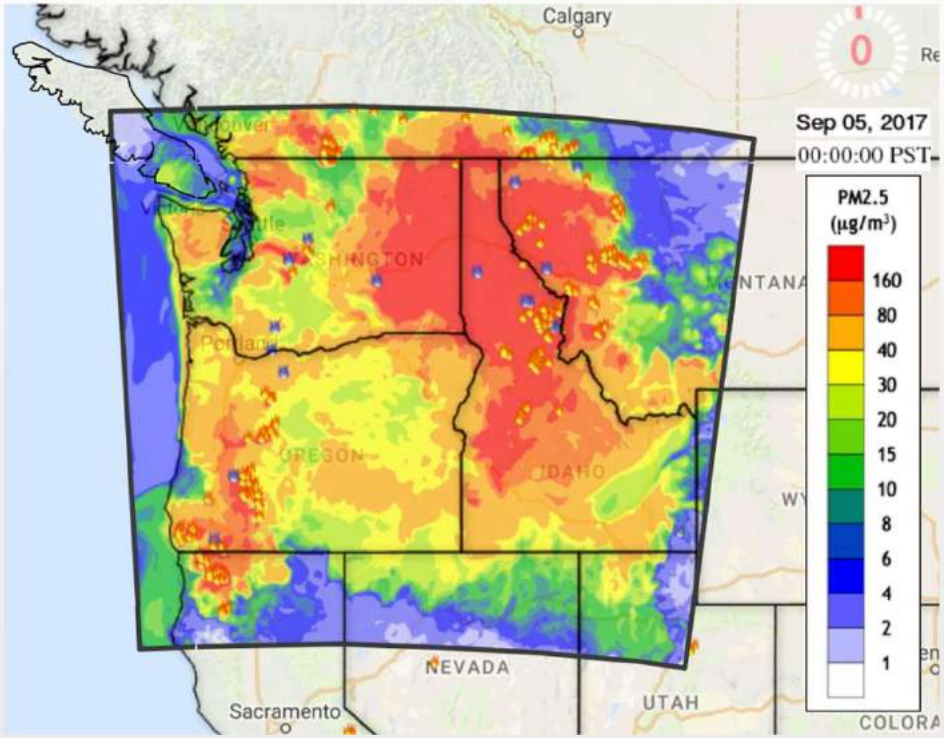
Outline

- Decadal Evaluation of AIRPACT
  - Introduction
  - Evolution of the Forecasting System
  - Meteorology
  - Pollutants
    - Ozone
    - $PM_{2.5}$
  - Summary
- Impact of Air Quality in the PNW
  - BenMAP

Air Information Report for Public Access and Community Tracking (AIRPACT)



- Predicts air quality in the PNW using
  - Weather Research and Forecasting Model (WRF)
  - Community Model for Air Quality (CMAQ)

- Evaluate approx. 10 years of AIRPACT forecast data against the EPA's AQS quality controlled data
  - Meteorology: used WRF derived meteorology (gaps in recorded data)
  - Pollutants: used hourly AIRPACT data at AIRNOW sites

Evolution of AIRPACT

	AIRPACT-3	AIRPACT-4	AIRPACT-5
RECORDED FORECAST	2007 - Dec 2012	Jan 2013 - Dec 2015	Jan 2016 - Current
GRID CELLS	12-km	4-km	4-km
VERTICAL LAYERS	21	21	37
MCIP	v3.3	v3.6	v3.6
SMOKE	v2.1	v2.7, v3.5	v3.5.1
METEOROLOGY	MM5 3.7.3, WRF v3.1.1	WRF v3.4.1, v3.5	WRF v3.6.1, v3.7.1
CMAQ	v4.6	v4.7.1	v5.0.2
MASS ADJUSTMENT (CMAQ)	denrate	yamo	yamo
GAS-PHASE MECHANISM	SAPRC99	SAPRC99	CB05
NON-MOBILE ANTHROPOGENIC EMISSIONS	2005 from Ecology, IDEQ, ODEQ	2007-2008 from Ecology, IDEQ, ODEQ	NEI 2014 v2
MOBILE EMISSIONS	MOBILE6	MOBILE6, MOVES	MOVES 2010b
FIRE EMISSIONS	BlueSky	SMARTFirev1/BlueSky SMARTFire v2, BlueSky 3.5.1 2014-Present	SMARTFire v2, BlueSky 3.5.1
BIOGENIC EMISSIONS	BEIS-3	MEGAN v2.0.4	MEGAN v2.1
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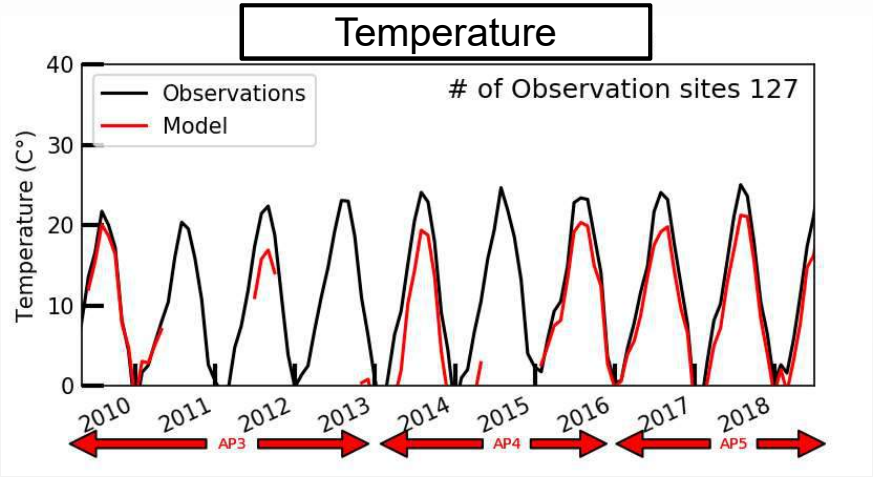
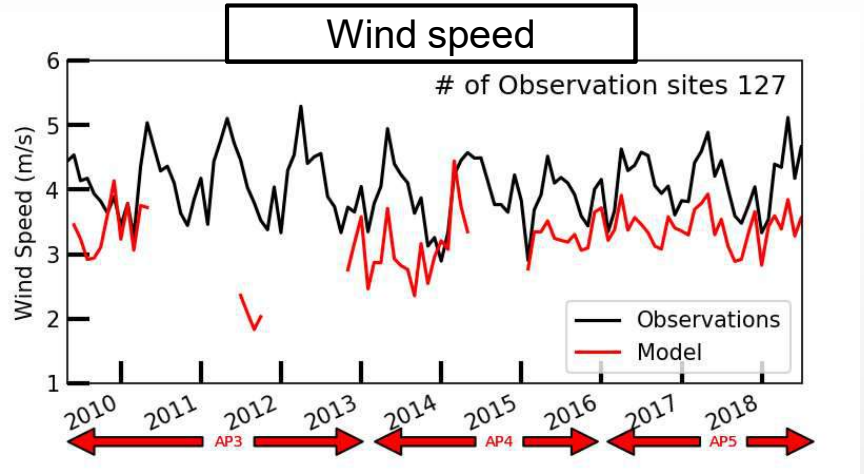
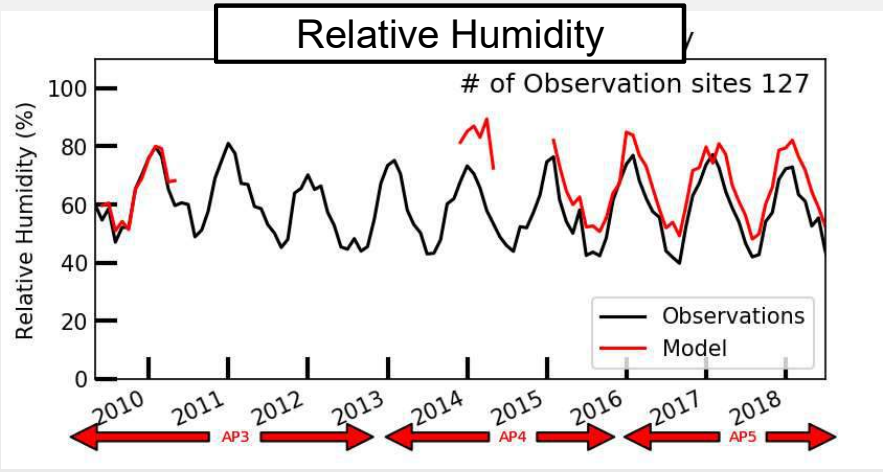
Meteorology

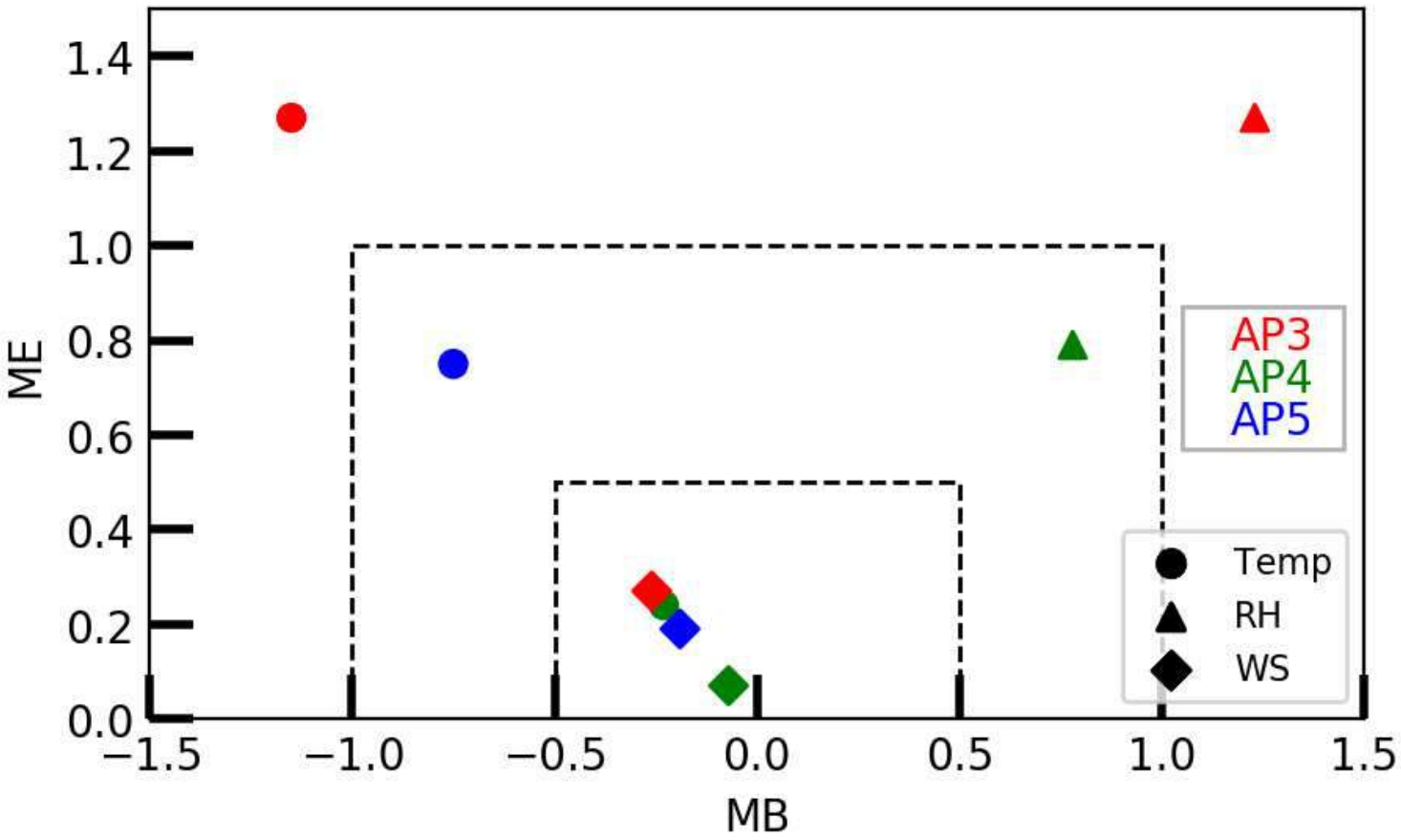
Monthly Averaged Meteorology







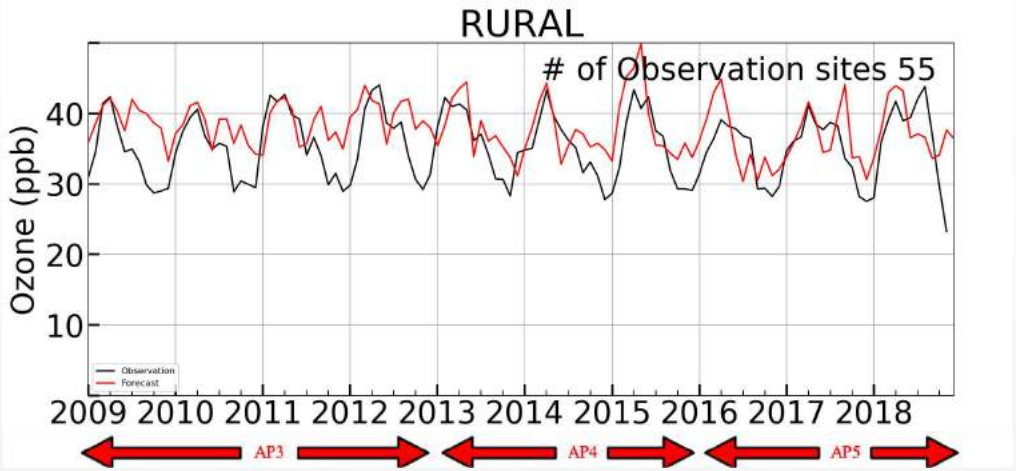
Hourly Overall Meteorology Performance

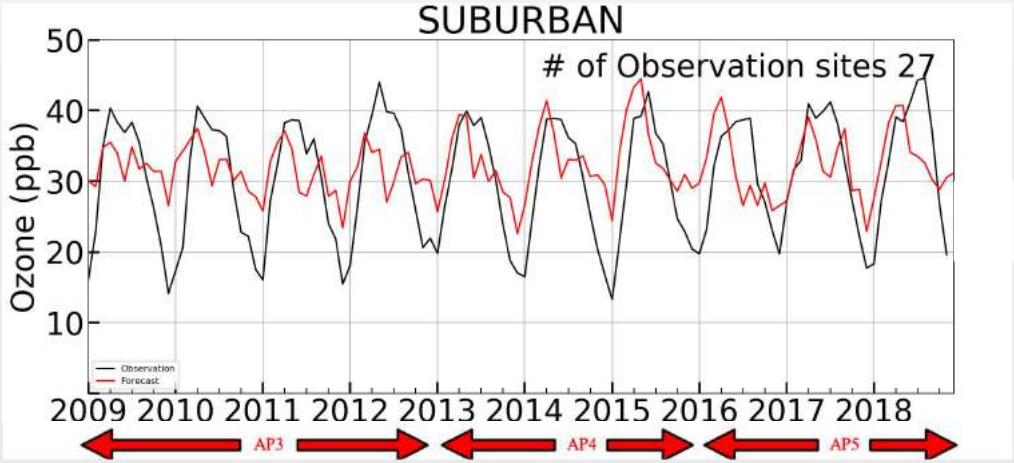


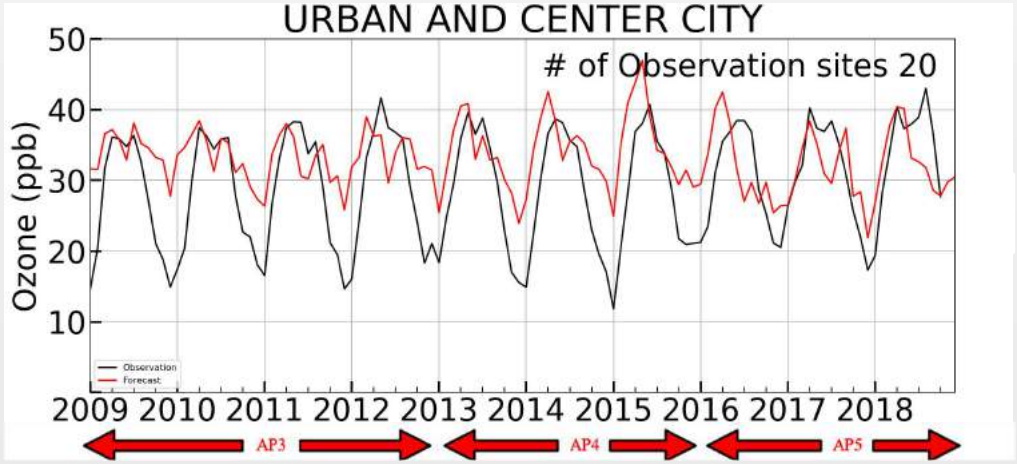
Note:
AP5 RH has a MB of 2.4, thus is not seen.

Pollutants

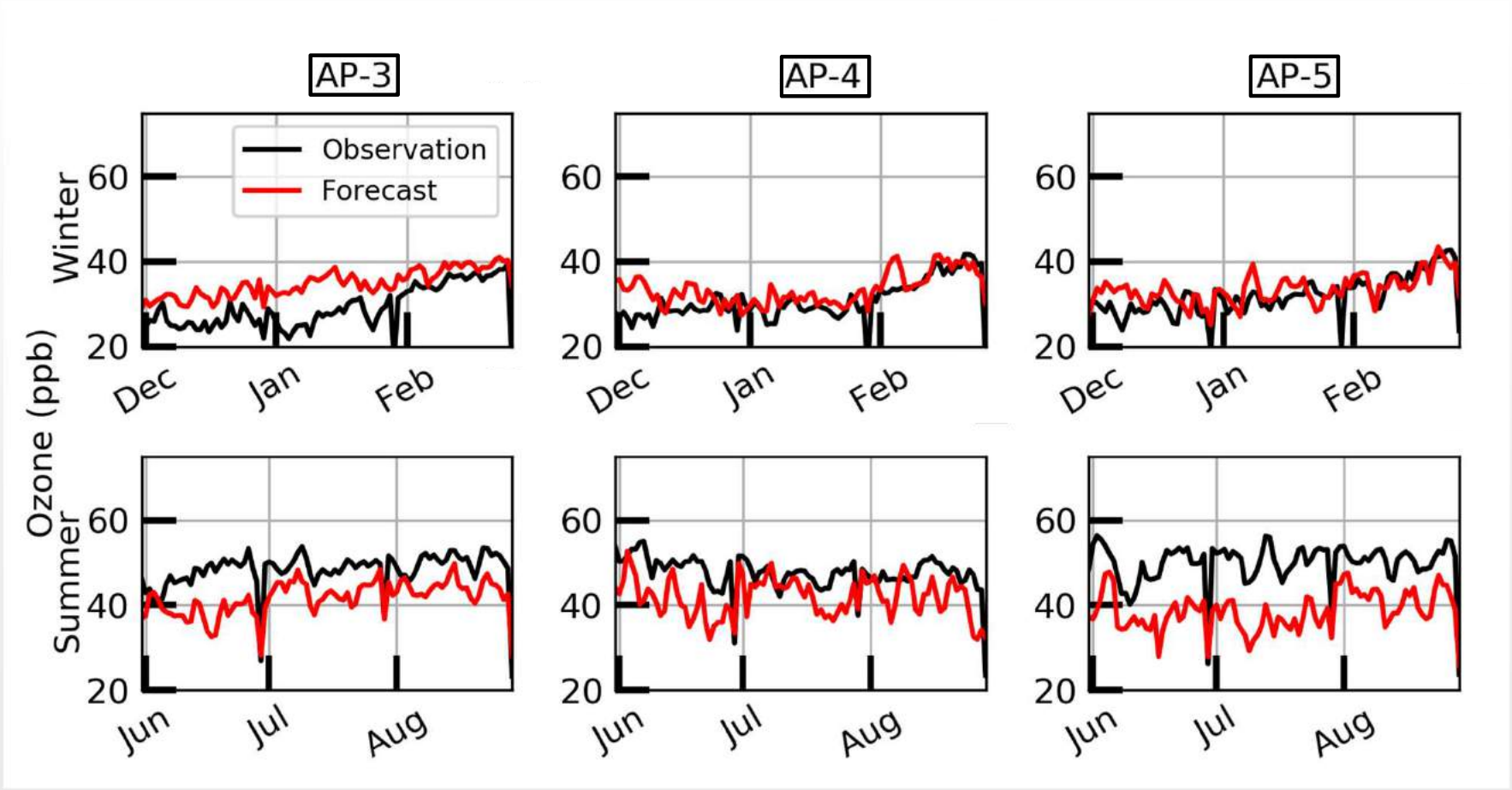
Ozone


RURAL
# of Observation sites 55
Ozone (ppb)
10
20
30
40
Observation
Forecast
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
AP3
AP4
AP5

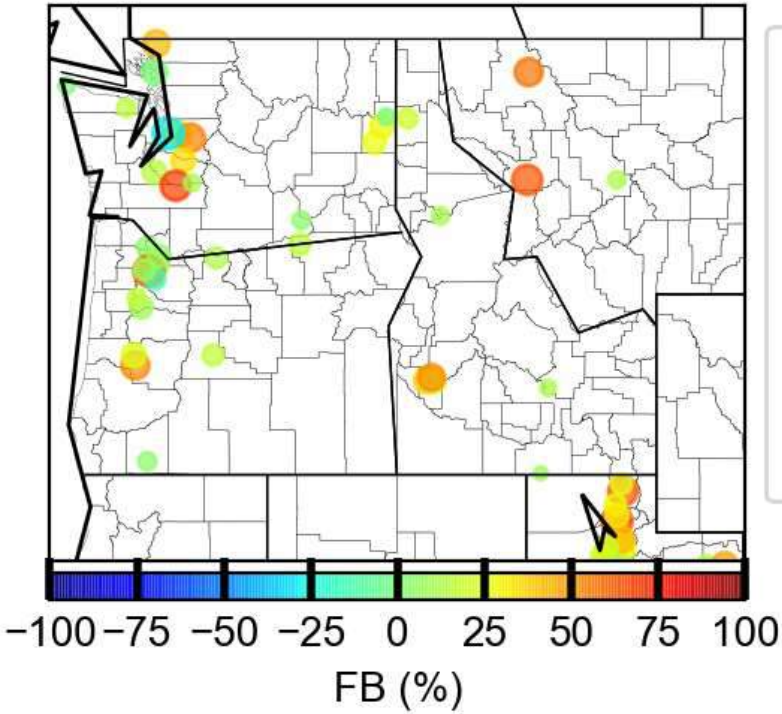

SUBURBAN
# of Observation sites 27
Ozone (ppb)
10
20
30
40
50
Observation
Forecast
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
AP3
AP4
AP5

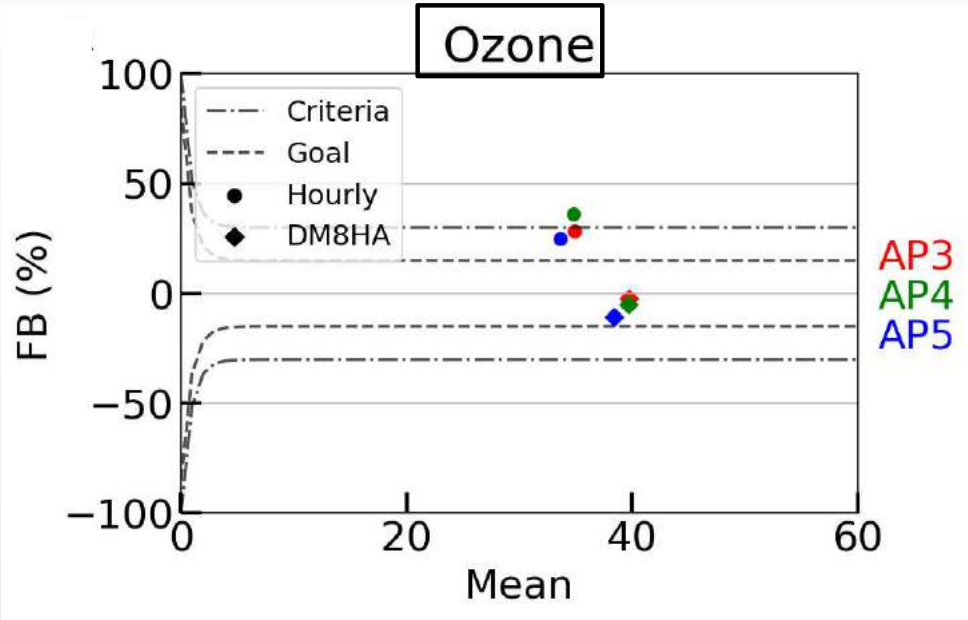

URBAN AND CENTER CITY
# of Observation sites 20
Ozone (ppb)
10
20
30
40
50
Observation
Forecast
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
AP3
AP4
AP5

Seasonal Changes – DM8HA

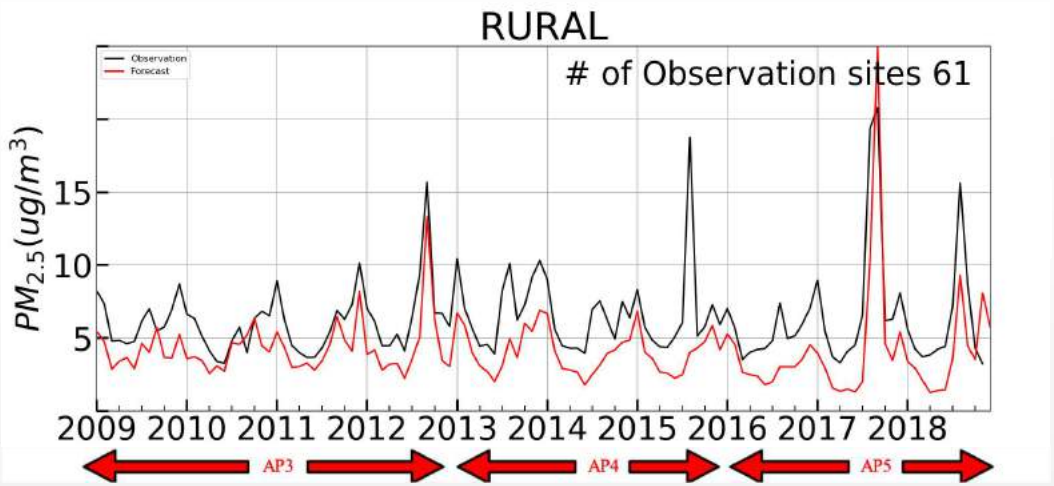


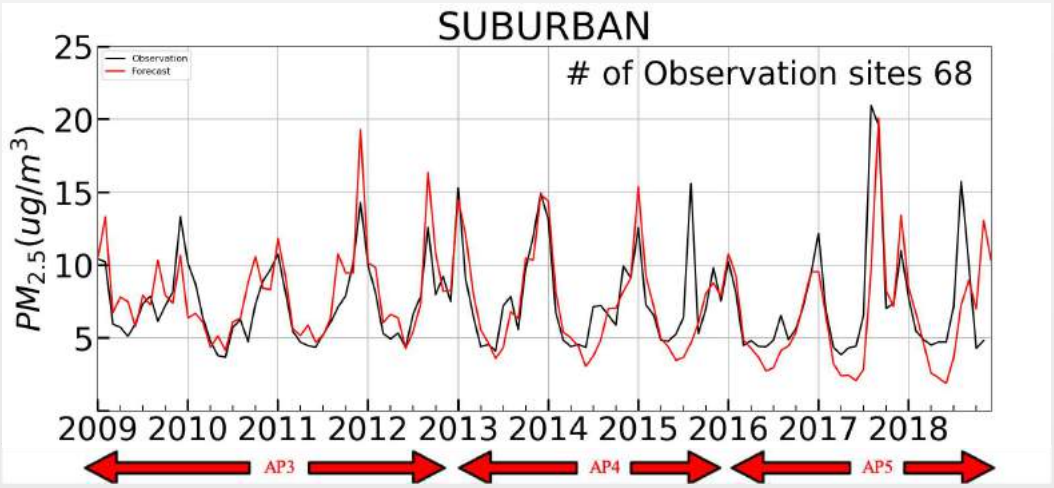
Hourly Ozone Bias/Error Map

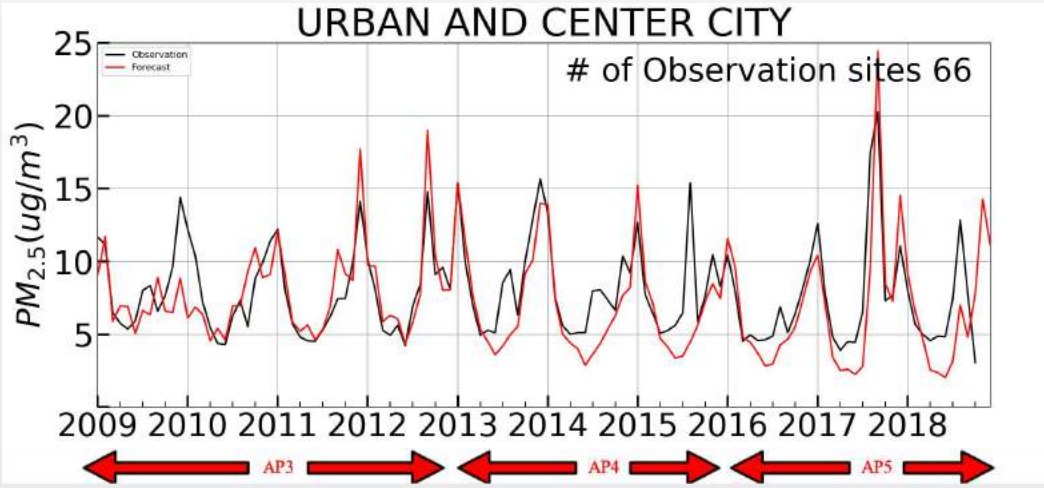




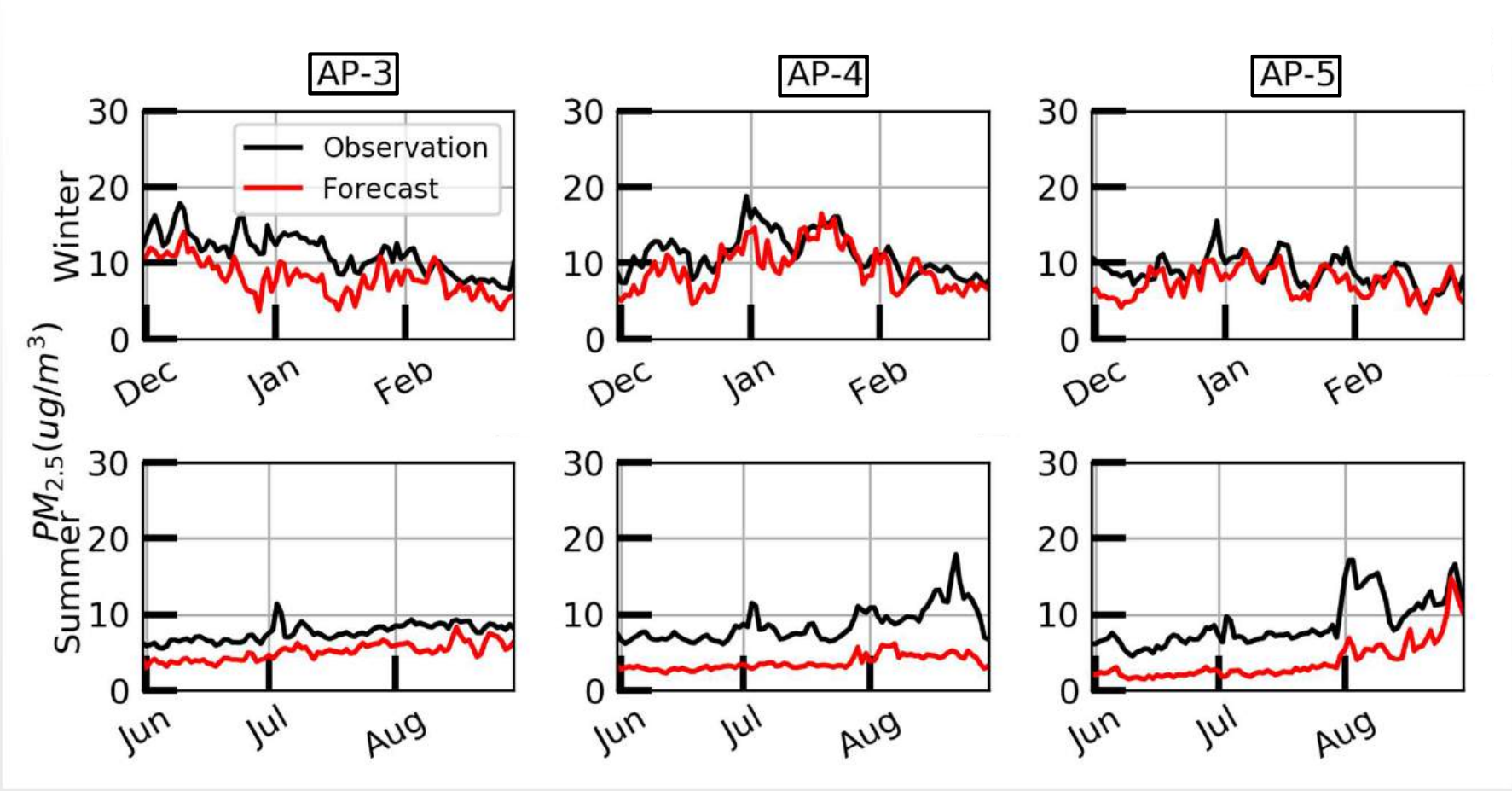
$PM_{2.5}$


RURAL
Observation
Forecast
# of Observation sites 61
$PM_{2.5}(ug/m^3)$
5
10
15
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
AP3
AP4
AP5


SUBURBAN
Observation
Forecast
# of Observation sites 68
$PM_{2.5}(ug/m^3)$
5
10
15
20
25
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
AP3
AP4
AP5

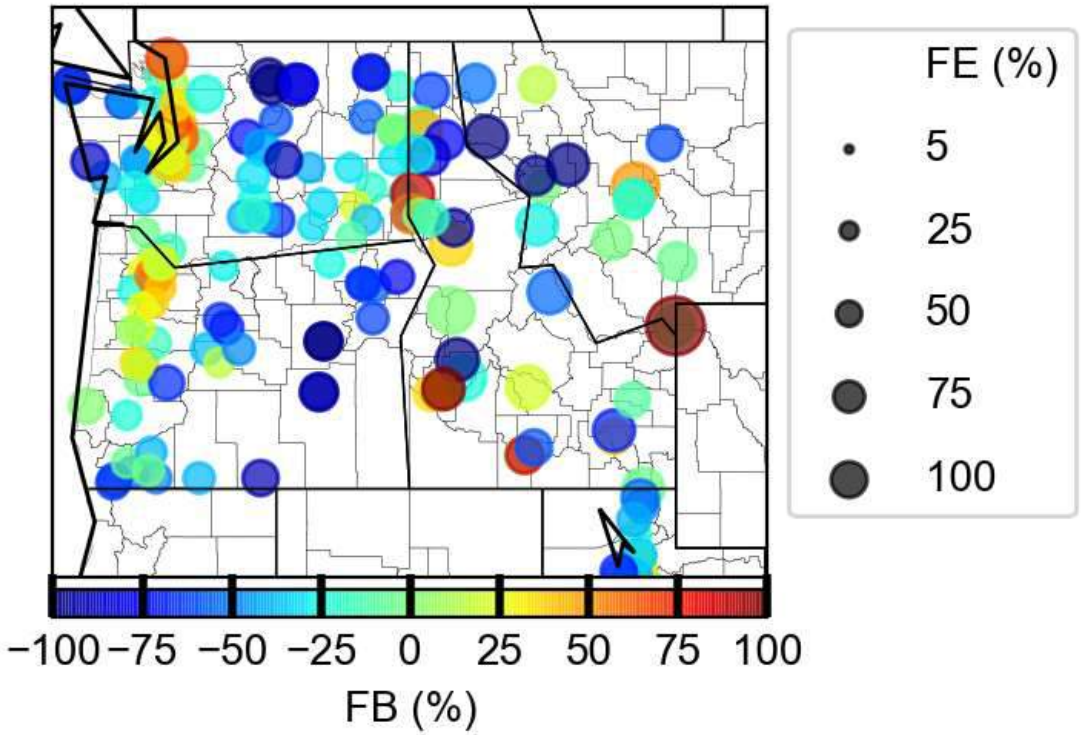

URBAN AND CENTER CITY
Observation
Forecast
# of Observation sites 66
$PM_{2.5}(ug/m^3)$
5
10
15
20
25
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
AP3
AP4
AP5

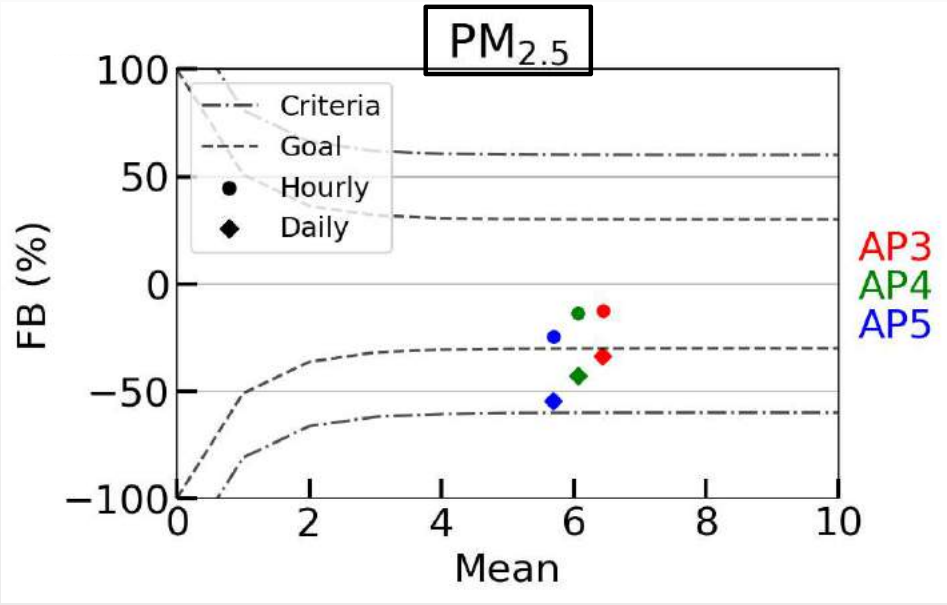
Seasonal Changes



Hourly $PM_{2.5}$ Statistics

Hourly $PM_{2.5}$ Bias/Error Map





Summary

- Meteorology
  - Significant improvement from AP-3 to AP-4 and AP-5.
    - AP-4 started to meet all criteria Benchmark
  - Small differences between AP-4 and AP-5
- Ozone
  - Hourly fraction bias for all versions is ~30%, but DM8HA meets goal of ±15%
  - DM8HA fraction error: AP-3 is 15.6%, while AP-5 is 17.5%
  - Significant improvement at urban and rural sites with newer version
  - Low concentrations are overpredicted in all versions.
  - High concentrations are overpredicted in AP-3 and AP-4, but become slightly underpredicted in AP-5
- PM2.5
  - Hourly forecasts meet benchmark goal of ±30% FB for all versions
  - However, daily forecasts' fractional error worsened from 39% in AP-3 to 59% in AP-5
  - In all versions, rural sites tend to underpredict PM2.5 concentrations
  - AP-5 starts to capture summer wildfire concentrations

BenMAP

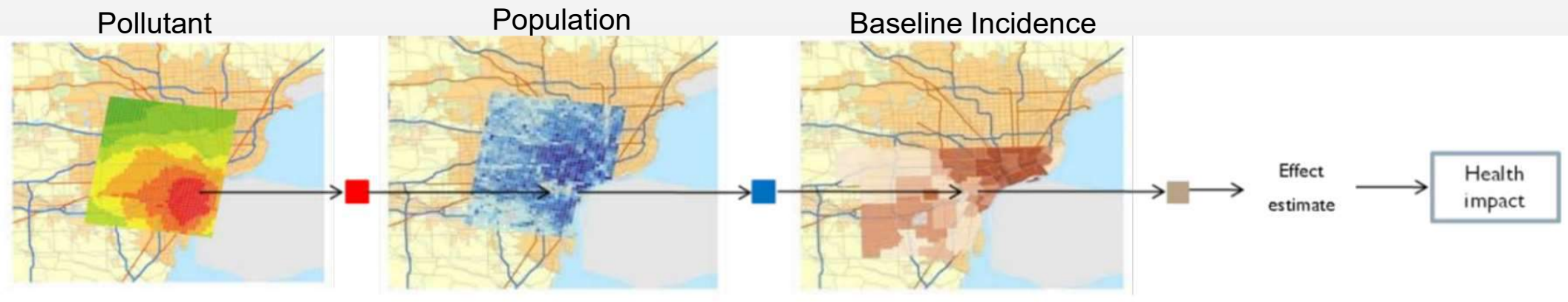
What is BenMAP?

- Benefits Mapping and Analysis Program
  - Developed by the EPA
  - Calculates impacts of air pollution on public health
    - Mortality, hospital visits, asthma exacerbation, etc…
  - Monetarize the health impacts

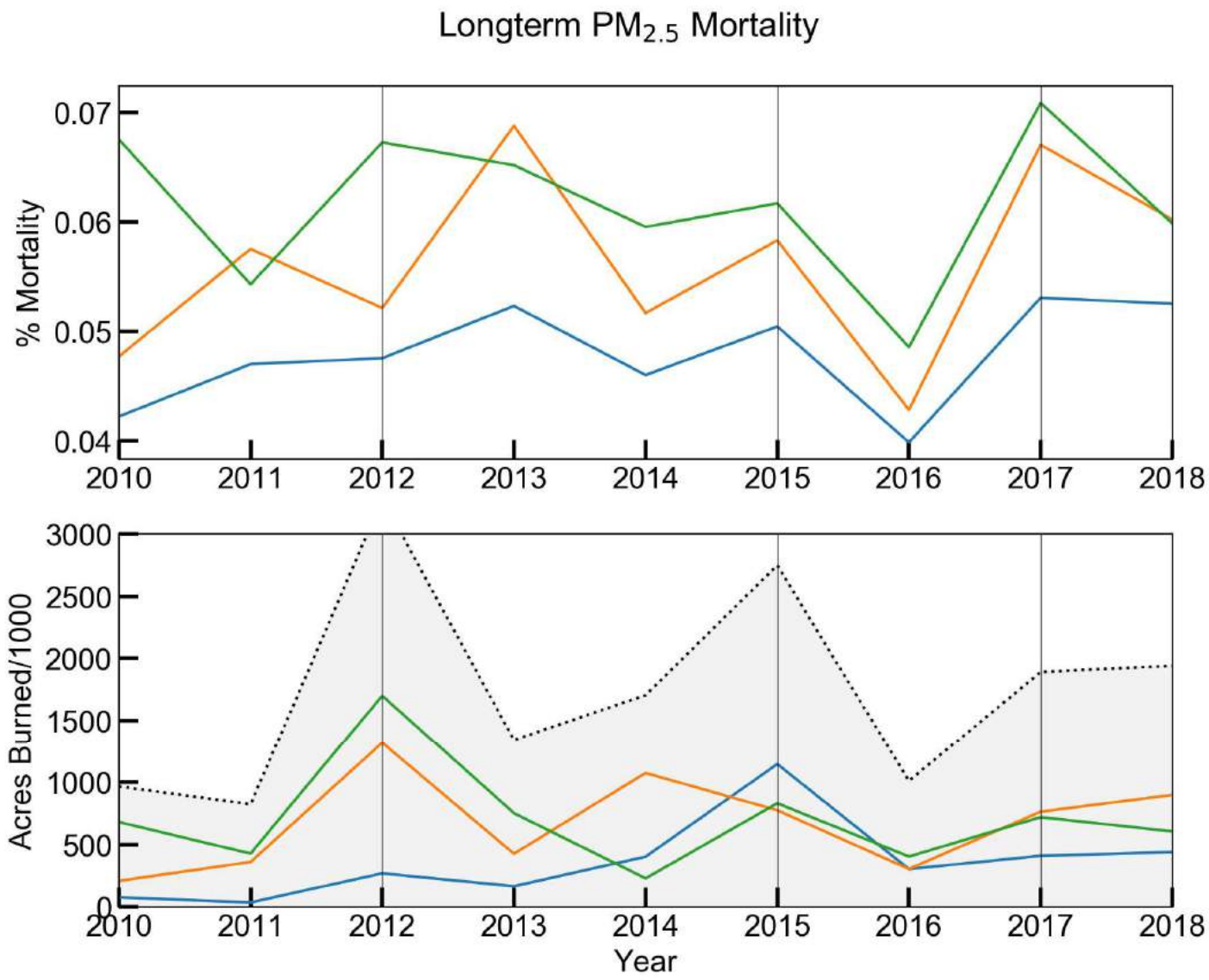
https://www.epa.gov/benmap

Mortality in BenMAP

- Mortality Function based on Krewski et al. 2009
  - Chronic log-linear function using annual $PM_{2.5}$ concentrations

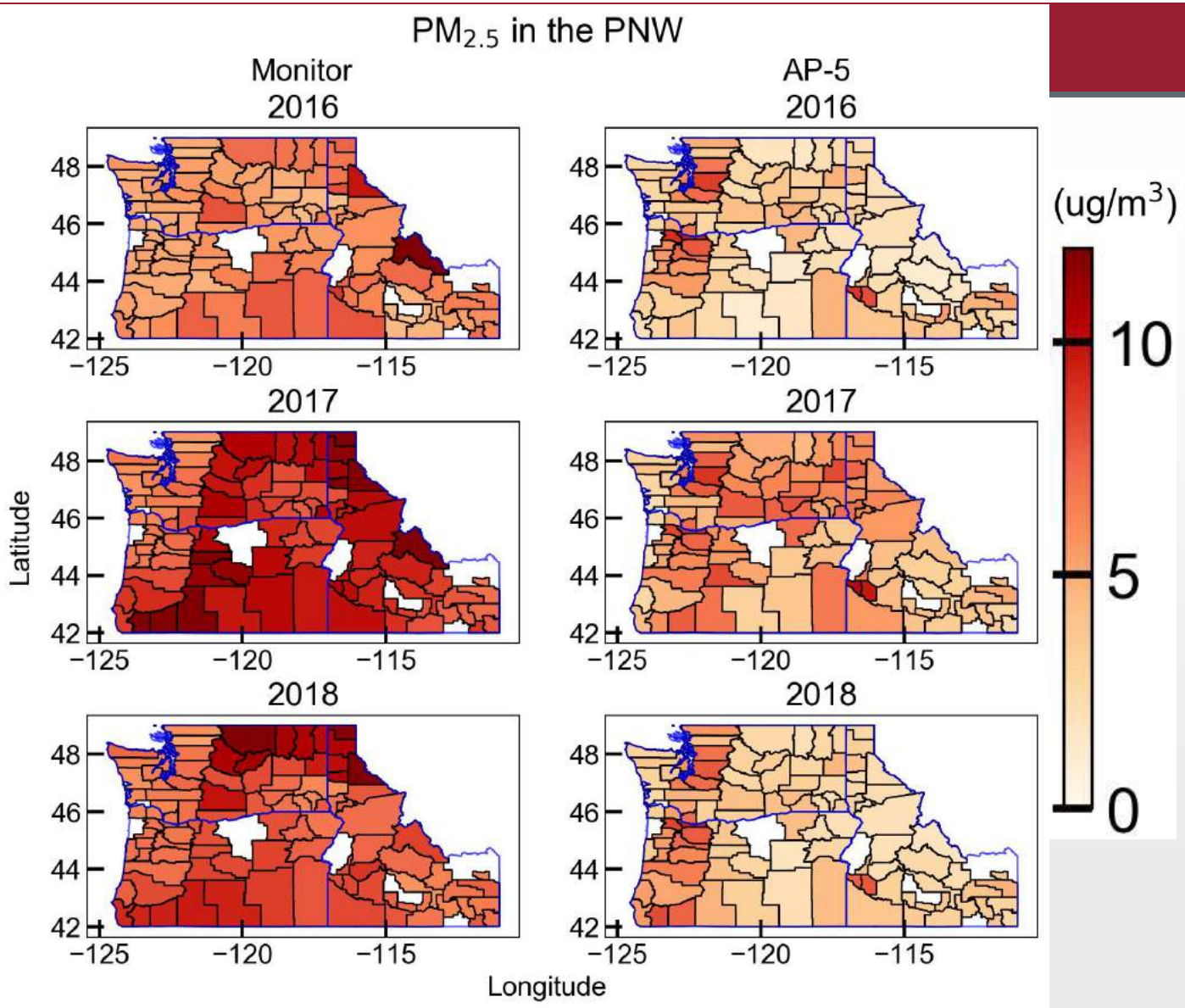


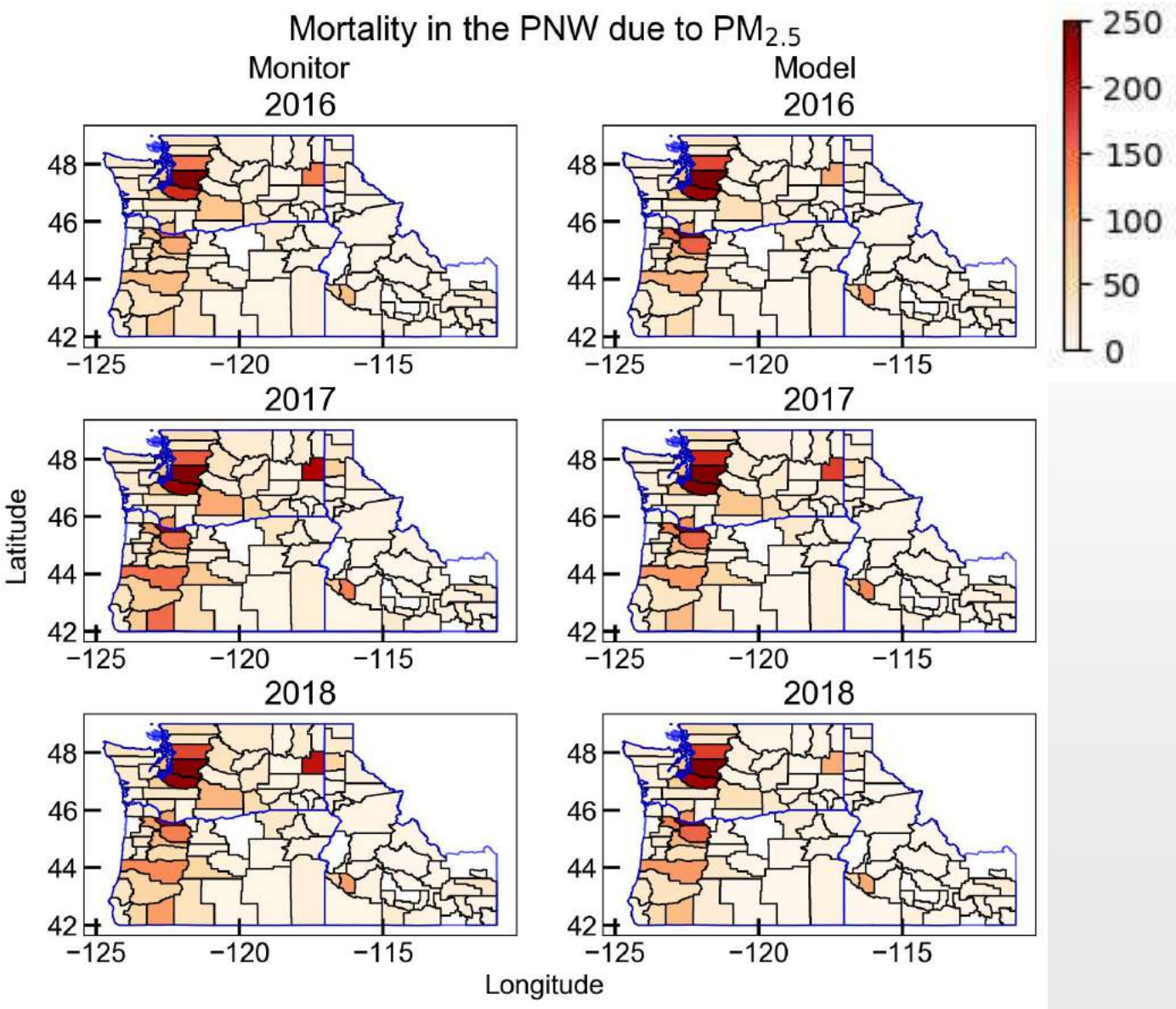
https://www.epa.gov/sites/production/files/2015-04/documents/benmap-ce_user_manual_march_2015.pdf

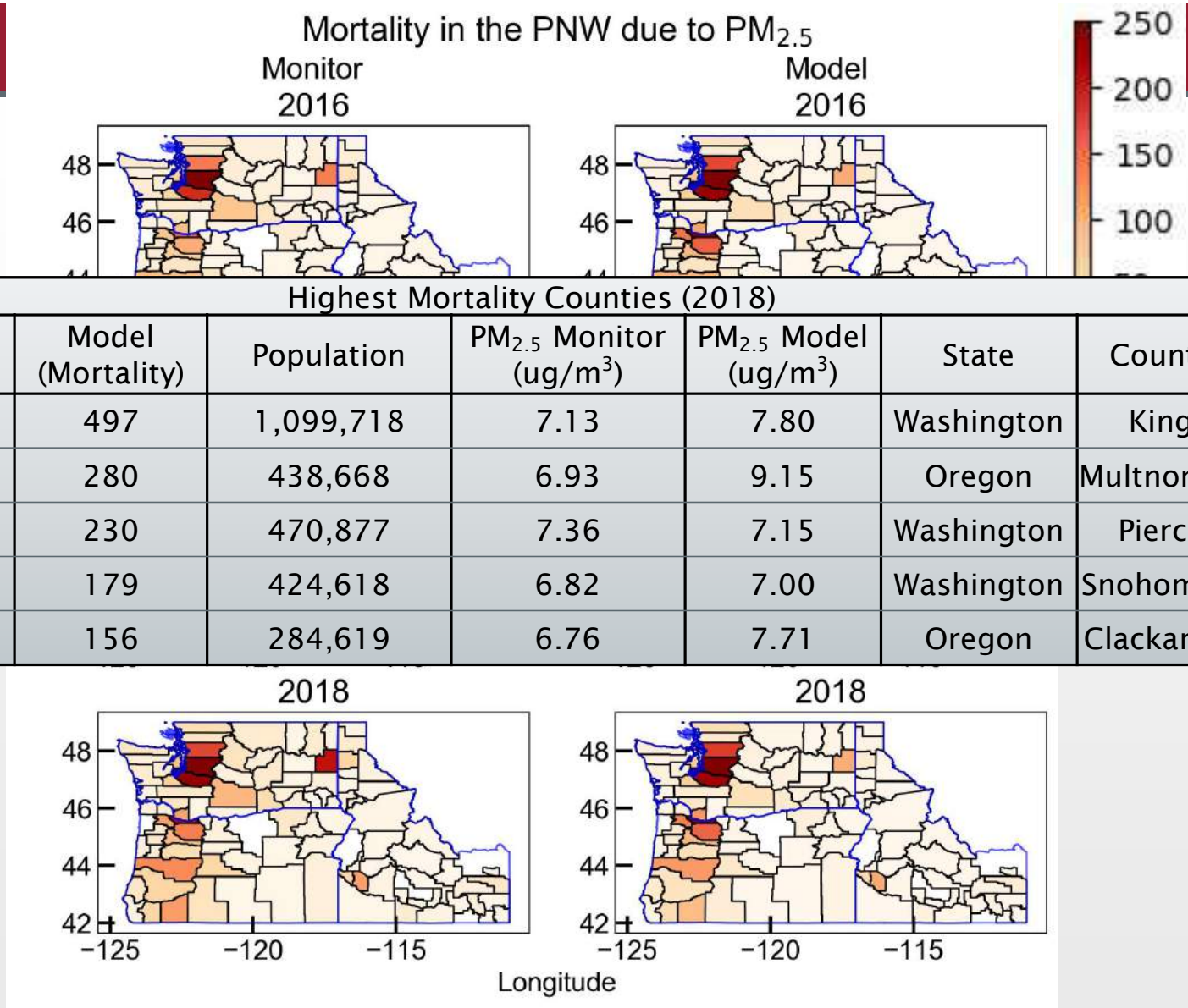


Mortality determined using VNA AQS data

https://www.nifc.gov/fireInfo/fireInfo_statistics.html

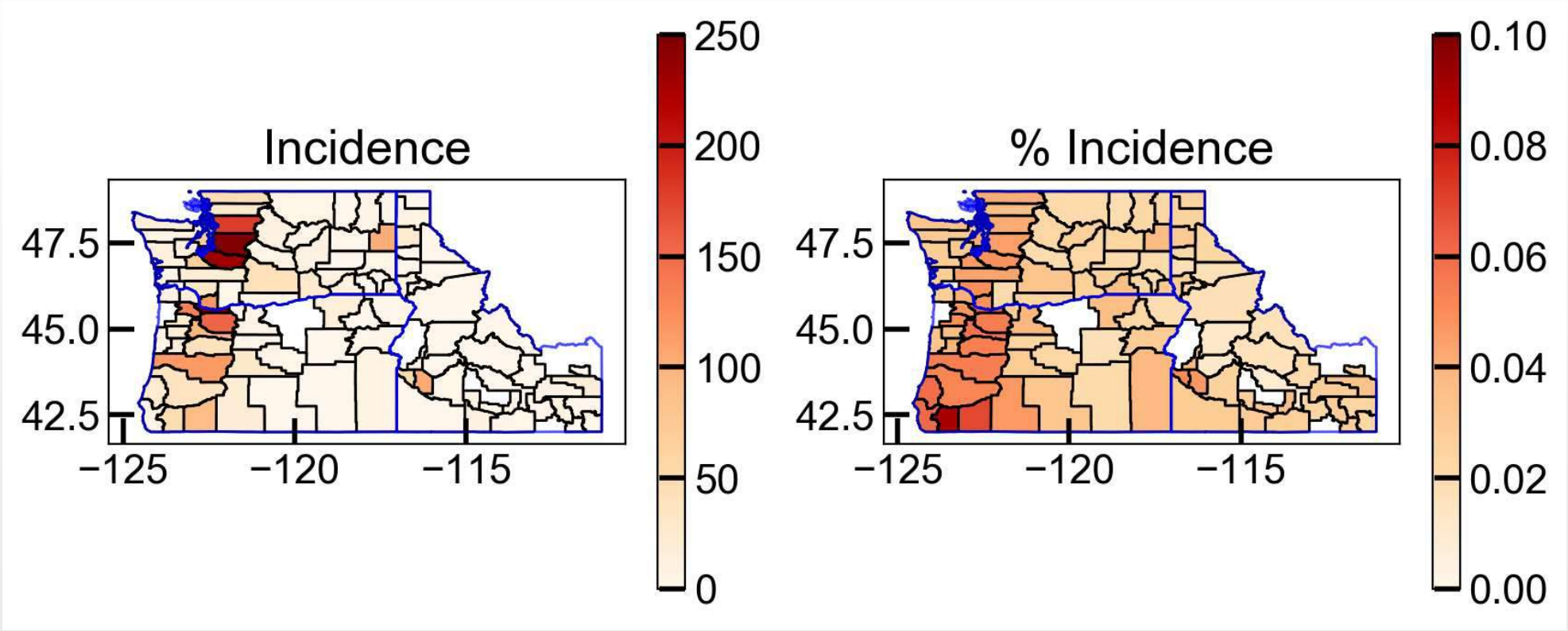

PM2.5 in the PNW
Monitor
AP-5
2016
2017
2018
Latitude
Longitude
48
46
44
42
−125
−120
−115
(ug/m3)
10
5
0


Mortality in the PNW due to $PM_{2.5}$
Monitor
Model
2016
2017
2018
Latitude
Longitude
48
46
44
42
−125
−120
−115
250
200
150
100
50
0



Highest Mortality Counties (2018)						
Monitor (Mortality)	Model (Mortality)	Population	$PM_{2.5}$ Monitor (ug/m^3)	$PM_{2.5}$ Model (ug/m^3)	State	County
451	497	1,099,718	7.13	7.80	Washington	King
215	280	438,668	6.93	9.15	Oregon	Multnomah
238	230	470,877	7.36	7.15	Washington	Pierce
173	179	424,618	6.82	7.00	Washington	Snohomish
136	156	284,619	6.76	7.71	Oregon	Clackamas

$PM_{2.5}$ AP-5 Determined Mortality in 2018



Valuation

- BenMAP valuation sets the value of a human life at roughly $8.7 million
- 2018 valuation for the highest mortality counties
  - King County
    - $3,463,727,000
  - Multnomah
    - $1,952,542,000

Summary

- Fire acres burned shows similar trend to annual mortality change from 2014 to 2018
- Health estimates between forecasted values and AQS monitor values are very similar
  - Total Mortality
    - Based on AQS monitor – 3,767
    - Based on AIRPACT – 3,114
  - Total Valuation
    - Based on AQS monitor – $26,570,084,000
    - Based on AIRPACT – $21,860,655,000