# HEI Virtual Workshop on Health Applications for Satellite-Derived Air Quality: Opportunities and Potential Pitfalls

## Resources

April and May 2022

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## Recommended Resources to Get Started

*If you are new to using satellite-derived air quality data for health applications, we recommend the following resources to get started.*

*EM Magazine* published a special issue on "New Insights in Air Quality Monitoring Using Satellite Data" in September 2021: https://www.awma.org/blog_home.asp?Display=111.

Copernicus is the European Union's Earth observation programme: https://atmosphere.copernicus.eu/.

The NASA Health and Air Quality Applied Sciences Team Connects NASA Data and Tools with Health and Air Quality Stakeholders. Information is provided throughout the website, particularly under the Tools and Resources Menu: https://haqast.org/.

The NASA Applied Remote Sensing Training (ARSET) provides trainings for beginner and advanced users of satellite data: https://appliedsciences.nasa.gov/arset.

US NIEHS workshop on Integrating Multiscale Geospatial Environmental Data into Large Population Health Studies:
https://www.niehs.nih.gov/news/events/pastmtg/2021/dert_geospatial_2021/index.cfm.

# Selected Relevant HEI Publications

*This is a selection of HEI publications that extensively relied on satellite data for exposure assessment. Publications are freely available at [www.healtheffects.org](www.healtheffects.org) and [www.stateofglobalair.org](www.stateofglobalair.org).*

**Health Effects of Exposure to Air Pollution**

Brauer M, Brook JR, Christidis T, Chu Y, Crouse DL, Erickson A, et al. 2019. Mortality–Air Pollution Associations in Low-Exposure Environments (MAPLE): Phase 1. Research Report 203. Boston, MA:Health Effects Institute.

Brunekreef B, Strak M, Chen J, Andersen ZJ, Atkinson R, Bauwelinck M, et al. 2021. Mortality and Morbidity Effects of Long-Term Exposure to Low-Level PM2.5, BC, NO2, and O3: An Analysis of European Cohorts in the ELAPSE Project. Research Report 208. Boston, MA:Health Effects Institute.

Dominici F, Schwartz J, Di Q, Braun D, Choirat C. Zanobetti A. 2019. Assessing Adverse Health Effects of Long-Term Exposure to Low Levels of Ambient Air Pollution: Phase 1. Research Report 200. Boston, MA:Health Effects Institute.

Dominici F, Zanobetti A, Schwartz J, Braun D, Sabath B, Wu X. 2022. Assessing Adverse Health Effects of Long-Term Exposure to Low Levels of Ambient Air Pollution: Implementation of Causal Inference Methods. Research Report 211. Boston, MA:Health Effects Institute.

Paciorek CJ, Liu Y. 2012. Assessment and Statistical Modeling of the Relationship Between Remotely Sensed Aerosol Optical Depth and PM2.5 in the Eastern United States. Research Report 167. Health Effects Institute, Boston, MA.

**Global Burden of Disease**

McDuffie E, Martin R, Yin H, Brauer M. 2021. Global Burden of Disease from Major Air Pollution Sources (GBD MAPS): A Global Approach. Research Report 210. Boston, MA:Health Effects Institute.

Health Effects Institute. 2020. State of Global Air 2020. Special Report. Boston, MA:Health Effects Institute.

GBD MAPS Working Group. 2016. Burden of Disease Attributable to Coal-Burning and Other Major Sources of Air Pollution in China. Special Report 20. Boston, MA:Health Effects Institute.

GBD MAPS Working Group. 2018. Burden of Disease Attributable to Major Air Pollution Sources in India. Special Report 21. Boston, MA:Health Effects Institute.

## Openly Available Data and Tools Shared by Workshop Participants

*Here we share some data access and tools shared by workshop participants. Items under our Recommended Resources for Getting Started are not repeated here. This list is intended for informational purposes and is not meant to be comprehensive.*

- Aerosol Robotic Network (AERONET): https://aeronet.gsfc.nasa.gov/
- Committee on Earth Observation Satellites (CEOS) https://ceos.org/ourwork/virtual-constellations/acc/
- Copernicus data catalogue: https://atmosphere.copernicus.eu/catalogue#/
- Early adopter programs for upcoming NASA missions
    - Atmosphere Observing System (AOS), https://aos.gsfc.nasa.gov
    - Multi-Angle Imager for Aerosols (MAIA), https://maia.jpl.nasa.gov/
    - Plankton, Aerosol, Cloud, ocean Ecosystem (PACE): https://pace.oceansciences.org/app_adopters.htm
    - Tropospheric Emissions: Monitoring of Pollution (TEMPO), https://weather.msfc.nasa.gov/tempo/
- Geostationary Environment Monitoring Spectrometer (GEMS) data from Korean National Institute of Environmental Research (NIER): https://nesc.nier.go.kr/product/view
- Global air quality datasets from the Washington University in St. Louis Atmospheric Composition Analysis Group led by Randall Martin: https://sites.wustl.edu/acag/datasets/
- NASA EarthData Health and Air Quality Data Pathfinder: https://earthdata.nasa.gov/learn/pathfinders/health-and-air-quality-data-pathfinder
- NASA Worldview: https://worldview.earthdata.nasa.gov/
- Surface PARTiculate mAtter Network (SPARTAN): https://www.spartan-network.org/data
- TROPOspheric Monitoring Instrument (TROPOMI): http://www.tropomi.eu/data-products for all and www.tropomino2.us for the United States only

## Articles Recommended by Workshop Participants

*Here we share some publications shared by workshop participants. This list is intended for informational purposes and is not meant to be comprehensive. It also does not include all references cited by the presenters, so interested parties are recommended to also view specific presentations for detailed information on a subtopic of interest.*


Bi J, Wildani A, Chang HH, Liu Y. 2020. incorporating low-cost sensor measurements into high-resolution $PM_{2.5}$ modeling at a large spatial scale. Environ Sci Technol 54:2152–2162; doi:10.1021/acs.est.9b06046.

Cooper MJ, Martin RV, McLinden CA, and Brook JR, 2020. Inferring ground-level nitrogen dioxide concentrations at fine spatial resolution applied to the TROPOMI satellite instrument, Environmental Research Letters; doi:10.1088/1748-9326/aba3a5.

Fiore A, Bratburd J, and Miller D, 2021. Satellite data for use in the national ambient air quality standards process. Envir Manag November 2021.

Fosu-Amankwah K, Bessardon GE, Quansah E, Amekudzi LK, Brooks BJ, and Damoah R, 2021. Assessment of aerosol burden over Ghana. Scientific African, 14, e00971; doi:10.1016/j.sciaf.2021.e00971.

Franklin M, Kalashnikova OV, Garay MJ, Fruin S. 2018. Characterization of subgrid-scale variability in particulate matter with respect to satellite aerosol observations. Remote Sensing 10:623; doi:10.3390/rs10040623.

Hoek G. 2017. Methods for assessing long-term exposures to outdoor air pollutants. Curr Environ Health Rep 4:450–462; doi:10.1007/s40572-017-0169-5.

Hoff RM and Christopher SA, 2009. Remote sensing of particulate pollution from space: Have we reached the promised land?, J Air Waste Manag Assoc, 59:6, 645-675; doi: 10.3155/1047-3289.59.6.645.

Holloway T, Miller D, Anenberg S, Diao M, Duncan B, Fiore AM, et al, 2021. Satellite monitoring for air quality and health. Annu Rev Biomed Data Sci; doi:10.1146/annurev-biodatasci-110920-093120.

Huang K, Bi J, Meng X, Geng G, Lyapustin A, Lane KJ, et al. 2019. Estimating daily $PM_{2.5}$ concentrations in New York City at the neighborhood-scale: Implications for integrating non-regulatory measurements. Science of The Total Environment 697:134094; doi:10.1016/j.scitotenv.2019.134094.

Kim J, Jeong U, Ahn M, Kim JH, Park RJ, Lee H, et al, 2020. New era of air quality monitoring from space: Geostationary Environment Monitoring Spectrometer (GEMS), Bulletin of the American Meteorological Society 101, 1; doi:10.1175/BAMS-D-18-0013.1.

Kirwa K, Szpiro AA, Sheppard L, Sampson PD, Wang M, Keller JP, et al. 2021. Fine-scale air pollution models for epidemiologic research: Insights from approaches developed in the Multi-Ethnic Study of Atherosclerosis and Air pollution (MESA Air). Curr Environ Health Rep 8:113–126; doi:10.1007/s40572-021-00310-y.

Liu Y, Diner DJ. 2017. Multi-Angle Imager for Aerosols: A satellite investigation to benefit public health. Public Health Rep 132:14–17; doi:10.1177/0033354916679983.

Marais E and Chance K, 2015. A geostationary air quality monitoring platform for Africa, Clean Air Journal; doi:10.17159/2410-972X/2015/v25n1a3.

Martínez-Alonso S, Deeter M, Worden H, Borsdorff T, Aben I, Commane R, Daube B, Francis G, George M, Landgraf J, Mao D, McKain K, and Wofsy S, 2020. 1.5 years of TROPOMI CO measurements: Comparisons to MOPITT and ATom, Atmos. Meas. Tech, 13, 4841–4864; doi:10.5194/amt-13-4841-2020.

McNeill J, Snider G, Weagle CL, et al, 2020. Large global variations in measured airborne metal concentrations driven by anthropogenic sources, Sci Rep; doi:10.1038/s41598-020-78789-y

Nastan A, 2022. Eyeing visibility from space: The upcoming Multi-Angle Imager for Aerosols (MAIA) Investigation. Envir Manag April 2022.

National Academies of Sciences, Engineering, and Medicine. 2021. leveraging advances in remote geospatial technologies to inform precision environmental health decisions: Proceedings of a workshop–in Brief. J Alper, A Bremer, and A Linn, eds. The National Academies Press:Washington, DC.

Penn E and Holloway T, 2020. Evaluating current satellite capability to observe diurnal change in nitrogen oxides in preparation for geostationary satellite missions. Environ Res Lett 15:034038; doi:10.1088/1748-9326/ab6b36.

Schneider R, Vicedo-Cabrera A, Sera F, Masselot P, Stafoggia M, de Hoogh K, et al. 2020. a satellite-based spatio-temporal machine learning model to reconstruct daily $PM_{2.5}$ Concentrations across Great Britain. Remote Sensing 12:3803; doi:10.3390/rs12223803.

Snider G, Weagle CL, Martin RV, van Donkelaar A, Conrad K, Cunningham D, et al. 2015. SPARTAN: a global network to evaluate and enhance satellite-based estimates of ground-level particulate matter for global health applications. Atmos Meas Tech; doi:10.5194/amt-8-505-2015.

Sorek-Hamer M, Just AC, Kloog I. 2016. Satellite remote sensing in epidemiological studies. Curr Opin Pediatr 28:228–234; doi:10.1097/MOP.0000000000000326.

Weagle CL, Snider G, Li C, van Donkelaar A, Philip S, Bissonnette P, et al, 2018. Global sources of fine particulate matter: Interpretation of $PM_{2.5}$ chemical composition observed by SPARTAN using a global chemical transport model, Environ Sci Technol; doi:10.1021/acs.est.8b01658.

Yao F, Si M, Li W, Wu J. 2018. A multidimensional comparison between MODIS and VIIRS AOD in estimating ground-level PM2.5 concentrations over a heavily polluted region in China. Science of The Total Environment 618:819–828; doi:10.1016/j.scitotenv.2017.08.209.

Young MT, Bechle MJ, Sampson PD, Szpiro AA, Marshall JD, Sheppard L, et al. 2016. Satellite-based $NO_2$ and model validation in a national prediction model based on universal kriging and land-use regression. Environ Sci Technol 50:3686–3694; doi:10.1021/acs.est.5b05099.