Welcome to the 4th International Surface Particulate Matter Network (SPARTAN) Meeting

Thank You!

The SPARTAN community:
>100 colleagues, >25 institutions, 15 countries

Many thanks to meeting sponsor

Washington University
May 18, 2023
Growing Range of Applications of SPARTAN

- Local pollution source information
- Global satellite-based pollution estimates
- Global health/environment assessments (GBD, WHO, OECD, World Bank)
- Simulation models for national/regional policy evaluation (GBD-MAPS)
- Anchor for local sensor networks
Recent and Ongoing Developments

- Major upgrade to analytical instrumentation (robotic weighing facility, XRF, IC Integrion)
- Organics via FTIR (AMS & UV-Vis in progress)
- Black carbon via image-based reflectance (IBR; Jeronimo et al. 2020) in addition to HIPS (IMPROVE)
- Revived operations across network following Covid-19 hiatus
- New sites as part of MAIA satellite instrument
- Additional sites to better resolve global variation
- Global mineral dust equation (Liu et al., 2022)
- Exploring oxidative potential
- Growing connections with low cost monitors (e.g., MAIA)
Growing Analysis Team

**Overall operations**
- Chris Oxford

**Trace elements**
- Xuan Liu

**Organics (AMS)**
- Yuxuan Ren
- Jhao-Hong Chen

**Data processing & GEOS-Chem**
- Haihui Zhu
- Yu Yan

**UV-Vis and Brown Carbon**
- Joshin Kumar

**Air Quality Analysts**
- Zilin Wei
- Summer Liu
- Kyla Fung

**FTIR & IMPROVE**
- Ann Dillner
Fine Particulate Matter (PM$_{2.5}$): Atmospheric Aerosols That Affect Longevity

- Outdoor PM$_{2.5}$ leading environmental risk factor for global burden of disease with 4 (Murray et al., Lancet, 2020) million attributable deaths annually.


- UN Sustainable Development Goals (3.9.1 & 11.6.2) require measurements of progress.

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### Contribution of major risk factors to loss of life expectancy

- Dietary Risks: 2 yr, 8 mo
- All Cancer: 1 yr, 10 mo
- Tobacco: 1 yr, 8 mo
- All Air Pollution: 9 mo
- Ambient PM$_{2.5}$: 7 mo
- Indoor Air Pollution: 5 mo
- Water Sanitation: 4 mo
- Lung Cancer: 3 mo
- Unsafe Sex: 2 mo
- Breast Cancer: <1 mo

**Exposure to outdoor PM$_{2.5}$ is estimated to shorten life expectancy by 1 year on average.**

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Health Effects Institute, State of Global Air, 2019
Evaluate and Enhance Satellite-Based Estimates of PM$_{2.5}$ Requires Information on Aerosol Optical Depth (AOD) to PM$_{2.5}$ Relationship

Satellite-derived PM$_{2.5}$ information source for:

- Global Burden of Disease
- OECD Regional Well Being Index
- World Health Organization
- Air Quality Life Index
- HEI State of Global Air
- World Bank
- Range of epidemiologic studies (low PM$_{2.5}$, PURE-Air, diabetes, birth outcomes)
- Contributed to Canadian annual PM$_{2.5}$ guideline (Crouse et al., 2012)

van Donkelaar et al., ES&T, 2021

Uncertainty driven by modeled relation between AOD and PM$_{2.5}$
Few Collocated Measurements of PM$_{2.5}$ & AOD

Collocated AOD and PM$_{2.5}$ Chemical Composition Measurements Even Fewer

2019 - 2020
- AOD/PM$_{2.5}$ collocation (12 sites)
- PM$_{2.5}$ only (5828 sites)
- AERONET only (487 sites)

Population Density
[People/km$^2$]
Surface Particulate Matter Network (SPARTAN) to Evaluate and Enhance Satellite-Based Estimates of PM$_{2.5}$

- Semi-autonomous PM$_{2.5}$ & PM$_{10}$ Impaction Sampling Station (AirPhoton)
- 3-λ nephelometer (AirPhoton) Scatter
- AOD from Sunphotometer (e.g. AERONET)
- Mass (35% RH) & BC (HIPS, IBR)
- Ions (IC) & Metals (XRF)
- Organics (FTIR, AMS) in progress
- BrC (UV-Vis) in progress

Measured:

$$\frac{\text{PM}_{2.5}}{\text{AOD}} = \left( \frac{b_{sp, \text{overpass}}}{\text{AOD}_{\text{overpass}}} \right) \left( \frac{b_{sp, 24h}}{b_{sp, \text{overpass}}} \right) \left( \frac{\text{PM}_{2.5, 24h}}{b_{sp, 24h}} \right)$$

$b_{sp} =$ nephelometer measurements of aerosol scatter

overpass = satellite overpass time

(Depends on size, composition, hygroscopicity)
SPARTAN: Growing Global Network with Increasing Information on $\text{PM}_{2.5}$ Chemical Composition

Globally consistent $\text{PM}_{2.5}$ mass and composition network

New sites in support of MAIA

Offers information about sources

Diner et al., JARS, 2018
**SPARTAN: Maximizing Information from Each Filter**

*Continue to Develop Analysis Stream*

- **Pre-weigh filters** → **Ship & sample** → **Post-weigh filters**

**Black carbon and organics (HIPS and FTIR)**
- Partnership with UC Davis (Ann Dillner and Nicole Hyslop)
  
**Trace elements (XRF)**
- Led by Xuan Liu in partnership with Jay Turner (WashU) & UC Davis (Jason Giacomo)

**Black & brown carbon (UV-Vis)**
- Partnership with Joshin Kumar, Sam Black, and Rajan Chakrabarty (WashU)

**Oxidative potential?**
- Led by Vishal Verma (UIUC)

**Black carbon (IBR)**
- Partnership with Michael Brauer (UBC)

**Soluble ions (IC)**
- Supported by Summer Liu, Zilin Wei, Kyla Fung, Haihui Zhu

**Organics (AMS)**
- Led by Yuxuan Ren in partnership with Jhao-Hong Chen and Brent Williams (WashU)

Overall operations led by Chris Oxford.
A Global-Scale Mineral Dust Equation

Dust = f(Al, Si, Ca, Fe, Ti, missing elements)

Account for Crustal Weathering Using Mineral to Aluminum, MAL = K/Al + Mg/Al + Na/Al

Dust = [1.89Al × (1 + MAL) + 2.14Si + 1.40Ca + 1.36Fe + 1.67Ti] × CF

Regional Variation in MAL Ratio

Liu, Turner, et al., JGR, 2022
Overview of SPARTAN PM$_{2.5}$ Mass and Composition

Low PM$_{2.5}$

Middle contains PM$_{2.5}$ Mass in ug/m$^3$

High Dust Fraction

High PM, Nitrate

150% increase in filter collection rate over last year

Data publicly available at spartan-network.org
Data to Evaluate and Improve Source Characterization

**GBD-MAPS Global**

McDuffie et al., Nature Comm, 2021

Support for Epidemiological Studies

Weichenthal, ... Brauer, Science Advances, 2022

Concerning Enhancements of Trace Elements

Xuan Liu

Data for Satellite-based Estimates of PM$_{2.5}$

van Donkelaar et al., ES&T, 2021
Seek Your Ideas to Develop Collaborations and Enhance the Grass-roots Surface Particulate Matter Network

Some goals:
• Assess methodological backbone & identify innovation opportunities
• Foster broader application

Logistics
• Early morning: Overview
• Late morning: Broader context
• Afternoon: Low cost monitors and future directions

• Full agenda
  – please allow 3 min for Q&A and changeover