

ARIES: Aerosol Research Inhalation Epidemiology Study

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



Figure 1. ARIES Core Site

Background

Findings from some epidemiology studies have shown discernible associations between daily levels of suspended particulate matter and adverse health effects. Interpretation of these associations has been difficult and controversial because particulate matter can be an index for a range of other substances in air as well as for weather and seasonal patterns.

On the basis of the epidemiology evidence, the United States Environmental Protection Agency (EPA) promulgated new National Ambient Air Quality Standards (NAAQS) for particulate matter 2.5 micrometers in diameter (PM_{2.5}) and smaller. These standards address long term (annual average) and short-term (24-hour average) concentrations of PM_{2.5}. Based on emerging data, it appears likely that many areas of the US will approach or exceed the annual-average threshold for compliance with the annual PM_{2.5} NAAQS.

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 SO₂, CO, NO, NO₂, NO_y, O₃, HNO₃, NH₃, 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 PM₁₀ or the difference between PM₁₀ and PM_{2.5}).

ARIES at a Glance

Component Funding (approximate distribution)

Air Quality	\$3.5 MM
Exposure Assessment	\$1.5 MM
Epidemiology	\$4.0 MM

Ambient Measurements (August 1998-August 2000)

Continuous (1-minute averages) O₃, NO, NO₂, NO_y, HNO₃, SO₂, CO, PM_{2.5} mass, wind speed, wind direction, temperature, relative humidity,

barometric pressure, solar radiation, precipitation
 Continuous (10-minute average)
 Particle-count (0.003 to 3.0 µm)
 Discrete (24-hour average)
 PM_{2.5} mass, ions, water-soluble metals, trace elements, organic carbon, elemental carbon
 PM_{coarse} mass, ions, water-soluble metals, trace elements
 Pollen and mold (>25 species)
 VOCs, oxygenated VOCs and multi-phase VOCs
 Ammonia

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.
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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

Atmospheric Research & Analysis
Desert Research Institute
EPRI
Emory University
Harvard University
Kaiser Permanente
Klemm Analysis Group
Oregon Health and Science University
University of Minnesota

Advisory Group

Tina Bahadori, American Chemistry Council
Rick Burnett, Health Canada
Isabella Romieu, Pan American Health Organization
Barbara Turpin, Rutgers University
John Vandenberg, US EPA
Warren White, Washington University

Published Papers

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ARIES Contacts

Air Quality Measurements and Sponsors' Project Manager

Alan Hansen, EPRI, 650-855-2738
 ahansen@epri.com

Health Effects Project Manager

Ron Wyzga, EPRI, 650-855-2577
rwyzga@epri.com

Air Quality Operational Details

Eric Edgerton, ARA, 919-678-1099
 ericedge@gte.net

Web Address

www.atmospheric-research.com
 Follow links to ARIES Home Page

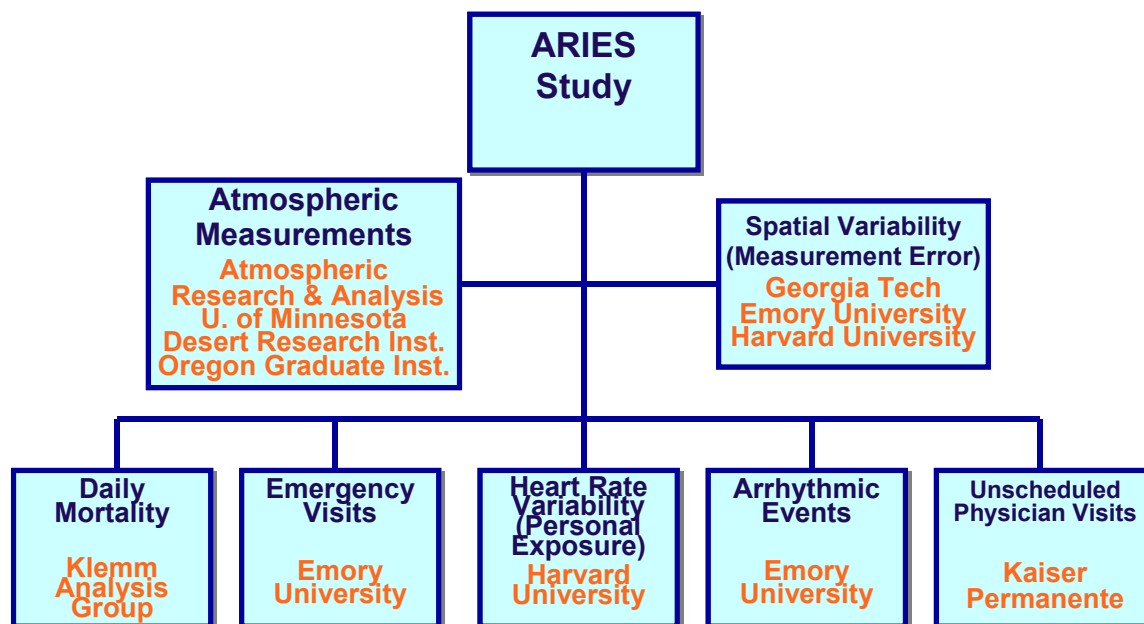


Figure 2. ARIES Components