

# Crustal Matter

Exploring the Differences Between  
Ambient Air Samples and Emission Inventory

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# Special Thanks

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  - Emissions Inventory and Analysis Group, United States Environmental Protection Agency
- Mentor: Dr. William F. Hunt, Jr.

# Crustal and Particulate Matter Background Information

- Crustal matter is nothing more than fugitive dust/soil that originates from the earth's crust. This consists of unpaved roads, agricultural tilling, construction, etc.
- Crustal matter is one of the many components of particulate matter. Particulate matter, also referred to as PM, are particles of solids or liquids suspended in the air. It is composed of PM<sub>2.5</sub> (or PM fine), PM<sub>10</sub>, and coarse PM.
- Other components of PM include organic chemicals, metals, and acids (e.g., nitrates and sulfates).
- The main source of PM<sub>2.5</sub> comes from the combustion or burning of fuels via power plants, industries, and motor vehicles.
- Our focus is on the ratio of crustal matter to PM<sub>2.5</sub>.

# The Discrepancy!

- We have taken on the task of understanding why the ratio of crustal matter to PM<sub>2.5</sub> is so different when comparing ambient air data (actual samples taken from the air) and emission inventory data (engineering estimates generally thought to be the truth).
- At the start of our research we were told the ratio as predicted by the 2001 emission inventory was 31.4% and the ratio as reflected by samples taken in 2002 was only 5 to 10%.

# Ambient Air Data

## STN

- Stands for “Speciation Trends Network”
- Approximately 50 sites
- Located in urban areas
- Predominately in the eastern U.S.
- Designated to distinguish the different species composing PM<sub>2.5</sub>

## IMPROVE

- Stands for “Interagency Monitoring of Protected Visual Environments”
- Approximately 140 sites
- Located in rural and Federal Class I Areas
- Predominately in the western U.S.
- Designated for visibility monitoring

# Initial Analysis

## AMBIENT AIR DATA (2002)

- STN
  - Median ratio: 4%
  - 50 % of all ratios lie between 3% and 6%
- IMPROVE
  - Median ratio: 9%
  - 50% of all ratios lie between 5% and 20%

## EMISSION INVENTORY (2002)

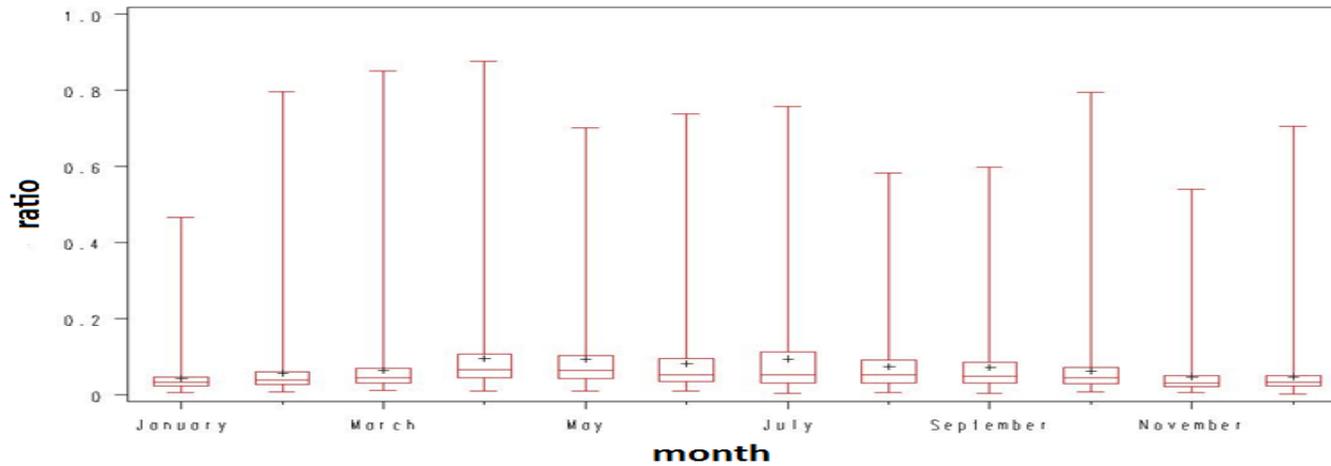
- Ratio for 2002: 27.5%
- The ratio for 2002 was slightly lower than the ratio for 2001, but not as low as the ambient data suggested it would be.

# So what's going on?

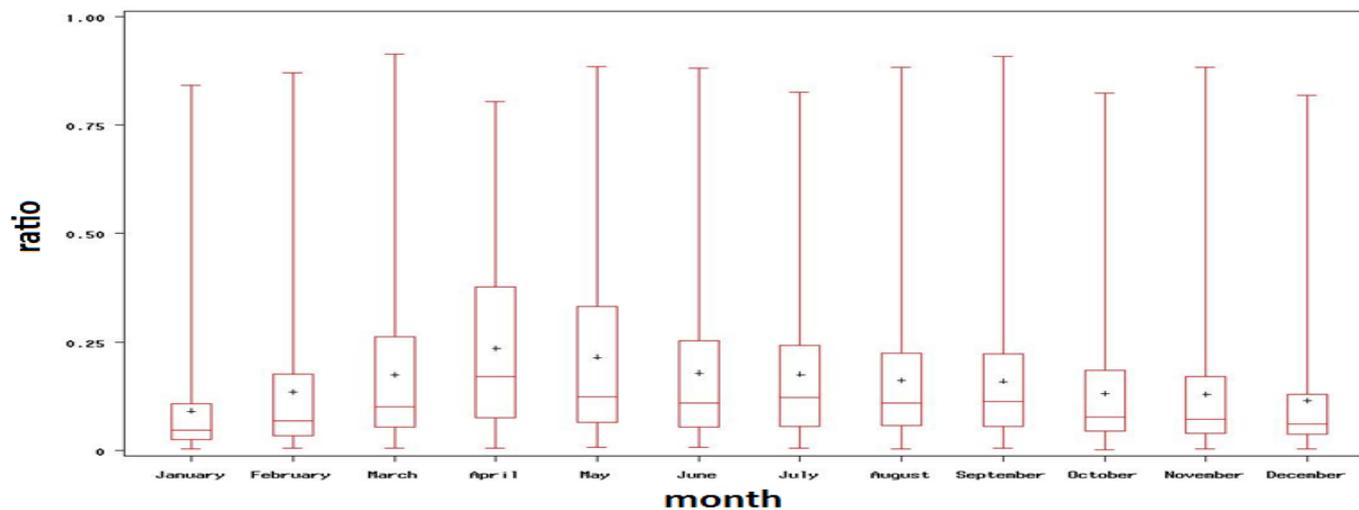
- Is there something wrong with the ambient air samples?
- Lets compare the two monitoring networks to see if they seem to agree with one another.
- An agreement would suggest valid data.

# STN and IMPROVE comparison: ratio by month

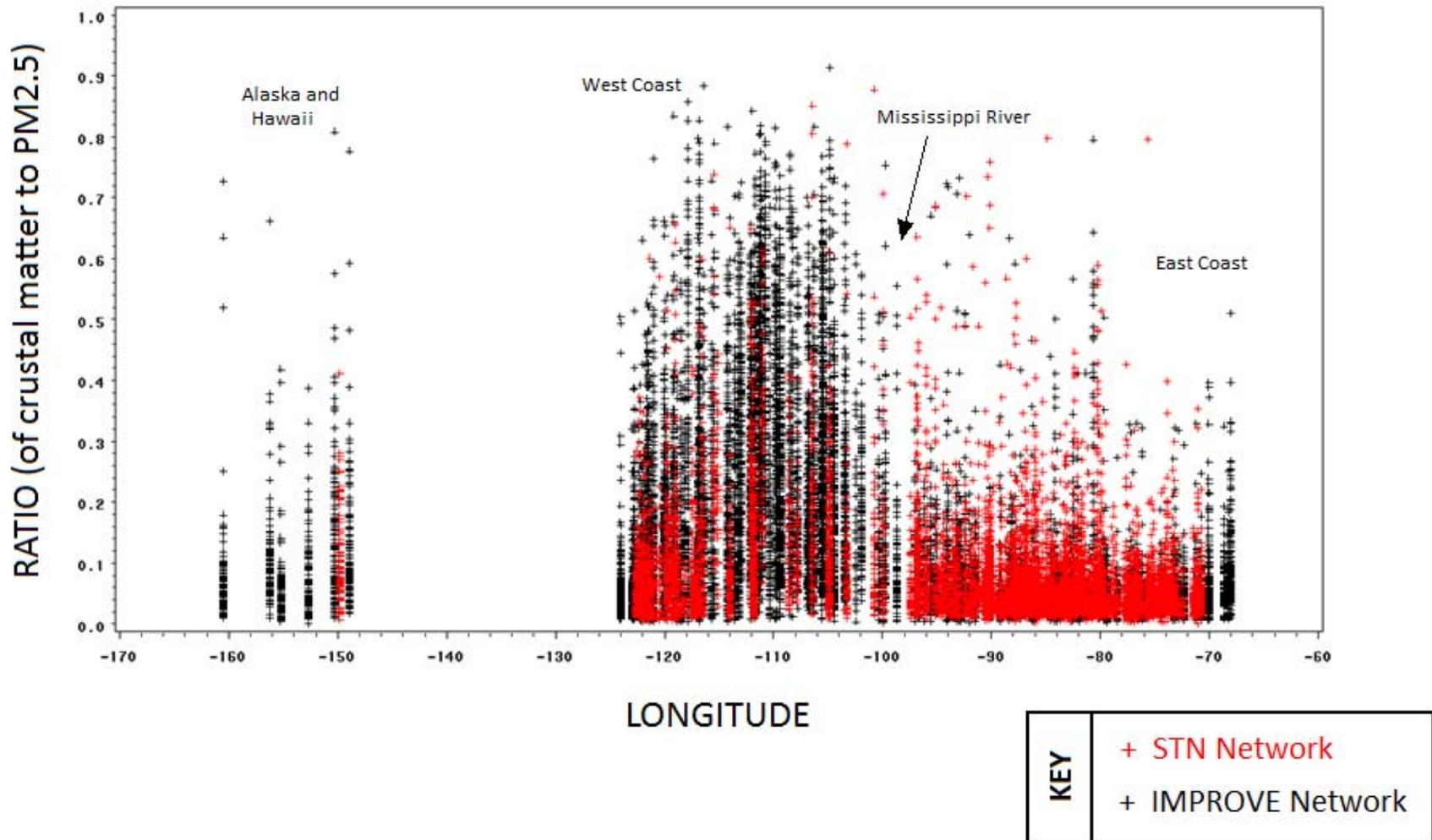
STN network



IMPROVE network

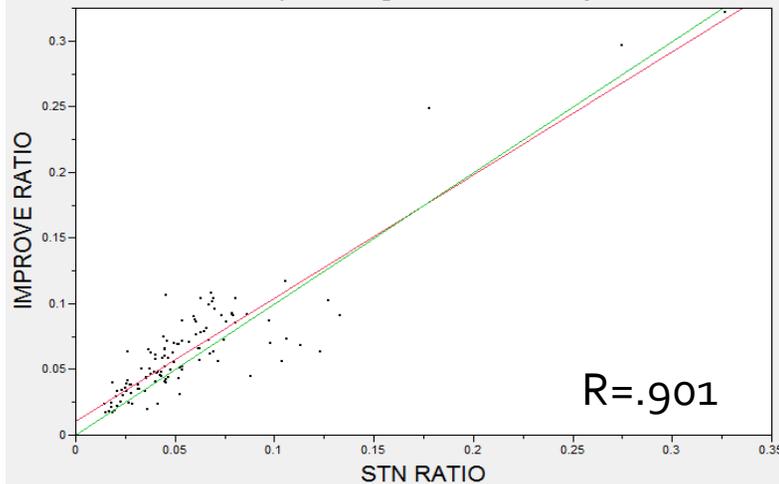


# STN and IMPROVE comparison: ratio by longitude



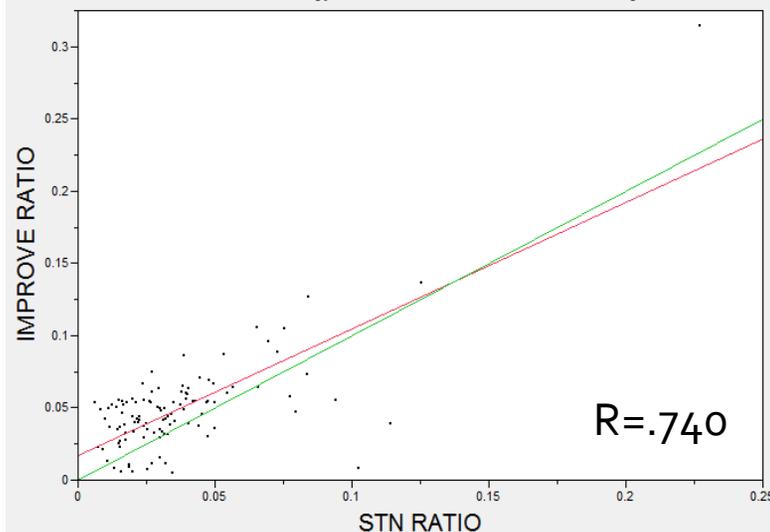
# STN and IMPROVE comparison: co-located sites

Seattle, Washington: 0.16 miles apart

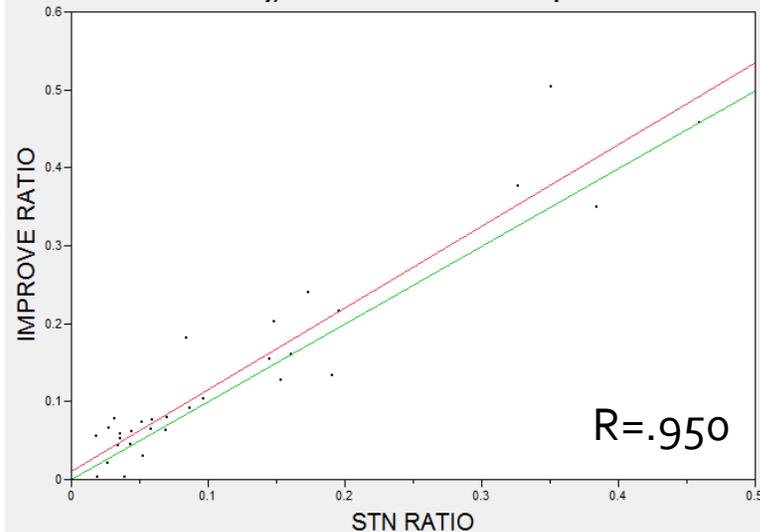


- Each point on the graph represents the ratio reading for one day for the STN network plotted against the corresponding IMPROVE reading.
- **Red lines:** Line of best fit (least squares regression line)
- **Green lines:** A one-to-one correspondence (what you would hope to see with co-located sites).

Stueben County, New York: 0.04 miles away



Ellis County, Oklahoma: 0.01 miles apart



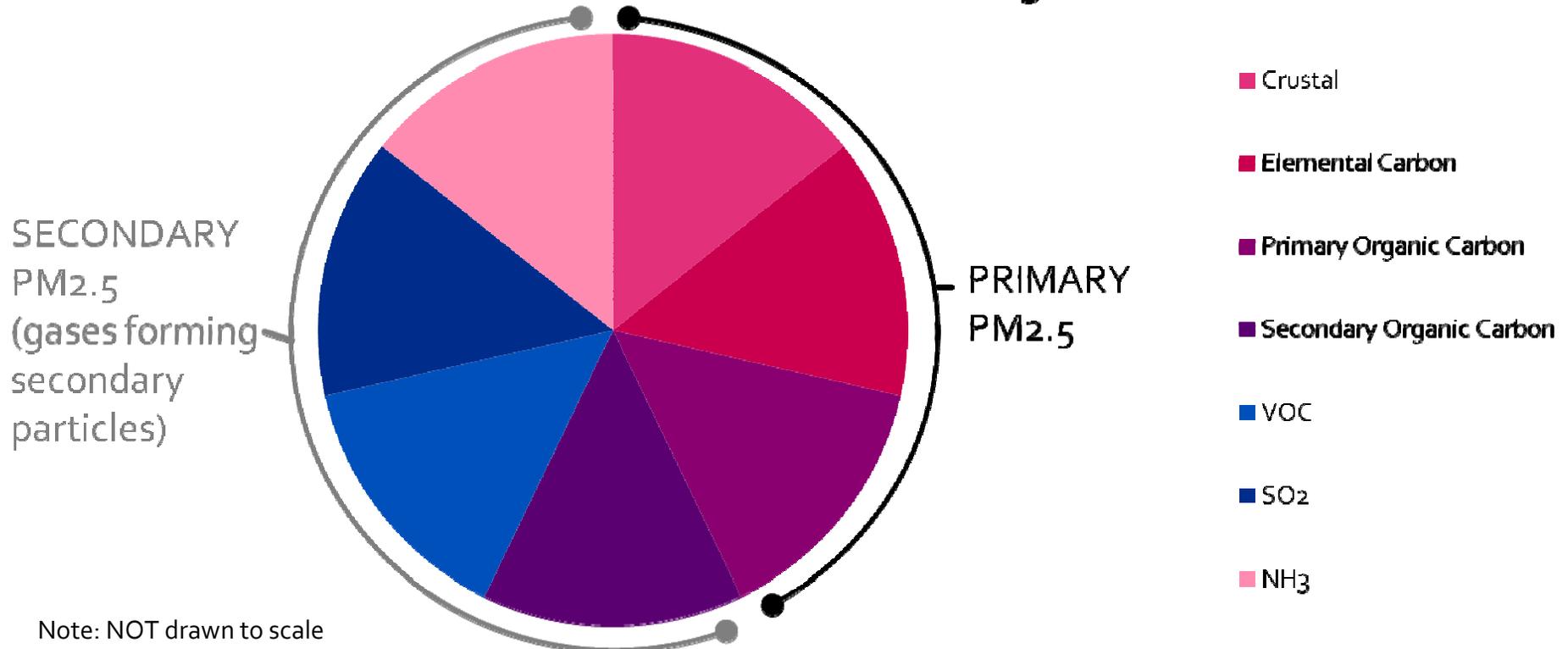
# STN and IMPROVE comparison: resulting inferences

- The same seasonal patterns are visible.
- STN and IMPROVE are especially consistent in the east, and less consistent in the west.
- Obvious inconsistencies are most likely due to the particular characteristics of the two different networks:
  - STN: urban areas, mostly in the east
  - IMPROVE: rural areas, mostly in the west
- On average, STN and IMPROVE readings are similar for sites in close proximity.
- Thus, we do believe there are no serious problems with the data.

# So now what?... A New Finding!

- We need to make sure we understand what the ratio is actually composed of. Crustal Matter is fairly simple; however, PM<sub>2.5</sub> is very complex.

## COMPONENTS OF PM<sub>2.5</sub>



Note: NOT drawn to scale

# Understanding the Ratio: emission inventory vs. ambient air

- The emission inventory is only able to (easily) estimate *primary* PM<sub>2.5</sub> emissions.
- Thus, the ratio as defined by the inventory is:
$$= \frac{\text{crustal matter}}{\text{primary PM}_{2.5}}$$
- The ratio we have used for the ambient air data is:
$$= \frac{\text{crustal matter}}{\text{total (primary and secondary) PM}_{2.5}}$$
- It is easy to see that the ambient air ratio *would* be smaller than the emission inventory ratio based on these different definitions.

# Making a better comparison

- In order to compare the ambient air samples with the emission inventory, we are only going to look at the ratio of crustal matter to *primary* PM<sub>2.5</sub>.
- The ambient samples of PM<sub>2.5</sub> are broken into its various species, however there is no clear way to tell which species are primary species and which are secondary.
- A rough estimate of the primary species as suggested by Tom Pace by has been used.
- Primary PM<sub>2.5</sub> estimate =  
crustal matter + elemental carbon + (2/3)\*organic carbon

# Ambient Air Analysis of the new, comparable ratio

## STN

- Lower Quartile: 8.0%
- Median: 12.2%
- Upper Quartile: 19.2%

## IMPROVE

- Lower Quartile: 13.7%
- Median: 23.8%
- Upper Quartile: 42.4%

These ratios, although larger than the ratios obtained in the previous analysis, still suggest the emission inventory estimate of the ratio is high.

REMINDER: The emission inventory estimate is 27.5%

# Drawing Conclusions

- The discrepancy between ambient air samples and the inventory is not as large as it was previously thought to be.
- There is no way to tell if the inventory or the ambient air samples are at fault for the discrepancy.
- The emission estimate may be high, or the ambient monitors may not be present in areas of high crustal emissions.

# Recommendations

- Ambient air monitors should be placed in areas where the presence of high crustal emissions is known. A lower estimate via the ambient data may be a result of no monitoring devices in the proximity of the crustal emissions.
- The emission inventory should present the ratio as the ratio of crustal matter to primary PM<sub>2.5</sub>.
- Anyone interpreting the ratio should be aware of the different denominators.
- When considering the ratio of total crustal matter to *total* PM<sub>2.5</sub>, a ratio of 5% to 10% as obtained by the ambient data is more reliable.

**Thank you for listening!**

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