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Source Apportionment

DEARS Stakeholder Meeting
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Detroit, MI

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Disclaimer

- *Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.*

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Overview

- Description of receptor models (CMB, PMF, APTR)
- Modeling approach
- Data and receptor models used for analysis
- Source apportionment results
  - Allen Park PMF
  - CMB results for DEARS Season 1 and 2
  - APTR results for DEARS
- Summary and future work

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EPA Receptor Models Applied in DEARS

- **Quantify sources with measured profiles and calculated profiles from EPA receptor models**
  - EPA Chemical Mass Balance (CMB) 8.2
- **Calculate source profiles and quantify sources using only sample data**
  - EPA Positive Matrix Factorization (PMF) 1.1
- **Identify the location of sources and their impact**
  - EPA Air Pollution Transport to Receptor (APTR) 1.0

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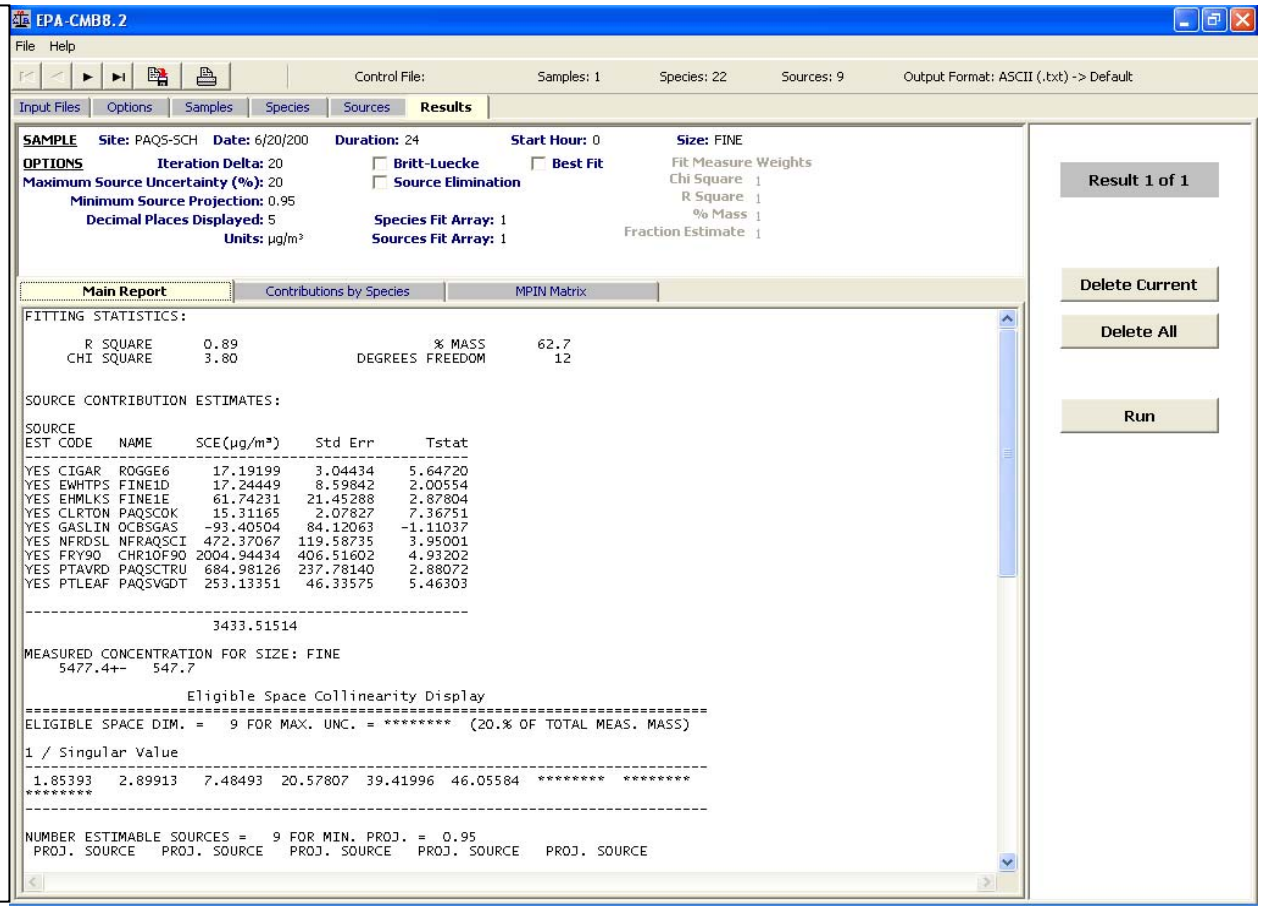
EPA Chemical Mass Balance (CMB) 8.2

- Data: sample concentration and uncertainty estimates, measured source profiles and profiles from EPA PMF or EPA Unmix
- Minimum number of samples: 1
- Output: diagnostics, source contributions and uncertainties for each sample



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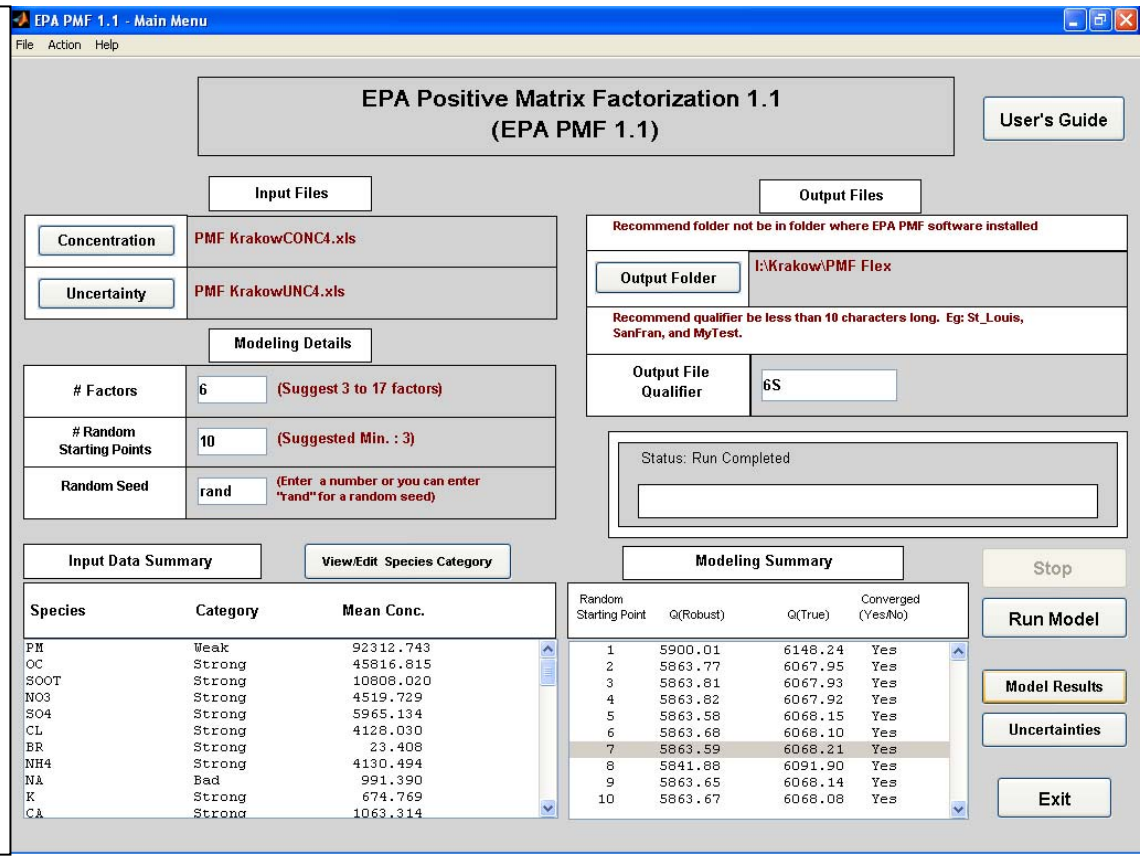
EPA Positive Matrix Factorization (PMF) 1.1

- Data: sample concentration and uncertainty estimates
- Minimum number of samples: 50
- Output: diagnostics, source profiles and uncertainties, and source contributions



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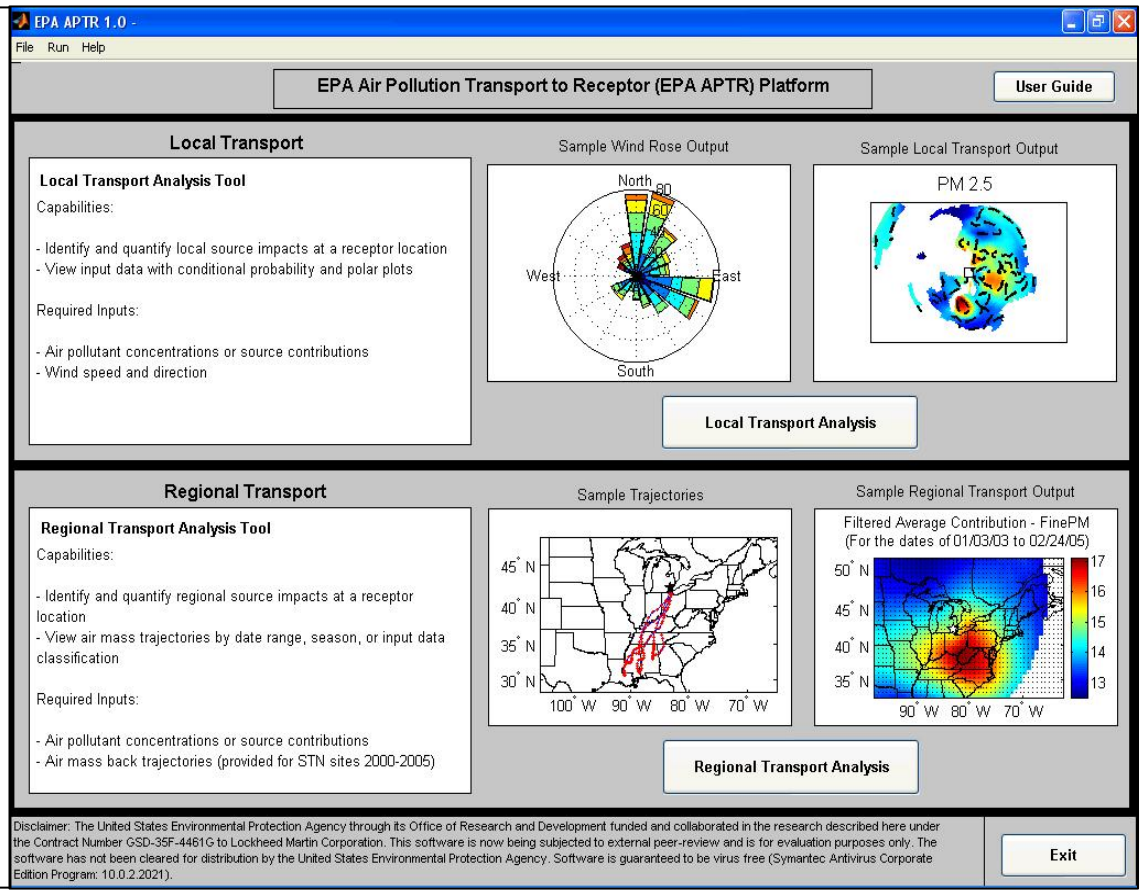
EPA Air Pollution Transport to Receptor (APTR) 1.0

- Local Transport Data: sample concentration, meteorological data, uncertainty estimates, and/or source contribution estimates
- Regional Transport Data: air mass trajectories, sample concentrations or source contribution estimates
- Output: impact of local and regional sources to a receptor location



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Modeling Approach

- CMB source profile selection based on report for LADCO ("Integration of Results for the Upper Midwest Urban Organics Study", 2006)
- Measured profiles specifically for Detroit area not available
  - Available profiles may not truly represent some sources impacting Detroit (in particular local sources)
  - PMF model used to obtain industrial source profiles
- APTR modeling conducted to determine local and regional source impacts

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Data Used for Analysis

- Allen Park STN Data
  - Years 2004 and 2005 (overlap with DEARS)
  - Inorganic (XRF), nitrate, organic carbon and elemental carbon
- DEARS Data
  - Season 1: July 13 to August 27, 2004
    - Total of 32 samples
  - Season 2: February 1 to March 19, 2005
    - Total of 35 Samples
- Chemical species used in the receptor models
  - Inorganic (XRF), organic carbon, and elemental carbon

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Receptor Models Used for Analysis

- EPA PMF 1.1
  - Extract mixed industrial profile and uncertainty
  - STN uncertainties are severely under-estimated
    - Uncertainty matrix developed by Dr. Jay Turner (Washington University, St. Louis) using co-located precision data from Cleveland STN data
- EPA CMB 8.2
    - Only 67 DEARS samples used in analysis
    - Motor Vehicle profile weighted (40% diesel and 60% gasoline)
    - Mixed Industrial profile obtained from PMF
- APTR 1.0 Model
    - Local and regional sources

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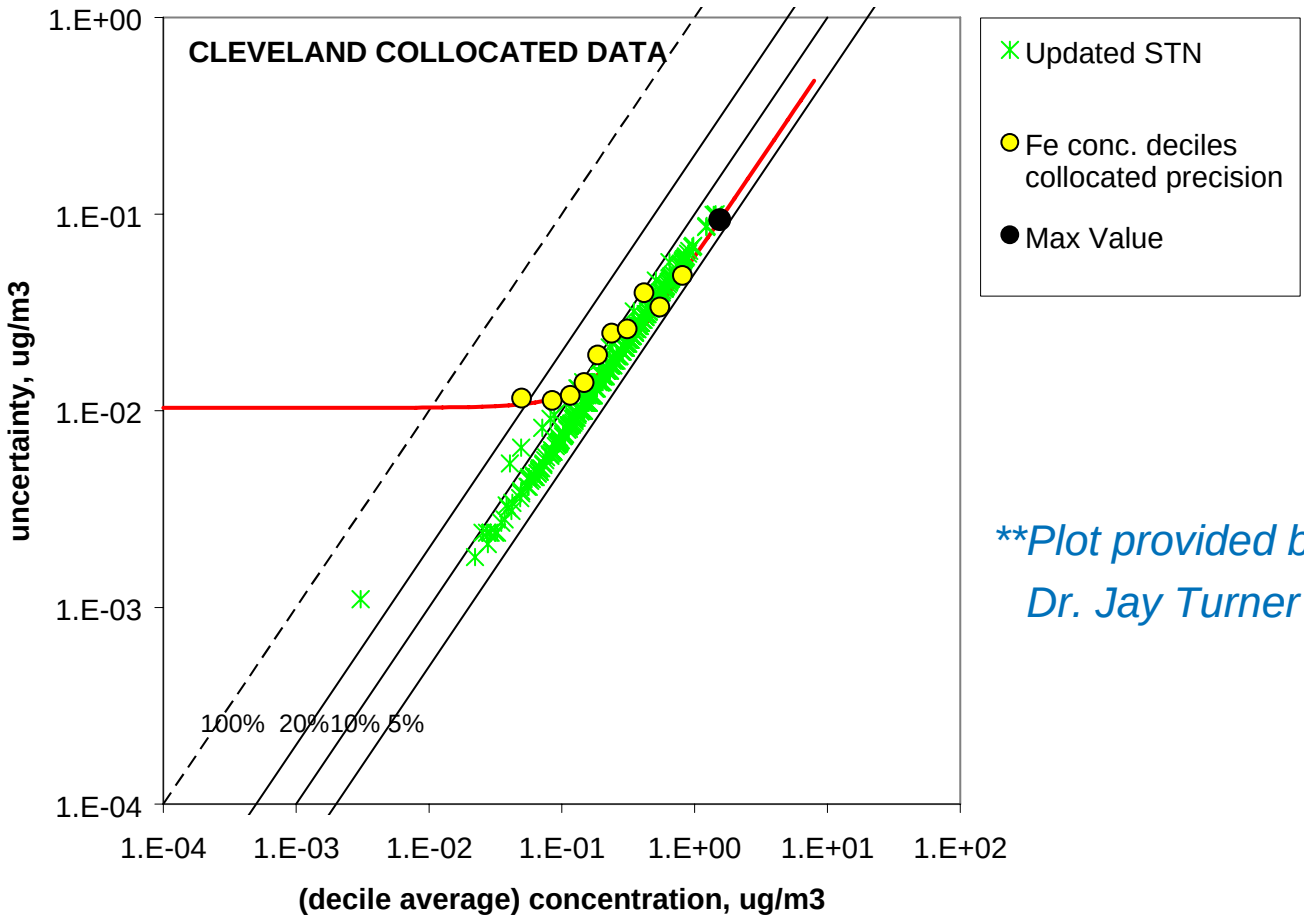
Source Profiles for CMB Analysis

Source	Reference
Secondary sulfate	EPA Speciate Database
Gasoline	Schauer et al., 2002
Diesel	Schauer et al., 1999
Road Dust	Rogge et al., 1993 Hidlemann et al., 1991
Biomass Burning	Fine et al., 2004
Mixed Industrial	PMF results (Allen Park STN data)

Uncertainty Matrix (Cleveland Fe Collocated Data)



***Plot provided by Dr. Jay Turner*

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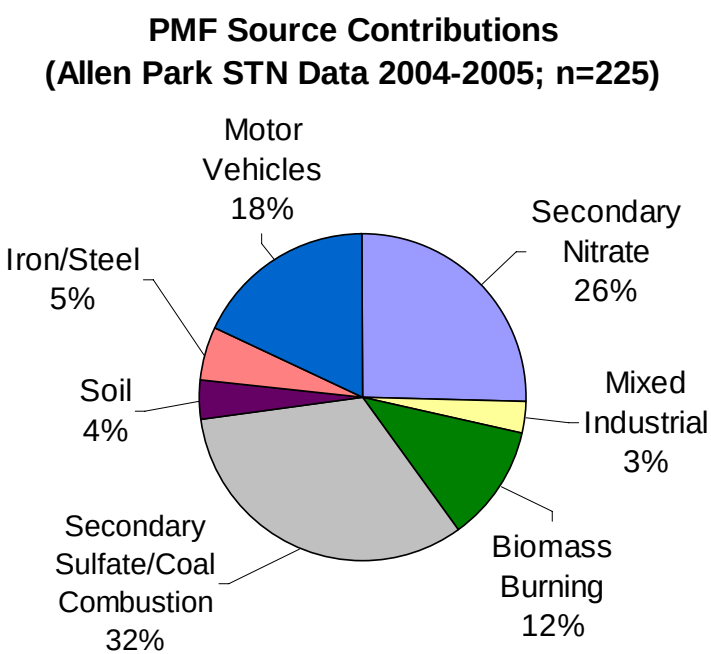
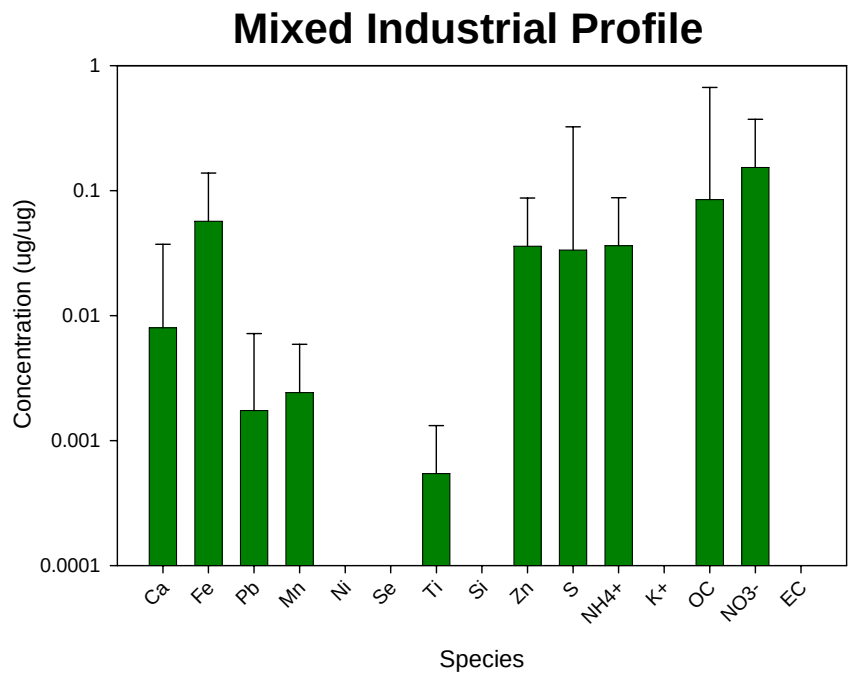
Motor Vehicle Composite Profile

- CMB model could not differentiate between gasoline and diesel profiles
- Composite profile developed based on Schauer et. al, 2001 report on PMF source contributions from Allen Park, MI (2002-2004)
  - 60% gasoline, 40% diesel
  - Weighting factor of 0.60 (gasoline) and 0.40 (diesel) given to each species in gasoline and diesel profiles
  - Species concentrations averaged to obtain composite profile

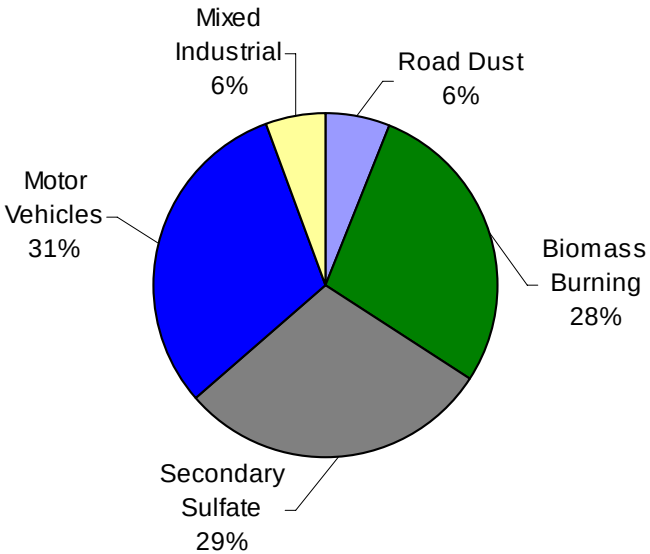
Results – Allen Park PMF





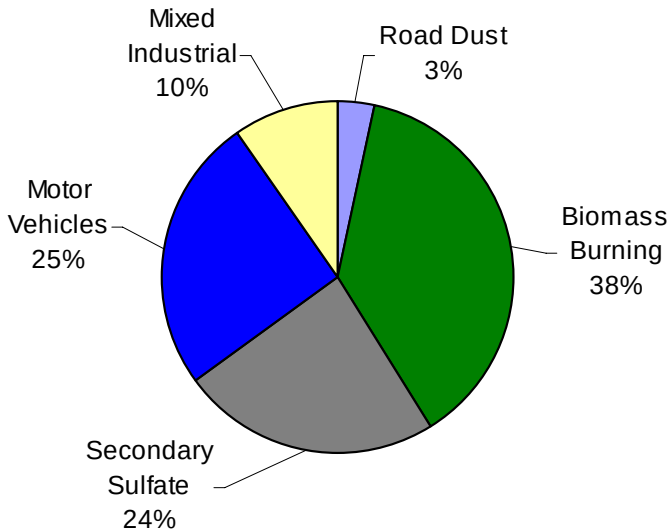
CMB Results
DEARS Season 1 and 2 Average Contributions

Season 1 - summer



PMF Biomass – 19.8%

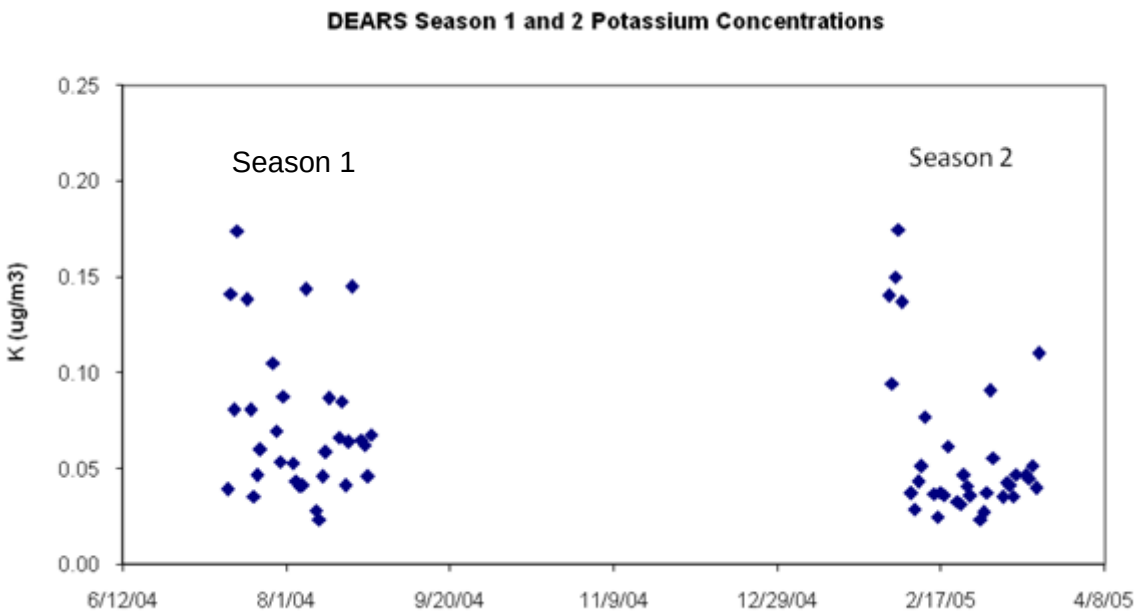
Season 2 - winter



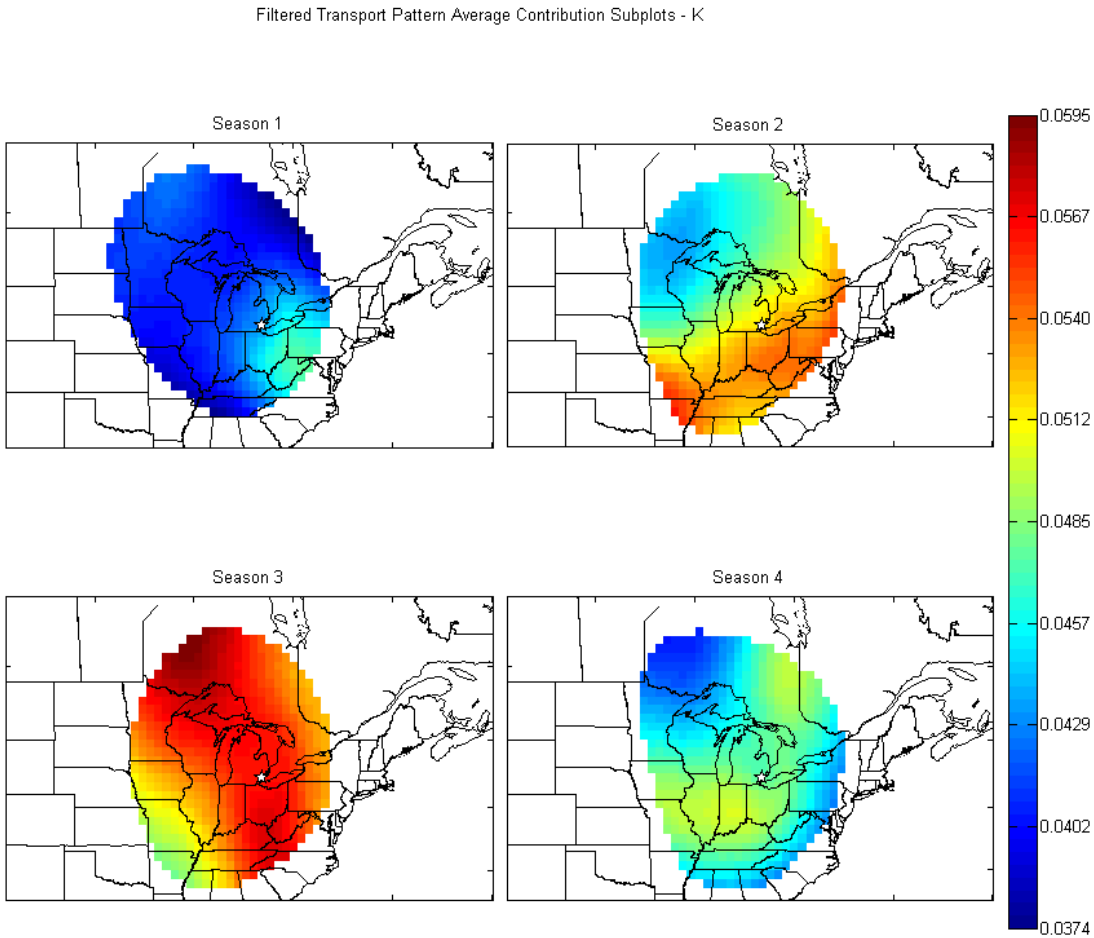
PMF Biomass – 9.0%

High Biomass Contributions during DEARS Compared to STN PMF

- Potassium is a marker for biomass burning and soil



STN APTR Potassium Results – Regional Transport



Season 1: Dec - Feb
Season 2: Mar - May
Season 3: Jun - Aug
Season 4: Sep - Nov

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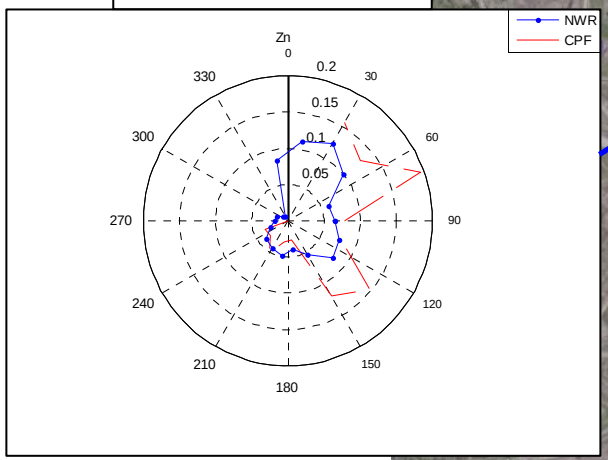
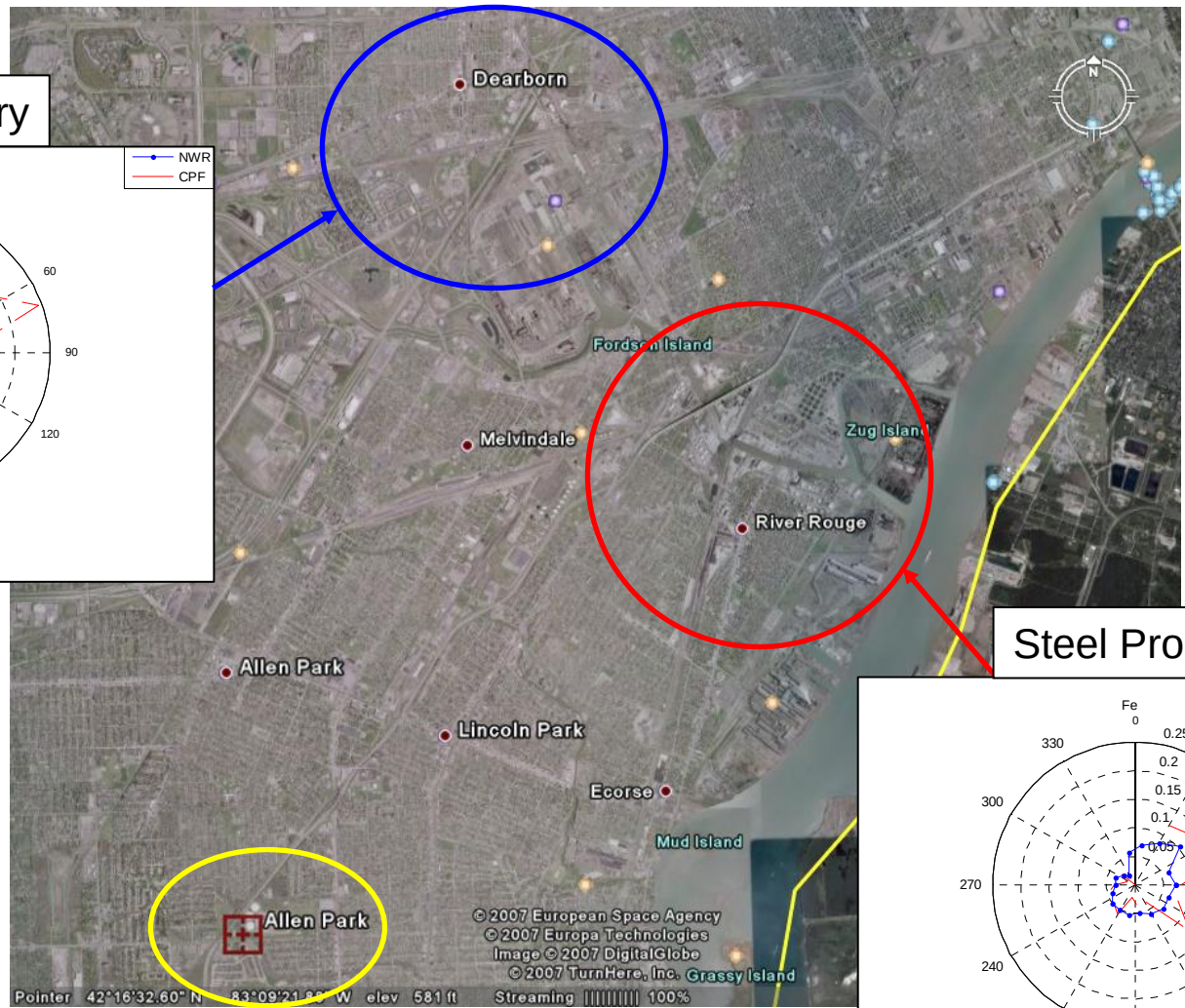
STI Report: Integration of Results for the Upper Midwest Urban Organics Study (March 31, 2006)

- Conclusions and Recommendations
  - Attribution of burning varied among the analyses, but we are confident that the range is correct (2 – 25% of organic matter).
  - Additional analyses with daily levoglucosan data (in CMB or PMF) or additional speciated $PM_{2.5}$ data including potassium ion would help increase the certainty, as would development of area- and fuel-specific burning profiles.
- DEARS
  - Daily K and levoglucosan data will reduce the uncertainty associated with the biomass contribution

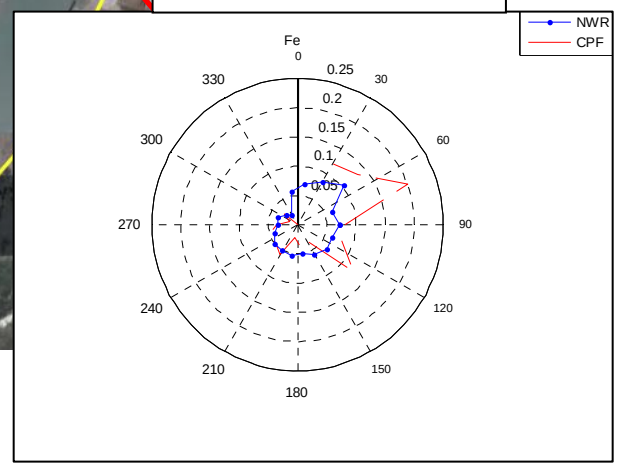
Local Sources Impacting Allen Park

Mixed Industry

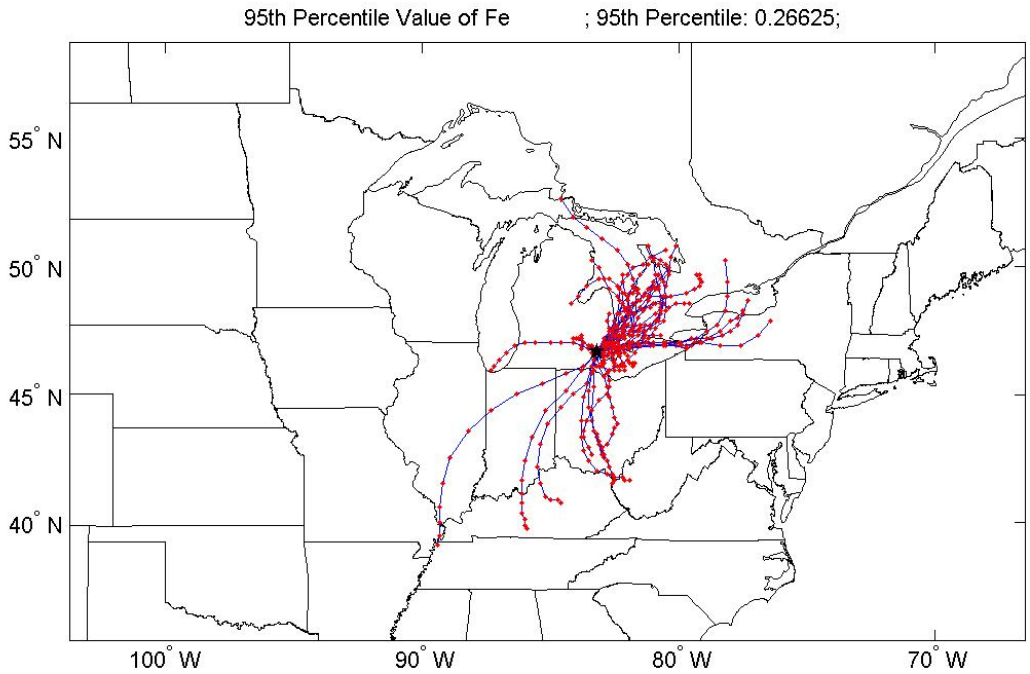




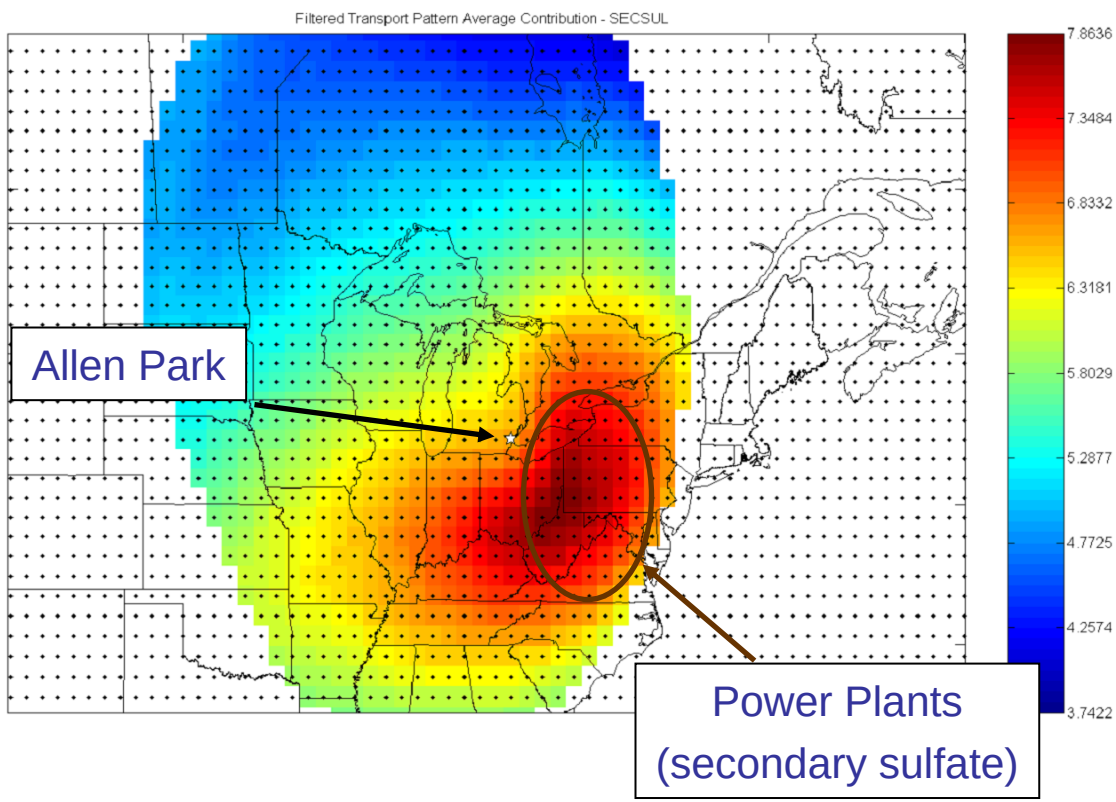
Steel Production



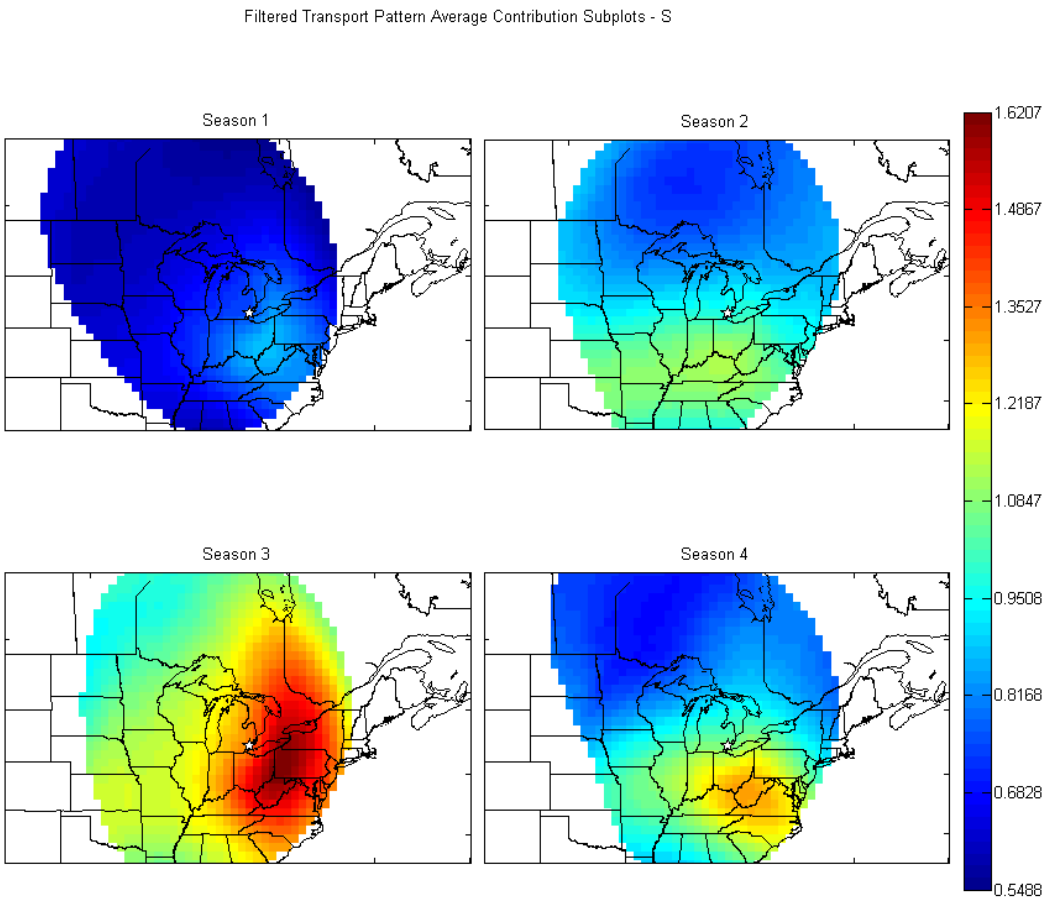
STN Fe Back-Trajectories (24 hour) for Concentrations above the 95th Percentile



Regional Sources Impacting Allen Park



STN Sulfur APTR Results – Regional Transport



Season 1: Dec - Feb
Season 2: Mar - May
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Season 4: Sep - Nov

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Summary

- Mixed industrial source profile obtained from PMF results used in CMB modeling
- Primary sources for DEARS Seasons 1 and 2 include motor vehicles, secondary sulfate, and biomass burning
- Biomass burning contributions higher than expected
  - Average biomass contributions < 2.5% from previous studies in Allen Park and Dearborn
  - Peaks in potassium concentration observed during summer and winter samples
    - No significant events during sampling to support high potassium levels

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Summary

- APTR Modeling – Local sources
  - Zn and Fe (species associated with industries) originated northeast of Allen Park
  - Industrial sectors heavily concentrated northeast of Allen Park
- APTR Modeling – Regional Sources
  - Secondary sulfate confirmed as a regional source impacting Allen Park
  - Secondary sulfate concentrations are higher in the vicinity of the Ohio River Valley

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Future Work

- Speciated organics analysis on DEARS samples
  - Assist in separating diesel and gasoline contributions
  - Biomass contribution
- Replacing industrial source profiles in CMB
  - Source samples collected from various operations at US Steel Facility as part of EPA study in St. Louis area
  - Sources will be resuspended and analyzed for various compounds (organics and inorganics)
- CMB analysis will be conducted on DEARS outdoor samples to evaluate spatial variability
- Analysis of Seasons 1-6 data with the Multilinear Engine Multiple Environment Receptor Model

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Acknowledgments

- Jay Turner (Washington University, St. Louis)
- Donna Kenski (LADCO)
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- Carry Croghan (EPA)
- Carvin Stevens (EPA)

EPA Receptor Models

Email: nerl_rm_support@epa.gov

EPA PMF1.1 and CMB available at:
http://www.epa.gov/scram001/receptorindex.htm