Integration of Global and Local Datasets for Particle Composition Exposure

Presented by Randall Martin

with contributions from

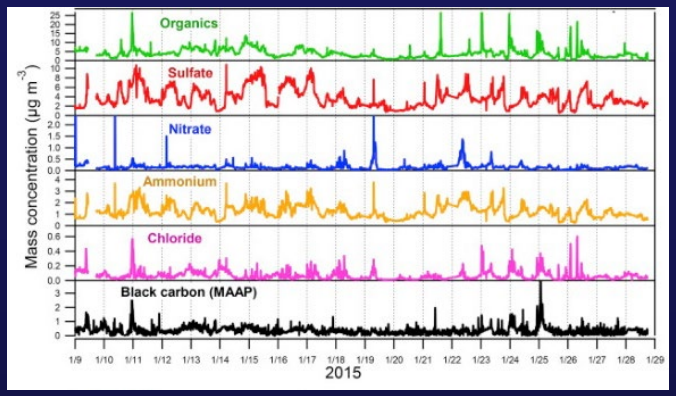
Melanie Hammer, Emmie Le Roy, Jun Meng, Emily Stone, Aaron van Donkelaar, Brenna Walsh, Crystal Weagle, Junwei Xu

Michael Brauer (UBC), Richard Burnett (Health Canada), Hong Chen (Health Canada), Dan Crouse (UNB), Christina Hsu (NASA), Ralph Kahn (NASA), Robert Levy (NASA), Alexei Lyapustin (NASA), Vanderlei Martins (UMBC), Yinon Rudich (Weizmann), Andrew Sayer (NASA)

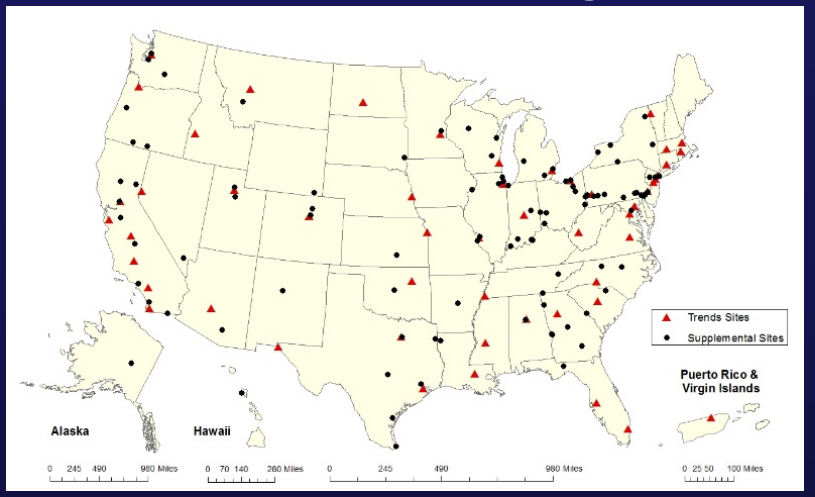
2020 Health Effects Meeting
29 April 2020

Methods for Inferring Ambient $PM_{2.5}$ Chemical Composition for Exposure Assessment

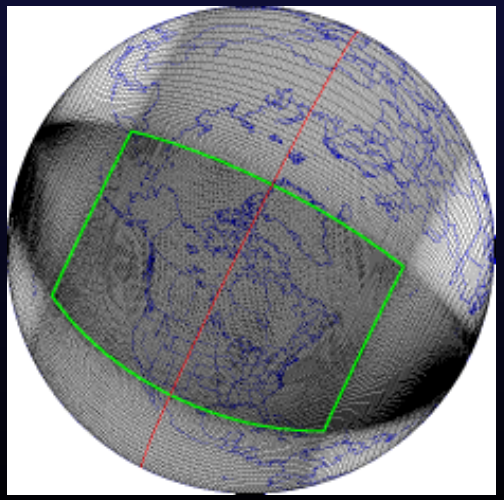
Targeted Measurement



Statistical Fusion to Monitoring Network



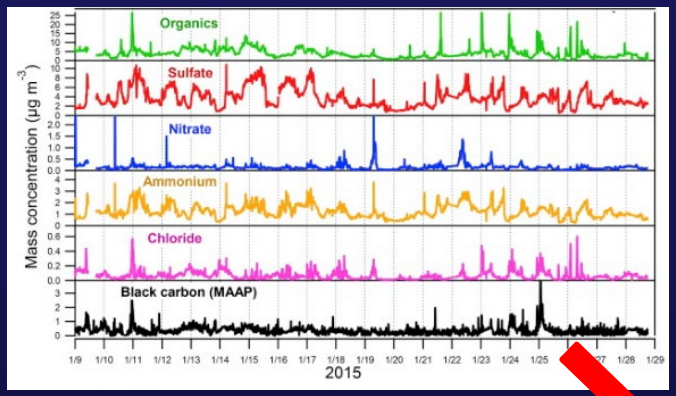
Chemical Transport Model



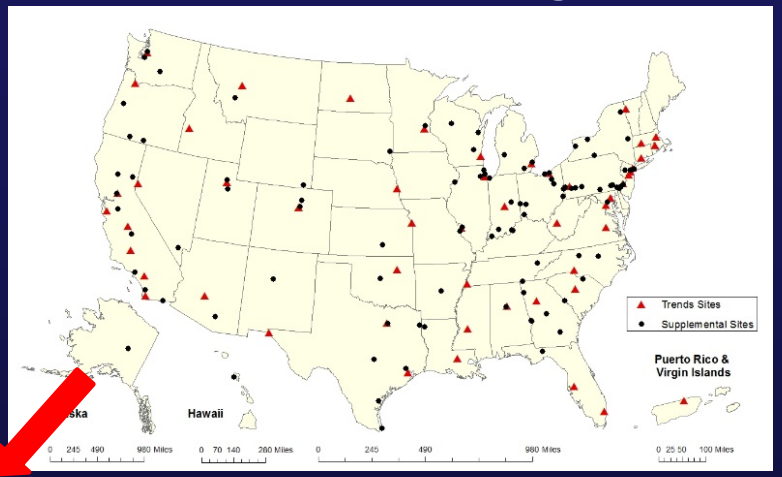
Satellite Remote Sensing

Methods for Inferring Ambient $PM_{2.5}$ Chemical Composition for Exposure Assessment

Targeted Measurement

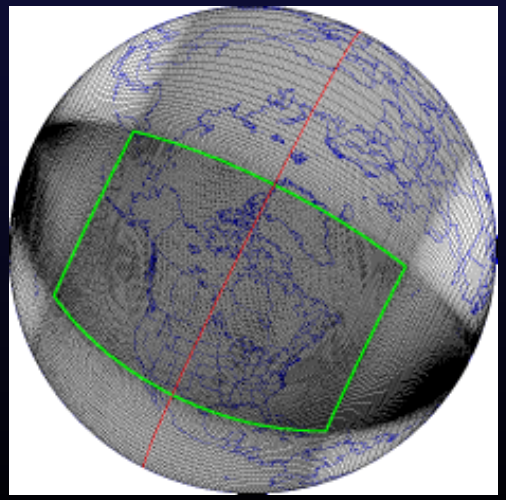


Statistical Fusion to Monitoring Network



Develop Representation of $PM_{2.5}$ Composition

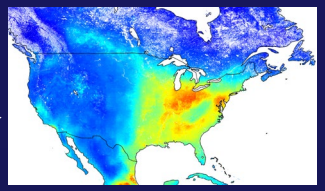
Chemical Transport Model



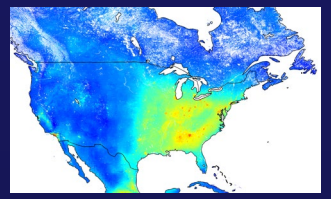
Satellite Remote Sensing

Estimation Process for $PM_{2.5}$ Composition

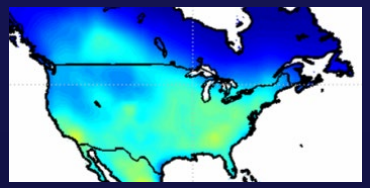
Satellite Aerosol Optical Depth (AOD)



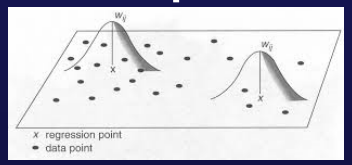
Geophysical $PM_{2.5}$ Composition



Hybrid $PM_{2.5}$ Composition

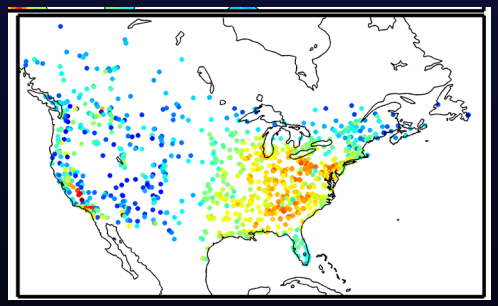


GEOS-Chem $PM_{2.5}$ composition / AOD



Statistical Fusion

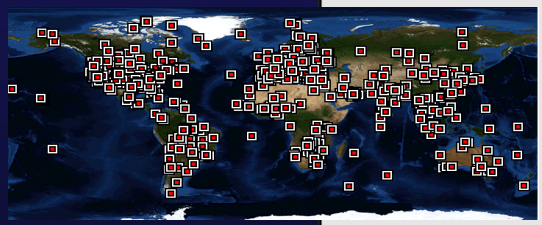
Measurements of $PM_{2.5}$ composition, scatter, and AOD



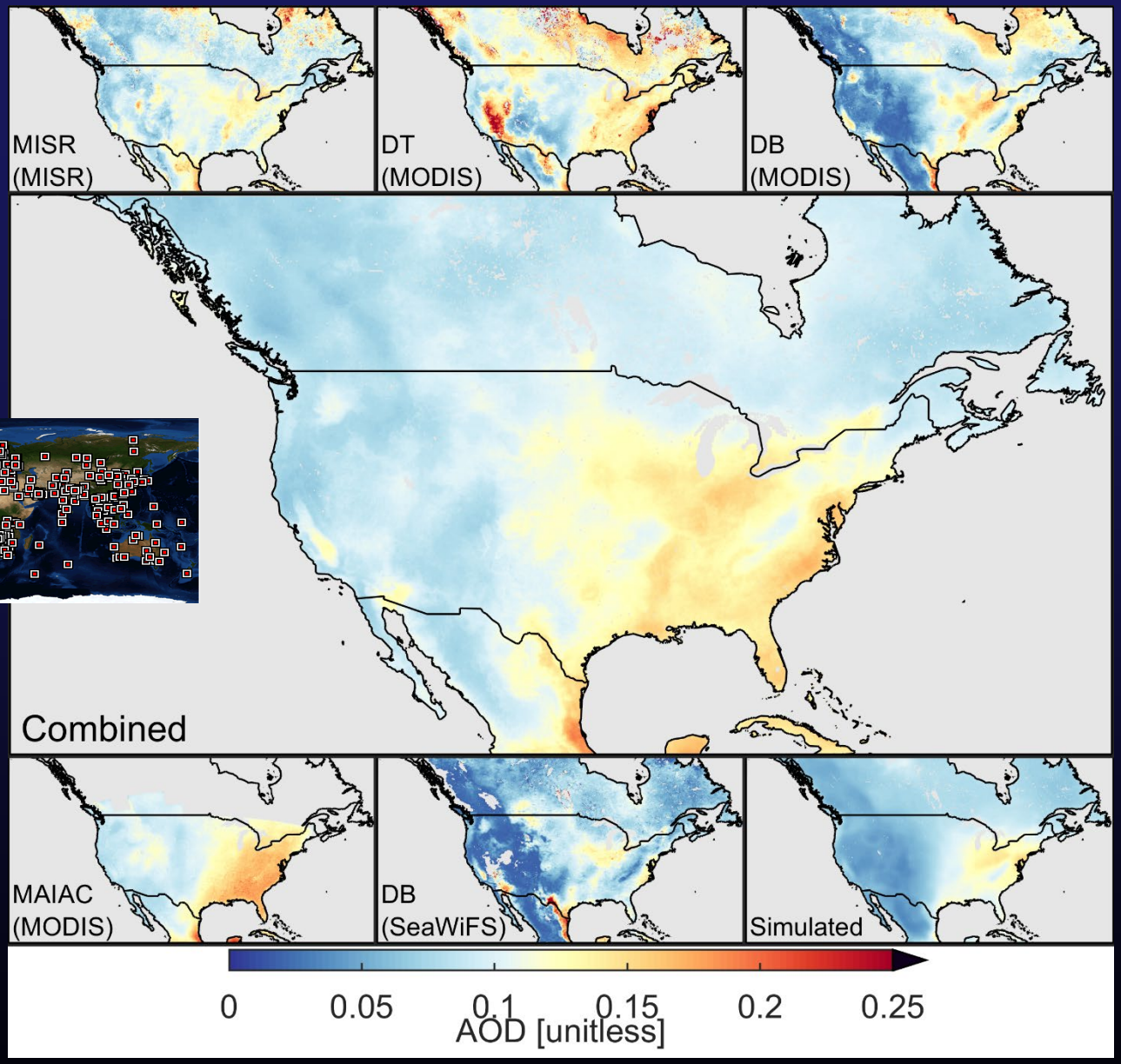
$PM_{2.5}$ monitoring networks

Aerosol Optical Depth (AOD) From Multiple Sources

Use AERONET AOD to Assess Relative Accuracy & Combine

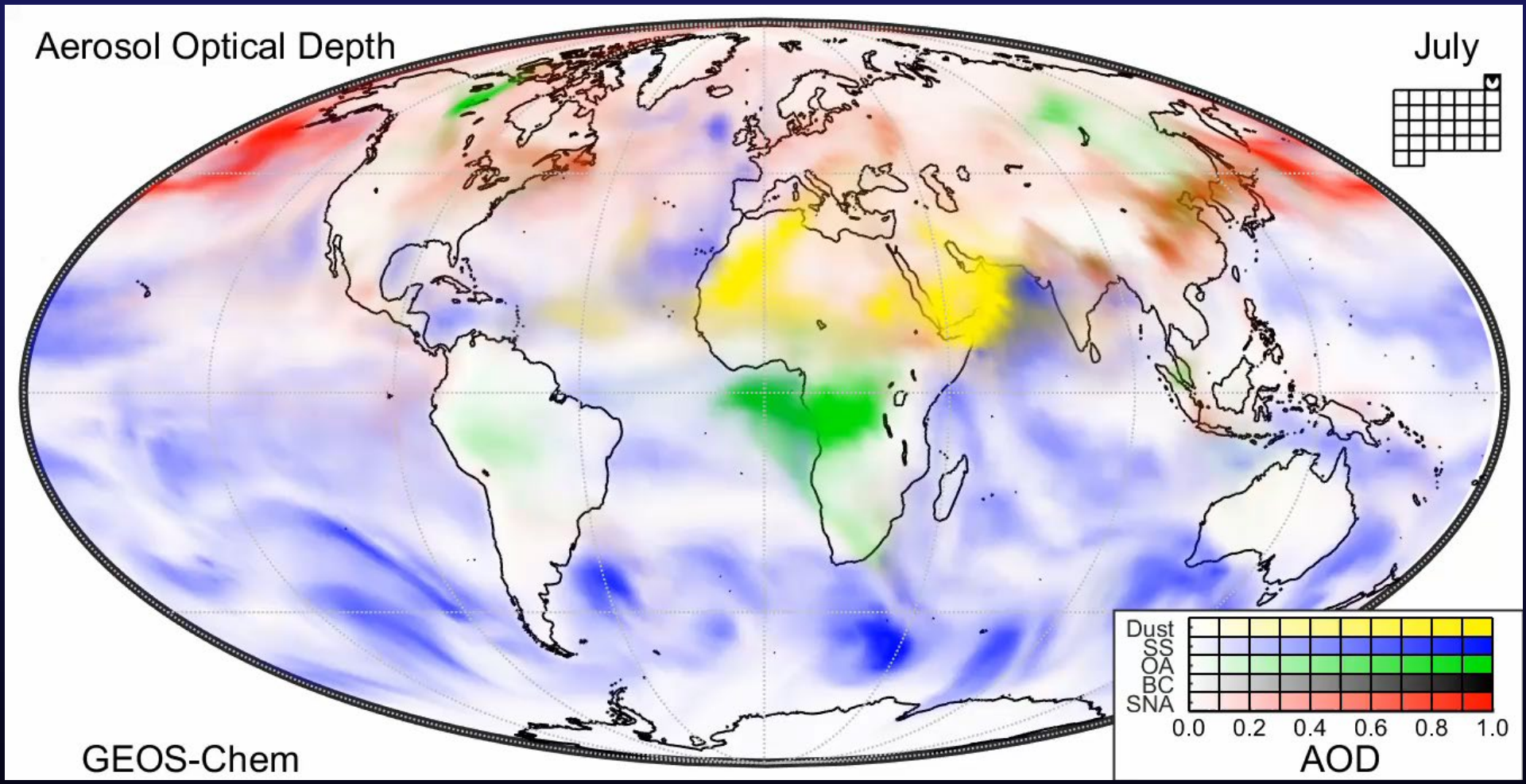


AERONET



van Donkelaar et al., 2019

Apply Chemical Transport Model (GEOS-Chem) to Calculate Solution to $PM_{2.5}$ Composition = *f*(x,y,t,AOD)



Aaron van Donkelaar & Melanie Hammer

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)
Black Carbon
Ions (IC)
Metals (XRF)
Organics (FTIR, AMS)

3-λ nephelometer (AirPhoton) Scatter

AOD from Sunphotometer (e.g. AERONET)

SPARTAN
Global Particulate Matter Network

Measured: **Surface/Column** **Diurnal** **Mass Scattering Efficiency**

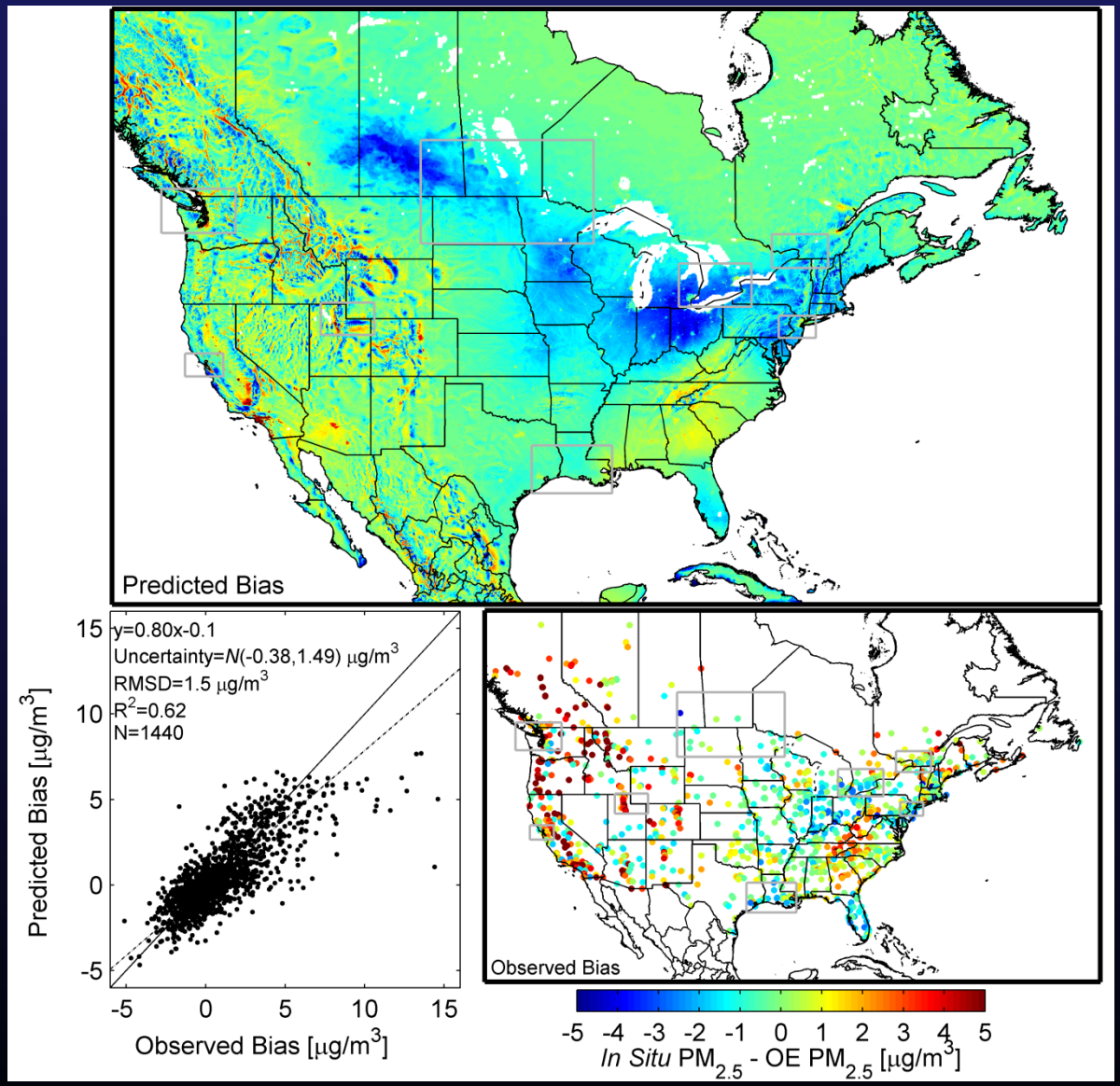
$$\frac{\mathrm{PM}_{2.5,\,\mathrm{Component}}}{\mathrm{AOD}} = \left(\frac{b_{sp,overpass}}{\mathrm{AOD}_{overpass}}\right)\left(\frac{b_{sp,24h}}{b_{sp,overpass}}\right)\left(\frac{\mathrm{PM}_{2.5,24\mathrm{h},\,\mathrm{Component}}}{b_{sp,24h}}\right)$$

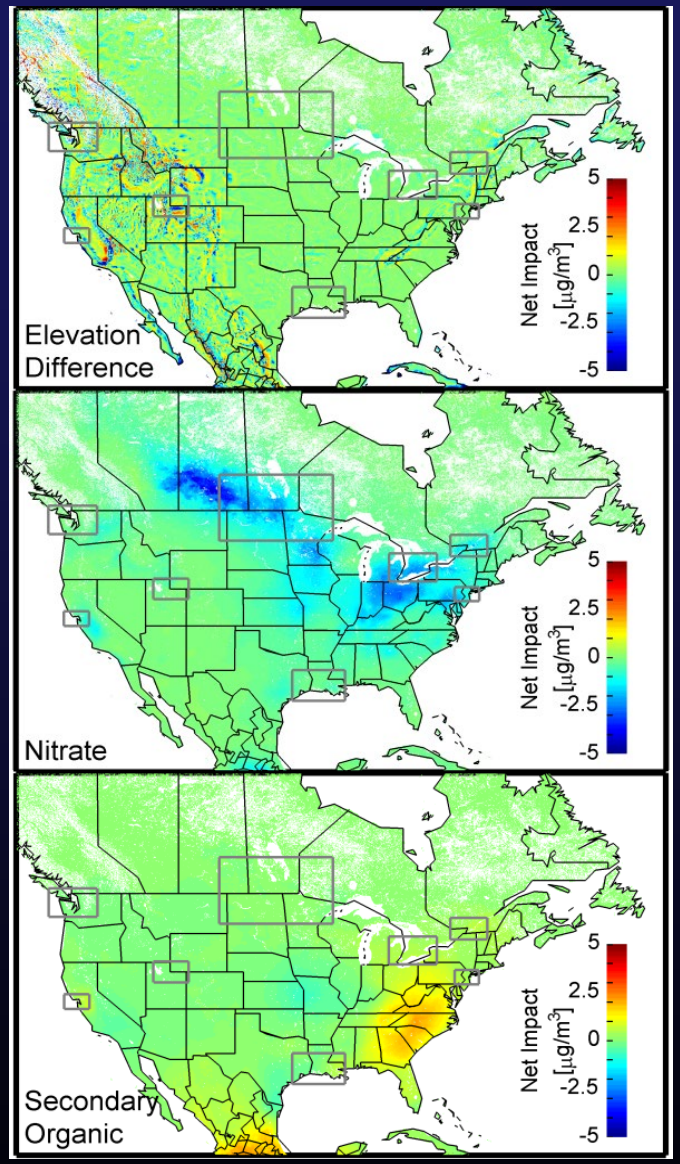
b_{sp} = nephelometer measurements of aerosol scatter

overpass = satellite overpass time

www.spartan-network.org

Statistical Fusion (Geographic Weighted Regression) with Ground-Based Monitors Tied to Geophysical Surfaces



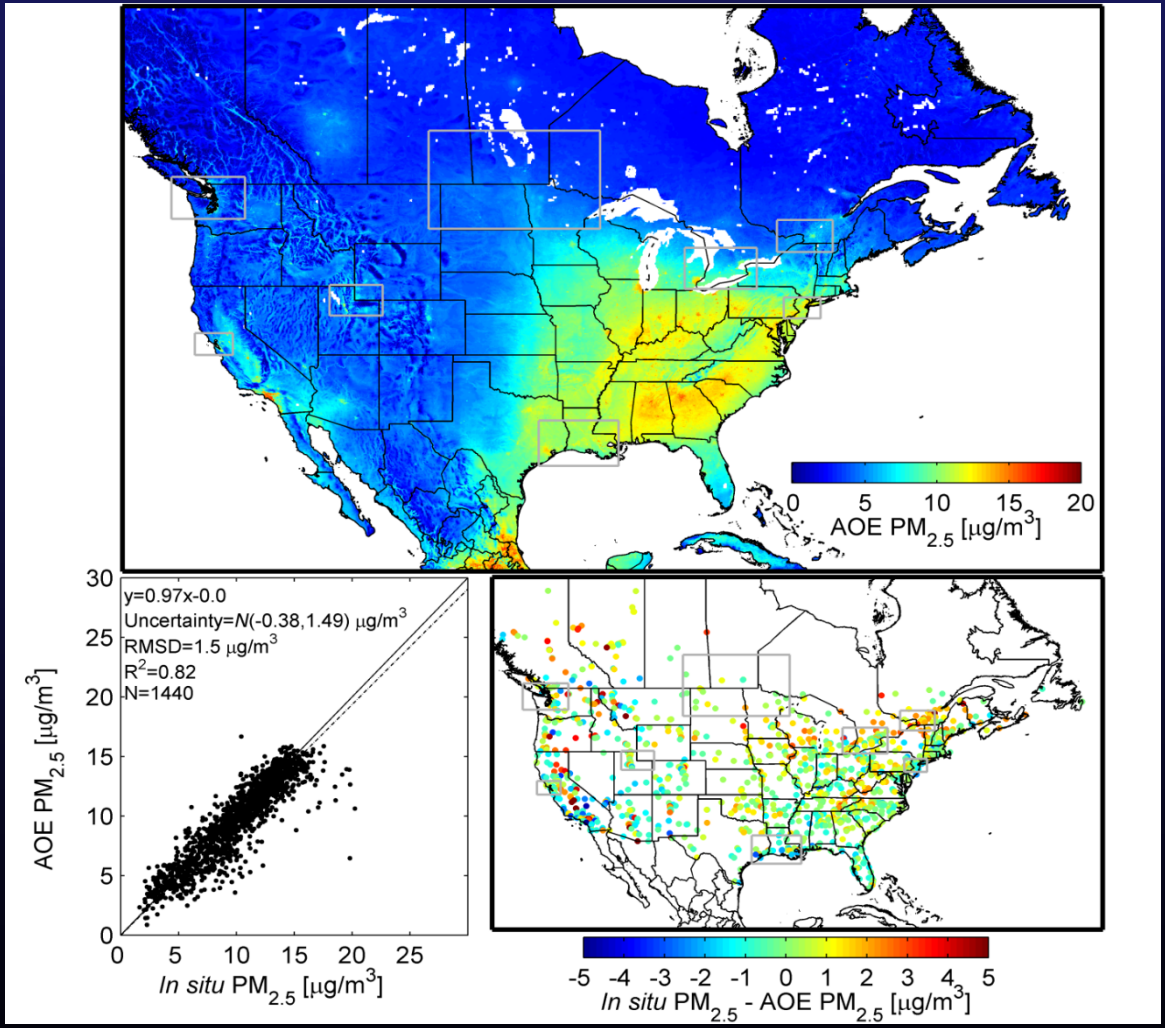


van Donkelaar et al., ES&T, 2015

Geophysical Emphasis of Approach is Robust to Limited Ground-based Monitors

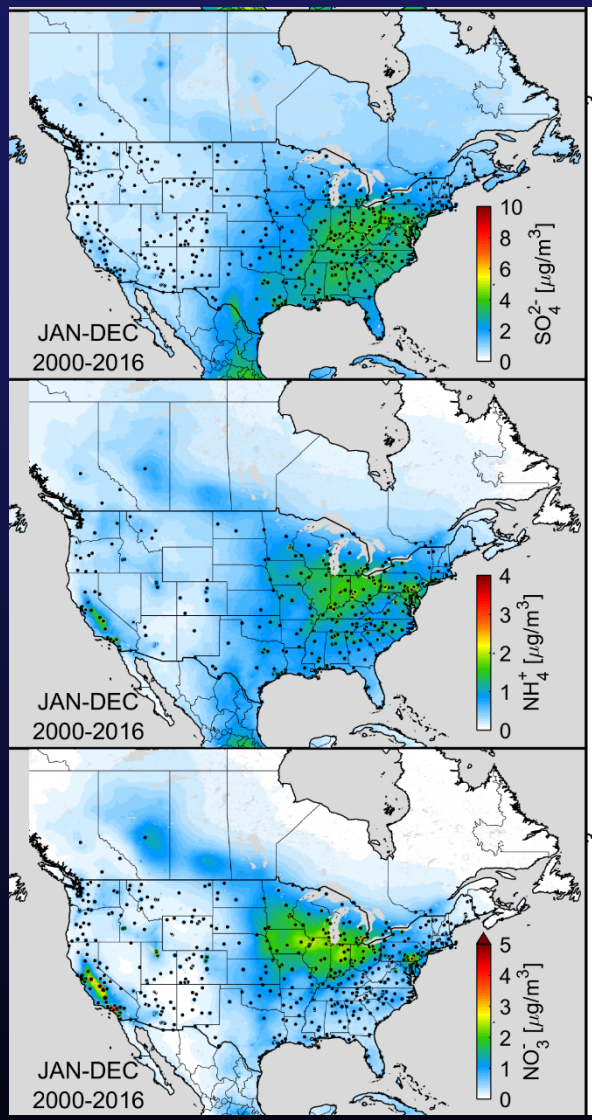
Performance remains high (R^2 decreases by 4%) even when most (70%) sites withheld for cross-validation

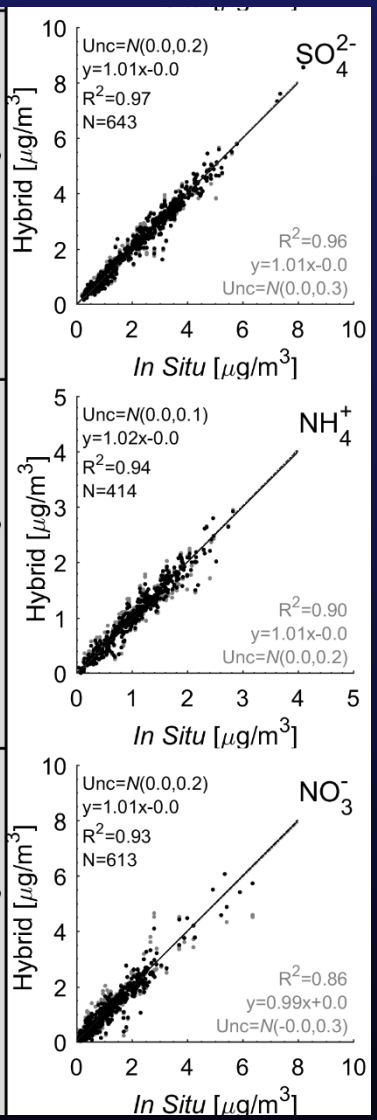
Implies promise for regions with few monitors (e.g. low PM, Canada), and for PM composition

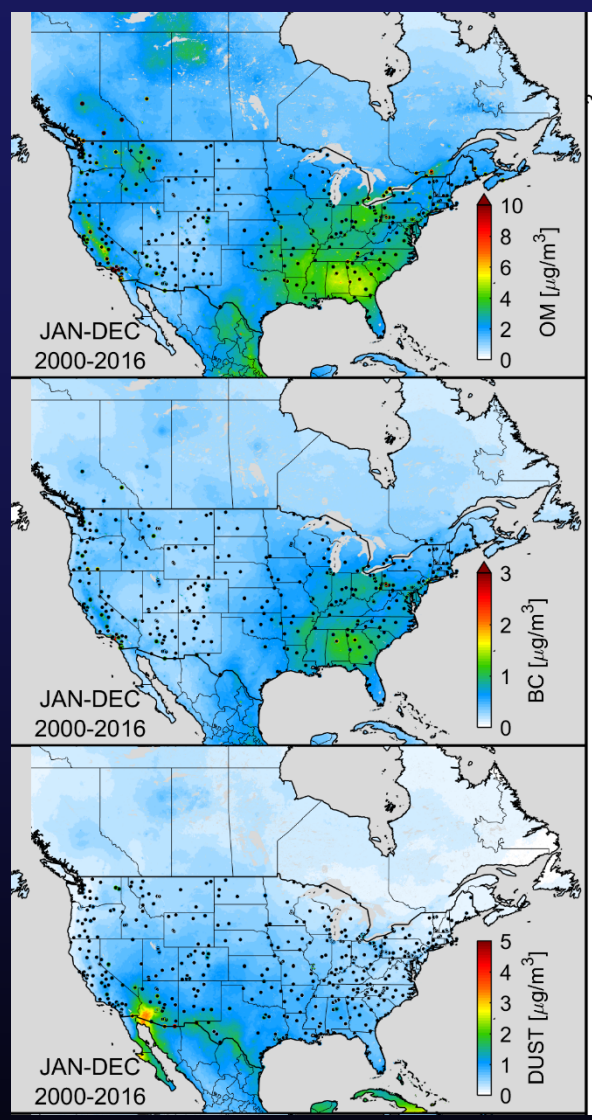


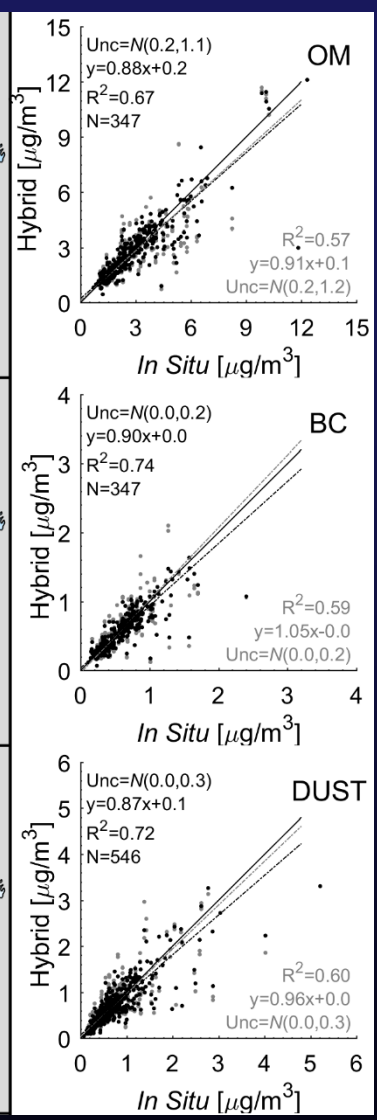
van Donkelaar et al., ES&T, 2015

$PM_{2.5}$ Chemical Composition



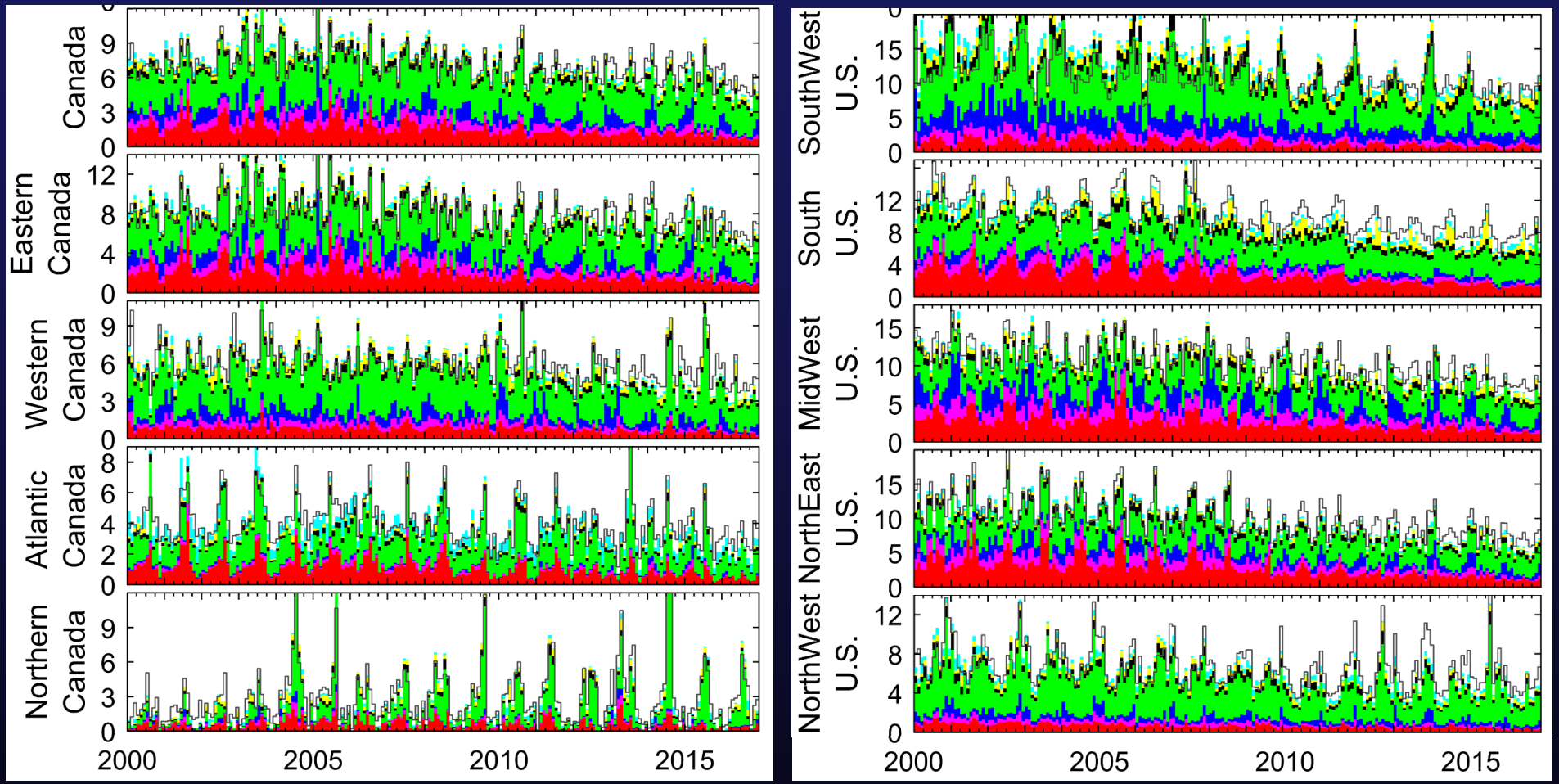






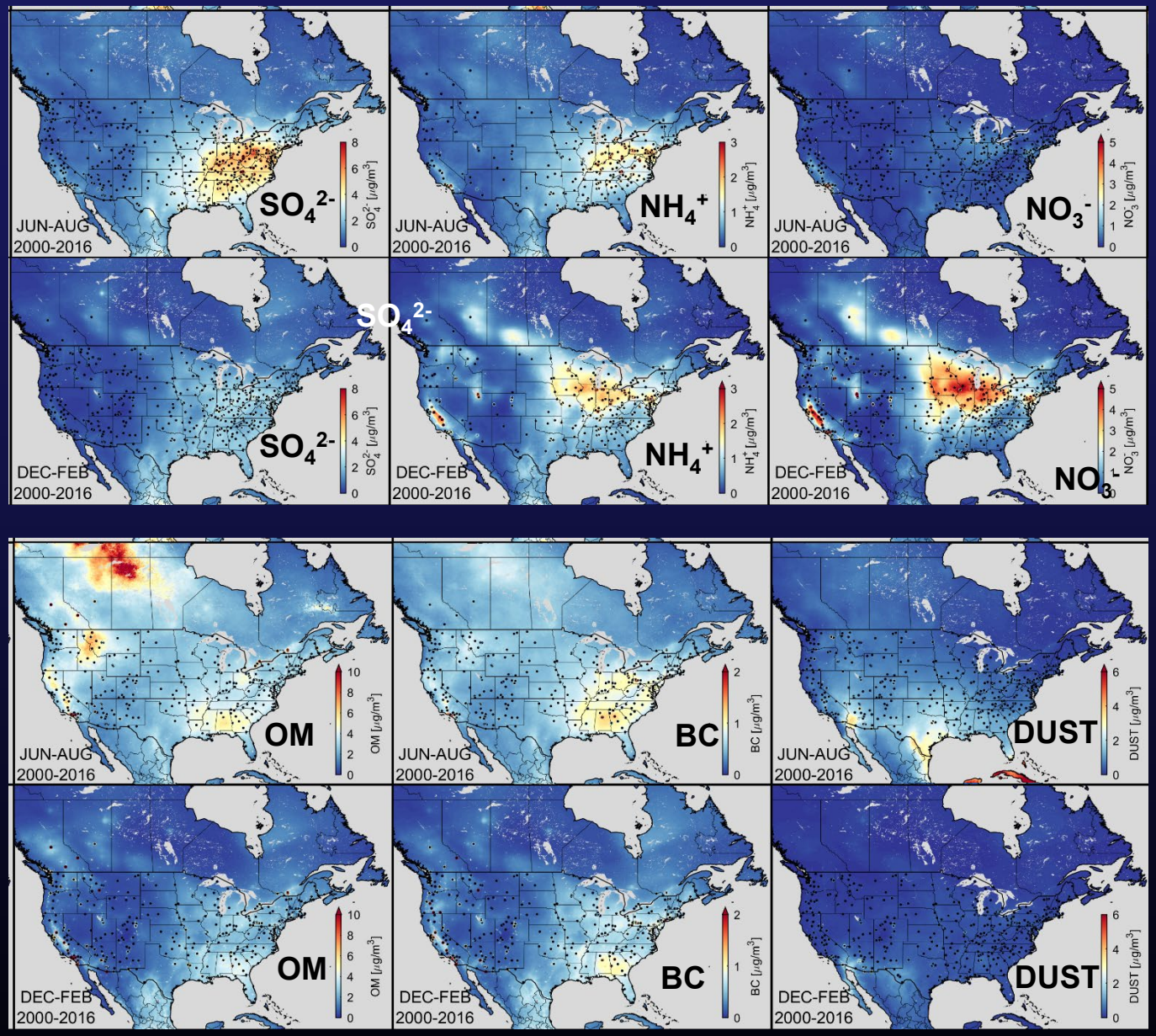
van Donkelaar et al., ES&T, 2019

Within-Region Differences in Population-Weighted $PM_{2.5}$ Composition ($\mu g/m^3$)



van Donkelaar et al., ES&T, 2019

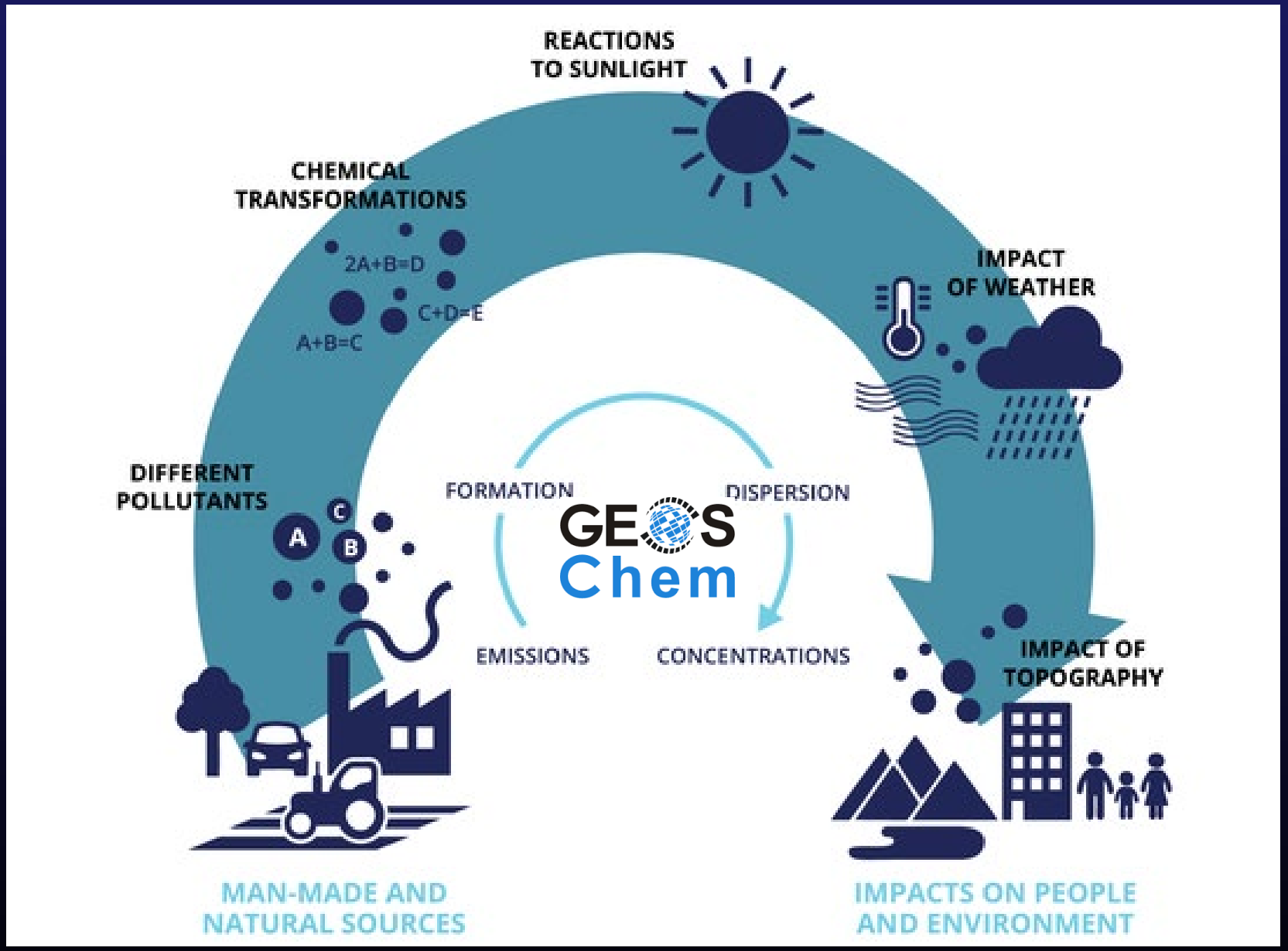
Seasonal Differences in $PM_{2.5}$ Composition



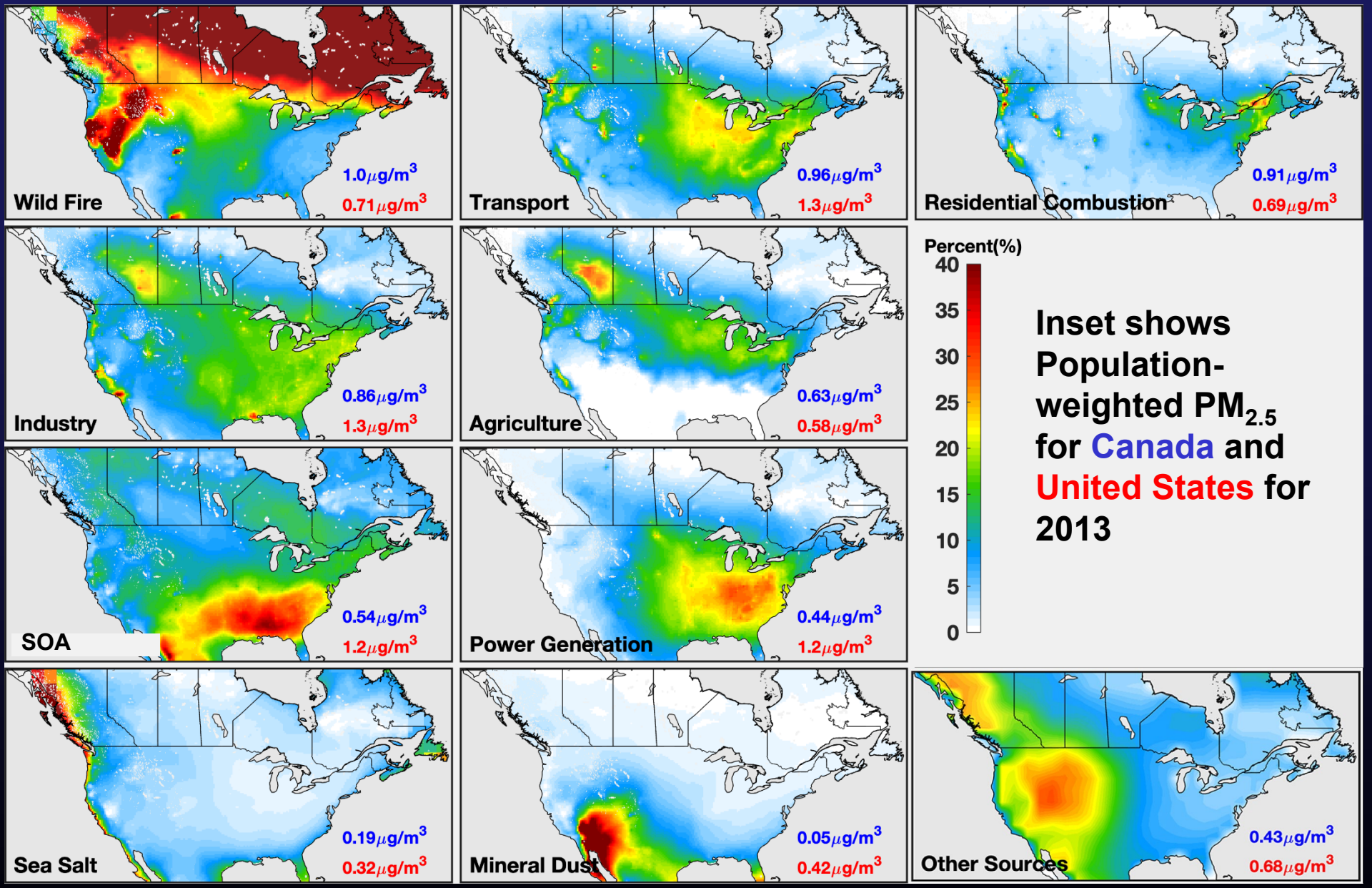
van Donkelaar et al., ES&T, 2019

What About Sources?

Apply GEOS-Chem to Attribute $PM_{2.5}$ Mass to Sources

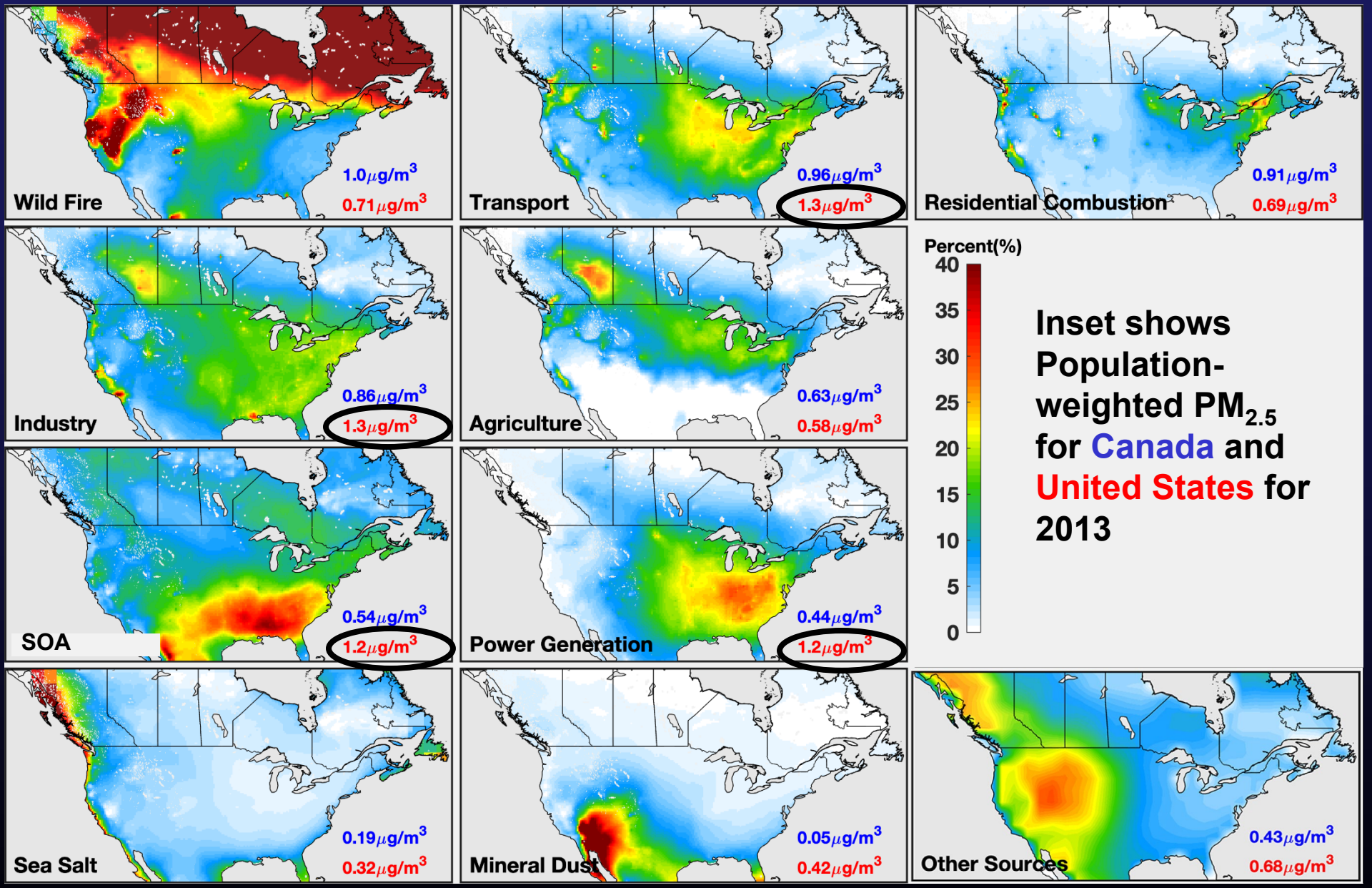


Sectoral Sources of $PM_{2.5}$



Meng et al., ES&T, 2019

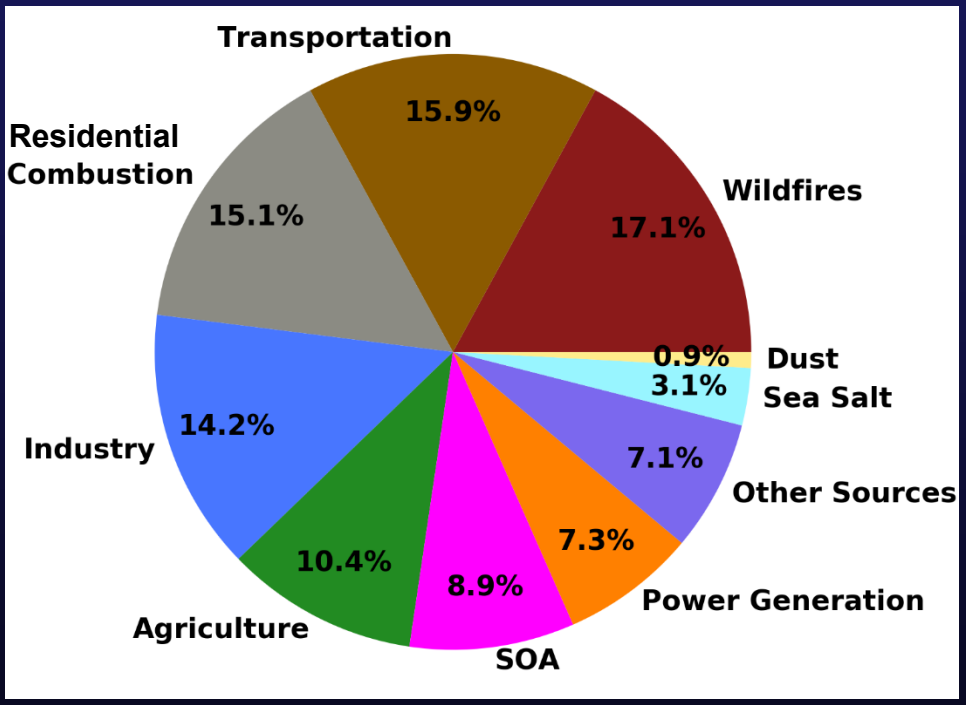
Sectoral Sources of $PM_{2.5}$



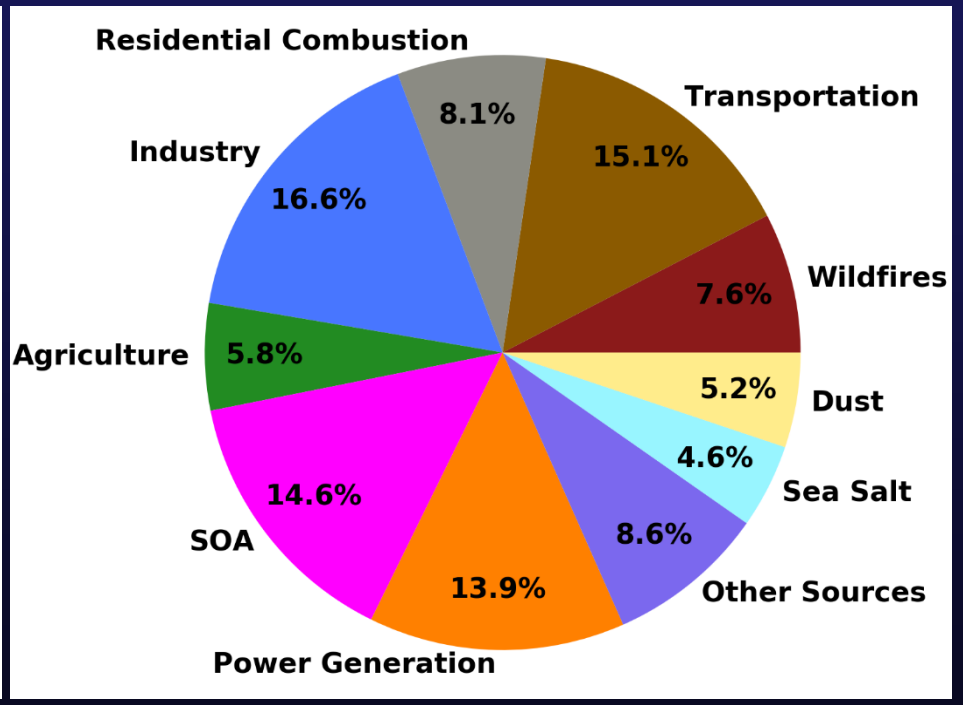
Meng et al., ES&T, 2019

Sectoral Sources of $PM_{2.5}$: Dominated by Anthropogenic Sources

Canada

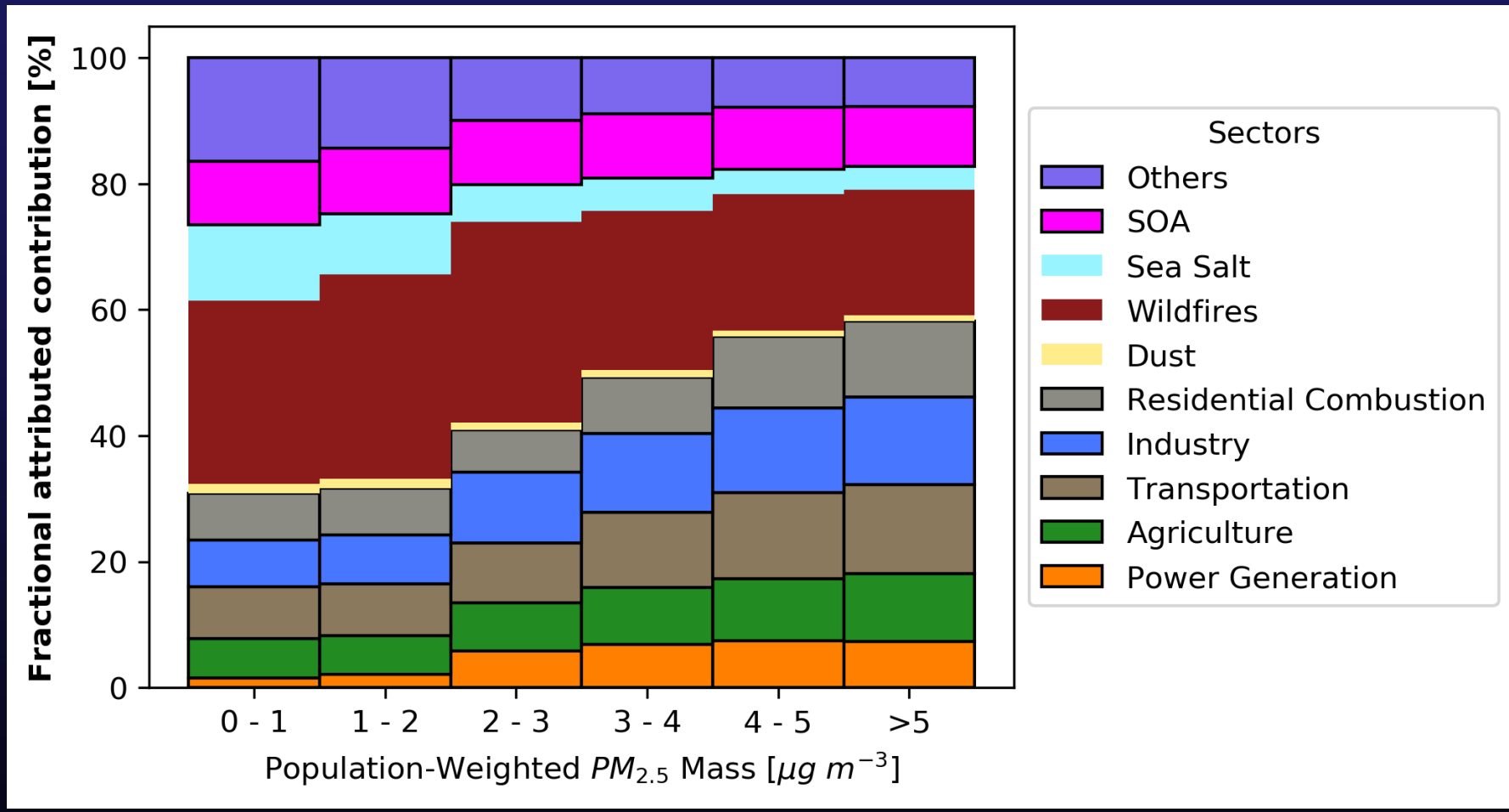


US



Meng et al., ES&T, 2019

Population-weighted Sectoral Contribution to $PM_{2.5}$
Anthropogenic Fraction Increases with $PM_{2.5}$ Loading

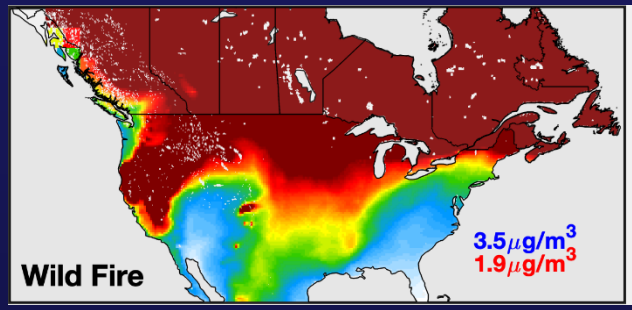


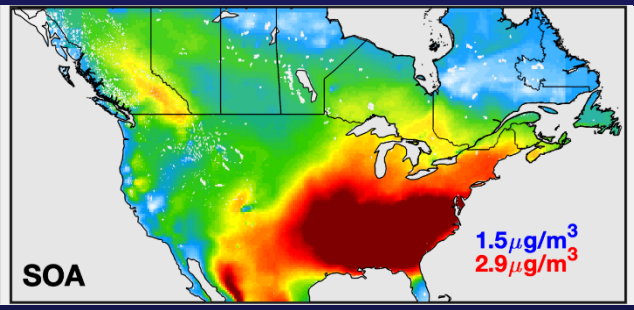
Meng et al. 2019

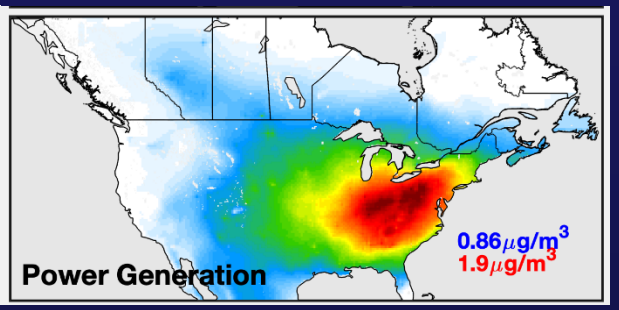
Seasonal Variation in Source Contributions

Dominant Sources Shown For Each Season

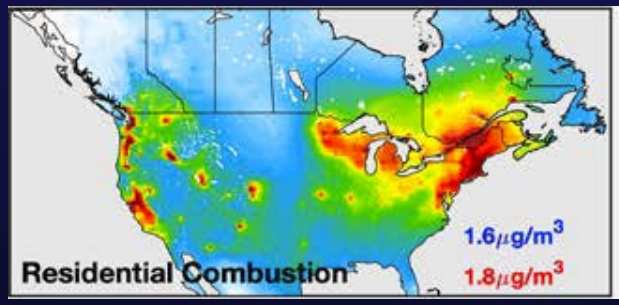
Summer

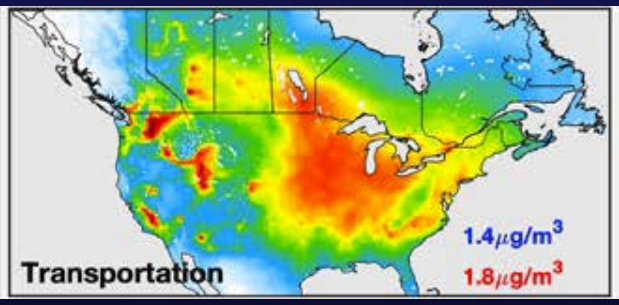


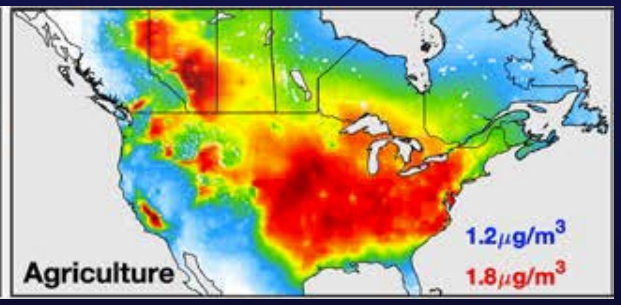




Winter





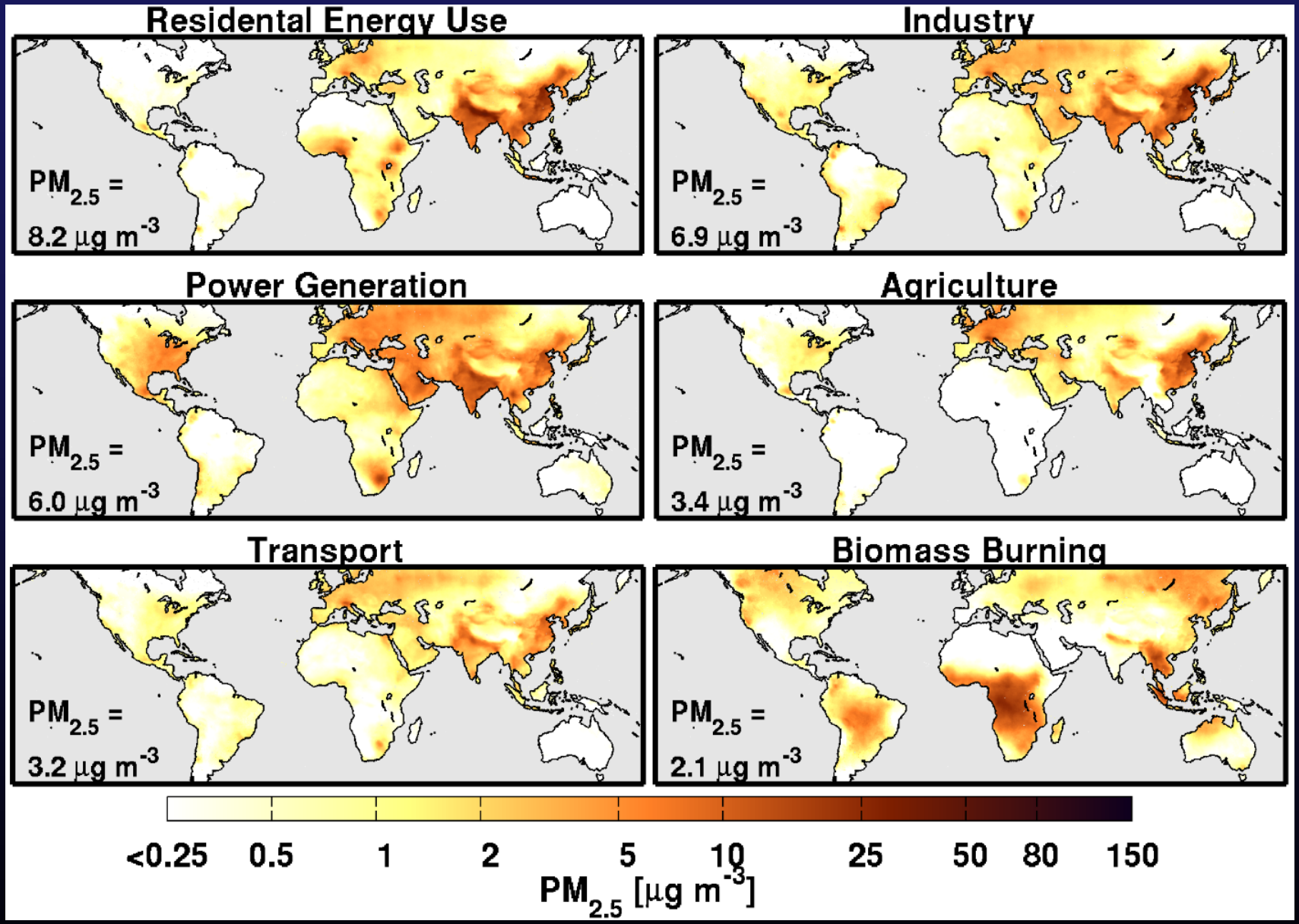


Inset shows Population-weighted $PM_{2.5}$ for Canada and United States for

Meng et al. 2019

Primarily Anthropogenic Sources of Outdoor $PM_{2.5}$

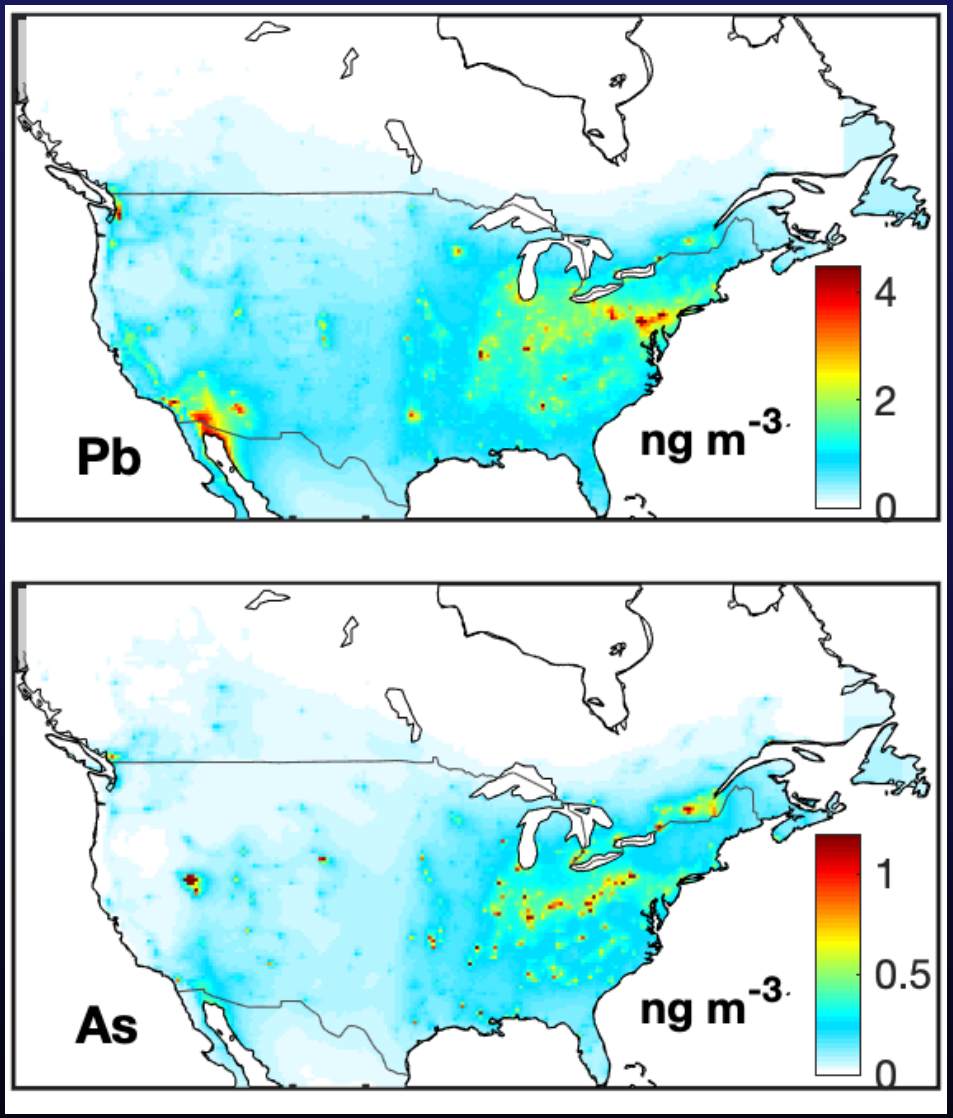
Residential Energy, Industry, and Power are Major Anthropogenic Sectors

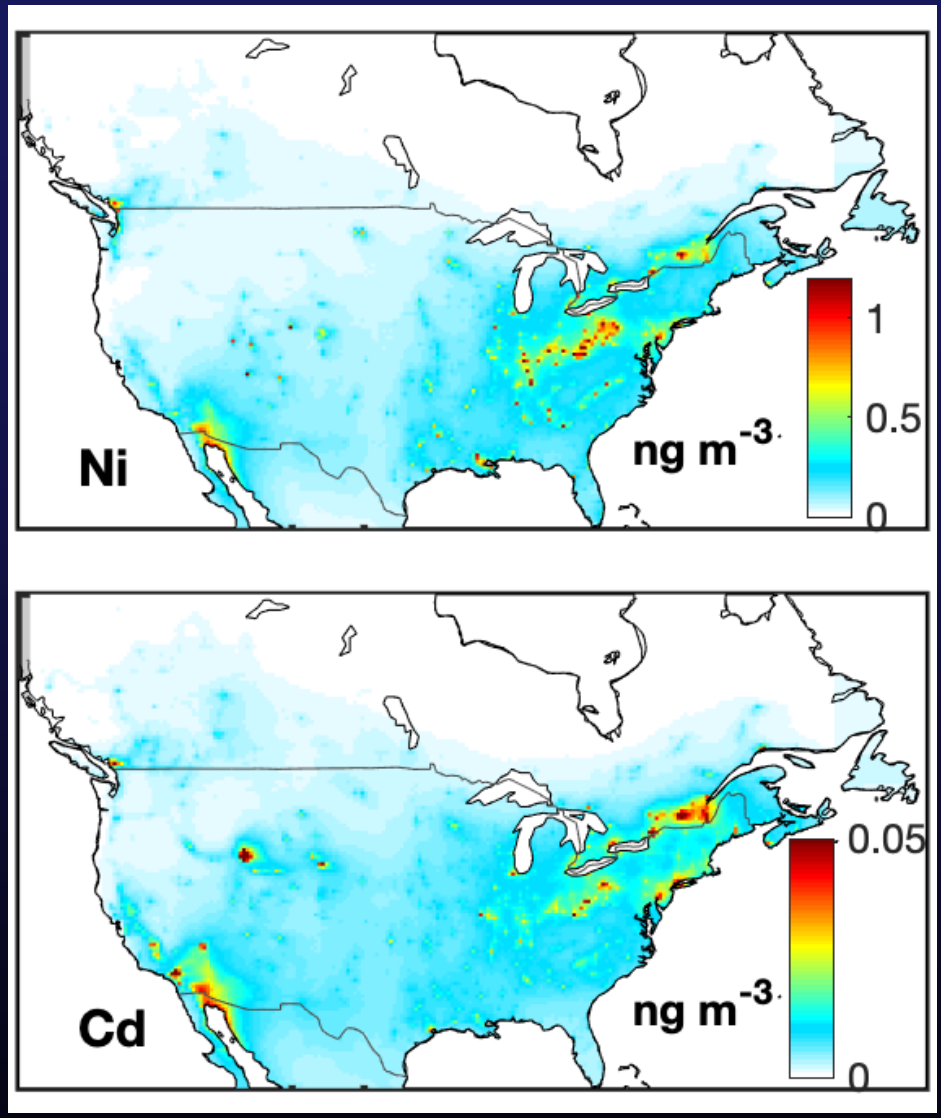


Inset shows global population-weighted $PM_{2.5}$.

Weagle et al., ES&T, 2018

Progress on Metals: Initial GEOS-Chem Simulation





Xu et al., AE, 2019

Forthcoming Satellite Observations on $PM_{2.5}$ Composition and Sources

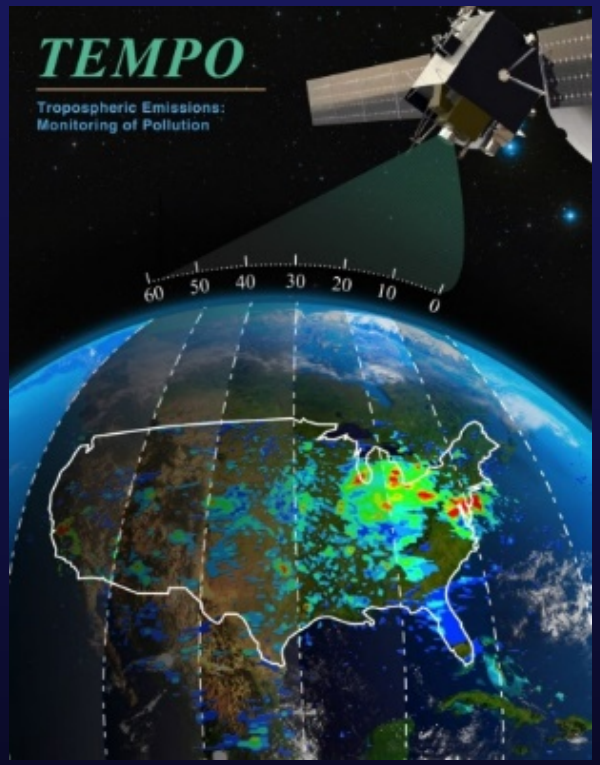
Information on Aerosol Type and Composition

Diner et al., JARS, 2018

SPARTAN
Global Particulate Matter Network

CEAMS

Information on Sources



Chance et al., 2019

Development of New Methods to Jointly Estimate Mortality Risk

Neuro-Oncology
20(3), 420–432, 2018 | doi:10.1093/neuonc/nox163 | Advance Access date 31 August 2017

Long-term exposure to ambient air pollution and incidence of brain tumor: the European Study of Cohorts for Air Pollution Effects (ESCAPE)

Zorana J. Andersen, Marie Pedersen, Gudrun Weinmayr, Massimo Stafoggia, Claudia Galassi, Jeanette T. Jørgensen, Johan N. Sommar, Bertil Forsberg, David Olsson, Bente Oftedal, Gunn Marit Aasvang, Per Schwarze, Andrei Pyko, Göran Pershagen, Michal Korek, Ulf De Faire, Claes-Göran Östenson, Laura Fratiglioni, Kirsten T. Eriksen, Aslak H. Poulsen, Anne Tjønneland, Elvira Vaclavik Bräuner, Petra H. Peeters, Bas Bueno-de-Mesquita, Andrea Jaensch, Gabriele Nagel, Alois Lang, Meng Wang, Ming-Yi Tsai, Sara Grioni, Alessandro Marcon, Vittorio Krogh, Fulvio Ricceri, Carlotta Sacerdote, Enrica Migliore, Roel Vermeulen, Ranjeet Sokhi, Menno Keuken, Kees de Hoogh, Rob Beelen, Paolo Vineis, Giulia Cesaroni, Bert Brunekreef, Gerard Hoek, and Ole Raaschou-Nielsen

SCIENTIFIC REPORTS

A New Method to Jointly Estimate the Mortality Risk of Long-Term Exposure to Fine Particulate Matter and its Components

Dan L. Crouse[1,†], Sajeev Philip[2], Aaron van Donkelaar[2], Randall V. Martin[2,3], Barry Jessiman[4], Paul A. Peters[5], Scott Weichenthal[6], Jeffrey R. Brook[7,8], Bryan Hubbell[9] & Richard T. Burnett[1]

Published in final edited form as:
Epidemiology. 2015 May ; 26(3): 321–327. doi:10.1097/EDE.0000000000000269.

$PM_{2.5}$ and survival among older adults: Effect modification by particulate composition

Marianthi-Anna Kioumourtzoglou[1], Elena Austin[2], Petros Koutrakis[1], Francesca Dominici[3], Joel Schwartz[1], and Antonella Zanobetti[1]

Environment International 133 (2019) 105268

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/en

ELSEVIER

Long-term residential exposure to $PM_{2.5}$ constituents and mortality in a Danish cohort

Ulla Arthur Hvidtfeldt[a,*], Camilla Geels[c], Mette Sørensen[a,b], Matthias Ketzel[c,d], Jibran Khan[c,e], Anne Tjønneland[a,f], Jesper Heile Christensen[c], Jørgen Brandt[c], Ole Raaschou-Nielsen[a,c]

Conclusions

- Targeted ground-based measurements, networks, statistical modeling, and chemical transport modeling, and satellite remote sensing all offer information to develop surfaces of $PM_{2.5}$ chemical composition

- Opportunities remain to further develop those estimates for application to epidemiological studies