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Ground-Based Speciated Particulate Matter Monitoring as Part of the Multi-Angle Imager for Aerosols (MAIA) Investigation: A Focus on Low- and Middle-Income Countries

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Exposure to airborne particulate matter (PM) is the leading environmental risk factor globally. People living in low- and middle-income countries (LMICs) are at higher risk due to elevated levels of PM. Although the connection between total mass concentrations of PM and various health outcomes is well-documented, the relative toxicity of specific PM types—mixtures of particles with different sizes, shapes, and chemical compositions—remains poorly understood. To address this gap, the National Aeronautics and Space Administration (NASA) and the Italian Space Agency (Agenzia Spaziale Italiana, ASI) are jointly implementing the Multi-Angle Imager for Aerosols (MAIA) investigation to explore the association between PM types and adverse health outcomes. The MAIA satellite instrument—a multi-angle imaging spectropolarimeter—will collect targeted measurements of column-integrated aerosol optical and microphysical properties, which will be integrated with measurements from a network of ground-based PM monitors and outputs of the WRF-Chem atmospheric model to generate daily maps of near-surface total PM_{10}, total $PM_{2.5}$, and speciated (sulfate, nitrate, organic carbon, elemental carbon, and dust) $PM_{2.5}$ mass concentrations at 1 km spatial resolution. The main focus of the MAIA investigation is a selected set of Primary Target Areas (PTAs) covering highly populated metropolitan regions distributed across the US, Europe, the Middle East, Africa, and Asia. Each PTA encompasses a region that is approximately

360 by 480 km. Three of the MAIA PTAs are in LMICs, including Ethiopia (Addis Ababa and vicinity), South Africa (Johannesburg and vicinity), and India (New Delhi and vicinity), where the MAIA project has deployed and is currently operating various types of surface-based PM pollution monitors. Fabrication of the MAIA satellite instrument was completed in October 2022, and its launch into sun-synchronous Earth orbit is anticipated to occur in 2025. This presentation will cover the ground-based PM monitoring component of the MAIA mission and present preliminary results collected thus far in the low- and middle-income PTAs (LMI-PTAs) and compare the observed total and speciated PM levels to those observed in other countries.

Where available, the MAIA project collects data from existing ground-based PM monitoring networks managed by government agencies, research groups, and other sources. In several PTAs, the MAIA project is capitalizing on the existing SPARTAN Surface Particulate Matter Network for $PM_{2.5}$ speciation and has expanded this network with additional filter samplers; deployed Colorado State University filter samplers to complement $PM_{2.5}$ speciation networks; and installed AethLabs microAeth MA350 monitors for black carbon measurements. In Ethiopia, where only a few $PM_{2.5}$ monitors have historically been operating, a set of cost-effective PurpleAir sensors has been deployed to enhance the spatial coverage of ground-based $PM_{2.5}$ measurements. The preliminary surface monitoring results indicate highly elevated PM concentrations in LMI-PTAs, which regularly exceed the WHO air quality guidelines. Notably, black carbon is found to be exceptionally high in these regions, reaching levels up to twelve times greater than those measured in developed countries.