PAUL SCHERRER INSTITUT

Jay G. Slowik :: Laboratory of Atmospheric Chemistry :: Paul Scherrer Institute

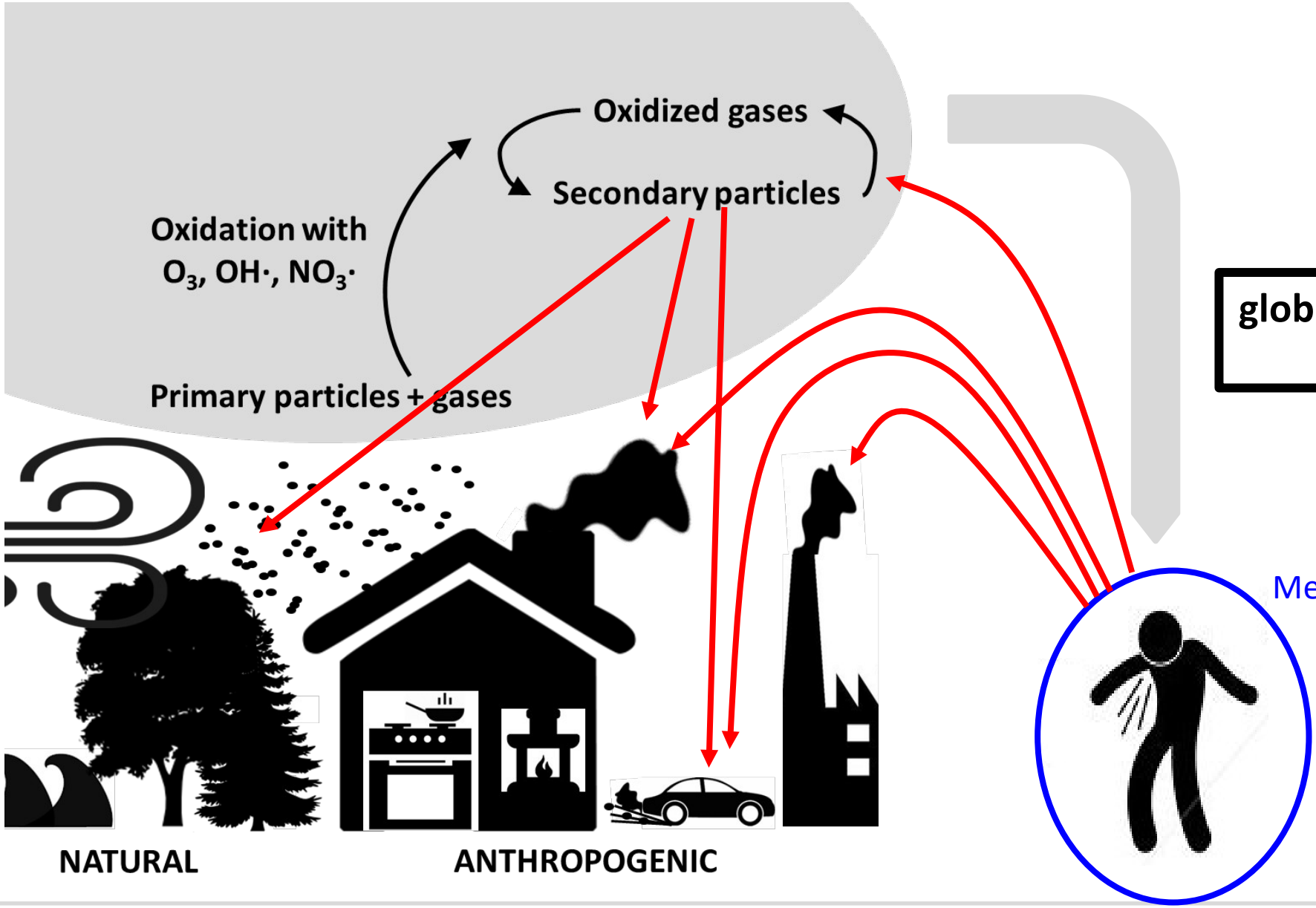
Advanced Source Apportionment and Aerosol Oxidation Potential

New Strategies for Improved Air Quality and Public Health

Better Air Quality Conference (BAQ 2023)
Manila, Philippines
November 15, 2023

LABOR FÜR ATMOSPHÄREN-CHEMIE

Aerosol sources and health risks



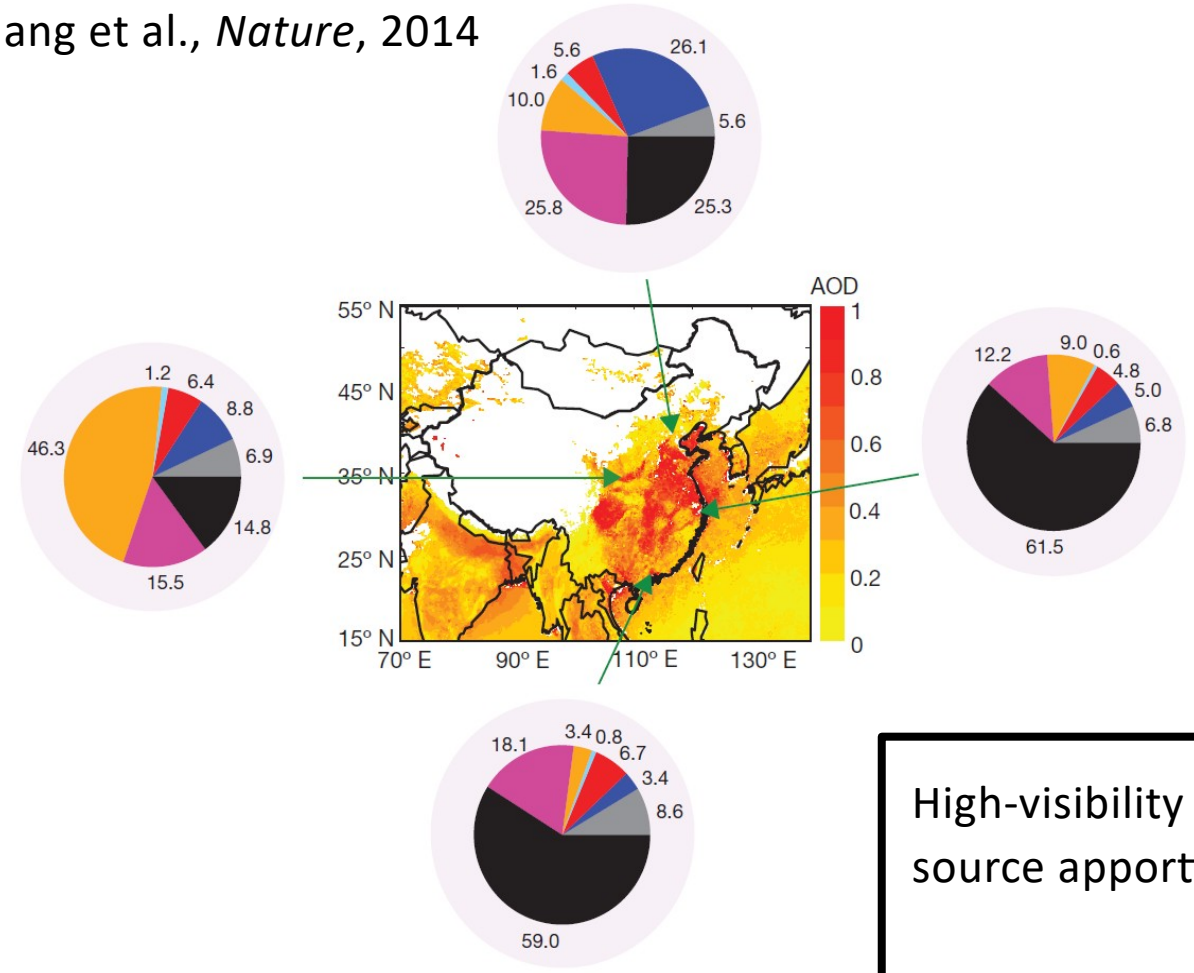
globally ~9 million premature deaths per year.

Measure particle composition

Source apportionment

Shortcomings in source apportionment

Huang et al., *Nature*, 2014



Sources/factors (%)

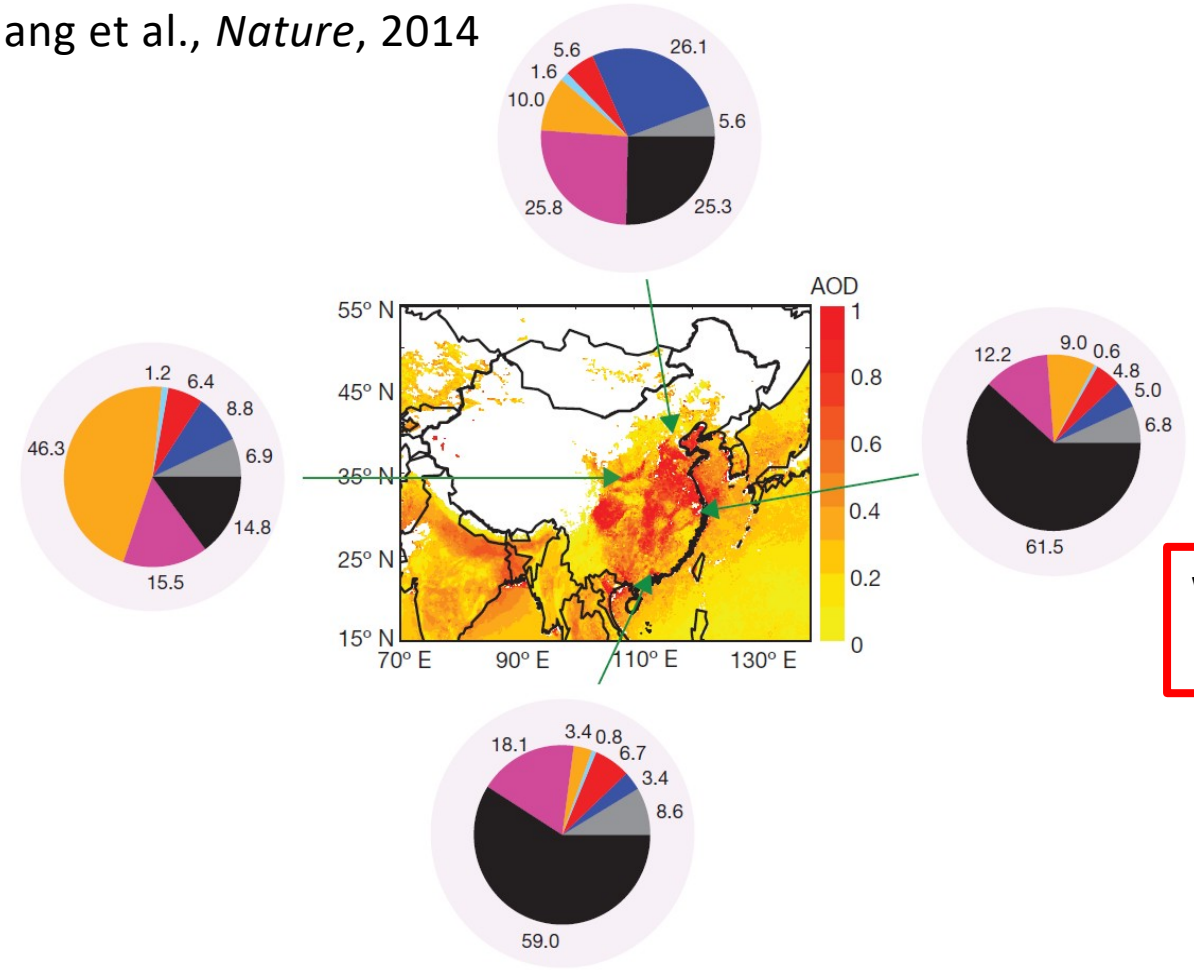
- Traffic
- Coal burning
- Biomass burning
- Cooking
- Dust related
- Secondary organic-rich
- Secondary inorganic-rich

High-visibility study (>3500 citations) of extreme haze in China via source apportionment of collected filter samples

Highlighted role of secondary species in extreme haze

Shortcomings in source apportionment

Huang et al., *Nature*, 2014



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Which source(s) control health risks?

What do these names mean?
How to relate to sources/processes?

Intense effort by leading researchers → results **1 YEAR** after measurement

Too slow!
- Fast response to acute events
- Policy motivation, design, implementation

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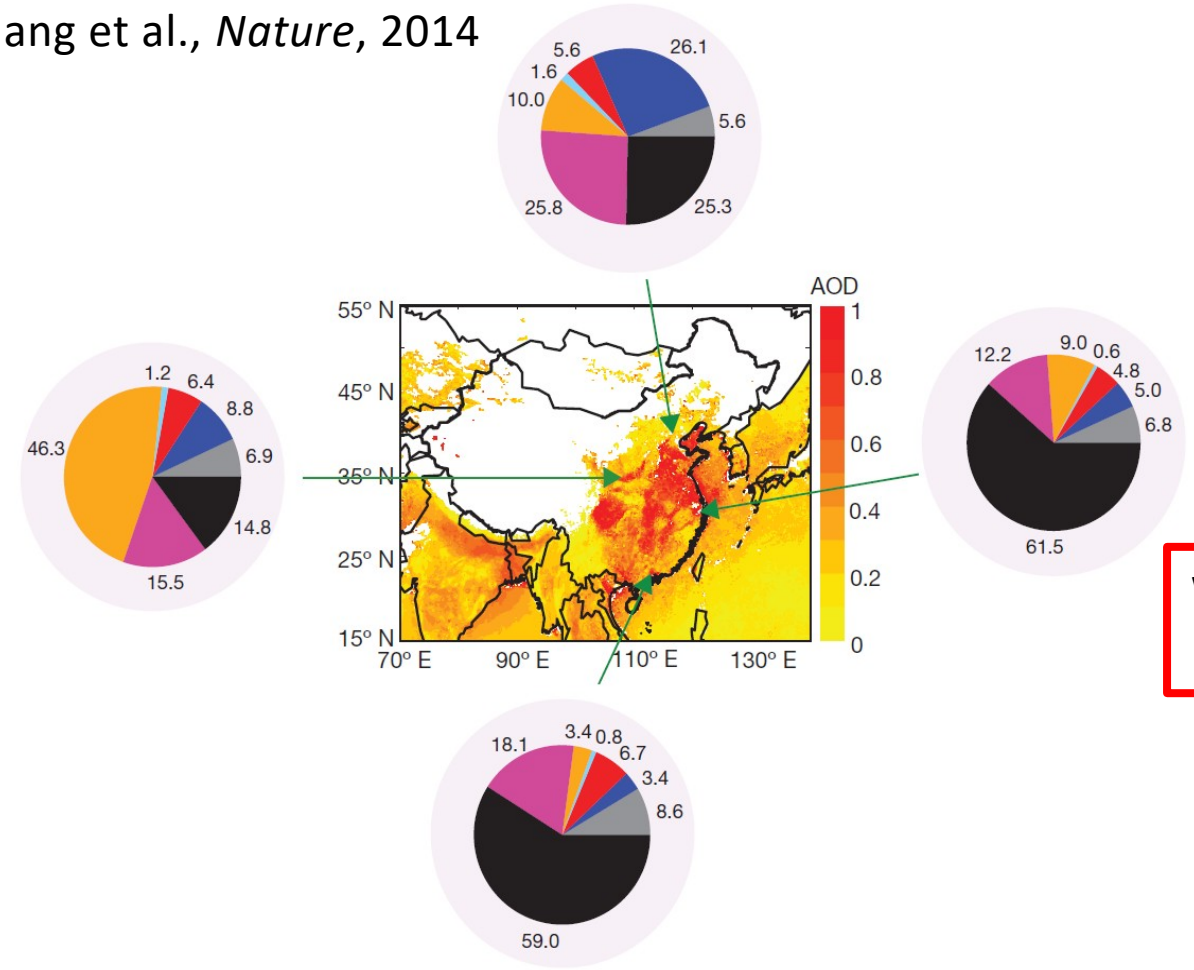

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Clean Air in China Project

- Advanced source apportionment of organic aerosol
- Link sources to reactive oxygen species (ROS)
- Develop real-time source apportionment model (DEZA PMF)

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Too slow!
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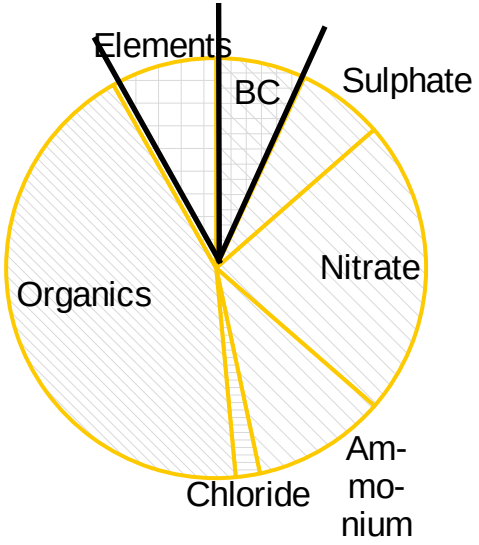
DEZA PMF: real-time source results

Information on particulate air pollution sources available within minutes of the measurement.

Xact ambient metals monitor

Aethalometer

Aerosol chemical speciation monitor (ACSM)



Step 1:

Measurements & standard analysis

Automated data processing

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Chemical composition (no sources)

Manousakas et al., in prep

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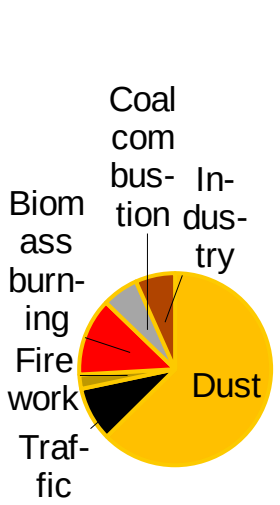

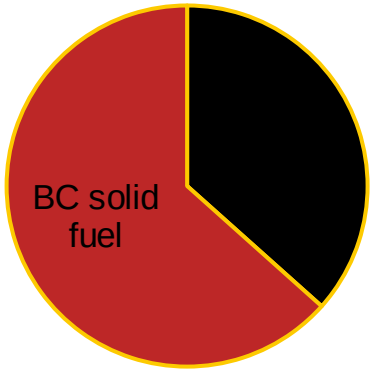

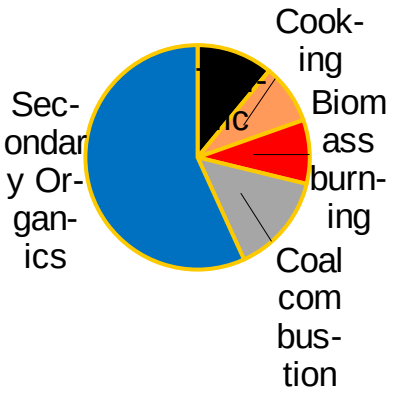

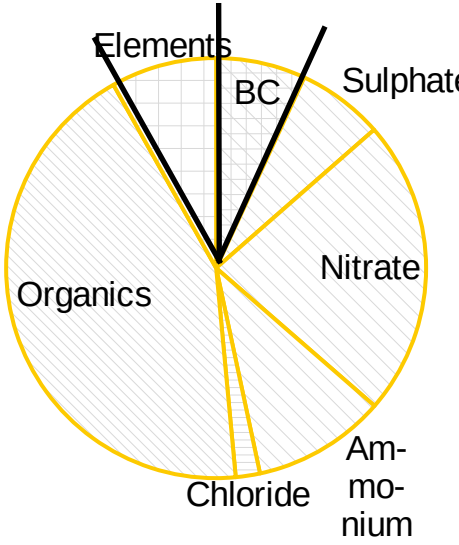

Step 2:

Automated source apportionment of individual instruments

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Instrument-specific sources

Manousakas et al., in prep

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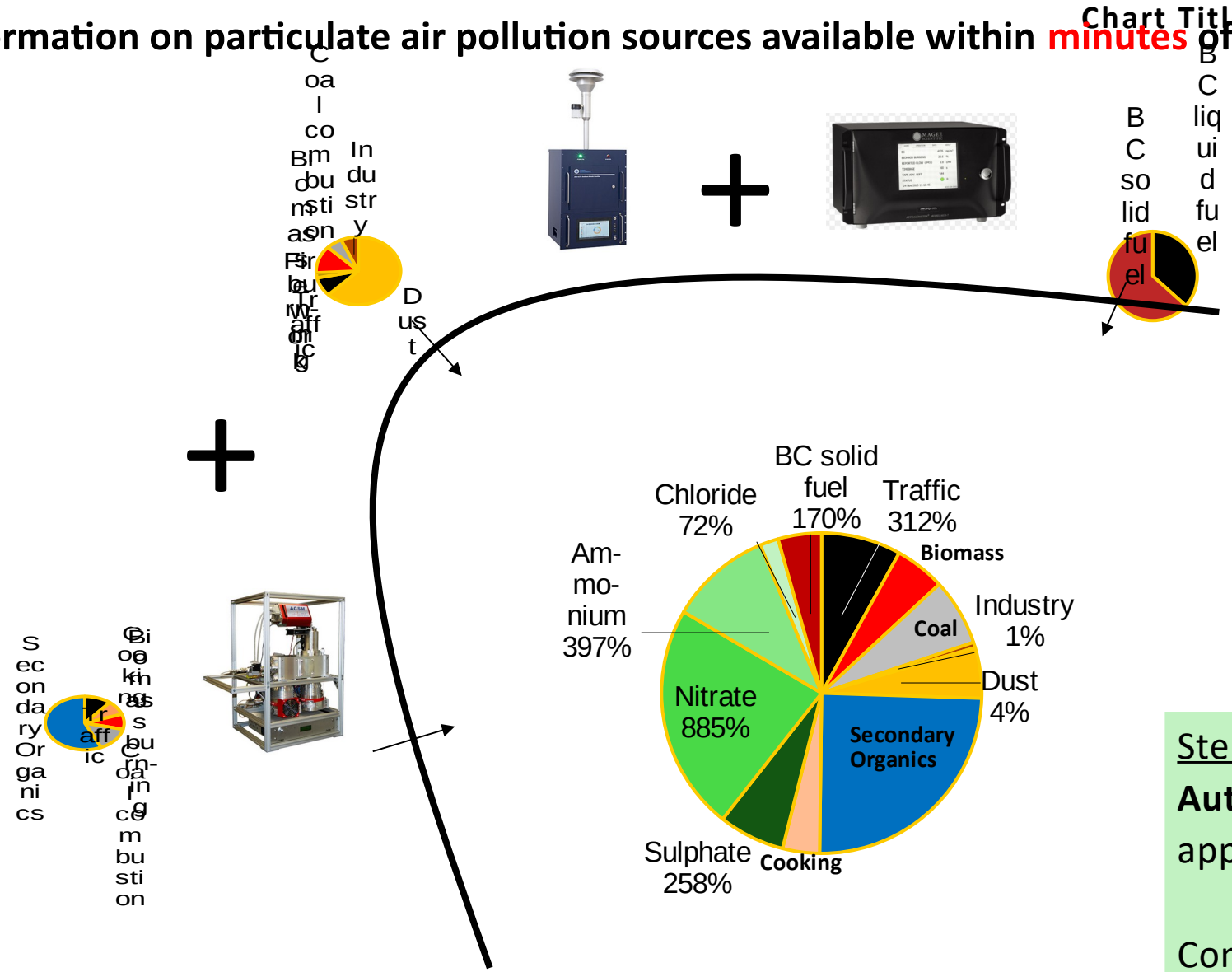

Manousakas et al., in prep

Step 3:

Automated recombination of apportionment results

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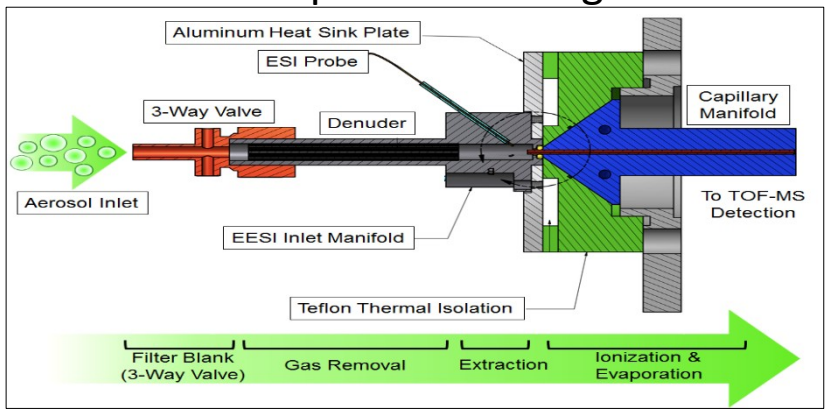
Complete source apportionment

Advanced source apportionment of secondary OA

EESI-TOF:

PSI-developed instrument

Molecular composition of organics

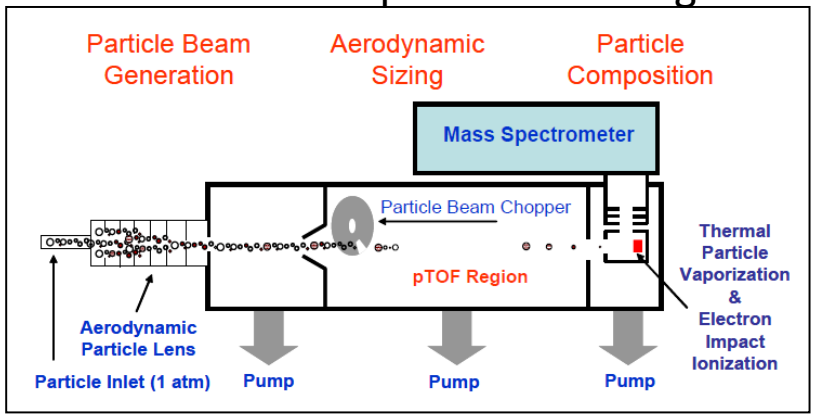


+

AMS:

Quantification of aerosol components

Limited chemical speciation of organics



Better chemical resolution → improved source apportionment

Online method (continuous field measurements)

Advantages:

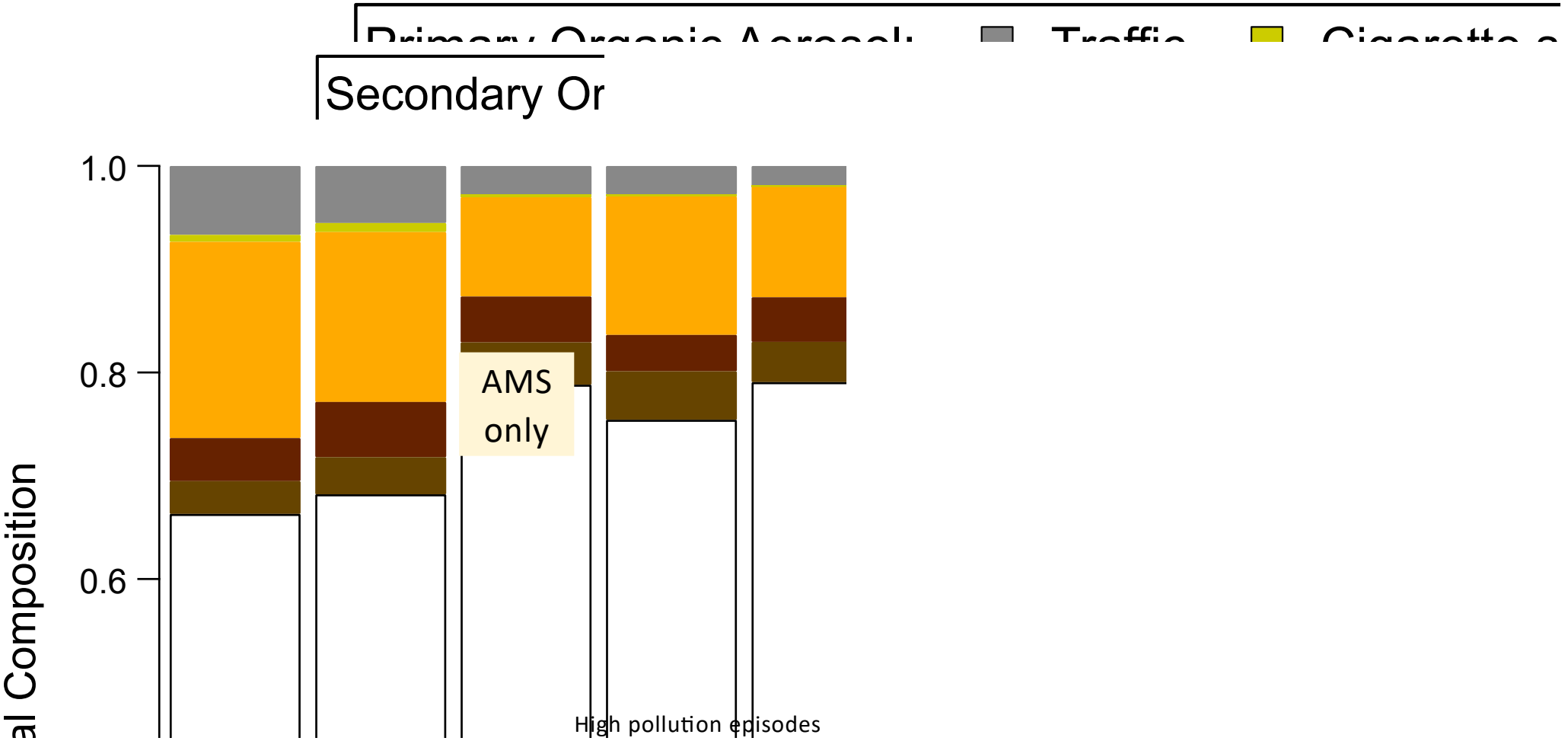
- Fast time resolution (matches human activity)
- Daily cycles
- Avoid collection/storage artifacts

Offline method (bring filter extracts to lab)

Advantages:

- Long (year or more) time series
- Spatial coverage
- Can analyze historical samples

Source apportionment: added value from EESI



SOA dominates... progressively more so as pollution increases

Qi et al., in prep

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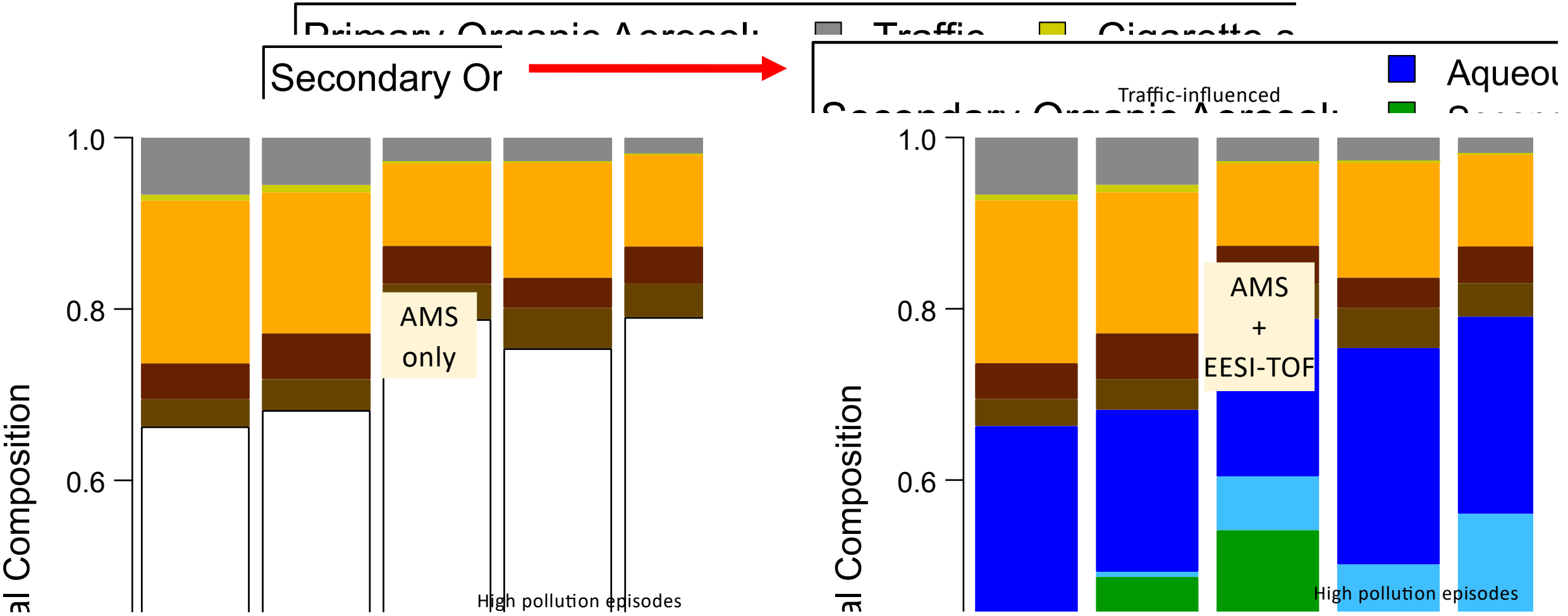


SOA dominates... progressively more so as pollution increases

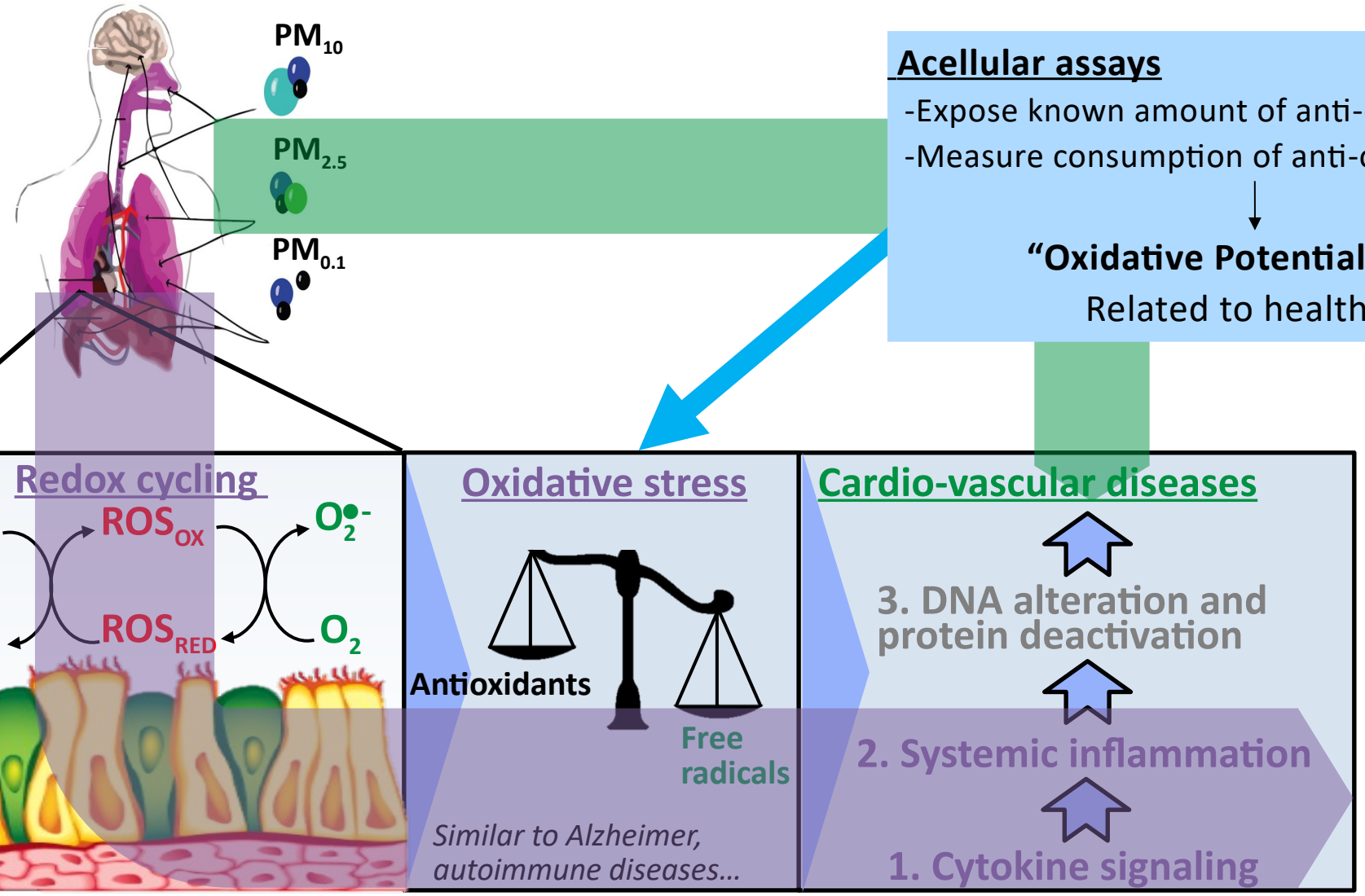
Aqueous SOA and aged/secondary biomass burning are important

Traffic-derived SOA not dominant but does matter, especially under less polluted conditions.

Qi et al., in prep

Oxidative potential (OP)

Epidemiology vs. Toxicology



Acellular assays

-Expose known amount of anti-oxidant to aerosol

-Measure consumption of anti-oxidant with time

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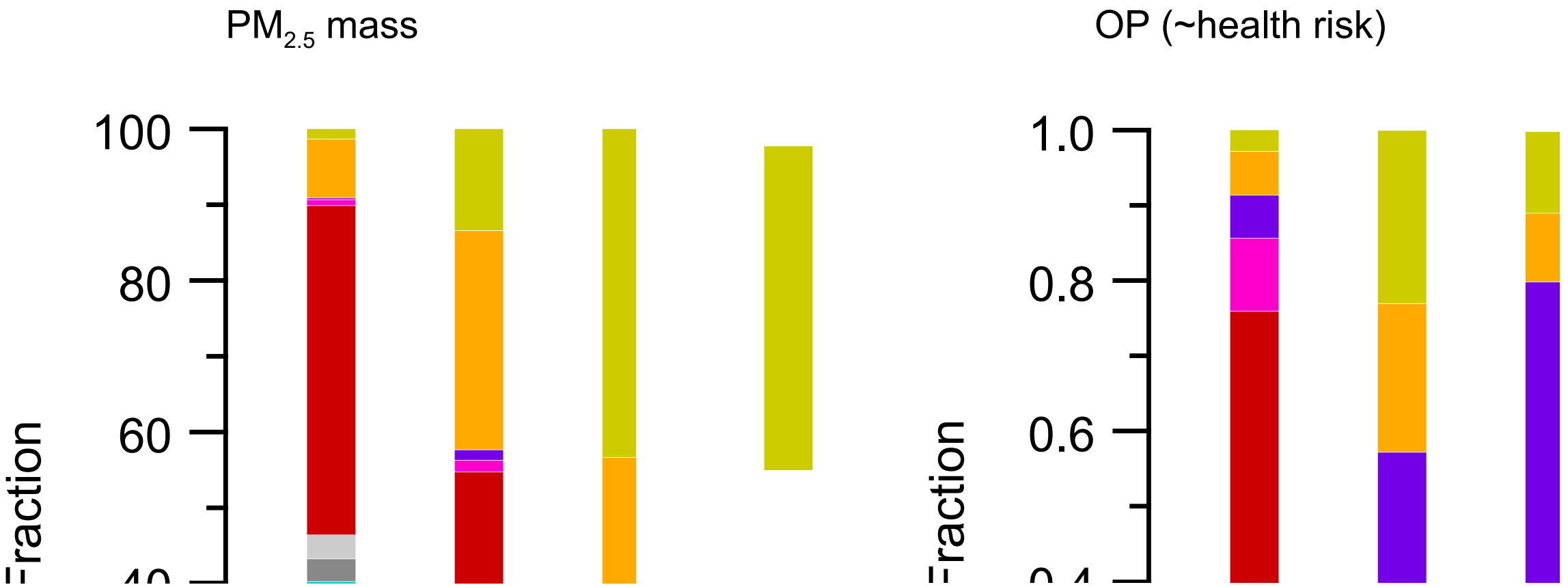
"Oxidative Potential ("OP")

Related to health risk

ROS = reactive oxygen species

Sources of oxidative potential (OP) in 6 Chinese cities

Chongqing (CHQ), Xi'an (XIA), Beijing (BEJ), Langfang (LGF), Shijiazhuang (SJZ), Wuhan (WHN)



OP-dominating sources are different from city to city:

- Dust: low toxicity but high mass → still the largest OP contributor in Xi'an (XIA) and Langfang (LGF).
- Non-exhaust traffic (e.g., brake wear) is important in Beijing (BEJ).
- Secondary organics ("OOAs") and solid fuels are important at all sites.

Conclusions

- Newly developed model for real-time source apportionment (DEZA PMF).
  - Results available within minutes of measurement
  - Not available anywhere else in the world
- Successful apportionment of secondary organic aerosol in terms of real-world sources and processes.
- Quantitative links between sources of PM and their potential health effects.

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