How can Concentrated Ambient Particles used in Health Studies be tied to Specific Source Types?

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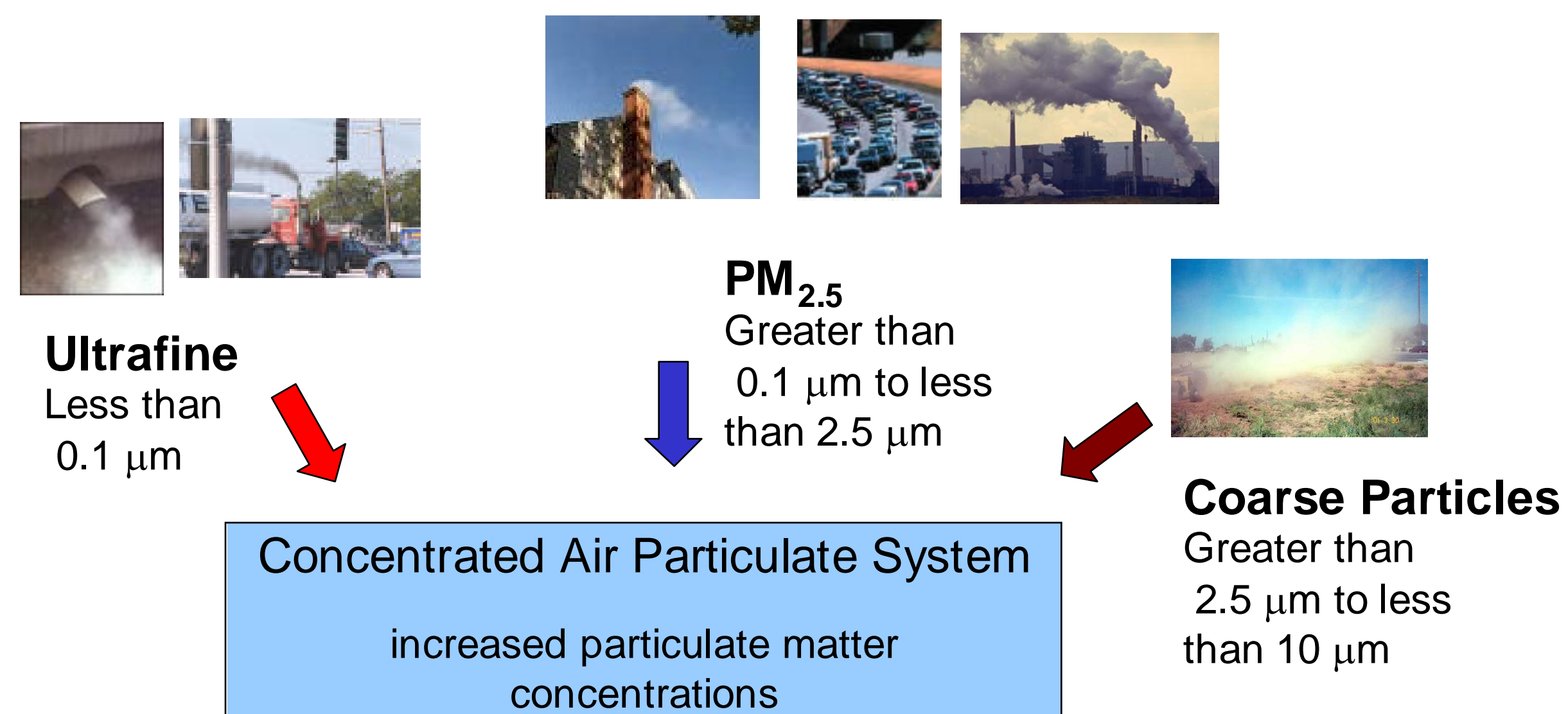
research and development

Science Question

Concentrated ambient particulate systems (CAPS) can be used to determine the association between specific source types and health outcomes. A team of NERL and NHEERL scientists are developing methods to measure and characterize concentrated particles and are also creating source-based exposure variables using receptor and hybrid receptor modeling. These exposure variables will be used in health effects analysis to determine the association between sources and health outcomes.

Research Goals

Associations between PM sources and health outcomes have been found in both epidemiology and toxicology studies. CAPS can be used to determine the association between ultrafine, $PM_{2.5}$, and coarse concentrated particle sources and a wide variety of health endpoints using the complex mixture of sources that are found in ambient air. The results from the CAPS studies can be used to guide the selection of sources for toxicology studies and may lead the development of future source based NAAQS.
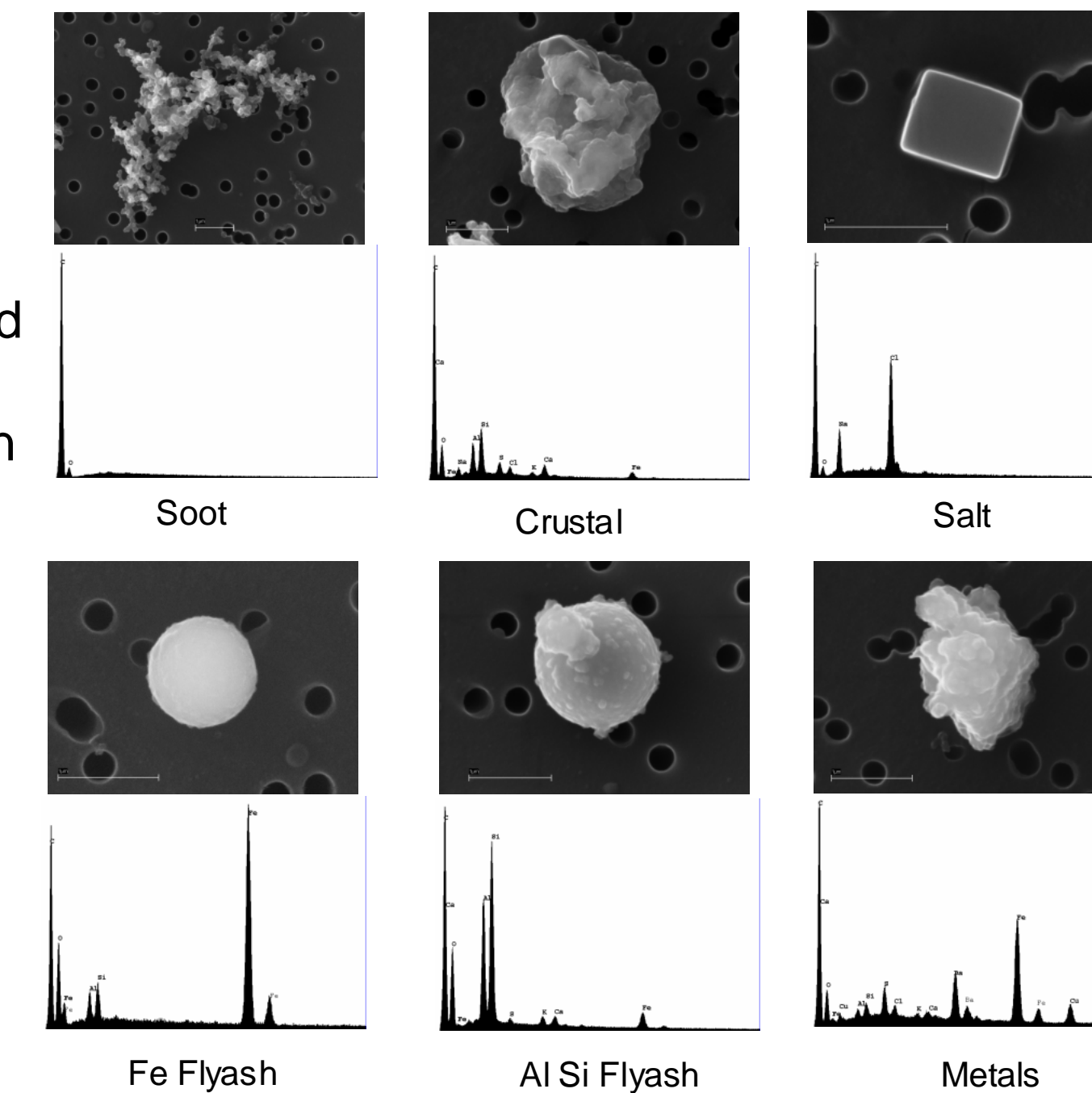
Methods/Approach

Ultrafine
Less than
0.1 μm

$PM_{2.5}$
Greater than
0.1 μm to less
than 2.5 μm

Coarse Particles
Greater than
2.5 μm to less
than 10 μm

Concentrated Air Particulate System
increased particulate matter concentrations

Filtered Air (Control)

Human or Animal Exposure Chamber

Health Endpoints

For humans, endpoints include spirometry, blood endpoints (clotting factors, catecholamines, inflammatory markers), Heart rate variability endpoints (time and frequency domain), and lung fluid endpoints from bronchoscopy (cell differentials, inflammatory markers).

Collect and Analyze Samples

Mass, inorganic (energy dispersive X-ray fluorescence (XRF) and Inductively Coupled Mass Spectrometry (ICP-MS), organic carbon (OC) and elemental carbon (EC), particle number, organic species concentrations

Mass, inorganic (XRF, ICP-MS), OC/EC, particle number, organic species concentrations

Mass, inorganic (XRF, ICP-MS), OC/EC, particle number, Scanning Electron Microscopy XRF (SEM/EDX)

Results/Conclusions

Current efforts are focusing on the coarse particle CAPS. No significant association was found between coarse particle mass and the health endpoints. Samples from the coarse particle concentrator study have been analyzed with XRF and SEM/EDX. As expected the coarse particle inorganic species that were reliably detected were associated with crustal sources: Al, Si, S, K, Ca, Ti, Fe, and Cu. Exposure variables are being generated using the results from the sample analysis and SEM/EDX particle classifications (composition and morphology (shape, size)).

Coarse particle CAPS

Soot | Crustal | Salt
Fe Flyash | Al Si Flyash | Metals

Statistical Analysis

Exposed Health Endpoint

vs.

Control Health Endpoint

Health Effects Associated with PM species and sources by particle size:
Ultrafine, $PM_{2.5}$, and Coarse

Individual species concentrations, source contributions, and source areas

EPA Receptor Modeling Tools

Unmix

Positive Matrix Factorization (PMF)

Chemical Mass Balance (CMB)

Quantitative Transport Bias Analysis (QTBA)

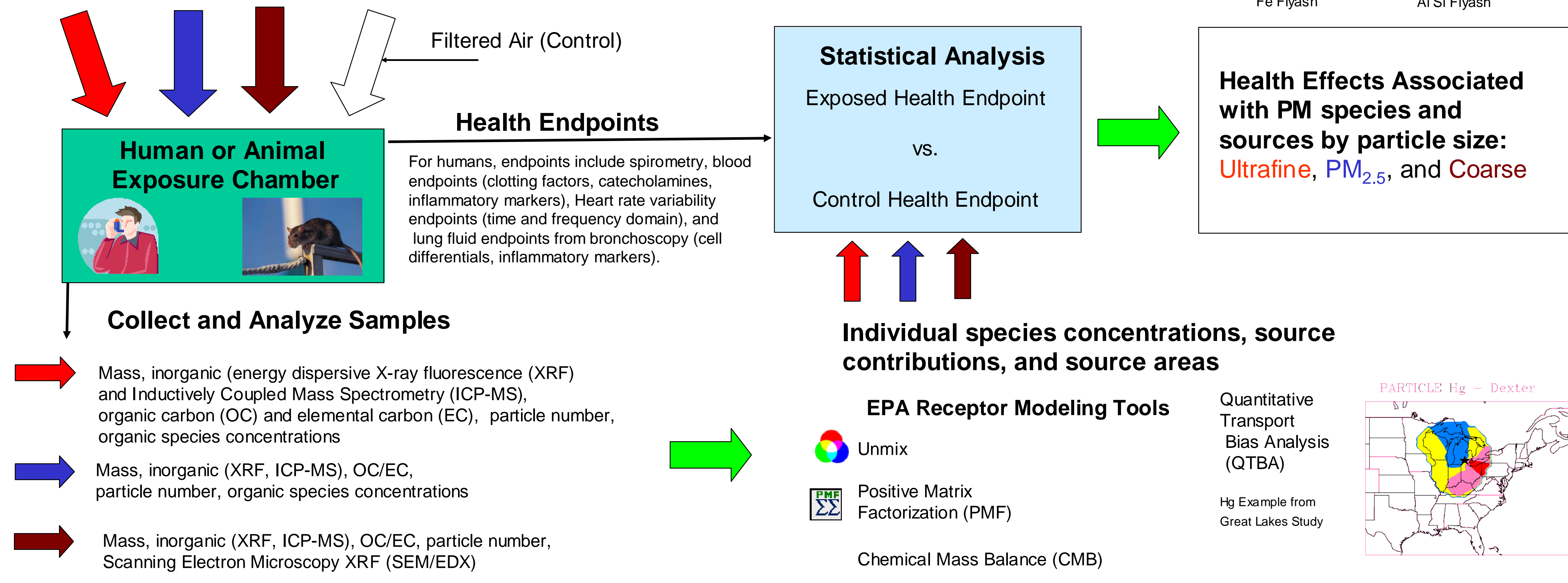Hg Example from Great Lakes Study

PARTICLE Hg - Dexter

Future Directions

Samples from $PM_{2.5}$ concentrator studies are also currently being analyzed by XRF. Exposure variables will be generated for the health effects analysis based on individual species concentrations, combinations of species, receptor model source contributions, and QTBA source areas.

Work with the PM Centers to develop CAPS source-based exposure variables and use the variables to determine the relationship between sources and health endpoints in multiple cities.

Impact and Outcomes

The results from CAPS can be used to evaluate the association between health outcomes and sources of ultrafine, $PM_{2.5}$, and coarse particles. The combination of particulate matter size and source information is a powerful tool for evaluating the association between health effects and sources. Results from these studies may help identify sources for future toxicological and exposure studies.

Source to Health Outcome