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US Airshed Planning:

Developing blueprints for action to improve air quality

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Justin Spenillo, US EPA Region 10
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At the end of this session, you should be able to answer:

- Develop understanding of Airshed Planning – Regulatory and Non-regulatory processes
- Gain experience with Airshed Planning tools
- Become familiar with Airshed Planning through Case Studies

Speaker Introductions

Alison Simcox, Particle Pollution Specialist, EPA R1

Based in Boston – Region 1 (New England states); 2015-present: provides technical expertise to Office of International & Tribal Affairs (OITA)

Air quality situation in Region 1

- Issues with $PM_{2.5}$ from wood burning, and ozone from vehicle & power-plant emissions.
- Primary source of energy for electricity: natural gas.
- Pollution from energy/industrial sources is generally well-controlled.

Justin Spenillo, Particulate Matter / Air Quality Planner EPA R10

Based in Seattle, Washington - Region 10 (Idaho, Alaska, Oregon, Washington); 2015-present: provides technical expertise to OITA

- Booming economy (Starbucks, Microsoft, Amazon), medium sized cities (< 1 million)
- Vast forests and wildlands, and small communities.

Air quality situation in Region 10

- Primary issues with $PM_{2.5}$: home heating (wood burning), summer forest fires.
- Energy sector primarily hydropower which has minimal emissions.
- Pollution from energy and industrial sources is generally well controlled.

Session Outline

- Airshed Overview
- Airshed Planning Processes:

  Nonregulatory Approach: Airshed Planning for transboundary areas

  Case Study – Great Lakes US / Canada

  Regulatory Approach: NAAQS + Designation/attainment planning

  Case Studies – Cleveland, Ohio,

  Case Study - Tacoma, Washington
- Airshed Planning Components:

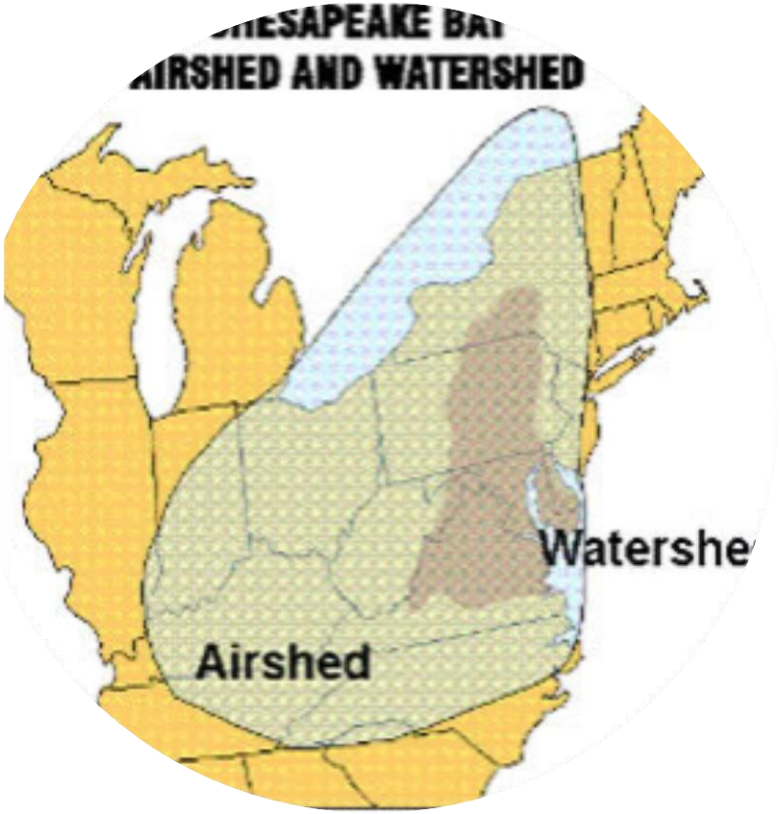
  Demo – Wind Rose Diagrams

  Demo – HYSPLIT Trajectories

  Monitoring Network Preview
- Identifying Control Strategies

What is an Airshed?

An “airshed” is a geographic area within which air pollution is freely and routinely transported and that is influenced by shared weather, terrain, and sources of pollutants.



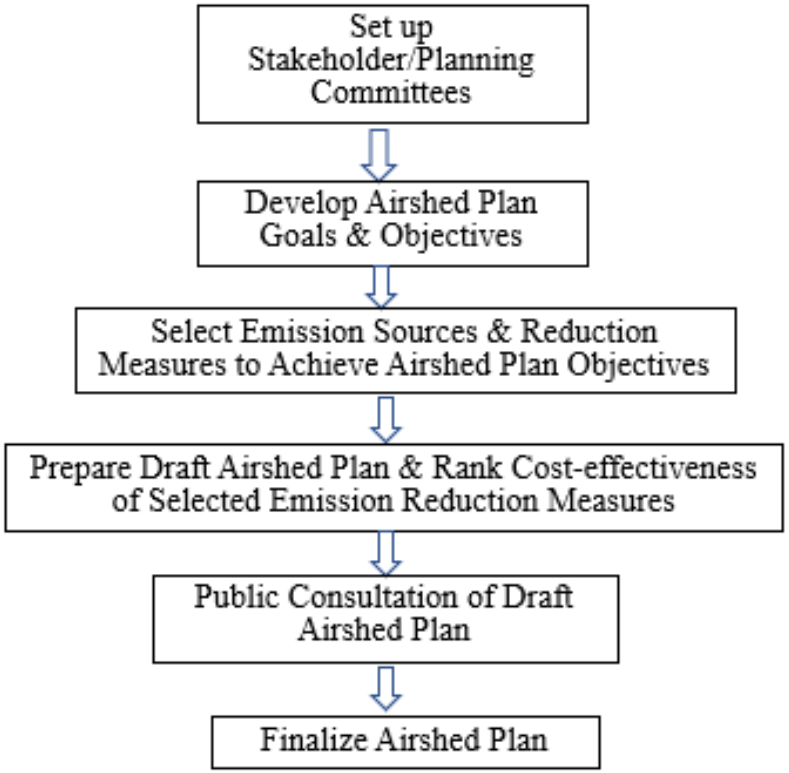
Why do an Airshed Plan?

- To improve everyone's health, and especially ***children's health***
  - Children inhale larger amounts of air pollutants per unit of body weight than adults and their immature lungs have limited metabolic capacity to address these exposures
- To integrate air-quality considerations into other planning processes (industrial permitting, municipal planning, regional growth strategies)
- To protect the natural environment (including visibility)
- To enhance public awareness and give public access to AQ data & research findings and information on how to reduce pollution & protect health
- To support economic development (including tourism)
- To provide industry with degree of certainty about future air-quality requirements

Airshed Planning is a team effort

- Can be a complex and resource-intensive effort
- Typically more than one agency is involved
- Partnerships and leveraged resources are <u>common</u> and <u>necessary</u>
- US nonattainment-area (or airshed) planning
  - EPA has oversight role and provides legal, policy, and technical support
  - Plan developed by state and local air programs
  - Stakeholder & community involvement is key

Airshed Planning Process: General flowchart



Nonregulatory Airshed Planning

Case Study: Great Lakes Basin

- Part of *Canada-U.S. Border Air Quality Strategy** - cooperative effort to reduce air pollution in North America, and builds on previous agreements under the *Canada-United States Air Quality Agreement*
- The 1991 *Agreement* led to reductions in acid rain in the 1990s, and was expanded in 2000 to reduce transboundary smog emissions under the *Ozone Annex*

* https://www.epa.gov/sites/production/files/2015-07/documents/great_lakes_basin_airshed_management_framework.pdf

Great Lakes Basin Airshed - Overview

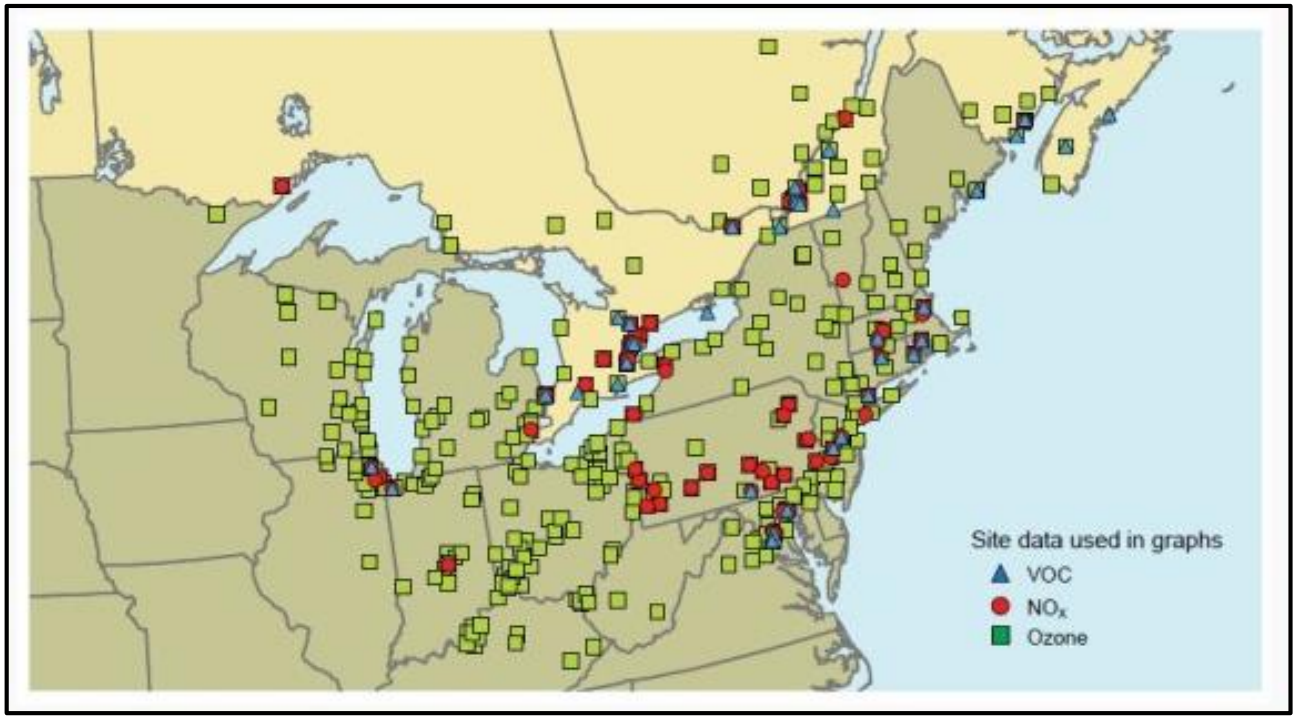
- SE Michigan and SW Ontario
- Air quality affected by domestic & transboundary sources
- Benefits of Airshed approach:
  - Enhances coordination between separate jurisdictions
  - Enhances information exchange between public, decision makers, and private sector
  - Enhances exchange of scientific & technical information

Airshed

Great Lakes Basin Airshed Project:
Border Air Quality Strategy Report

- 4,500 square miles; includes three cities (Detroit, Ann Arbor & Port Huron) in eight counties
- Monitors in SW Ontario and SE Michigan exceed NAAQS for ozone and $PM_{2.5}$
- Major sources: industrial, mobile, area (small businesses)

Monitoring Sites for Ambient Ozone, NO_X, and VOC



Great Lakes Basin Airshed Project:

Airshed Characterization Workgroup

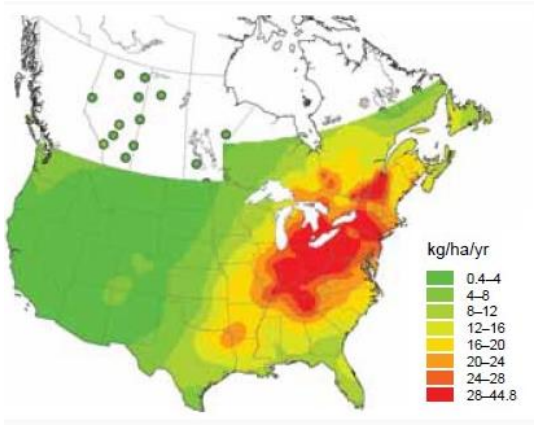
- Binational network of technical contacts needed
- Some compatibility of monitoring systems between the two countries (quality of data, instruments, collection methods)
- Several modeling tools used by each country, but this adds information about ozone and PM levels
- Need to explore differences in AQI and forecasting systems of both countries

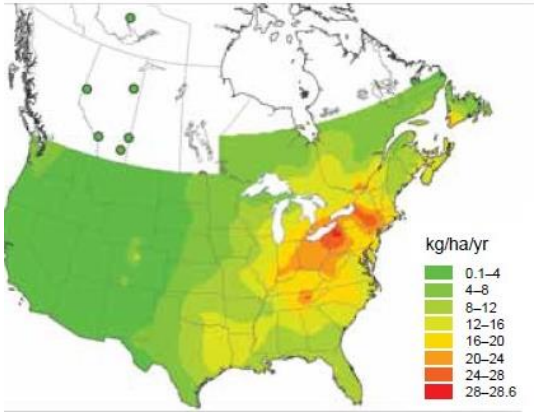
Great Lakes Basin Airshed Project:
Policy Needs Workgroup

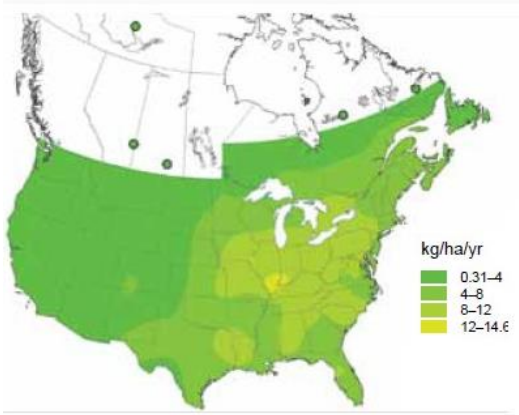
- Need to consider differences in administrative frameworks between the two countries
- US government has stronger role than Canadian government in approving permits and state programs to address air pollution
- Canadian government addresses transboundary air pollution, but required to cooperate with provinces & territories to manage local air pollution and implement international agreements

Great Lakes Basin Airshed Project:
Voluntary/Early Action Workgroup

- Most Early Action efforts initiated by the federal governments
- Local governments should take lead in identifying & initiating community actions
- Federal government should provide cities/towns with information about effective & low risk options (low-hanging fruit) and provide guidance or help with implementation
- Encourage/incentivize voluntary actions (transportation, energy conservation, pollution prevention) that improve air quality
- Promote existing energy-focused programs that have AQ benefits







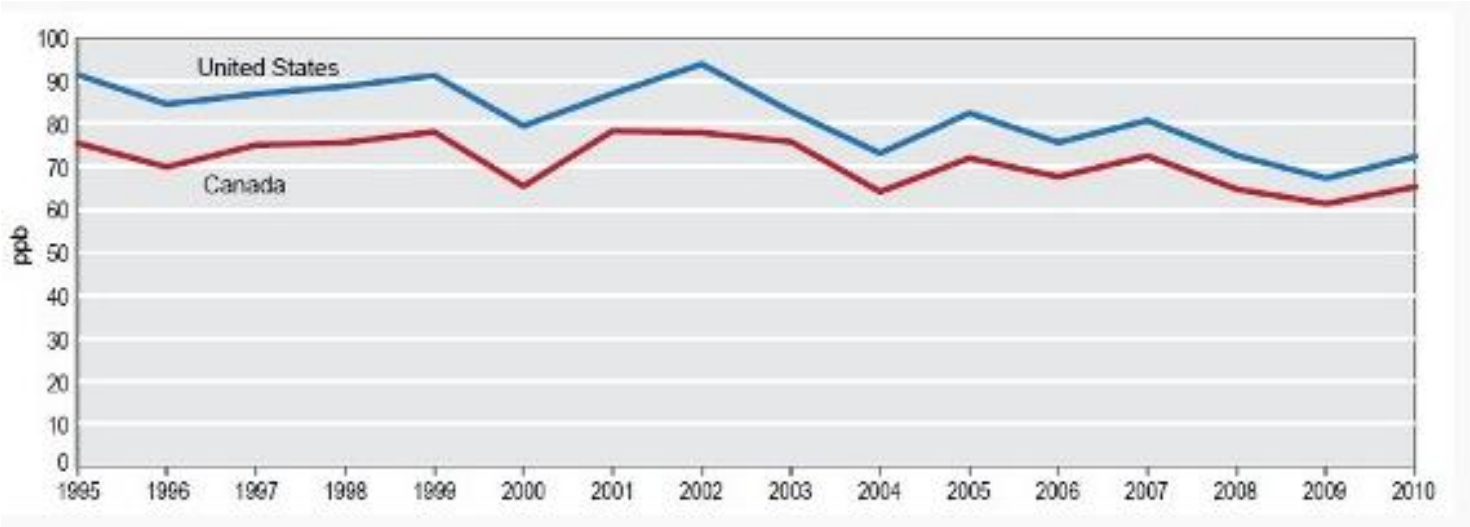
Left to right Annual Wet Sulfate deposition 1990, 2000, 2010

- By 2010, all regions receiving less than 15 kg/ha/year of wet sulfate deposition. Reductions directly related to decreases in SO_2 emissions in both US and Canada
- Similar story for annual wet Nitrate deposition

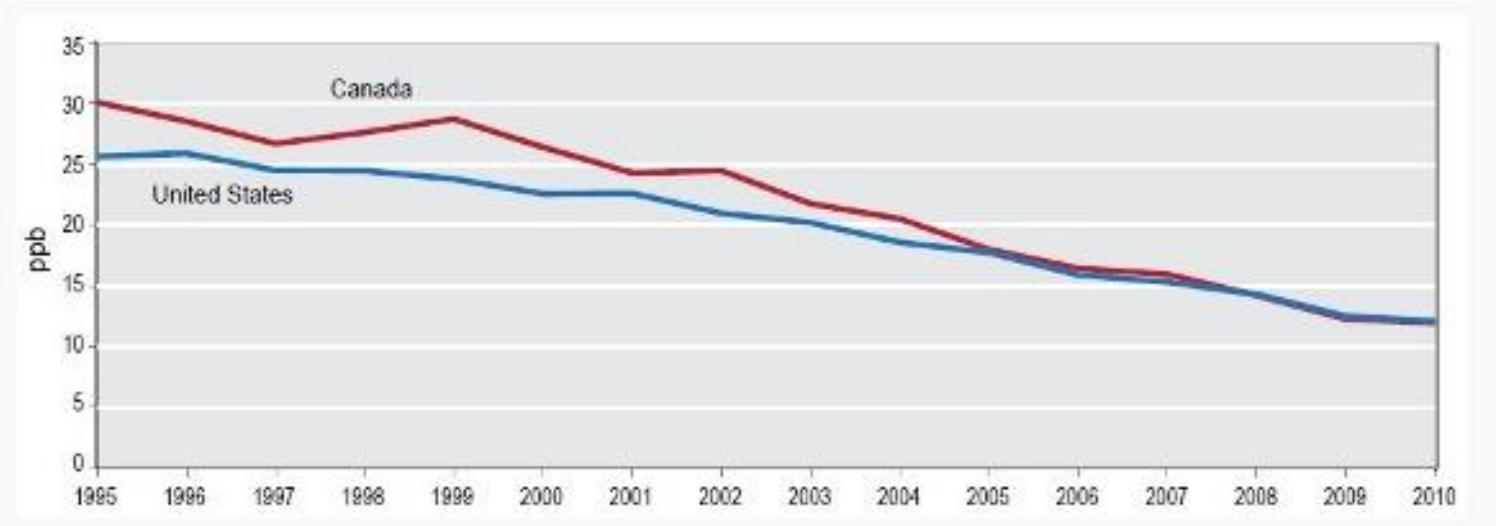
Source: Canada-United States Air Quality Agreement Progress Report 2012: chapter 1 (https://www.canada.ca/en/environment-climate-change/services/air-pollution/publications/canada-united-states-air-quality-report-2012/chapter-1.html)

Sites within 500 km of US-Canada Border, 1995-2010

Top: Annual Average (4th Highest Daily) Max 8-hour Ozone



Bottom: Average Ozone-Season (May-Sept) 1-hour NO_X



Great Lakes Basin Airshed Project:
Current Status

- Great Lakes Basin project has been folded into Canada-United States Air Quality Agreement
- Access to monitoring, modeling, and regulatory contacts is key to implementing actions
- Has resulted in closer agreement of AQ and vehicle standards between US & Canada
- International program is especially helpful for resolving local AQ border issues
- Annual meeting – location alternates between US and Canada

Regulatory Airshed Planning

- Background information on NAAQS - National Ambient Air Quality Standards
- Review Designations Process
- Case Studies – $PM_{2.5}$ NAAQS Designations for Cleveland, Ohio, & Tacoma, Washington

Airshed Planning Goal: Meet AQ Standards

Primary standards protect public health, including the health of sensitive populations such as ***children***.

EPA required under Clean Air Act (CAA) to set **NAAQS** for six criteria pollutants:

1. Particulate matter (PM_{10} and $PM_{2.5}$)
2. Ozone
3. Sulfur dioxide
4. Nitrogen dioxide
5. Carbon monoxide
6. Lead

NAAQS -

Ozone
&
Particulate
Matter

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm [9]	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 µg/m³	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m³	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m³	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 µg/m³	Not to be exceeded more than once per year on average over 3 years

Setting the NAAQS

- Review required by law <u>every five years</u>
- Process:

  Planning – EPA staff hold kick-off workshop & develop *Integrated Review Plan*

  Assessment – EPA staff develop 3 documents: *Integrated Science Assessment*, *Risk & Exposure Assessment*, and *Policy Assessment*.

  i. Developed to be assess data and risk, especially sensitive populations including **children** and the elderly.

  ii. Reviewed by Clean Air Scientific Advisory Committee (CASAC)

  Rulemaking – EPA management makes decision about level(s) of NAAQS after reviewing input from federal agencies, CASAC, and public.

NAAQS Designations

- With each new NAAQS, Clean Air Act (CAA) requires EPA to designate all areas of the country as attaining or not attaining the standard
- Each area designated *attainment, nonattainment, or unclassifiable*
- CAA spells out air-quality planning requirements for nonattainment areas

Designations process

- EPA is required to designate areas within 2 years of promulgation of a NAAQS.
- Final designations are published in the *Code of Federal Regulations*.

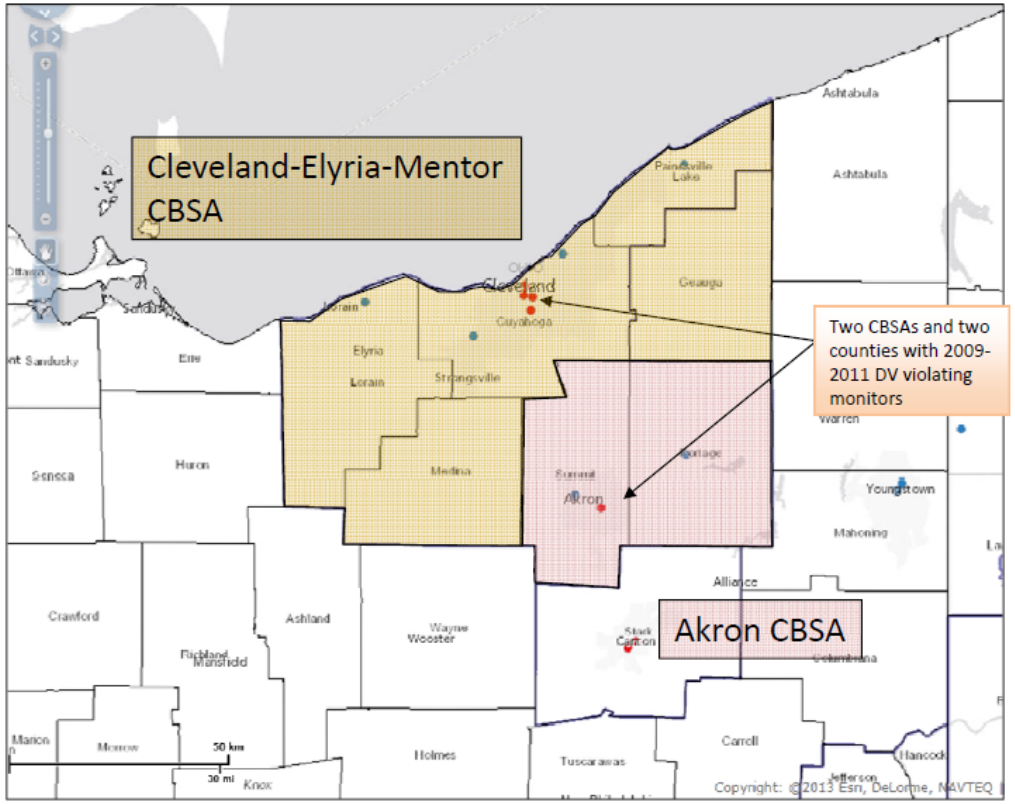
Milestone/Activity	After NAAQS promulgation
EPA issues designations guidance	4 months
States submit designation recommendations	1 year
EPA evaluates recommendations and sends 120 day letters	1 years and 8 months
Deadline for comments (we accept comments from public and states)	1 year 10 months
Administrator signs final designations	2 years

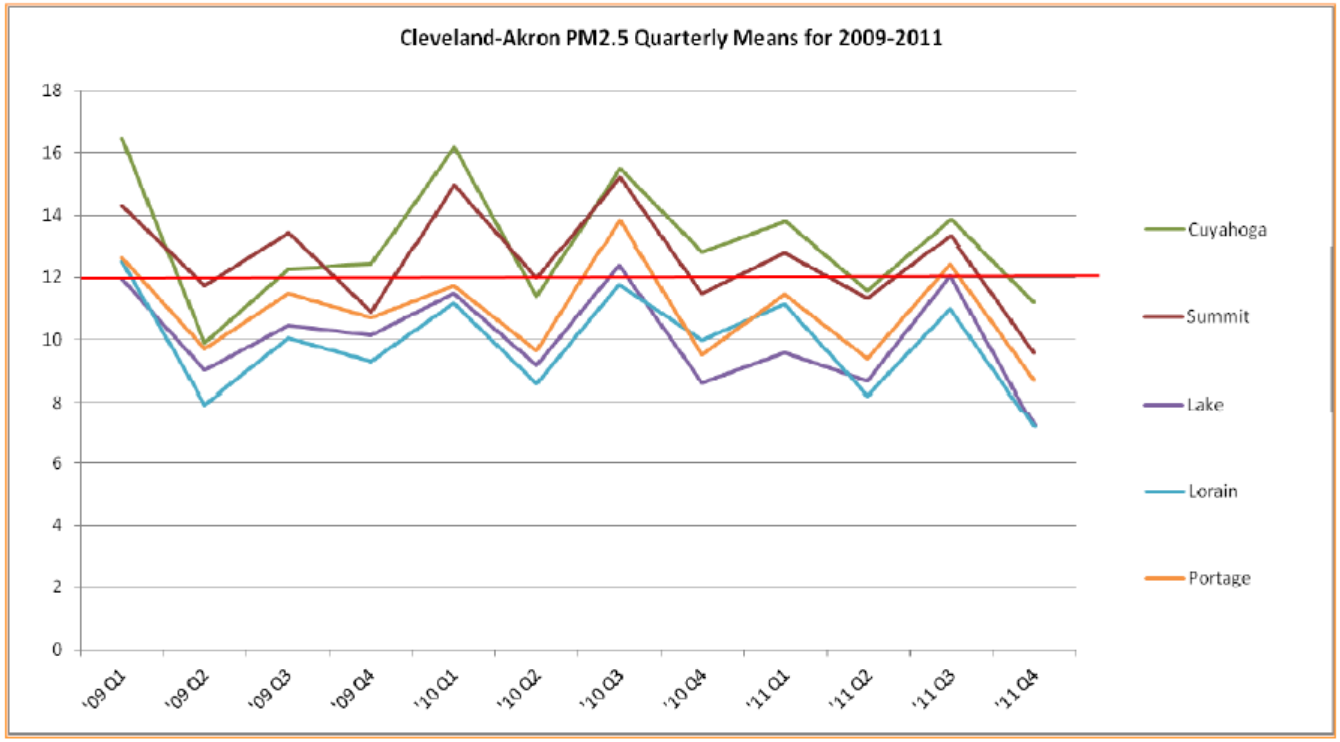
Determining boundaries of nonattainment areas: 5-factor analysis

1. Air quality data - design values (DVs), seasonal data, composition analysis, rural vs urban contribution
2. Emissions and emissions-related data - emissions inventory, population density, commuting patterns, vehicle miles traveled (VMT)
3. Meteorology - modeling, windroses (speed & direction)
4. Geography/Topography - airshed & watershed features, roads, land features
5. Jurisdictional (legal) boundaries

Example 5-factor analysis: Ohio (Cleveland & Akron)

Factor 1: Air Quality





Note degree of correlation over 3-year period for all Cleveland and Akron CBSA monitors even though not all are violating NAAQS

Ohio example:
Assessment of Factor 1: Air Quality

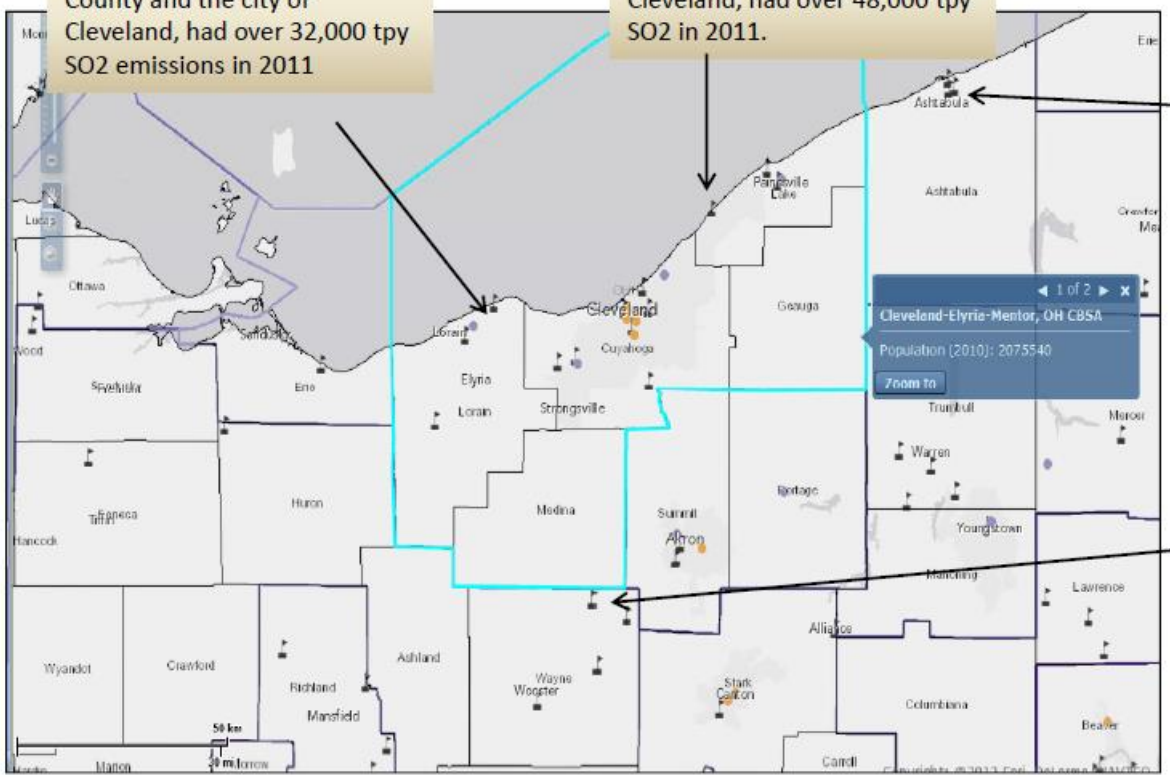
- Two counties have monitors regularly exceeding NAAQS of 12.0 µg/m^3
- Two counties had some NAAQS exceedances during 2009-2011
- There are clear seasonal peaks in $PM_{2.5}$
- Consider local and regional $PM_{2.5}$ source contributions (also includes sulfate and nitrate, NOx emissions, elemental carbon, and crustal (dust))

Ohio example:
Factor 2: Emissions and Emissions-related data

Avon Lake Power Company in northern Lorain County, immediately west of Cuyahoga County and the city of Cleveland, had over 32,000 tpy SO2 emissions in 2011

Cleveland Electric Iluminating Co. Plant in western Lake County, to the east of Cleveland, had over 48,000 tpy SO2 in 2011.

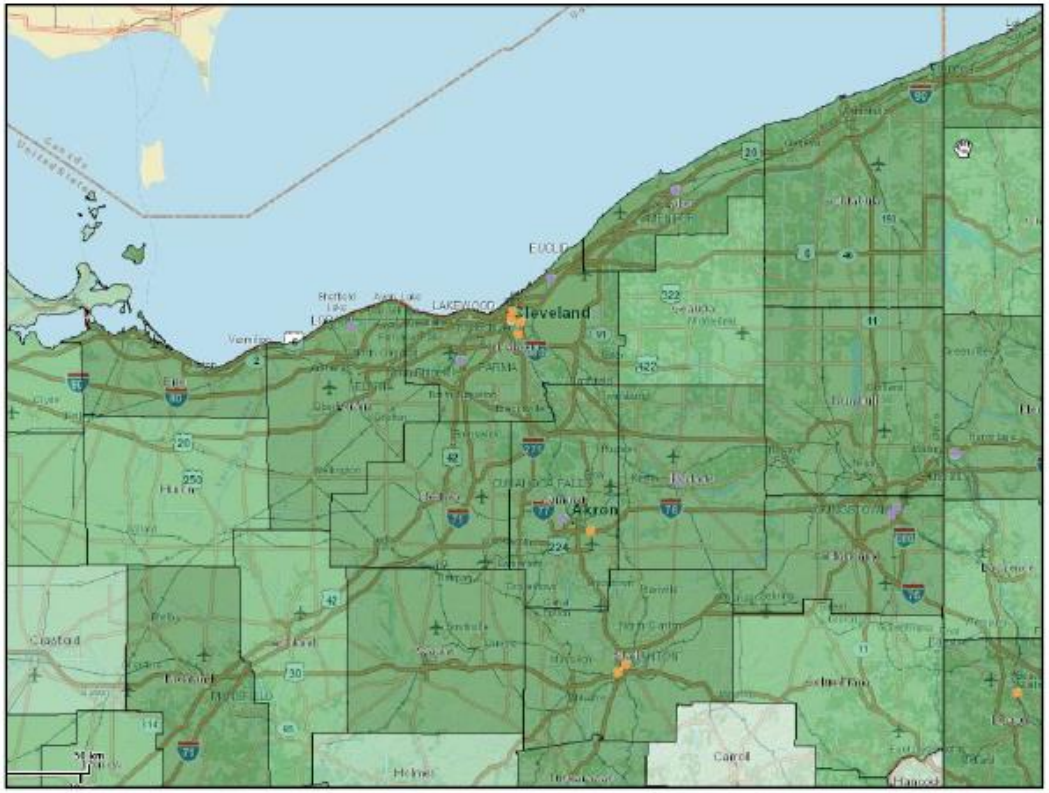
In northern Ashtabula County, FirstEnergy Generation Corp. power plant with over 3,400 tpy SO2 emissions in 2011 and two Millennium Inorganic Chemicals plants with close to 2,500 tpy total VOC in 2011.



Wayne County, southwest of Akron, two large point sources in the northeast portion of the county, including City of Orrville Dept of Utilities (over 13,000 tpy SO2 in 2011) and Morton Salt Inc with over 4,000 tpy SO2.

Factor 2: Vehicle Miles Traveled (VMT) shows areas likely to have elevated NOx, VOCs & direct $PM_{2.5}$

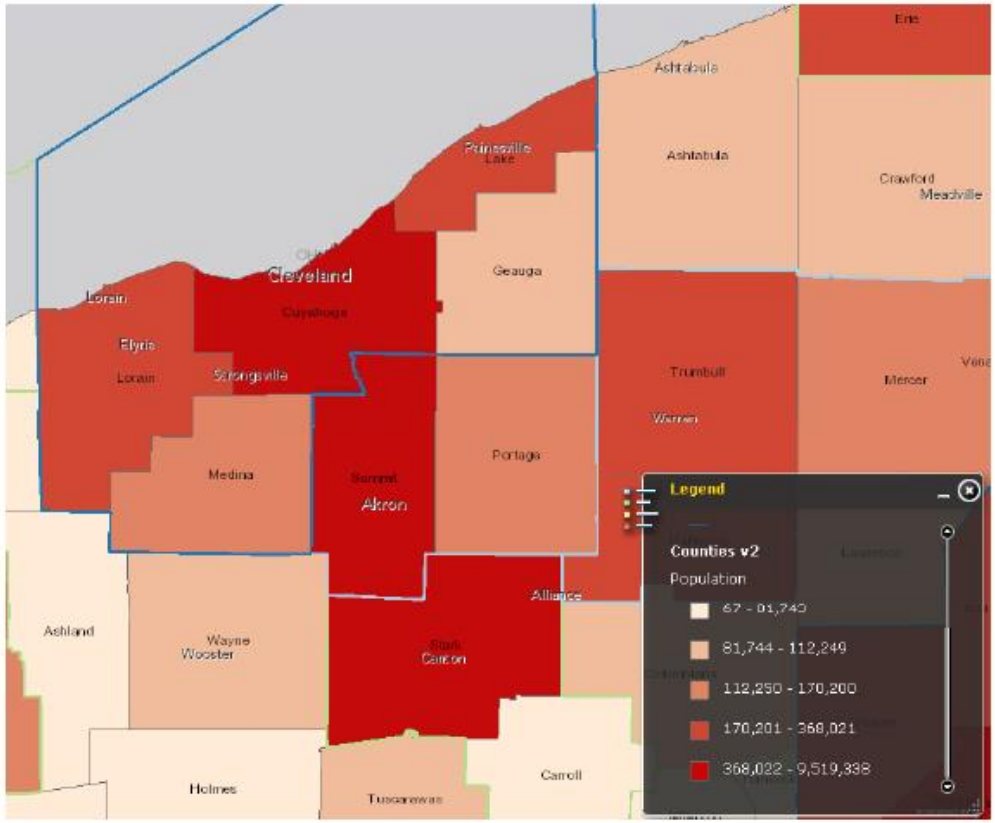
County	VMT 2010	Percent	Cumulative
Cuyahoga	10,441,337,655	35%	35%
Summit	5,636,455,011	19%	54%
Stark	3,078,116,937	10%	64%
Lorain	2,435,782,506	8%	72%
Lake	2,172,294,290	7%	79%
Portage	1,703,175,680	6%	85%
Medina	1,580,013,546	5%	90%
Wayne	1,086,668,001	4%	94%
Ashtabula	1,071,810,361	4%	97%
Geauga	765,557,120	3%	100%



2010 County Level Annual VMT overlay of streets base map

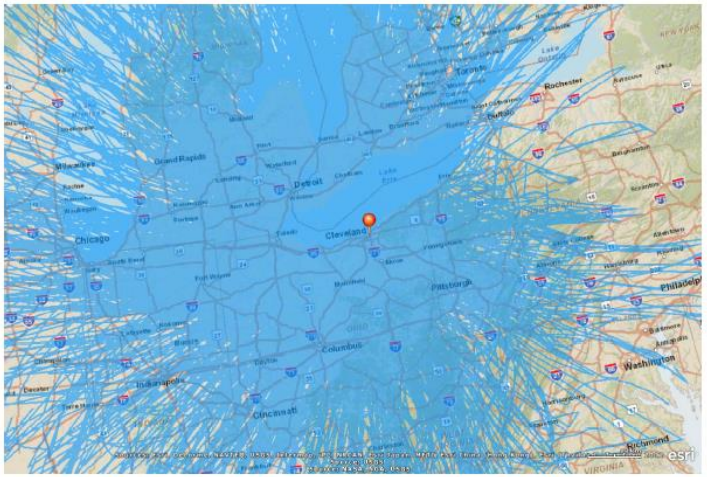
Factor 2: higher population areas more likely to have high emissions.

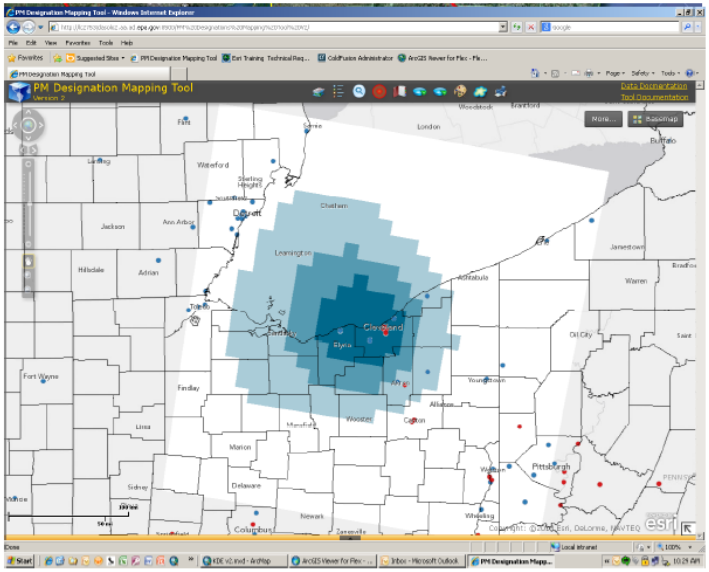
County	Pop Density per sq. mile	Pop. 2010	Percent	Cumulative
Cuyahoga	3,040	1,393,978	41%	41%
Summit	1,315	542,899	16%	56%
Stark	656	378,098	11%	67%
Lorain	578	284,664	8%	76%
Lake	997	227,511	7%	82%
Portage	309	152,061	4%	87%
Medina	358	151,095	4%	91%
Wayne	201	111,564	3%	94%
Ashtabula	146	102,728	3%	97%
Geauga	225	90,895	3%	100%



2010 County-level population

Factor 3: Meteorology: HYSPLIT



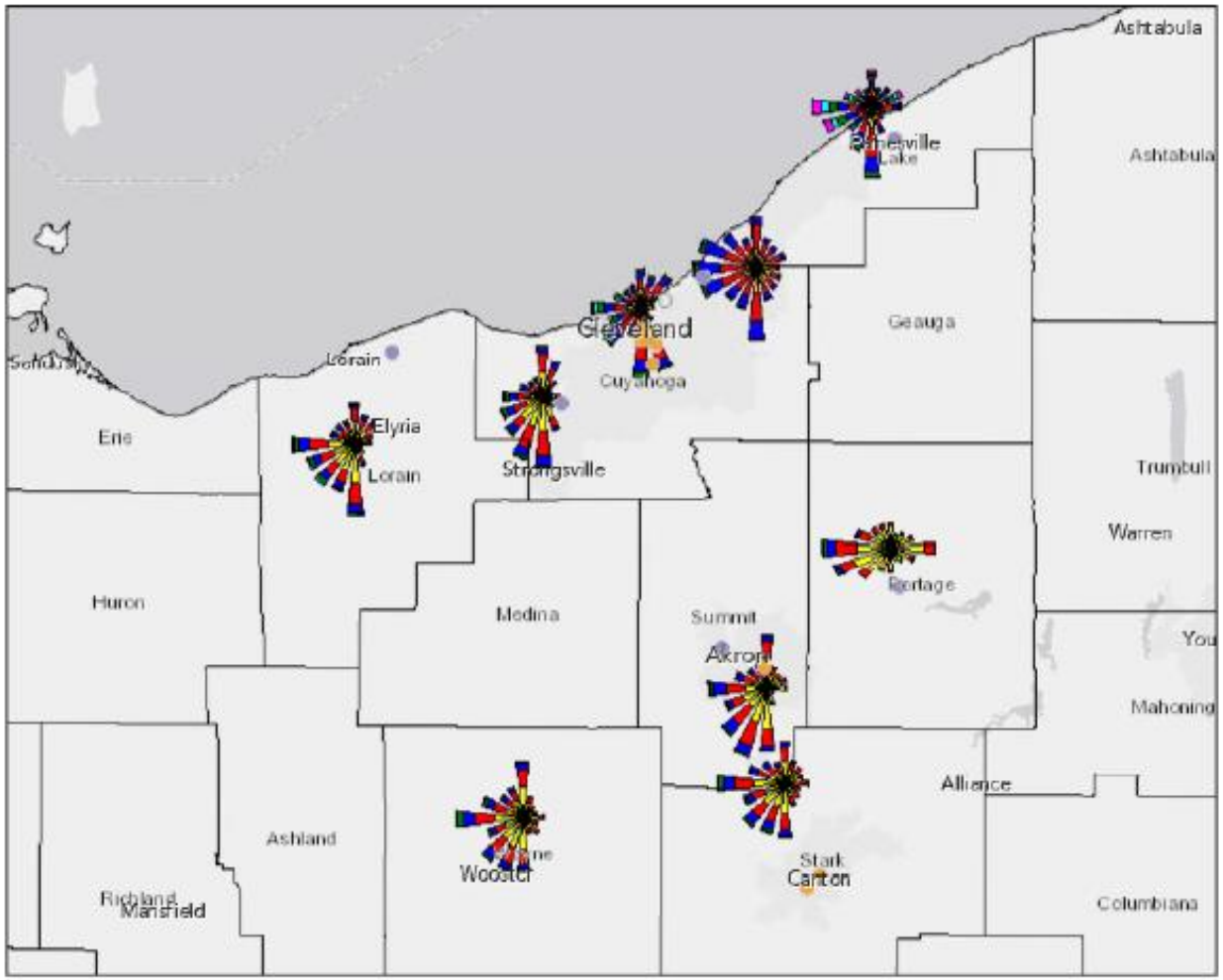


Above: selected trajectories

Right: Kernel Density Estimation shows density of trajectory endpoints at a location (e.g., a grid cell)

Factor 3 - Meteorology: Windroses

Pattern of mostly S-SW winds at 4 to 10 m/s suggesting emission sources in those upwind directions

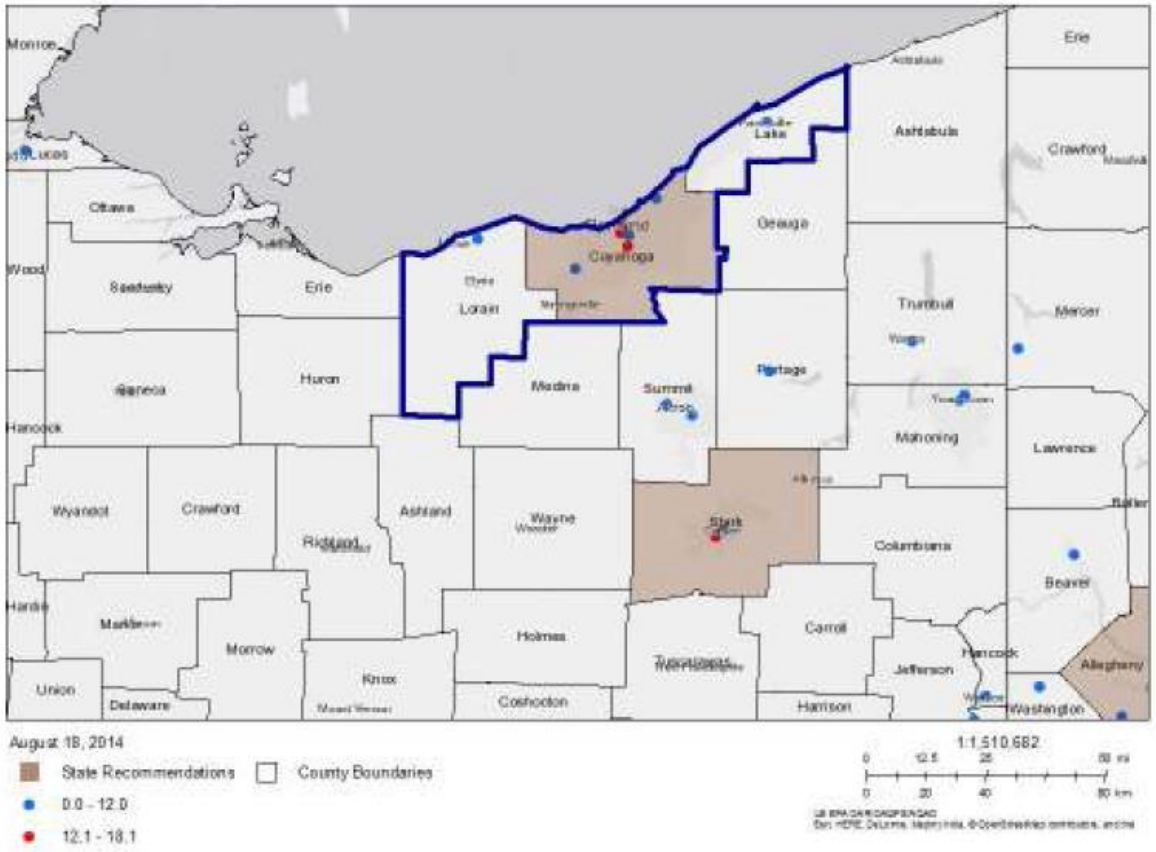


Factor 4: Geography / Topography

- No distinguishable features

Factor 5: Jurisdictional boundaries (legal boundaries)

- County boundaries used



Tacoma, Washington: a case study for the 2006 $PM_{2.5}$ 24-hour NAAQS

Airshed Characteristics

- In December 2007, Washington (the State) recommended that the monitor located at 7802 South L Street in Tacoma, Pierce County, be designated as "nonattainment"
- Design value = 42 $\mu g/m^3$ (2004-2006)
- Elevated $PM_{2.5}$ concentrations in winter during inversions likely due to wood smoke from woodstoves
- Relatively low $PM_{2.5}$ concentrations during the rest of the year

Regional View: Tacoma and Surrounding Counties in Washington State

Approach to defining nonattainment area for violating monitor

Five-Factor Analysis:

1. Air quality data (Design values, seasonal data, composition analysis, rural vs urban contribution)
2. Emissions data (Emissions Inventory, Population density, Commuting patterns)
3. Meteorology (Modeling, Wind Speed and Direction)
4. Geography / Topography (Airshed and watershed features, land features)
5. Jurisdictional boundaries (Legal Boundaries)

Factor 1: Air Quality Data in Seattle / Tacoma region

County	State Recommended Nonattainment?	Design Values 2004-06 ($\mu g/m^3$)	Design Values 2005-07 ($\mu g/m^3$)
Pierce, WA	yes	42	43
King, WA	no	29	31
Snohomish, WA	no	33	35
Thurston, WA	no	N/A	N/A
Island, WA	no	N/A	N/A
Kitsap, WA	no	N/A	N/A
Mason, WA	no	N/A	N/A

Factor 1: Air Quality Data in Seattle / Tacoma region

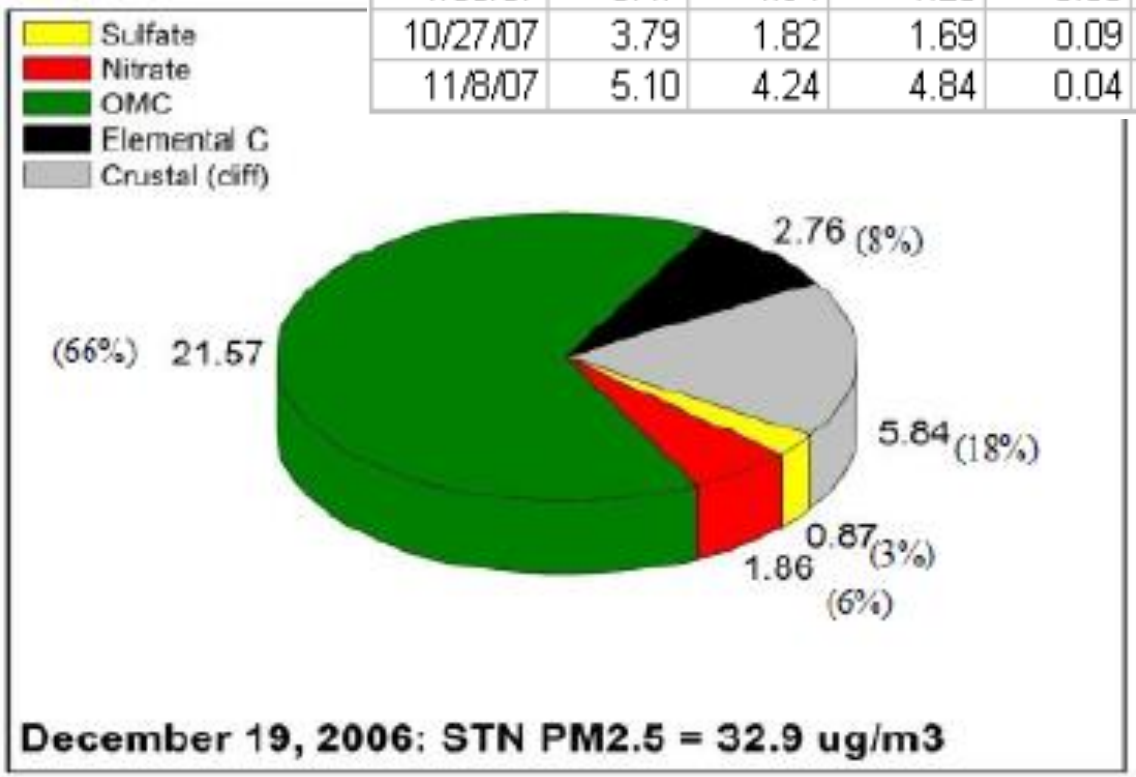
County	CES Score (Rank)	PM2.5 emissions - total (tpy)	PM2.5 emissions - carbon (tpy)	PM2.5 emissions - other (tpy)	SO2 emissions (tpy)	NOx emissions (tpy)	VOC emissions (tpy)	NH3 emissions (tpy)
King, WA	100 (1)	6,362	4,168	2,194	7,361	75,825	89,446	2,564
Pierce	60 (2)	3,766	2,255	1,511	3,200	31,905	32,097	1,410
Thurston	17 (3)	2,221	1,348	873	478	8,389	14,985	1,620
Kitsap	14 (4)	2,204	1,201	1,004	442	6,199	9,588	274
Snohomish	13 (5)	3,714	2,223	1,492	2,256	22,687	28,861	1,932
Skagit	11	1,605	819	786	10,345	12,417	11,173	1,809
Island	4	841	453	388	485	4,463	4,128	358
Mason	3	767	439	328	100	1,623	3,846	90

Factor 1: Elevated Winter Time Air Quality Data in Tacoma

Top 5% PM2.5 Values at L Street FRM for 2004-2007								
Rank	Date	ug/m3	Date	ug/m3	Date	ug/m3	Date	ug/m3
1	11/4/2004	57.00	12/15/2005	45.50	12/16/2006	68.00	1/15/2007	58.60
2	11.20/2004	51.30	12/6/2005	43.50	12/31/2006	50.20	2/2/2007	46.70
3	1/7/2004	43.70	11/15/2005	40.50	12/28/2006	42.70	11/23/2007	45.20
4	11/13/2004	39.50	2/9/2005	40.30	2/19/2006	33.70	1/12/2007	44.70
5	1/13/2004	33.50	1/23/2005	39.00	12/19/2006	32.60	1/30/2007	38.20
6	12/23/2006	31.90	12/9/2005	38.70	11/1/2006	32.30	10/27/2007	31.70
7			2/21/2005	38.70				

Factor 2: Tacoma emission composition

Date	Nitrate	Soil	Sulfate	Marine	Mobile	Smoke	% Smoke
11/1/06	1.46	4.76	0.70	0.04	5.39	23.14	65
12/19/06	2.87	1.50	0.00	0.08	2.64	22.77	76
12/31/06	0.71	1.04	2.11	0.03	0.71	43.73	90
1/12/07	5.97	0.00	0.00	0.11	2.23	28.80	78
1/30/07	5.47	4.94	1.20	0.05	3.47	26.75	64
10/27/07	3.79	1.82	1.69	0.09	4.27	18.05	61
11/8/07	5.10	4.24	4.84	0.04	5.77	9.93	33

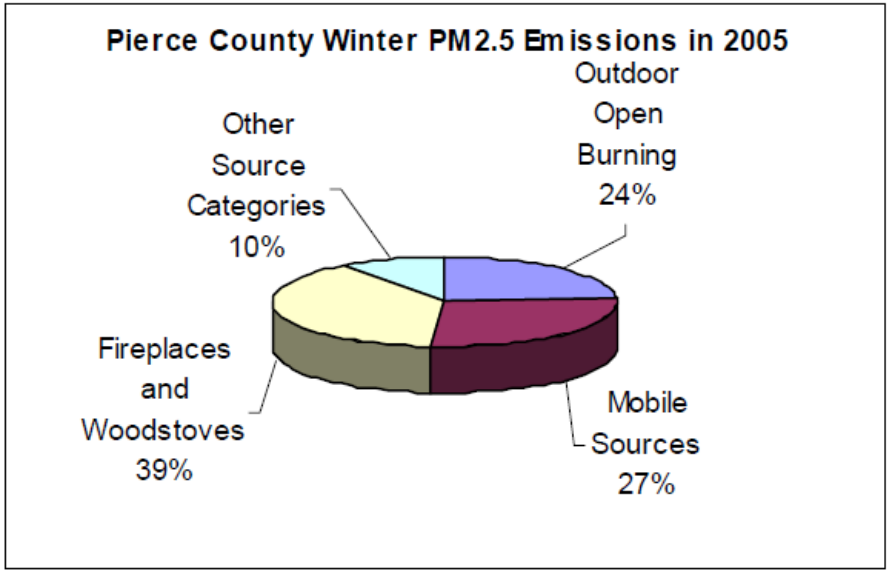


Positive Matrix Factorization

- and –

Speciation

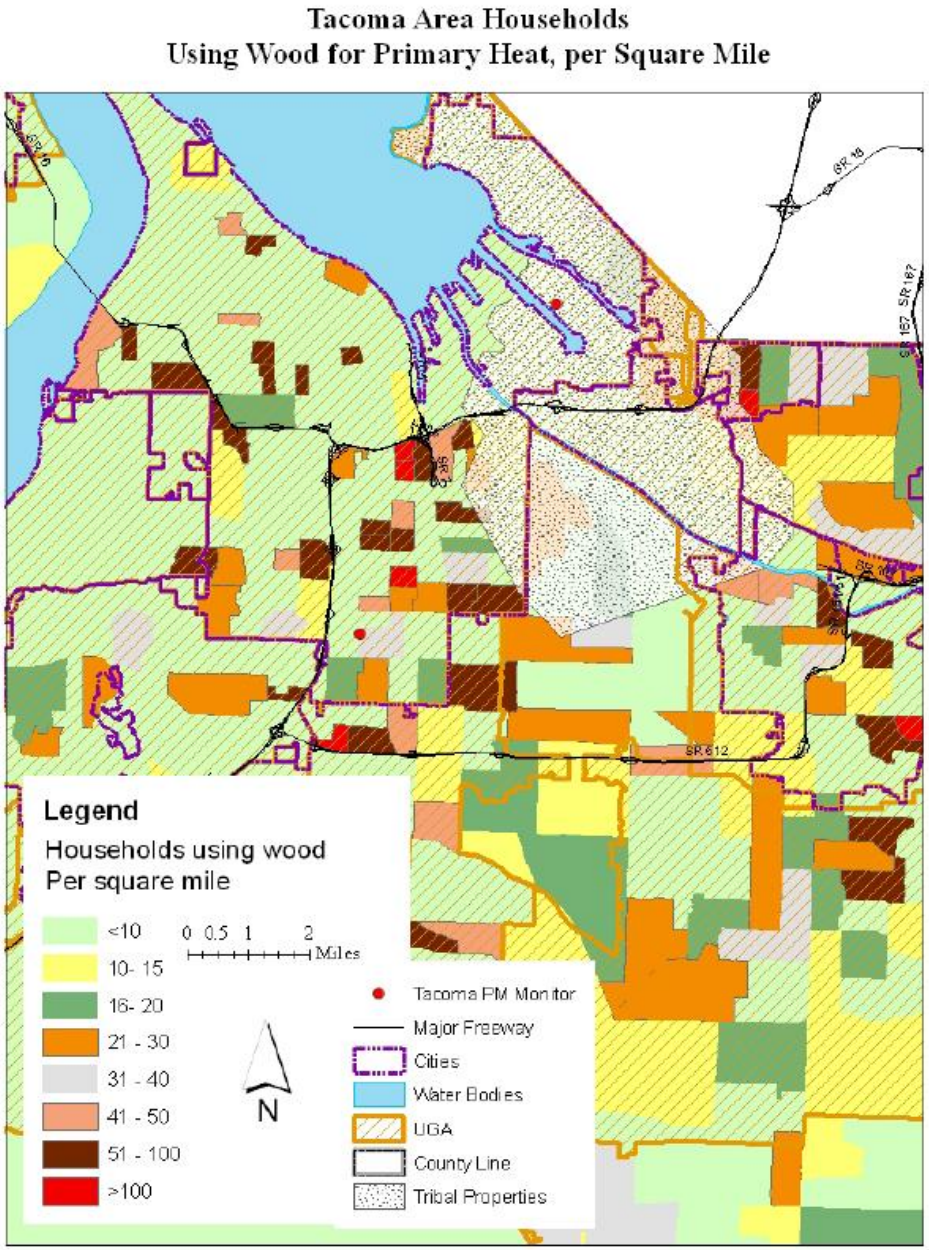
Factor 2: Emissions data – Wood Smoke



PM2.5 Emission Source Categories and Subcategories	2005 Subcategory PM2.5 Emissions				
	tpy	tons/season			
	Annual	Summer	Fall	Winter	Spring
Outdoor Open Burning					
Land clearing burning	941	282	282	151	226
Yard waste burning	185	56	56	30	44
Forest wildfires and managed burns	117	35	35	19	28
Structural fires	11	3	3	3	3
Agricultural waste burning	4	1	1	1	1
Mobile Sources					
On-road gasoline vehicles	296	77	74	71	74
Non-road diesel engines	280	78	67	62	73
On-road diesel vehicles	201	52	50	48	50
Non-road gasoline engines	80	22	19	18	21
Ocean-going vessels	54	14	14	14	14
Harbor vessels	35	9	9	9	9
Railroad diesel engines	27	7	7	7	7
On-road CNG and LPG engines	4	1	1	1	1
Aircraft ground support engines	3	1	1	1	1
Aircraft	2	1	1	1	1
Non-road LPG engines	2	1	1	1	1
Recreational boats	52	22	17	0	13
Fireplaces and Woodstoves					
Wood stove wood burning	430	22	60	206	142
Fireplace wood burning	165	8	23	79	54
Fireplace and wood stove firelog burning	78	4	11	37	26
Pellet stove wood burning	6	0	1	3	2
Other Source Categories					
Industrial point sources	181	45	45	45	45
Natural gas burning	67	3	9	32	22
Boiler and furnace distillate oil burning	11	1	2	5	4
Propane furnaces and boilers	2	0	0	1	1
Totals	**3,234**	**744**	**787**	**842**	**860**

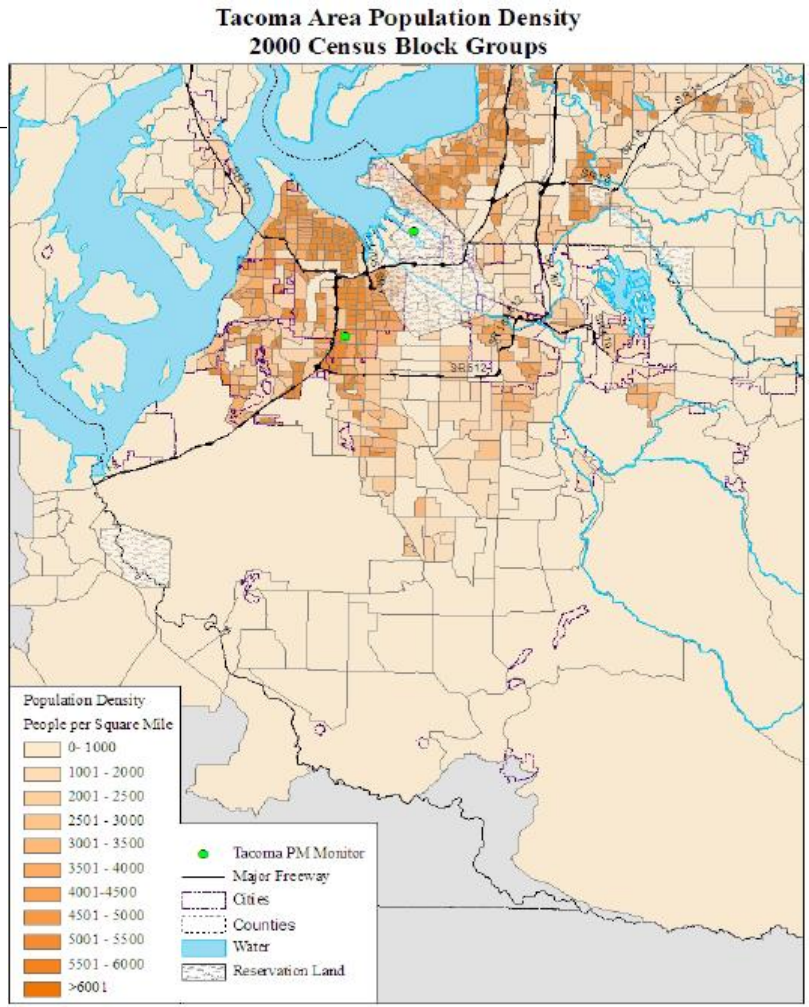
Factor 2:

Emissions Map – Wood Smoke usage in Tacoma

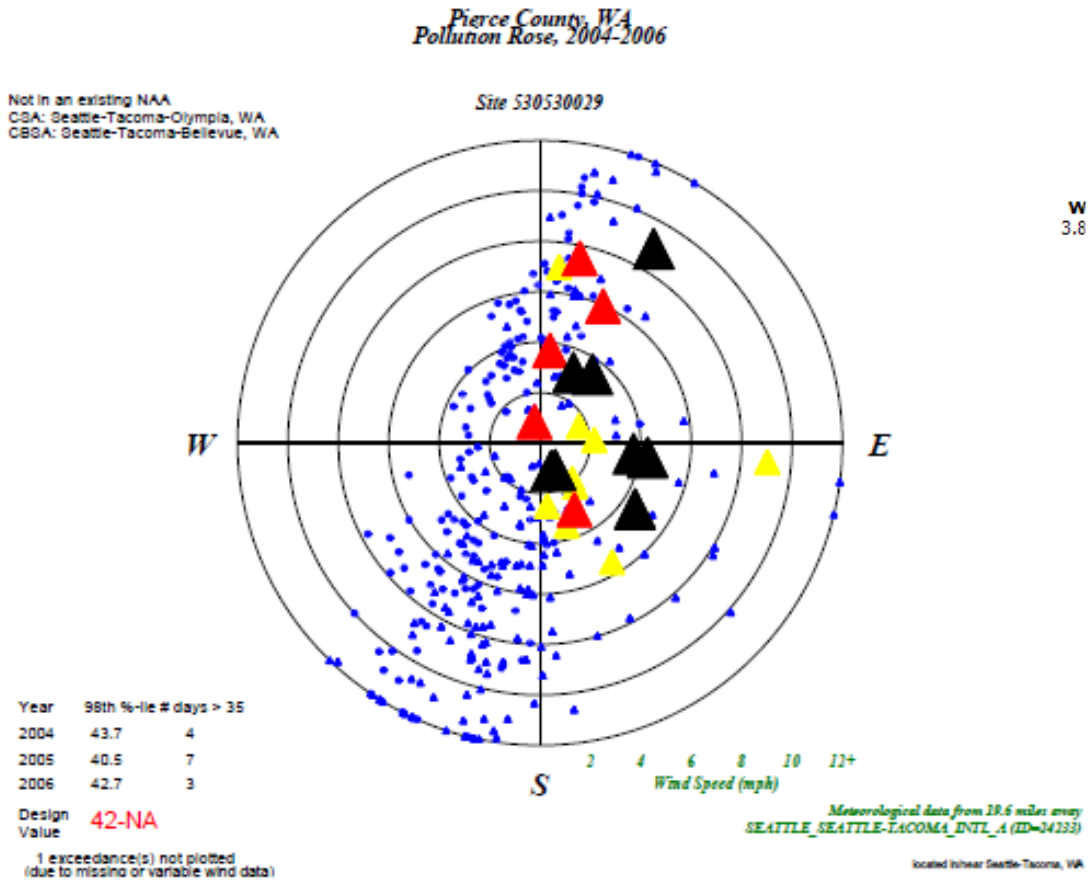


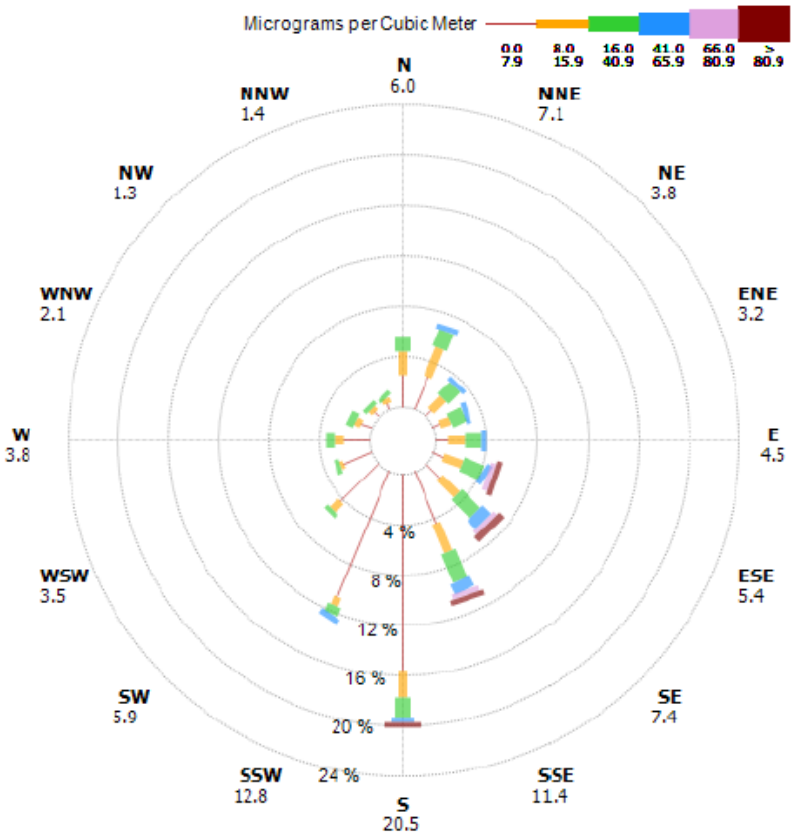
Factor 2: Emissions: population and commuting

Daily Category of Travel	2000 Reference Data	2040	Units
Work Person Trips	293,886	535,330	Trips
Non-work Person Trips	1,757,784	3,183,447	Trips
Freeways Vehicle Miles Traveled	6,288,090	8,870,622	VMT
Arterials/Local Streets VMT	10,650,108	16,299,840	VMT
Freeways Vehicle Hours Traveled	129,929	191,106	VHT
Arterials/Local Streets VHT	363,175	617,769	VHT



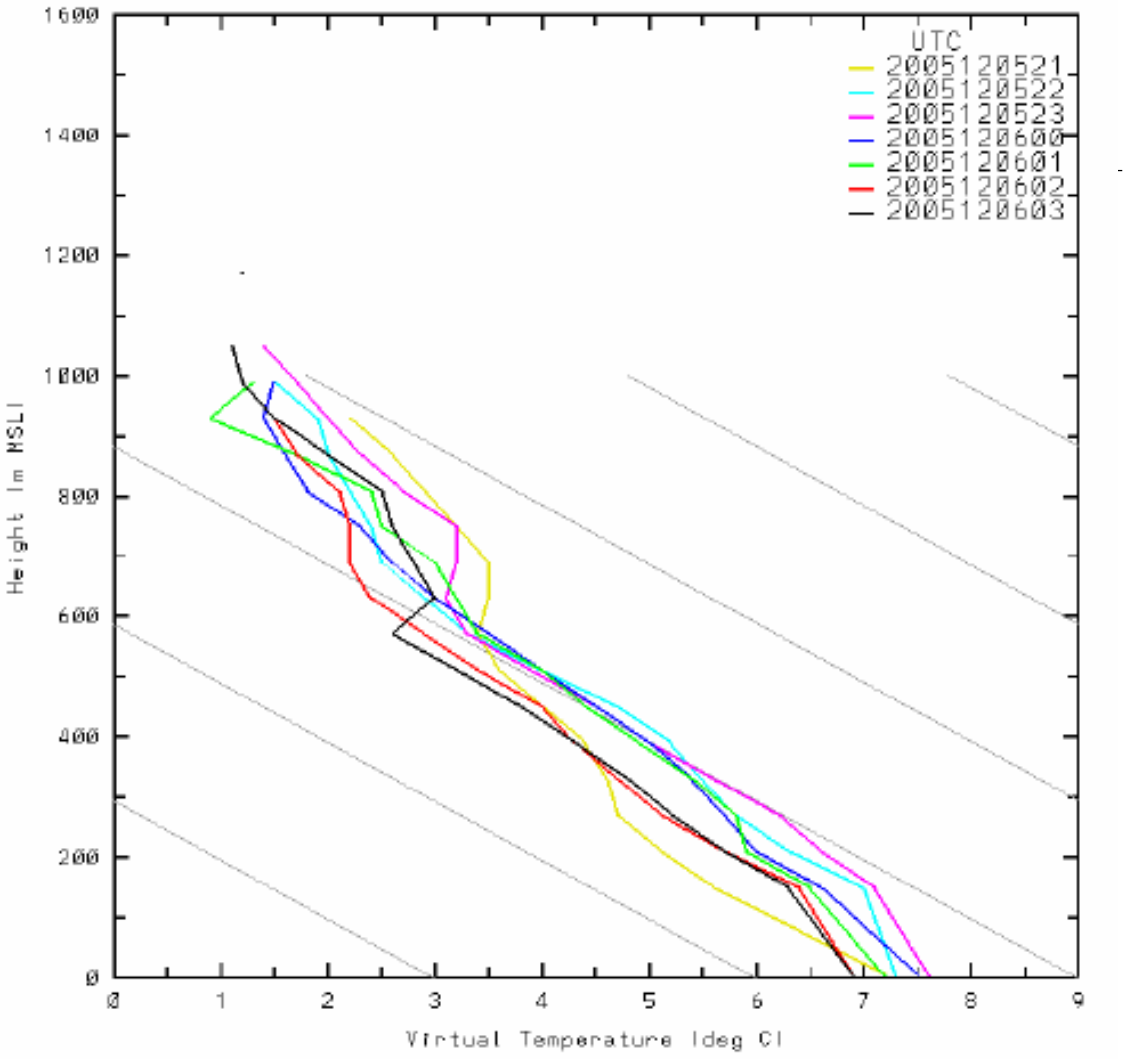
Factor 3: Meteorology, Pollution Roses





Factor 3:

Meteorology - Inversion Profile

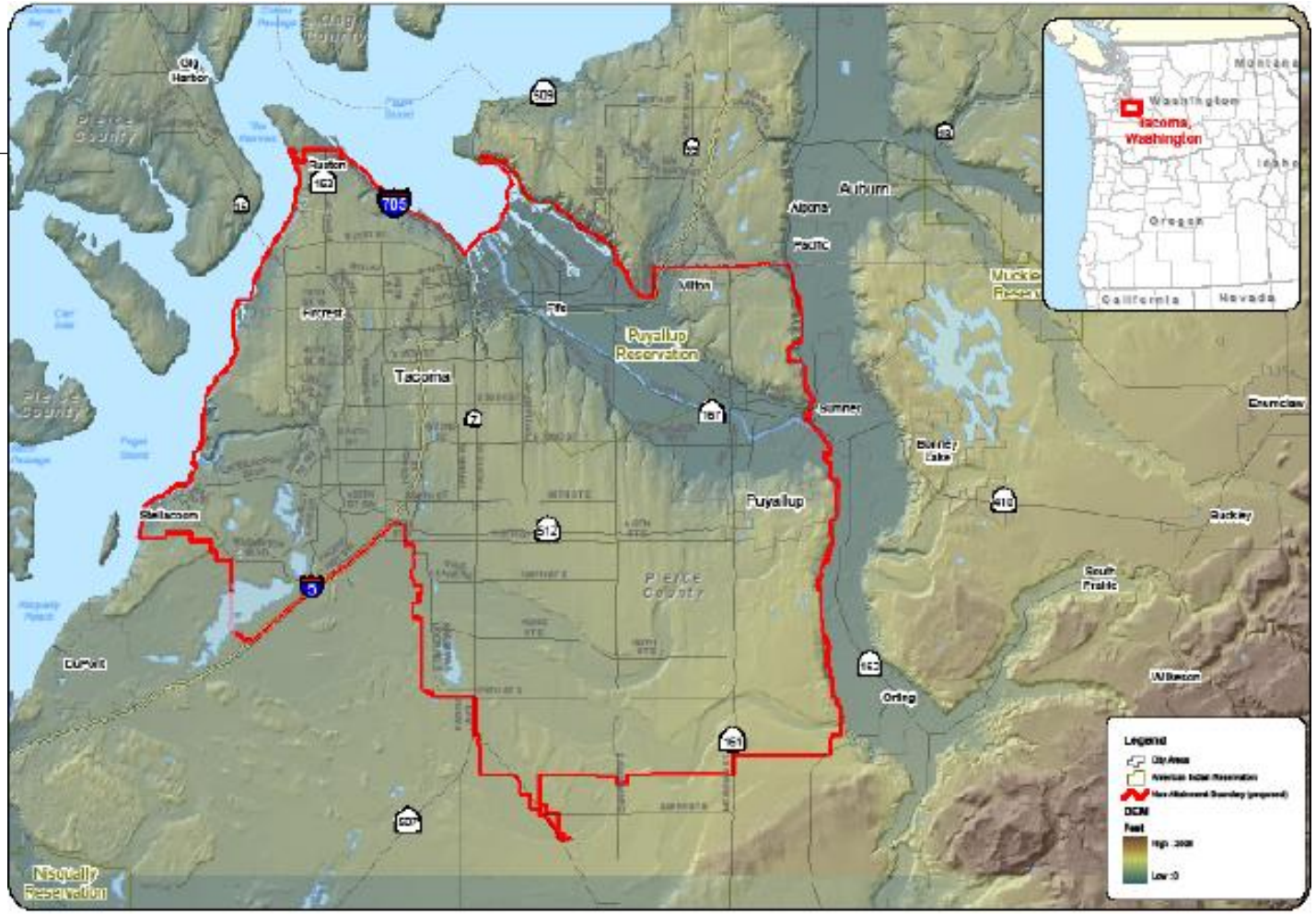


Factor 4:

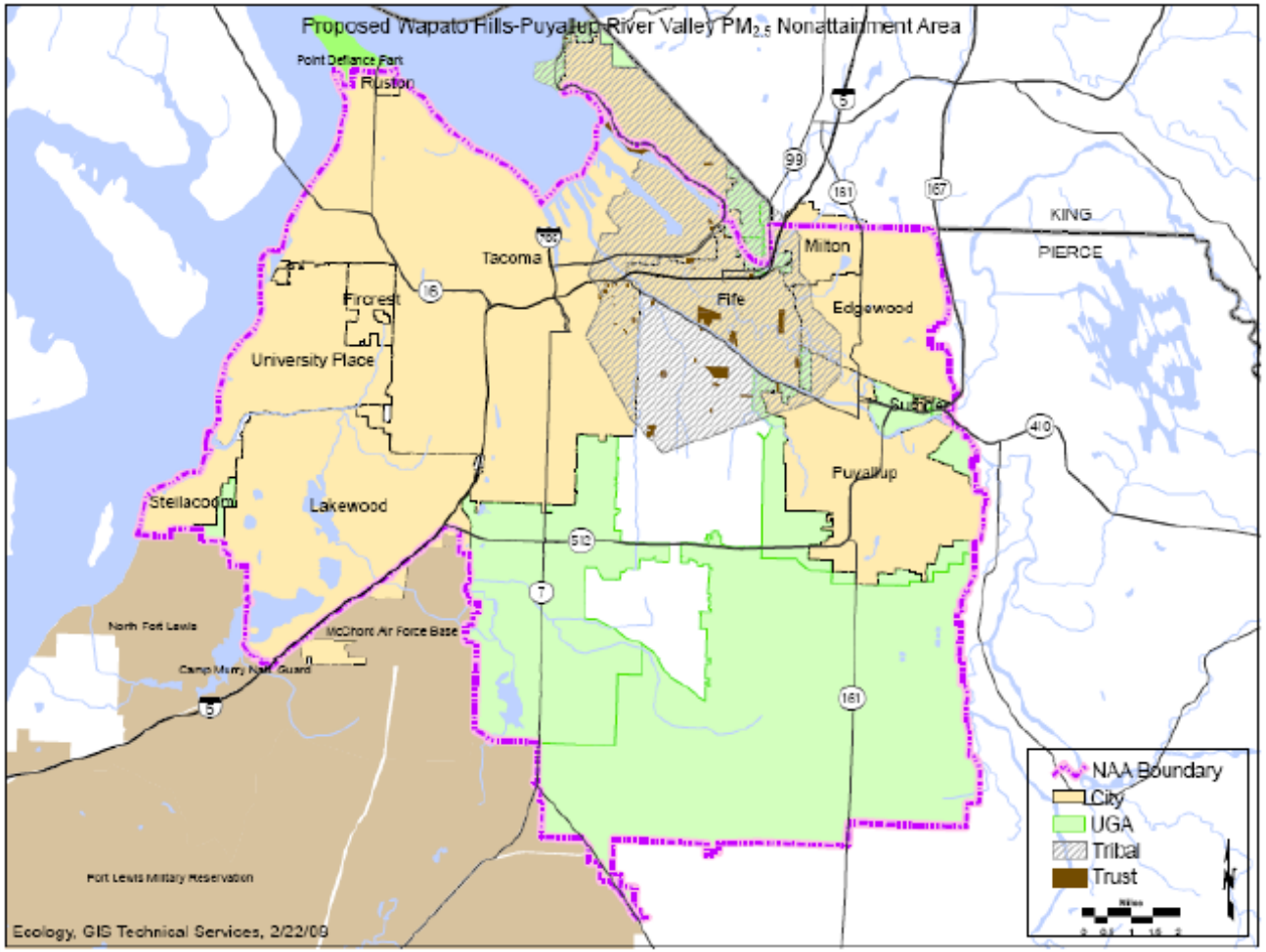
Area Topography

Factor 4:

Topography



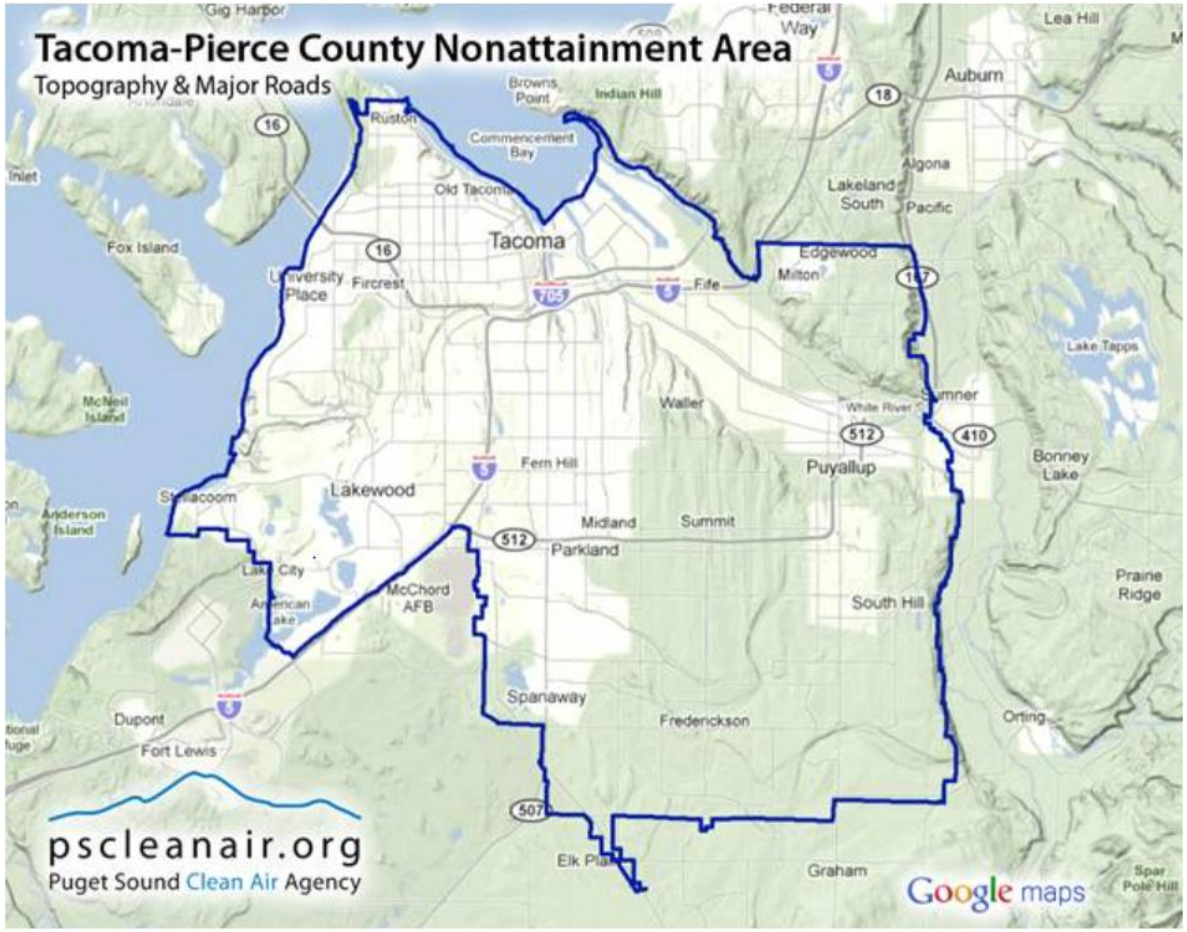
Factor 5: Jurisdictional boundaries



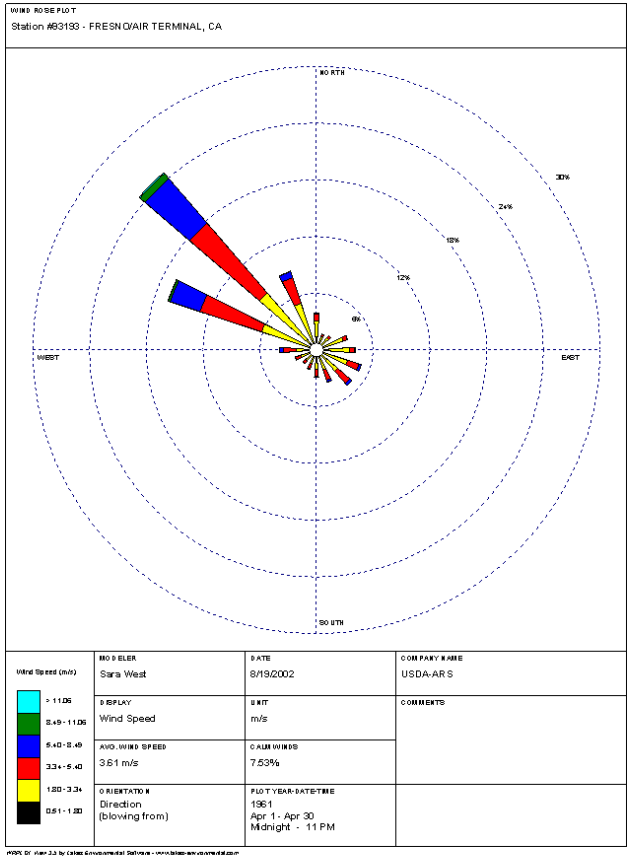
Tacoma: Conclusions of 5-Factor Analysis

- Air Quality Data, Emissions Data, and meteorology – indicative of woodstoves
- Pollutant Transport – no evidence
- Speciation – predominantly carbonaceous organic matter (OMC)
- Tacoma L Street Monitor – indicative of woodstoves and local emissions
- Nonattainment the result of local woodstove emissions
    - Elevated concentrations are a local phenomenon
    - Local, not regional issue

Tacoma 2006 24-hour $PM_{2.5}$ Nonattainment Area



https://www3.epa.gov/pmdesignations/2006standards/rec/letters/10_WA_EPAMOD.pdf



Demo - Producing Windroses

- US Department of Agriculture, Natural Resources Conservation Service

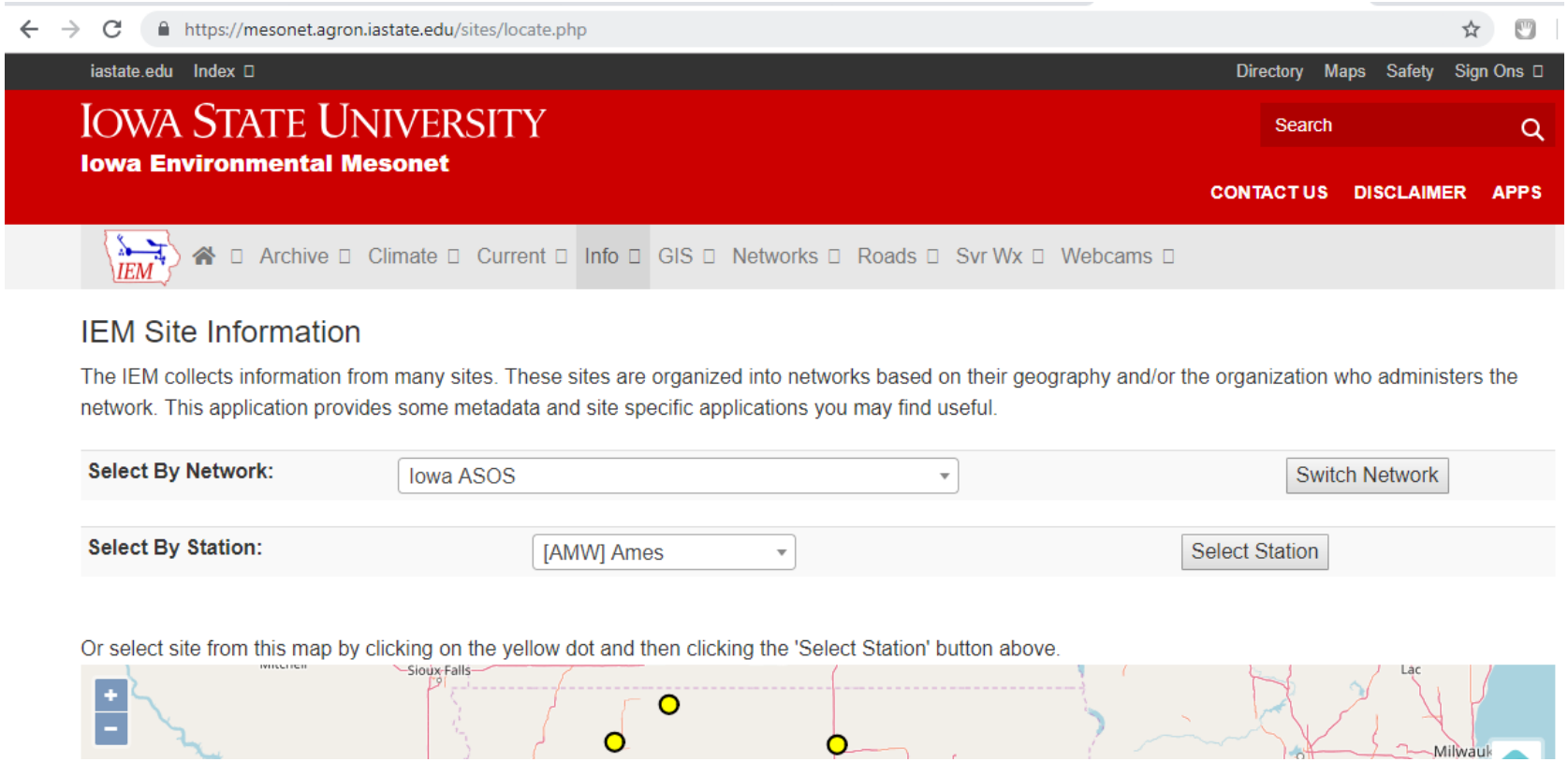
https://www.wcc.nrcs.usda.gov/climate/

https://www.wcc.nrcs.usda.gov/climate/windrose_ex.html

- WRPLOT View™ Freeware

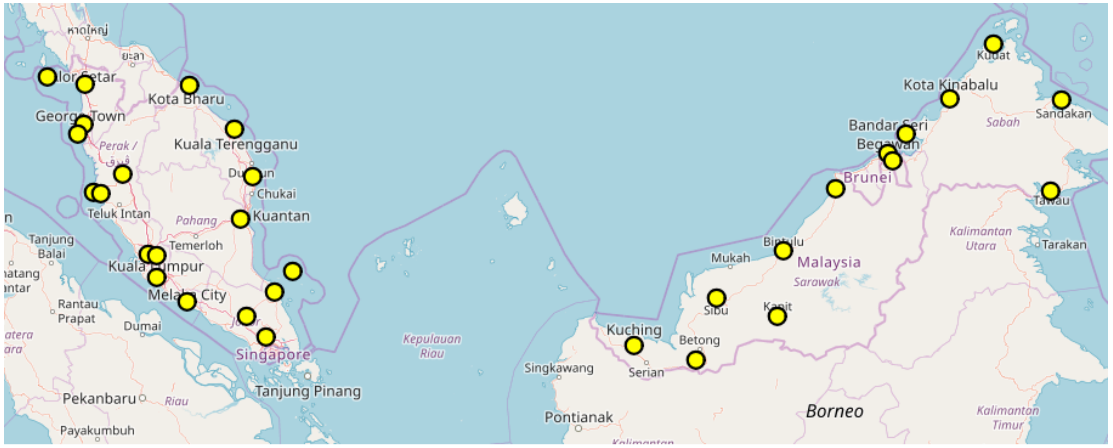
https://www.weblakes.com/products/wrplot/index.html

Worldwide Windroses

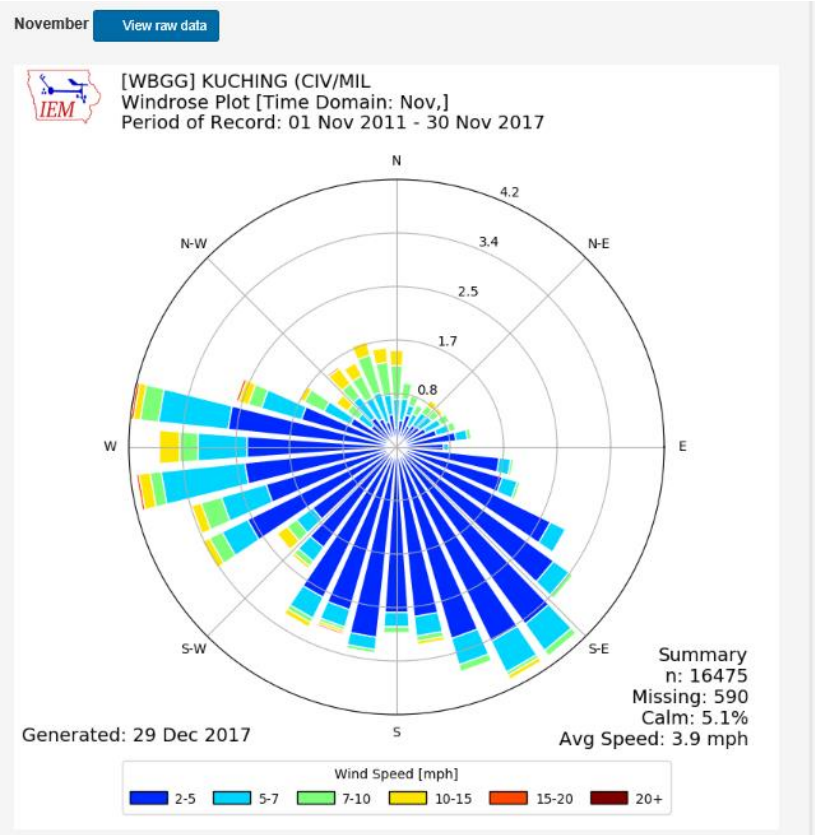


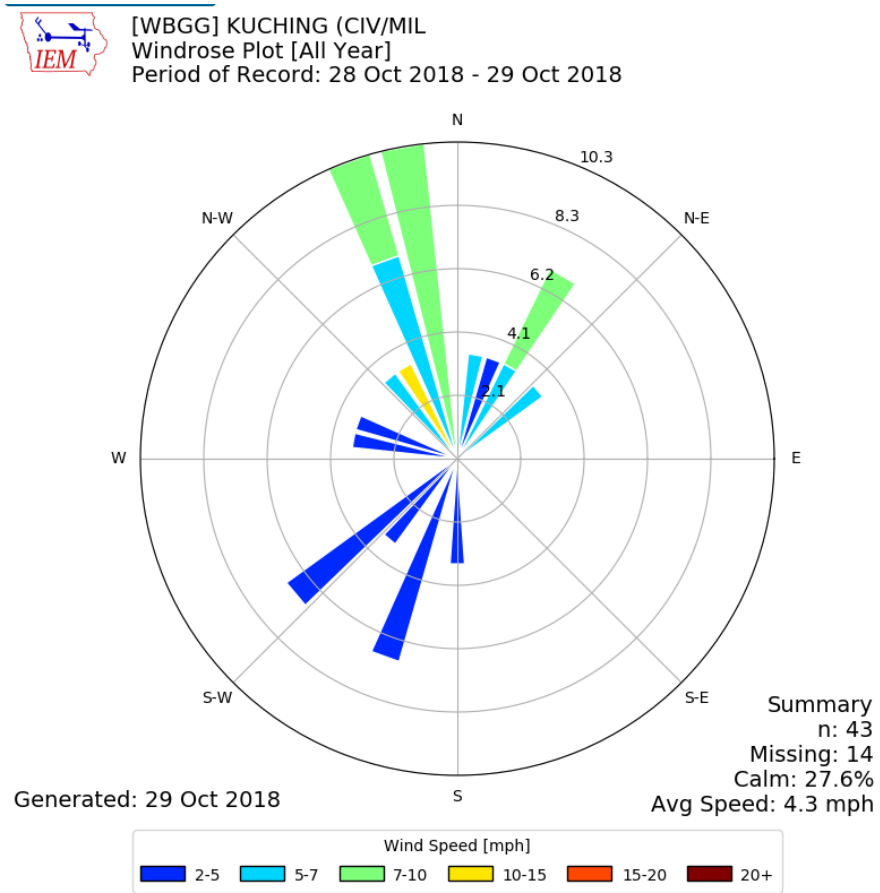
https:// https://mesonet.agron.iastate.edu/current/
mesonet.agron.iastate.edu/sites/windrose.phtml?station=WBGB&network=MY__ASOS

Example Windroses for Kuching, Malaysia



Click on desired location for map of weather station and option to produce packaged or customized windroses





Packaged windrose: Nov 2011-2017

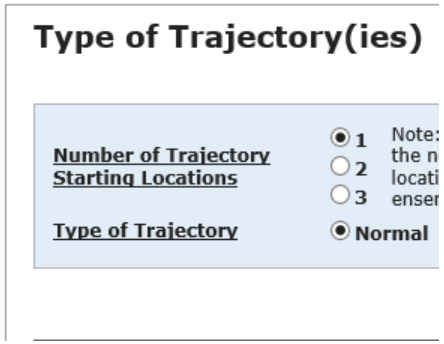
Customized windrose: Oct 28-29, 2018

Demo – HYSPLIT Trajectories

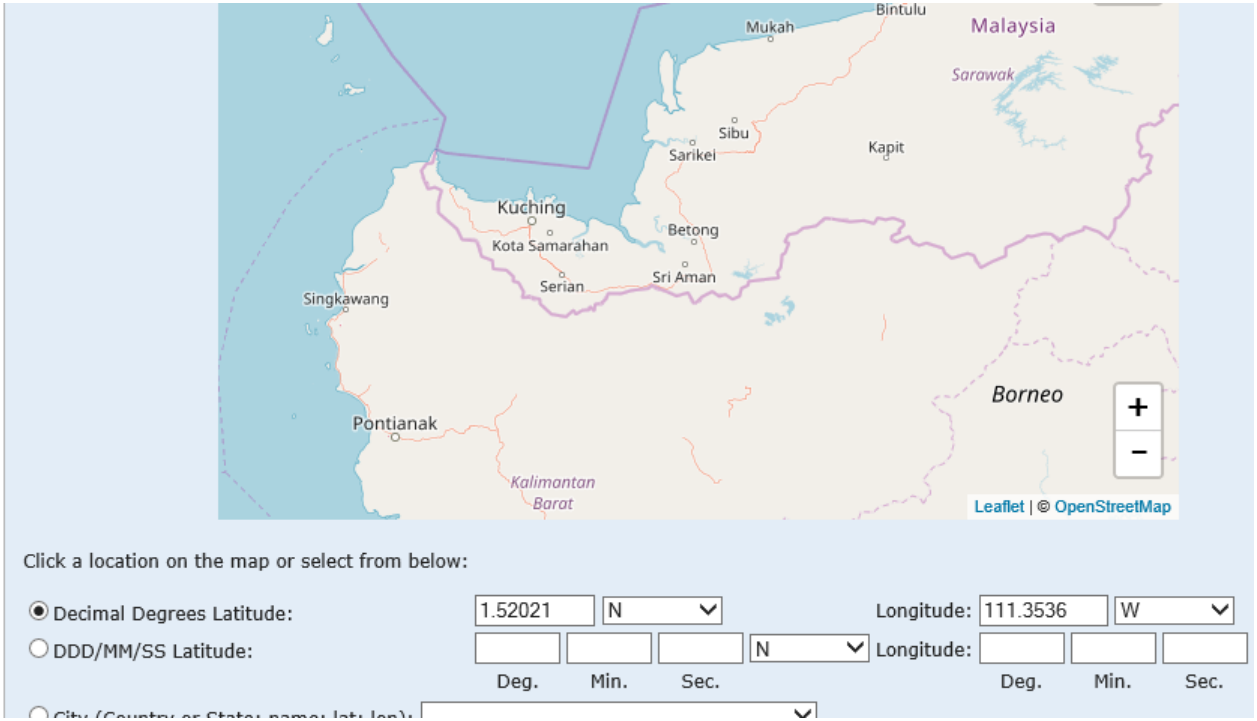
- Purpose: Helps to identify sources contributing to air quality issues
- NOAA's HYSPLIT model can be used worldwide - http://ready.arl.noaa.gov/HYSPLIT_traj.php
- Training Module http://mce2.org/wmogurme/images/workshops/ASEAN/day1/saide/Act_HYSPLIT_English_v2.pdf

HYSPLIT – Trajectories, Kuching Demo

Step 1 – Select Trajectories

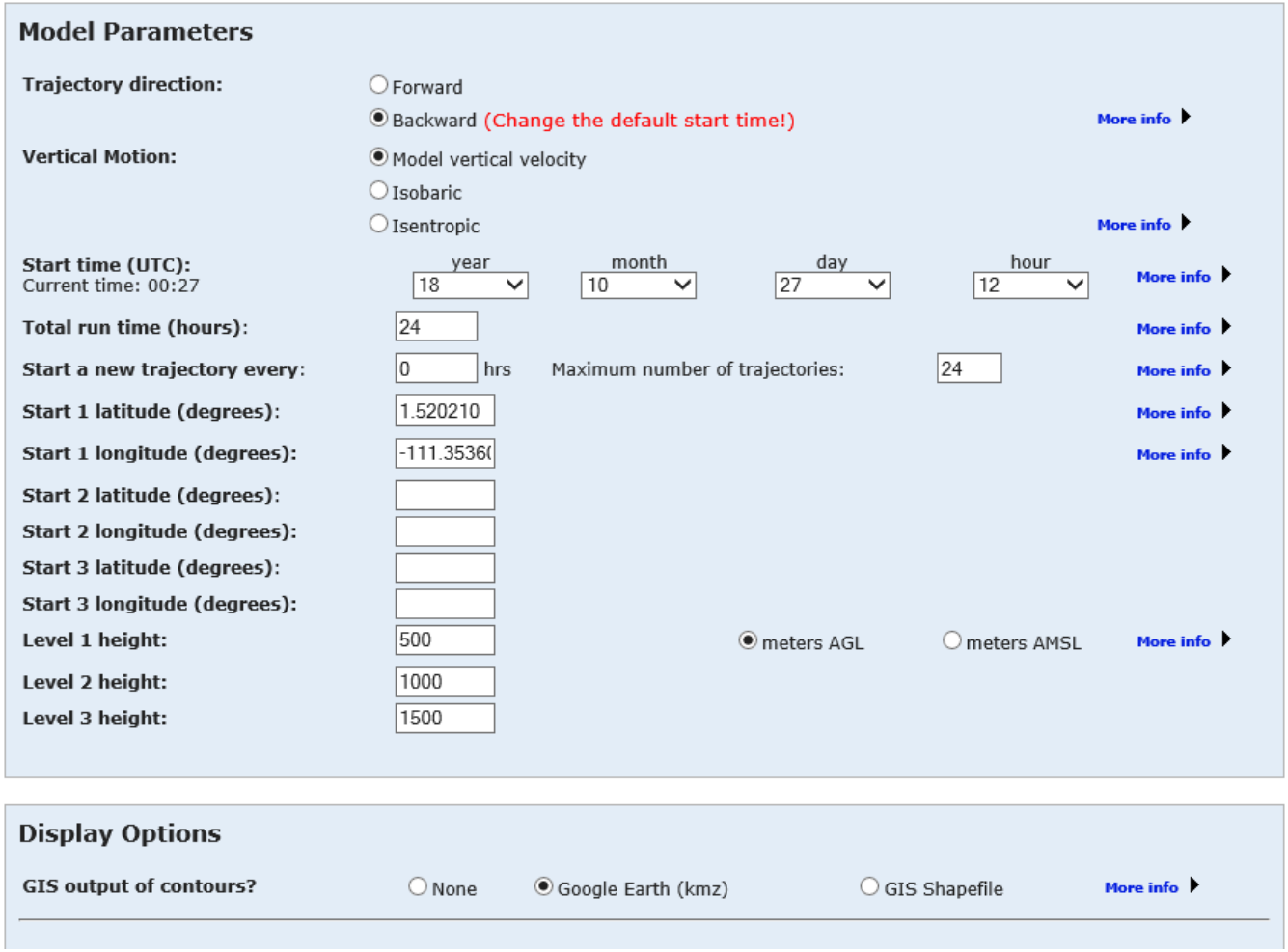


Step 2 – Select Location

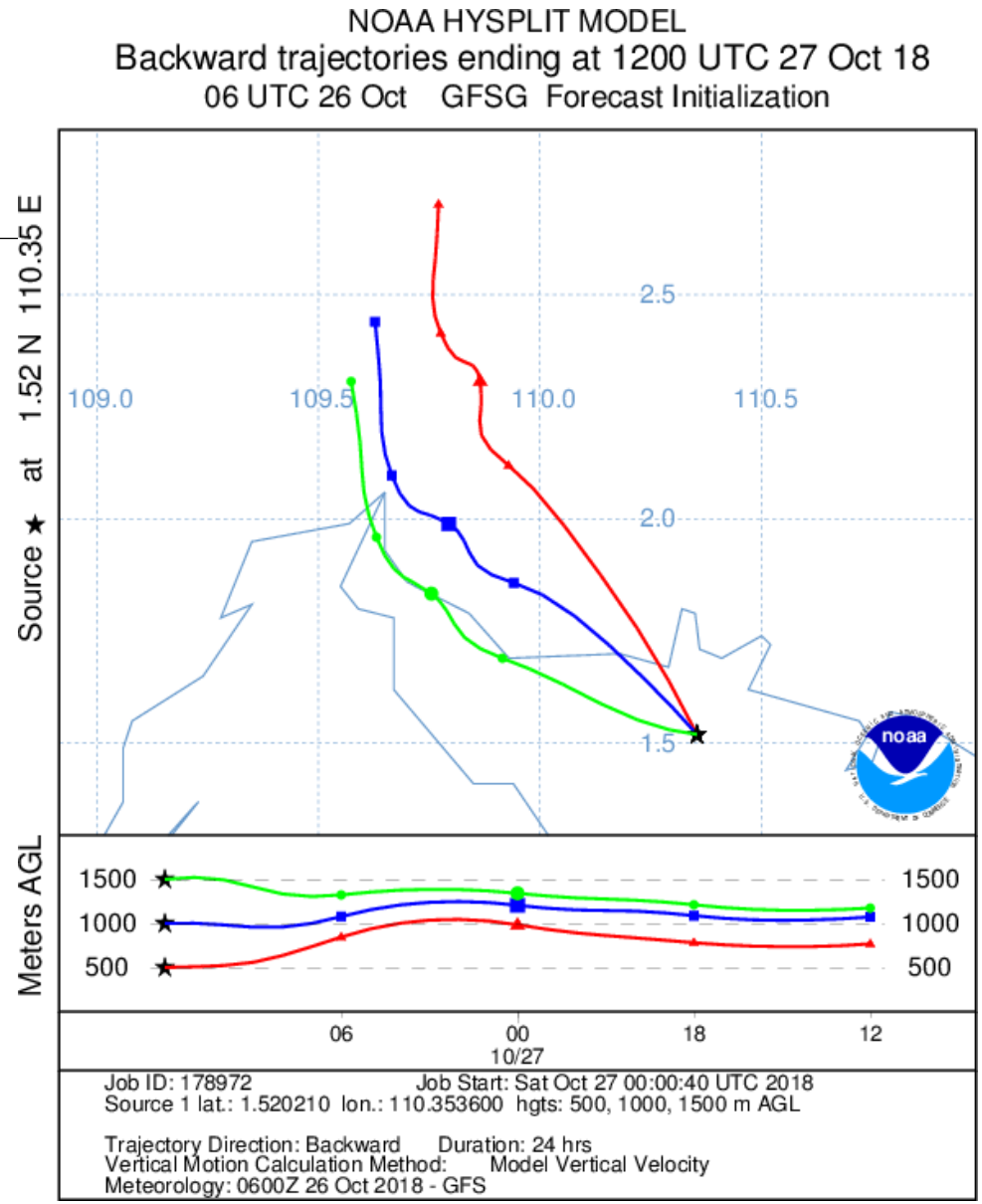


HYSPLIT – Trajectories, Kuching Demo

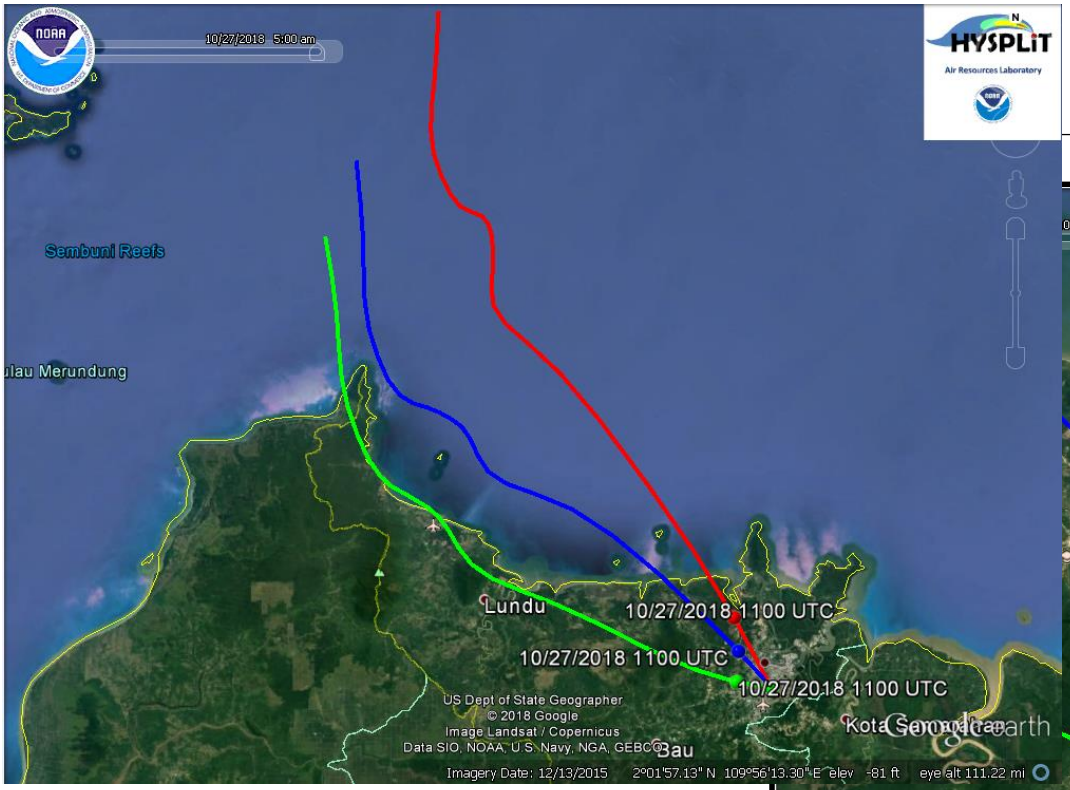
Step 3 – Select Parameters



Kuching HYSPLIT Forecast – 27 October 2018



Kuching HYSPLIT Forecast – 27 October 2018



A Word on Monitoring Networks

- Monitoring data is key to assessing air quality
- Monitoring sites provide information on:
  - Background air pollution levels
  - Typical levels in populated areas
  - Peak levels
  - Air pollution transported into/out of a city or region
  - Air pollution levels near specific emissions sources
- Spatial scales: Microscale, Middle scale, Neighborhood, urban, regional, national, and global

Monitoring using Air Sensors

- Air sensors (portable monitors) can be used to screen for local air quality
- BUT sensor technology is still under development
- EPA is evaluating sensors by placing them near regulatory monitors. See Sensor Evaluation Tables
  - https://www.epa.gov/air-sensor-toolbox/evaluation-emerging-air-pollution-sensor-performance
  - Just released: https://www.epa.gov/air-research/peer-review-and-supporting-literature-review-air-sensor-technology-performance-targets
- Main problems:
  - Humidity - uptake of water by particles can give erroneously high readings
  - Variability in sensor manufacturing process
- Selected sensor needs to be tested in studies that co-locate sensor with a reference monitor

Identifying Control Strategies ($PM_{2.5}$ focus)

Mobile (on-road) sources

- Cleaner motorcycles
- Cleaner cars and fuels; inspections
- Cleaner public bus/truck fleets (engine retrofits/filters, cleaner fuels)
- Traffic controls (anti-idling, signal timing, traffic flow, street design, shared transit)
- Pedestrian (car-free) zones
- Alternative/shared transit (bike-sharing, cleaner vehicles, rideshare, telework)
- Unpaved roads/parking lots (fugitive-dust control, speed limits, paving)

Mobile (non-road) sources

- Gasoline/diesel vehicles (retrofits, cleaner fuels, anti-idling, etc.)
- Port emissions
- Recreational marine vessels
- Commercial marine vessels
- Locomotives (reduced idling, cleaner fuels)
- Aircraft ground support (reduced idling, cleaner fuels, e-vehicles)

Identifying Control Strategies (cont.)

Area (dispersed) sources

- Open burning of trash, forests, crop residues - see handout
- Cooking with wood, coal, or dung (cleaner cook stoves & fuels, venting)
  - Residential
  - Commercial & street vending
- Diesel generator sets at hotels, hospitals, markets, etc. (switch to natural gas engines, use low-S diesel)
- Brick kilns
- Industrial and commercial
  - Energy efficiency
  - Process/fuel changes
  - Green building design
- Fugitive dust: reduce dust from trucks, construction sites
- Temples: alternatives to incense/paper burning

Identifying Control Strategies (cont.)

Large stationary (point) sources

- Power plants (set renewable energy targets, use more combined heat & power (CHP), use more gas, improve coal-plant efficiency)
- Industrial and commercial
  - Control fugitive dust
  - Improve energy efficiency, use more CHP
  - Back-up power (alternative fuels and sources)
- Municipal
  - Energy efficiency

Other strategies

- Reducing urban heat-island effect (tree planting, cool pavements, green roofs)
- Incentives/awards programs (energy-efficiency rebates, stove-changeout vouchers/rebates, clean-air awards)

US EPA Contacts

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THANK YOU!!!

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- **Clean Air = Healthy People and Environment**

- EPA supports regional air quality programs.

  – and –

  Welcomes new opportunities to improve air quality.

IEP's South/Southeast Asia – Air Improvements in the Region (SSEA-AIR)

- 2019 Air Quality Workshop
- 2019 Webinar Series on Airshed Planning
- Ongoing technical support and Web Platform

- **To learn more: attend our BAQ sessions during BAQ and stop by our booth!**