

Pre-IC Technologies – Air Monitoring

Aaron Kettle

Product Manager – Sample Preparation and IC Hyphenation

5/18/2021

 The world leader in serving science



Agenda

1

Introduction to Air Monitoring

Air Pollution Sources, Monitoring Air Pollution, URG is Our Business Partner

2

How Air Monitoring is Achieved

Ambient Air Monitoring Methodology, How the AIM Works

3

Who Buys the AIM?

Regulatory Drivers, Current Customers

4

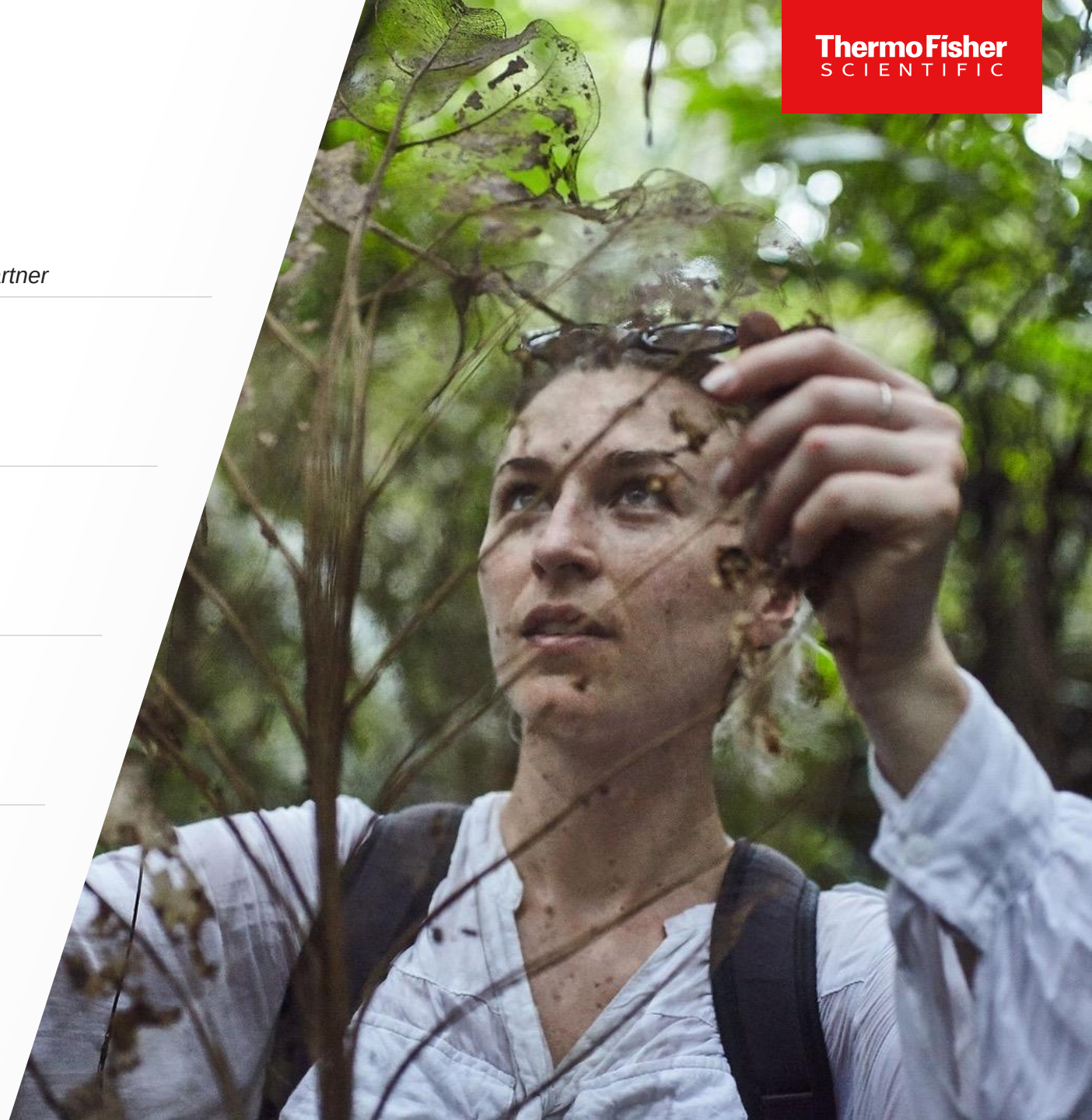
Competitive Landscape

Metrohm MARGA Systems

5

Open Discussion – AIM Channel Strategy

Regional Requirements and Organization, Regional Demand

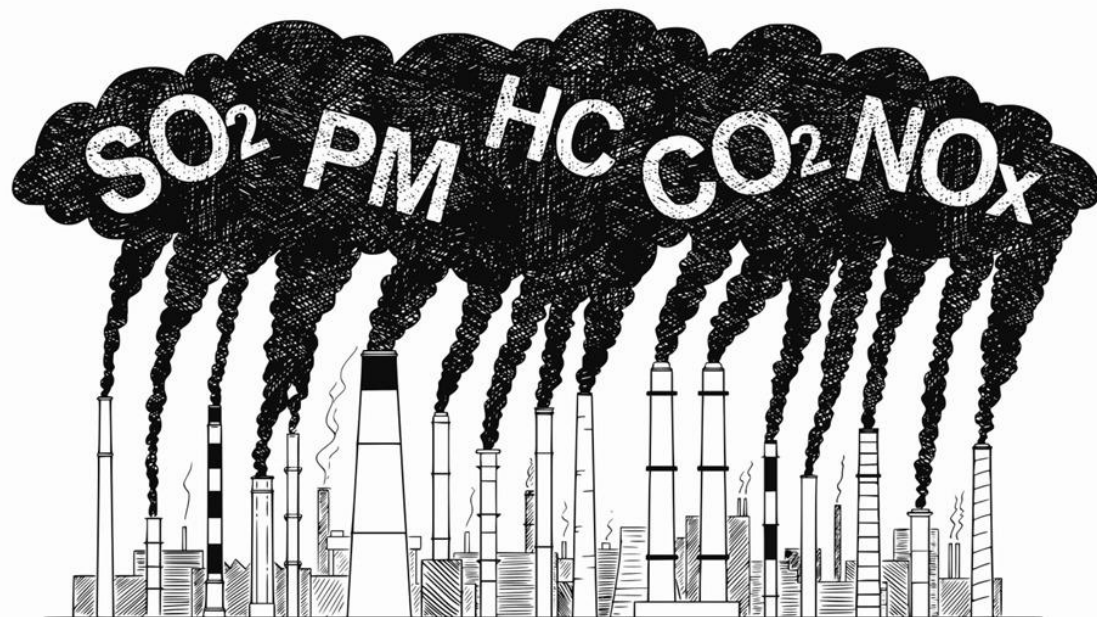


Introduction to Air Monitoring

Ambient Air Pollution Sources and Monitoring

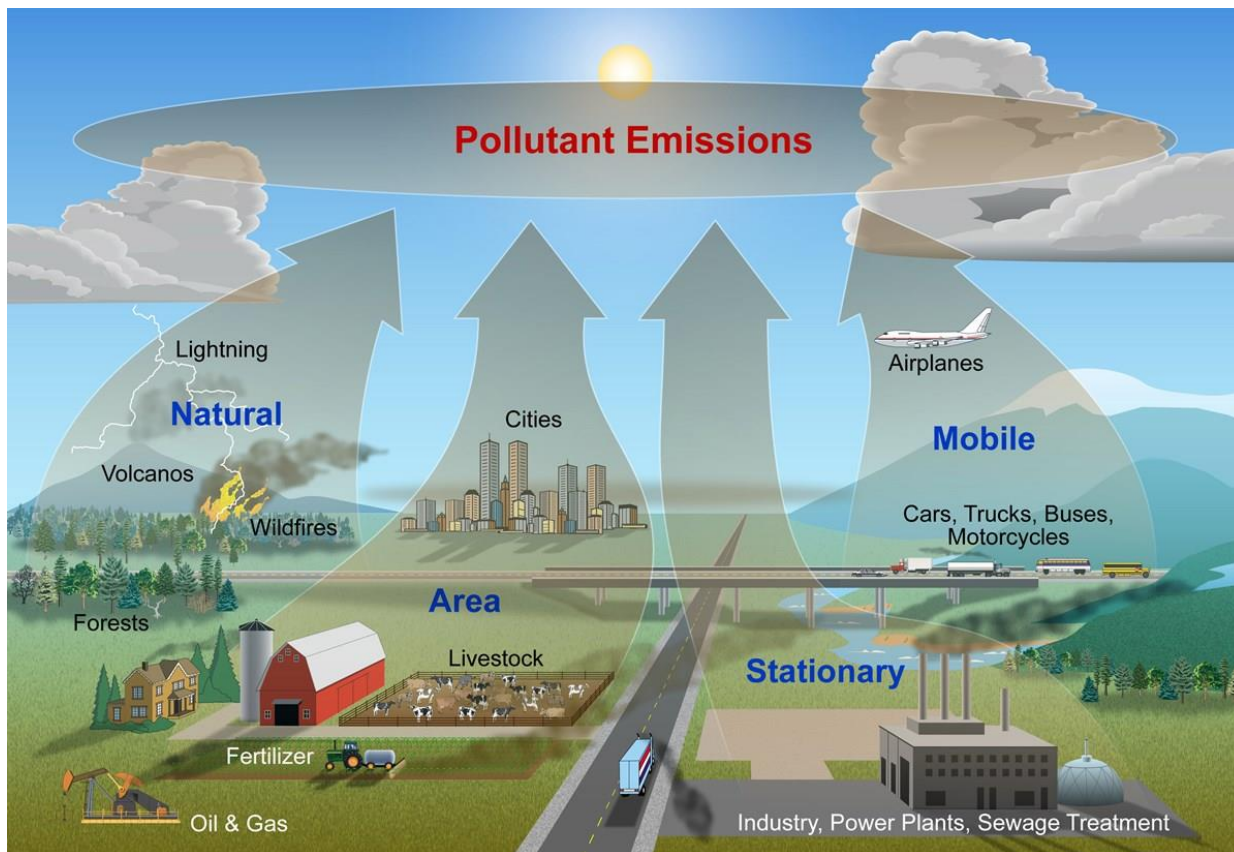


What is Ambient Air Pollution?



- Mixture of solid particles, gases, and liquid droplets found in the air resulting from dirt, soot, aerosols, dust, and exhaust.
- Made up of many different inorganic (nitrate, sulfate, ammonium) or organic (carbon, semi-volatile) compounds.
- Divided into particulate matter (PM) and gases. Both can be solubilized and analyzed as ions using Ion Chromatography.

Where Does Ambient Air Pollution Come From?

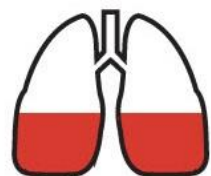


- There are four main types of air pollution sources:
 - **Mobile sources** – such as cars, buses, planes, trucks, and trains
 - **Stationary sources** – such as power plants, oil refineries, industrial facilities, and factories
 - **Area sources** – such as agricultural areas, cities, and wood burning fireplaces
 - **Natural sources** – such as wind-blown dust, wildfires, and volcanoes
- Mobile and stationary sources account for most of the persistent air pollution and the resulting health problems that arise.

Why is Air Pollution Harmful to Health?

THE INVISIBLE KILLER

Air pollution may not always be visible, but it can be deadly.



29%

OF DEATHS FROM
LUNG CANCER



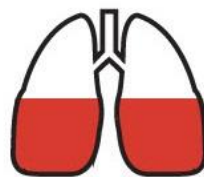
24%

OF DEATHS FROM
STROKE



25%

OF DEATHS FROM
HEART DISEASE



43%

OF DEATHS FROM
LUNG DISEASE

- In recent years, air pollution and its impact on people's health has become a significant issue on the global health agenda.
- According to a recent World Heart Federation report, more than 20% of all cardiovascular disease deaths are caused by air pollution—that's more than three million deaths every year.
- Air Pollution increases the risk of CVD largely through fine particulate pollution.
 - Particulate matter (PM) 2.5 microns or smaller found in smoke and haze get into the bloodstream and cause critical health issues
 - PM 2.5 result from the emissions of automobiles, power plants, and industrial processes

Source: World Heart Federation News Advocacy Report for Air Pollution, June 2019.

How is Air Pollution Monitored?

- Air pollution is measured by taking real-time samples using the URG-9000D Ambient Air Monitor (AIM)
- The AIM System can be configured with Integrion Ion Chromatography systems to provide time-resolved direct measurements in PM 2.5 and gases
 - **Anions:** particulate nitrate, sulfate, nitrite, phosphate, and chloride; gas phase hydrogen chloride, nitric acid, nitrous acid and sulfur dioxide
 - **Cations:** particulate ammonium, sodium, calcium, potassium and magnesium; gas phase ammonia



Integrion (Anions)

URG-9000D AIM

Integrion (Cations)

URG: Our Business Partner for Air Monitoring



Julie Stone
Vice President, Global Sales & Marketing
116 S. Merritt Mill Road
Chapel Hill, NC 27516 USA

Phone: +1 (919) 942-275
Email: jmstone@urg.com

MISSION

- URG is helping to ensure the air we breathe is the best it can be by being actively involved in the research and development of sampling instrumentation for a variety of ambient air measuring technologies.
- URG develops strong partnerships with our clients to address and solve ambient air measurement problems so that together we can share in the preservation of the world's health. We partner with our customers to meet their needs through innovation and engineered excellence.



US EPA Approvals

URG works closely with the US EPA to ensure you're getting the best systems.



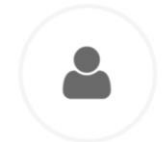
World Wide Distribution

Our air sampling systems and products are used all over the world.



High Quality Instrumentation

All systems and products go through a detailed quality and performance check.



Customer Support

Our team is always available to answer any questions that may arise.

How Air Monitoring is Achieved

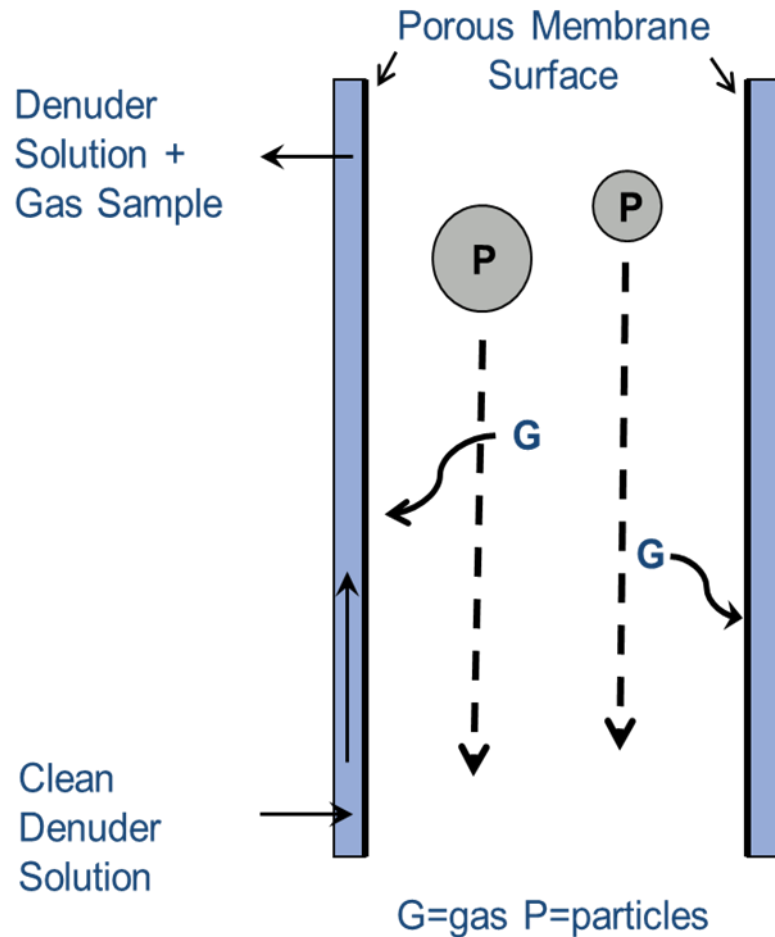
Ambient Air Monitoring Methodology

How Does the URG-9000D Work?

- The URG-9000D Ambient Ion Monitor (AIM) provides time-resolved direct measurement of the particulate and gases found in PM 2.5.
- Air is drawn in through a PM-2.5 sharp cut cyclone to remove the larger particles from the air stream.
 - The sample is drawn through a **Denuder** where gases are solubilized into water for analysis by IC.
 - The particle-laden air stream next enters the **Aerosol Super-Saturation Collector** where they solubilized and then injected into the Integriion systems.
 - The AIM can collect and analyze up to 14 days unattended.
 - The data is automatically analyzed every hour (with optional 15-to-30-minute intervals depending on the configuration).
 - The AIM reports the results in micrograms per cubic meter.

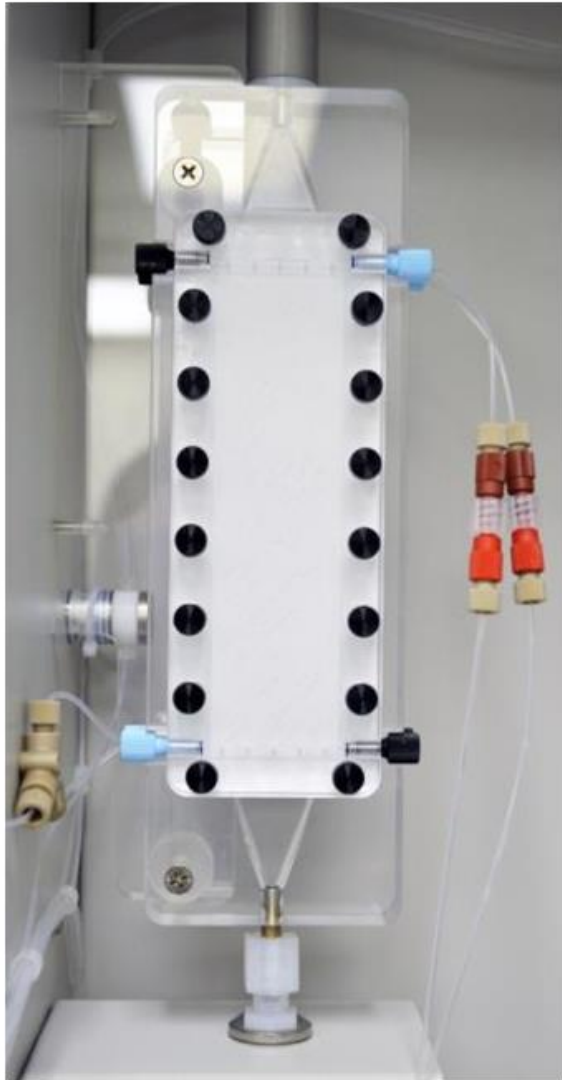


How Does the Denuder Work?



- Purpose to is solubilize gases in the air sample into a water sample that can be analyzed by Ion Chromatography
- The selective removal of gases from gas-particle mixtures by a denuder exploits the large difference in diffusion coefficients between gases and particles
- When an air sample is drawn through a parallel plate denuder, gas molecules of the air sample diffuse through the membrane walls of the denuder into deionized water and are captured
- Gas molecules are solubilized into an aqueous sample that contains ions that can be analyzed by Ion Chromatography (SO_2 coverts to SO_4^{2-} for example)

Benefits of the AIM Denuder Design



- High diffusivity of gases causes them to migrate to denuder wall surfaces where they are removed from the sample stream
- High inertial momentum and low diffusivity of small particles (PM 2.5) allow them to pass through the denuder and into the saturation collector
- Denuder orientation prevents particle settling and there are no moving parts that break or require maintenance
- Pre-cut membrane material allows for quick replacement and no issues with bacterial growth
- Can be switched without interrupting sample collection

Aerosol Super Saturation Collector



- Like the gas sample, the particle sample is placed into a water matrix to allow for IC analysis
- Solubilization is achieved by using a steam generator to provide a super-saturated (H_2O) environment for the particulate matter
- The particle sample moves into a mixing chamber and are “grown” to achieve high collection efficiencies
- Ionic particles become liquid by absorbing moisture in the mixing chamber’s humid environment and condense into solution in a condensing coil
- The super saturated particles are then separated and delivered to the IC for analysis

The AIM is Controlled by Chromeleon 7.2

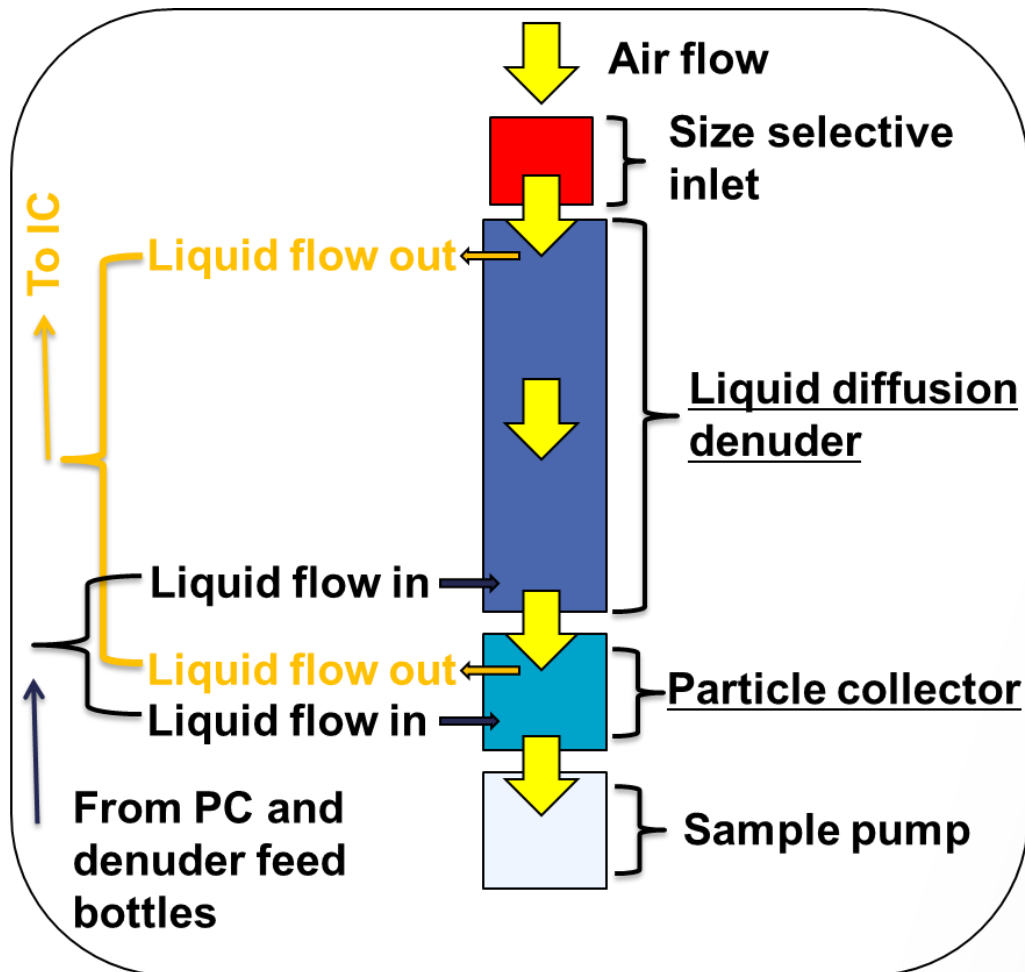
- Ease-of-Use: Single software control improves operational simplicity
- Consolidated Controls and Results: Complete view of AIM and IC operations from the Home Panel
- Streamlined Workflow: Only 4 clicks to setup sequences and report data for 2-Weeks of continuous use
- Flexibility & Efficiency: Users can customize the Home Panel, sequence setup, and reports



AIM Home Panel In Chromeleon 7.2



AIM Summary



- Ion Chromatography (IC) based using two Integrion systems
- Automated time resolution, direct measurement technique
- Liquid diffusion denuder to collect and solubilize gases in air samples
- Aerosol saturation collector to solubilize PM 2.5 in air samples
- Capable of determining gas and particulate ions to meet all regulatory standards and methods
- Can run up to 14 days unattended with data automatically analyzed every hour

Who Buys the AIM?

Regulatory Compliance and Current Customers

World Health Organization Air Quality Guidelines

- The WHO Air Quality Guidelines (AQGs) inform policy-makers about the health impacts of air pollutants and provide appropriate targets for air quality that is safe for health. Countries can select among a broad range of policy options for the most appropriate to improve air quality and achieve a better protection of people's health.
- The Guidelines are intended for a global audience. They have been developed to support actions for healthy air quality across different contexts. At the same time, they acknowledge the need for each country to set up its own air quality standards to protect the public health of their citizens based on local conditions.
- Updated in 2005, these Guidelines include air quality guidelines for Europe, including important new research from low-and middle-income countries where air pollution levels are at their highest. WHO has reviewed the accumulated scientific evidence and to consider its implications for selected air pollutant PM 2.5 and gases which are applicable across all WHO regions.

Regulatory Compliance Drives Demand for Air Monitoring

- The U.S. EPA is required by the Clean Air Act to monitor air pollution and set air quality standards to protect public health and the environment.
- The National Ambient Air Quality Standards sets the standards for six common air pollutants that are considered especially harmful: particulate matter (PM), ground level ozone, carbon monoxide, nitrogen oxides, sulfur dioxide and lead (Criteria Pollutants).
- The U.S. EPA calls these pollutants “criteria” air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels and standards to monitor them.
- On December 14, 2012, the U.S. EPA strengthened the annual health National Ambient Air Quality Standards for fine particles (PM_{2.5}). This recent update to the primary standard reduces the acceptable amount of PM_{2.5} allowed in the air.

Who is Using the AIM?

- National Government Agencies



- Universities



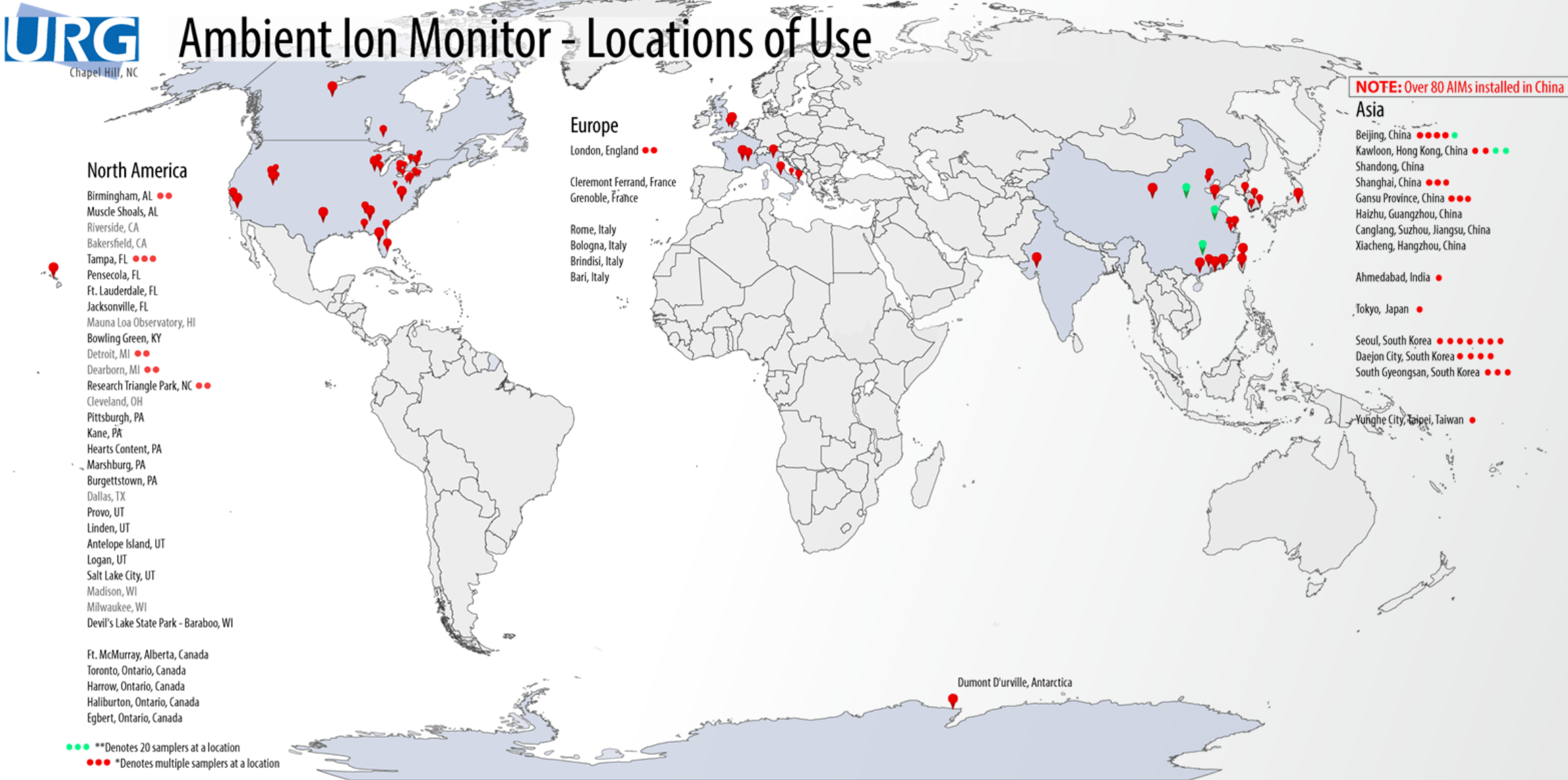
UNIVERSITY OF
TORONTO



- State and Regional Laboratories



Global AIM Locations



21

Proprietary & Confidential | aaron.kettle@thermofisher.com | 18-May-2021

Competitive Landscape

Metrohm MARGA Systems

MARGA Autonomous Monitoring System

Monitoring for **Ae**Rosols and **G**ases in **Ambient** air (MARGA)



MARGA M Continuous Monitoring

- Integrated IC and air monitor
- ICs cannot be removed and used separately



MARGA R Air Monitoring for Research Campaigns

- Separate 940 Professional Vario IC system and air monitor
- Released following the MARGA M to follow the URG design

MARGA vs. AIM



Air Monitoring: Our Advantages

Chromeleon

- Full control of all systems within Chromeleon
- Extensive reporting features
- Full audit trails

URG-9000D

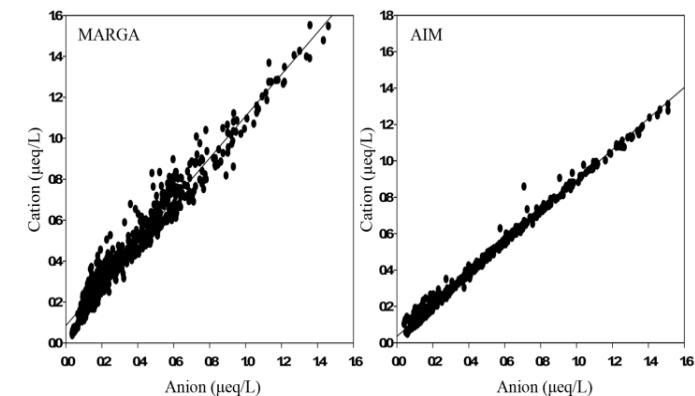
- 15 min. sampling resolution (1 hour for MARGA)

All our standard IC benefits

- Simple, effective suppression (including cations)
- Reagent-Free ion chromatography
- Wide choice of robust separation columns

J. of the Korean Society for Environmental Analysis, 104-111, 2014
Comparison and Assessment of Two Different Types of Real Time
Atmospheric Water Soluble Ion Analyzers

- Contact aaron.kettle@thermofisher.com for English translation of paper
- Comparison shows:
 - AIM has better performance for anions
 - Strong differences for cations (AIM > MARGA)



AIM vs. MARGA Feature Comparison



Feature	Ambient Ion Monitor (AIM)	MARGA	AIM Value
Denuder	- Parallel Plate Denuder - No moving parts - Membrane replacement every 6 weeks 99.8% efficient - Denuder can be changed without stopping the sampler	- Rotating Wet Denuder (RWD) - Moving mechanical parts - Potential for microbial growth - Repairs on the RWD require that the sampler be taken out of service or stopped.	- Less moving parts requires less maintenance which means lower operating cost and more uptime - No issues with bacterial growth-less maintenance-more uptime - Does not require shutting down sampler for maintenance - Membrane prevents particles form getting into the gas sample - Denuder Orientation prevents particle settling - New membrane change out time has been reduced to just minutes
Aerosol Collection	Steam Jet Aerosol Collector	Steam Jet Aerosol Collector	- Patented steam generator reduces sodium and calcium background - The parallel plate denuder design ensures that the particles get to the steam jet collector - Confidence in the results; superior performance for cations

AIM vs. MARGA Feature Comparison



Feature	Ambient Ion Monitor (AIM)	MARGA	AIM Value
Sample Time	• 60, 30, 15-minute intervals	• 60-minute intervals	• Flexibility to adjust (shorten) the collection time increases analysis per hour which means more data points per hour • More data points per hour means more accurate results
Unattended Operation	• 2 Weeks	• 1 Week	• Less labor = lower operating costs
Remote Access	• Remote Access, Operation, and Data Transfer	• Remote Access, Operation, and Data Transfer	• Even though both analyzers can be controlled remotely, the power and versatility of Chromeleon makes it the logical choice. Chromeleon control is the value for remote use.

AIM vs. MARGA Feature Comparison

Feature	Ambient Ion Monitor (AIM)	MARGA	AIM Value
Detection Limit for Gases	• HCl, HNO₃, HNO₂, SO₂: 0.005µg/m³ • NH₃: 0.0025µg/m₃ • Collection rate of 0.18m³/hr. of air into 5 mL of H₂O	• HCl, HNO₃: 0.005µg/m³ • HNO₂, NH₃: 0.008µg/m³ • SO₂: 0.01µg/m³ • Collection rate of 1m³/hr.	• Lower detection limits have obvious values, but it also means that less sample needs to be loaded on the column to achieve the same results. This provides longer column lifetime and lower operating costs.
Detection Limit for Particles (PM 2.5)	• Cl, NO₃, SO₄: 0.005µg/m³ • NH₄, Na, K, Ca, Mg: 0.0025 µg/m³ • Collection rate of 0.18m³/hr. of air into 5 mL of H₂O	• Cl, NO₃, SO₄: 0.005µg/m³ • NH₄, Na, K, Ca, Mg: 0.008 µg/m³ • Collection rate of 1m³/hr. of air into 5 mL of H₂O	

AIM Channel Strategy

Open Discussion for Regional Requirements

Open Discussion: Regional Feedback and Needs

Region	Current State	How to Work with URG Going Forward	Regional Feedback and Questions
APJ	- URG works with APM in Korea; IC system are bought direction from BU; APM installs and trains the customer. - Other countries have not sold the AIM with IC.	- Korea: Establish a lead sharing program for IC? - Other countries: Training will be needed from URG to sell the AIM with our IC. Can we leverage China expertise for training? Are you willing to have URG visit our commercial site to give training?	
EU	- France, UK, and Italy have sold the AIM with ICS; are there still expertise to install and train the customer? - Other countries have not sold the AIM with IC.	- Retraining for France, UK, and Italy? - Other countries: Training will be needed from URG to sell the AIM with our IC. URG can travel to our commercial office to give the training, or we can send our reps to their facility in North Carolina.	
NA	URG has always sold the IC with AIM direct to customers. This is due to the installation and training requirement for the workflow.	- Establish lead sharing and get credit for IC? - We quote the IC direct to URG? - We get service reps trained to install and train the customer on the workflow?	

Thank you

