Interactions among the Centers, EPA and the Broader Research Community

As noted in the 2002 SAB interim report on the PM Centers, "there is a clear need for and benefit from increased inter-Center interaction." It is through such interactions that the PM Center program becomes more than five Centers working individually – and opportunities arise for enhanced scientific collaborations and research productivity. The PM Centers report that they have benefited from the interactions among the Centers, EPA and other scientists. These interactions and follow-up collaborations are stimulated through various means including the annual PM Centers meetings, the bi-monthly work-in-progress web-conferences, participation on one another's Science Advisory Committees (SACs), other professional meetings and informal contact. According to one Center's report, "the interactions with both the other Centers and EPA have been extremely valuable in terms of developing clearer ideas for research, actually obtaining PM samples for study, being involved in field studies, and serving in an advisory capacity. Were it not for the Centers, these activities would not have occurred."

Below are a few illustrative examples of the benefits of interactions among the current PM Centers.

Select Examples of PM Center Interactions

PM Center Directors Annual Meetings: The Centers and EPA hold annual meetings to exchange information and foster multi-disciplinary communication and coordination. Each Center and EPA takes a turn hosting the meeting. Planning is done over several months by a cross-Centers planning committee of about 10 members, representing a mix of disciplines. The annual meetings often include presentations and participation by experts external to the Centers to promote these interactions (Tab 4-T). The "kick-off" meeting for the new Centers and the final meeting summarizing results of the Centers are open to a broad audience. The meetings in-between are more limited to enhance small group working sessions among the investigators.

These working meetings have influenced research at the Centers in a number of ways. For example, the statisticians from the Centers and EPA meet annually and share methodological challenges and innovative solutions on cross-Center issues regarding estimation of the health effects of air pollution, characterization of exposure-response relationships, and the handling of measurement error. Discussions among health, exposure and atmospheric science researchers at the meetings influenced the Johns Hopkins Center to include a lower dose point in their animal bioassays and to make changes that improved the performance of their sequential PM collector. A guest speaker at one of the annual meetings inspired the San Joaquin Valley Aerosol Health Effects Research Center (SAHERC) to rebudget funds to include a project investigating endothelial function with flow cells. Discussions at a special session on concentrated ambient particles (CAPs) and panel studies in 2006 influenced the Harvard PM Center in the design of its controlled human exposure studies.

Technological Exchange: The Centers have reported efficiencies by tapping one another's technological expertise. The Harvard PM Center developed an ultrafine concentrator prototype and transferred the technology to the University of Rochester, providing extensive training. Unforeseeable technical challenges arose during the initial implementation, requiring close collaboration between the two Centers. Subsequently, Harvard improved the technology and provided Rochester with a second, higher performing instrument. Harvard also collaborated with SAHERC on technology for collection of size segregated PM samples using high volume collectors. SAHERC has built a burner to generate various kinds of soot for animal exposures but the flame generates other pollutants that may interfere with assessment of PM health effects. To control this problem, SAHERC is now incorporating technologies they received from the EPA lab and the Harvard PM Center. Working with the SCPC and using its particle concentrator for field studies, SAHERC researchers are now in a better position to compare findings between the two Centers.

Scientific Advisory Committee Meetings: Each Center has an External Scientific Advisory Committee (SAC), which meets annually to review Center progress and provide advice and guidance. The SACs include representatives who sit on multiple PM Center SACs, which helps facilitate interaction among the Centers. In addition, each SAC is required to have at least one representative from another PM Center and one representative from EPA to promote interaction. Several Centers exceed these minimum requirements (see SAC member lists attached).

Through issues raised at SAC meetings, PM Center investigators have assisted one another in carrying out field studies, expanding several projects, and improving comparability of results. SAHERC is providing assistance to the Johns Hopkins PM Center in carrying out field work in the San Joaquin Valley. The SCPC has supported the SAHERC's field exposures in the area of Parlier, CA, and conducted concentrated air particle studies of PM from agricultural sources and activities. The Harvard PM Center and SCPC are collaborating on assessment of animals exposed subchronically to concentrated air particles in Boston. One study was expanded resulting in assessment of multiple outcomes on the same animals using expertise of the two Centers. As a result of discussions at the Harvard SAC meeting about controlled human exposure studies, researchers from the Harvard Center visited the Rochester PM Center to compare methods and share information. These discussions and comparisons were also undertaken with EPA researchers at the annual PM Centers meeting.

Workshops: As issues emerge at SAC meetings, PM Center annual meetings, or other interactive venues, the Centers have elected to sponsor workshops to advance understanding or develop recommendations for how best to proceed with research. These workshops may be planned independently, or in cooperation with EPA, other Centers and the broader research community. The original PM Centers conducted a number of workshops including one of the first on air pollution and cardiovascular disease, and another on comparative approaches for source apportionment studies. The current Centers are continuing these efforts, including a series of meetings to address challenges in using ambient air quality data for air pollution health studies. Specific questions first

emerged on this topic at a Johns Hopkins PM Center SAC meeting, resulting in workshops organized jointly with EPA and the Health Effects Institute. Tab 4-U includes a listing of workshops sponsored by the current PM Centers.

Work-in-Progress Web-Conferences and Center Director Calls: In response to the previous SAB panel report on the PM Centers, EPA sought additional opportunities for interaction among the PM Centers and EPA staff. One need was to provide more inexpensive opportunities for larger numbers of less senior researchers to meet and interact. As a result, EPA and the Centers began bimonthly work-in-progress seminars via web-conference. EPA encourages the Centers to allow more junior level investigators to present the preliminary results of a Center project. The presentations are generally no more than 30 minutes, allowing equal time for questions and discussion. Participation averages 30-40 people, with most Center Directors and many senior investigators in attendance. These seminars provide an opportunity for the Centers and EPA to share recent research results and identify expertise in other Centers and EPA that can be helpful to a project (Tab 4-V).

In addition to the work-in-progress web conferences, Center Directors meet bimonthly by conference call to discuss Center integration opportunities and coordination issues.

Round Robin Research Collaborations: Round robin analytical comparisons among the Centers, EPA, and other air pollution researchers represent yet another form of interaction. These efforts require considerable time and effort in coordination and planning, yet were not part of the Centers original budget proposals.

The original Centers organized a project called the Multiple Air Pollutant Study (MAPS). EPA, PM Center and other investigators collaborated to collect size-fractionated PM samples (ultrafine, fine and coarse) from eight different geographical areas. Each area was chosen because it has a different source profile. The goal of the project was to compare the biological response of cultured cells or animals to particles from all the locations, and link differences in biological response to different PM components or sources. The same sampling devices were used to collect particles in all locations and the same standard operating procedure was followed for collection of particles and removal of particles from filters. The EPA analyzed the particles for chemical components and provided samples to any PM Center or EPA investigator who wanted to participate in the project. A symposium at the 2004 Society of Toxicology meeting focused exclusively on MAPS projects. Two manuscripts describing linkage between health effects and PM sources have been published and others are in preparation. In addition, original PM Center participants were able to leverage preliminary data obtained in the MAPS study to obtain additional funding.

The current PM Centers and EPA are collaborating on a round-robin type experiment to assess the capabilities and accuracies of two different methods of measuring trace elements – XRF and ICP-MS. Samples were collected from three locations across the country and each sample is being tested at up to five different laboratories under each method. A more detailed description of this effort is attached in the following pages.

Communicating Integrated Results of the PM Centers Program: In addition to the types of activities described above, the PM Centers have worked as an integrated team to report results, scientific insights and major advances. The original centers produced an interim report of findings published in Environmental Health Perspectives in 2003 (full text at: http://www.ehponline.org/members/2003/5750/5750.pdf), and have completed a final, integrated report along with three technical supplements (Tab 1-B, Tab 4-R). In addition, this group, together with EPA, presented the findings of the PM Centers program at a final meeting in Washington, DC in 2004 (http://es.epa.gov/ncer/publications/workshop/9-27-2004/agenda.html). Each speaker presented integrated findings from all of the Centers for each given topic. At a 2005 review of ORD's Air Research program by its Board of Scientific Counselors (BOSC), the PM Centers worked with EPA to summarize and integrate research results in posters and presentations. In its report, the BOSC subcommittee noted "there is a strong interaction, coordination, and synergism among various laboratories and centers, as is evidenced in the oral presentations, poster presentations, and documents provided to the Subcommittee." The current Centers will be involved in the upcoming BOSC review in 2009 and will also complete a final, integrated report.

In summary, EPA and the PM Centers program have increased inter-Center interactions and believe this has been highly beneficial to the program. There is high enthusiasm among the Center Directors and PM Center investigators to continue these valuable collaborations since they helped to expand the scientific knowledge of PM-induced effects from respiratory to extrapulmonary organ systems (cardiovascular, central nervous system). Likewise, the mechanistic understanding of such effects has dramatically increased through the Centers' Program. Enhanced interactions among investigators from research institutions across the country have enabled researchers to share resources and harmonize research efforts through inter-comparison studies, shared laboratory protocols or jointly developed data analysis strategies. Collectively, these interactions among scientists from different institutions and disciplines have significantly advanced research on health effects of PM.

PM Centers Analytical Methods Project

Overview:
The PM Centers and EPA are collaborating on a round-robin type experiment to assess the capabilities and accuracies of two different methods of measuring trace elements – XRF and ICP-MS. Samples were collected from three locations across the country and each sample is being tested at up to five different laboratories under each method.

The goal of the project is to compare XRF and ICP-MS measurements from a set of common samples to see if the measurements agree. The hypothesis going into the experiment (based on previous work) is that XRF will be the most consistent technique for lighter elements while ICP-MS will be the most consistent technique for heavier elements. The strengths and weaknesses of each technique are generally not acknowledged by researchers in the field right now, and it is suspected that some of the measurements being put into public datasets are actually not that accurate. This project will help everyone involved to understand the capabilities of each method.

The first phase of the project involved XRF analysis of samples. Three labs completed the XRF analyses: DRI, RTI, and IMPROVE. The samples are currently at EPA and will be analyzed soon before returning to Davis. After XRF is complete, the samples will be sent to five ICP-MS labs for analysis.

Analytical Methods Project Sampling Plan

PM Analysis Comparison Phase 1: Elemental Analysis

Motivation: The ability to measure the elemental composition of airborne particles is a critical issue because (1) trace elements contained in airborne particles may cause adverse health effects and (2) trace elements may be used as chemical source profiles to understand source contributions to airborne particulate matter. The true ability to measure the elemental composition of airborne particles is not completely understood at the present time. Minimum detection limits (MDLs) for analysis methods are often based on simplified tests using ideal standards that do not suffer from the same interferences as true environmental samples. Simple consistency checks comparing the precision of collocated measurements do not always yield expected results. A need exists to better characterize the abilities of standard analysis methods for the measurement of airborne particle elemental composition.

Background: There are a number of analysis methods for the elemental characterization of airborne particles including X-ray Fluorescence (XRF), Particle Induced X-ray Emissions (PIXE), Neutron Activation Analysis (NAA), and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). XRF is used in large sampling networks such as IMPROVE and STN. XRF and ICPMS are used in numerous research projects funded by EPA, CARB, and other agencies studying air quality problems. XRF and ICPMS are the only techniques proposed for the elemental analysis of airborne particulate matter by the 5 EPA Centers studying the health effects of airborne particulate matter.

Hypothesis: Based on preliminary research, the following hypotheses are proposed.

(1) XRF is the most accurate and precise technique with the lowest MDLs that is available for the measurement of light crustal elements contained in airborne particles including silicon, sulfur, calcium, iron, and zinc.
(2) ICPMS is the most accurate and precise technique with the lowest MDLs that is available for the measurement of heavier elements including arsenic, selenium, bromine, rubidium, strontium, cadmium, tin, antimony, barium, thallium and lead.

These hypotheses will be tested through the analysis of a set of collocated ambient samples.

Equipment and Materials: One subset of the samples will be collected with Reference Ambient Air Samplers (RAAS) (Andersen Instrument, Smyra GA). Each RAAS unit will be configured to draw 10 LPM through each collection filter (30 LPM through each cyclone) yielding a cut size of 1.8 µm (PM1.8). This sample flow rate is chosen to correspond with MOUDI samplers that will also be used for collection.

A second subset of samples will be collected using Micro Orifice Uniform Deposit Impactors (MOUDIs) (MSP Corp, Shoreview MN). An AIHL-design cyclone will be operated upstream of each MOUDI to remove particles larger than 1.8 µm in diameter form the sample stream. All MOUDI samplers will be operated at the manufacturer recommendation of 30 LPM.

A third subset of samples will be collected downstream of a PM10 inlet operated at 18 LPM split evenly between 3 samples.

All samples will be collected on Teflon filters (Teflo R2PJ047). Samples will be stored in individual Petri dishes with unique id numbers that are sealed with Teflon tape and stored at -18^{o}C after sample collection. Standard clean sample handling protocols will be employed during all procedures.

Phase 1 Analysis Protocol – PM1.8 Samples:
Step 1.
PM1.8 samples will be collected in Davis, Research Triangle Park, and Fresno. Sample collection at UCD will take place between 5/17/2006 – 5/31/2006. Sample collection at Fresno will take place between 9/1/2006 – 9/30/2006. Sample collection at RTP will take place between 9/1/2006 – 9/30/2006. The distribution of collected samples is described in Table 1 below.

Table 1: Distribution of PM1.8 samples used for XRF vs. ICPMS comparison.

Sample Event	Location	# Co-located Samples	# Samples Analyzed by XRF*	# Samples Analyzed by ICPMS**
1	Davis	18	9	18 * 2
2	Davis	18	9	18 * 2
3	Fresno	18	9	18 * 2
4	RTP	12	6	12 * 2
5	RTP	12	6	12 * 2

* Samples will be sent as whole filters to XRF labs and returned to UC Davis after round-robin cycle is complete

** Samples will be cut in half prior to ICP-MS analysis

Step 2.

A subset of the PM1.8 samples along with blank filters will be sent to the XRF labs involved in the study as shown in Table 2. Each lab will receive an initial set of samples that have not been analyzed by other labs. After sample analysis is complete, each lab will ship their samples to another lab in a "round-robin" fashion as shown in Table 2 and Figure 1. The "round-robin" will continue until each lab has re-analyzed their initial set of samples. During each set of analysis, each lab will measure the concentration of elements contained on each filter twice on separate days. Data from both sets of analysis will be reported to EPA along with any notes describing standard QA/QC tests. All samples will be returned to UCD after the "round-robin" XRF testing is complete.

Samples will be shipped in Petri dishes sealed with Teflon tape sealed inside a plastic bag which is in turn placed inside several layers of shipping materials. All labs will follow their cleanest possible sample handling protocols.

Table 2: Round-robin XRF analysis schedule

XRF Lab	Initial Samples*	Round Robin "Send To"	Round Robin "Receive From"	Total Samples
EPA	D1(2), D2(3), F3(2), R4(2), R5(1), B1(2), B2(3), B3(2), B4(2), B5(1)	IMPROVE	RTI / Chester	98
IMPROVE	D1(2), D2(2), F3(3), R4(2), R5(1), B1(2), B2(2), B3(3), B4(2), B5(1)	DRI	EPA	98
DRI	D1(2), D2(2), F3(2), R4(1), R6(2), B1(2), B2(2), B3(2), B4(1), B5(2)	RTI / Chester	IMPROVE	96
RTI / Chester	D1(3), D2(2), F3(2), R4(1), R5(2), B1(3), B2(2), B3(2), B4(1), B5(2)	EPA	DRI	98

* first letter indicates sample location: D=Davis, R=RTP, F=Fresno, B=Blank; second number indicates sample event shown in first column of Table 1; last number in parenthesis indicates number of samples from that event.

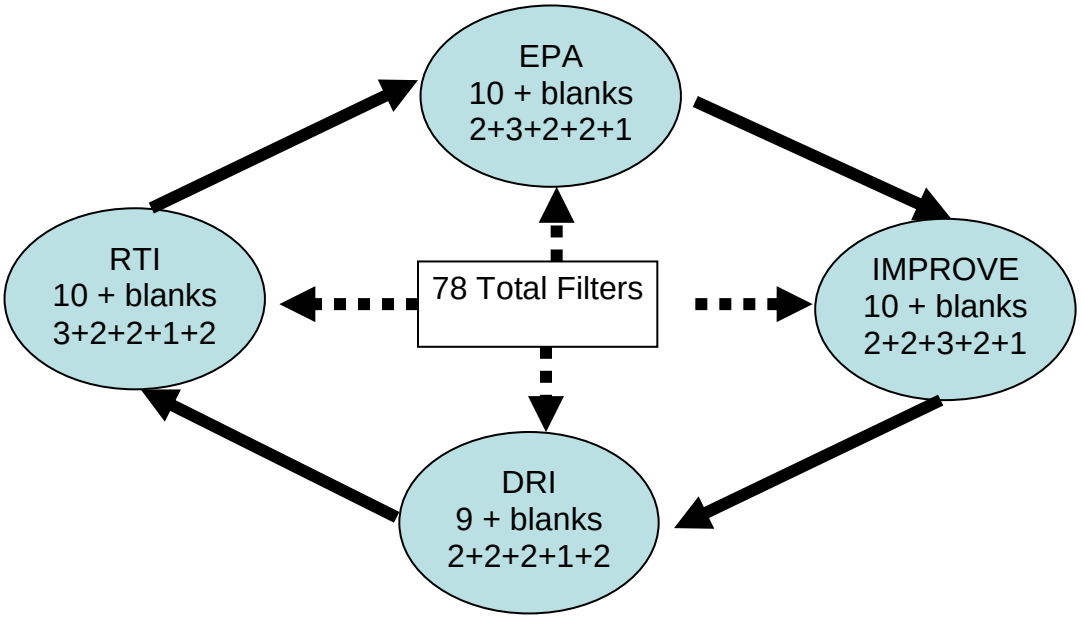

Figure 1: Schematic of XRF round-robin analysis.

Step 3.
UCD will divide the PM1.8 samples in half to double the number of samples available for ICPMS analysis. The divided samples along with blank filters will then be sent to the 5 ICPMS labs participating in the study as shown in Table 3 and Figure 2. Each ICPMS lab will receive some allotment of samples that have been previously analyzed by XRF and some samples that have not yet been analyzed. Each ICPMS lab will measure the concentration of elements contained on each filter twice on separate days. Both sets of analysis will be reported to EPA along with notes describing standard QA/QC tests. Samples will be archived at each ICPMS lab until the study is complete.

Table 3: ICPMS analysis schedule

ICPMS Lab	Sample Set 1*	Sample Set 2**	Total Samples
EPA	D1(3), D2(4), F3(3), R4(3), R5(2), B1(1), B2(1), B3(1), B4(1), B5(1)	D1(4), D2(3), F3(4), R4(2), R5(2), B1(1), B2(1), B3(1), B4(1), B5(1)	40
Clarkson	D1(3), D2(4), F3(3), R4(3), R5(2), B1(1), B2(1), B3(1), B4(1), B5(1)	D1(4), D2(3), F3(4), R4(3), R5(2), B1(1), B2(1), B3(1), B4(1), B5(1)	41
Davis	D1(4), D2(4), F3(4), R4(2), R5(3), B1(1), B2(1), B3(1), B4(1), B5(1)	D1(4), D2(4), F3(4), R4(3), R5(2), B1(1), B2(1), B3(1), B4(1), B5(1)	44
JHSPH	D1(4), D2(3), F3(4), R4(2), R5(3), B1(1), B2(1), B3(1), B4(1), B5(1)	D1(3), D2(4), F3(3), R4(2), R5(3), B1(1), B2(1), B3(1), B4(1), B5(1)	41
Wisconsin	D1(4), D2(3), F3(4), R4(2), R5(2), B1(1), B2(1), B3(1), B4(1), B(5)	D1(3), D2(4), F3(3), R4(2), R5(3), B1(1), B2(1), B3(1), B4(1), B5(1)	40

* Previously analyzed by XRF. See footnote for Table 1 to decode sample key.

** Not previously analyzed by XRF. See footnote for Table 1 to decode sample key.

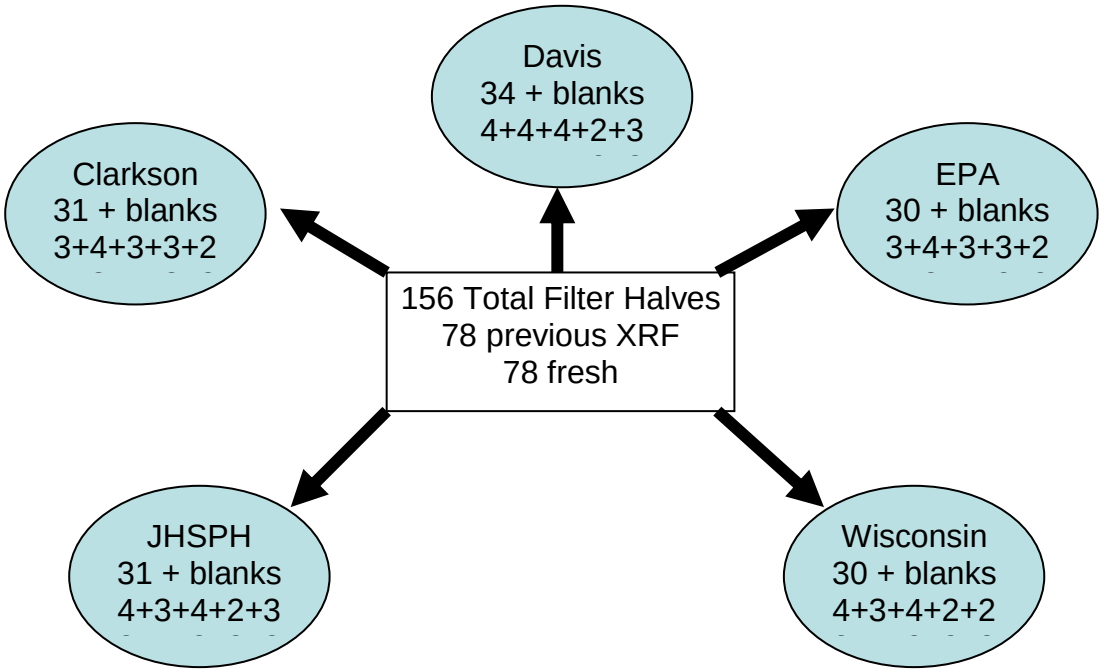

Figure 2: Schematic of ICPMS analysis.

Step 4.
All labs will report the results of their measurements to EPA including estimated value, uncertainty for estimated value, MDLs, procedure used to measure MDLs, blank readings, and actual sample measurements. EPA will receive the data and will store it with a lab-key that identifies the sample period but does not identify the laboratory or the technique used to make the measurements. EPA will send all data to UCD where it will be analyzed to determine precision of each measurement and to identify common trends that may exist within the measurements. UCD will report results of the analysis back to the working group at which point the data will be made available to all participants.

Step 5.
Based on the results from Steps 1-4, the working group will decide how to best use the PM10 samples and the MOUDI samples that were collected. I think the initial results will tell us how to use these samples in the most efficient manner possible. One simple check will be to send sets of MOUDI samples to each laboratory so that they can be analyzed with the same technique that was used for PM1.8 samples. This will enable direct comparison between collocated MOUDI and PM1.8 filter samples. The final decision about the MOUDI and PM10 samples will be made by the working group.

Scientific Training

The PM Centers support a number of graduate students and post-doctoral researchers, providing scientific training and inspiration for the next generation of air pollution researchers.

The 2002 Interim Review of the PM Centers by the Science Advisory Board noted, "The Centers also provide excellent educational opportunities, allowing for the training of young investigators in an atmosphere of interdisciplinary research. Those who are trained outside and across the traditional disciplinary silos that have marked much of traditional training and who are accustomed to collaborative research are more likely to transfer this understanding to their future work. This birthing of a "next generation" of scientists is an important product of the PM Centers Program that can potentially change the way research is conducted in the future in all areas of environmental science."

PM Center	Graduate Students	Post-Docs
Harvard University	34	14
Johns Hopkins University	5	6
Rochester University	8	9
SCPC	19	18
SAHERC	23	11
TOTAL:	**89**	**58**

Description of Scientific Advisory Committee (SAC)

Each Particulate Matter Center is advised by a nine- to twelve-member Scientific Advisory Committee (SAC) established by the Center Director. The function of this Committee is to assist in evaluating the merit, value and contribution of research projects, and the relevance and importance of individual organizational elements to accomplishing the overall goals of the Center. The SAC meets annually to discuss the progress of Center activities. Following each meeting, the SAC provides written recommendations to the Center Director. The Director then prepares a written response to the recommendations.

Each SAC consists of individuals who are experts in technical fields related to the goals of the Center and represent a balance of the disciplines in the Center's research program. Additionally, each SAC must contain at least one representative from another PM Center (many Centers exceed this minimum requirement) and one representative from EPA. This overlap fosters increased collaboration and exchange of ideas across Centers and with EPA.

The following pages list each Center's SAC members.

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