Atmospheric measurements, exposure assessment, and health data in Atlanta are combined to test hypotheses concerning the health effects of PM$_{2.5}$.

The health-based particulate matter standards will be reconsidered by EPA in 2002-2003, based upon a review of new health information.

The Inception of ARIES

The mandated timeline for the review process meant that EPA decisions would significantly benefit from new high-quality data on PM$_{2.5}$ mass and composition. This signaled the need for a collaborative effort between the public and private sectors to facilitate and expedite relevant data acquisition. In January 1998, Southern Company and EPRI formed a consortium of sponsors and eminent researchers to undertake a state-of-the-art air quality, health, and epidemiology study which promises to provide integral scientific input into the regulatory and standard-setting process in the years 2000 and beyond.

Measurements from the Southeastern Aerosol Research and Characterization study (SEARCH) and the convergence of a variety of complementary studies provided the baseline infrastructure for launching such a comprehensive study in Atlanta. After intensive planning and peer-review, investigators initiated ARIES air quality monitoring and health data collection in August 1998.

Objectives

The objective of ARIES is to investigate (via epidemiology and exposure studies) associations between air quality and human health and produce results in time for
consideration of the health basis of the NAAQS and for subsequent development of State Implementation Plans (SIPs). Fine PM may be an indicator (but not necessarily a cause) of adverse effects associated with inhalation — other pollutants, or PM components that co-vary with PM, may be the underlying cause. What sets ARIES apart from prior studies is that its focus is not on PM alone but on an unprecedented range of potential agents in the air, including VOCs, aeroallergens, and specific PM components. This comprehensive sampling approach enables a more robust and explicit investigation of the relationship between human health and airborne pollutants.

The study is fundamental by design, so that the results in terms of association between air quality and health will be generic and not limited to Atlanta. It is expected that the study will generate hypotheses to be tested through mechanistic studies and will provide data to test the relevance of results from toxicology studies. In short, ARIES will provide the underpinning of health-related studies for years to come.

**Scope**
ARIES is a multi-faceted study in which the disciplines of atmospheric research, epidemiology, exposure assessment, health assessment, and modeling were considered as parts of the whole from the inception of study design (see Figure 2). A comprehensive daily monitoring program will provide epidemiologists with a characterization of aerosol (gas and particle) physical, chemical, and biological (aeroallergenic) properties that has not been available to them before. There are four components of ARIES:

- **Air Quality Characterization:** PM$_{2.5}$ mass and composition, as well as related gas-phase and particle-phase pollutants, are measured every day at the Jefferson Street core monitoring station shown in Figure 1 with at least 24-hour time resolution. The air quality field measurements include SO$_2$, CO, NO, NO$_2$, NO$_x$, O$_3$, HNO$_3$, NH$_3$, and VOCs in the gas phase; major ions, including acidity, elemental/organic carbon (EC/OC), elements, water-soluble transition metals, and solvent-extractable carbon in the particle phase; pollen and mold; and particle number and size distribution from nanometers to micrometers in diameter.

- **Air Pollution Mortality:** daily mortality data are being collected and analyzed in a multi-pollutant ecological time-series study.

- **Air Pollution Morbidity:** daily data on emergency room (ER) visits are collected from practically all hospitals in the Atlanta area. The focus is on ER visits for coronary and respiratory symptoms. A parallel study is also being conducted to understand the influence of daily air quality on unscheduled physician visits at a large health-maintenance organization. Finally, the health study will evaluate the physiologic responses of a group of patients with more severe cardiac conditions (those with implanted defibrillators).

- **Exposure & Health Assessment:** a personal/indoor/outdoor exposure assessment study will help the epidemiologists assess how well ambient measurements can represent personal exposures for groups of individuals with recent heart attacks and with chronic obstructive pulmonary disease. This information may also have applications in validation of personal exposure models. The health study will also examine any association between exposure and cardiac response for these...
participants. The representativeness of ARIES core site is also being assessed through specialized studies of spatial variability within Atlanta in ASACA.

Schedule
The first phase, including the full suite of data collection, began in July 1998 and ended in August 2000. ARIES is therefore one of the few studies that will be in a position to provide valuable new monitoring and health data in time for EPA’s review of the PM standard. To add statistical power, most of the air quality and much of the health data collection are planned to continue through 2003.

Collaborations
EPA selected Atlanta as its first designated ‘Supersite’ and conducted an intensive one-month experiment at the ARIES site in August 1999. The cooperative structure of ARIES allows for and fosters collaboration with EPA in integrating these private and public sector experiments.

Results to Date
Several scientific papers describing ARIES research findings have been published. These are listed below, and detailed findings can be found in the papers. Highlights from published findings include:

- Detailed characterization of PM$_{2.5}$ demonstrates the importance of carbonaceous matter;
- There are discrete episodes of elevated ultrafine particle numbers that are believed to be tied to anthropogenic emissions;
- PM$_{2.5}$ composition varies from hour-to-hour, day-to-day, and season-to-season. Sulfate comprises the largest fraction of PM$_{2.5}$ in summer, while carbonaceous matter comprises the largest fraction in the spring, fall, and winter;
- To date there are no reported statistically significant associations between deaths in Atlanta and any air quality variable; these results are based upon the first year of data; increased observations could change this result;
- Morbidity results are presently available only for hospital emergency room admissions data. To date no air quality variable has been associated with increased asthma or chronic obstructive pulmonary disease (COPD) admissions. Increased cardiovascular admissions have been associated with several air quality variables: carbon monoxide (CO); PM$_{2.5}$ elemental carbon (EC); PM$_{2.5}$ organic carbon (OC); and PM$_{coarse}$ mass (i.e., the "coarse" fraction of PM$_{10}$ or the difference between PM$_{10}$ and PM$_{2.5}$).

ARIES at a Glance

<table>
<thead>
<tr>
<th>Component Funding (approximate distribution)</th>
<th></th>
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<tbody>
<tr>
<td>Air Quality</td>
<td>$3.5$ MM</td>
</tr>
<tr>
<td>Exposure Assessment</td>
<td>$1.5$ MM</td>
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<tr>
<td>Epidemiology</td>
<td>$4.0$ MM</td>
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</tbody>
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<tr>
<th>Ambient Measurements (August 1998-August 2000)</th>
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<tbody>
<tr>
<td>Continuous (1-minute averages) O$_3$, NO, NO$_2$, NOy, HNO$_3$, SO$<em>2$, CO, PM$</em>{2.5}$ mass, wind speed, wind direction, temperature, relative humidity, barometric pressure, solar radiation, precipitation</td>
</tr>
<tr>
<td>Discrete (24-hour average) PM$<em>{2.5}$ mass, ions, water-soluble metals, trace elements, organic carbon, elemental carbon PM$</em>{coarse}$ mass, ions, water-soluble metals, trace elements, pollen and mold (&gt;25 species) VOCs, oxygenated VOCs and multi-phase VOCs Ammonia</td>
</tr>
</tbody>
</table>

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Fact Sheet

Measurements by Collaborators
- Single particle composition and size-resolved particle composition by NOAA
- Continuous PM$_2.5$ mass and speciated monitoring at other sites by GIT (ASACA)
- PM density (experimental) by University of Minnesota
- EPA Supersite experiments

Sponsors
- American Automobile Manufacturers Assoc.
- American Electric Power Service Corp.
- Alabama Electric Cooperative
- Allegheny Energy
- American Petroleum Institute
- BG&E/Constellation
- Central & South West Corp.
- Connectiv
- Detroit Edison
- Duke Energy Corp.
- Dynegy Midwest Generation
- EPRI
- First Energy Corp.
- Great River Energy
- LG&E Energy
- Midwest Generation
- Minnesota Power
- National Rural Electric Cooperative Association
- NiSource/NIPSCO
- Oglethorpe Power Corp.
- Reliant Energy HL&P
- Salt River Project
- South Carolina Electric & Gas Co.
- Southern Company
- Tennessee Valley Authority
- TXU Electric
- U.S. Department of Energy
- Wisconsin Electric Power Co.
- WPS Resources
- Xcel

Collaborators
- Southern Oxidants Study (SOS)
- Southern Center for the Integrated Study of Secondary Air Pollutants (SCISSAP)
- Southeast Aerosol Research Characterization Study (SEARCH)
- Assessment of Spatial Aerosol Composition in Atlanta (ASACA)
- EPA Supersite Program

Scientific Team
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- Desert Research Institute
- EPRI
- Emory University
- Harvard University
- Kaiser Permanente
- Klemm Analysis Group
- Oregon Health and Science University
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- Rick Burnett, Health Canada
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- Barbara Turpin, Rutgers University
- John Vandenberg, US EPA
- Warren White, Washington University

Published Papers
- Tolbert, P. E.; Klein, M.; Metzger, K. B.; Peel, J.; Flanders, W. D.; Todd, K.; Mulholland, J. A.; Ryan, P. B.; Frumkin, H. Interim results of the Study of Particulates and Health in Atlanta (SOPHIA), J. Exposure Anal. & Environmental Epidemiology, 2000, 10, 446-460.

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Follow links to ARIES Home Page

Figure 2. ARIES Components