Cutting Through the Haze: Real-Time Air Monitoring in Action

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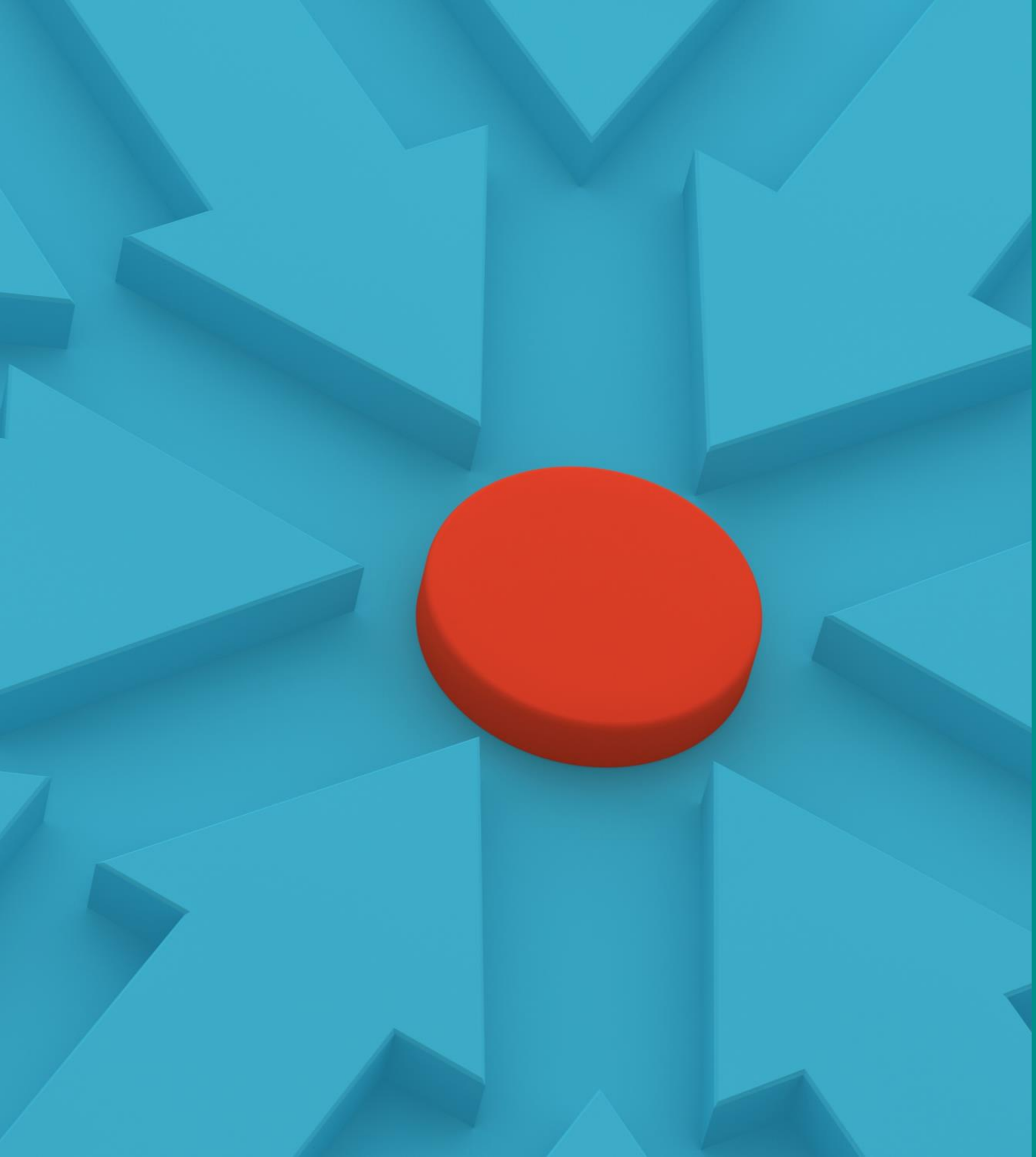
In today's presentation we will cover…

- Current state of air quality monitoring
- **M**onitor for **A**e**R**osols and **G**ases in ambient **A**ir (MARGA)
- Case study: Firework-related pollution events on New Year's Eve
- Field Studies: MARGA in action



Current State of Air Quality Monitoring

Air Quality Monitoring Today

- ✓ In recent years, there’s been a shift toward **modernizing air quality monitoring**.
- ✓ New regulations and health data highlight the need for **higher time resolution and chemical specificity**.
- ✓ The EPA’s **Air Quality Monitoring 2.0** initiative promotes hybrid networks, **pairing low-cost sensors with reference-grade instruments**.
- ✓ Traditional methods still play a role but often **miss short-term pollution events**.
- ✓ Emerging technologies are now making it possible to **track both gases and aerosols in real time,** with far greater detail than before.

Current Methodologies

Filter-Based Sampling

- **Use:** Measuring PM2.5 or PM10 mass and composition.
- **How:** Air is drawn through filters for 24 hours. Filters are weighed and analyzed in a lab (e.g., for sulfates, nitrates, metals).
- **Common in**: Regulatory monitoring (EPA, EEA), long-term studies.

Continuous Gas Analyzers

- **Use:** Real-time monitoring of gases like NOx, SO_2, O_3, and CO.
- **How:** Instruments use specific detection principles (e.g., UV photometry, chemiluminescence).
- **Common in**: Urban air monitoring stations, compliance sites.

Current Challenges in Air Quality Monitoring

Daily / 24-hour integrated samples

Delayed data availability due to required lab processing

Labor intensive due to manual collection, transportation and lab work

Low resolution of events due to result being an average over time

Monitor for **A**e**R**osols and **G**ases in ambient **A**ir (MARGA)

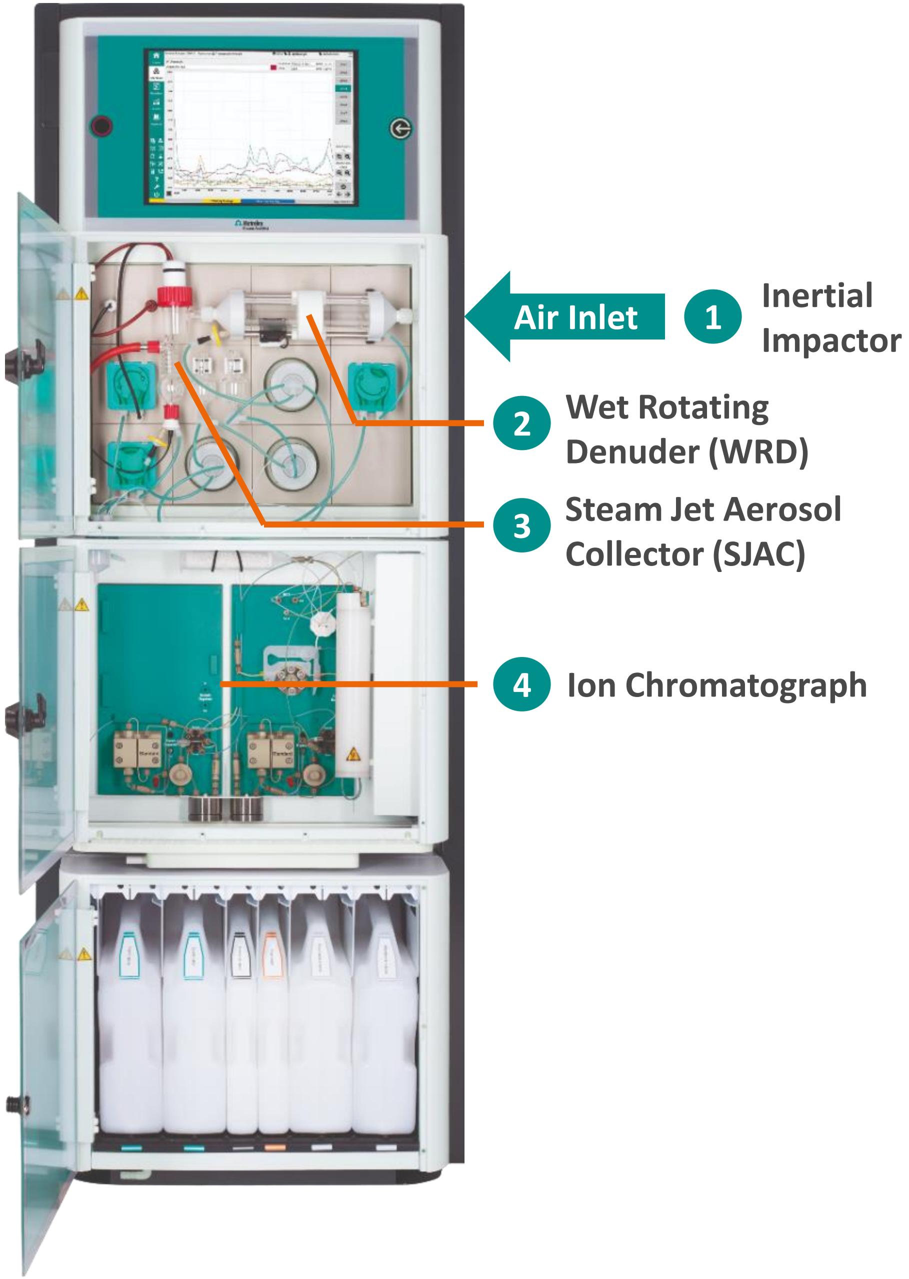
2060 MARGA Process Analyzer

Aerosols

- Cl^-
- NO_3^-
- SO_4^{2-}
- NH_4^+
- Na^+
- Ca^{2+}
- Mg^{2+}
- K^+
- F^+

Gases

- HCl
- HNO_3
- HONO
- SO_2
- NH_3
- HF
- NH_3



2060 MARGA Configurations

2060 MARGA R

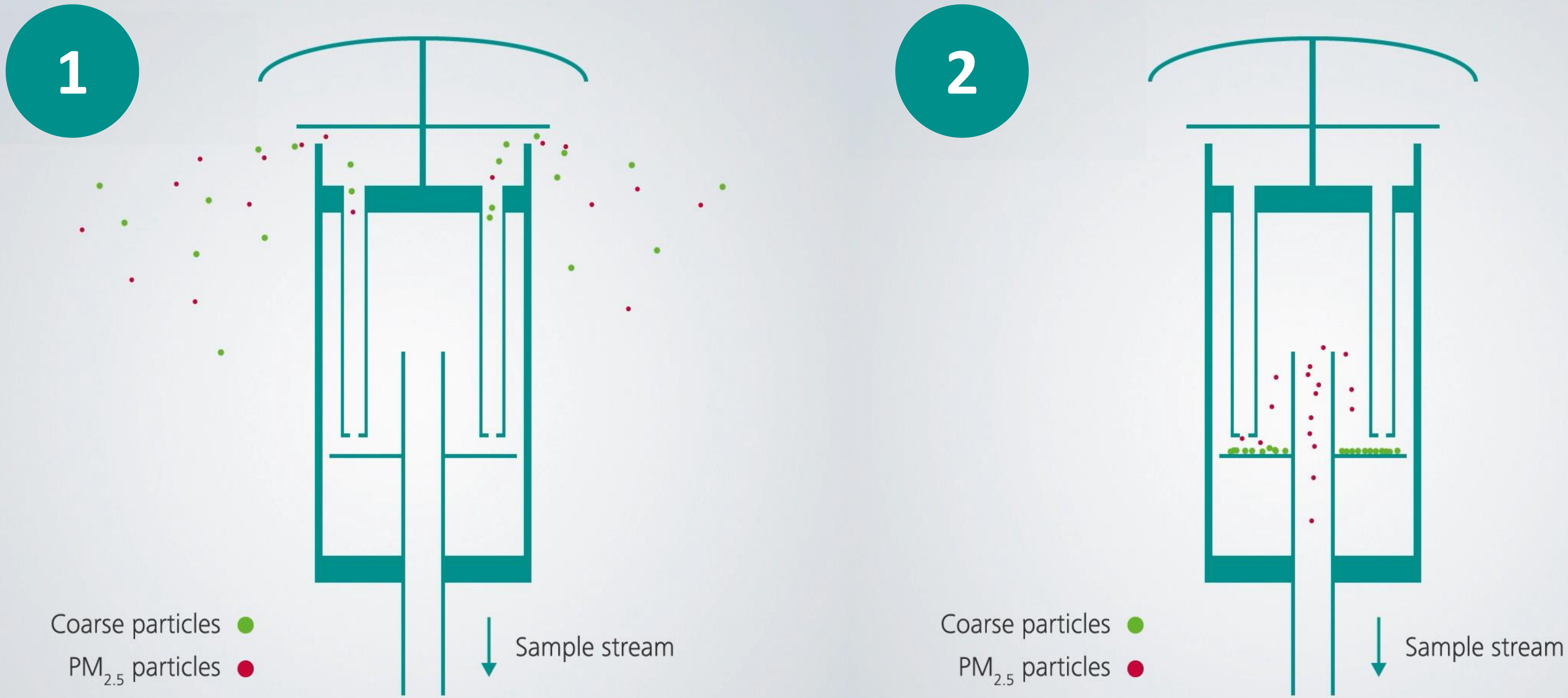
Ideal for campaigns
IC can be used as stand-alone lab instrument

2060 MARGA M

Continuous monitoring at permanent site

Inertial Impactor

Air Inlet – Inertial Impactor



Wet Rotating Denuder (WRD)

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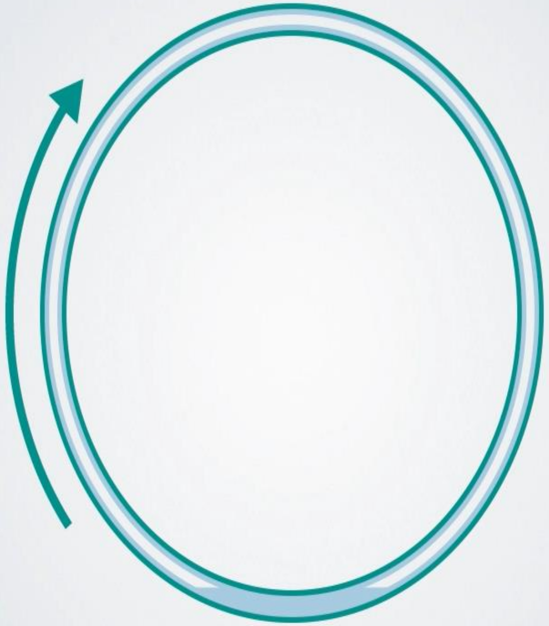
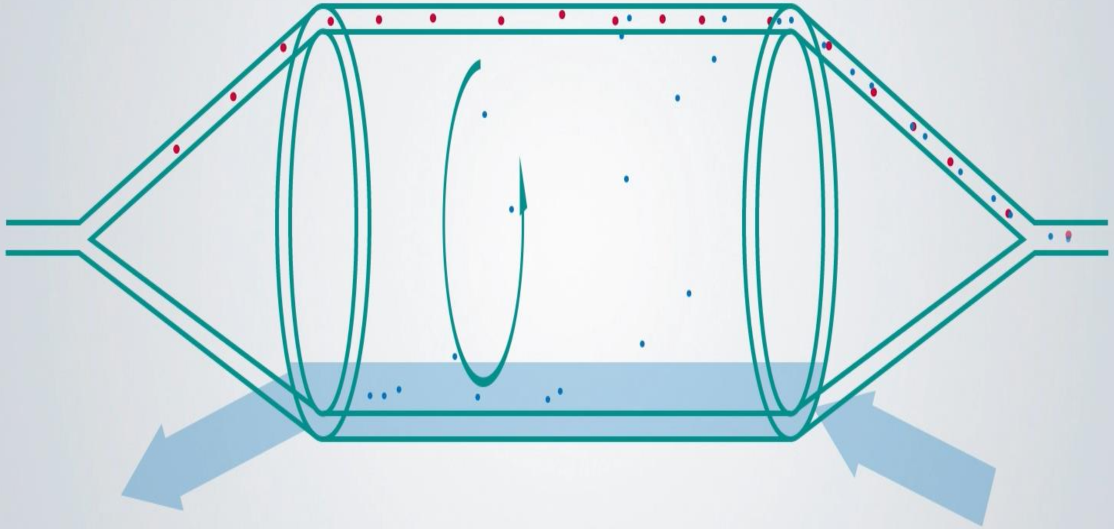
1



The WRD rotates to create a large surface area liquid film to absorb the gases

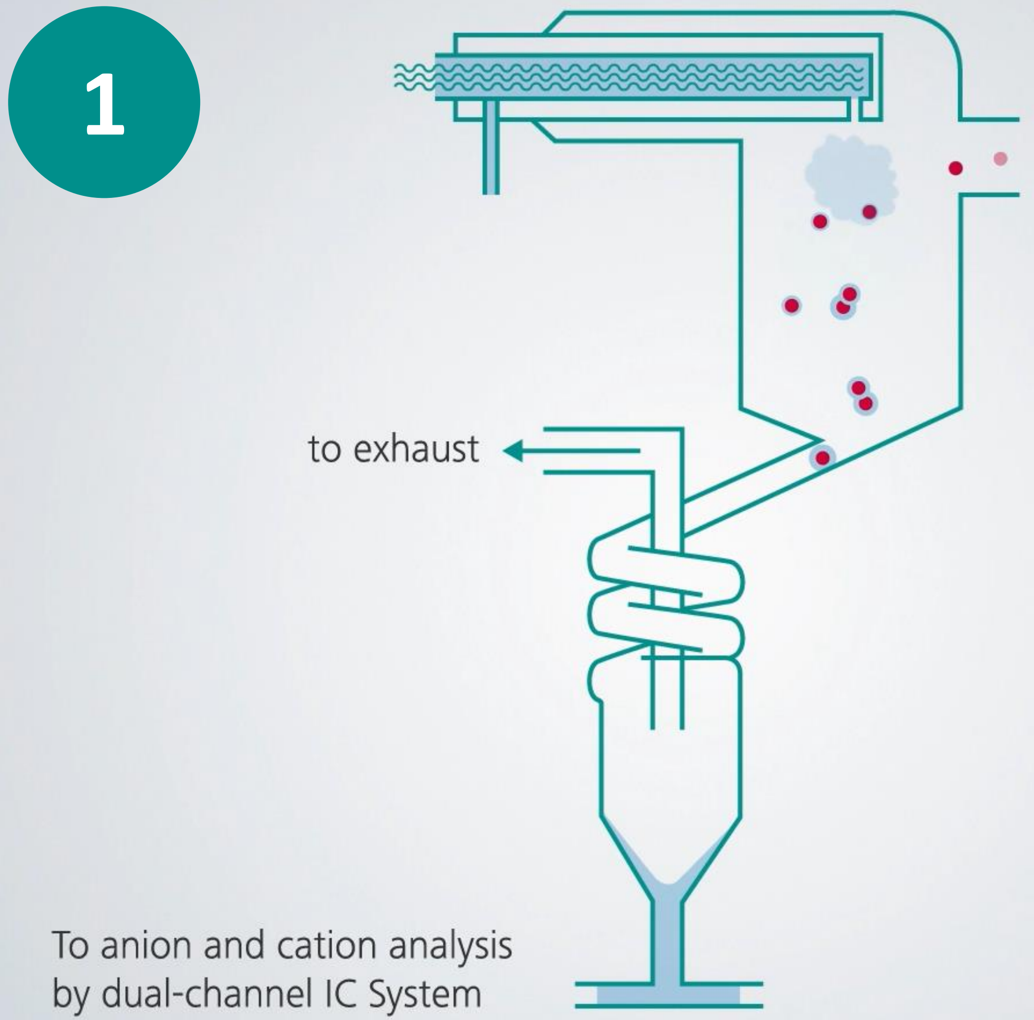
2

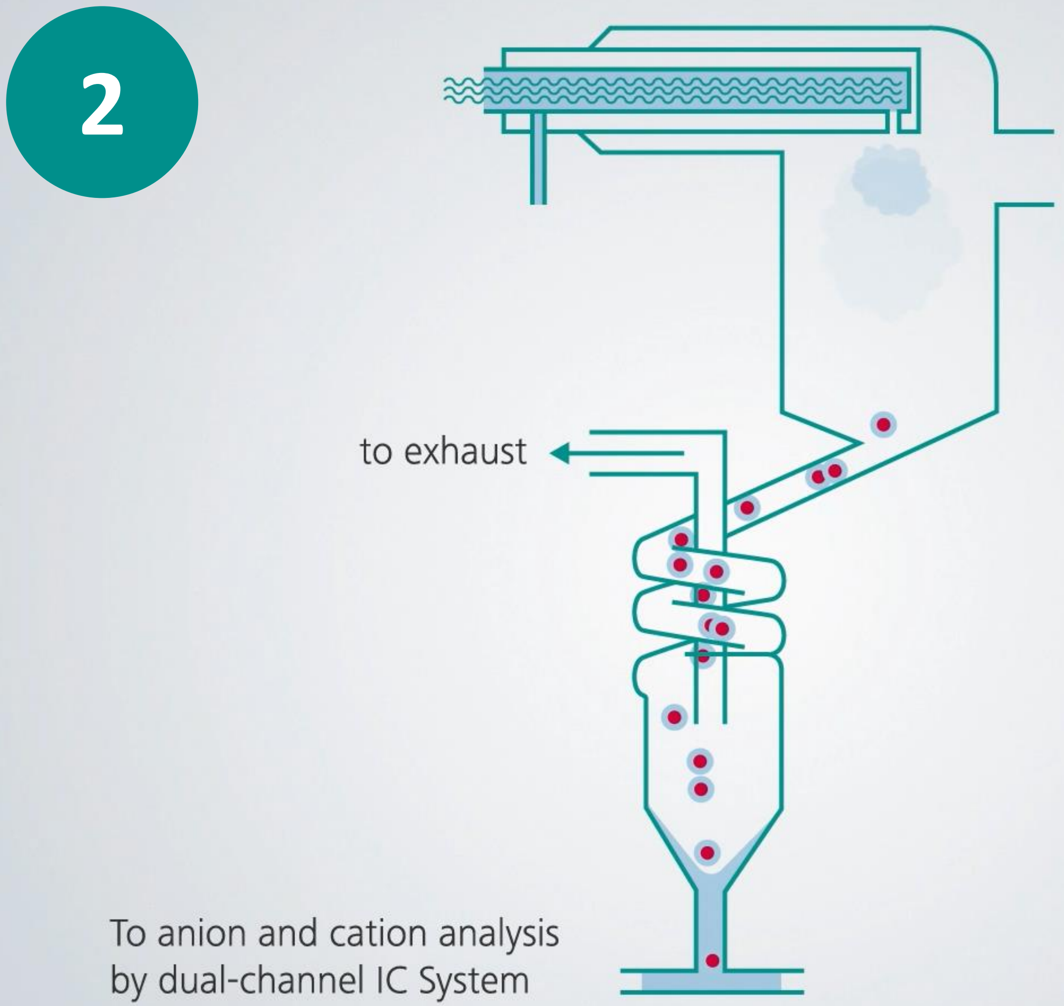


To anion and cation analysis by dual-channel IC System

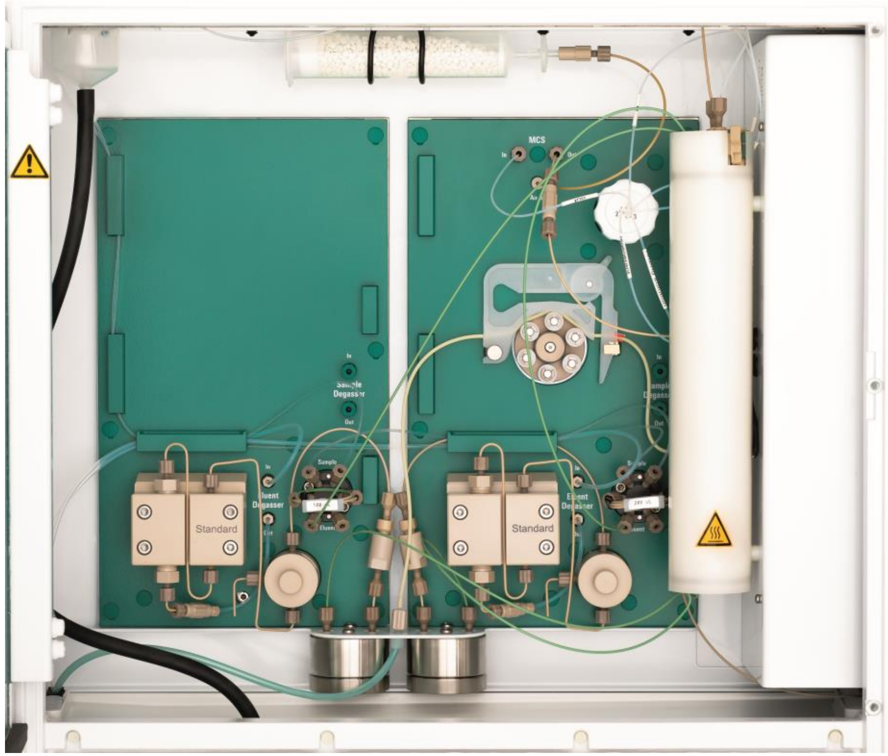
Steam Jet Aerosol Collector (SJAC)

Steam Jet Aerosol Collector (SJCA)

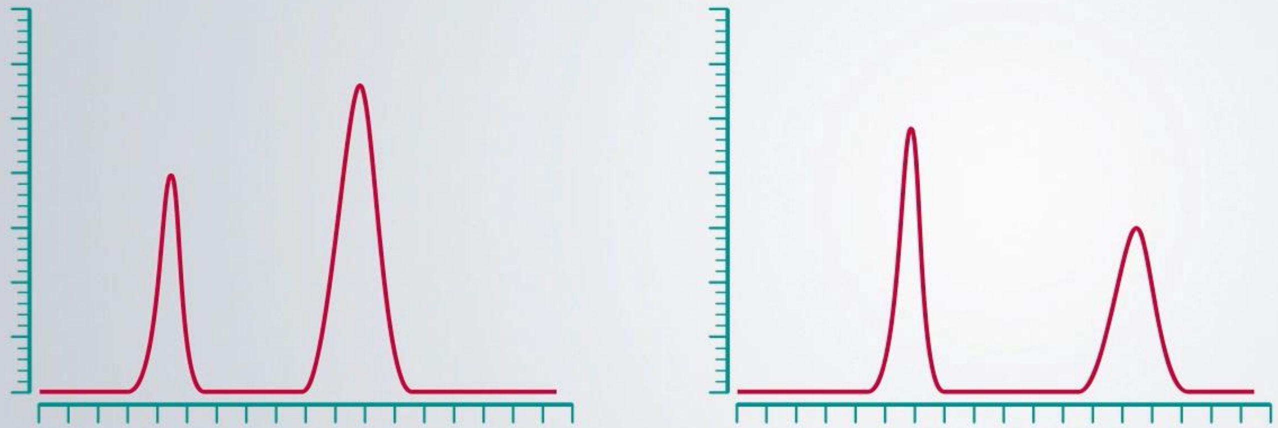




Ion Chromatograph



Dual Channel Ion Chromatography



Anion analysis
(of aerosol and gas fraction)

Cation analysis
(of aerosol and gas fraction)

Limits of Detection

Sample: 1 m^3 ambient air
Water soluble components absorbed into 15 mL absorbance liquid.

- The 2060 MARGA offers much lower detection limits compared to the original MARGA, with improvements up to 10 times more sensitive.
- Chloride, nitrate, and sulfate are now detectable at concentrations as low as 0.001 to 0.002 µg/m^3.
- The 2060 MARGA adds support for new analytes like lithium and bromide, which were not measurable with the previous system.
- These lower limits allow for better detection of background levels, earlier identification of pollution events, and more precise source analysis.

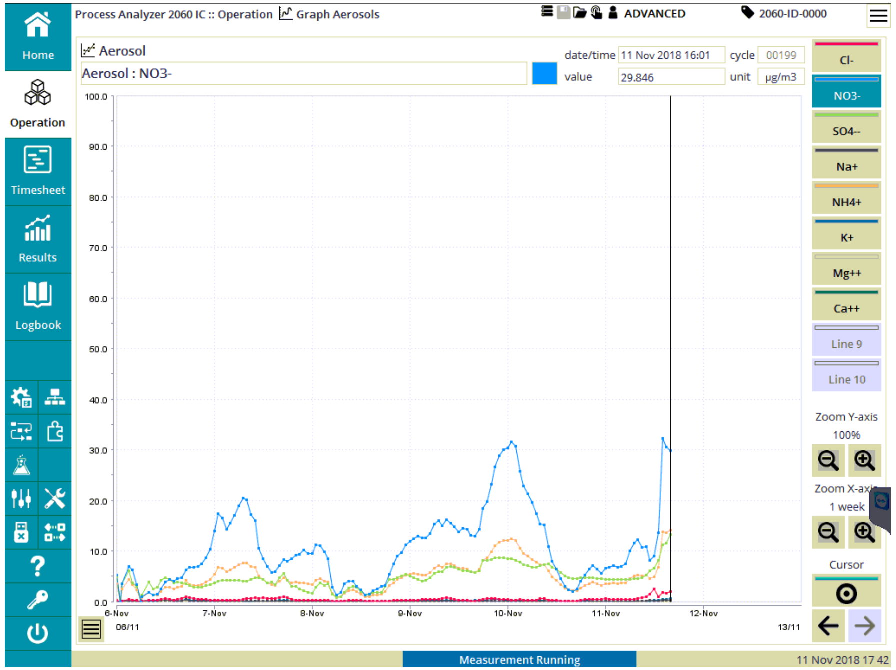
Component	LOD in air (µg/m^3)	
	2060 MARGA	MARGA
Lithium	0.005	---
Sodium	0.02	0.05
Ammonium	0.02	0.05
Potassium	0.05	0.09
Magnesium	0.02	0.06
Calcium	0.05	0.09

Component	LOD in air (µg/m^3)	
	2060 MARGA	MARGA
Chloride	0.001	0.01
Nitrite	0.001	0.02
Bromide	0.002	---
Nitrate	0.002	0.05
Sulfate	0.002	0.03

Data Handling with IMPACT

- **Real-time data** – process data is collected and displayed on the touchscreen user interface instantly
- **Data integrity** – All data are stored in an encrypted database to prevent data tampering
- **Remote capabilities** – Access the analyzer from anywhere using TeamViewer or VNC (cellular modem required)

Trend Graph - Aerosols



Trend Graph - Gases

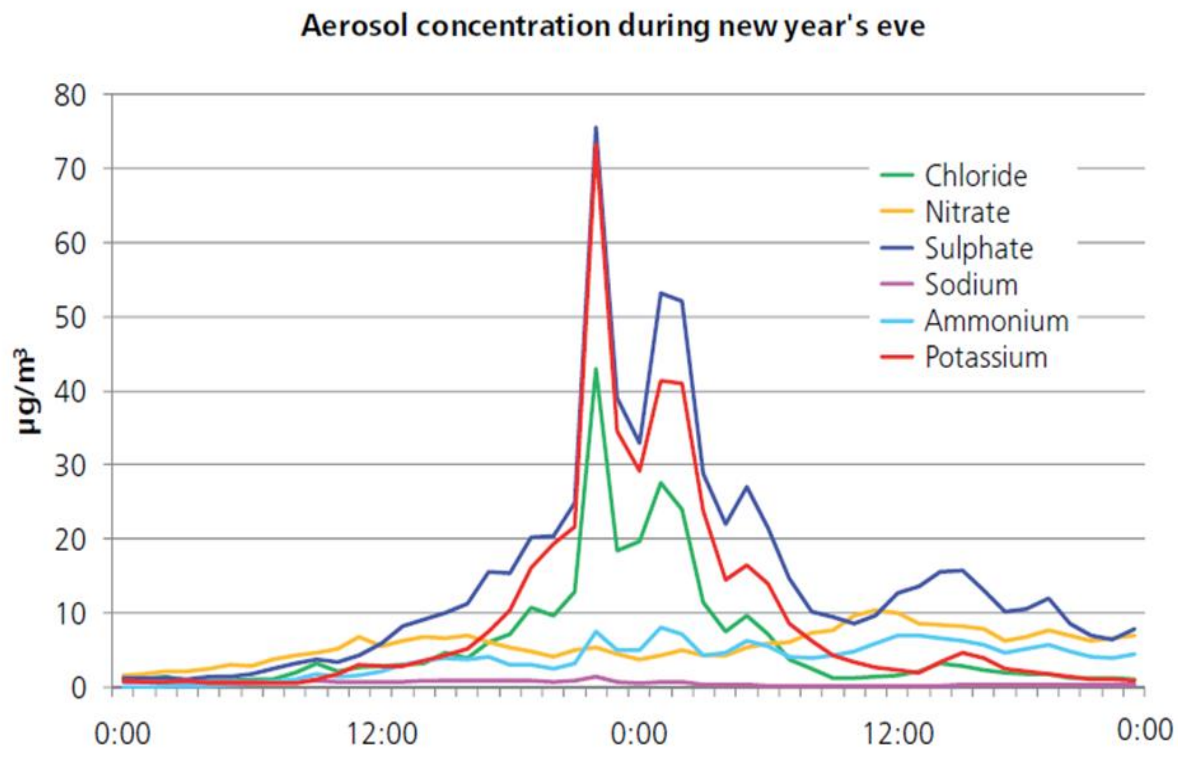
Case study: Firework-related pollution events on New Year’s Eve

Air Pollution from Fireworks

- Fireworks release a rapid burst of air pollutants, including particulate matter (PM), metallic compounds, and gaseous byproducts.
- Short-term pollution spikes in $PM_{2.5}$ and PM_{10} are common and concentrations can rise by several hundred percent within minutes.
- **Typical cations detected:**
  - K^{+} (Potassium) – Used as an oxidizer; prominent in colored fireworks
  - Na^{+} (Sodium) – Produces yellow color
  - Mg^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, Cu^{2+} – From metal salts used for color effects
- **Typical anions detected:**
  - Cl^{-} (Chloride) – Combines with metals to form colorant salts
  - NO_3^{-} (Nitrate) – Common oxidizer
  - SO_4^{2-} (Sulfate) – From sulfur-containing compounds used as fuel or stabilizers
- **Gaseous species may include:**
  - SO_2, NOx, CO, and sometimes ozone precursors

2060 MARGA and Fireworks

- The 2060 MARGA captured a clear, time-resolved pollution event tied to fireworks at midnight.
- Multiple aerosol components increased simultaneously, showing the complex chemical signature of firework emissions.
- The event was short-lived but intense, underscoring the need for hourly resolution in air quality monitoring.
- This type of data enables source identification, event attribution, and supports regulatory and public health analysis.
- Traditional 24-hour methods would have missed both the timing and severity of the event.



Field Studies: MARGA in Action

The importance of vehicle emissions as a source of atmospheric ammonia in the megacity of Shanghai

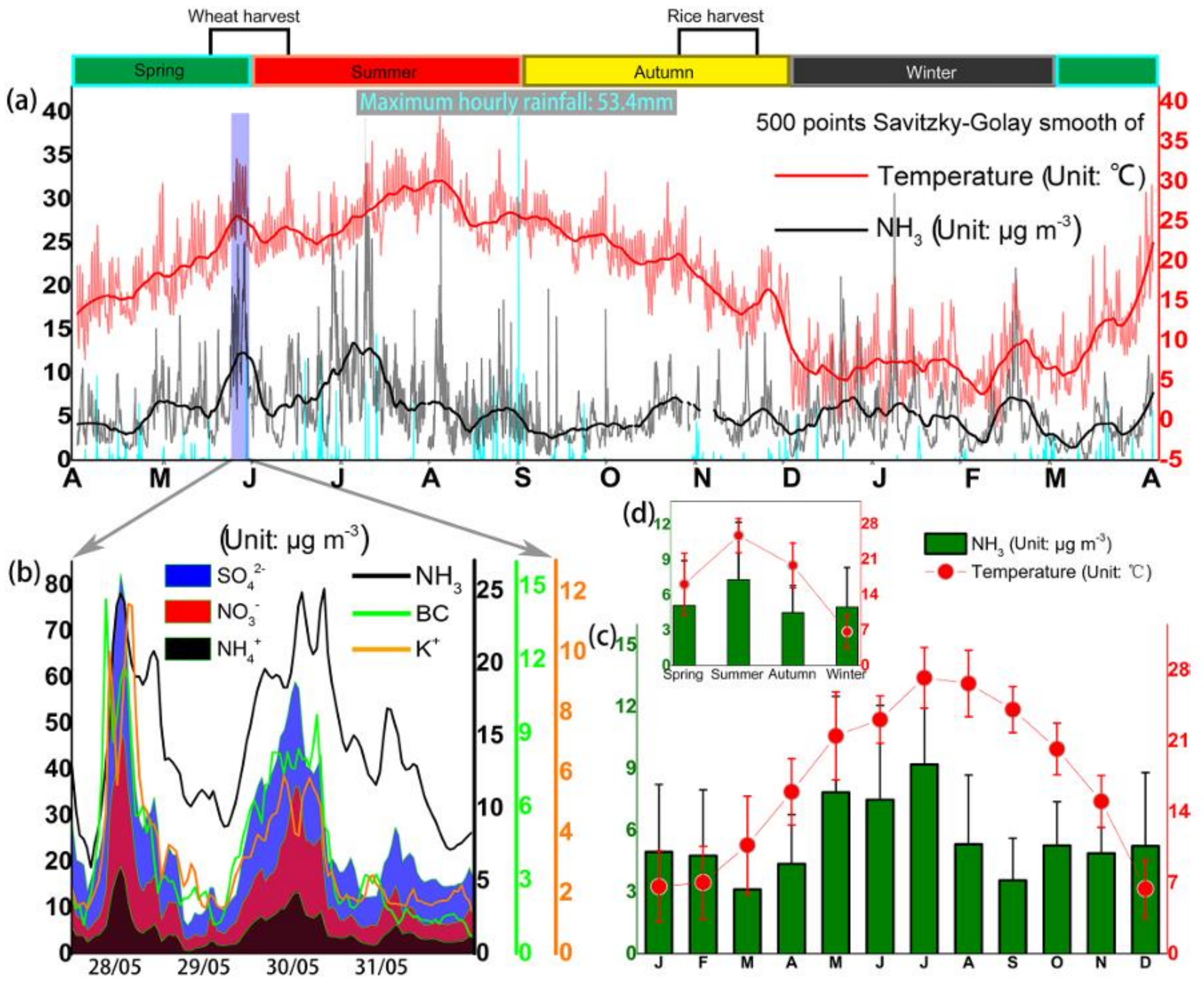
Researchers used the MARGA system to measure hourly concentrations of NH_3, NH_4^+, and related aerosol species in the North China Plain over a full year.

The data revealed clear seasonal variation in NH_3, with highest levels during summer and harvest periods, likely tied to fertilizer use and temperature-driven volatilization.

A strong positive correlation between temperature and NH_3 was observed, reinforcing the role of thermally driven emissions.

Episodes of high secondary aerosol formation were linked to elevated NH_3, SO_4^{2-}, and NO_3^- concentrations.

These results highlight the importance of continuous gas-aerosol monitoring for understanding ammonia chemistry and its role in regional haze formation.

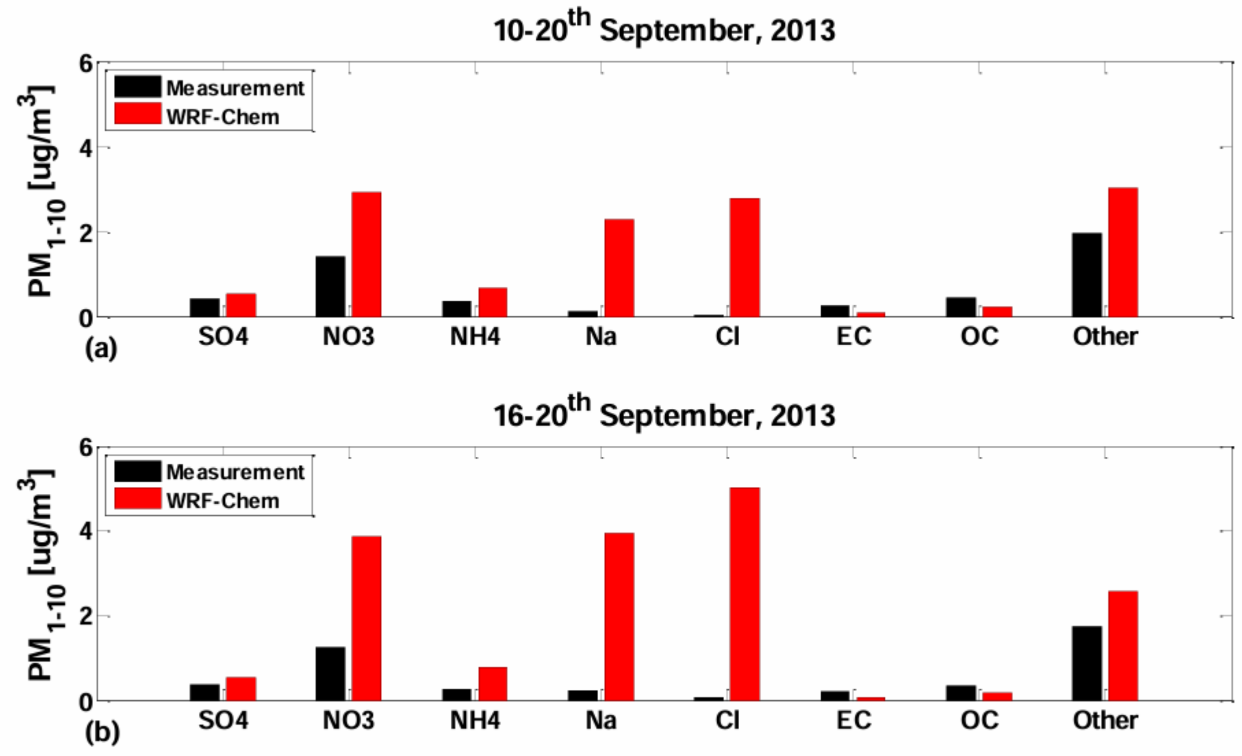


(a) Temporalvariations of hourly NH_3 concentrations (gray) and temperature (red), along with 500-point Savitzky–Golay smoothed records in Shanghai from 3 April 2014 to 2 April 2015. Rainfall is shown in cyan. The vertical blue rectangle highlights NH_3 pollution episodes that occurred during the wheat harvest season. (b) Time series of NH_3, BC, SO_4^{2-} , NO_3 , NH_4 , and K concentrations during periods of pollution associated with biomass burning. Monthly (c) and seasonal (d) variations of NH_3 average concentrations and temperature.

The importance of vehicle emissions as a source of atmospheric ammonia in the megacity of Shanghai, (Y. Chang et al.), Atmospheric Chemistry and Physics, 2016, 16, p. 3577 - 3594

Sea salt emission, transportation and influence on nitrate simulation: a case study in Europe

- Researchers used the MARGA system in Hong Kong to measure hourly concentrations of water-soluble ions in PM_{1-10} during a regional pollution event.
- The MARGA provided time-resolved data for sulfate, nitrate, ammonium, sodium, and chloride to evaluate model accuracy.
- These measurements were compared to predictions from the WRF-Chem atmospheric model.
- WRF-Chem overpredicted key species such as nitrate and chloride, especially during the later sampling period.
- The study shows how MARGA data can support model validation and improve future air quality forecasts.

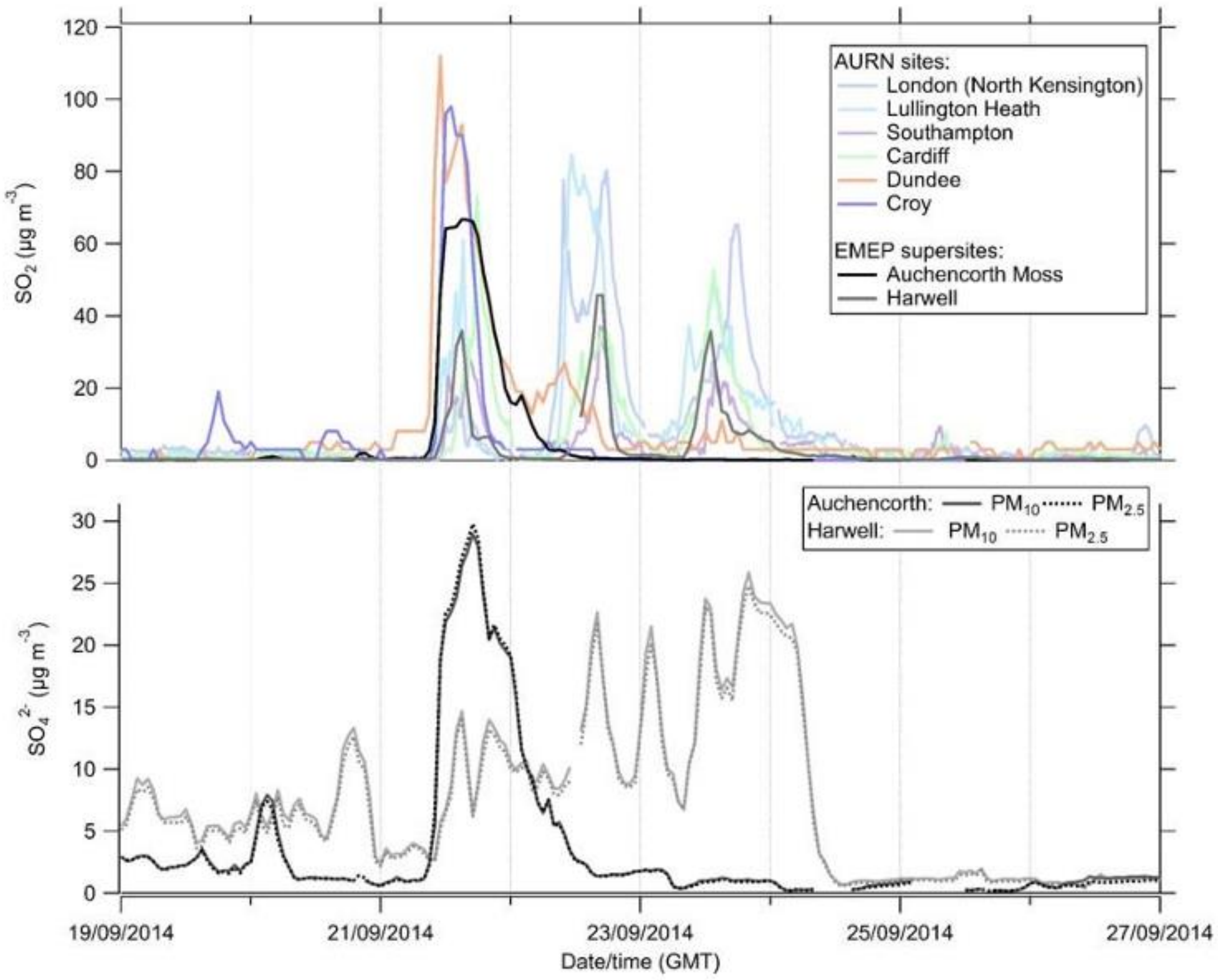


Comparison of coarse mode aerosol (PM1-10) chemistry compounds between WRF-Chem model results and Melpitz measurements. (a) averaged in the HOPE-Campaign period of September 10-20, 2013; (b) averaged in the marine air mass period of September 16-20, 2013.

Sea salt emission, transportation and influence on nitrate simulation : a case study in Europe, (Y. Chen et al.), Atmospheric Chemistry and Physics Discussions, 2016, 309, p. 1 - 26

Impacts of the 2014-2015 Holuhraun eruption on the UK atmosphere

- The study investigated a large-scale SO_2 and sulfate pollution event over the UK in September 2014.
- Researchers used the MARGA system at EMEP supersites (Auchencorth and Harwell) to measure hourly sulfate concentrations.
- The event was linked to industrial emissions transported from mainland Europe, confirmed by trajectory analysis.
- MARGA data showed a strong correlation between elevated SO_2 and secondary sulfate, supporting evidence of regional transformation.
- The results highlight the value of high-resolution, chemically speciated data for identifying and characterizing cross-border pollution events.



Time series of SO_2 hourly measurements made at 6 AURN sites in the UK and the two UK EMEP supersites measurements of SO_2 and PM10/2.5 SO_4^{2-}. (NOTE: SO_2 at Auchencorth Moss is underestimated between 11:00 and 22:00 (GMT) on the 21/09/14)

Environmental effects of ashfall in Argentina from the 2008 Chaitén volcanic eruption, (R. S. Martin et al.), Journal of Volcanology and Geothermal Research, 2009, 184, 3, p. 462 - 472

Metrohm 2060 MARGA Advantages

1. Measures gases and aerosols simultaneously
2. Captures hourly, time-resolved data
3. Fully automated with minimal manual handling
4. Remote access via cellular modem
5. Designed for real-world conditions

Thank You

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