Update on the Multi-Angle Imager for Aerosols (MAIA) Mission

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CEOS Atmospheric Composition – Virtual Constellation
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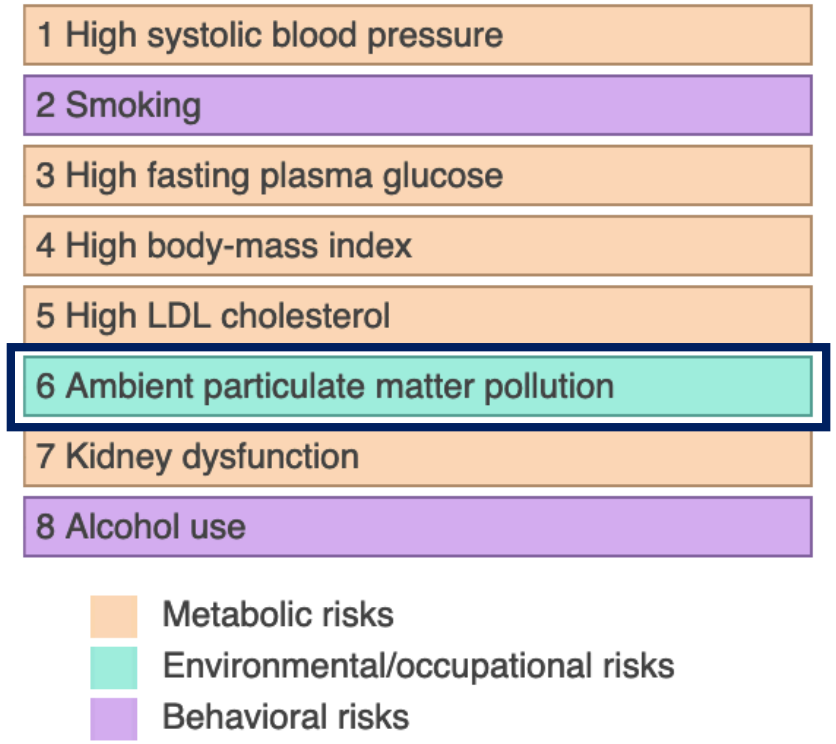
The MAIA mission is a joint partnership between NASA and Agenzia Spaziale Italiana (ASI)

NASA and ASI signed an Implementing Arrangement (IA) in January 2023

NASA contributions	ASI contributions
MAIA satellite instrument	PLATiNO-2 spacecraft
Near Space Network (uplink/downlink)	Launch (2025)
Instrument Operations Center	Mission Operations Center
Data processing and archive center for NASA data products (ASDC)	ASI data center for data product distribution and archive
Science Team for NASA's Earth Venture Instrument (EVI) investigation	Science Team for additional Italian science applications

Motivation

Ambient airborne particulate matter (PM) is the top environmental health risk worldwide (2019 Global Burden of Disease)



The toxicity of different **PM types**—mixtures of particles with different sizes, shapes, and compositions—is not well understood.

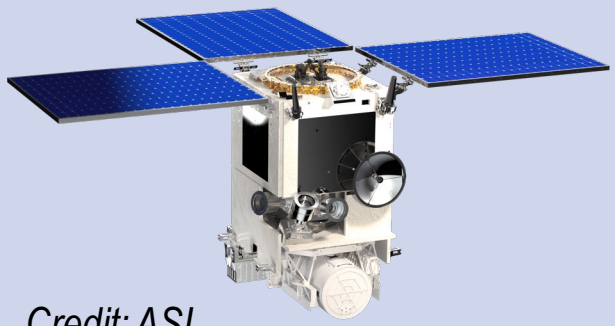
"[T]here is not enough evidence to identify differences in the effects of particles with different chemical compositions..." *(WHO, 2013)*

MAIA will explore linkages between exposure to different types of PM and human health.

- Daily-averaged total PM_{10}, total $PM_{2.5}$, and speciated $PM_{2.5}$ will be mapped in selected areas on a 1-km grid

Sulfate | Nitrate | OC | EC | Dust

Elements of the MAIA investigation



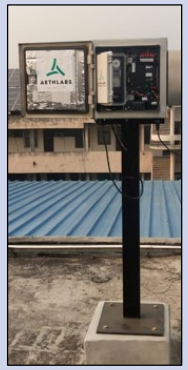
Credit: ASI

Satellite instrument aboard ASI PLATiNO-2 S/C

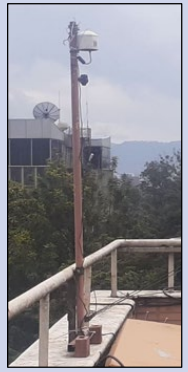
- Multiangle UV/VNIR/SWIR and polarization imagery

AirPhoton filter-based sampler

CSU filter-based sampler



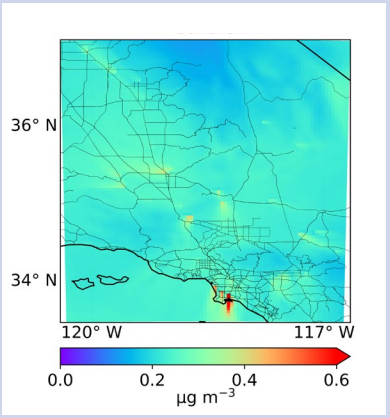
AethLabs micro-aethalometer



PurpleAir sensor

Surface monitors

- Conversion of retrieved aerosol properties to PM concentrations
- Bias correction of Chemical Transport Model PM estimates



Chemical Transport Model (WRF-Chem)

- Meteorological data
- Spatial/temporal PM gap-filling

Birth, death, and hospitalization records, epidemiological studies

- Association of PM exposure with health effects

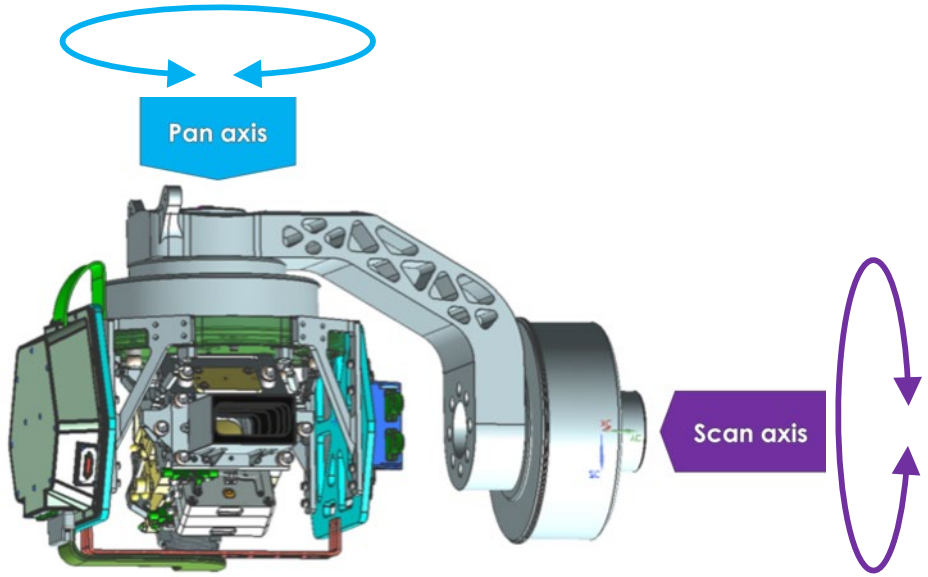
Fabrication and environmental testing of the MAIA satellite instrument were completed in October 2022

Assembled instrument contains a pointable spectropolarimetric camera

Band (nm)	General purpose	Special attribute
364	aerosol absorption	
388		
414		
440	fine particles	polarimetric
551		
646		polarimetric
749		
762.5		O_2 absorption
865		
943		water vapor
1044	coarse particles	polarimetric
1608		
1882		cirrus screening
2124		land surface

MAIA observation sites consist of a globally distributed set of target areas

Biaxial gimbal provides along-track multi-angle views and a wide cross-track field of regard

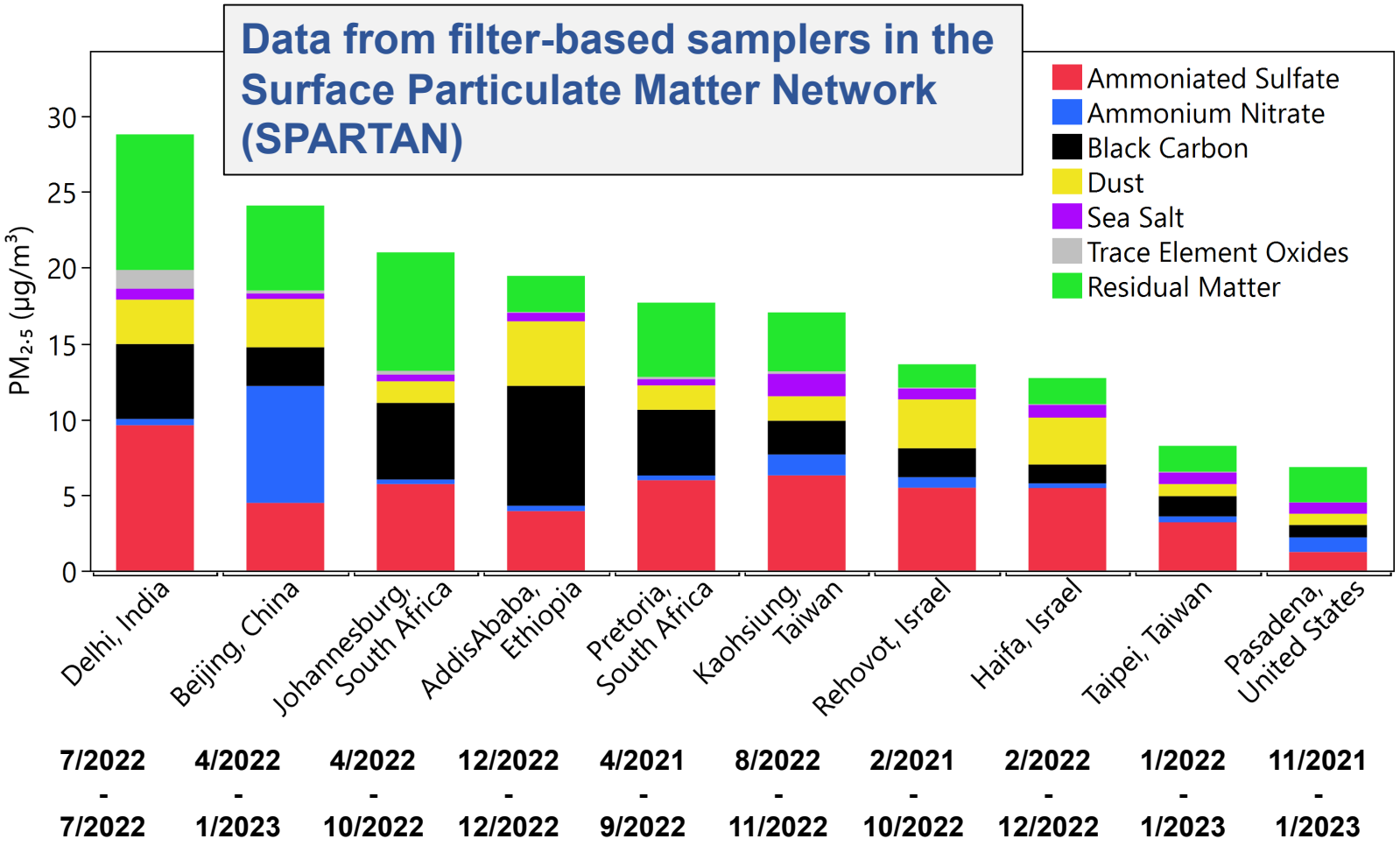


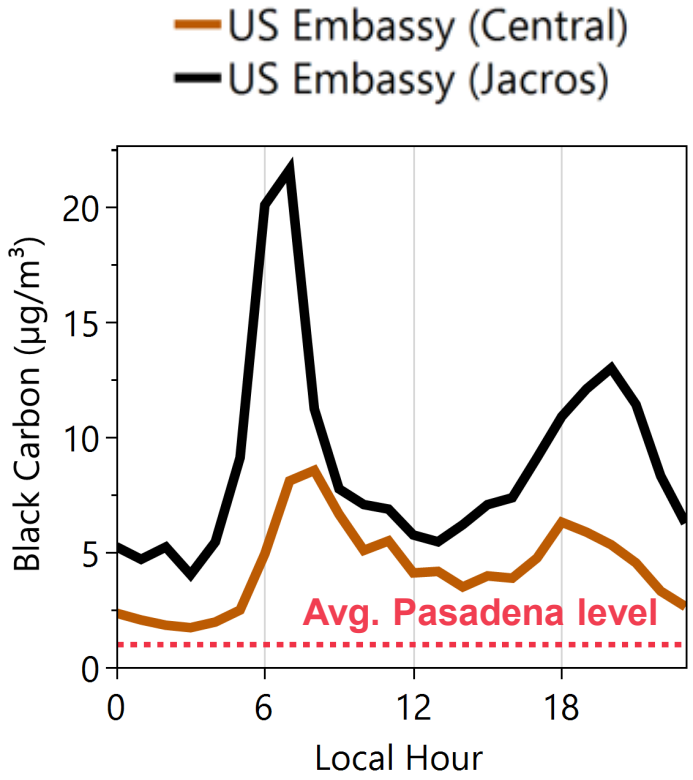
Pan (cross-track) axis provides ±49° field of regard, enabling frequent target revisits

Scan (along-track) axis enables multiangle imagery (±60° at instrument) over the selected target areas

- Primary Target Areas (PTAs): Surface monitor data collections, epidemiological studies
  - 3 - 4 satellite observations/week
- Secondary Target Areas (STAs): Air quality and climate studies
  - Typically 1 - 3 satellite observations/week
- Calibration/Validation Target Areas (CVTAs)
  - Instrument and algorithm performance maintenance

Prelaunch surface monitoring data show diverse $PM_{2.5}$ levels and composition across PTAs





Black carbon levels are remarkably high in Addis Ababa, Ethiopia

Surface monitor data calibrate the Geostatistical Regression Models used for PM mapping

Regressions of MAIA aerosol properties against surface monitor measurements calibrate the transformation from aerosol parameters to near-surface ambient PM

Regressions of Chemical Transport Model (CTM) PM against surface monitor data correct for model biases

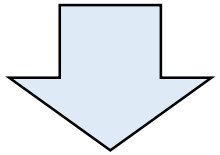
PM concentrations = α (Spatiotemporal offsets)

- Training: surface measurements
- Mapping: estimates from the calibrated data model

\+ β x Aerosol optical depth (L2) or CTM PM (L4)

\+ γ x Geospatial predictors (elevation, urban density, population, green space)

\+ δ x Spatiotemporal predictors (e.g., meteorological variables, aerosol parameters, CTM PM)



Satellite- and CTM-based PM maps are combined using Bayesian ensemble averaging.

Planned MAIA EVI standard data products (NetCDF format)

Data Product	Contents	Spatial Grid	Temporal Info
L1 Georectified Imagery	Map-projected radiance and polarization data	250 m	Time/days of target overpass
L2 Cloud Mask	Cloud confidence and quality indicators	1 km	Time/days of target overpass
L2 Aerosol Product	AOD, fractional AOD by size/shape/absorption, size distribution, refractive index	1 km	Time/days of target overpass
L2 PM Product	PM_{10}, $PM_{2.5}$, speciated $PM_{2.5}$ (sulfate, nitrate, OC, EC, dust)	1 km	24-hr averaged/ days of target overpass
L4 PM Product	Gap-filled PM_{10}, $PM_{2.5}$, speciated $PM_{2.5}$ (sulfate, nitrate, OC, EC, dust)	1 km	24-hr averaged/ daily
Ancillary Geographic Product	Land use information	125 m - 1 km	Static
Surface Monitor Product	Measured surface-based PM data monitor sites	Point data	Various sampling frequencies

Concluding remarks

- MAIA surface monitor operations are currently underway
  - Facilitated by many international collaborators with support from NASA, USAID, the US Department of State, and regional/national environmental agencies.
- Launch of the MAIA mission into sun-synchronous low-Earth orbit with 10:30 am equator crossing is expected in 2025.

Raw image taken with the MAIA camera, June 2021

https://maia.jpl.nasa.gov

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