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

Thank You!

The SPARTAN community:

>100 colleagues, >25 institutions, 15 countries

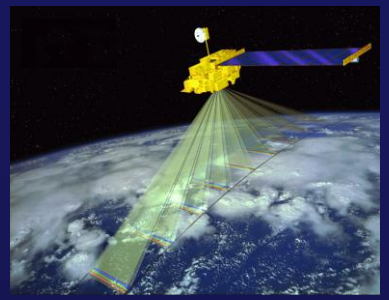
SPARTAN
Global Particulate Matter Network

Many thanks to meeting sponsor

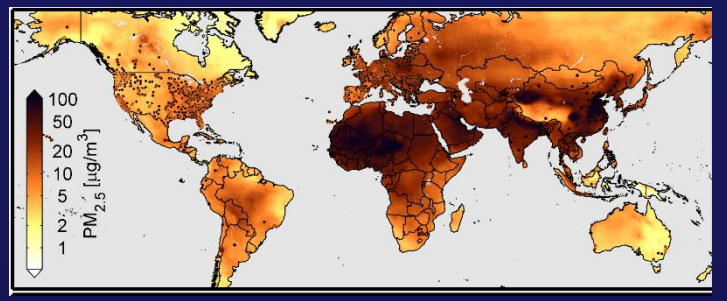
CLEAN AIR FUND

Washington University
May 18, 2023

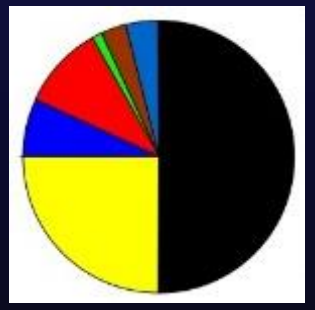
Growing Range of Applications of SPARTAN



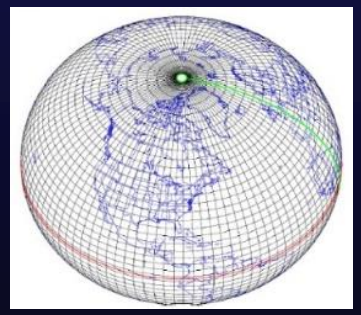
Global satellite-based pollution estimates



Global health/environment assessments (GBD, WHO, OECD, World Bank)



Local pollution source information



Simulation models for national/regional policy evaluation (GBD-MAPS)

Anchor for local sensor networks

Recent and Ongoing Developments

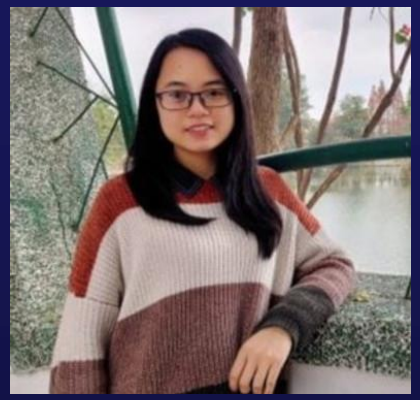
- Major upgrade to analytical instrumentation (robotic weighing facility, XRF, IC Integrion)
- Organics via FTIR (AMS & UV-Vis in progress)
- Black carbon via image-based reflectance (IBR; Jeronimo et al. 2020) in addition to HIPS (IMPROVE)
- Revived operations across network following Covid-19 hiatus
- 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

Chris Oxford

Overall operations

Xuan Liu



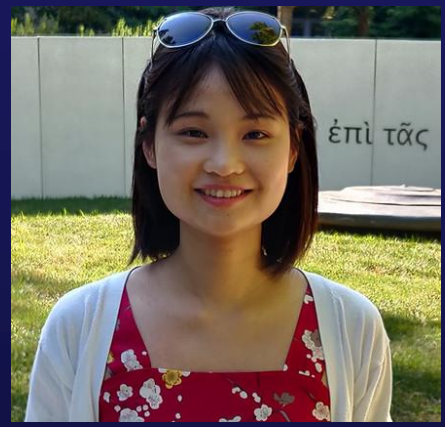
Trace elements

Yuxuan Ren

Jhao-Hong Chen

Organics (AMS)

Haihui Zhu

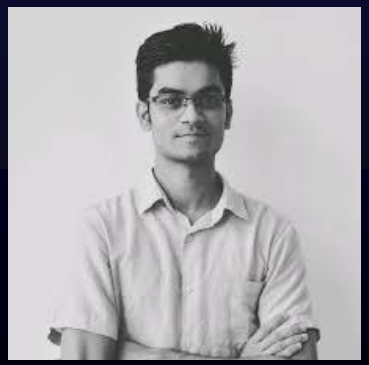


Data processing & GEOS-Chem

Yu Yan

Interpretation w/GEOS-Chem

Joshin Kumar



UV-Vis and Brown Carbon

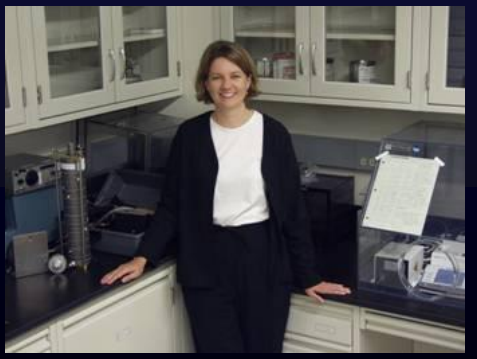
Zilin Wei

Summer Liu

Kyla Fung

Air Quality Analysts

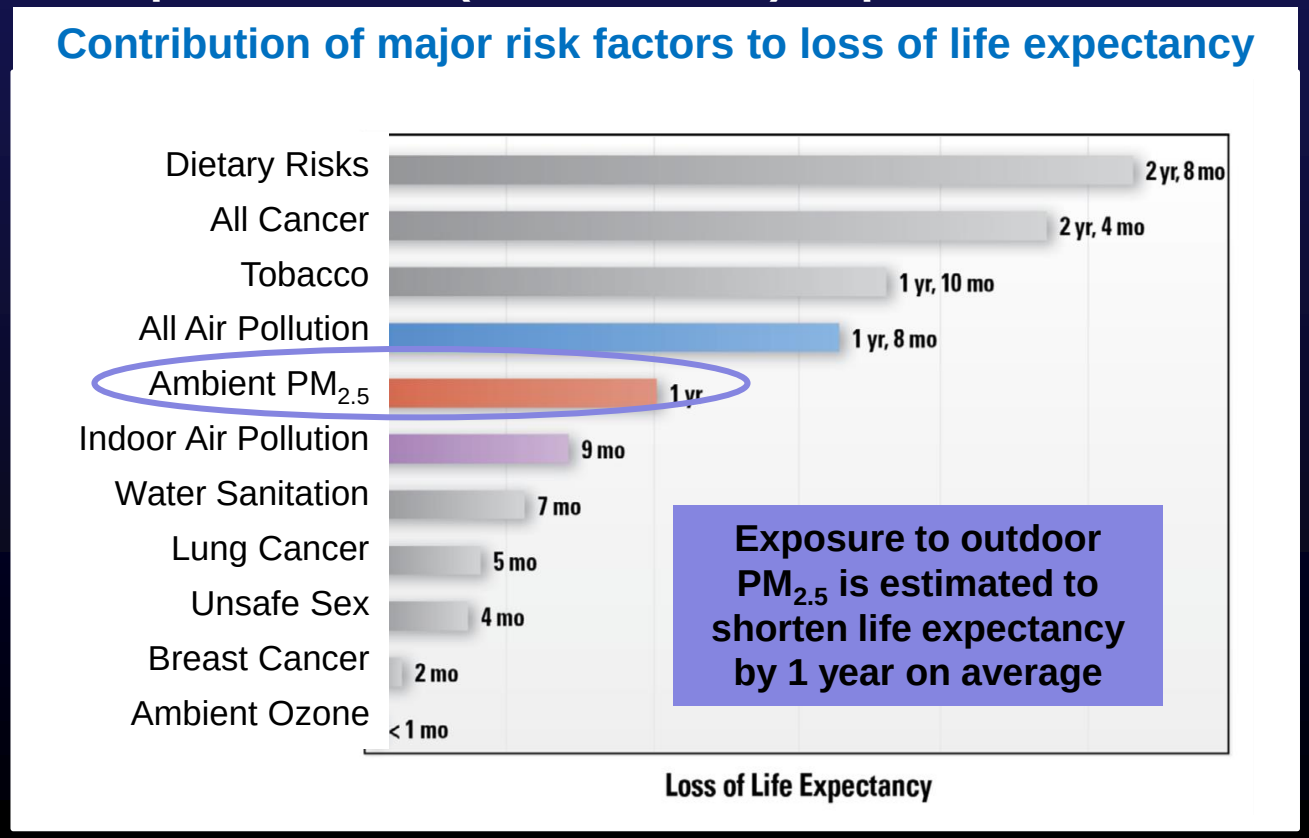
Ann Dillner



FTIR & IMPROVE

Fine Particulate Matter ($PM_{2.5}$): Atmospheric Aerosols That Affect Longevity

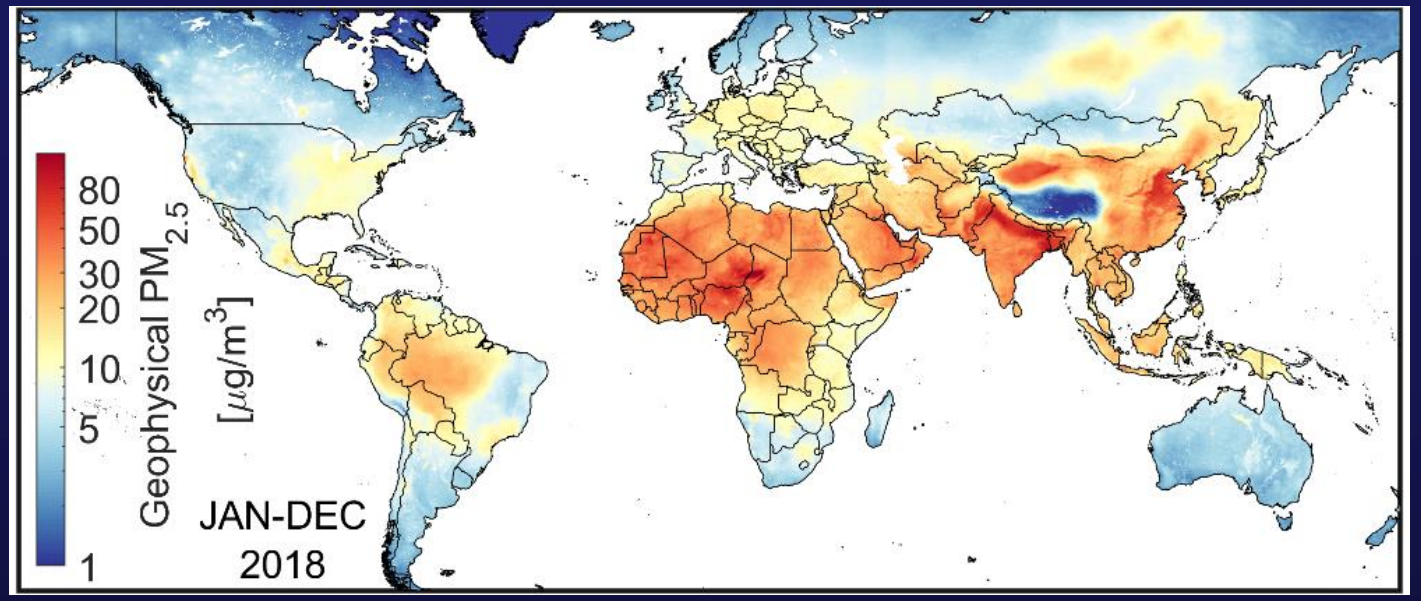
- Outdoor $PM_{2.5}$ leading environmental risk factor for global burden of disease with for global burden of disease with 4 (Murray et al., Lancet, 2020) million attributable deaths annually
- Annual global welfare costs projected to rise from US$3 trillion in 2015 to US$18-25 trillion in 2060 (OECD, 2016)
- UN Sustainable Development Goals (3.9.1 & 11.6.2) require measurements of progress



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



van Donkelaar et al., ES&T, 2021

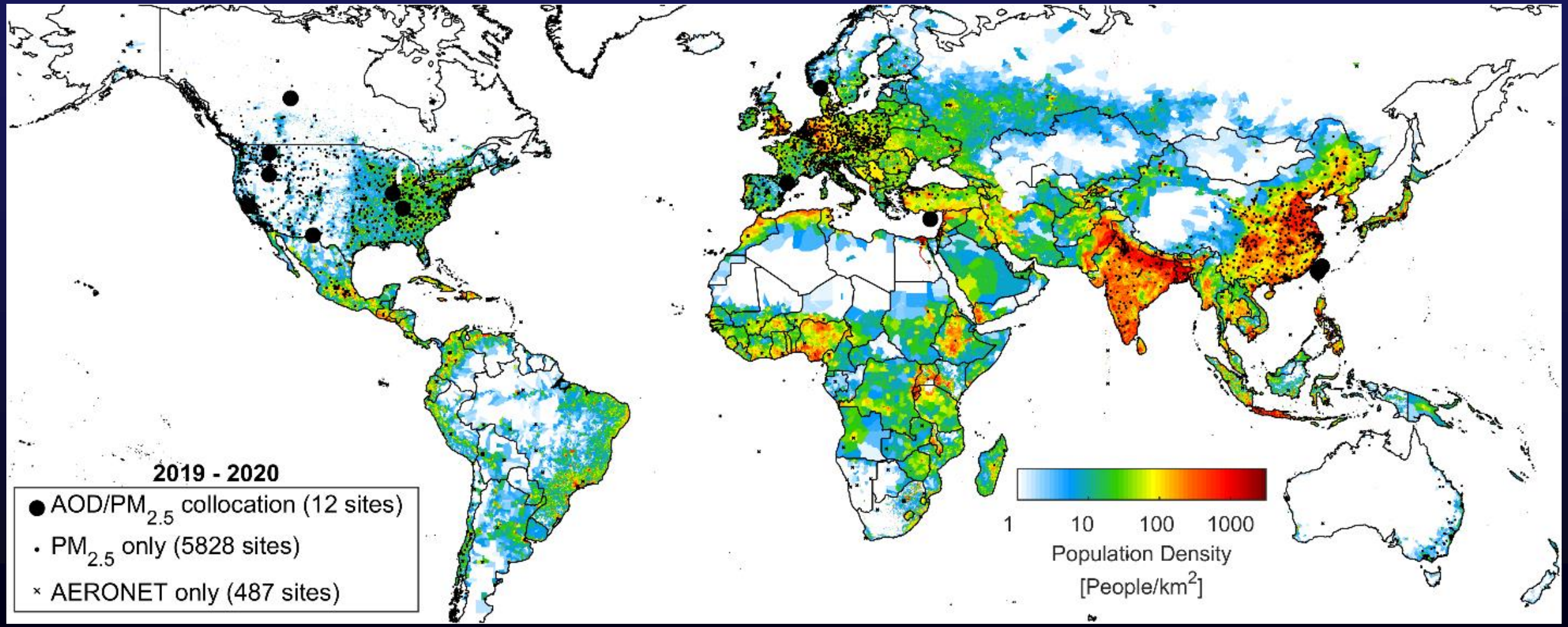
Uncertainty driven by modeled relation between AOD and $PM_{2.5}$

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)

Few Collocated Measurements of $PM_{2.5}$ & AOD

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



Non-SPARTAN Data

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)

Mass (35% RH)
BC (HIPS, IBR)
Ions (IC)
Metals (XRF)
Organics (FTIR, AMS) in progress
BrC (UV-Vis) in progress

3-λ nephelometer (AirPhoton) Scatter

AOD from Sunphotometer (e.g. AERONET)

Measured:

Surface/Column

Diel

Mass Scattering Efficiency

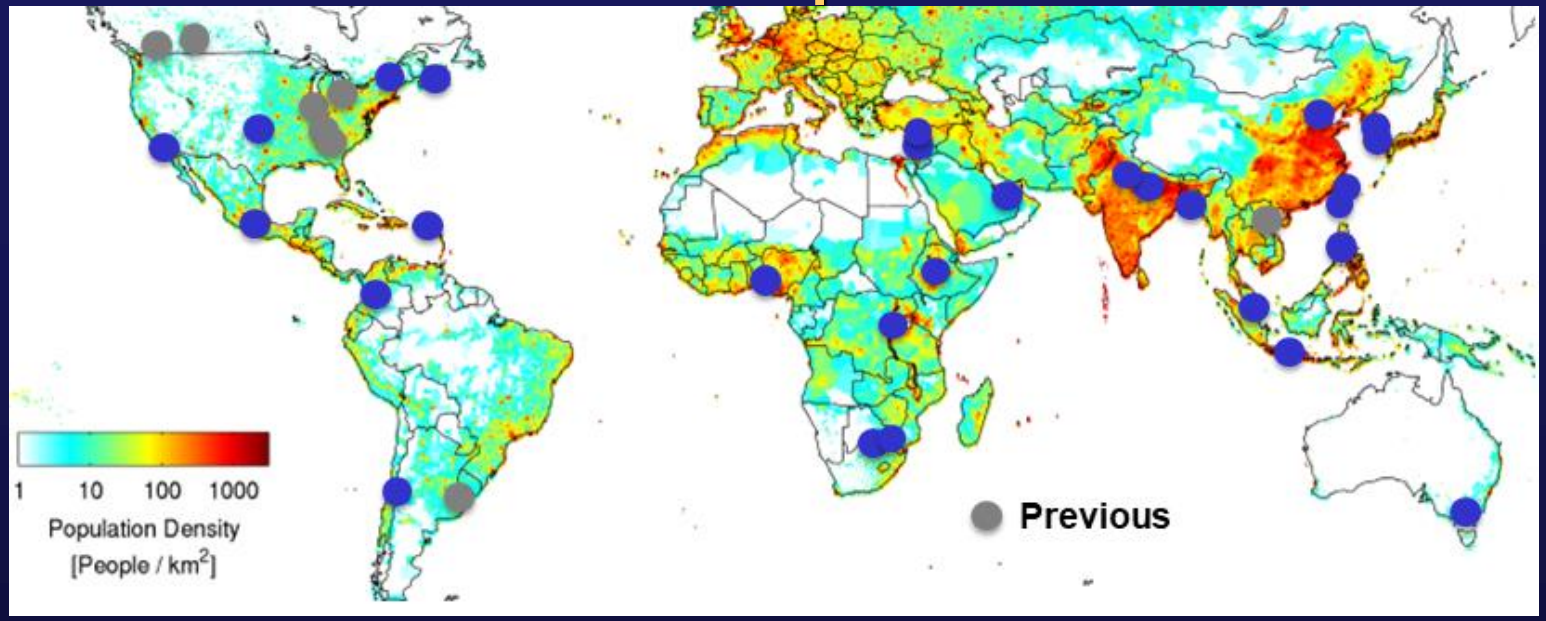
(Depends on size, composition, hygroscopicity)

$$\frac{PM_{2.5}}{AOD} = \left(\frac{b_{sp,overpass}}{AOD_{overpass}}\right)\left(\frac{b_{sp,24h}}{b_{sp,overpass}}\right)\left(\frac{PM_{2.5,24h}}{b_{sp,24h}}\right)$$

b_{sp} = nephelometer measurements of aerosol scatter

overpass = satellite overpass time

SPARTAN: Growing Global Network with Increasing Information on $PM_{2.5}$ Chemical Composition



Globally consistent $PM_{2.5}$ mass and composition network

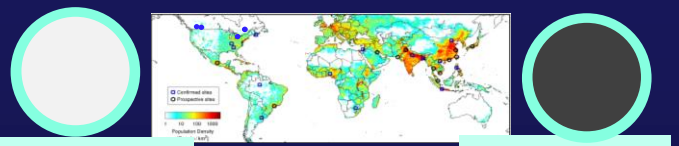
New sites in support of MAIA

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)

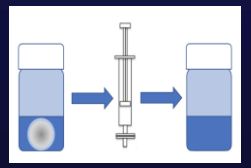
Soluble ions (IC)

Black & brown carbon (UV-Vis)

Partnership with Joshin Kumar, Sam Black, and Rajan Chakrabarty (WashU)

Black carbon (IBR)

Partnership with Michael Brauer (UBC)



Organics (AMS)

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

Oxidative potential?

Led by Vishal Verma (UIUC)

www.spartan-network.org

Overall operations led by Chris Oxford

Supported by Summer Liu, Zilin Wei, Kyla Fung, Haihui Zhu

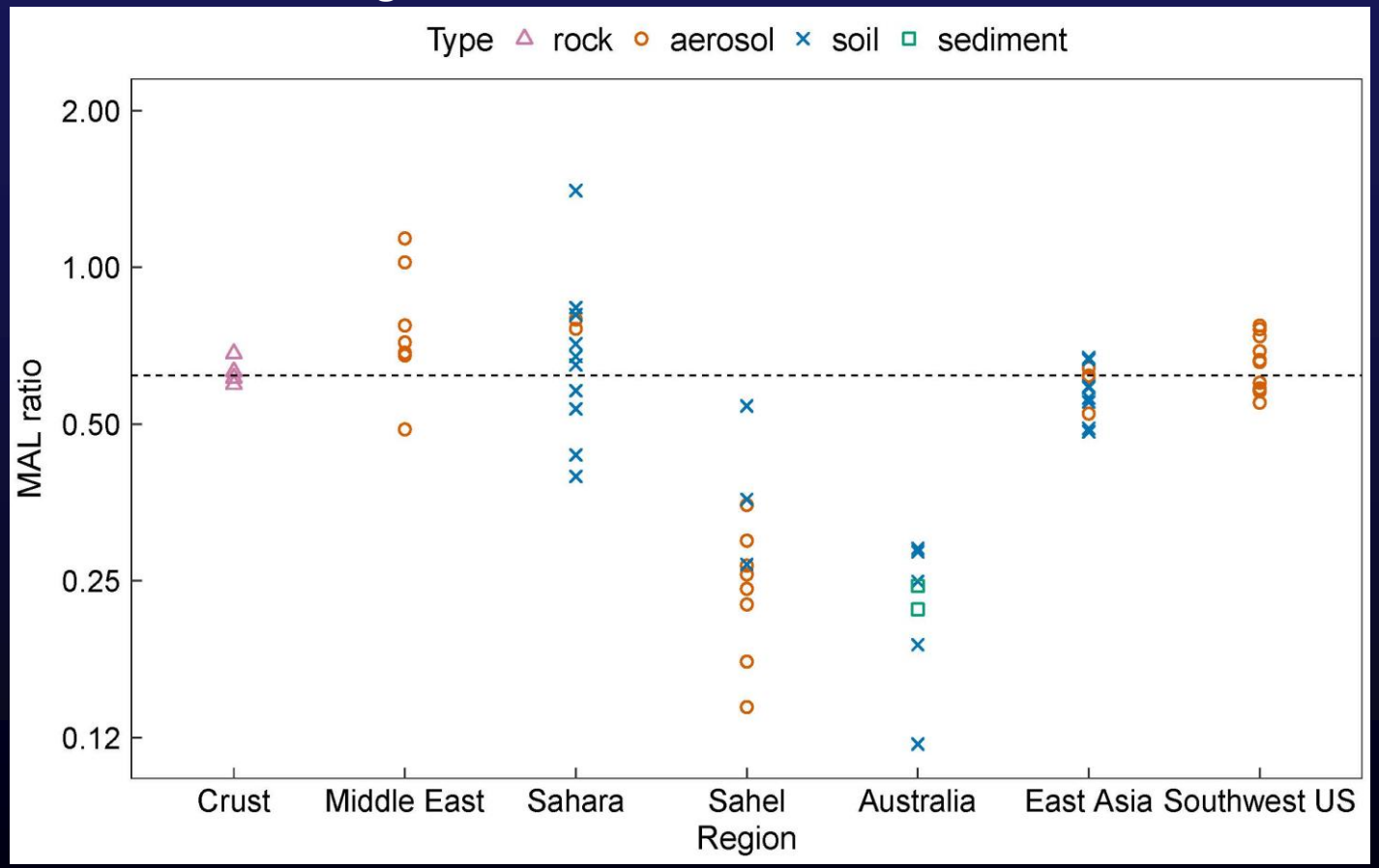
A Global-Scale Mineral Dust Equation

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

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

$$\text{Dust} = [1.89\text{Al} \times (1 + \text{MAL}) + 2.14\text{Si} + 1.40\text{Ca} + 1.36\text{Fe} + 1.67\text{Ti}] \times \text{CF}$$

Regional Variation in MAL Ratio

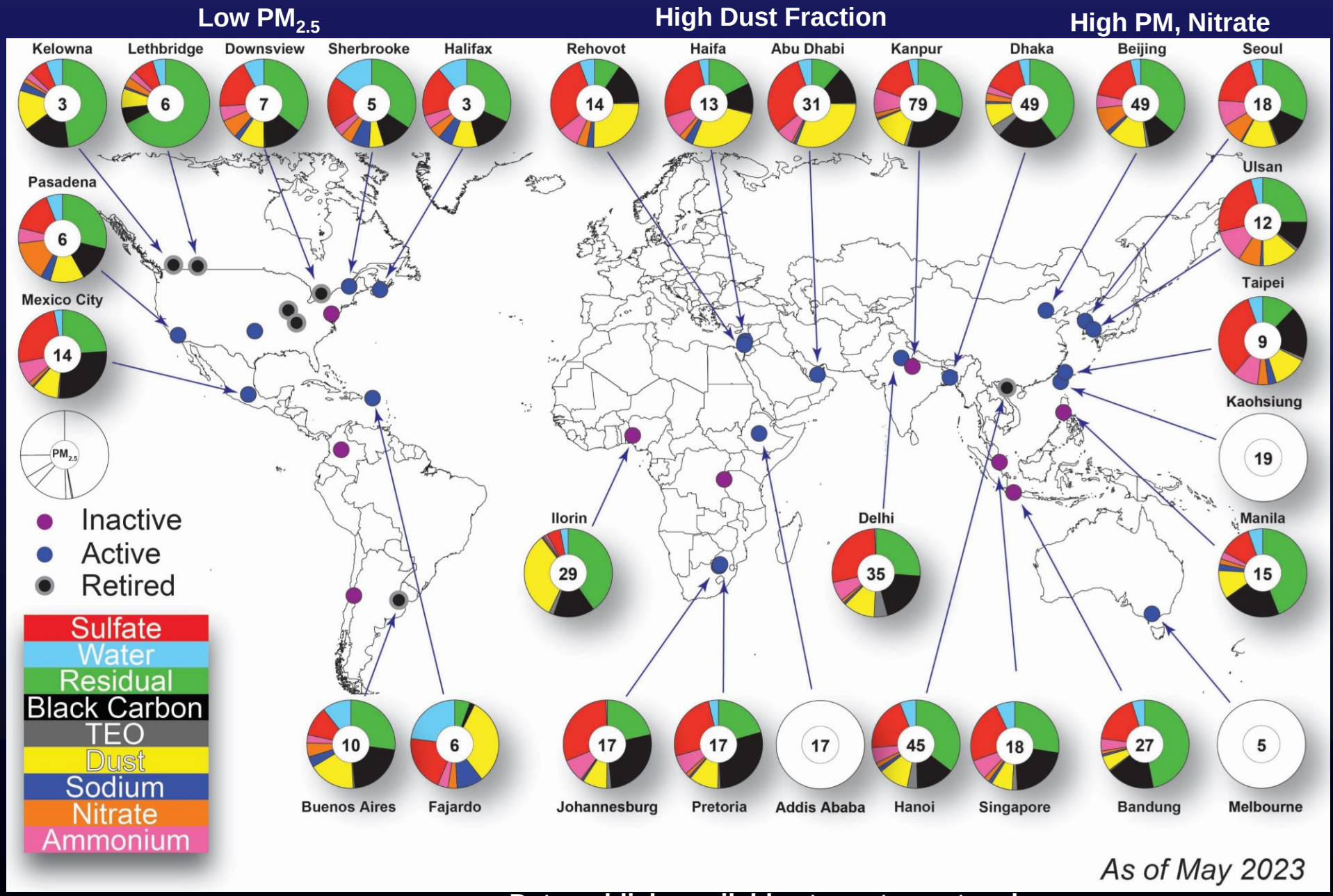


Highly weathered dust in Sahel and Australia

Liu, Turner, et al., JGR, 2022

Overview of SPARTAN $PM_{2.5}$ Mass and Composition

150% increase in filter collection rate over last year

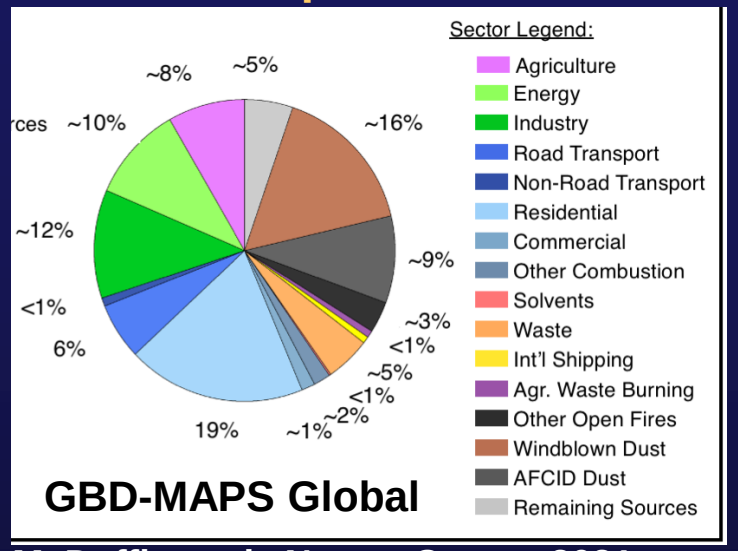


Middle contains $PM_{2.5}$ Mass in ug/m^3

Data publicly available at spartan-network.org

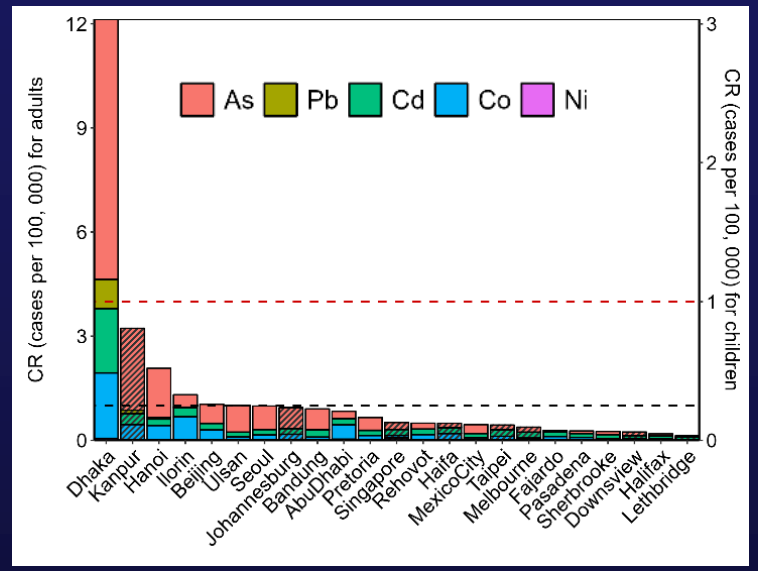
SPARTAN Data Inform Insight into Sources,Concentrations, and Health Effects

Data to Evaluate and Improve Source Characterization



McDuffie et al., Nature Comm, 2021

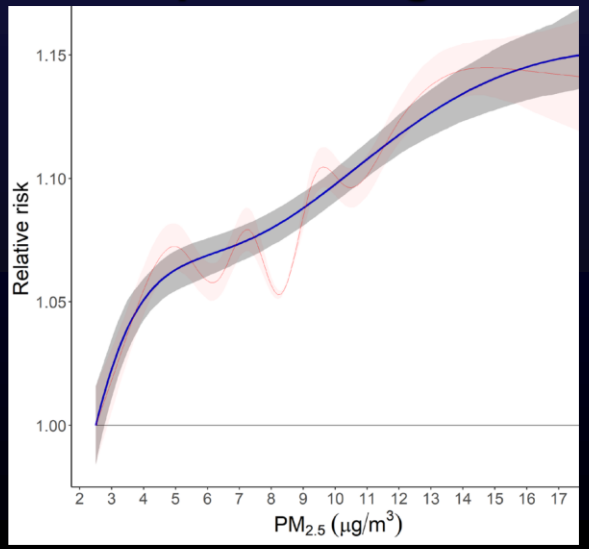
Concerning Enhancements of Trace Elements



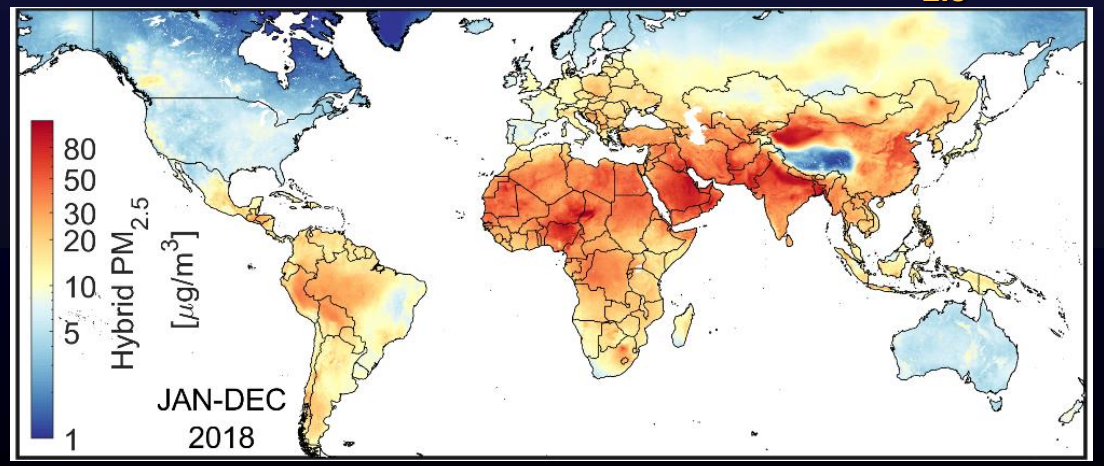
Xuan Liu

Support for Epidemiological Studies

Weichenthal, … Brauer, Science Advances, 2022



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**