

Application of PMF in the Northern Great Lakes: A Tale of Two Studies

Kurt Paterson

Michigan Technological University

Department of Civil and Environmental Engineering

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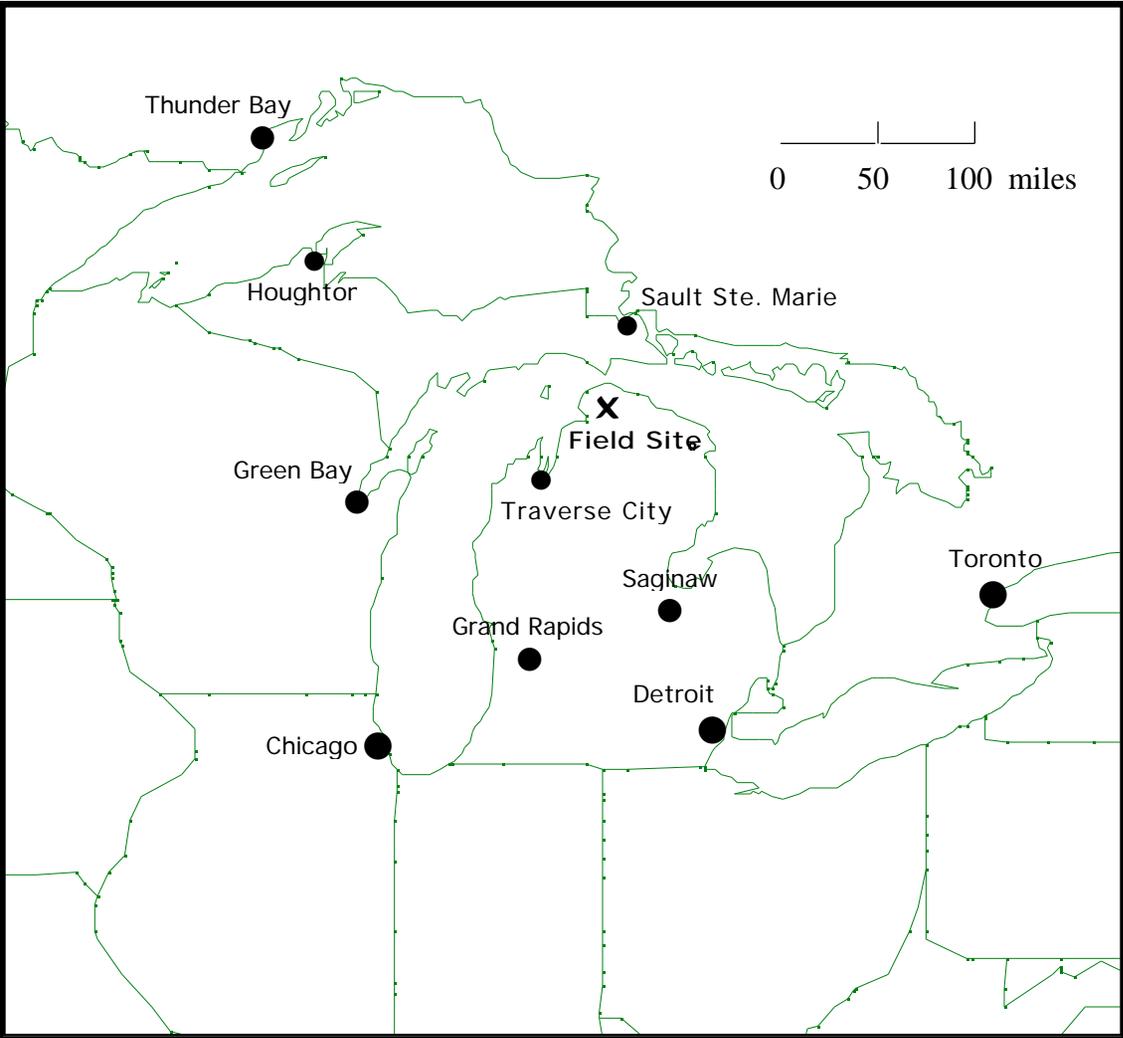
Two Studies

- **Study 1: Mixture of trace gases and particulate matter**
- **Study 2: Particle size distribution and mass concentration**

Objectives

- **Assess sources which influence air quality in the northern Great Lakes**
- **Understand particle dynamics and physics in this region**

The Field Site



Method (Tools)

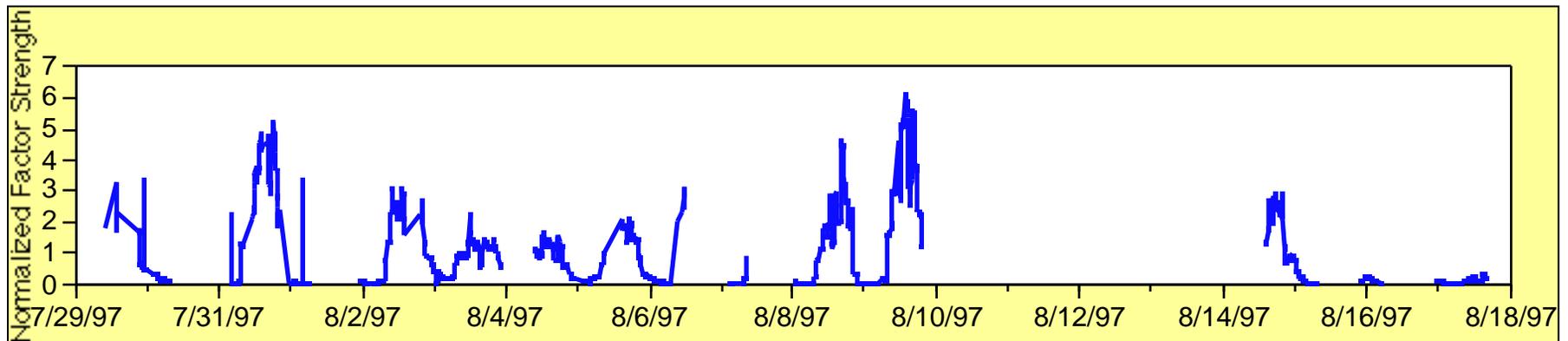
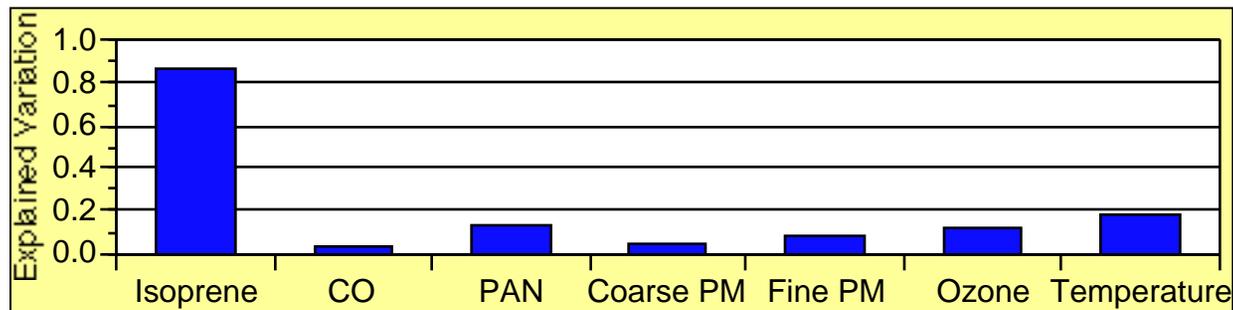
- **Explained variation**
- **Time series**
 - ↳ **Spectral analysis**
 - ↳ **Digital filtering**
- **Met data analysis**
- **Residence time analysis**

Study 1: Method (Input)

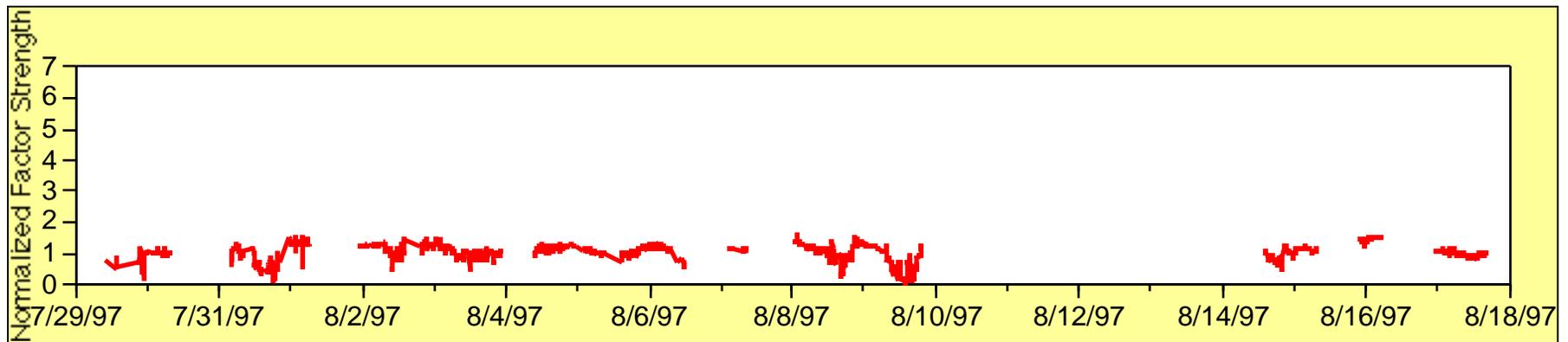
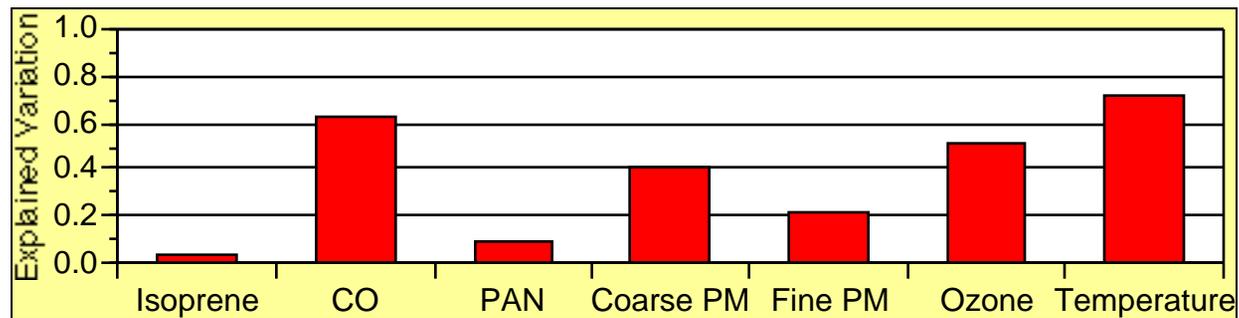
→ Input Matrix

- July 29 to August 17, 1997
- Isoprene, CO, PAN, coarse PM (1.5 μm - 10 μm), fine PM (0.12 - 1.5 μm), O₃, Temperature
- 5 minute frequency
- 2116 observations
- 0.5 MDL used for values < MDL

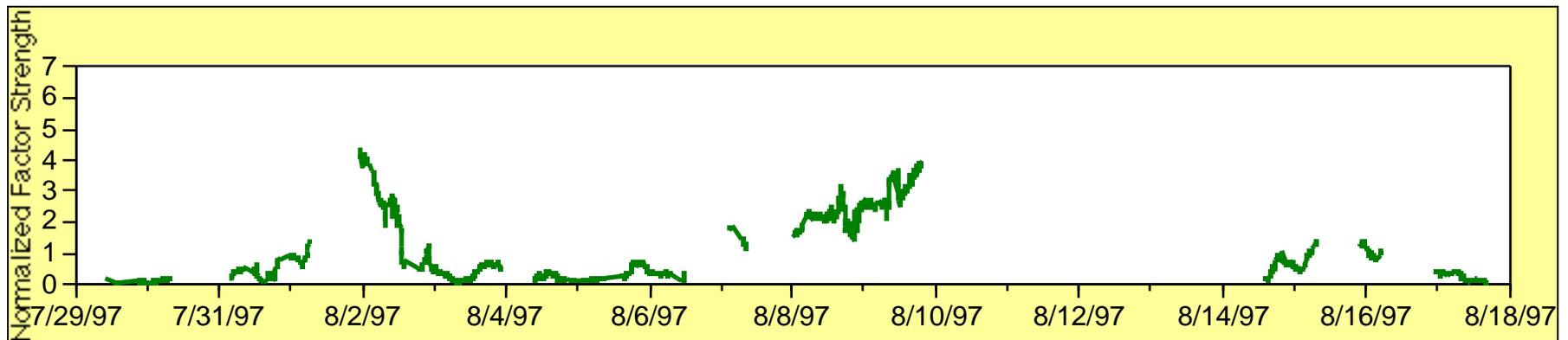
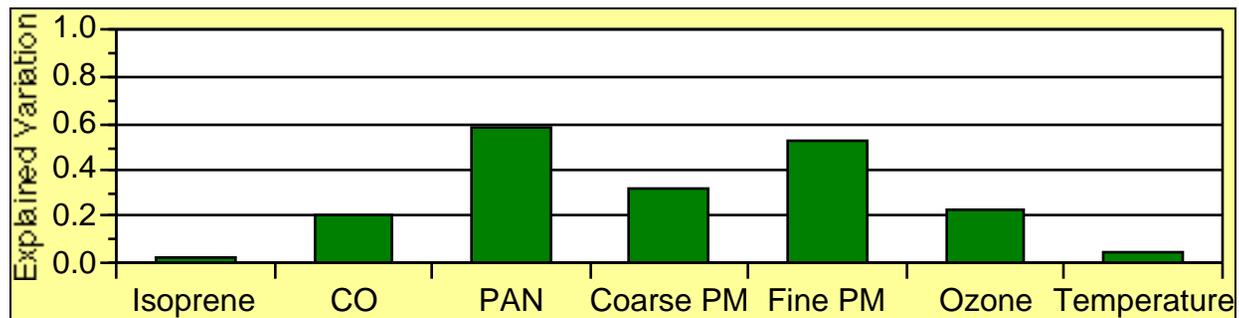
Study 1: PMF Results (Factor 1)



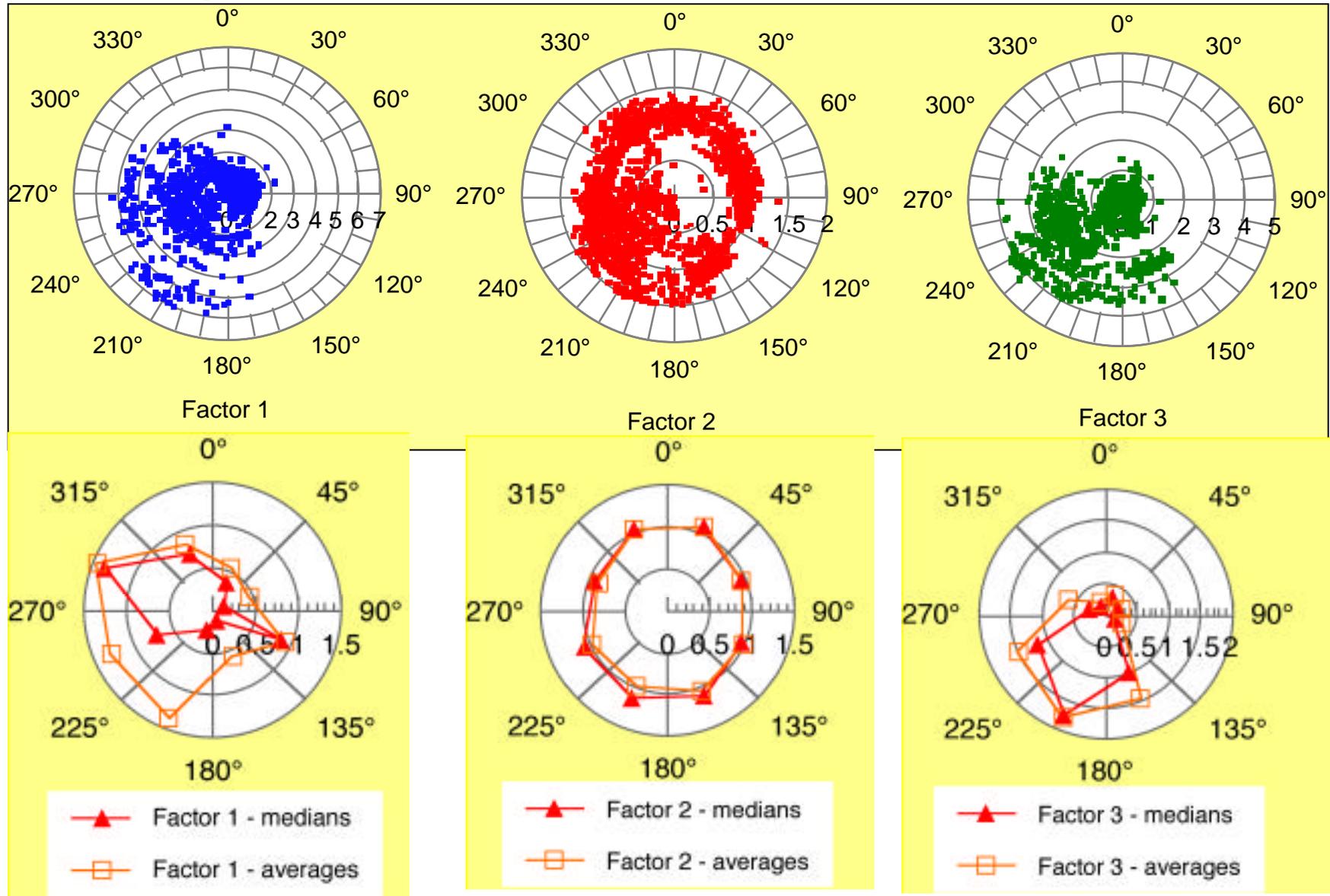
Study 1: PMF Results (Factor 2)



Study 1: PMF Results (Factor 3)



Study 1: PMF Results (wind direction)



Study 1: PMF Results (residence time)

→ Assess Factor 3

- ↘ +/- 1 std dev for dirty and clean events

- ↘ Three-day back trajectories

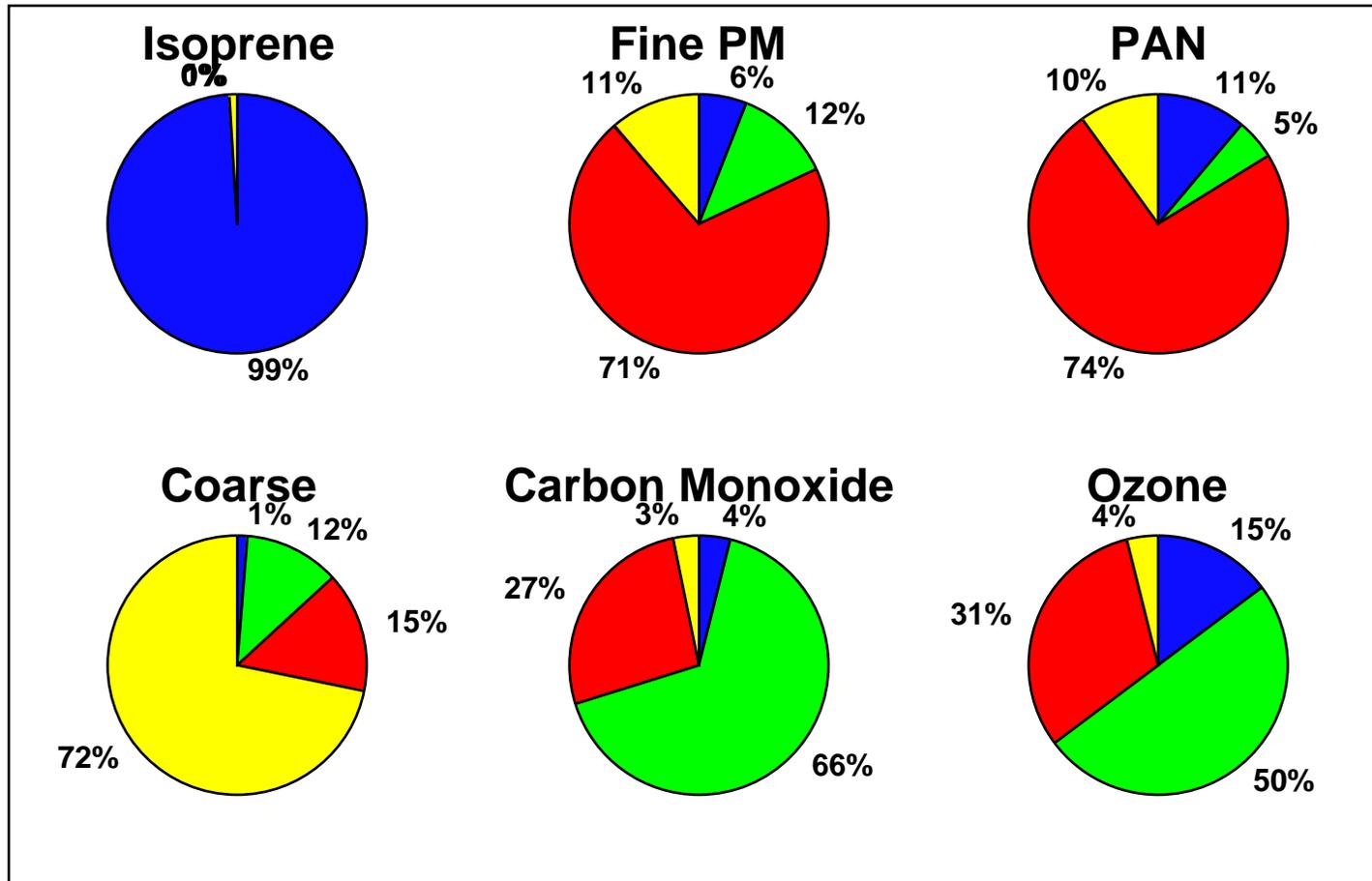
→ Dirty region -- industrial Midwest

→ Clean region -- central Canada

Study 1: PMF Results (apportionment)

	Isoprene (ppb)	CO (ppb)	PAN (ppt)	Coarse PM (#/cm ³)	Fine PM (#/cm ³)	Ozone (ppb)	Temp. (°C)
Factor 1 (biogenic)	1.128	4.0	25	0.006	43.2	5.4	5.0
Factor 2 (local)	0.003	71.0	11	0.053	87.7	18.2	16.0
Factor 3 (transport)	0.002	29.4	174	0.067	499.8	11.4	1.2
Sum of factor contributions	1.132	104.4	210	0.126	630.7	35.1	22.2
Measured mean	1.136	107.6	235	0.447	705.0	35.9	22.3
% difference	-0.3	-3.0	-10.4	-71.8	-10.5	-2.1	-0.5

Study 1: PMF Results (apportionment)



Biogenic
Local
Long-range
Residual

Study 2: Objectives

- **To assess relationships between particle size and particle mass**
- **To assess dynamics of particle modes**
- **Data reduction**

Study 2: Method (Input)

→ Input Matrix

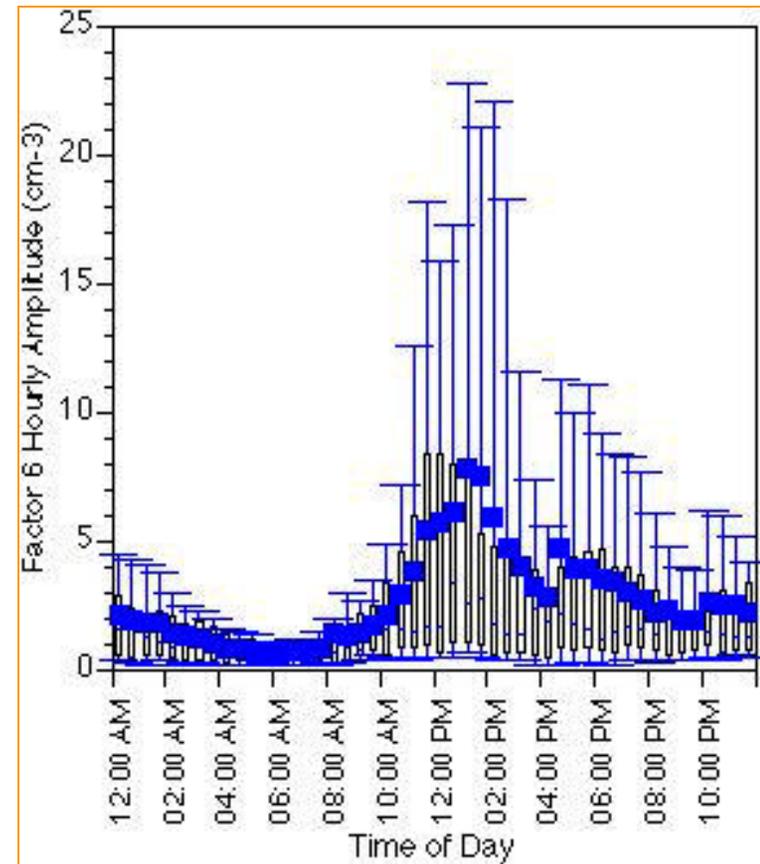
- Particle size distribution (PSD), PM_{2.5}
- 100 sizes ranging from 5 nm to 7.5 μm
- August 9 - September 6, 1998
- 21 days, 1046 half-hour data
- 1046 rows (time) × 100 columns (PSD)
- 0.5 MDL used for values < MDL

Study 2: PMF Results

Factor (nm)	Size (nm)	Peak (nm)
6	5 - 33	20
5	35 - 90	54
1	96 - 207	147
3	215 - 850	485
2	950 -2500	1450
4	2900 -7500	5300

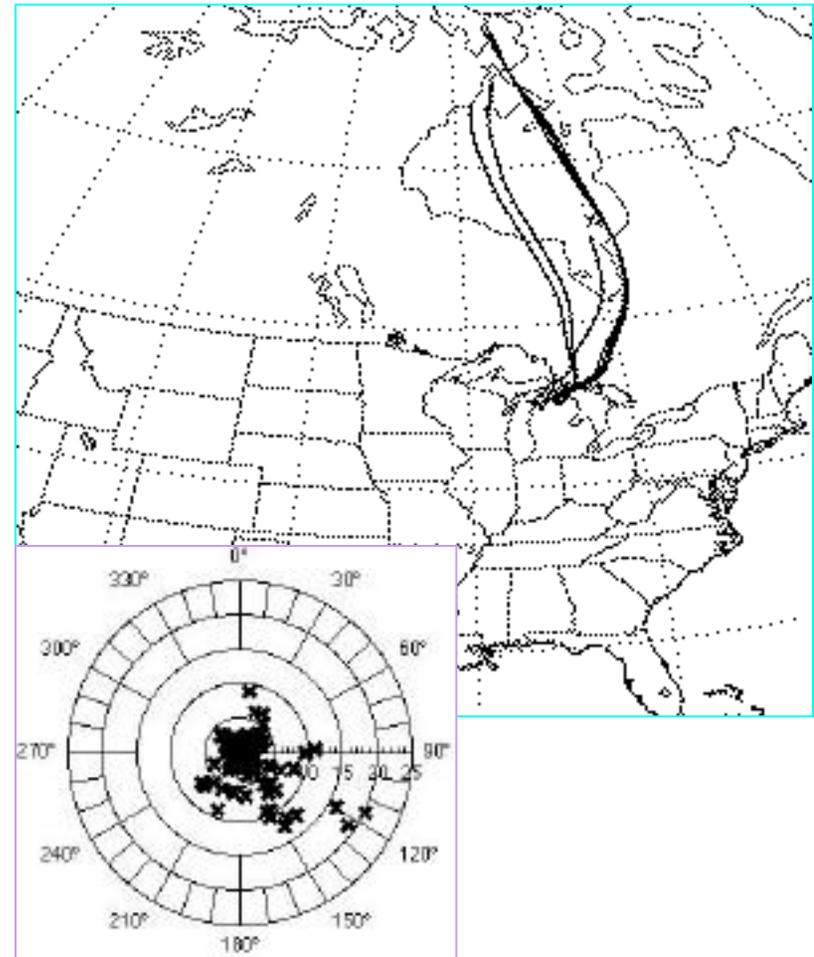
Study 2: PMF Results (diurnal)

- **Smallest particles, 5 - 33 nm (Factor 6)**
 - ↘ related to the sunlight intensity
 - ↘ products of photochemical reactions



Study 2: PMF Results (transport)

- **Smallest particles, 5 - 33 nm (Factor 6)**
 - ↘ **high levels during stagnant air**
 - ↘ **from the east of the site, possibly Interstate-75**

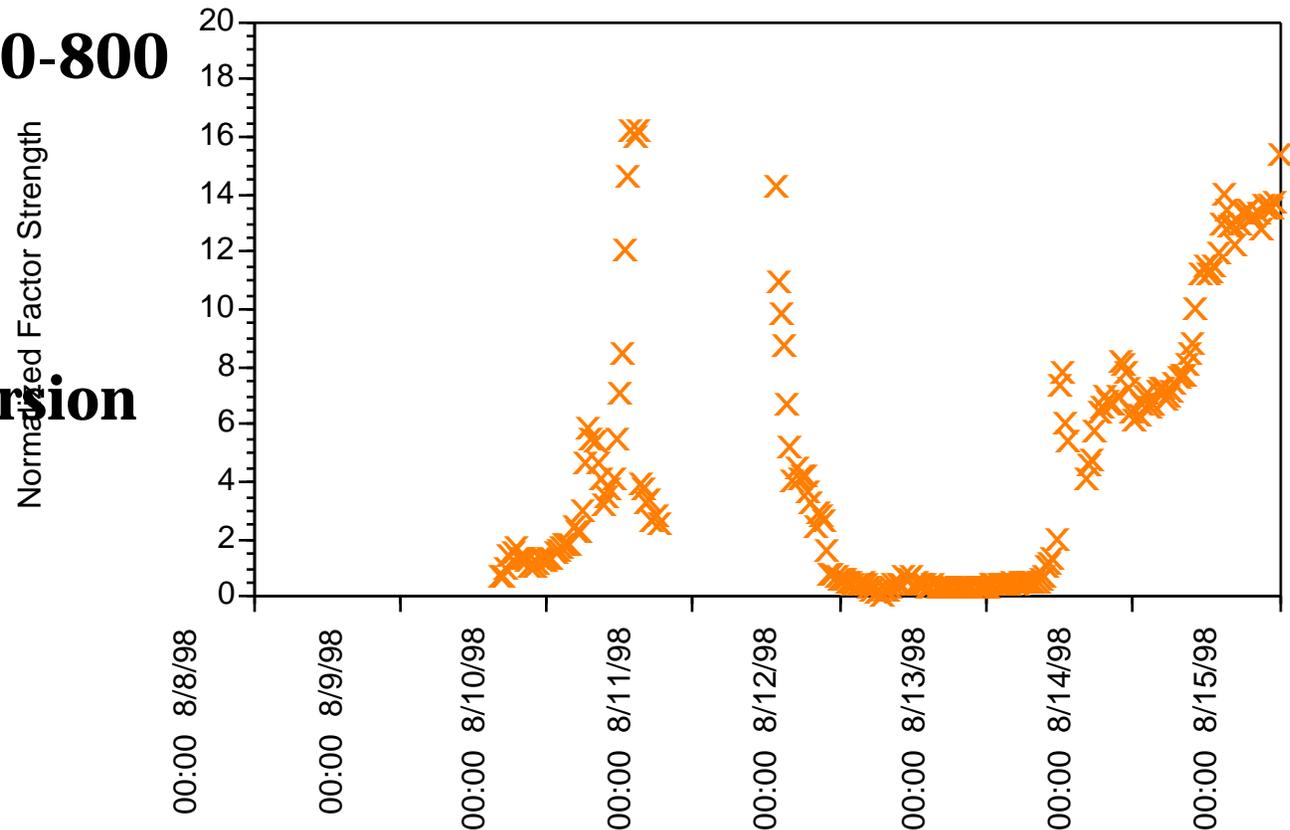


Study 2: PMF Result (time series)

➔ Accumulation, 220-800 nm (Factor 3)

✚ Major strength swings

✚ Multi-day excursion



Study 2: PMF Results (vs. PM2.5)

Factor	PSD (nm)	R2
6	5 - 33	0.0103
5	35 - 90	0.0248
1	96 - 207	0.2995
3	215 - 850	0.53
2	950 -2500	0.0026
4	2900 -7500	0.0034

Study 2: Some Findings

- ➔ **PMF makes it simpler to assess dynamics and influences for a wide range of particle sizes**
 - **Sizes most influenced by long-range transport: 100-220 nm, 220-800 nm (Upper Midwest)**
 - **Strong diurnal cycles: 5-30 nm, 220-800 nm**
 - **Little influence from wind speed, pressure**
 - **Temperature and humidity most influences ultrafine**
 - **Particle number concentration is lowered by 40 - 90% after raining during the nighttime**
 - **PM2.5 most influenced by 220-800 nm**

Next Steps

- **Add particle composition to 1998 data**
- **Try UNMIX on 1997 and 1998 data**