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

David J. Diner[1]
Sina Hasheminassab[1]
Feng Xu[2]

[1]Jet Propulsion Laboratory, California Institute of Technology
[2]School of Meteorology, University of Oklahoma

CEOS Atmospheric Composition – Virtual Constellation
16 October 2024

Jet Propulsion Laboratory
California Institute of Technology

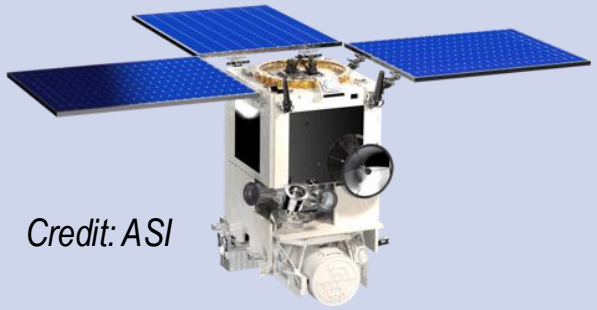
Agenzia Spaziale Italiana

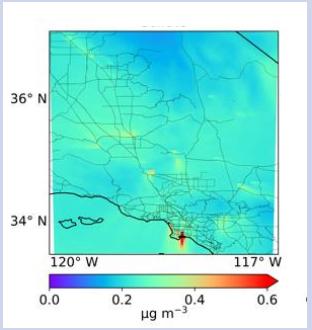
Reviewed and determined not to contain export-controlled CUI

© 2024 California Institute of Technology.
Government sponsorship acknowledged.

The MAIA mission is a partnership between NASA and Agenzia Spaziale Italiana (ASI)

MAIA will explore linkages between exposure to different types of ambient particulate matter (PM) – mixtures of particles with different sizes, shapes, and compositions – and human health.


Credit: ASI



Satellite Observatory data

- Multiangle UV/VNIR/SWIR and polarization imagery

Surface monitor measurements

- Conversion of retrieved aerosol properties to surface PM concentrations

WRF-Chem outputs

- Meteorological data; PM gap-filling

Health records

- Birth, death, hospitalization

Publicly available

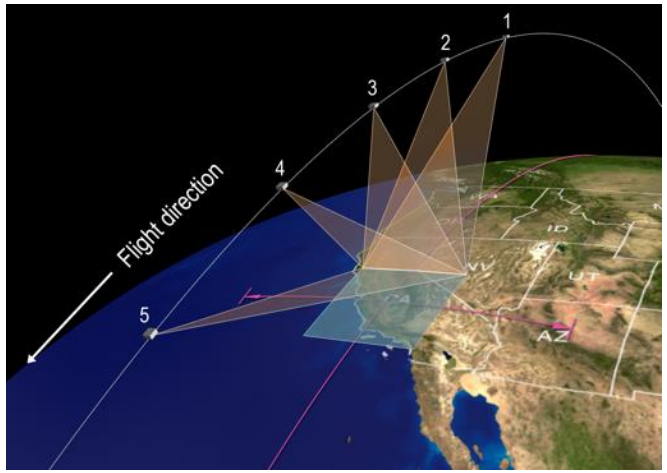
Daily-averaged total PM_{10}, total $PM_{2.5}$, and speciated $PM_{2.5}$ in globally-distributed target areas on a 1-km grid

Sulfate | Nitrate | OC | EC | Dust

Privacy protected

Epidemiological study results

Fabrication of the MAIA satellite instrument was completed in October 2022



The instrument contains a 14-band spectro-polarimetric camera that is pointable in two axes:

- along-track for multi-angle viewing of targets
- cross-track to enable frequent target observations

Band (nm)	Aerosol bands
364	absorbing particles
388	
414	
440*	fine particles
551	
646*	
749	
865	
1044*	coarse particles
1608	
	Specialty bands
762.5	O_2 absorption
943	water vapor
1882	cirrus screening
2124	land surface

Spacecraft and launch update

- Integration of the MAIA instrument onto the PLATiNO-2 host spacecraft is expected to begin in 2025.
- ASI's plan is for MAIA/PLATiNO-2 to be launched on a Vega-C launch vehicle in 2026.
- The PLATiNO-2 spacecraft is being built by an industrial consortium (known as a Raggrupamento Temporaneo di Impresa, or RTI) consisting of SITAEL, Thales Alenia Space Italia, Airbus, and Leonardo.

Target area updates

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

- Chile: upgraded from STA to PTA
  - The National Space Council (chaired by Vice President Harris) requested increased NASA emphasis on observations in South America.
  - NASA's Earth Action Program provided funding for operation of two SPARTAN stations in Chile.

- South Korea: upgraded from STA to PTA
  - The Korean National Institute of Environmental Research (NIER) has agreed to share speciated PM data from their continuously-monitoring air quality supersites with MAIA.

- China: downgraded from PTA to STA
  - Congressional law that prohibits bilateral collaboration between NASA and entities in China resulted in undesirable scientific compromises and programmatic risks.

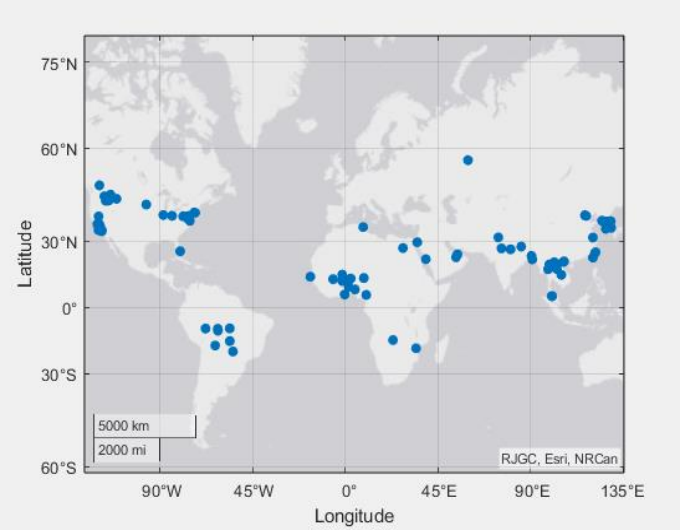
The MAIA surface monitor air pollution network is currently in operation

	Existing Networks		MAIA Deployed Monitors			
						
Instruments	**Various**		**SS5i-$PM_{2.5}$ filter-based sampler**	**Aerosol Mass Outdoor Sampler (AMOS)**	**microAeth MA350**	**PA-II-SD**
Supplier	Various		AirPhoton (SPARTAN network)	Colorado State University	AethLabs	PurpleAir
Pollutants	Total $PM_{2.5}$/PM_{10}	$PM_{2.5}$ speciation	$PM_{2.5}$ speciation	$PM_{2.5}$ speciation	Black carbon	Total $PM_{2.5}$
Locations	All primary target areas ($PM_{2.5}$ only in Ethiopia)	Spain, Italy, South Korea, USA	Chile, Ethiopia, India, Israel, Taiwan, South Africa, USA	Ethiopia, India, Taiwan, South Africa, USA	Ethiopia, India USA	Ethiopia

- Surface monitor data are used to train the PM estimation models
- PM concentrations are estimated using various predictors:
  - AOD
  - other aerosol properties
  - temperature
  - relative humidity
  - roadway density
  - land use
  - population density
  - random effects

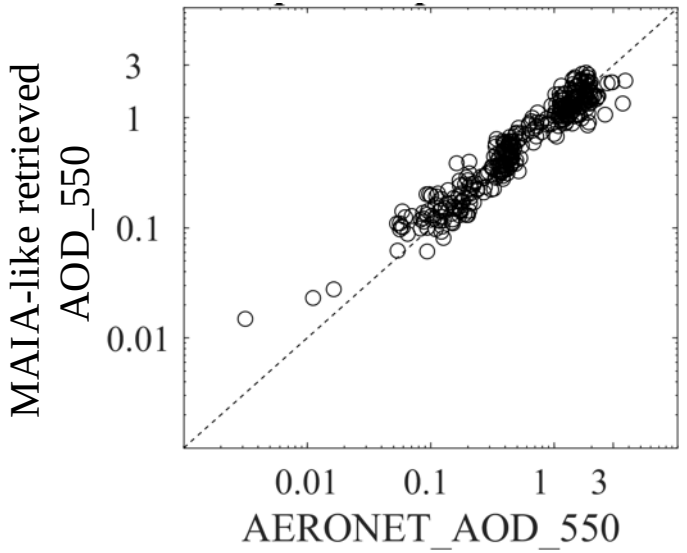
MAIA approach to aerosol retrievals

- A coupled Markov Chain/adding-doubling radiative transfer (RT) code models radiance and polarization fields at the top of atmosphere.
- The full-physics RT code is too slow for operational purposes. A neural-network (NN)-based RT approach is used to boost computational efficiency.
- The retrieval uses an optimal estimation (OE) approach and includes a pre-OE step that constrains AOD based on an adaptation of the MISR aerosol algorithm.
- Algorithm testing is underway.

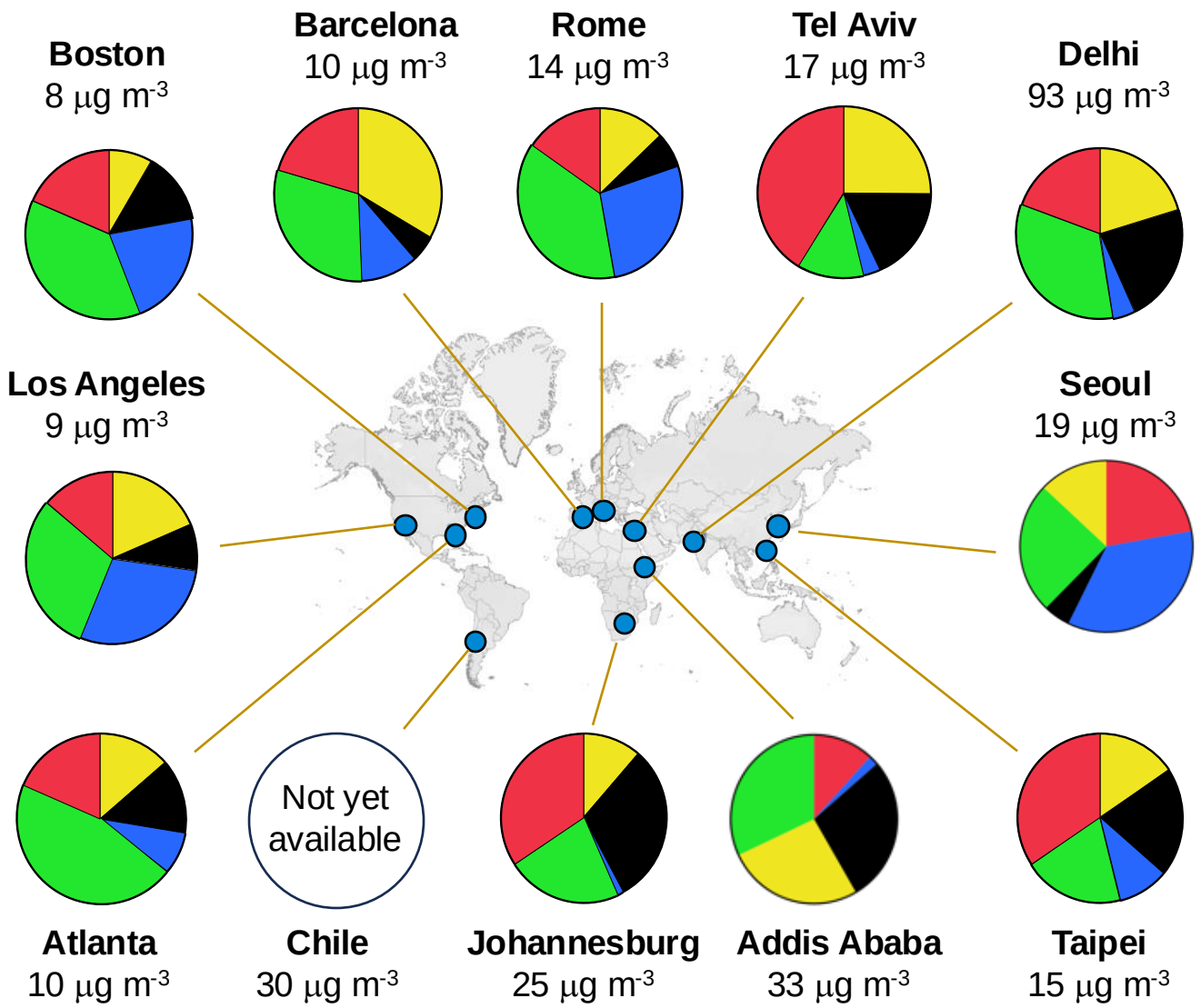


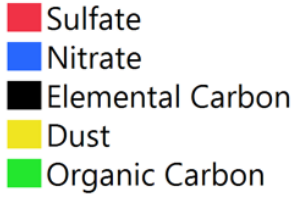
MISR and MODIS radiances from 2022-2023 were used to simulate MAIA observations at different AERONET locations

Comparison of the retrieval results with AERONET AODs

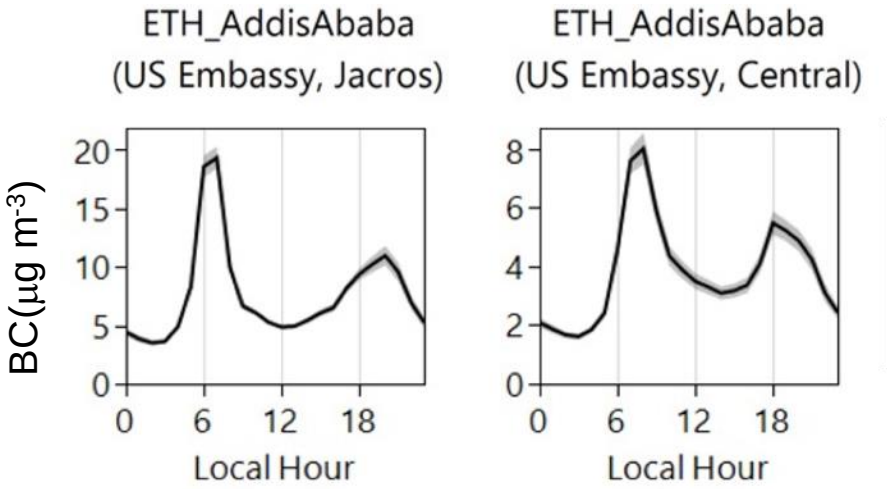


Fine particulate matter concentrations and chemical compositions from surface monitor data (2022-2023)





Black Carbon (BC) Levels Measured by microAeth MA350 in Addis Ababa



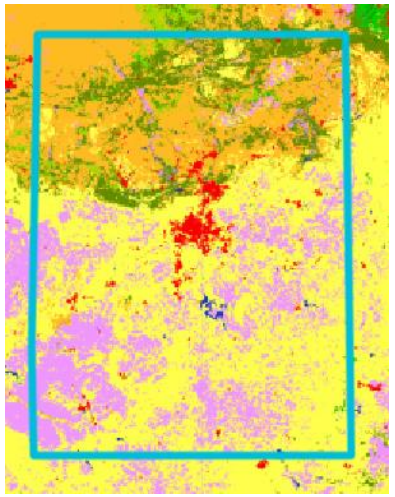
MAIA Geographic Information Visualization Tool (GIVT)

GIVT is a web-based interactive GIS tool publicly available on the MAIA website: https://maia.jpl.nasa.gov/mmgis/

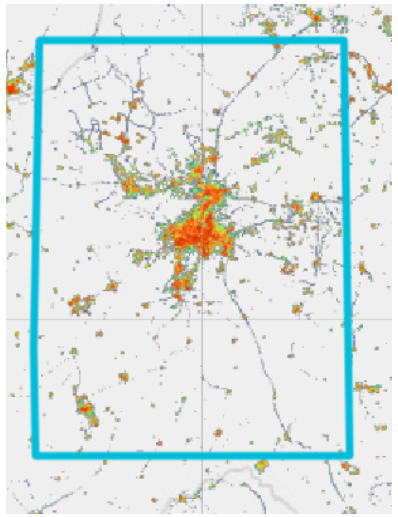
Capabilities:

- Map MAIA target areas and location/type/metadata of surface monitors
- Visualize and download Ancillary Geographic data maps from all MAIA target areas
- Access dynamic surface PM data collected from MAIA PTAs and assess the surface monitor network status
- Visualize PM data and compare levels across regions
- Download user-selected portions of the surface monitor data

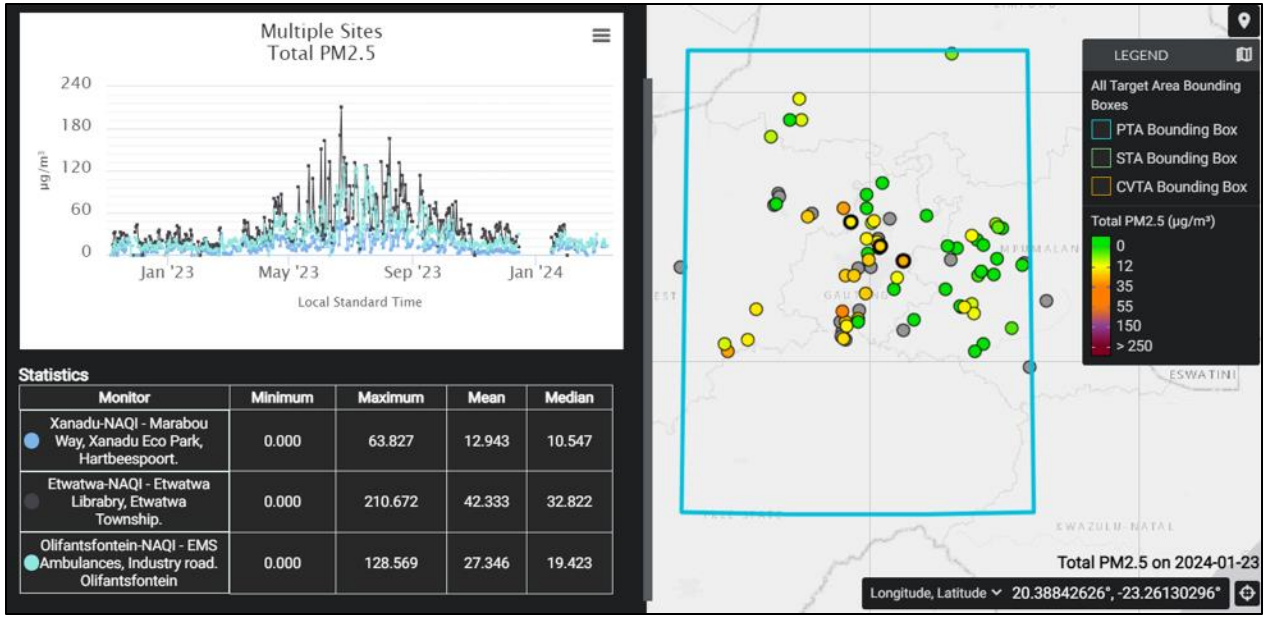
Land Cover
(ZAF-Johannesburg)



Roadway Density
(ZAF-Johannesburg)



Example Surface Monitor Data Visualization in ZAF-Johannesburg PTA



Concluding remarks

- The MAIA satellite instrument will be launched in 2026 (flight mission duration: 3 years).
- MAIA will generate daily maps of total $PM_{2.5}$, total PM_{10}, and speciated $PM_{2.5}$ (sulfate, nitrate, EC, OC, dust) at 1-km spatial resolution in 12 PTAs.
- Surface-based total and speciated PM data collection is now underway in most PTAs. The data can be explored using the GIVT tool on the MAIA website.
- MAIA data products will be publicly available at NASA's Atmospheric Science Data Center.
- Epidemiologists on the MAIA Science Team will investigate linkages between PM type and human health.

https://maia.jpl.nasa.gov