Techniques Utilizing Ambient PM2.5 Air Quality Data to Aid in the 24 hour Designation Process

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AQAG/AQAD/OAQPS

EPA State / Local / Tribal Training Workshop:
PM 2.5 Final Rule Implementation and 2006
PM 2.5 Designation Process

June20-21

What are the techniques?

- SLICE
  - Stratify and quantify daily PM2.5 concentrations into regional and urban contributions
  - Estimate the immediate increment by site
- Residence Time Weighted Emissions
  - Use of wind trajectories to weight county level emissions
  - Highlights counties whose emissions are upwind of high sites on high days
- Urban Gradient
  - Neighboring site gradient estimator
  - Helps to identify sites with a potential local source influence on a daily basis

About the techniques

- Techniques provide important information in regard to the magnitude of area and local influences on PM2.5
- None are meant to be prescriptive but are available to aid in providing a better indication of influencing areas and sources
- All are evolving by varying degrees

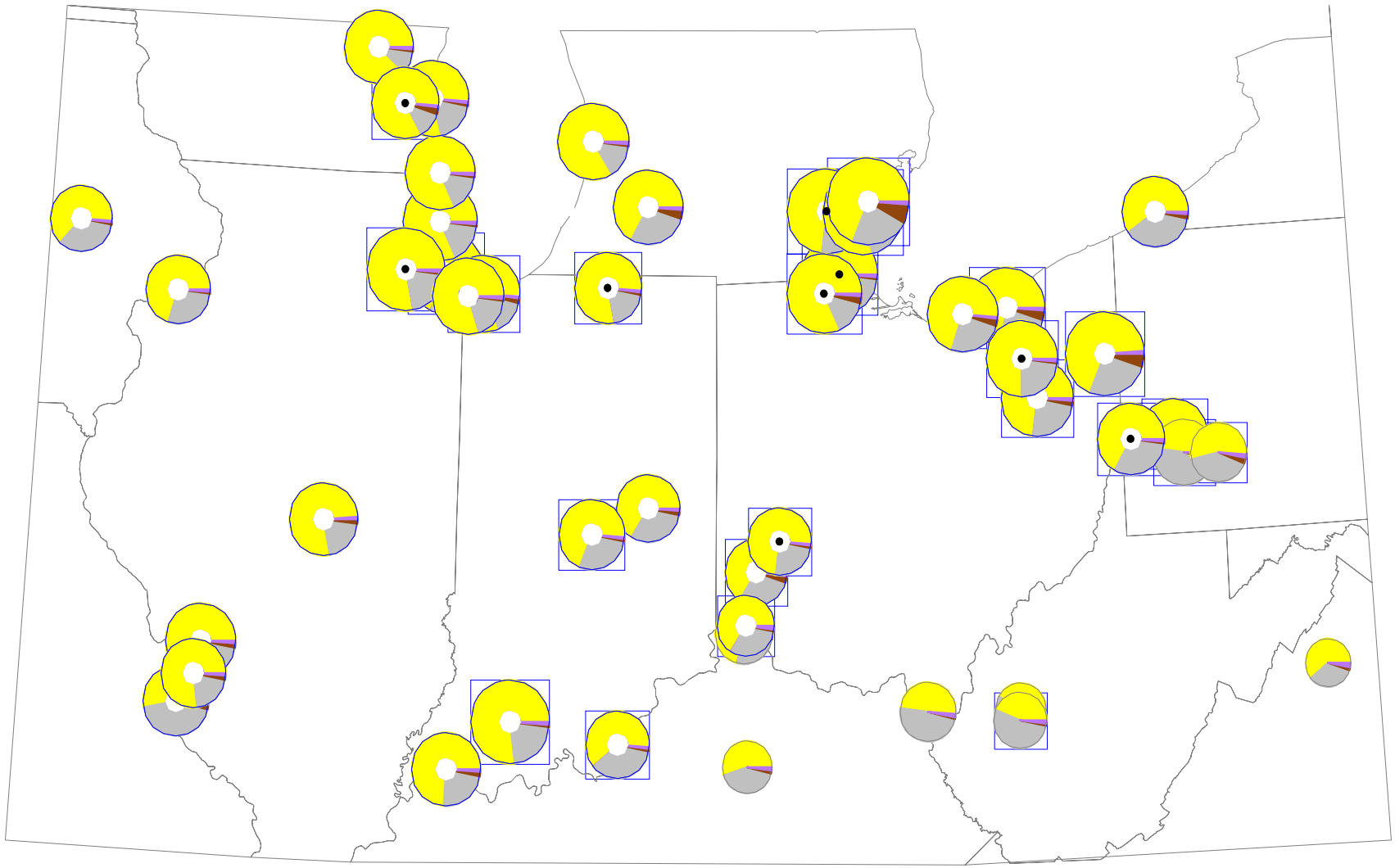
1st Technique: SLICE

(Spatially Layered Interpolated Component Estimator)

- Technique clusters ambient monitoring data into “natural” classifications allowing for increments above background to be calculated
- Indicator of possible urban emissions affecting ambient concentrations
- Technique is utilized on daily basis

FRM PM2.5 speciation - 06/27/2005

Large Regional Sulfate Event



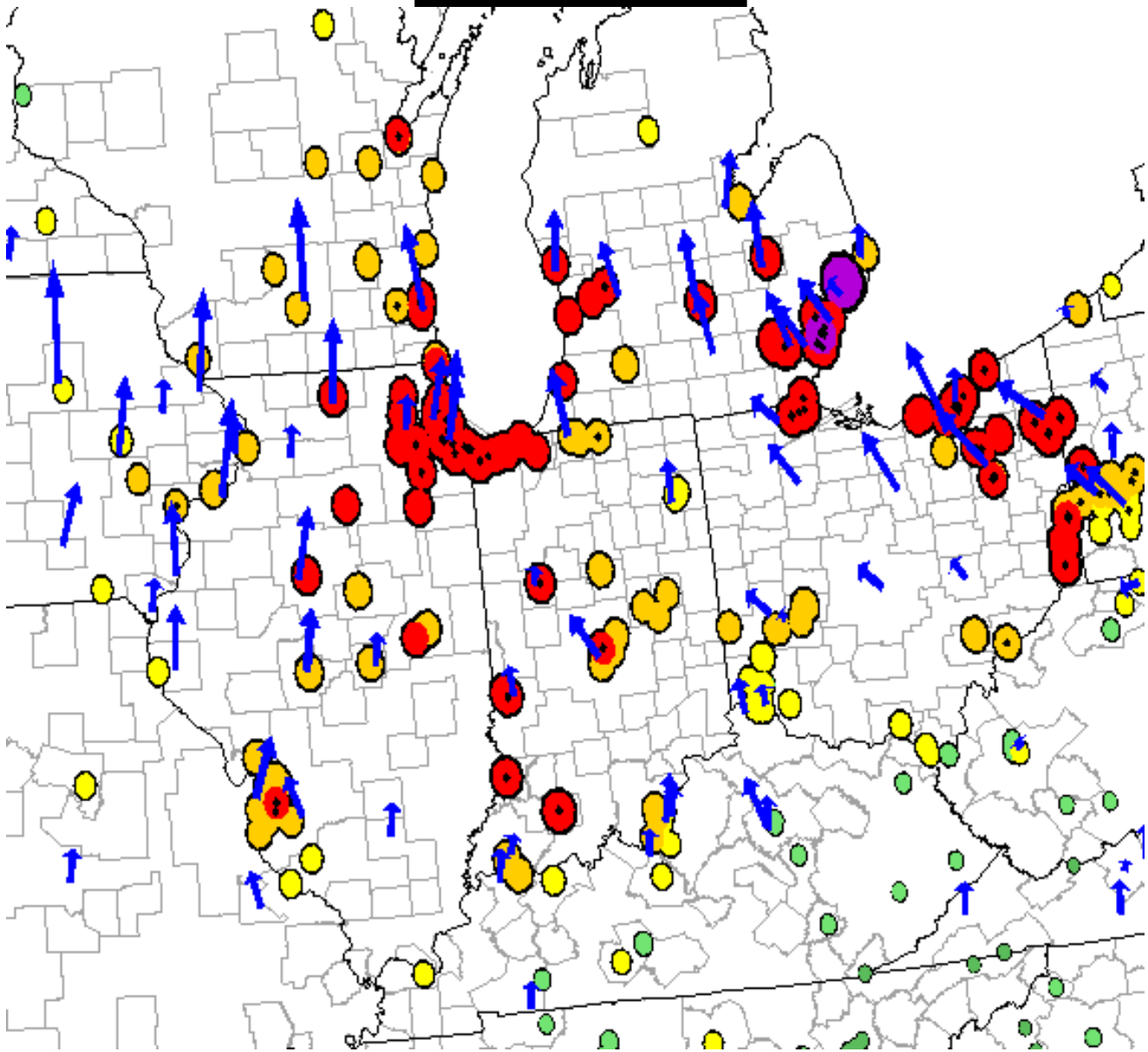
PM2.5 > 95th%ile (pie with white dot):
PM2.5 > 95th %ile (wo SANDWICH data)

missing STN

lower conc value (pie wo white dot)
Other PM2.5 wo SANDWICH data

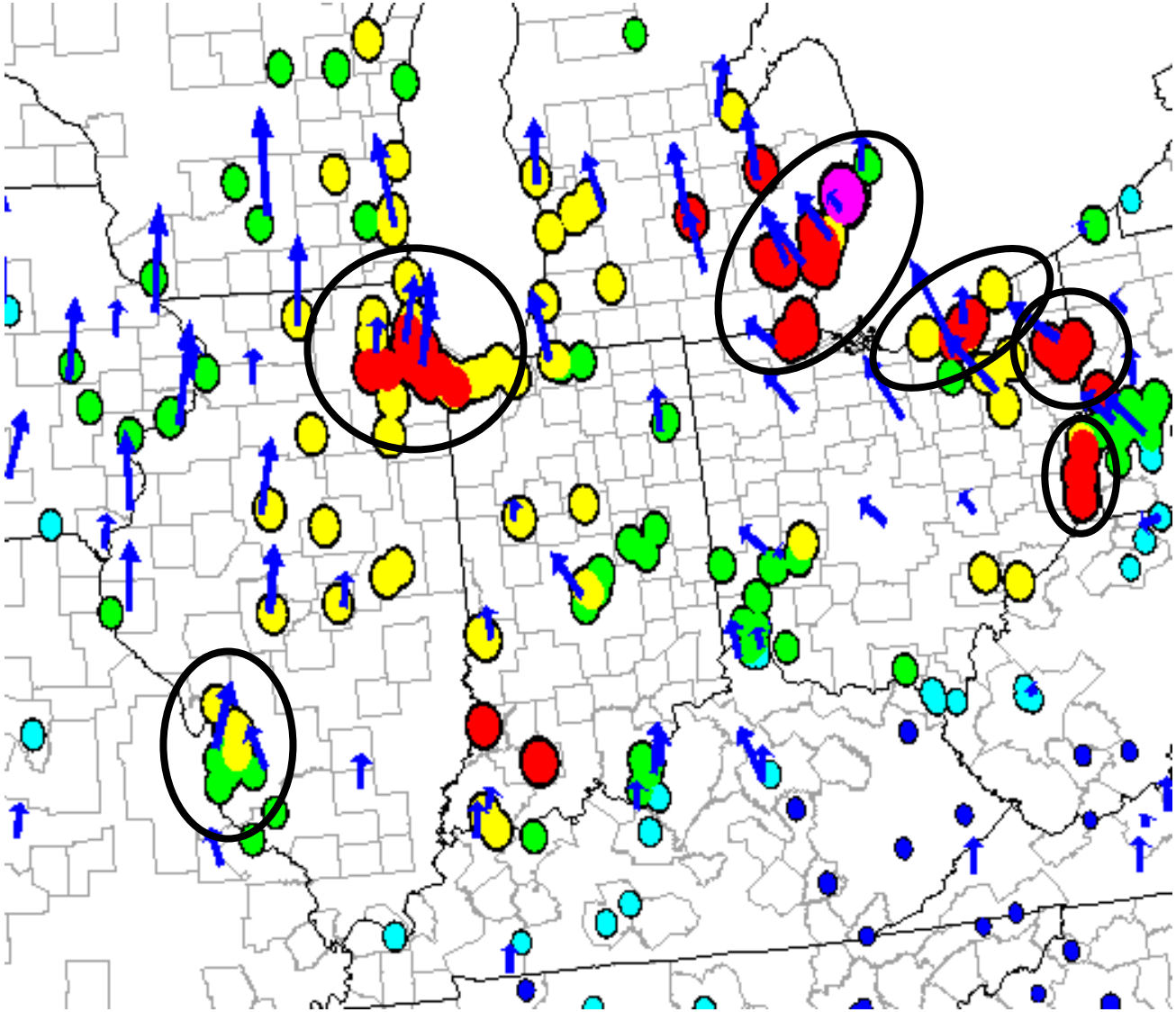
24-hrDV>35ug/m3 (red=only 24-hr elig.)

06/27/2005



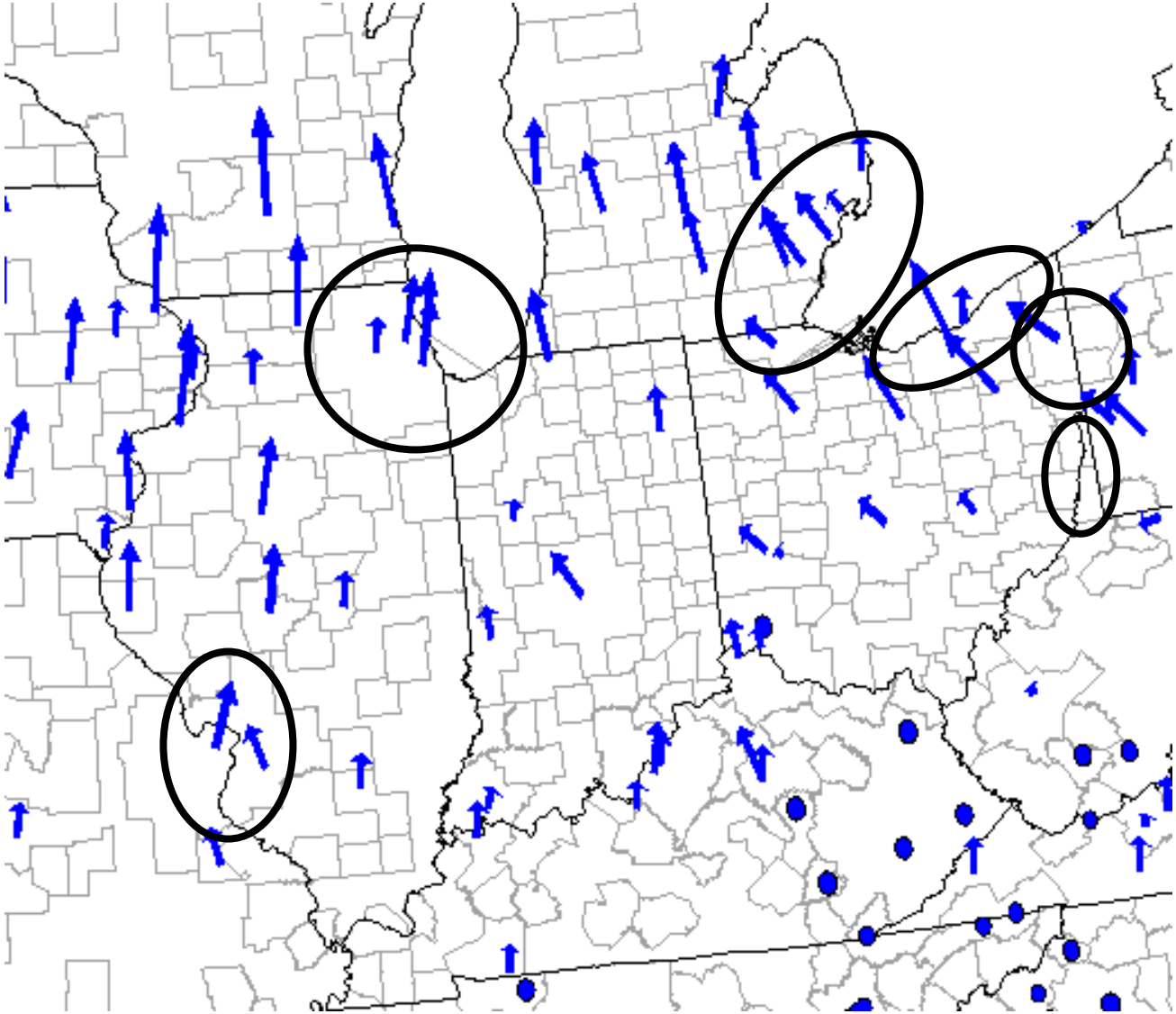
Higher concentrations observed in major urban areas in the northern part of the domain

06/27/2005



6.0 - 23.0 ug/m3	23.1 – 34.3 ug/m3	34.4 – 42.5 ug/m3	42.6 – 50.3 ug/m3	50.4 – 61.1 ug/m3	61.1 – 79.2 ug/m3
Regional	Regional	Regional	**Regional/Urban**	Urban	**Urban/Microscale**

06/27/2005



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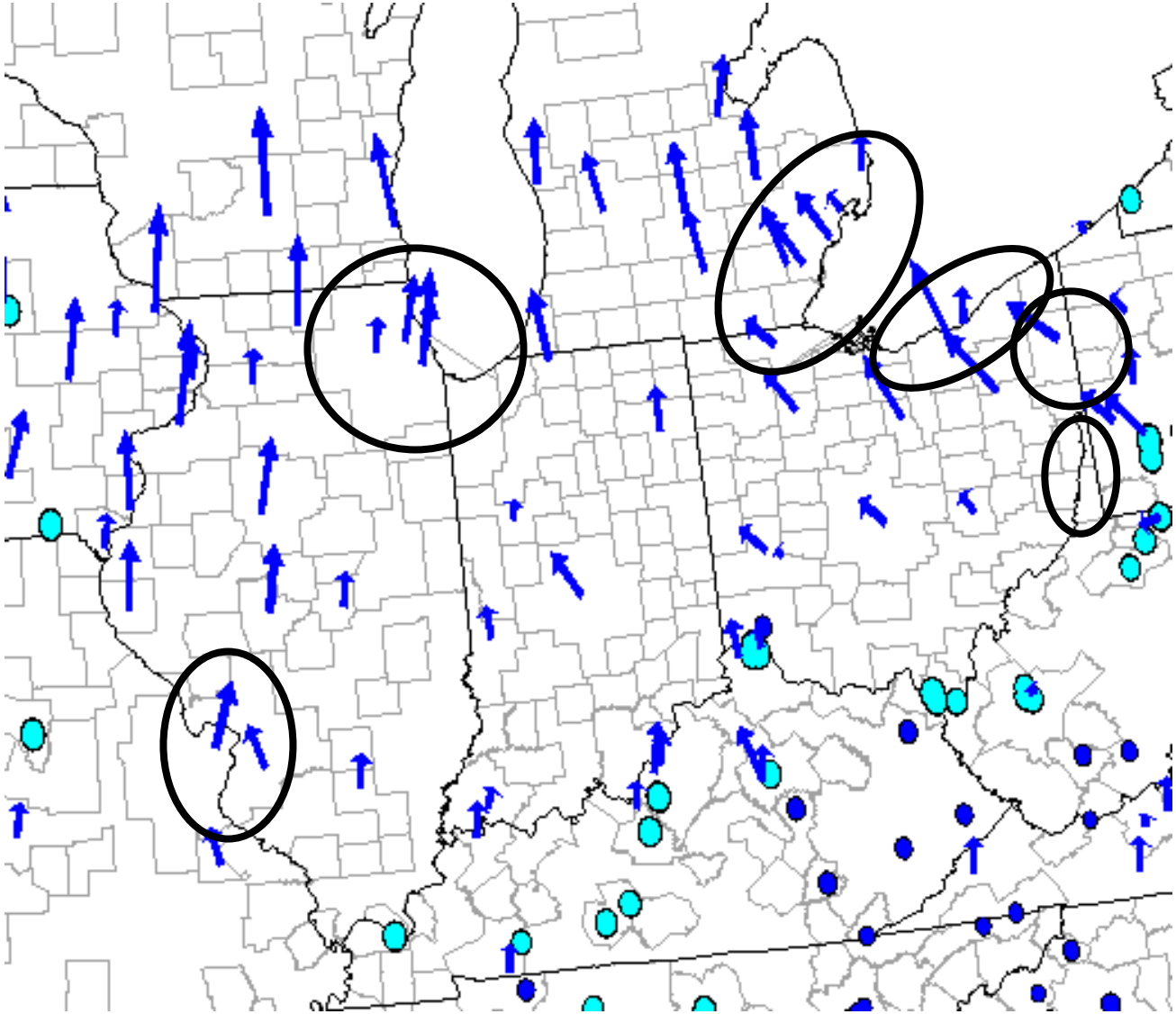
Regional	Regional	Regional	**Regional/Urban**	Urban	**Urban/Microscale**

1st Slice

06/27/2005



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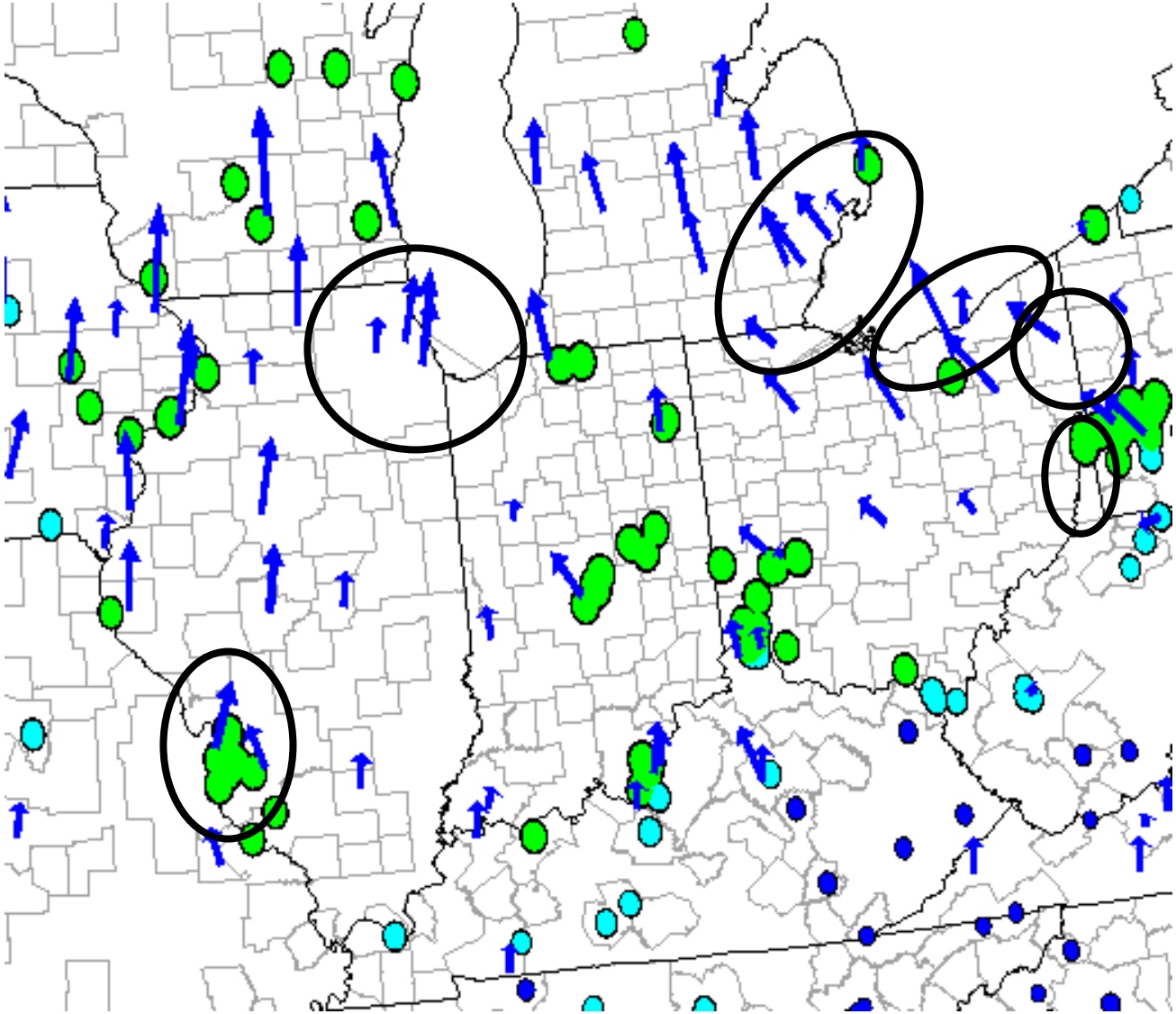
Regional	Regional	Regional	**Regional/Urban**	Urban	**Urban/Microscale**

2nd Slice

06/27/2005



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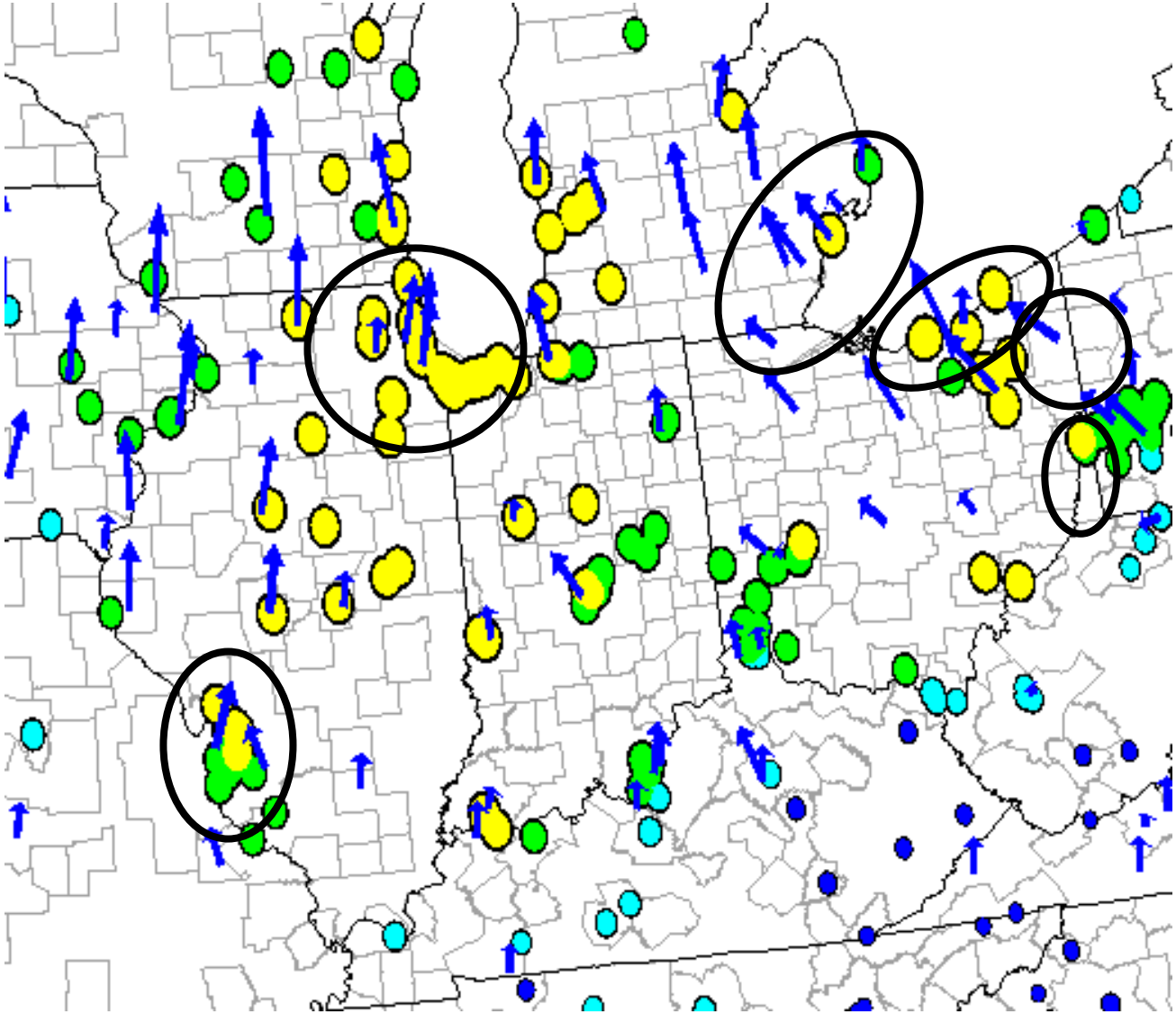
Regional	Regional	Regional	**Regional/Urban**	Urban	**Urban/Microscale**

3rd Slice

06/27/2005



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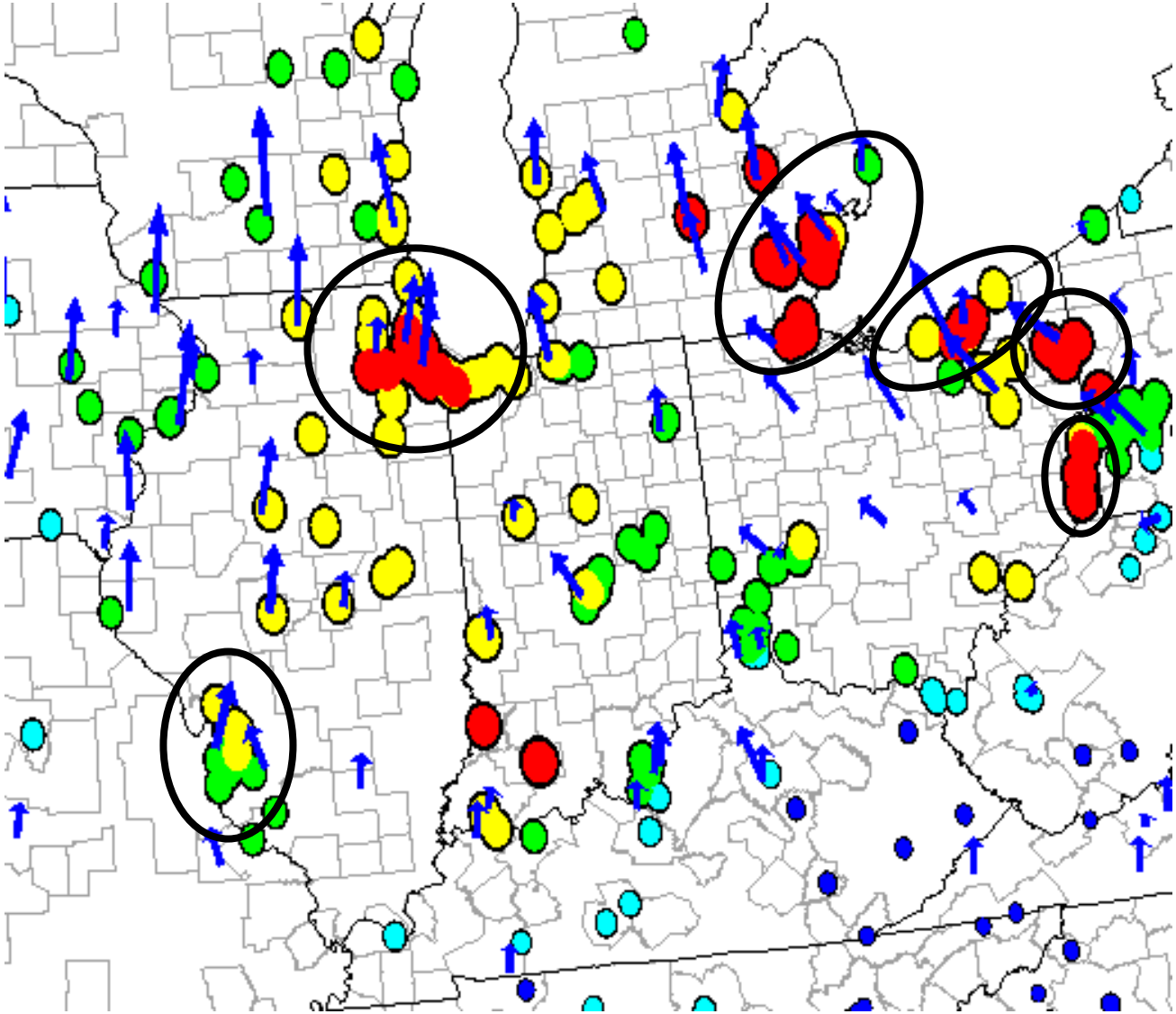
Regional	Regional	Regional	**Regional/Urban**	Urban	**Urban/Microscale**

4th Slice

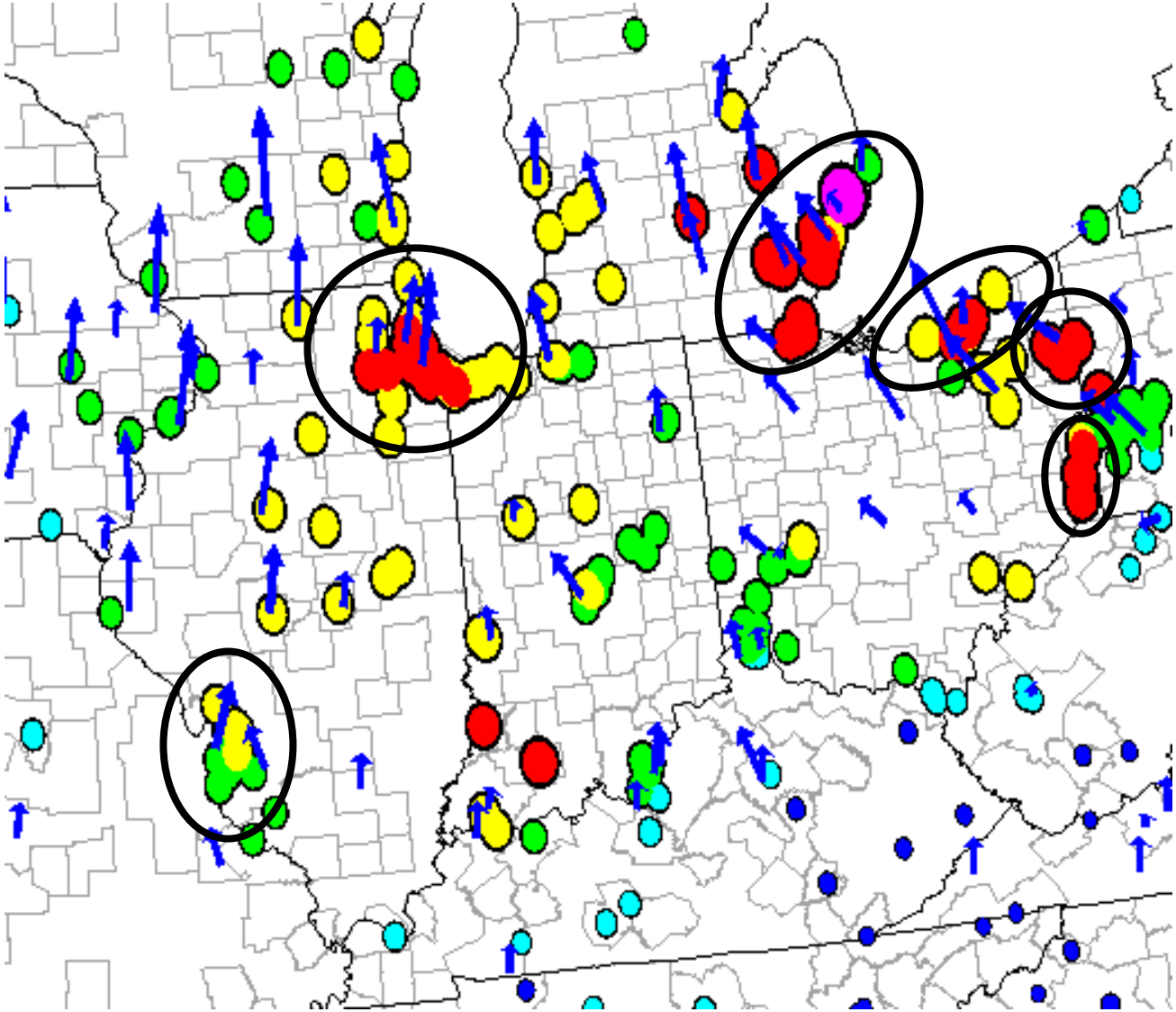
06/27/2005



6.0 - 23.0 ug/m3	23.1 – 34.3 ug/m3	34.4 – 42.5 ug/m3	42.6 – 50.3 ug/m3	50.4 – 61.1 ug/m3	61.1 – 79.2 ug/m3
Regional	Regional	Regional	**Regional/Urban**	Urban	**Urban/Microscale**

5th Slice

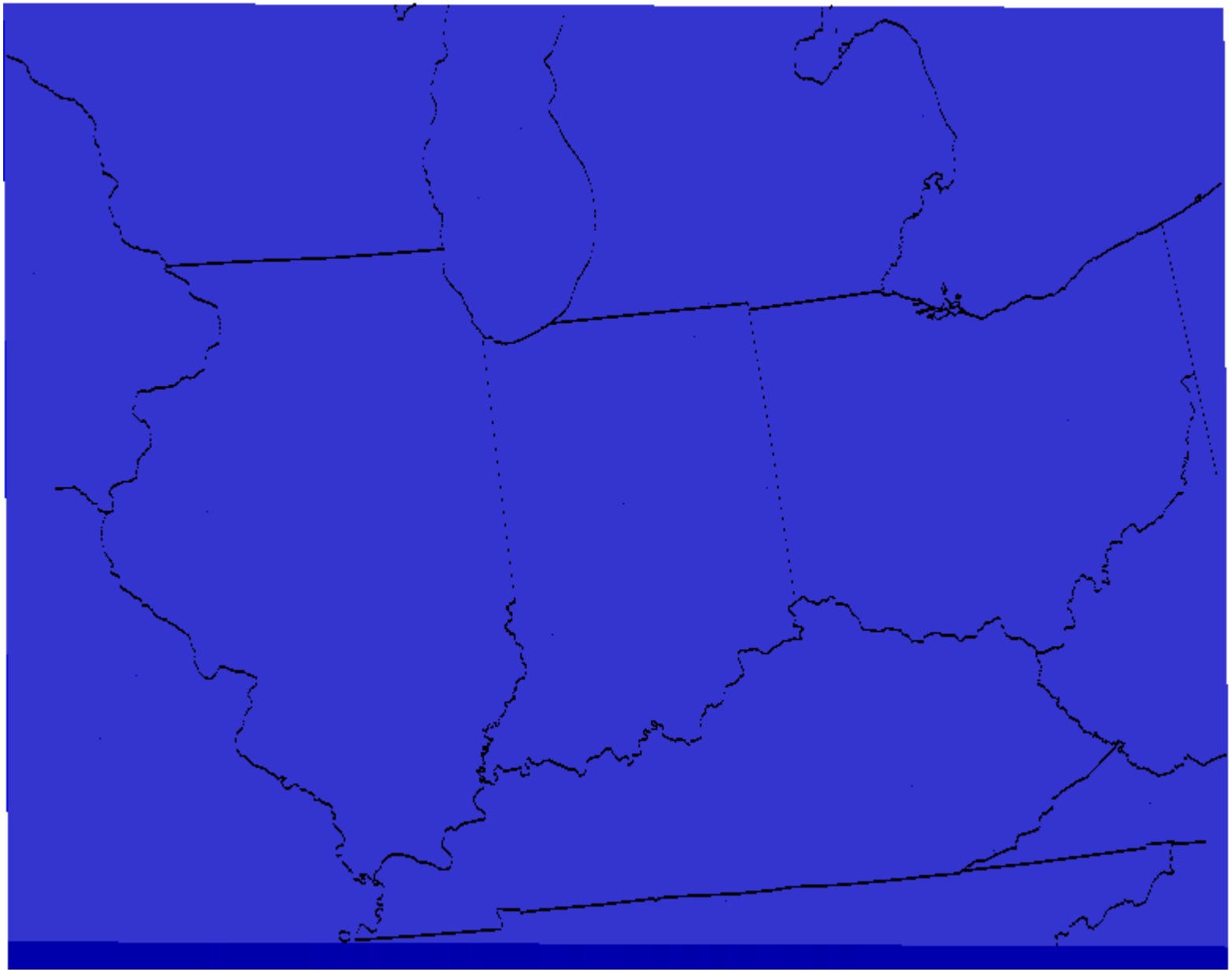
06/27/2005



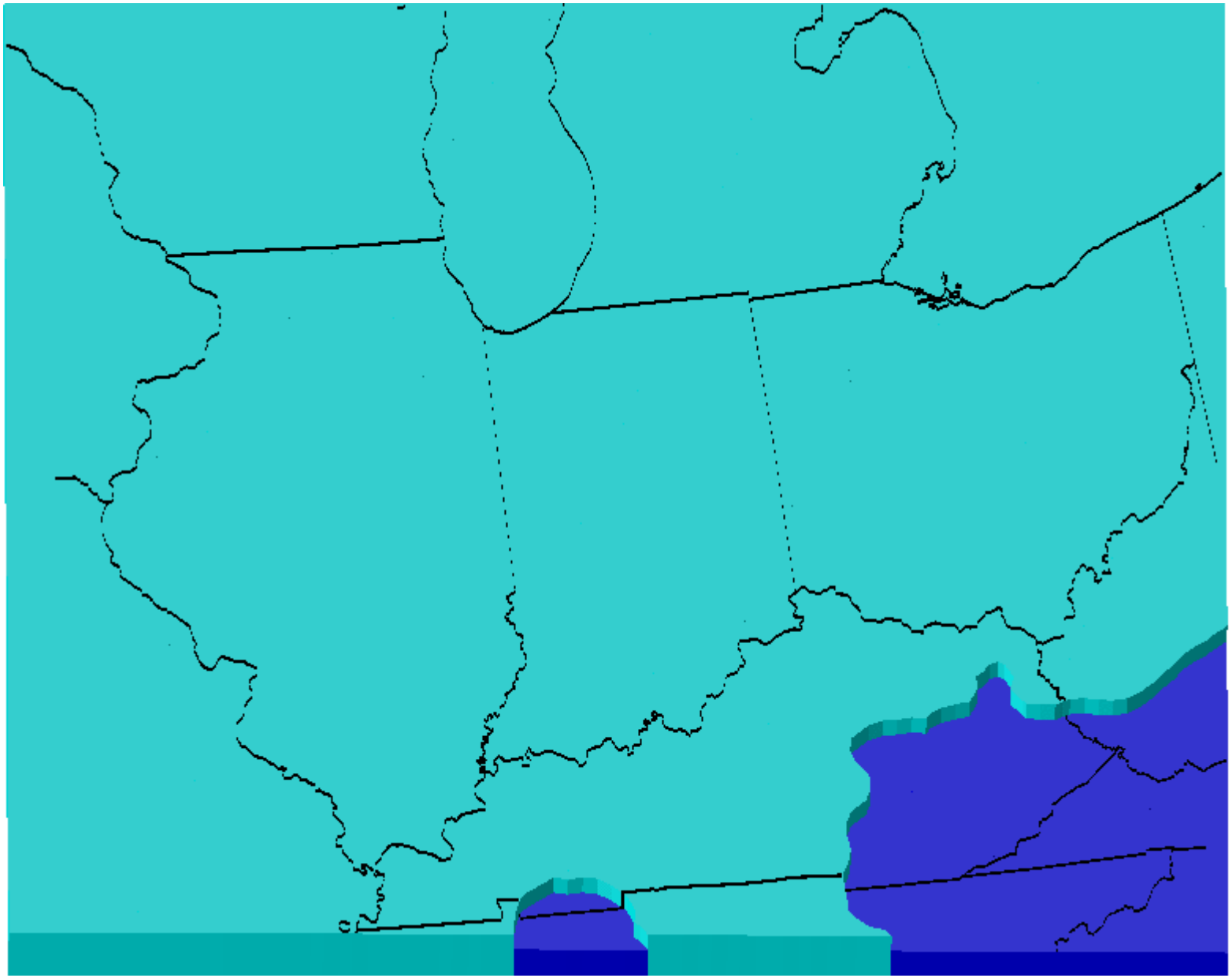
6.0 - 23.0 ug/m3	23.1 – 34.3 ug/m3	34.4 – 42.5 ug/m3	42.6 – 50.3 ug/m3	50.4 – 61.1 ug/m3	61.1 – 79.2 ug/m3
Regional	Regional	Regional	**Regional/Urban**	Urban	**Urban/Microscale**

6th Slice

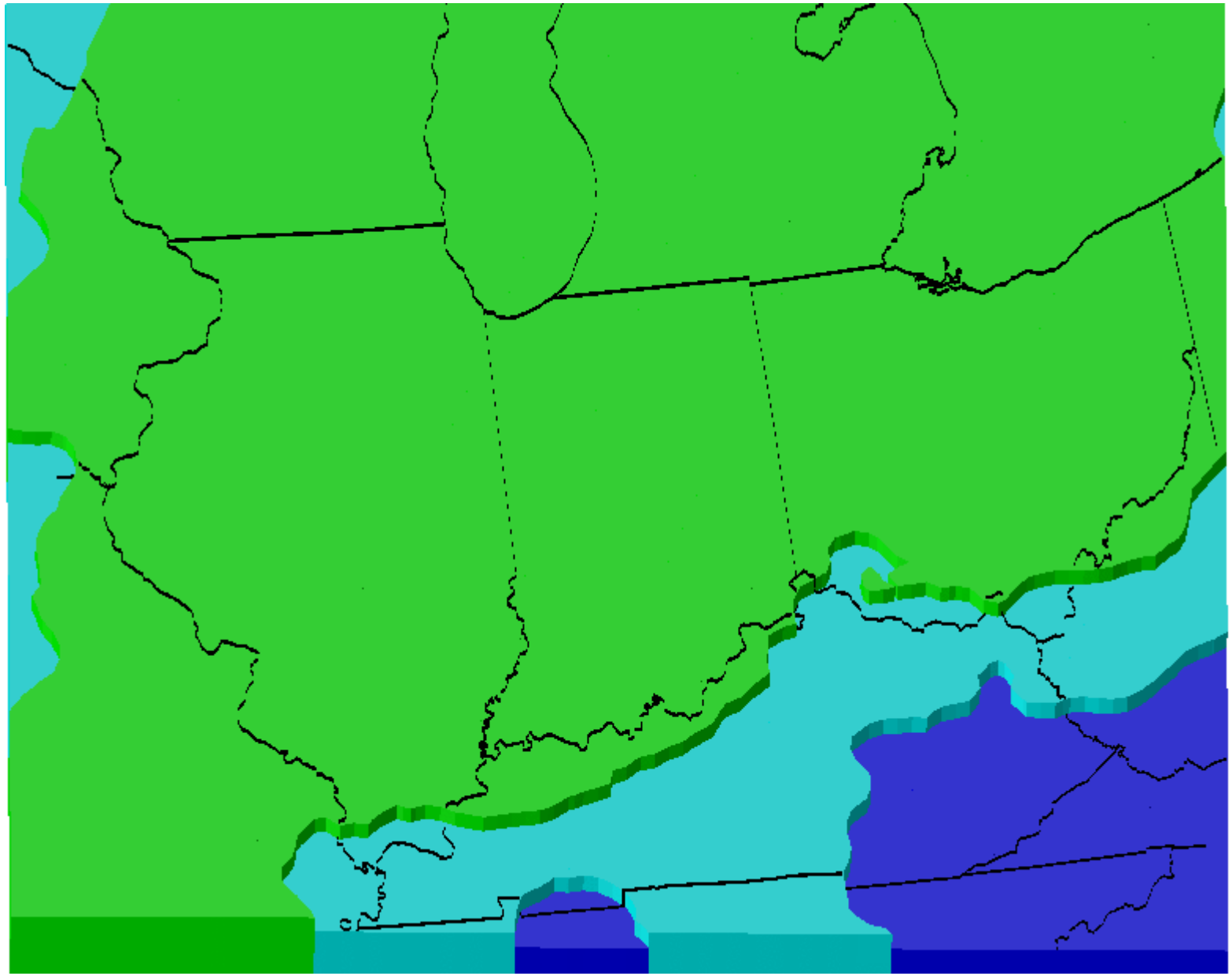
This base slice is considered to be the underlying regional layer for the domain



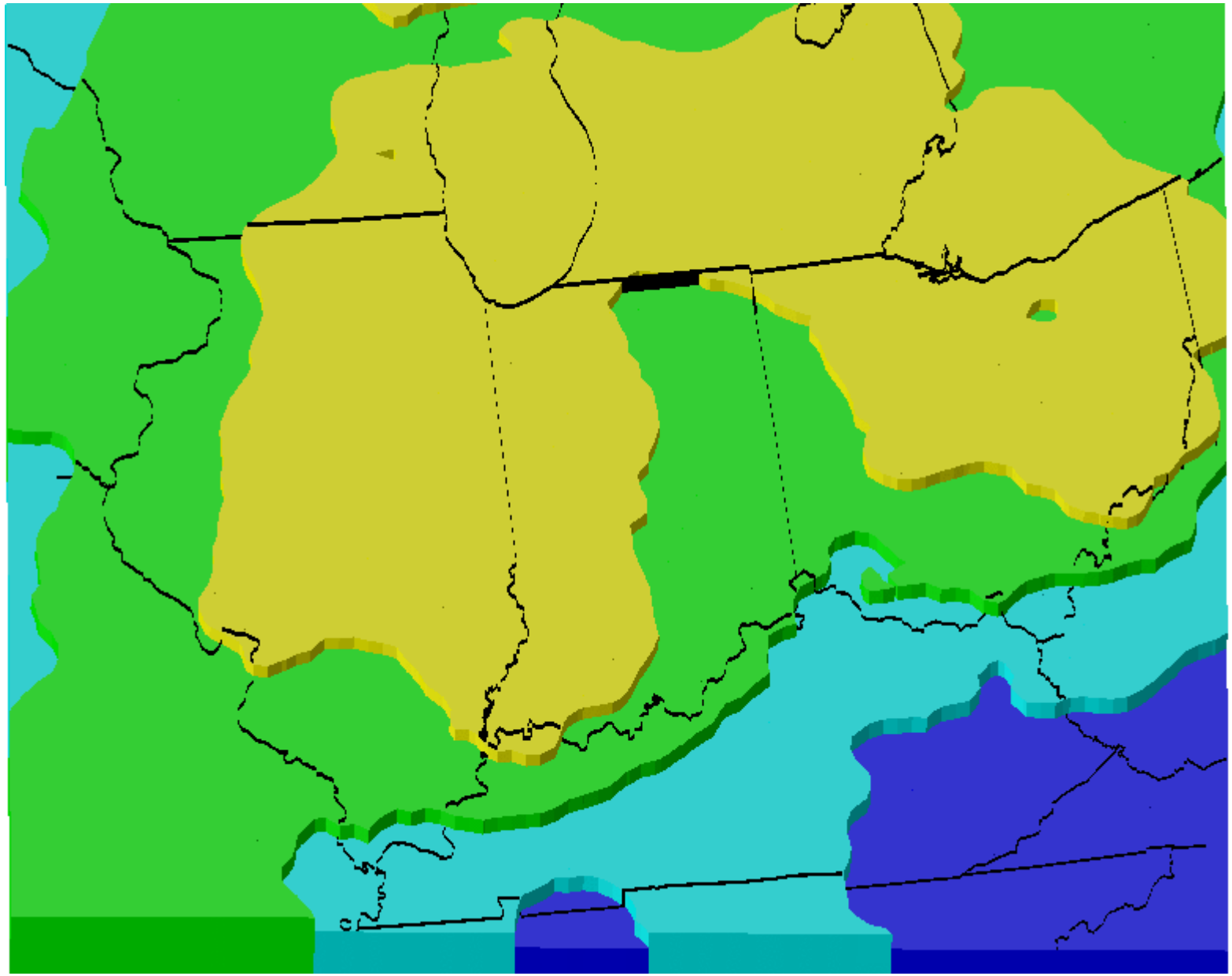
The next regional slice is added on top of the base slice



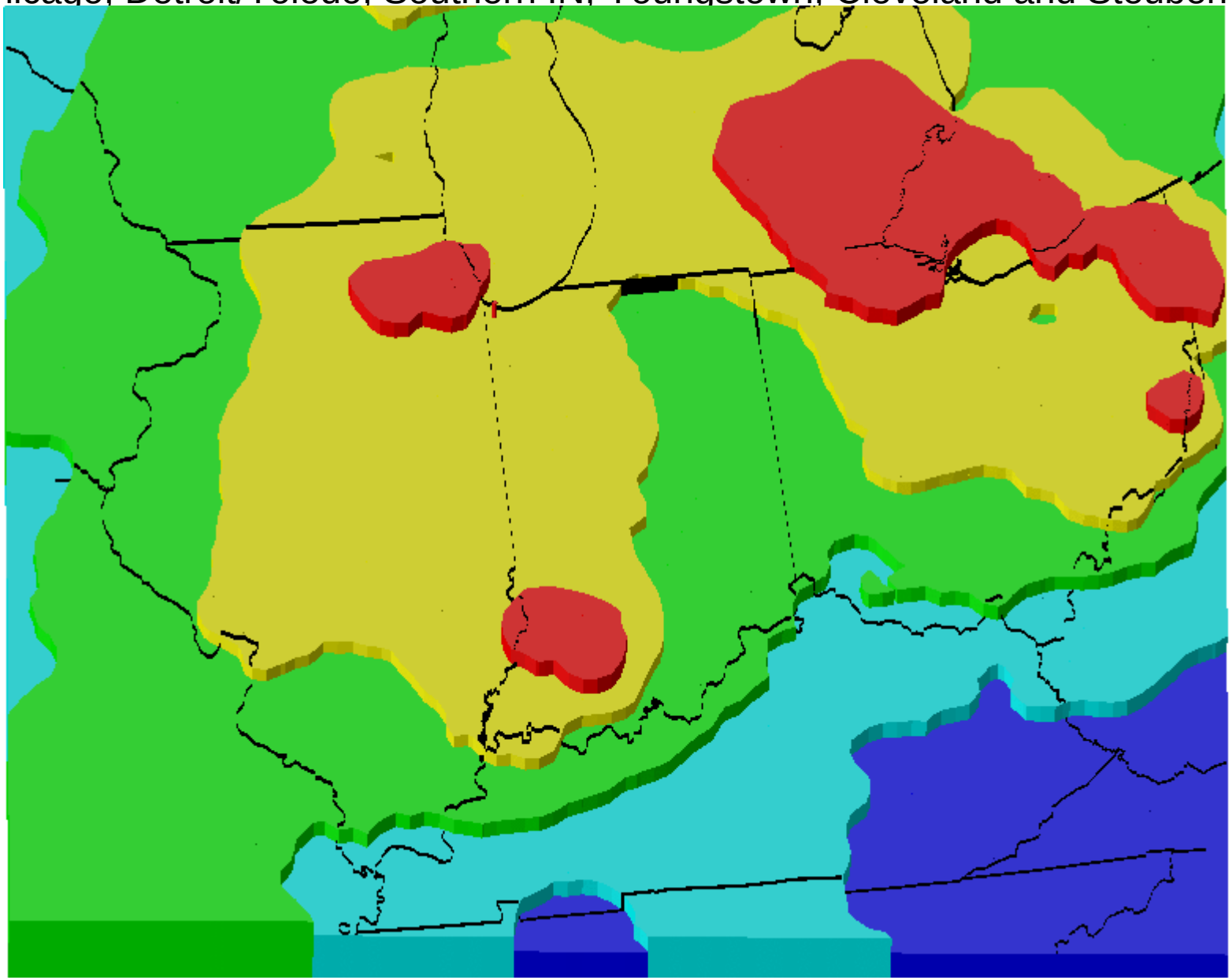
Another regional slice is added on top of the two existing slices



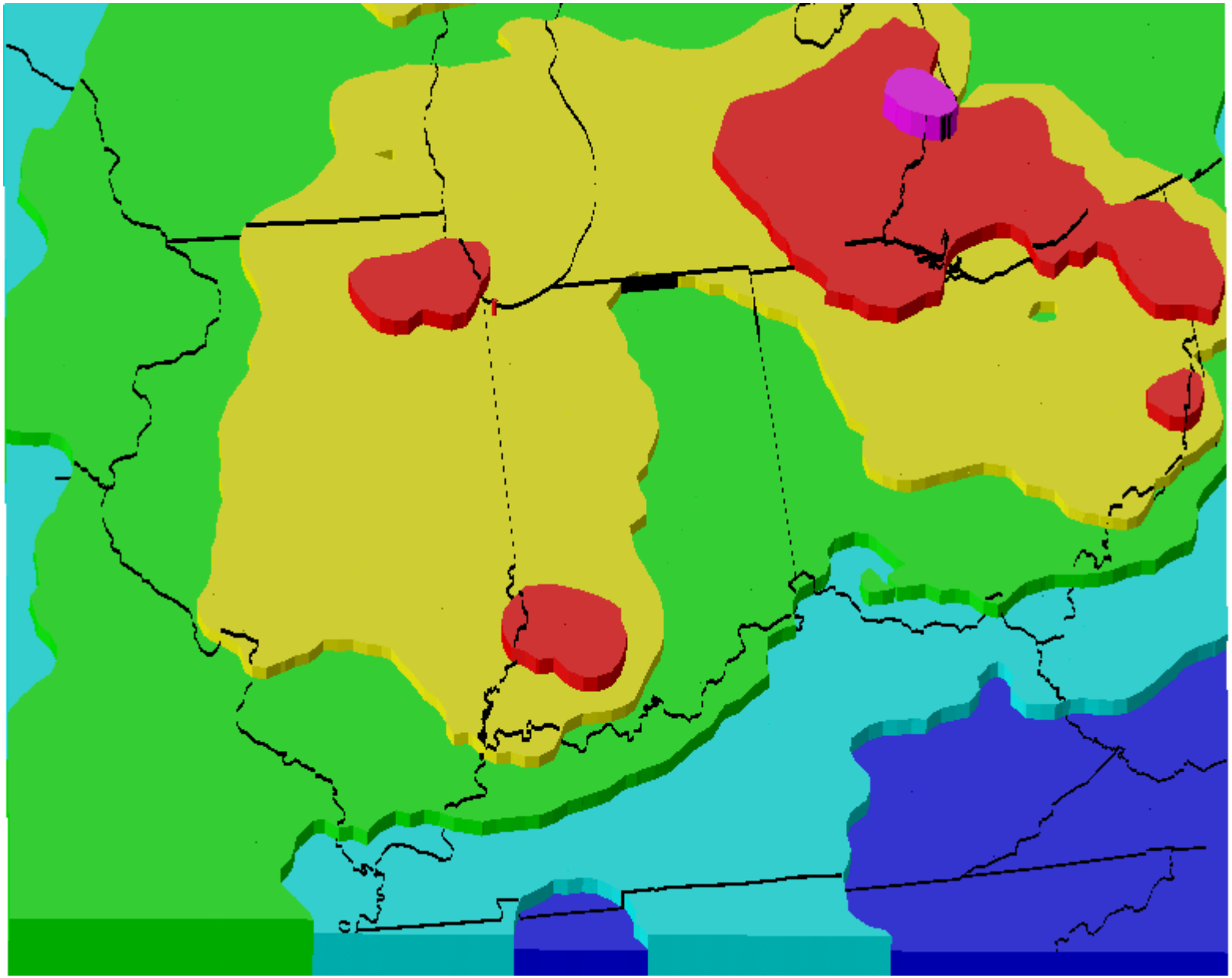
A regional/urban slice is added to the existing three layers



Urban area emissions contribute to “island” effects in Chicago, Detroit/Toledo, Southern IN, Youngstown, Cleveland and Steubenville



An urban/microscale “island” appears downwind of Detroit in the last slice



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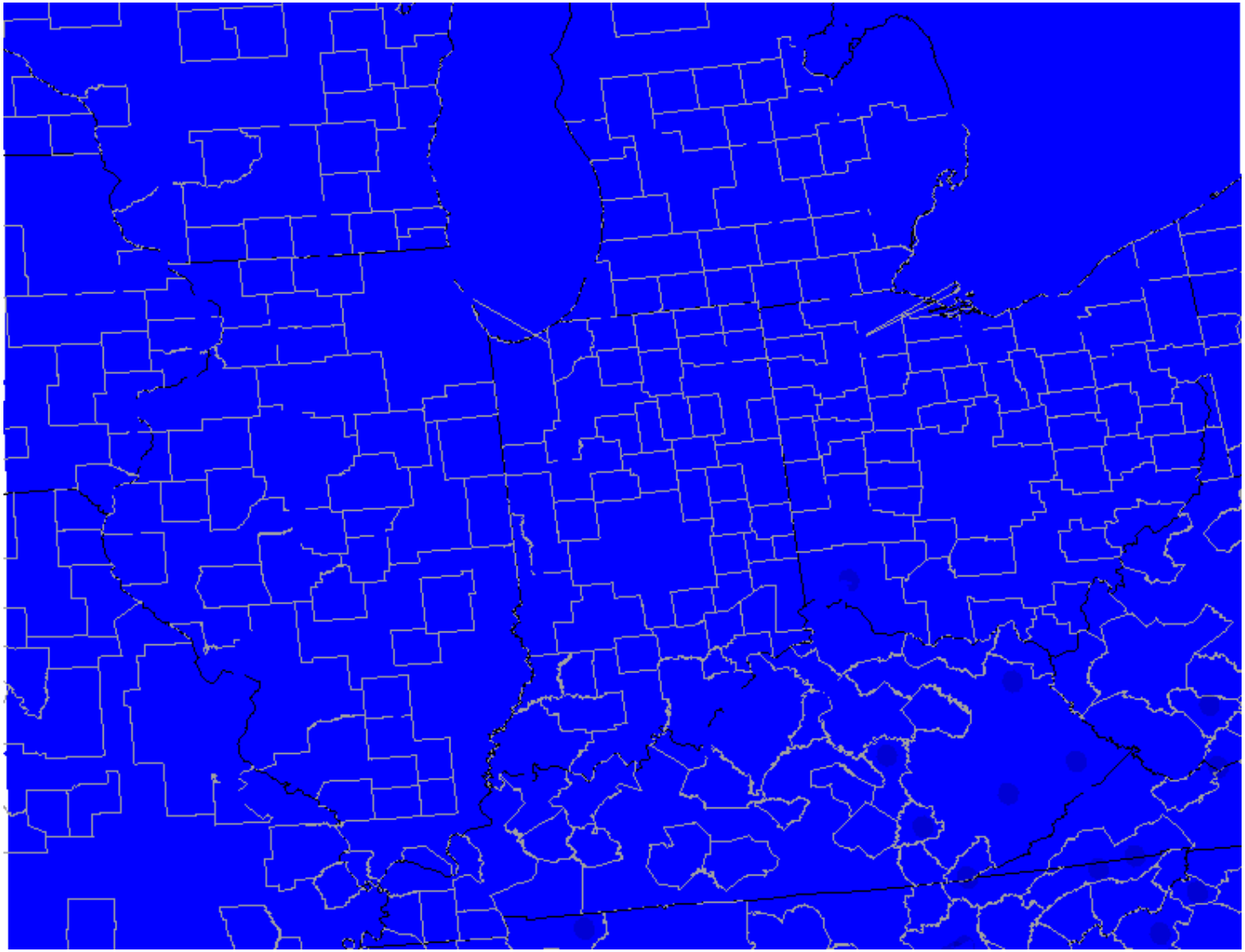
This is the base layer on which all other slices are placed

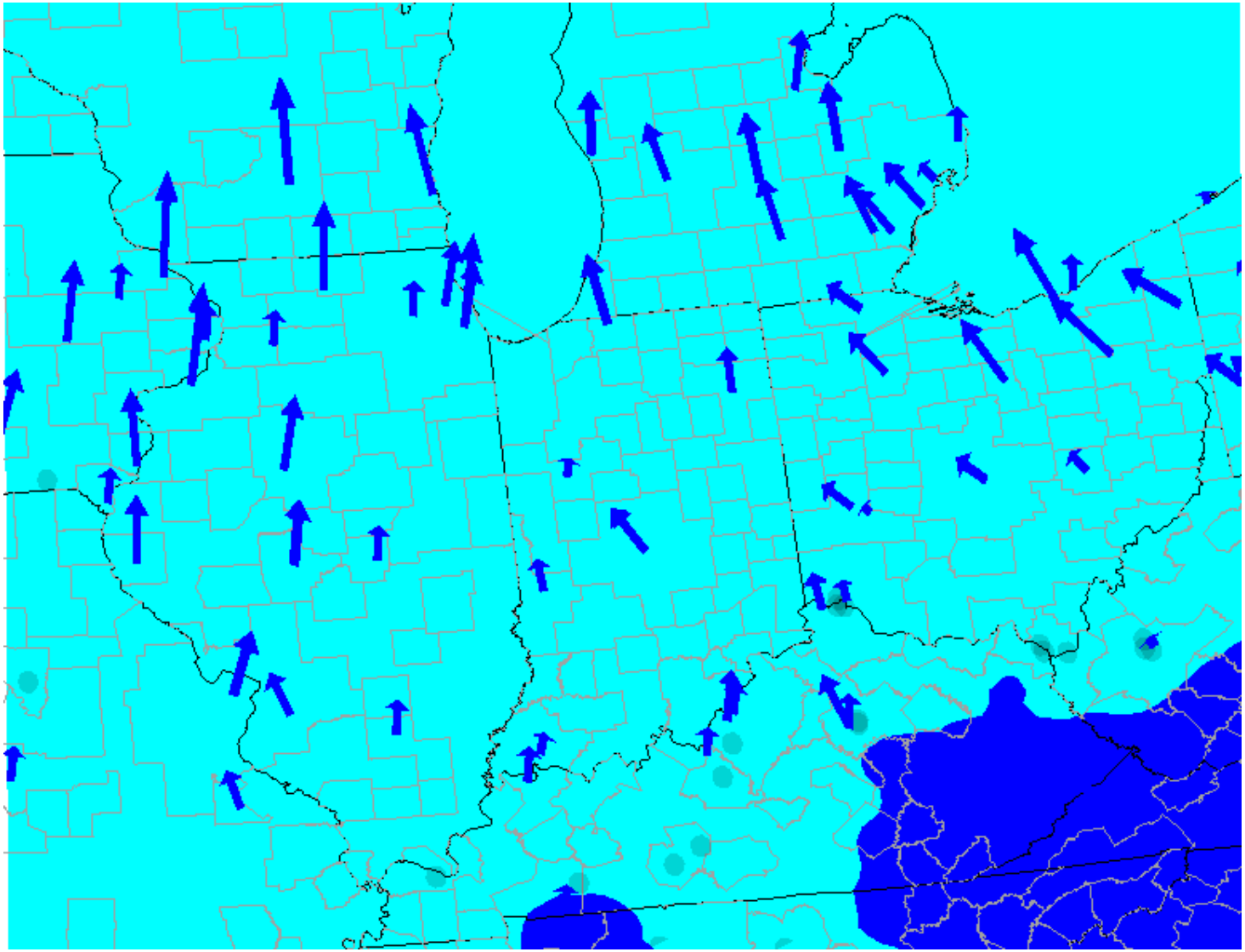


6.0 – 23.0 ug/m3

Regional	Regional	Regional	Regional/Urban	Urban	Urban/Microscale

Up to 23 ug/m3

06/27/2005



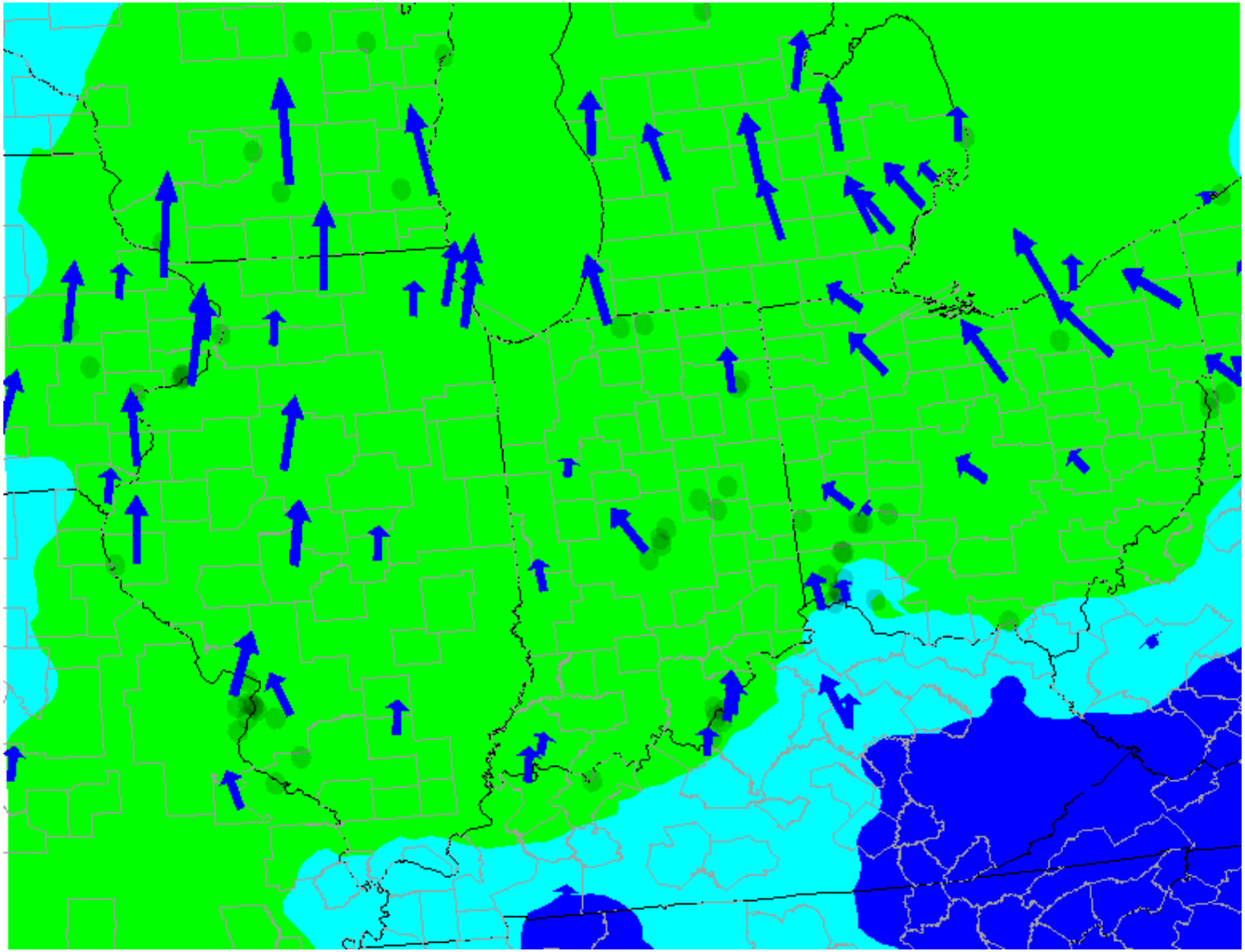
6.0 – 23.0 ug/m3

Up to 11.3 ug/m3

Regional	Regional	Regional	Regional/Urban	Urban	Urban/Microscale

Up to 34.3 ug/m3

06/27/2005



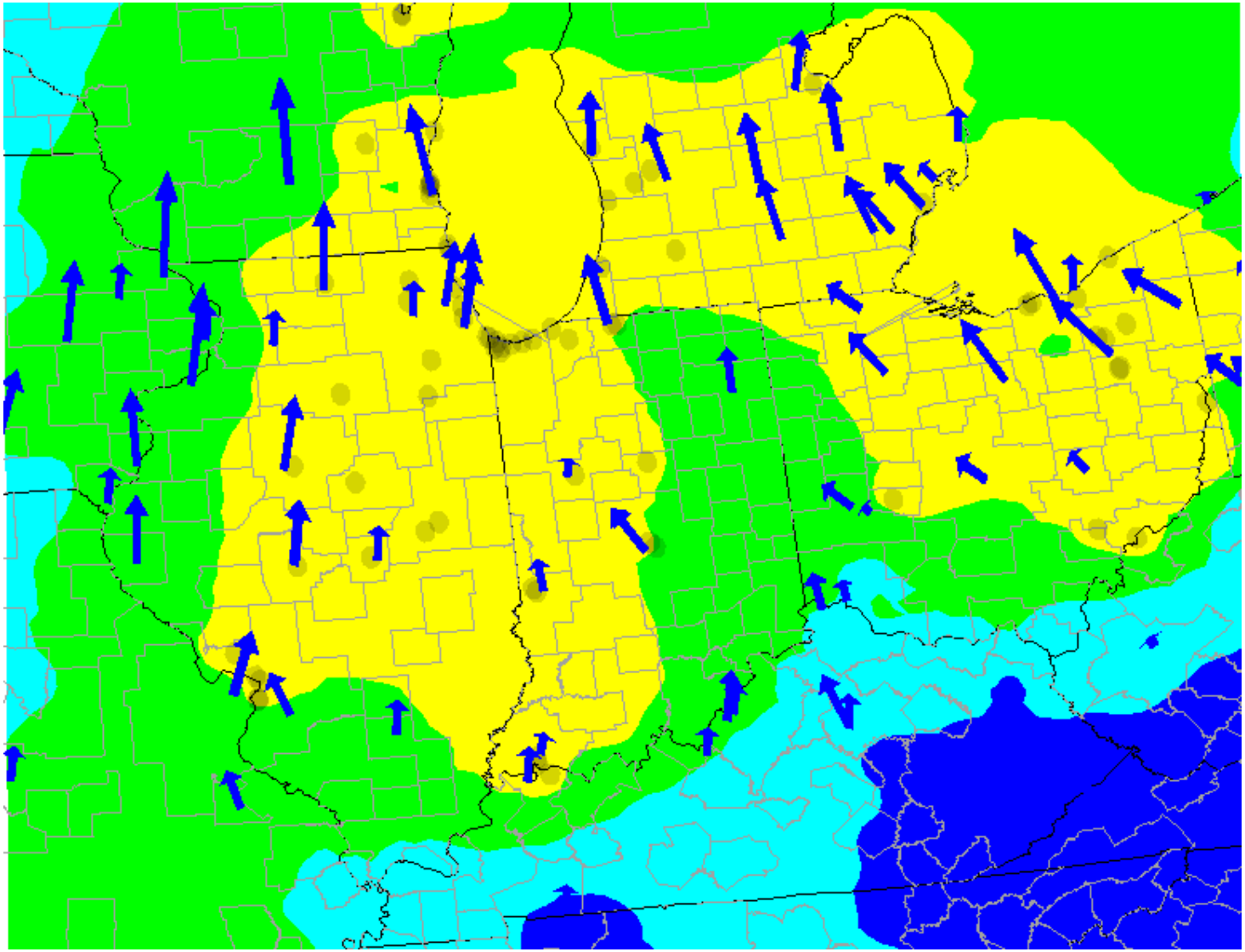
23.1 – 34.3 ug/m3

Up to 8.2 ug/m3

Regional	Regional	Regional	Regional/Urban	Urban	Urban/Microscale

Up to 42.5 ug/m3

06/27/2005

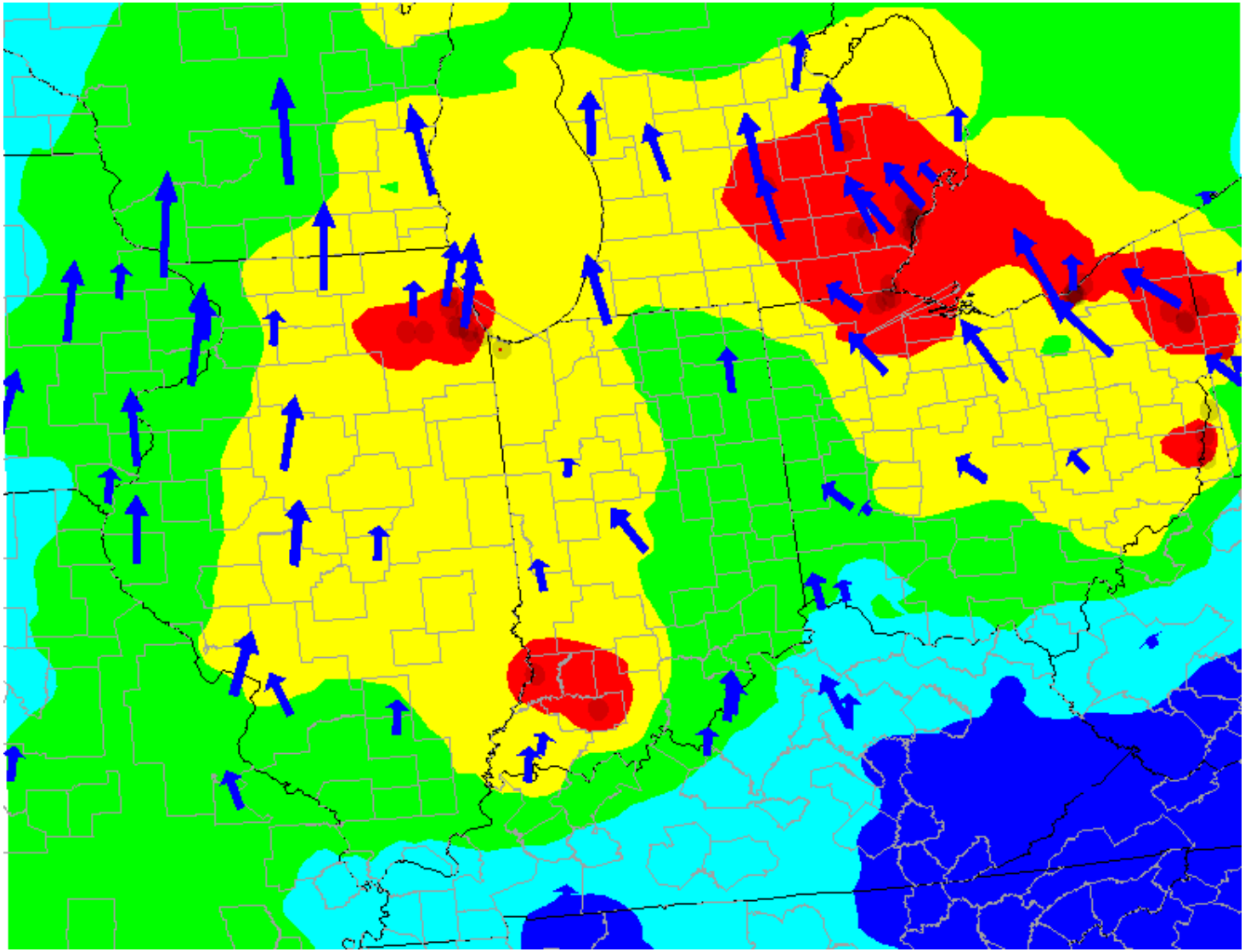


34.4 – 42.5 ug/m3 Up to 7.8 ug/m3

Regional	Regional	Regional	**Regional/Urban**	Urban	**Urban/Microscale**

Up to 50.3 ug/m3

06/27/2005

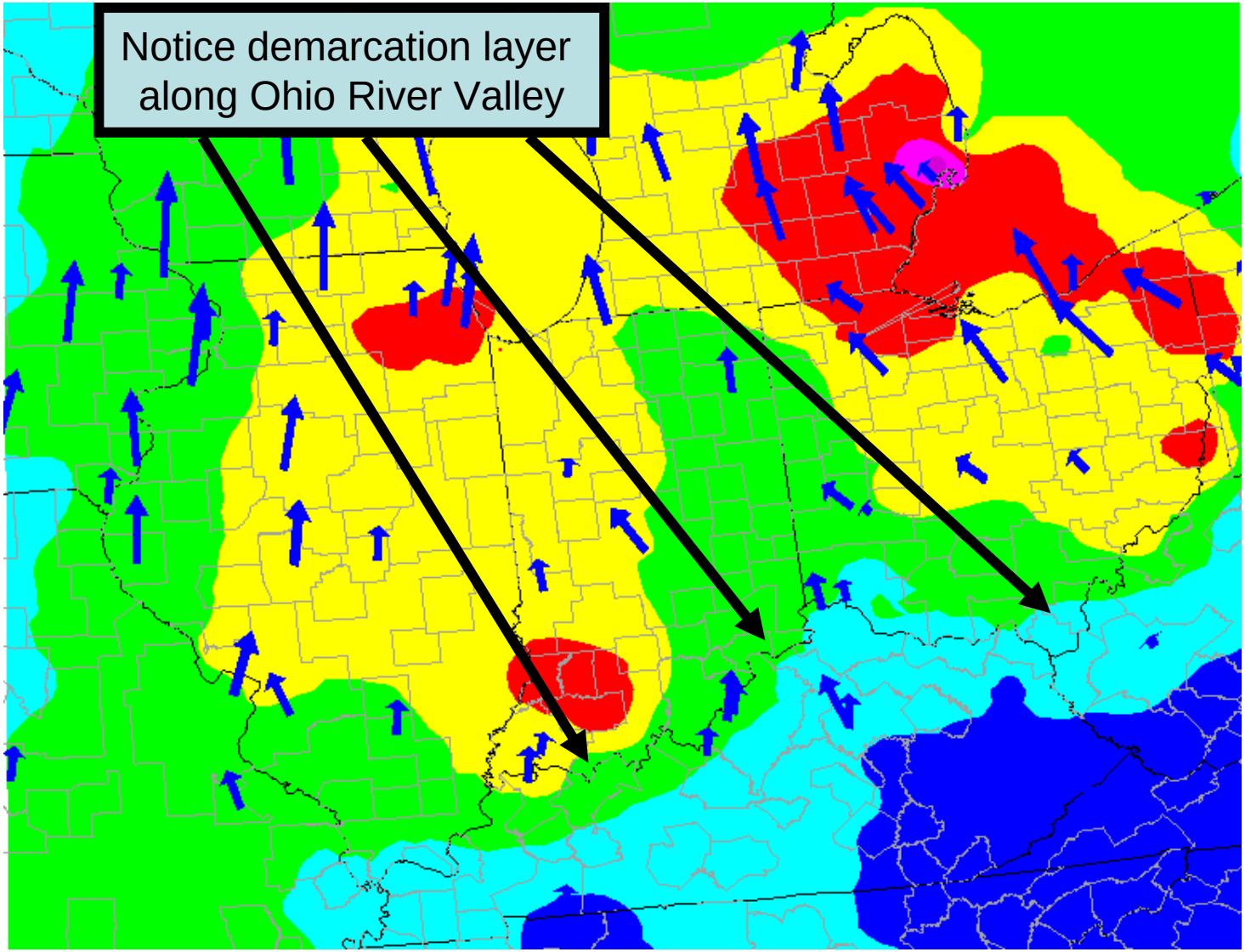


42.6 – 50.3 ug/m3 Up to 10.8 ug/m3

Regional	Regional	Regional	Regional/Urban	Urban	Urban/Microscale

Up to 61.1 ug/m3

06/27/2005



50.4 – 61.1 ug/m3 Up to 18.1 ug/m3

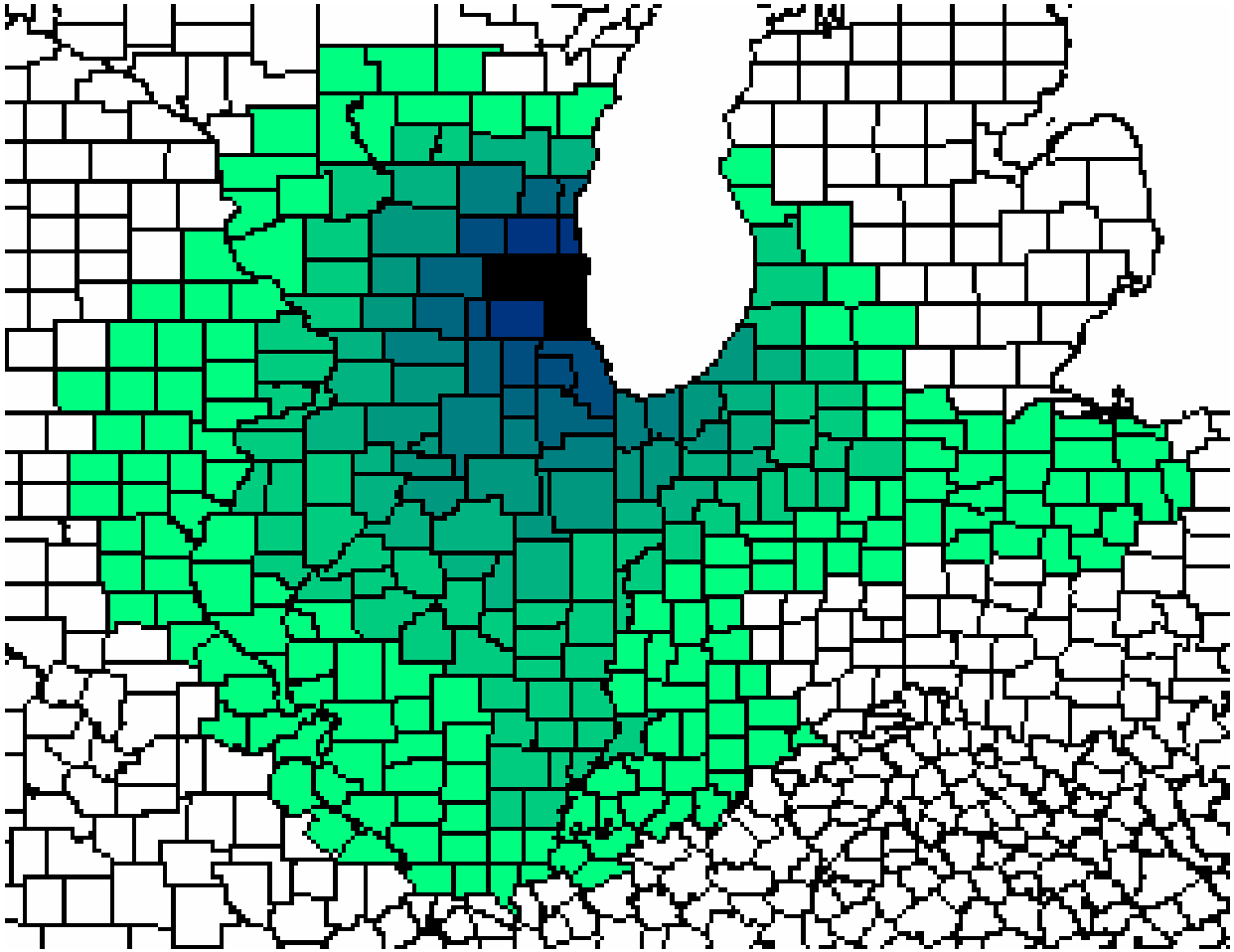
Regional	Regional	Regional	Regional/Urban	Urban	Urban/Microscale

Up to 79.2 ug/m3

2nd Technique: Residence Time Weighted Emissions

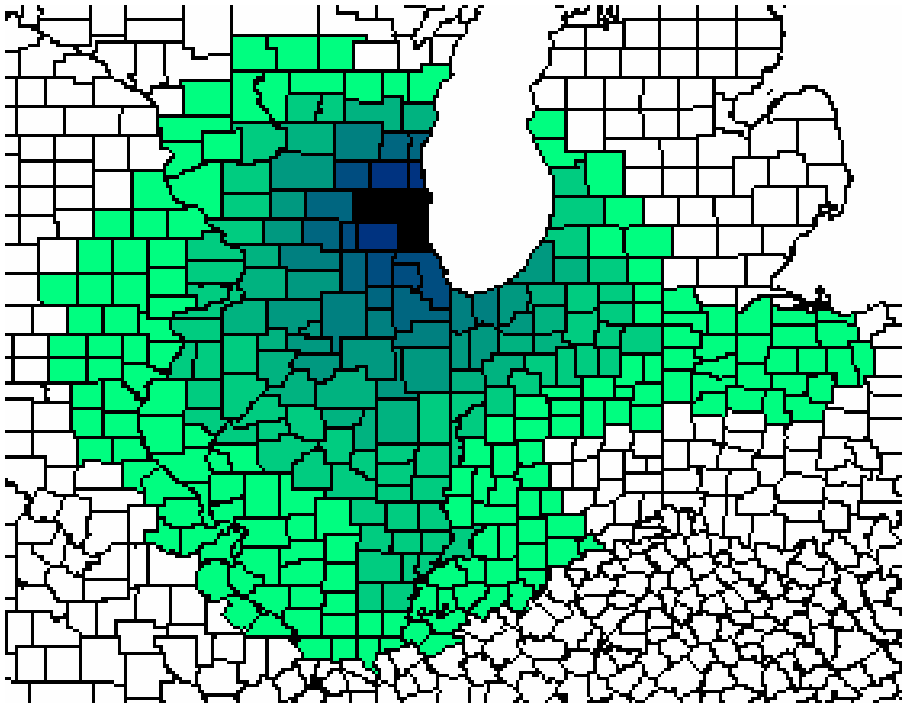
- Utilize trajectories on days when PM2.5 is greater than area's lowest 98th percentile by year
- Incorporate information from SLICE to include sites within an "urban island" rather than just a single site to determine the location of air masses influencing an entire area
- Use the results from the calculated trajectories to determine a trajectory density (i.e. what areas do most of the trajectories pass through) to act as a series of weights for emissions estimates
- Utilize county level emissions estimates to determine those areas with the greatest impact
- Aggregate weighted emissions by season into a Total Influential Emissions Score for high days

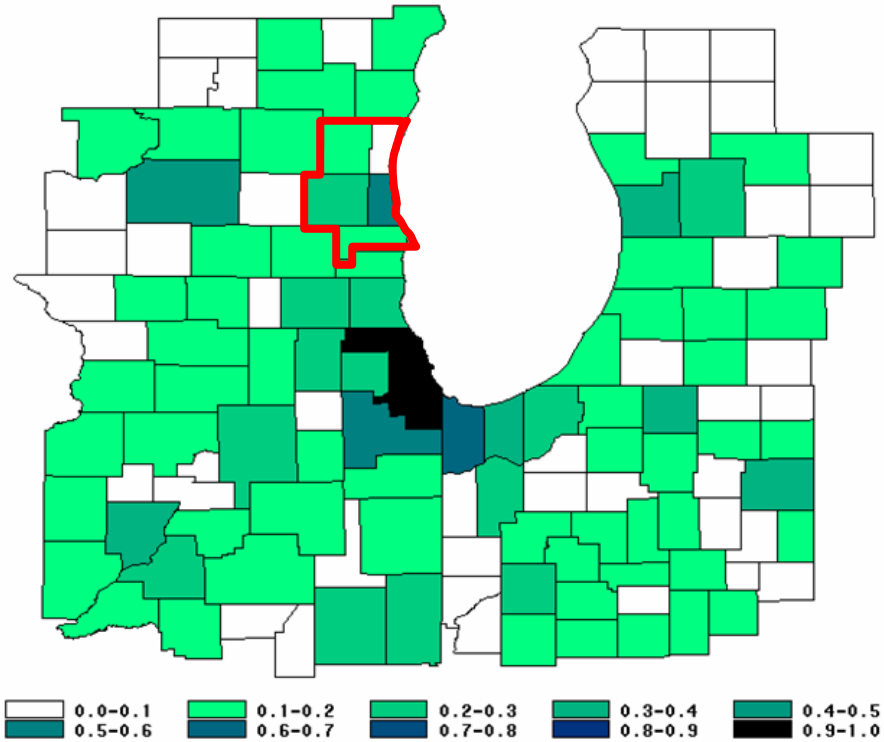
Trajectory Density for High Days for 2003-2005 in Milwaukee, WI



0.0-0.1 0.1-0.2 0.2-0.3 0.3-0.4 0.4-0.5
0.5-0.6 0.6-0.7 0.7-0.8 0.8-0.9 0.9-1.0

Normalized Density

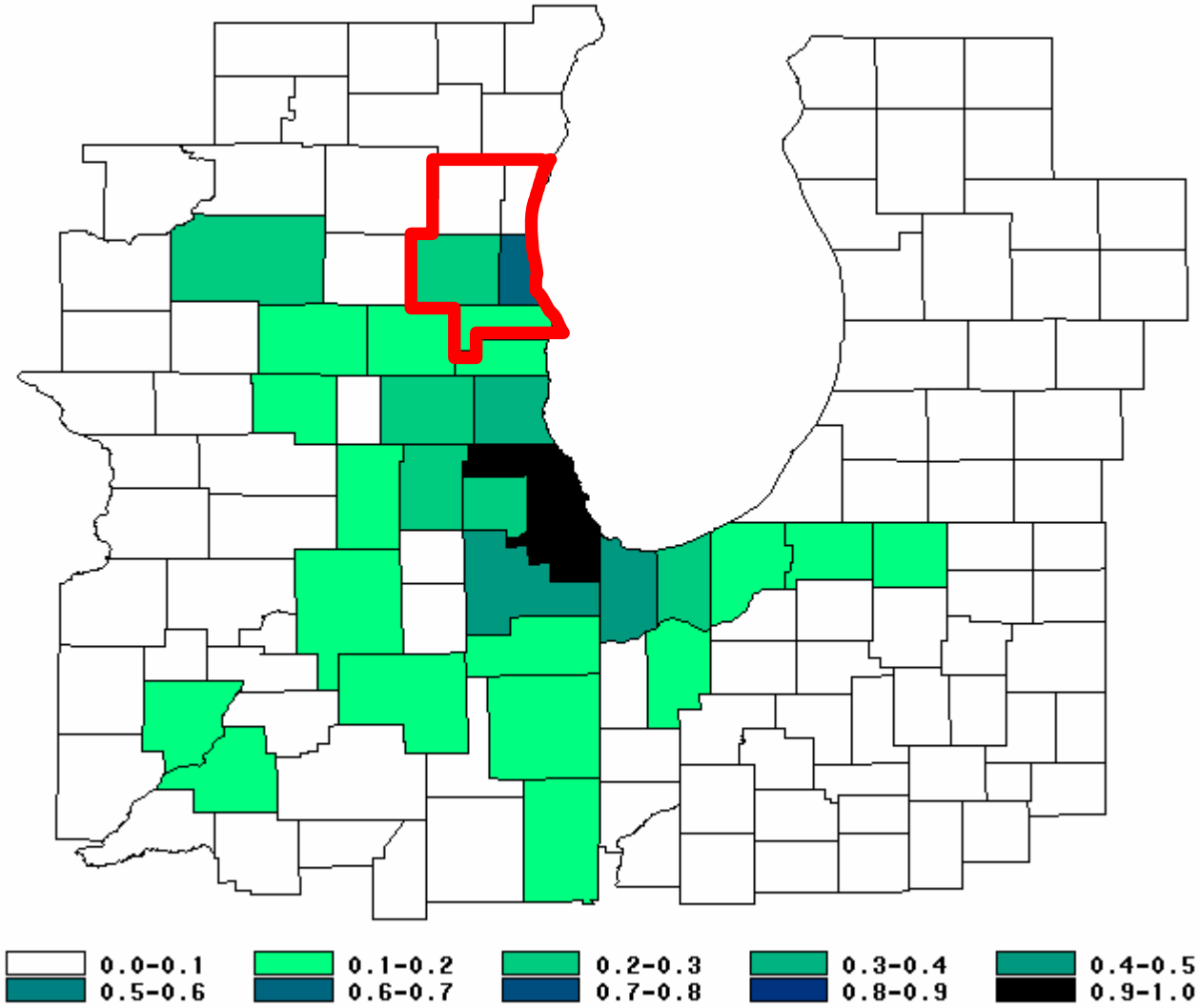




Trajectory Densities times Total PM2.5 Emissions

EQUALS . . . . . .

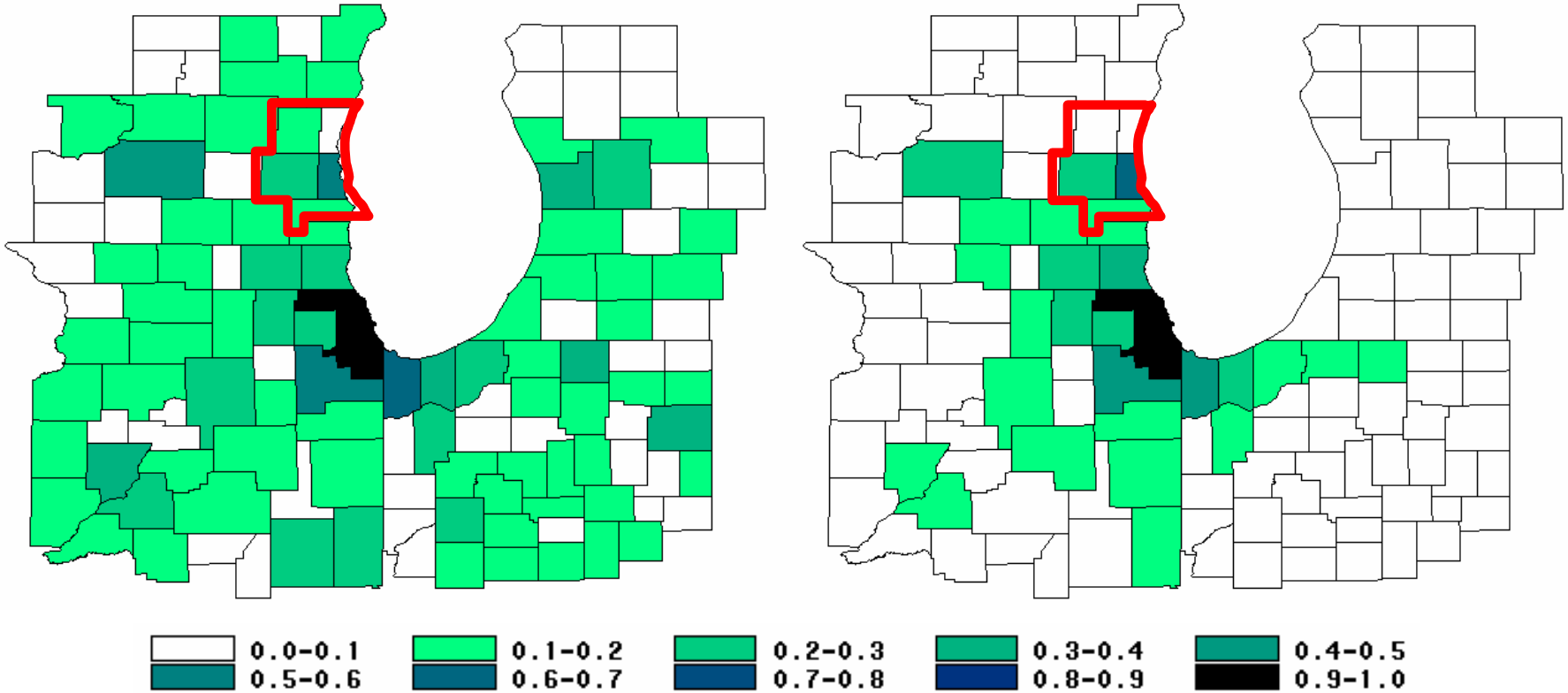
Weighted Total PM2.5 Emissions



Comparison of Milwaukee Area Total PM2.5 Emissions Before and After Weighting

Before weighting

After weighting

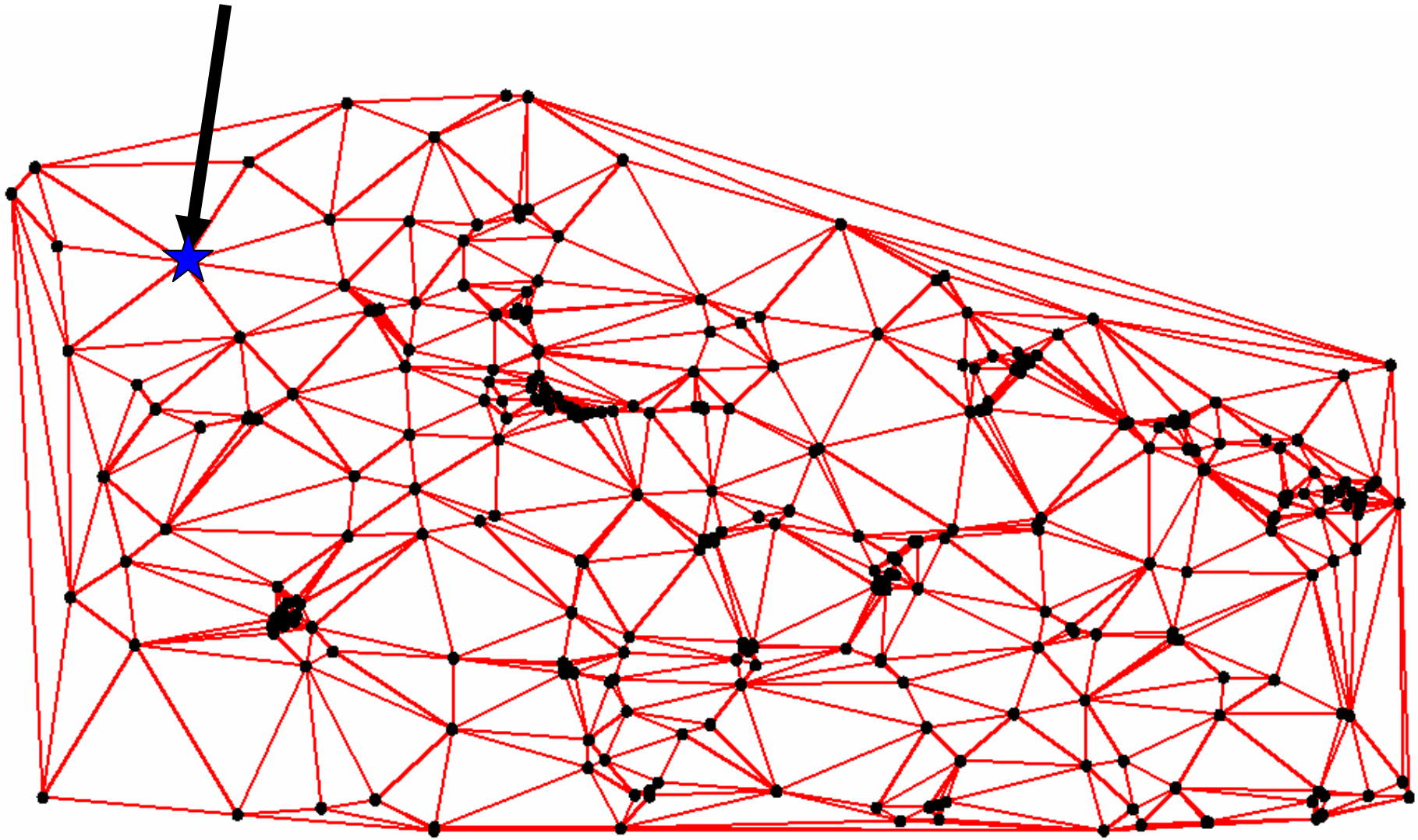


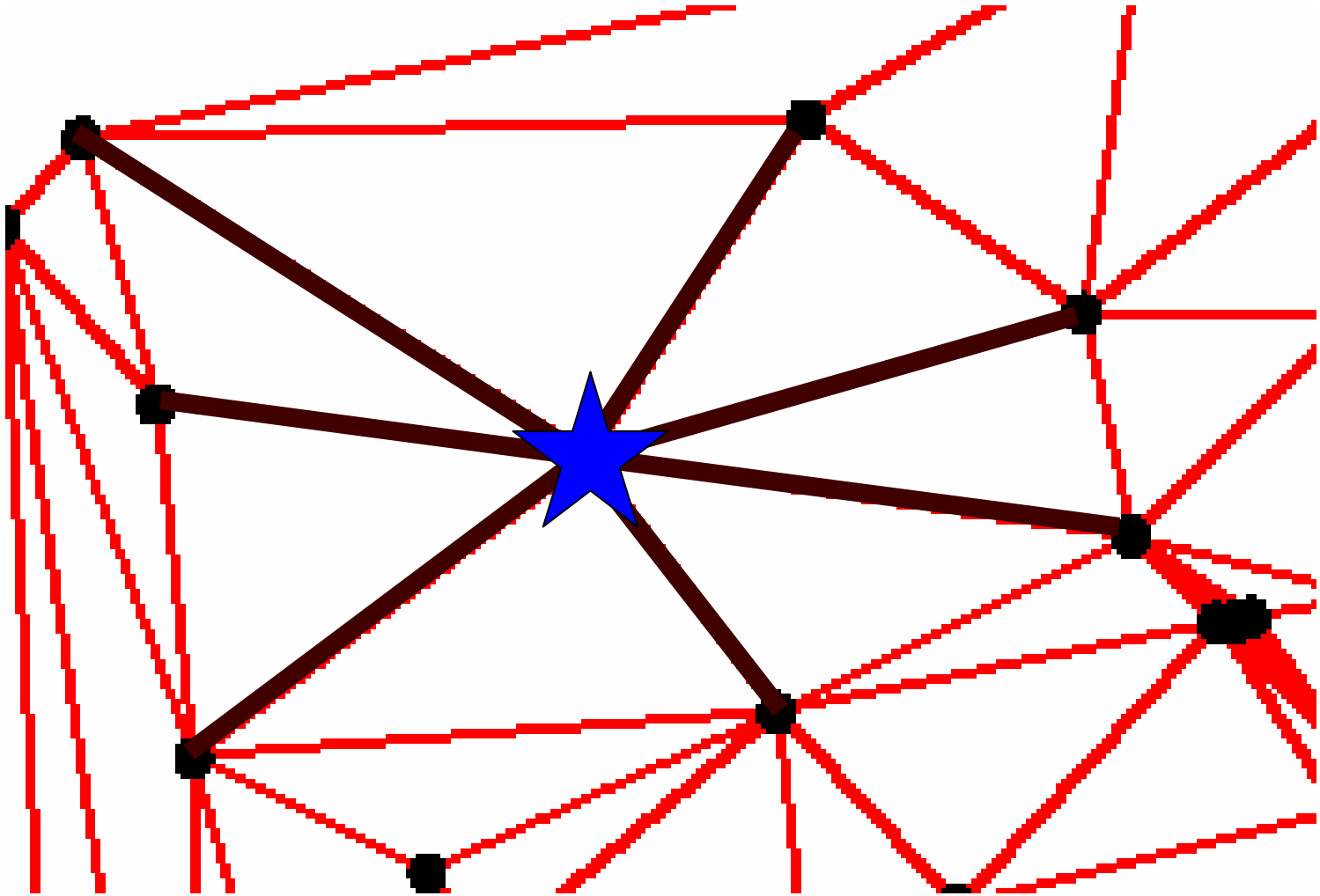
Greater emphasis is placed on those counties where air on high days passed through

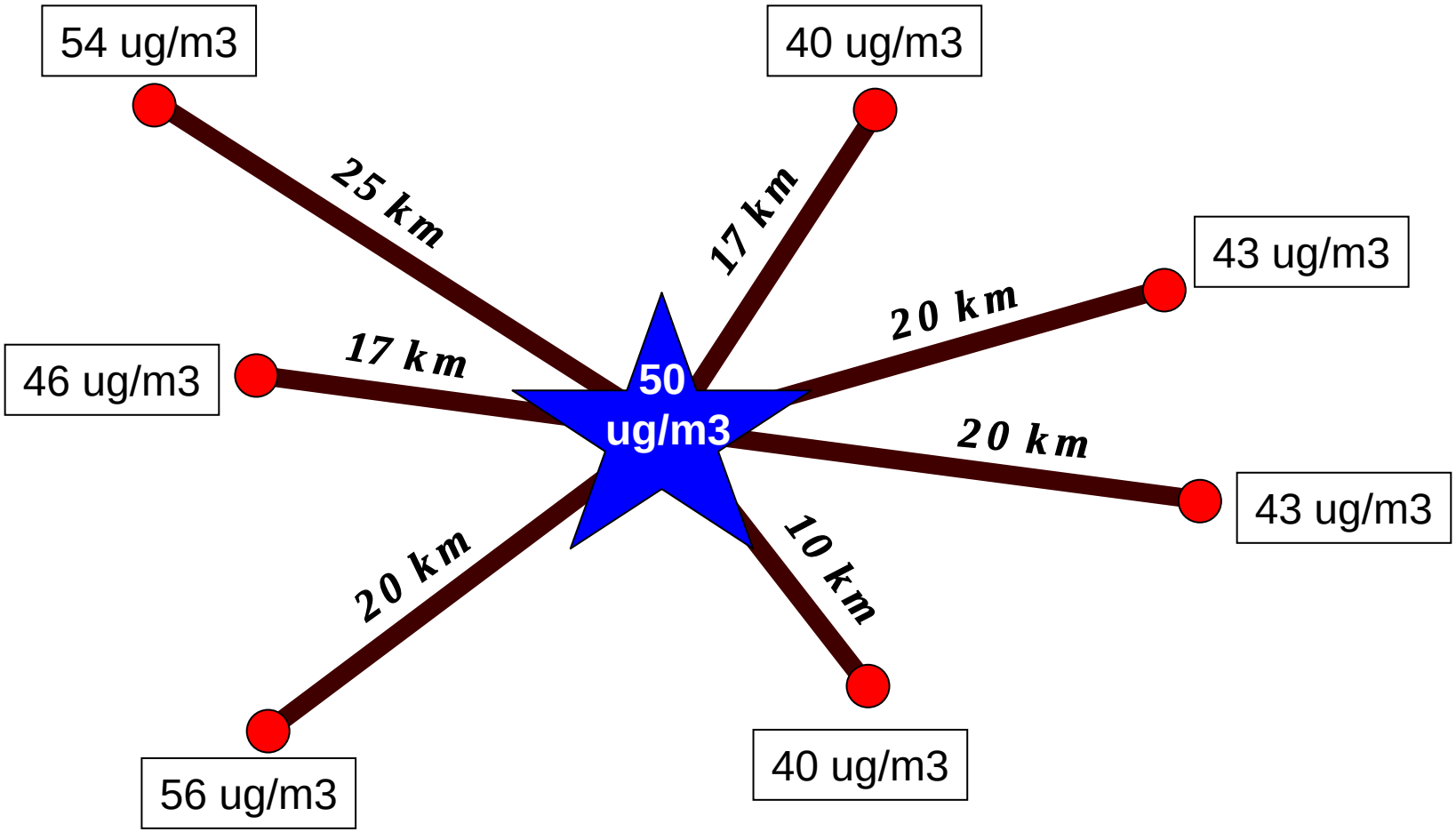
3rd Technique: Urban Gradient

- Identify sites predominantly affected by local sources
- Technique is utilized on a daily basis
- Examines total net gradient between each site and its “neighboring” sites
- Weighted by distance to take into account monitors far apart from one another
- Examine only those sites with net positive gradient
- Utilize meteorological, emissions and satellite data to examine potential sources of gradient

Let’s look at one site in particular







Distance weighted gradient:
(-4 ug/m3 * 0.06) + (10 ug/m3 * 0.13) + ….. + (4 ug/m3 * 0.13) = 6.2 ug/m3

Use percentiles of the gradients' distribution to distinguish high values

Urban Gradient Legend

- PM2.5 Point Sources from National Emission Inventory

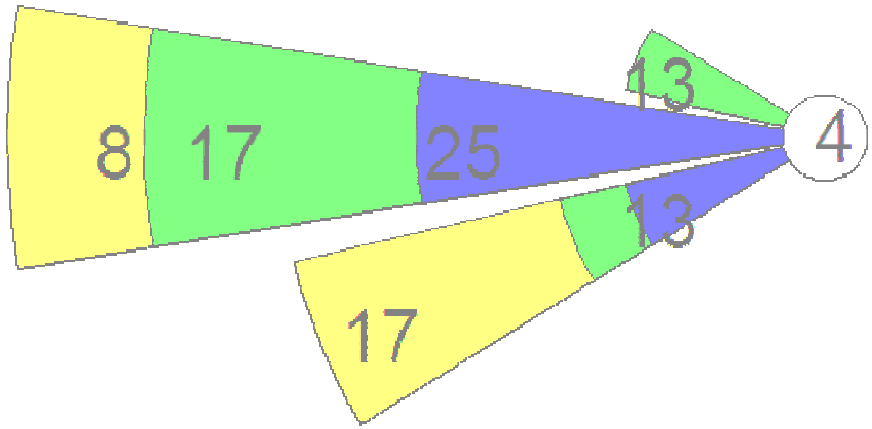
0.5 to 5 tons/year

6 to 15 tons/year

16 to 30 tons/year

31 to 50 tons/year

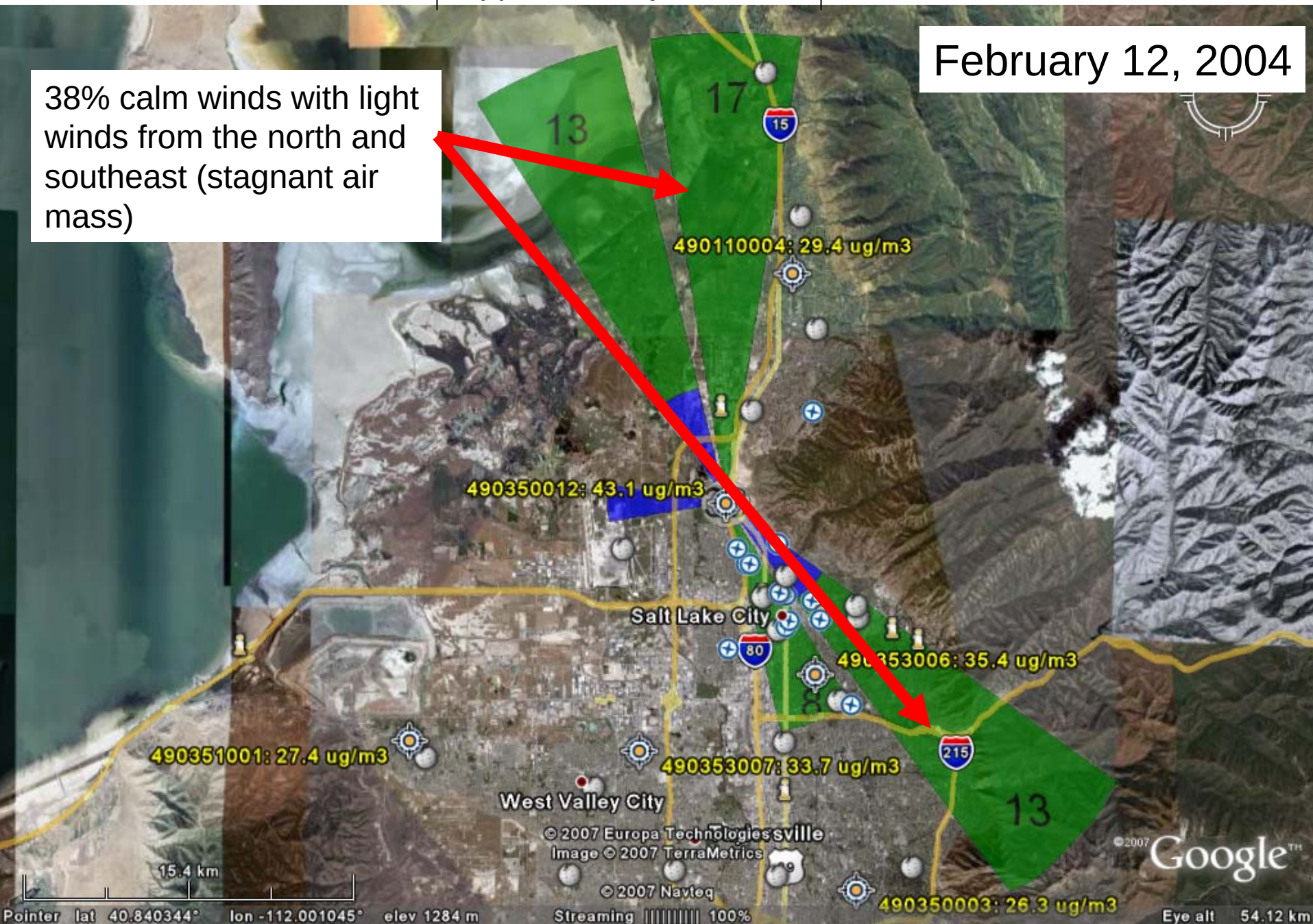
Greater than 50 tons/year



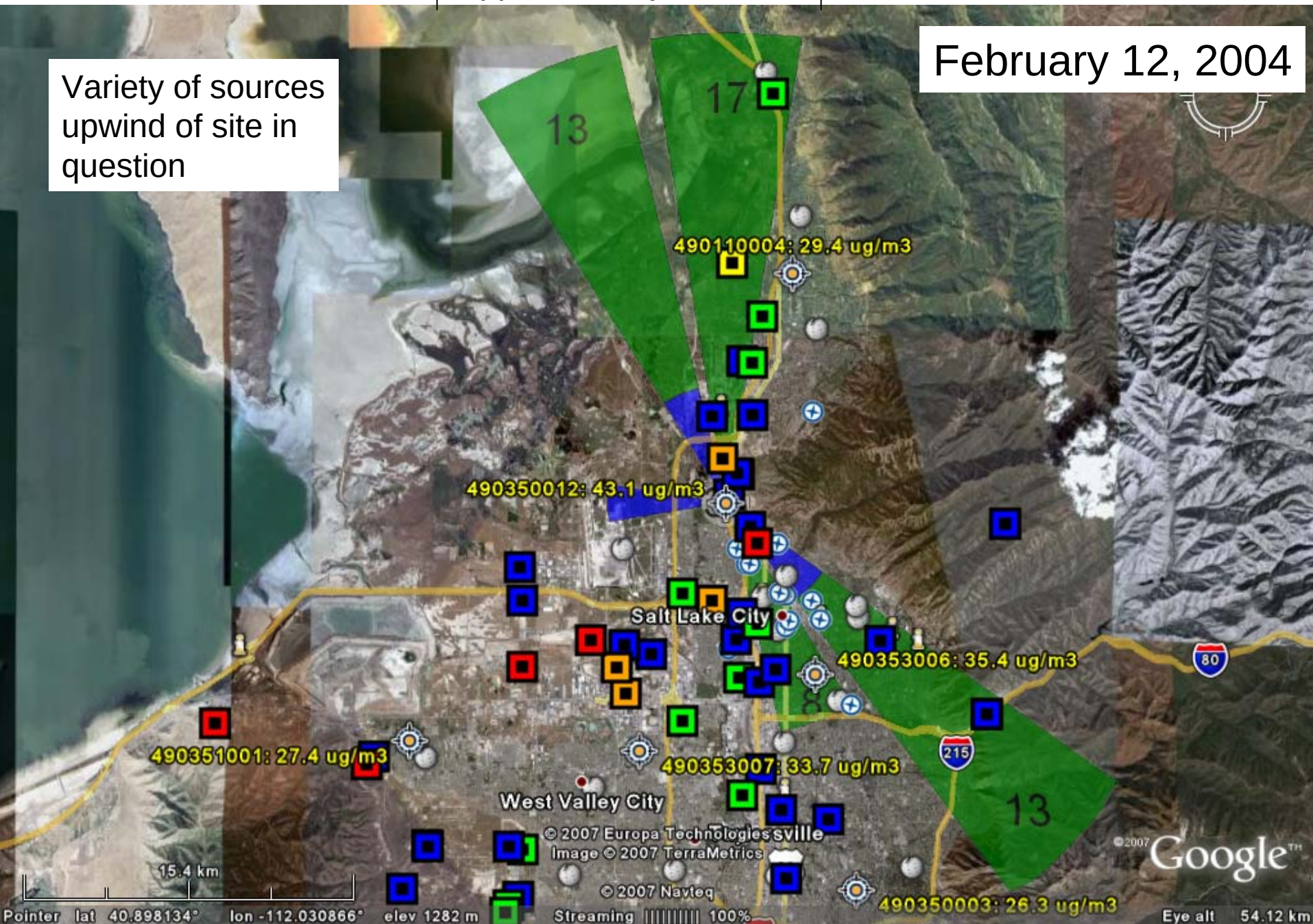
- Windroses
  - Frequency distribution of 24 hour measured wind speeds by wind direction
  - Numbers represent the percentage that the wind speed was coming from that direction during the day
  - Colors represent wind speeds (Cooler colors represent lower wind speeds)
    - Blue: 1-5 mph
    - Green: 5-10 mph
    - Yellow: 10-15 mph
    - Orange: 15-20 mph
    - Red: 20-25 mph
    - Purple: >25 mph

approximately 110 miles

approximately 40 miles



approximately 40 miles

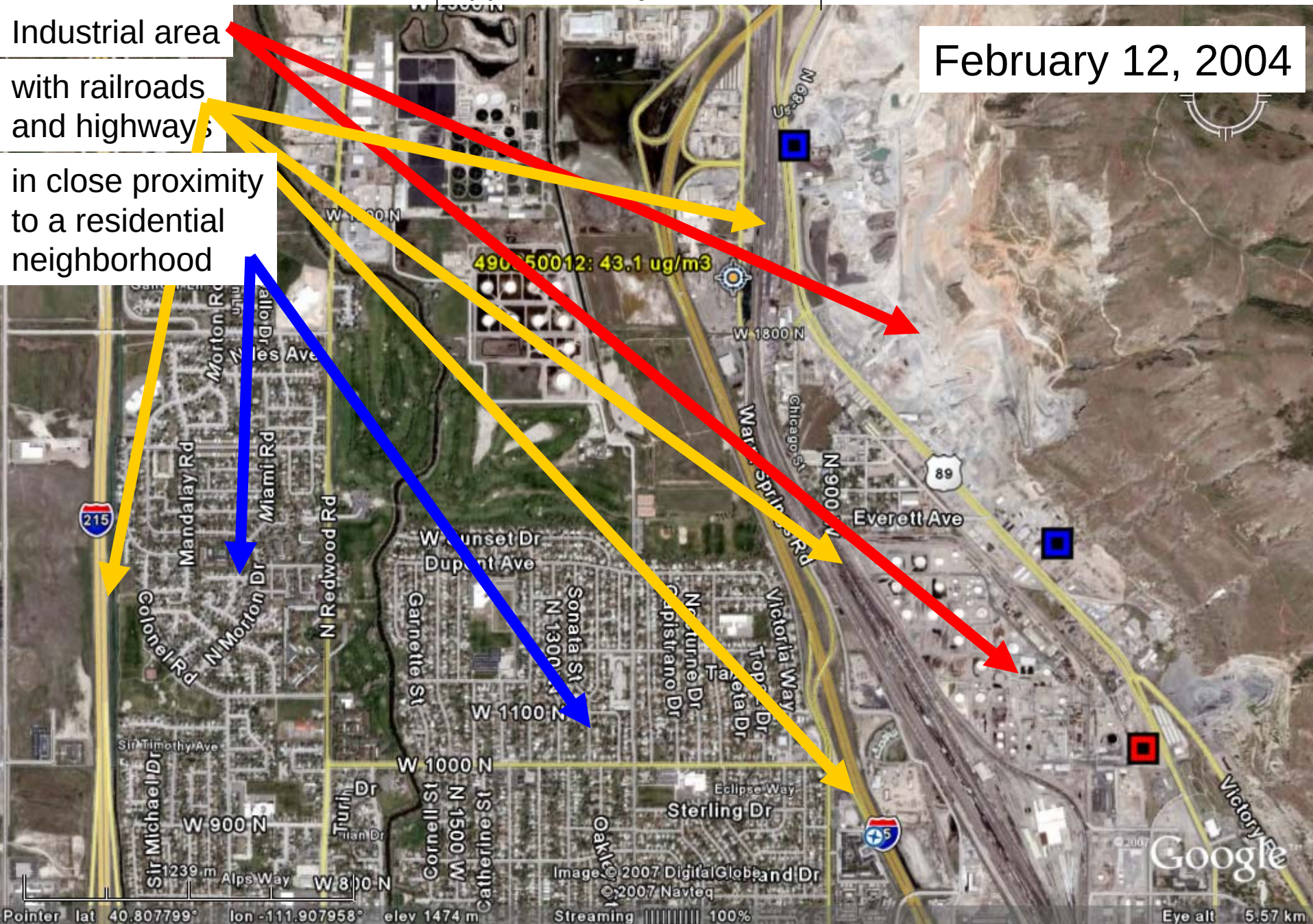


approximately 5-7 miles

Industrial area

with railroads and highways

in close proximity to a residential neighborhood



Urban Gradient

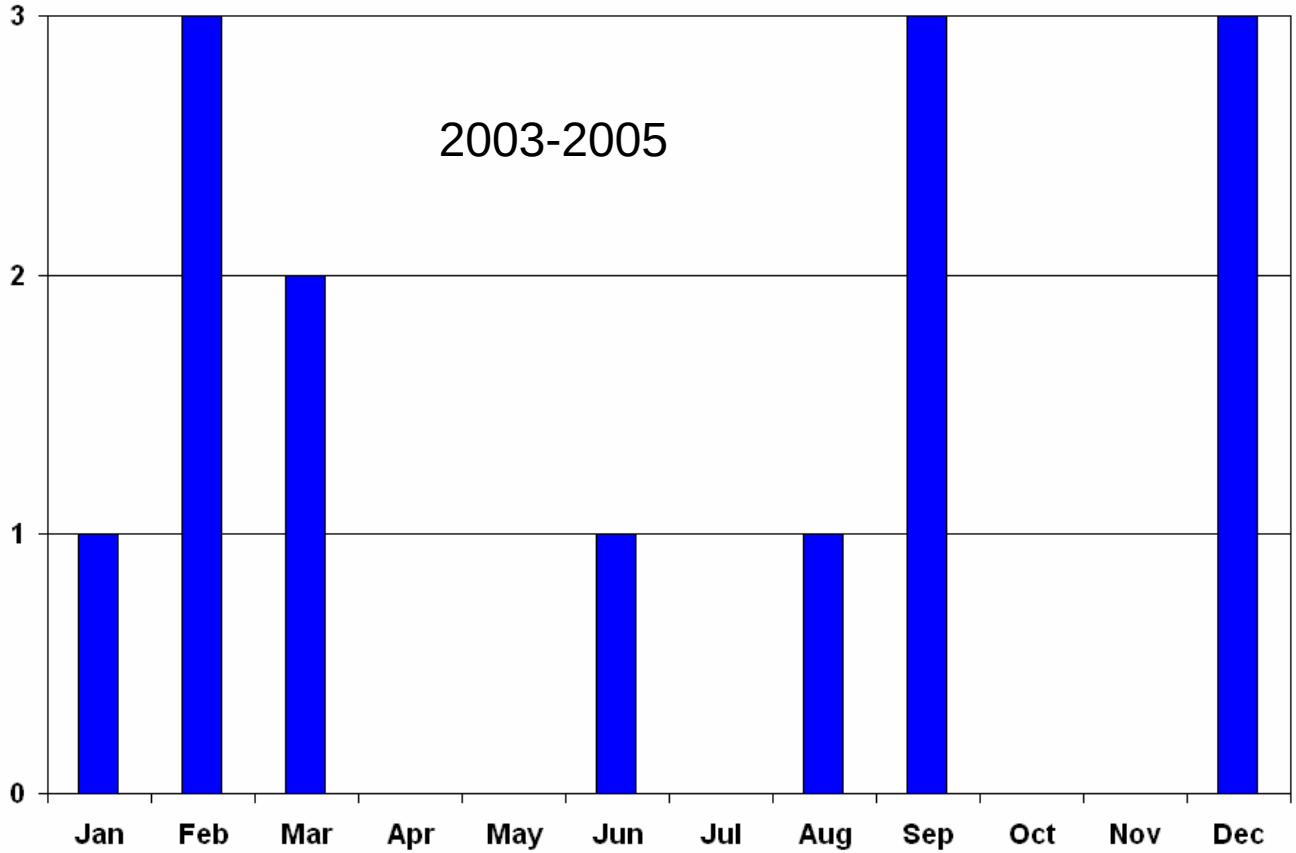
- Exploring how often gradients in areas with high 24 hour concentrations occur on days greater than 35 ug/m3
- Attempting to quantify the magnitude of the gradient in relation to regional and urban influences to determine the local source influence above and beyond the regional and urban contributions

Integrating the Three Techniques

- Envision using all three techniques for areas across the country
  - ***Residence time weighted emissions:*** Isolate geographic areas which may be substantial contributors to the area's ambient PM2.5 concentrations on more of a regional scale
  - ***SLICE + Urban Gradient***: Integrate between the two techniques to isolate specific days with gradients above and beyond the overall urban contribution

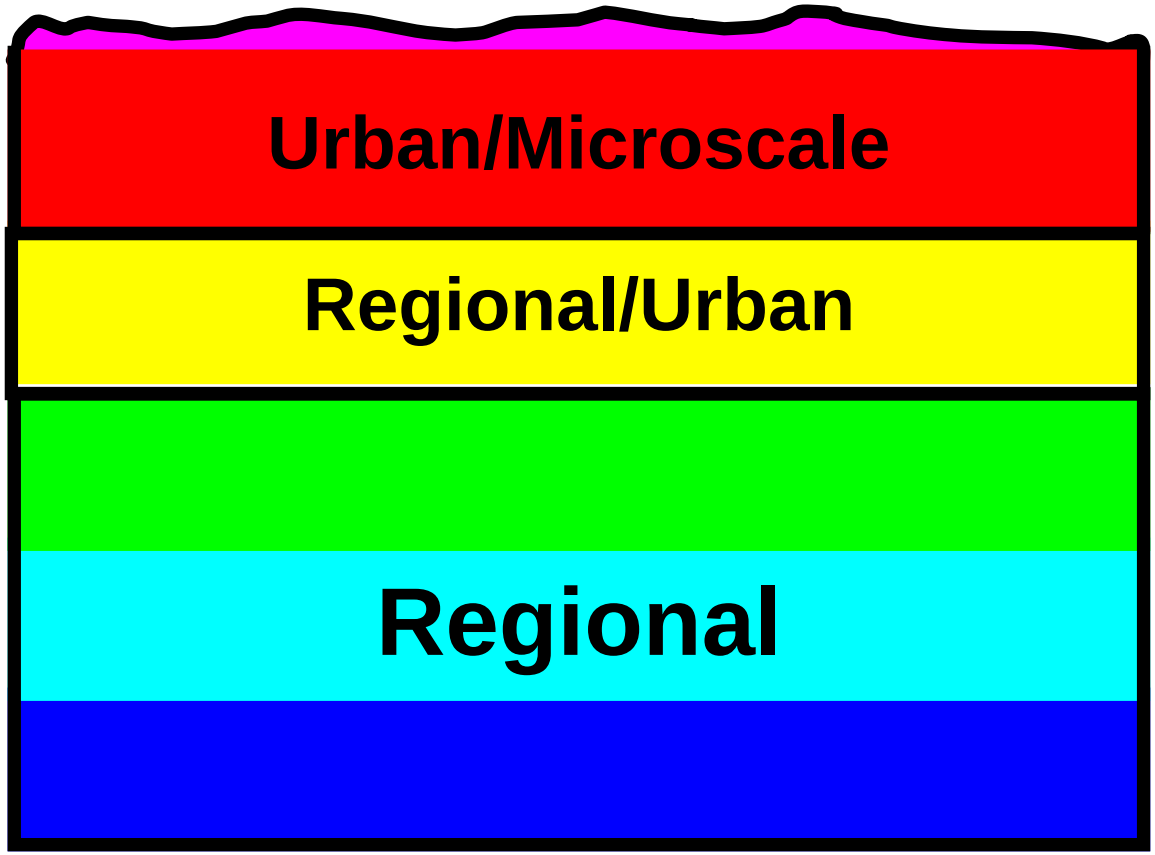
An Example of Utilizing All Three Techniques in Milwaukee, WI

- When did the high days in Milwaukee occur?



The high days in Milwaukee mostly occur during the winter months.

Milwaukee High Day SLICE Results

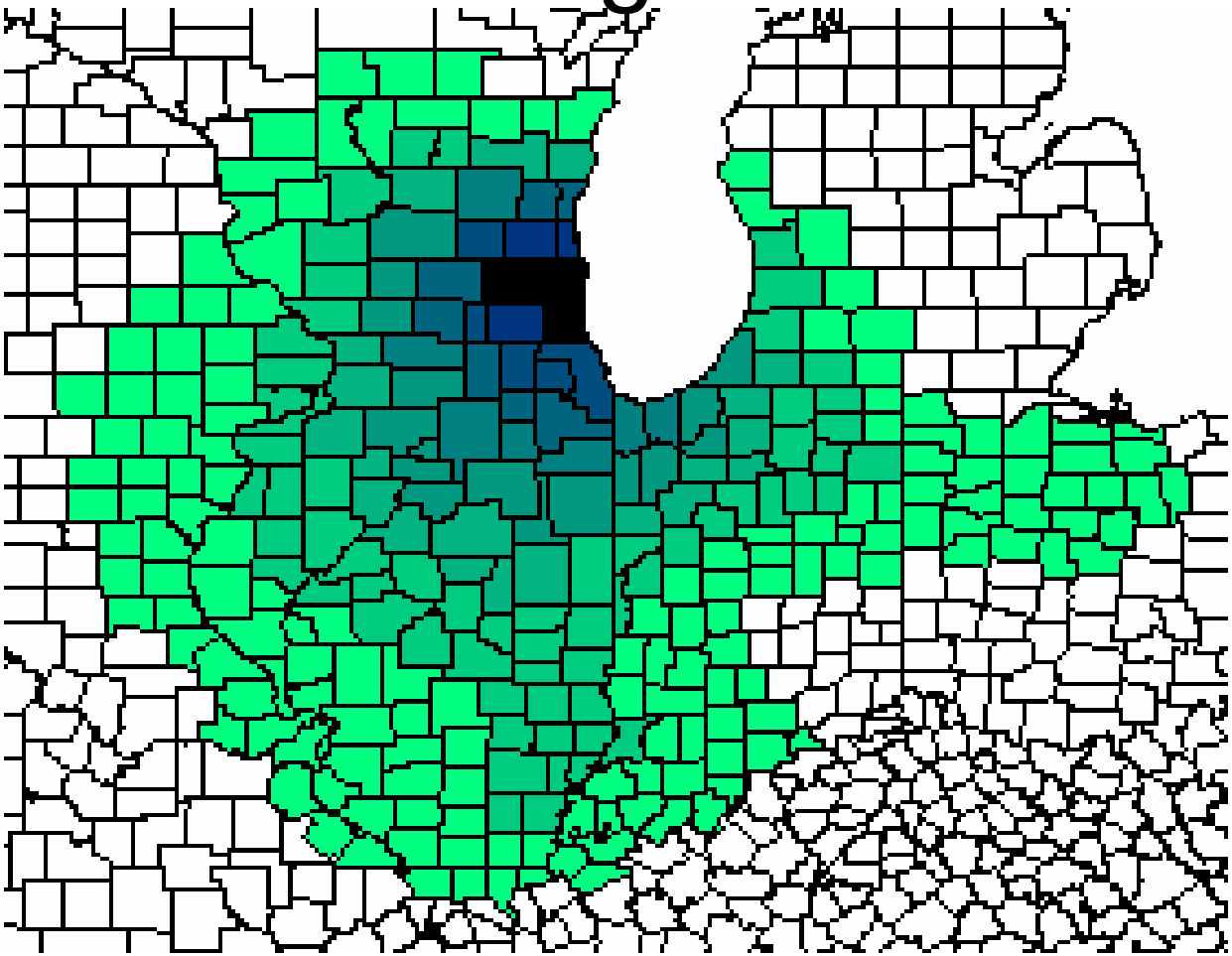


Mean: 2.9 ug/m3
Range: 0.0-16.6 ug/m3

Mean: 5.4 ug/m3
Range: 0.0-10.5 ug/m3

Mean: 28.8 ug/m3
Range: 19.9-41.0 ug/m3

Residence Time Weighted Emissions



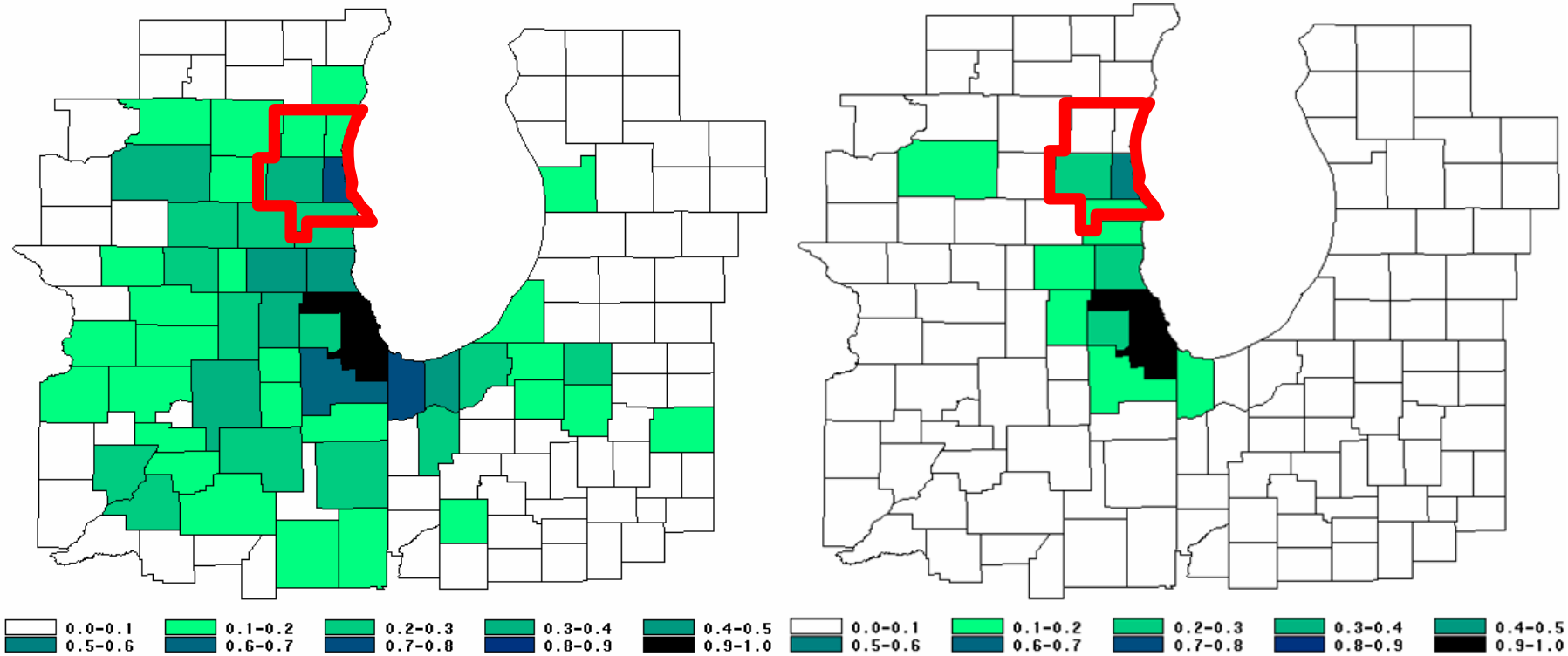
Trajectory densities for the high days in Milwaukee CSA.

A lot of the trajectories coming into Milwaukee go through central Illinois and Northwest Indiana as well as the “collar” counties surrounding Milwaukee

Residence Time Weighted Emissions

Crustal weighted emissions

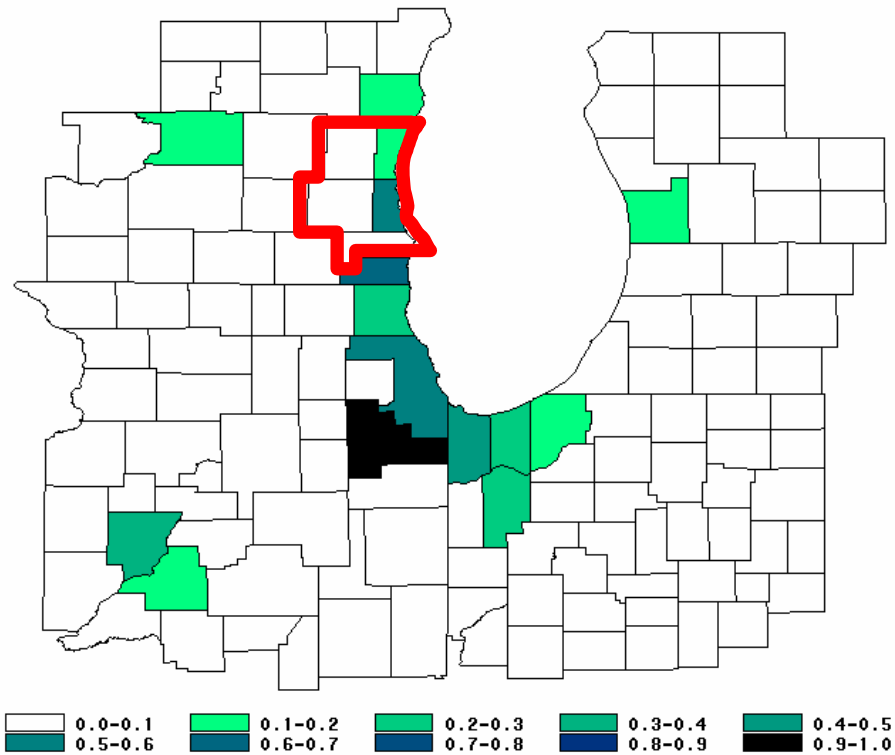
Total Carbon (EC and OC) weighted emissions



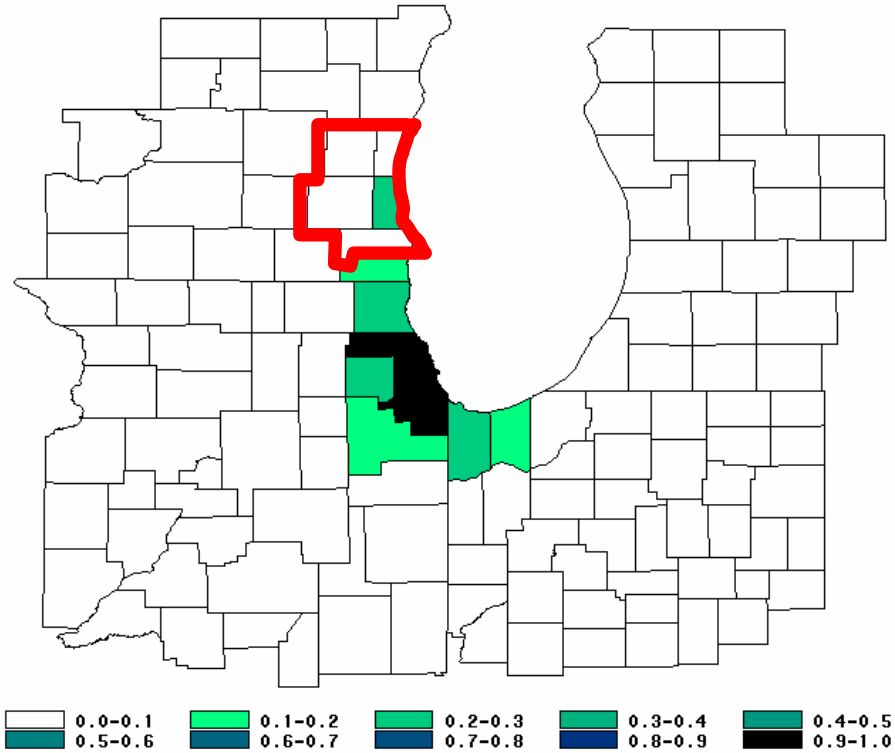
Weighted crustal and total carbon emissions would suggest local impacts from the Milwaukee CSA as well as possible impacts from Chicagoland area

Residence Time Weighted Emissions

SO2 weighted emissions



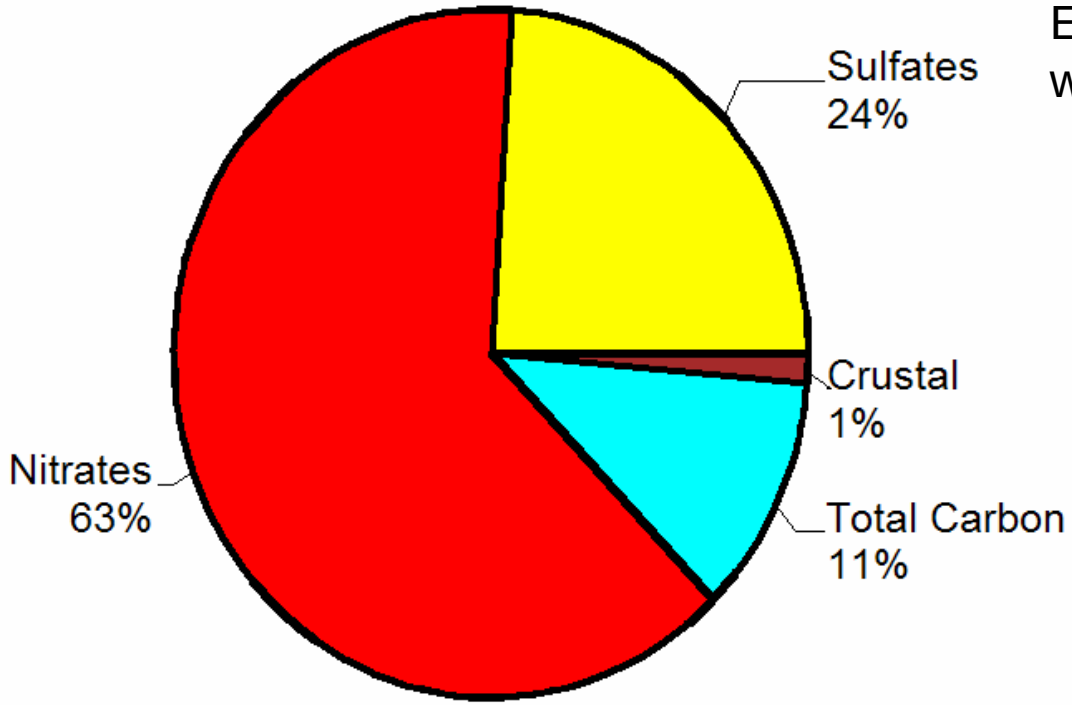
NOx weighted emissions



SO2 and NOx as an indicator of secondary PM2.5 suggest emission influences from the Chicago area with some indication that there are also contributions from emissions within Milwaukee County

Creating a Total Influential Emissions Score

- Look at the average species composition across the high days by season for the daily increment over and above the seasonal average



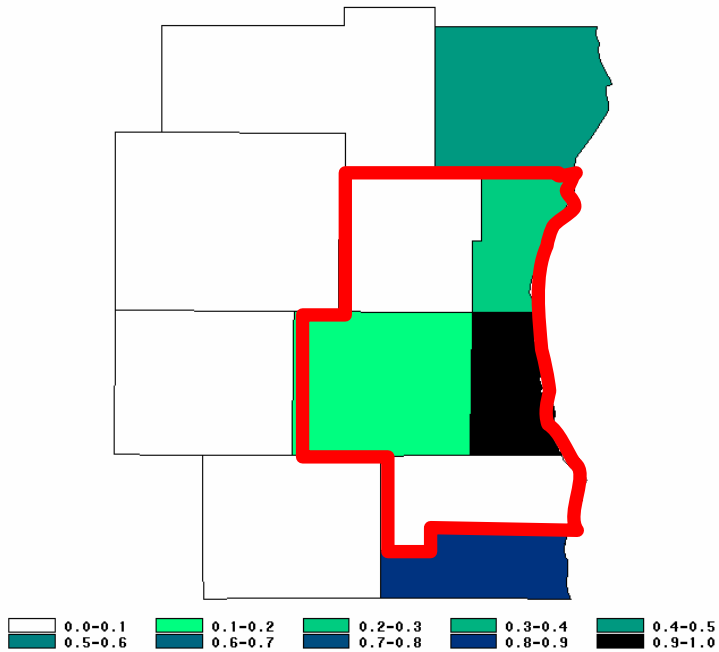
Example of the average winter composition

Other seasonal compositions will look different (e.g. summer will have a majority of sulfates)

Total Influential Emissions Score

- Multiplying the corresponding seasonal weight by each component and summing over all seasons give the total influential emissions score for the area **(CSA +surrounding counties)**

County	Total Influential Emissions Score
Dodge	3848
Fond du Lac	4010
Jefferson	4176
Kenosha	63986
Milwaukee	74107
Ozaukee	18083
Racine	6002
Sheboygan	35692
Walworth	4700
Washington	3900
Waukesha	13110

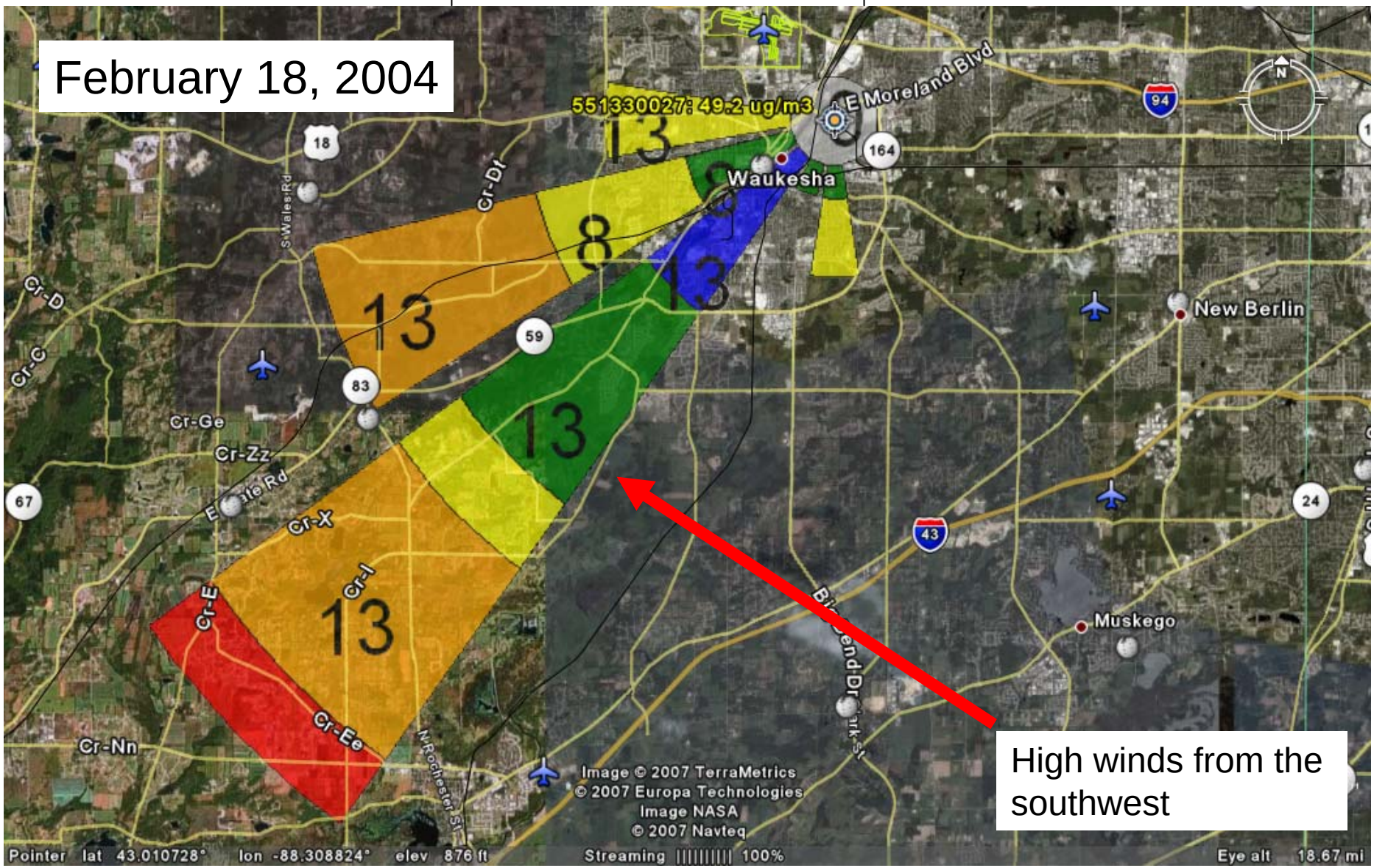


Milwaukee Site Gradients

approximately 300 miles

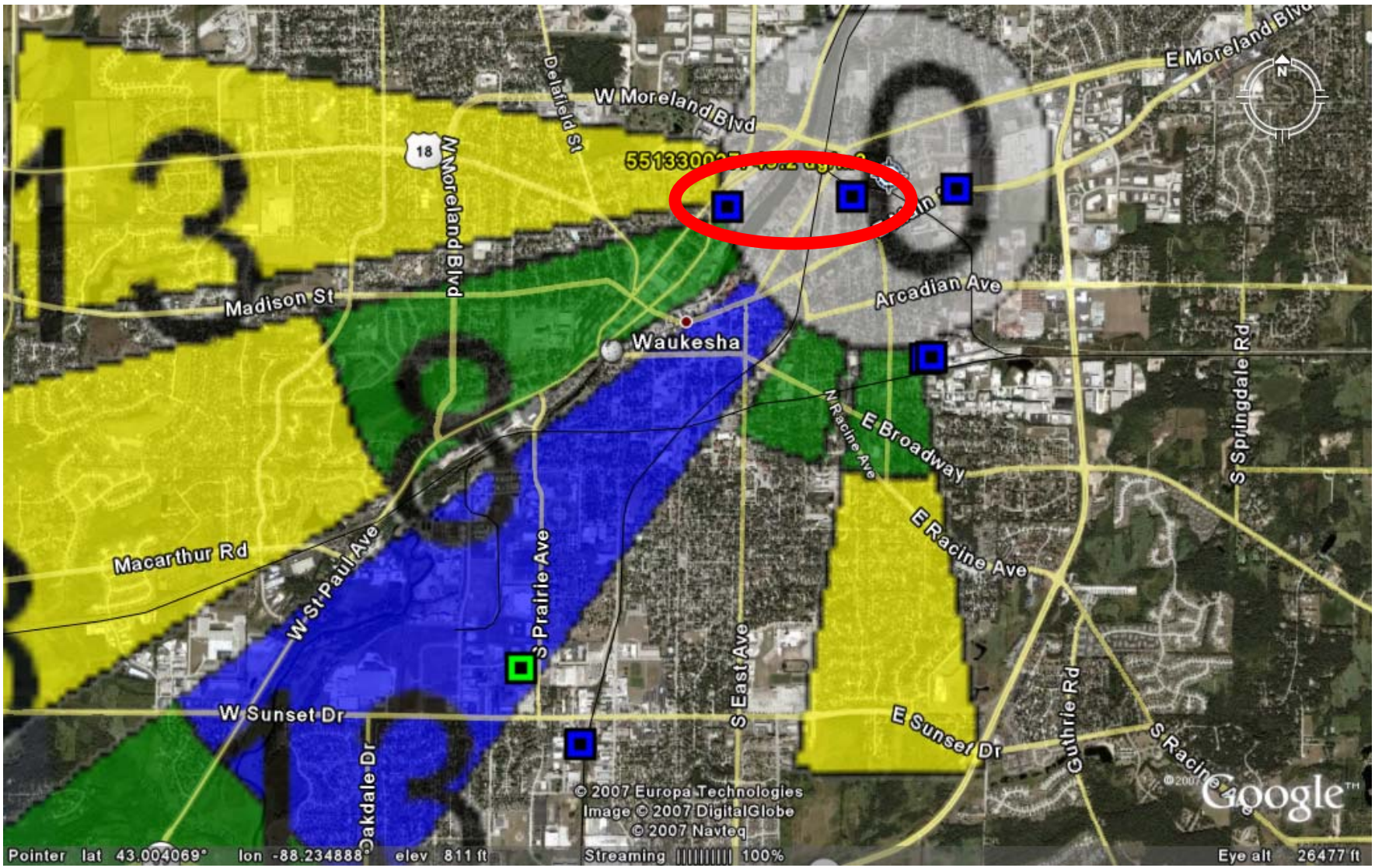
What did the winds look like?

approximately 20 miles

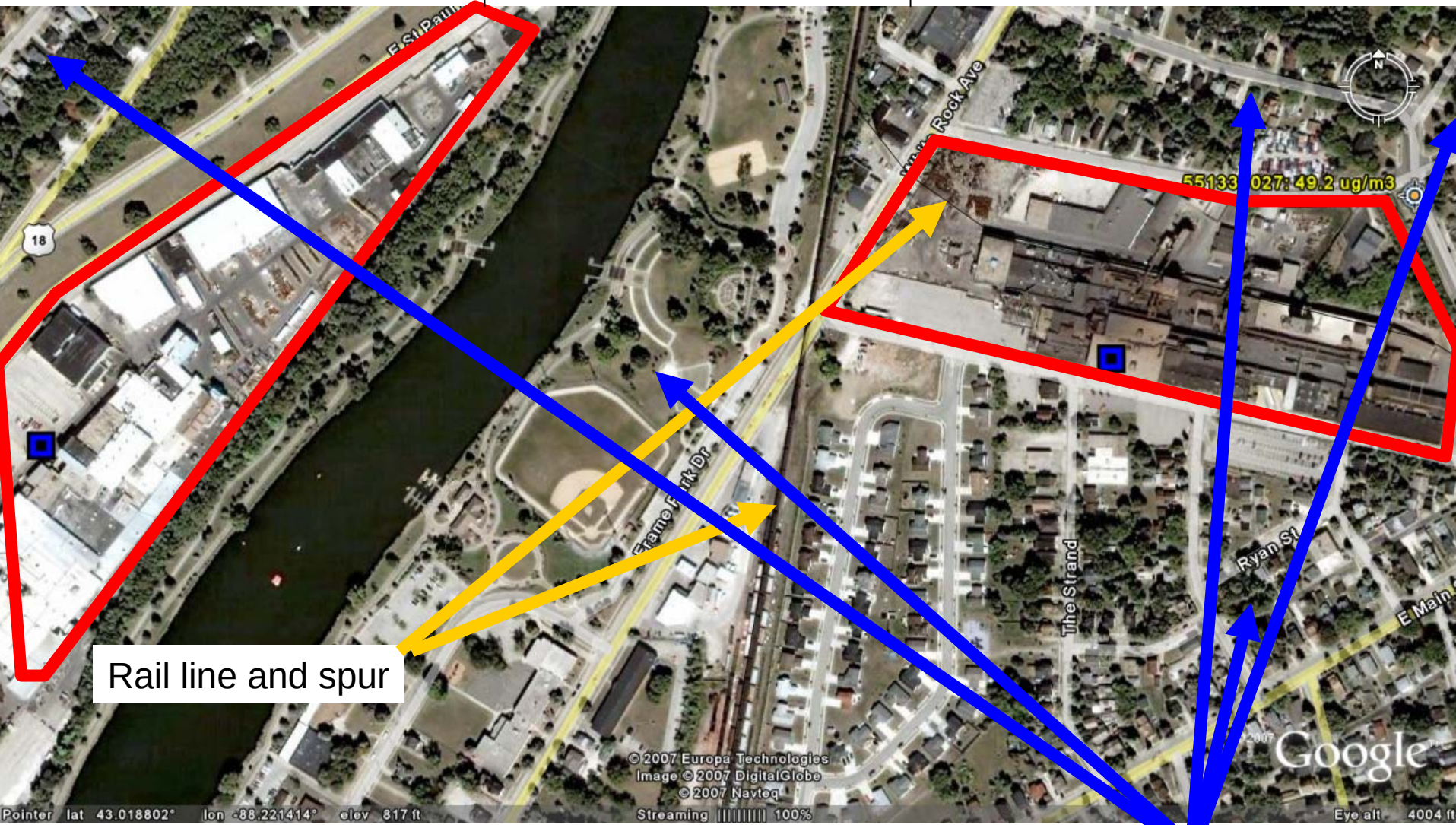


What local sources are nearby?

approximately 5-7 miles



Less than one mile



What does the example show?

- High days in Milwaukee can have high regional concentrations even before the urban contribution is added into the total PM2.5 concentration
- Winds on the high days in Milwaukee predominantly come from the south blowing across central Illinois and also includes the Chicagoland area

What does the example show?

- Total Influential Emissions Scores show that emissions from counties outside the Milwaukee CSA influence the ambient PM2.5 concentrations in Milwaukee
- Urban Gradients
  - More analysis is needed to determine frequency of days with higher gradients
  - Need to determine magnitude of the gradient in relation to the regional and urban contributions to better estimate the contribution from the local sources versus the regional/urban contributions for control strategy purposes