

AIR QUALITY MONITORING

Part 5 – Trending and interpreting the data



Community Action to Promote Healthy Environments (CAPHE)

Stuart Batterman (stuartb@umich.edu)

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Wind Roses

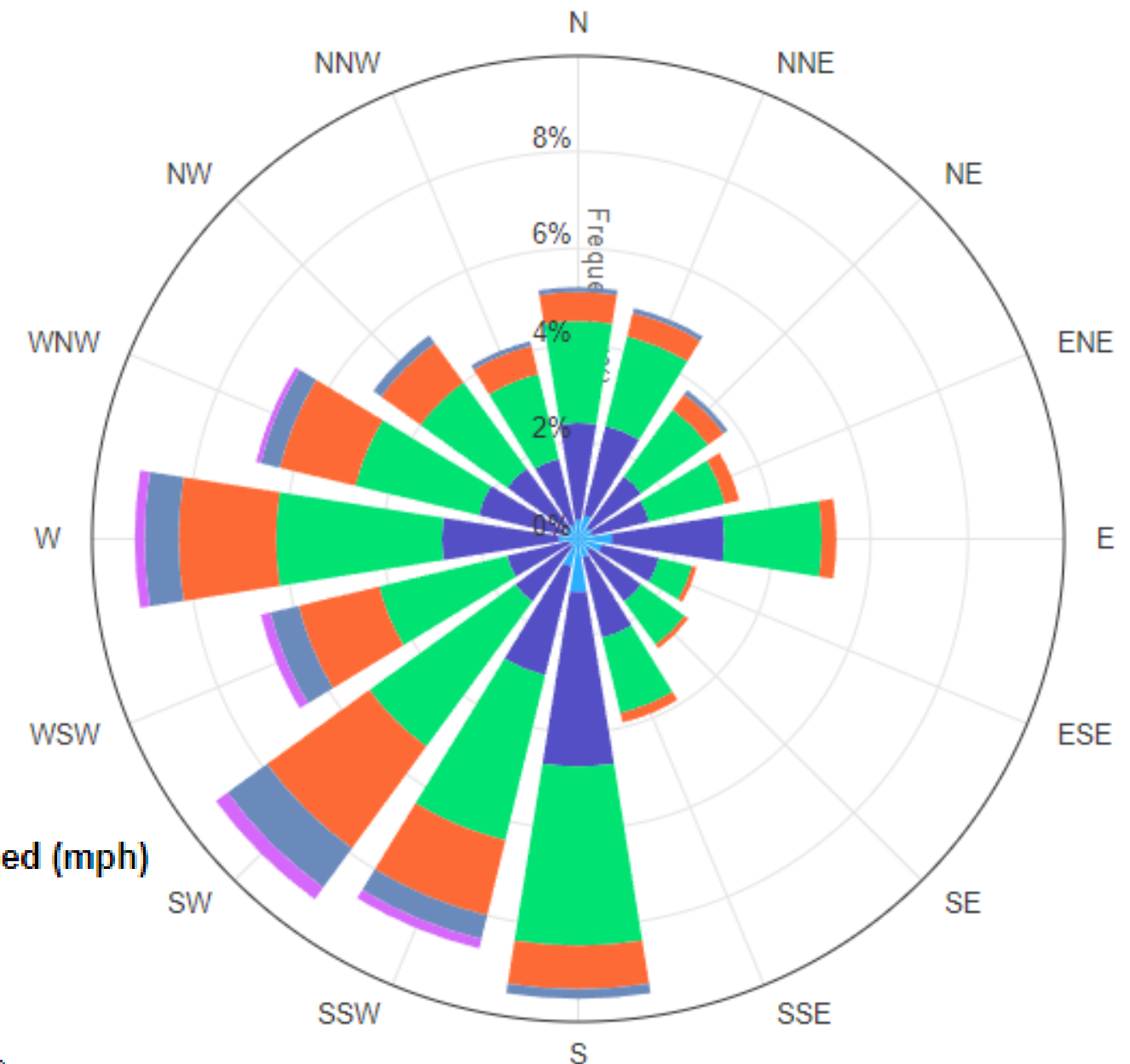
A wind rose displays how wind speed and direction typically occur at a particular location. They show the frequency of winds over a time period by wind direction, with color bands showing wind speed ranges. The direction of the longest “spoke” (or “arm” or “petal”) shows the wind direction that occurs most frequently.

- ▶ Wind roses shows how often winds blow **from** each direction.
- ▶ The 16 cardinal directions are used, e.g., north (N), NNE, NE, etc.
- ▶ The spoke length is calibrated to concentric circles that represents different frequencies (e.g., 0% at the center to 10% at the outer circle.)
- ▶ Color-coded bands show wind speed ranges.

Wind roses help to understand influence of local air pollution sources.

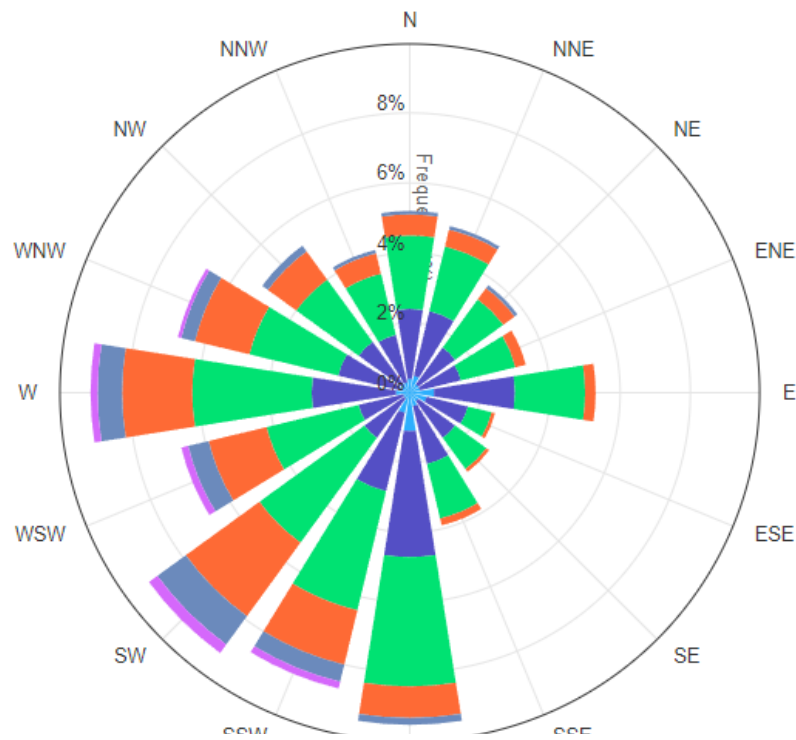
Wind Rose for Detroit Metro Airport

Jan. 1, 2017 - Dec. 31, 2022
Sub-Interval: Jan. 1 - Dec. 31, 0 - 23

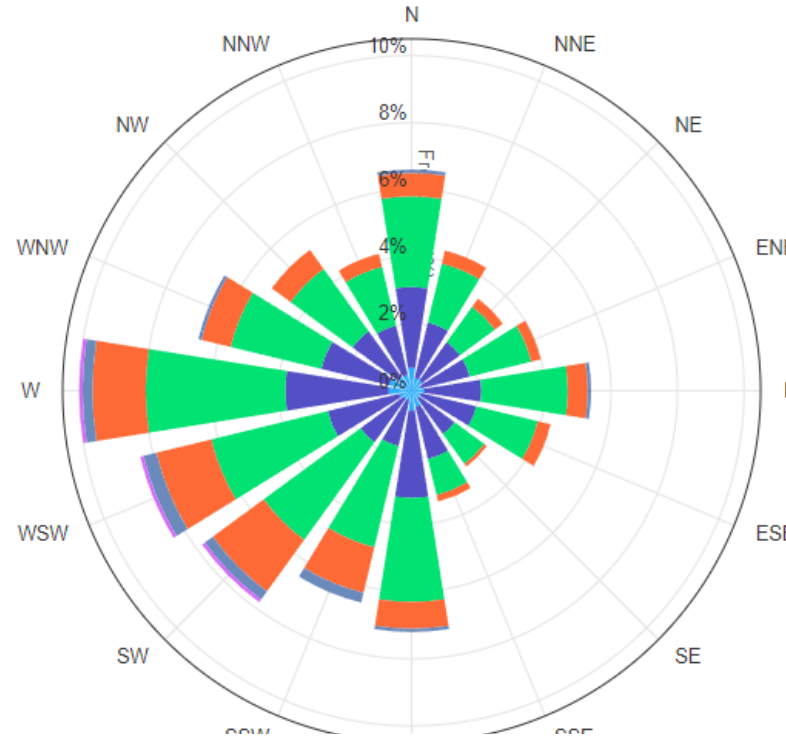


Wind roses – depend on location

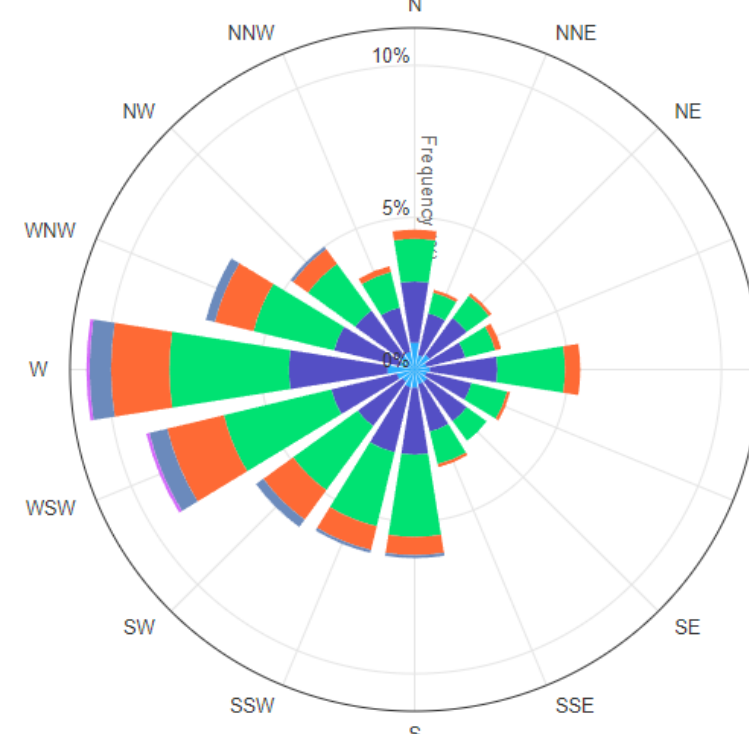
1 Detroit Metro Airport
Wayne County



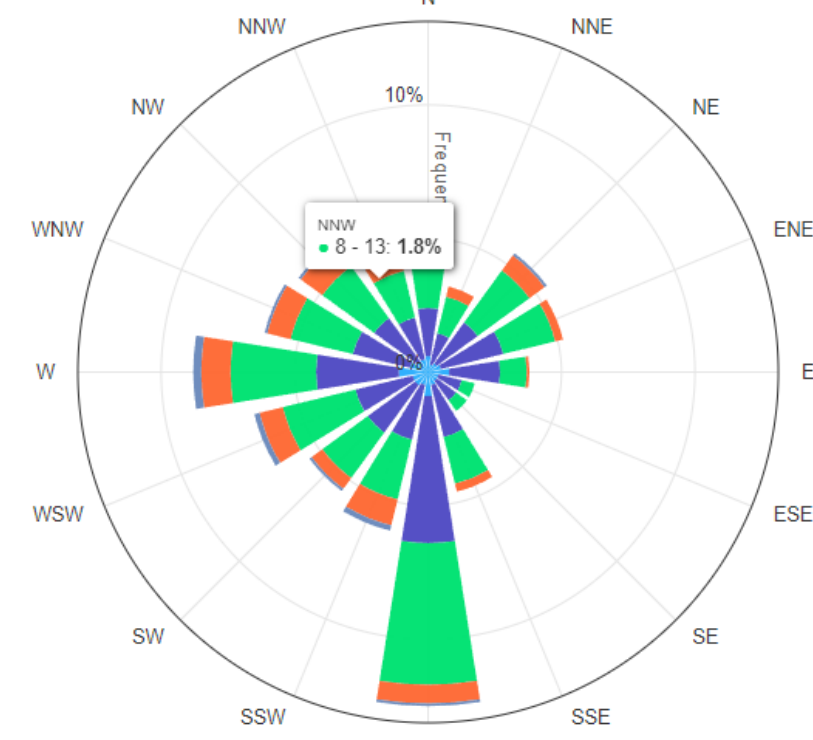
2 Detroit City Airport
Wayne County



3 Custer Airport
Monroe County



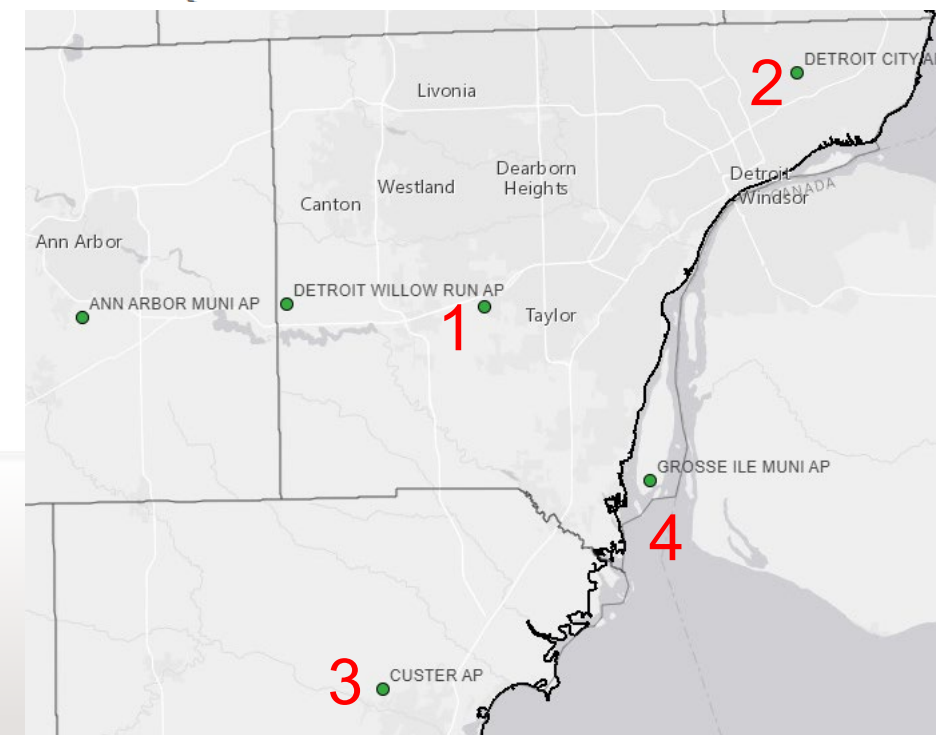
4 Gross Ile Muni Airport
Wayne County



- 4 - 8
- 8 - 13
- 13 - 19
- 19 - 25
- 25 - 32

Map showing location of airports →

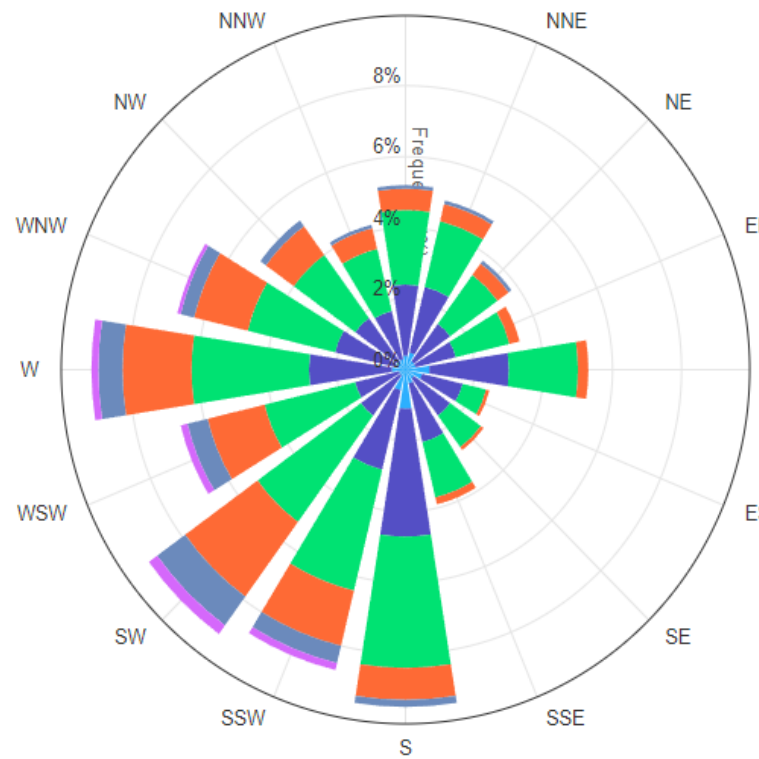
All sites are relatively close, but wind speed and direction are influenced by nearby terrain features and water bodies



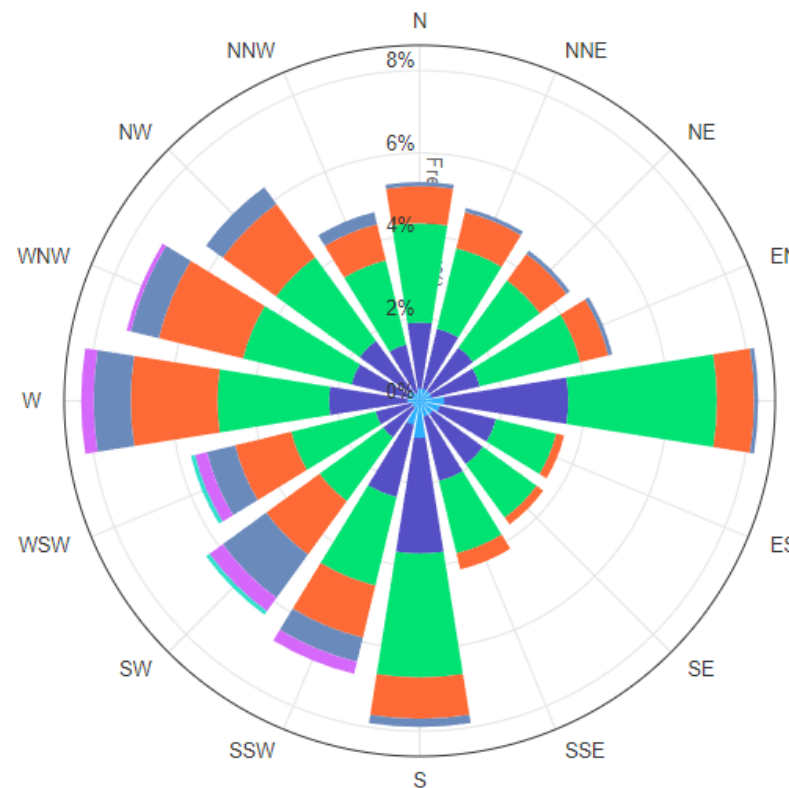
5 year 2017-2021 data

Wind roses – depend on season and time of day

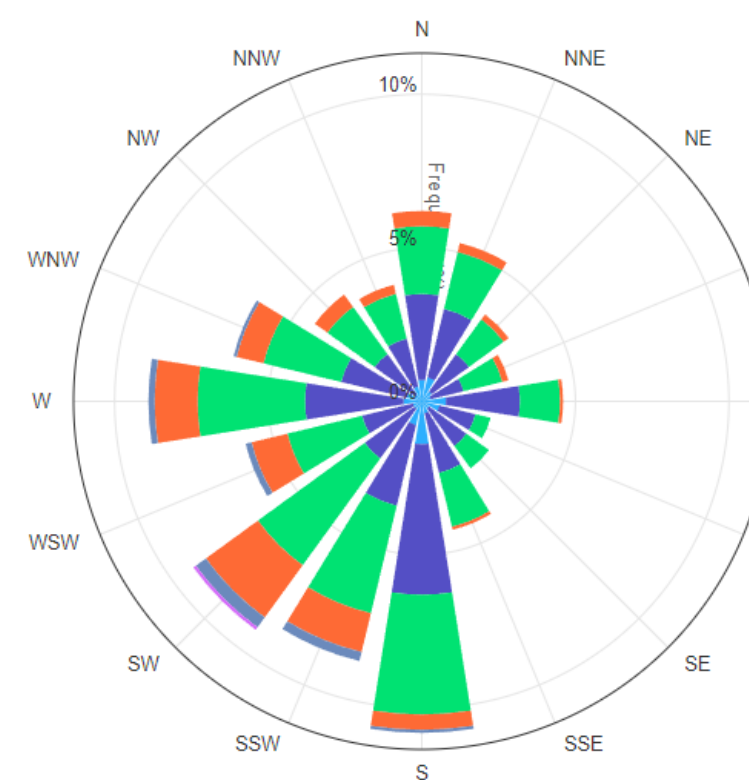
1 Detroit Metro Airport Annual



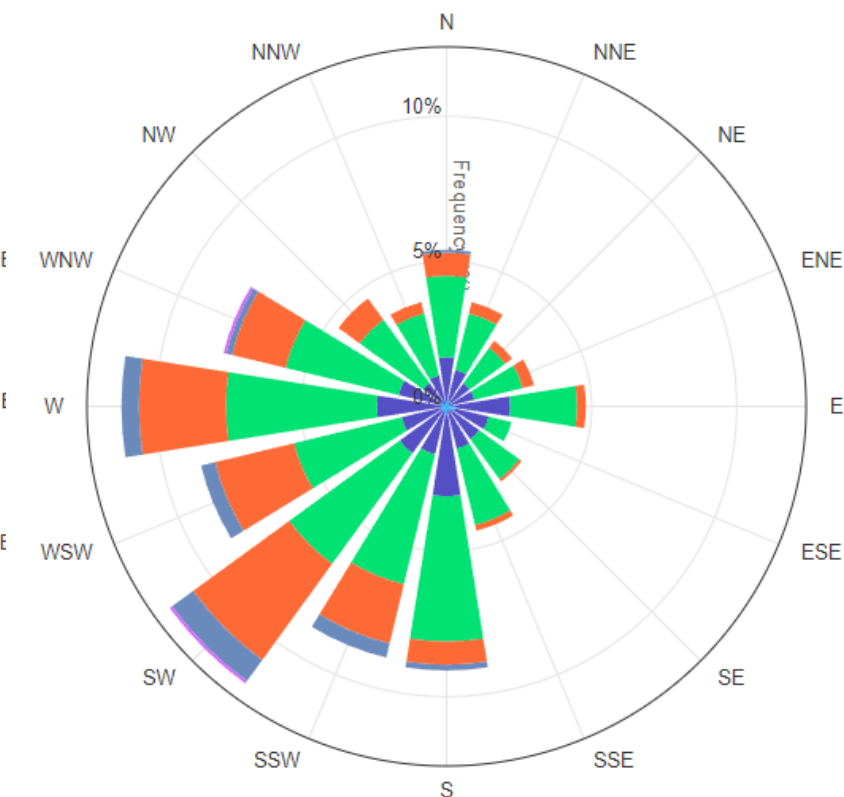
2 Detroit Metro Airport Spring (March-May)



3 Detroit Metro Airport Summer (June-Aug)



4 Detroit Metro Airport Summer & 8 am-5 pm

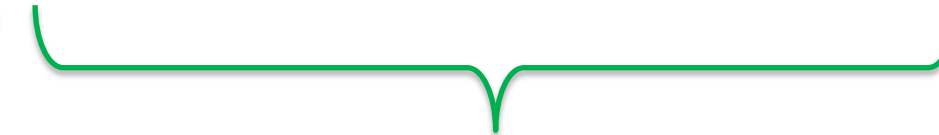


Wind Speed (mph)

- 1.3 - 4
- 4 - 8
- 8 - 13
- 13 - 19
- 19 - 25
- 25 - 32



In Michigan, winds tend to depend strongly on seasons. Often, winds in spring and fall are highly variable; winds in summer often are often southerly; winds in winter are largely from the northwest.



Time of day is important as industrial activity and traffic often occurs during 8-5 (working hours). Wind patterns and pollutant dispersion are strongly influenced by time of day.

Pollution Roses

Pollutant roses are graphical displays that show concentration at a monitoring point by wind direction or sector. Pollution roses can indicate the pollution due to upwind emission sources. Roses are typically constructed with 16 sectors, like a standard compass, each sector with a “petal” or “arm” that has a length proportional to concentration in that direction.

- ▶ If the pollution rose has one or several “petals” with high concentrations, then a pollution source is likely in those directions.
- ▶ If the wind rose is symmetrical or round, with all petals showing about the same direction, then there is little effect of wind direction. This may mean that there are sources in many directions, that the pollutant is coming from distant sources, or the pollutant is formed in the atmosphere.

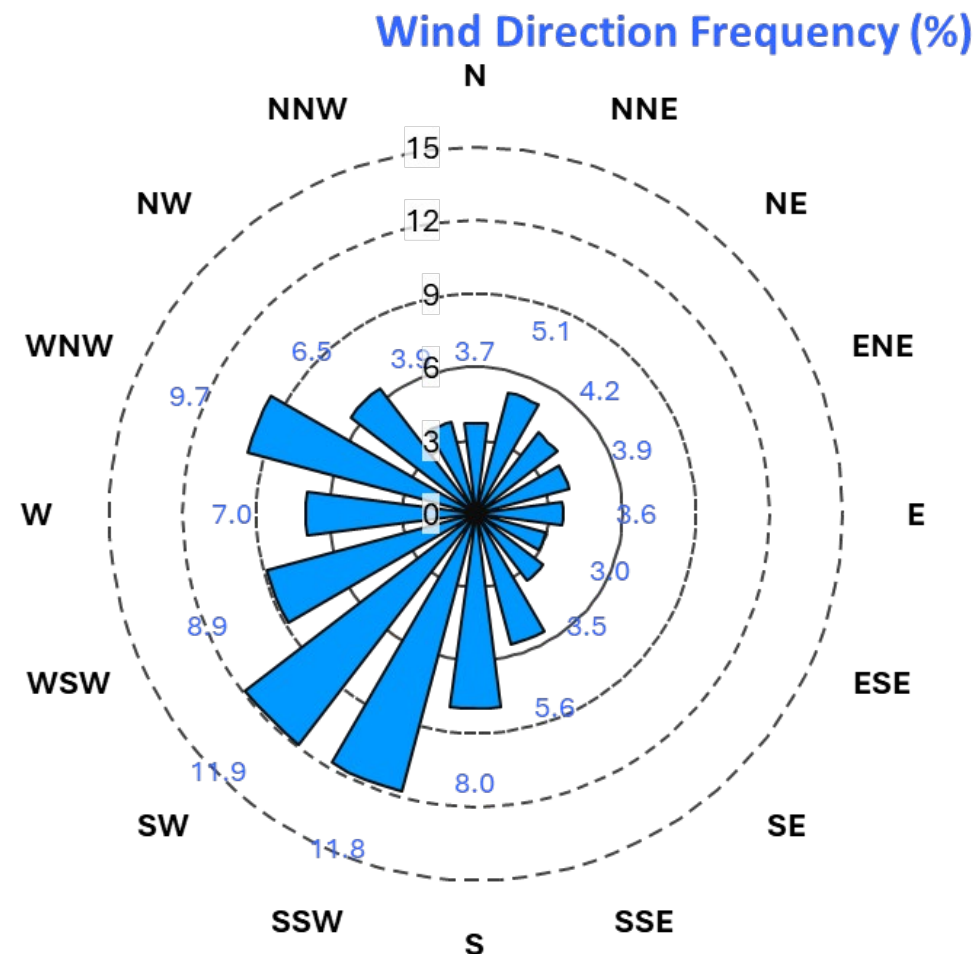
Pollution roses are most informative for certain pollutants, mainly those that have low background levels and strong local sources. To make effective use of pollution roses:

- ▶ You need quite a bit of hourly data, typically months to years
- ▶ It helps to only consider data when winds exceed 3-5 m/s to avoid periods when winds meander and wind directions at remote sites may not be useful. Roses won't work with low wind speeds.
- ▶ Often, displaying medians or upper percentile concentrations may be more powerful than the mean.
- ▶ Consider the wind rose for the same period, which will show you which sectors had wind.

In the best case, wind roses for different locations can intersect and point to the offending source.

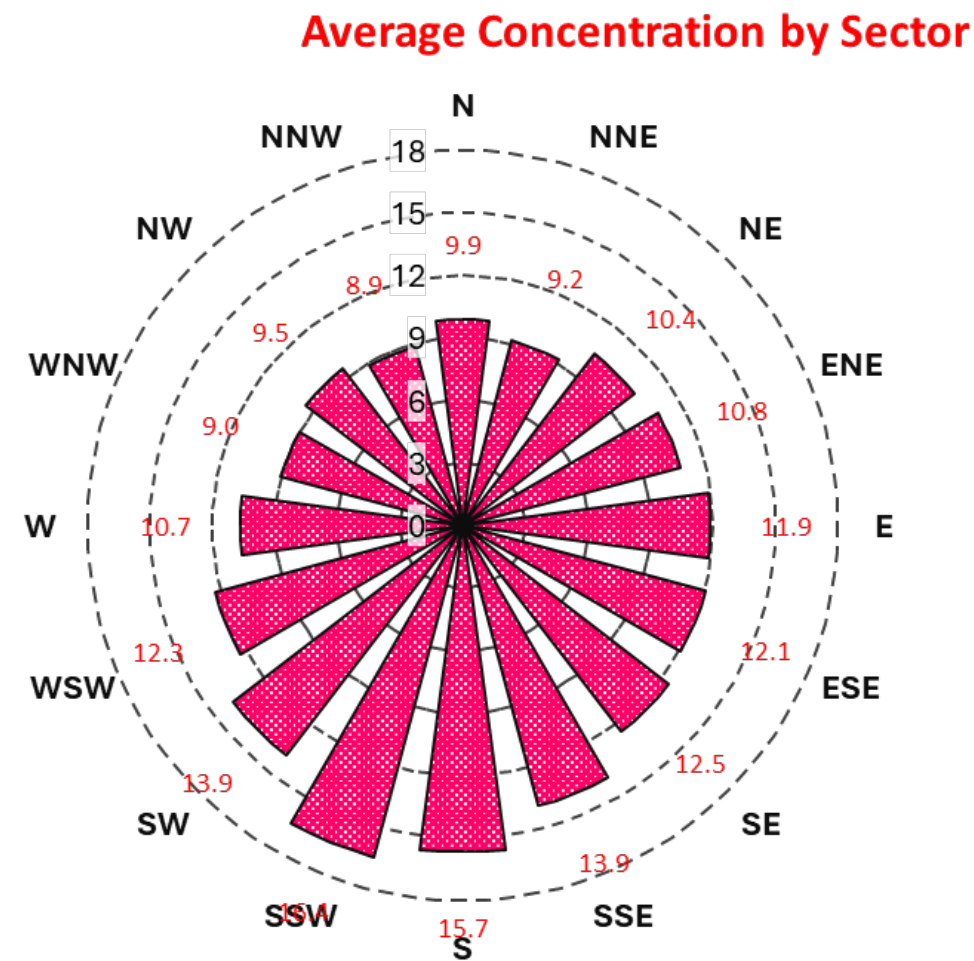
Wind and pollution roses

Simplified Wind Rose



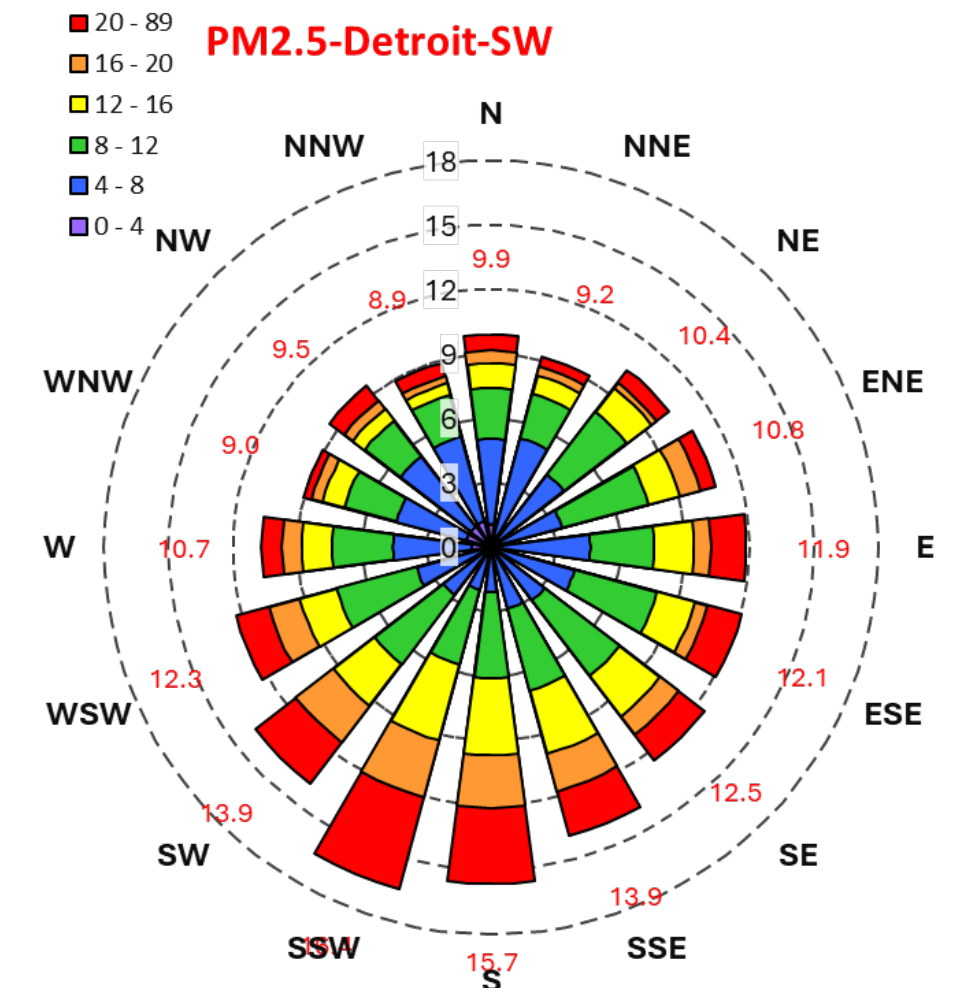
- Where winds come from
- Excludes low winds (<2 m/s) that typically meander.
- Uses hourly data from 2022
- Detroit SW monitoring site

Pollution Rose for average PM_{2.5}



- Average PM_{2.5} concentration by sector
- Excludes low winds (<2 m/s) that typically meander.
- Uses hourly data from 2022.

Pollution Rose for PM_{2.5} ranges



- Concentrations by sector, when the wind is that sector
- In the highest sector – SSW – winds occur 12% of time and PM_{2.5} averages 17 ug/m³ and reached 89 ug/m³.

Long and short-term trends for PM_{2.5}

Site: Detroit-SW **Year:** 2022
ID: 261630015 **Min wind rose speed:** 2.0
Met: Detroit-SW **Max wind rose speed:** 100.0
Pollutant: PM2.5

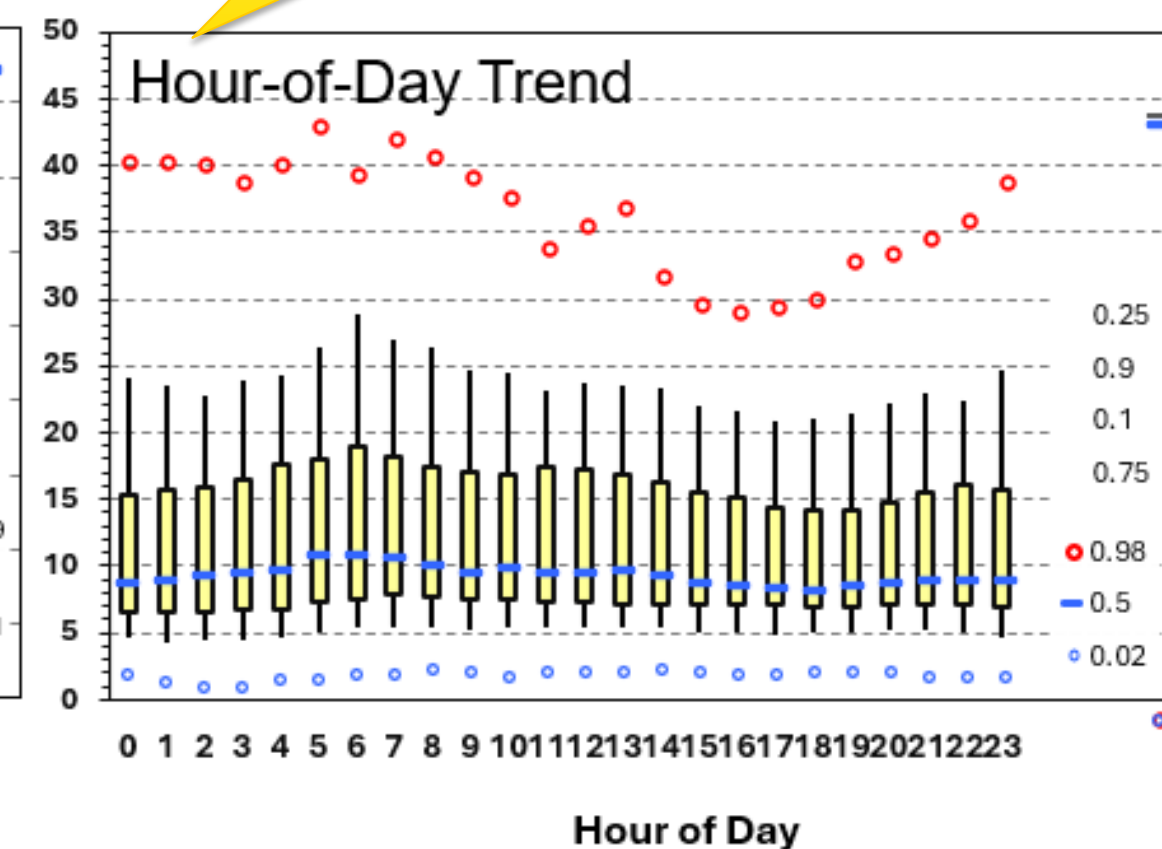
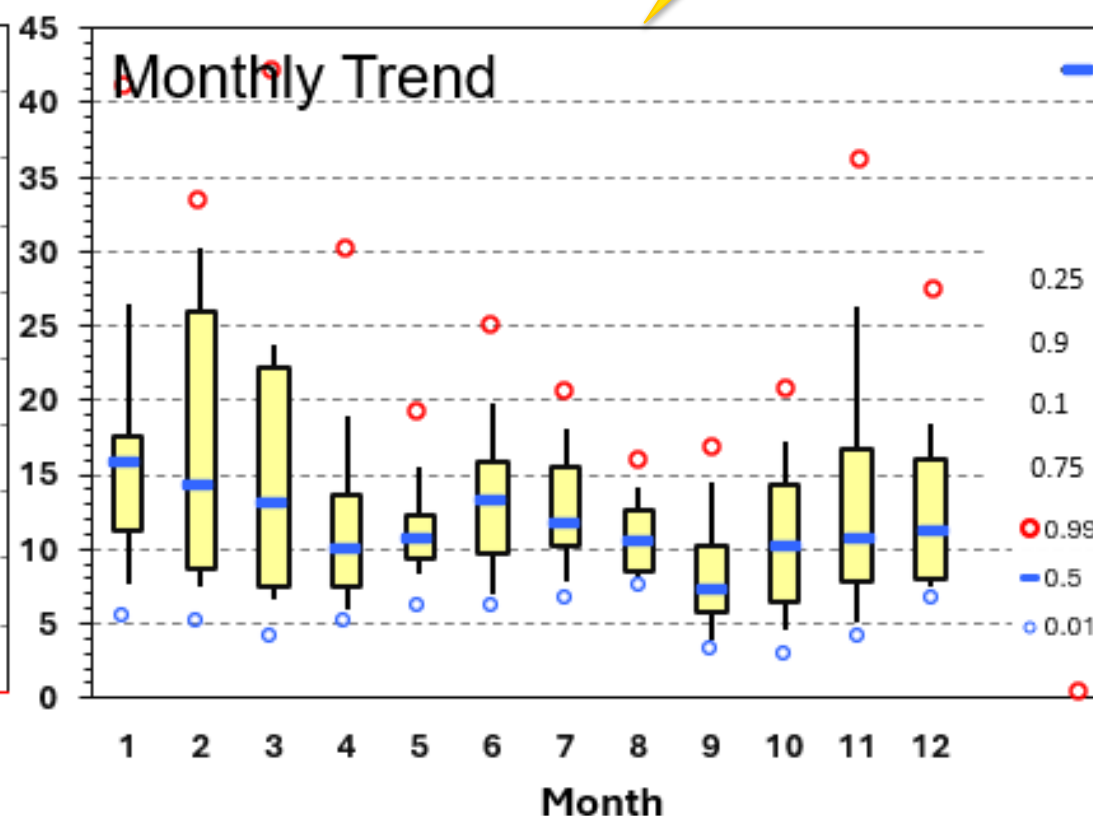
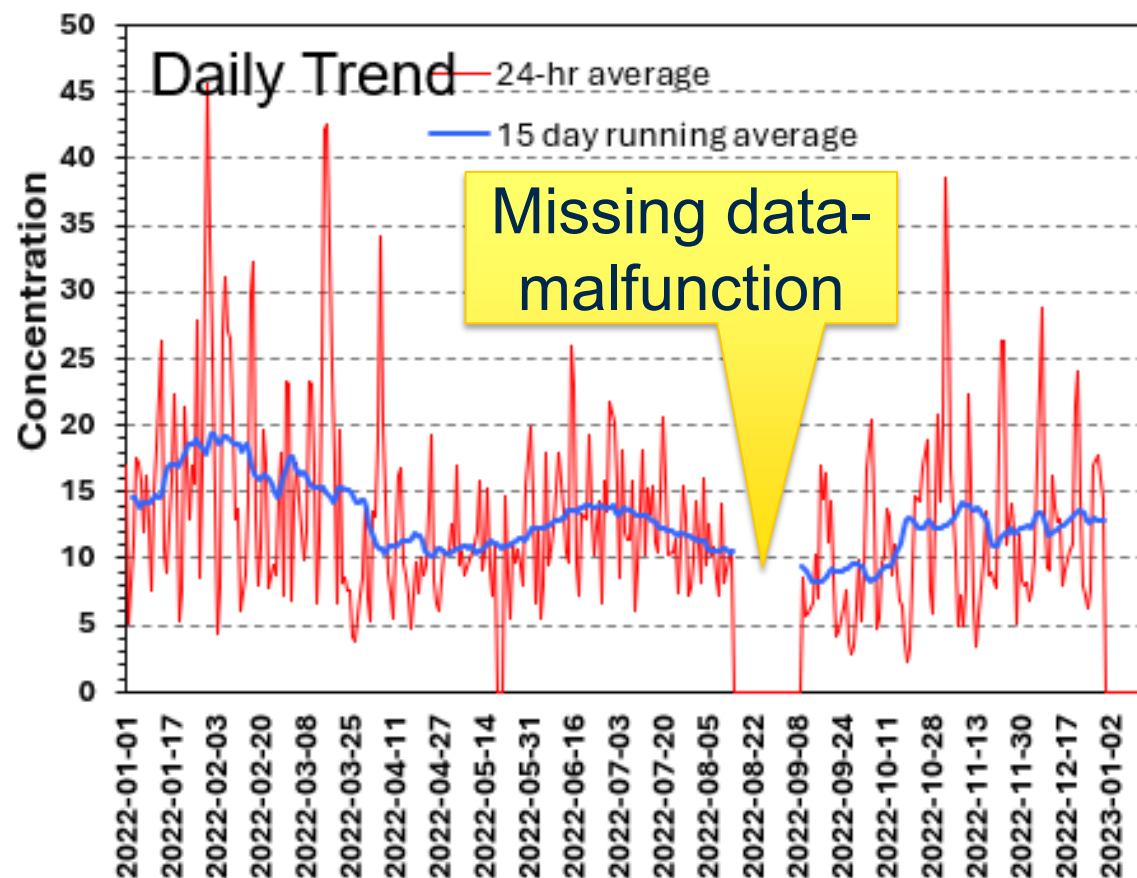
	PM2.5	Wind Speed	Wind Direction
Ave	13.0	2.6	203
Stdev	8.7	1.4	96
Max	88.6	8.5	360
90th Percentil	23.8	4.5	327
75th Percentil	16.3	3.5	300
Median	10.5	2.2	205
25th Percentil	7.1	1.8	138
Min	0.50	0.0	0
NOBs	8100	8756	8756

Statistics of PM2.5 levels

Number of hourly points

Monthly trend
 shows 99th, 90th, 75th, 50th,
 25th and 10th percentile levels

Hour-of-day trend
 shows 99th, 90th, 75th, 50th,
 25th and 10th percentile levels

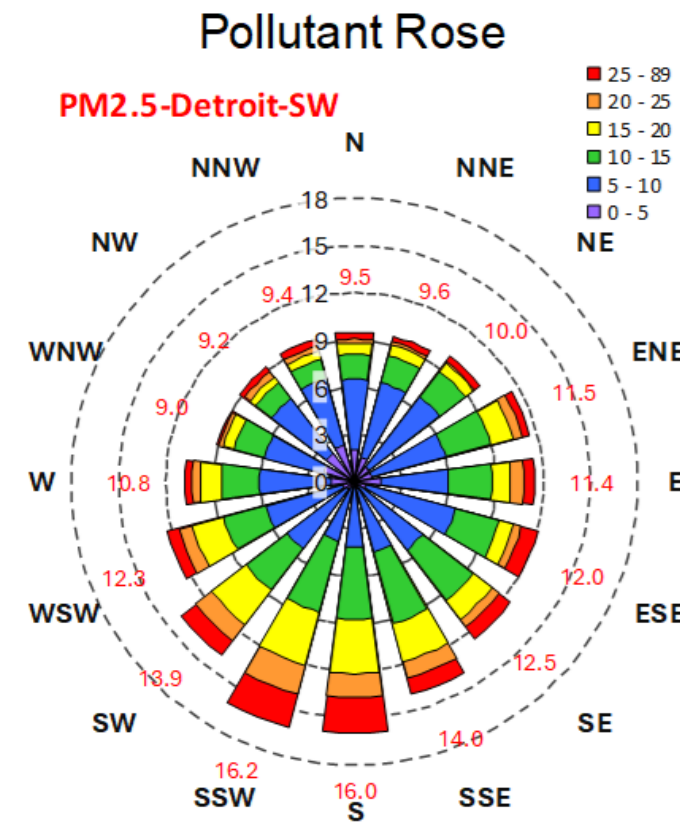
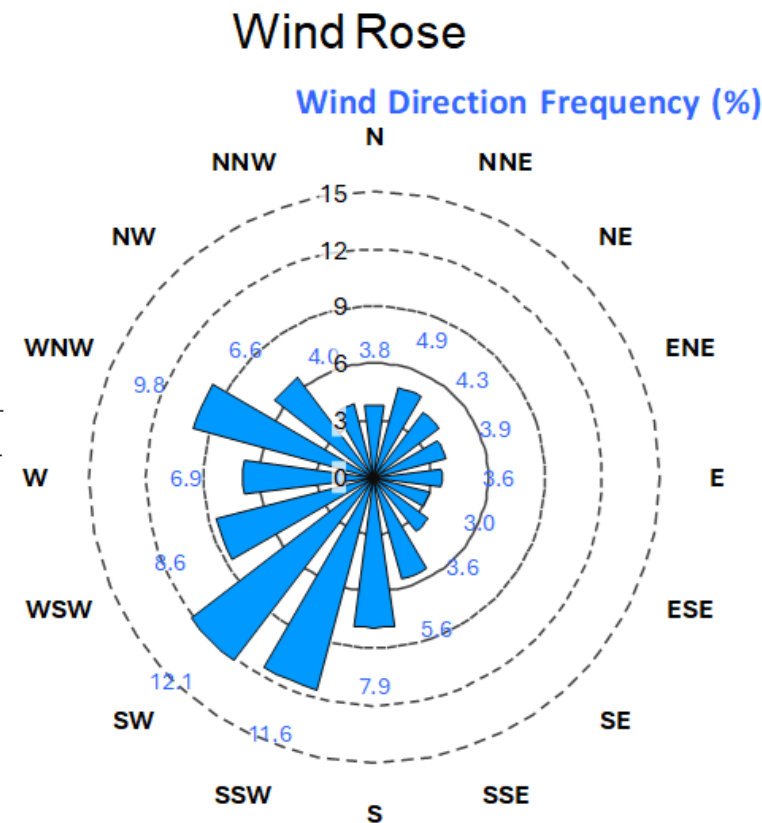


PM_{2.5} at Detroit-SW

PM_{2.5} at Detroit-SW

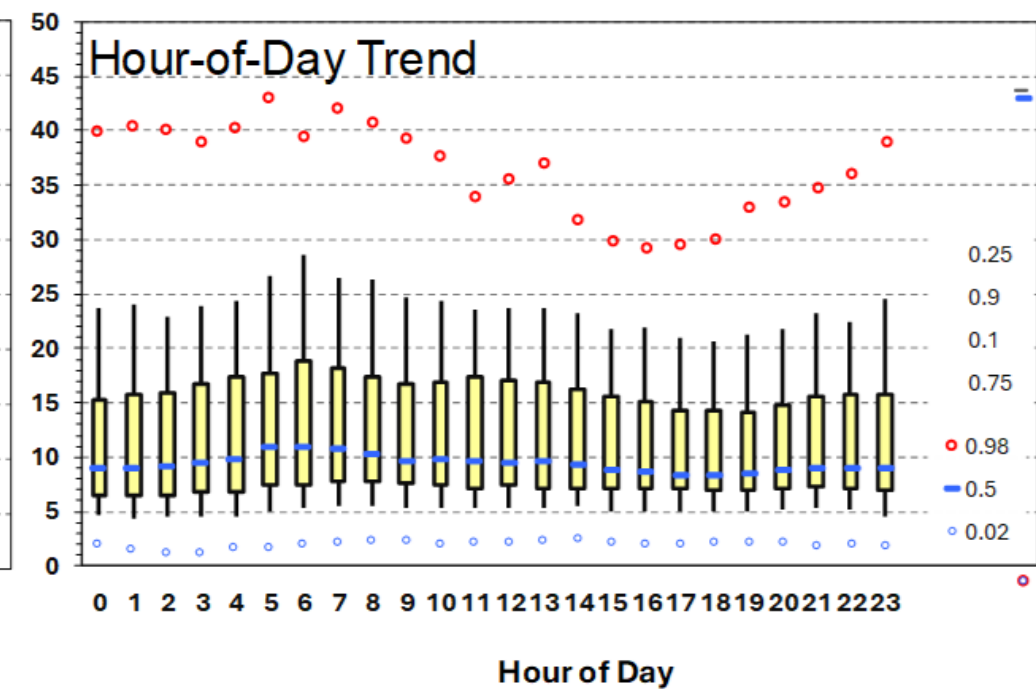
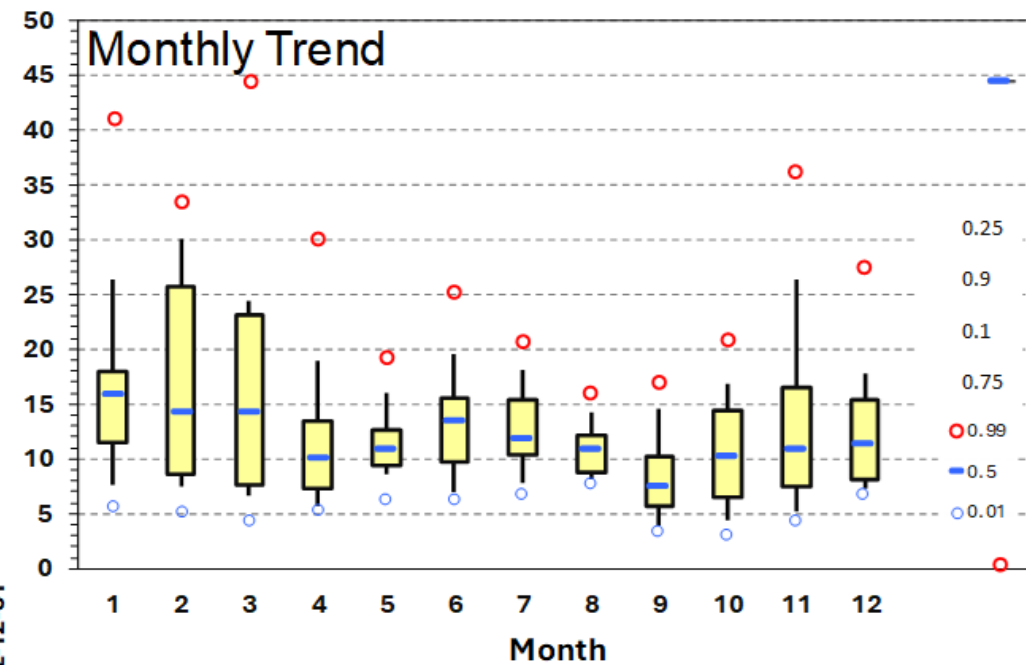
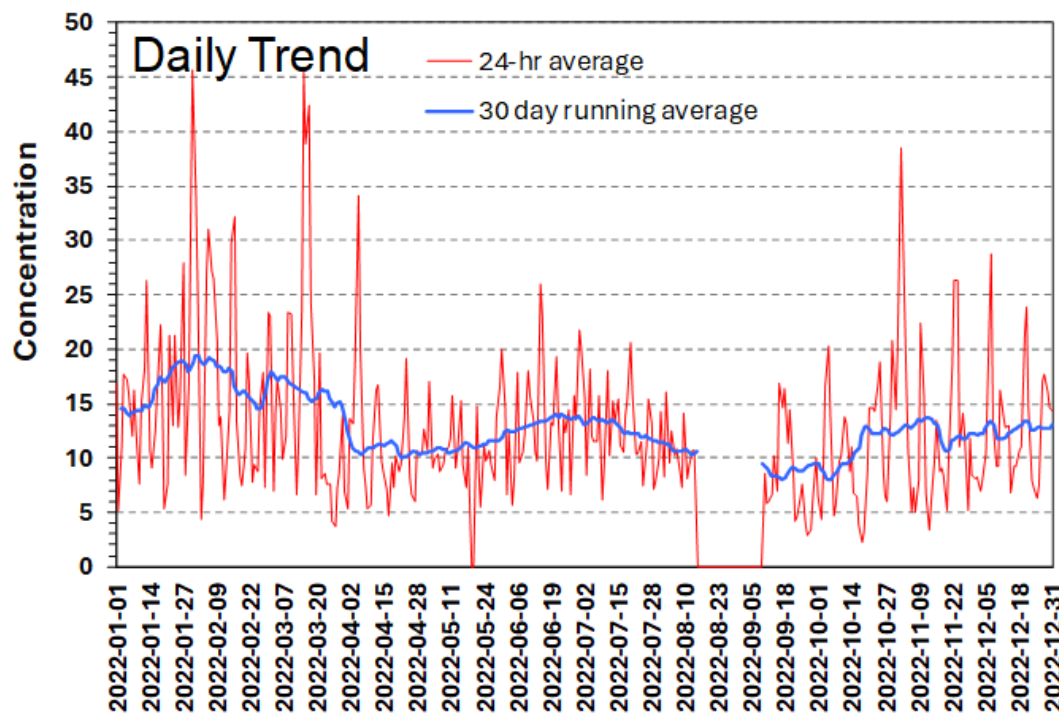
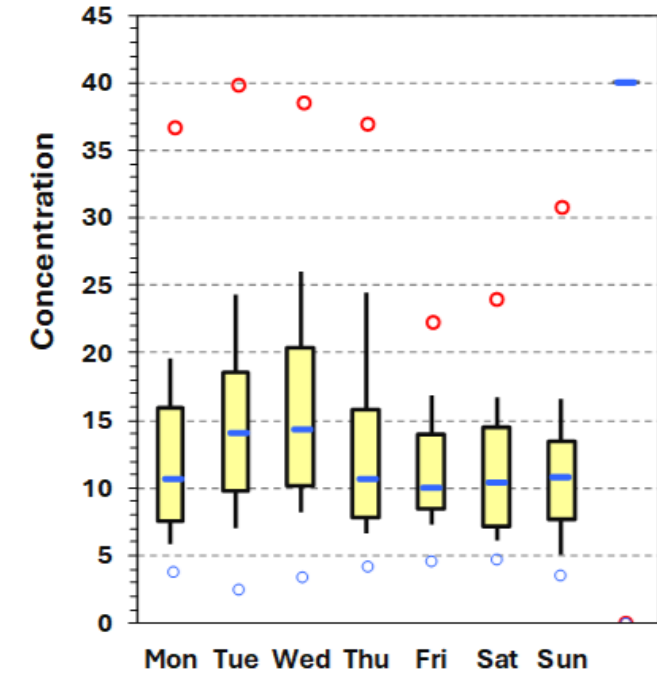
Site: Detroit-SW **Year:** 2022
ID: 261630015 **Min wind rose speed:** 2
Met: Detroit-SW **Max wind rose speed:** 100
Pollutant: PM2.5

	PM2.5	Wind Speed	Wind Direction
Ave	13.0	4.2	201
Stdev	8.7	2.6	92
Max	88.6	17.5	365
90th Percentile	23.8	7.7	312
75th Percentile	16.3	5.7	275
Median	10.5	3.9	212
25th Percentile	7.1	2.6	143
Min	0.50	0.0	-1
NOBs	8100	8760	7913



■ 25 - 89
■ 20 - 25
■ 15 - 20
■ 10 - 15
■ 5 - 10
■ 0 - 5

Day-of-Week Trend

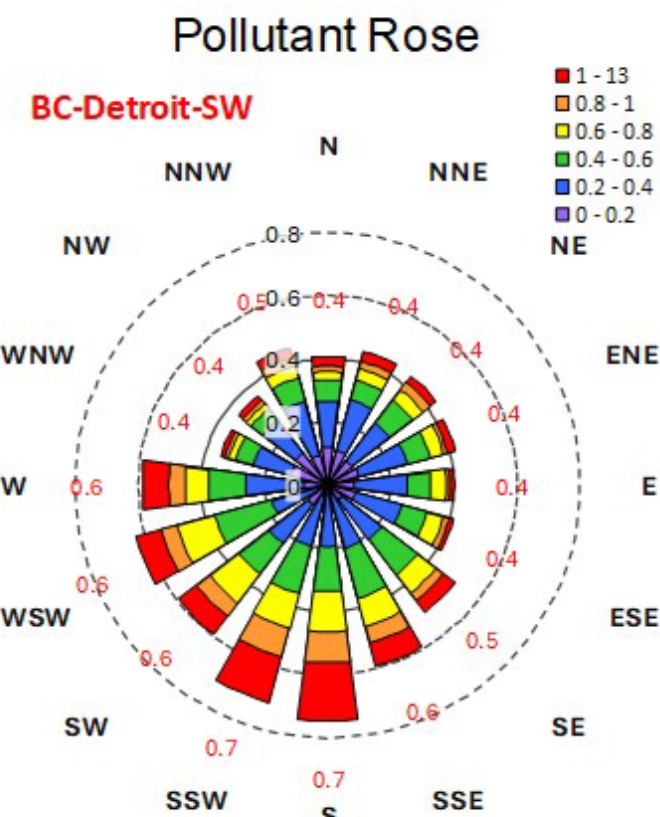
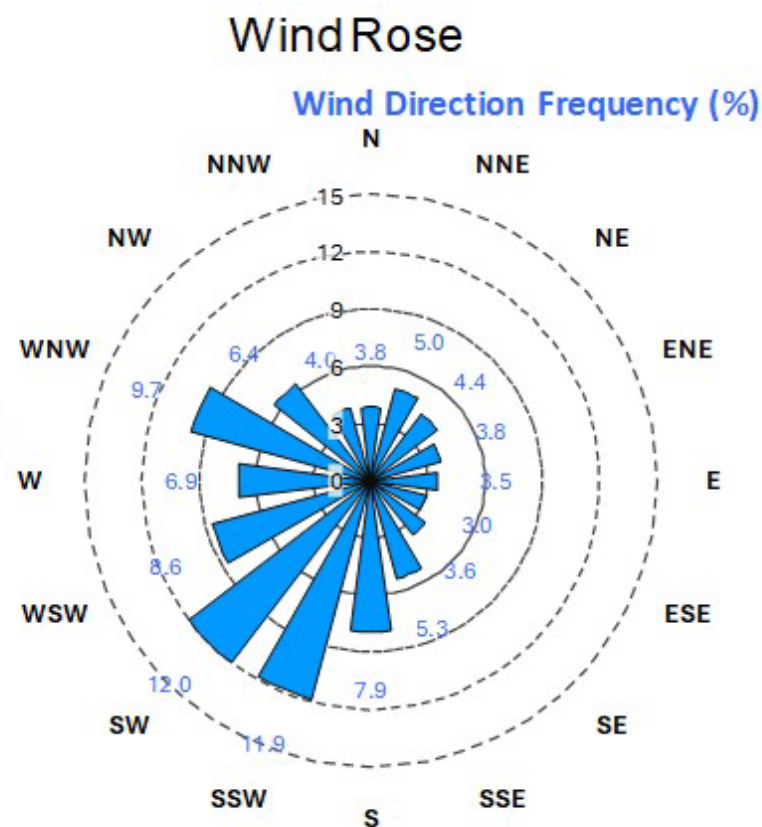


Black Carbon at Detroit-SW

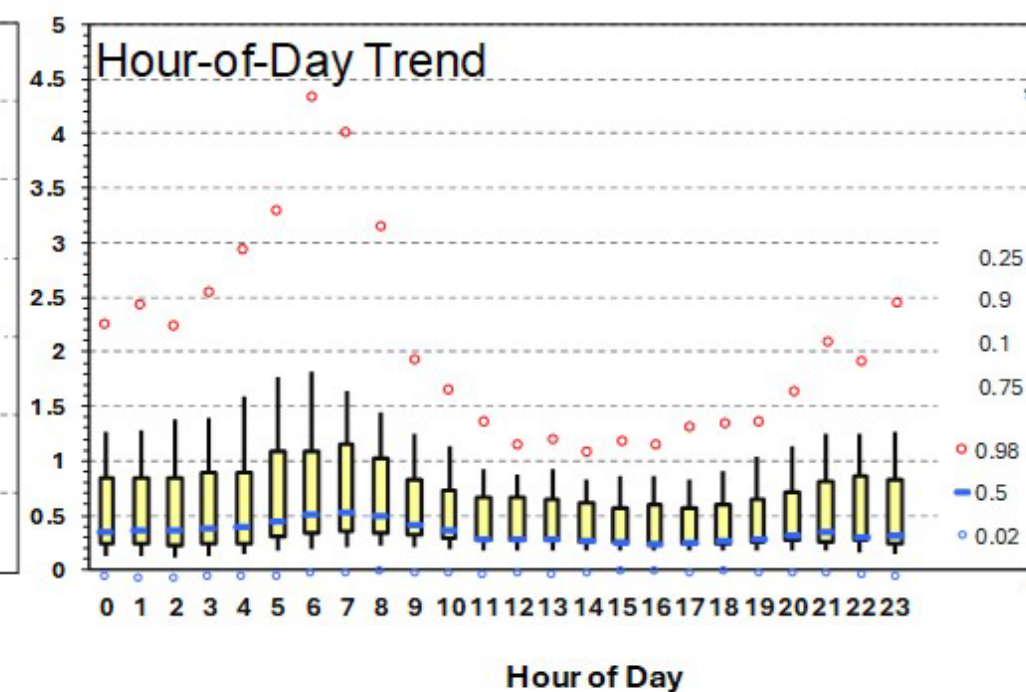
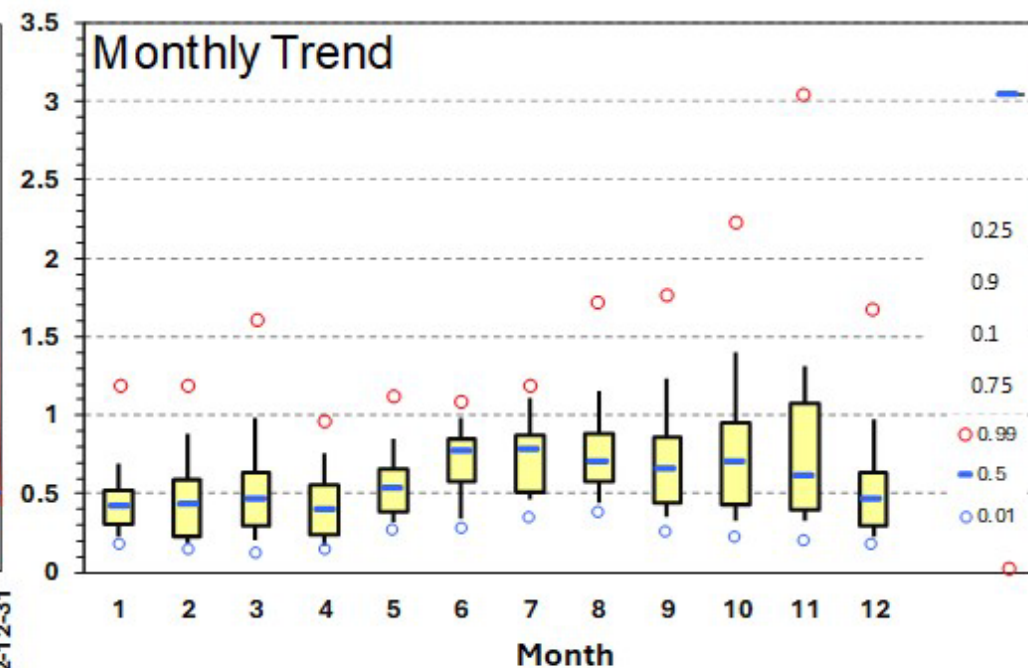
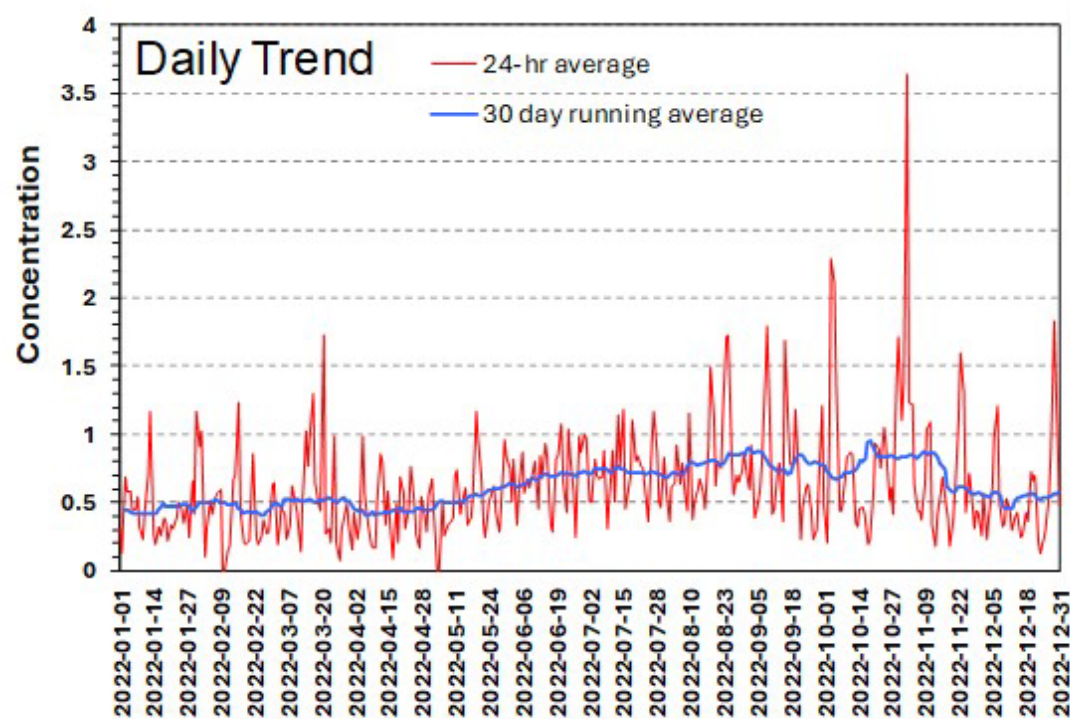
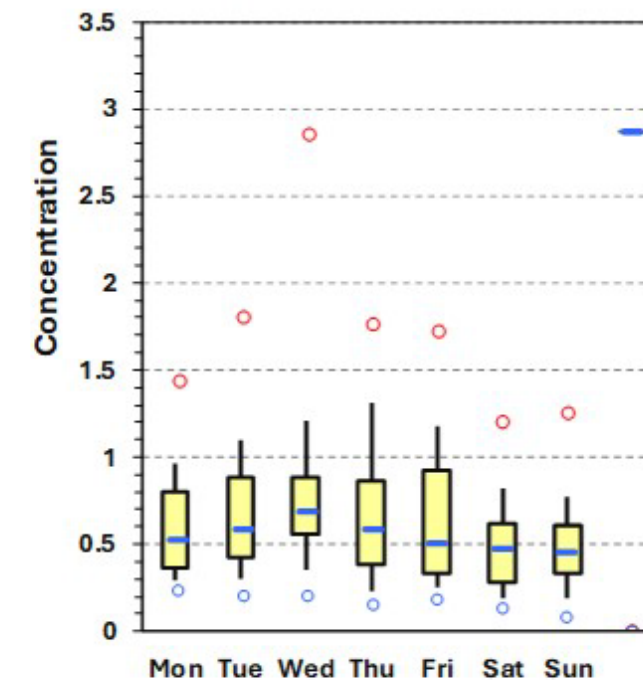
BC at Detroit-SW

Site: Detroit-SW **Year:** 2022
ID: 261630015 **Min wind rose speed:** 2
Met: Detroit-SW **Max wind rose speed:** 100
Pollutant: BC

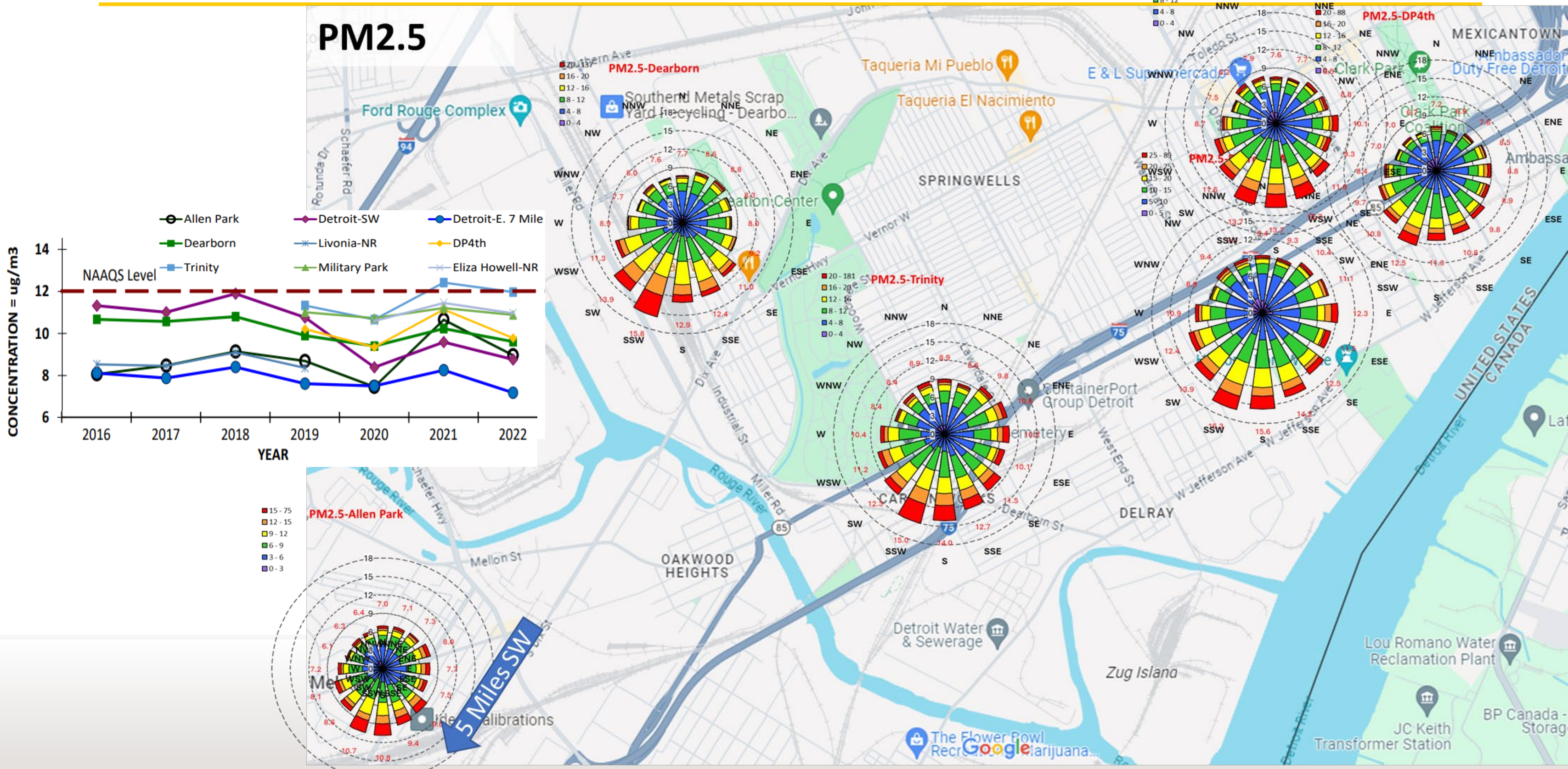
	BC	Wind Speed	Wind Direction
Ave	0.6	4.2	201
Stdev	0.6	2.6	92
Max	12.6	17.5	365
90th Percentile	1.2	7.7	313
75th Percentile	0.8	5.7	276
Median	0.5	3.9	212
25th Percentile	0.3	2.6	143
Min	0.04	0.0	-3
NOBs	8704	8760	7913



Day-of-Week Trend



PM_{2.5} pollution roses & long-term trends



Black carbon pollution roses

