Multi-Angle Imager for Aerosols (MAIA)

David J. Diner
Jet Propulsion Laboratory,
California Institute of Technology

and the MAIA Team

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The decision to implement MAIA will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for information purposes only.

Aerosol impacts on human health

Airborne particulate matter (PM) is a well-known cause of cardiovascular disease and mortality.

> 4 million premature deaths per year

PM has also been associated with respiratory disease, lung cancer, low birth weight, and other adverse health outcomes.
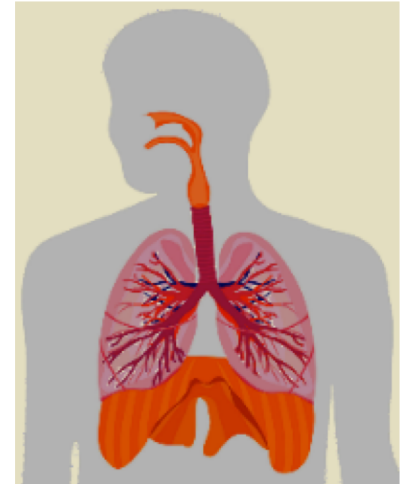
The relative toxicity of specific **PM types** is not well understood.

PM "type" refers to the fractional proportions of coarse particles, fine particles, and fine particle physical and chemical components.

"The use of central fixed-site monitors to represent population exposure is a key factor limiting our knowledge as to which PM types pose the greatest health risks." — *US EPA (2013)*
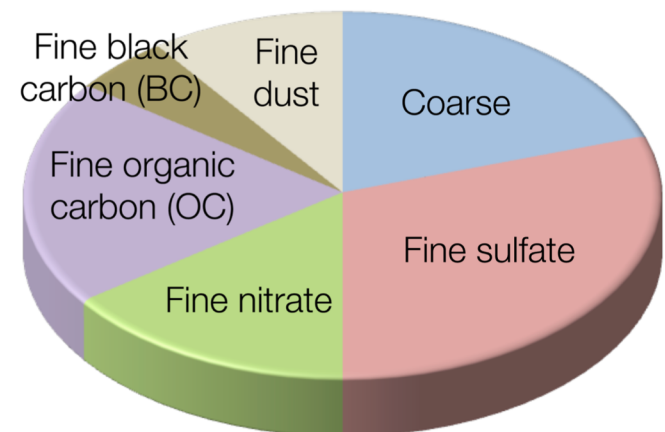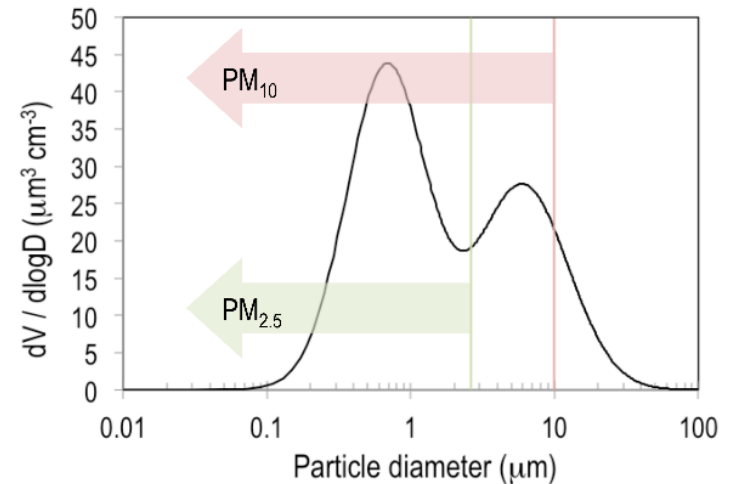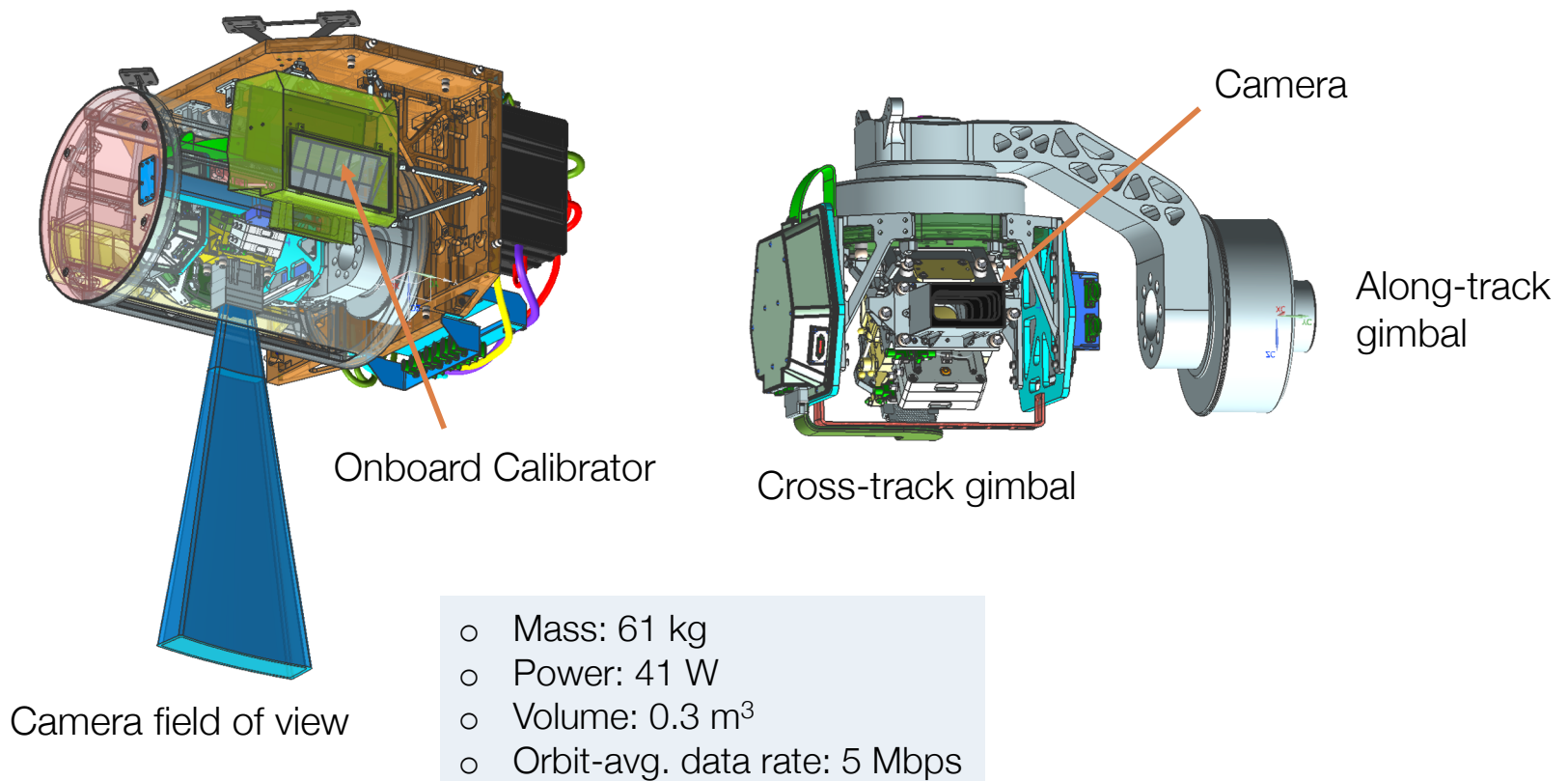
The Multi-Angle Imager for Aerosols (MAIA) satellite investigation was selected in March 2016 as part of NASA's Earth Venture Instrument program.

MAIA's primary objective is to assess the impacts of different size and compositional mixtures of airborne particulate matter (PM) on human health.

MAIA instrument

- o UV-VNIR-SWIR spectropolarimetric camera on a 2-axis gimbal
- o Launch ~2021 on a commercial spacecraft (3 yr nominal mission)

Camera

Onboard Calibrator

Along-track gimbal

Cross-track gimbal

Camera field of view

- o Mass: 61 kg
- o Power: 41 W
- o Volume: 0.3 m^3
- o Orbit-avg. data rate: 5 Mbps

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MAIA observing characteristics

Along-track

Cross-track

o Along-track multiangle viewing to ±70° at Earth

o Cross-track pointing for target observations ≥3x/week

o Globally distributed 200 km x 350 km targets
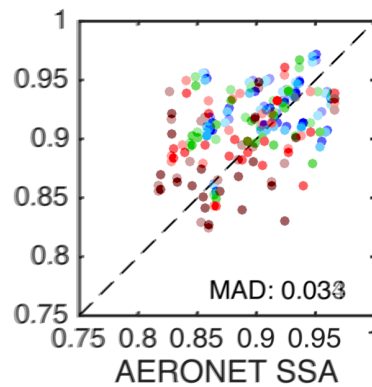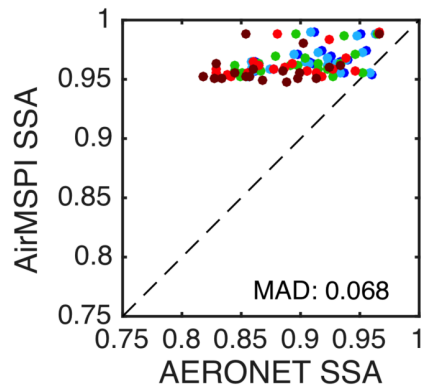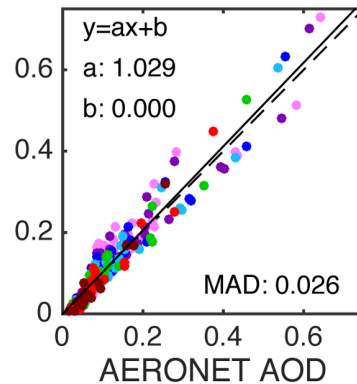
o Resolution ~200 m (nadir) to ~1 km (oblique)
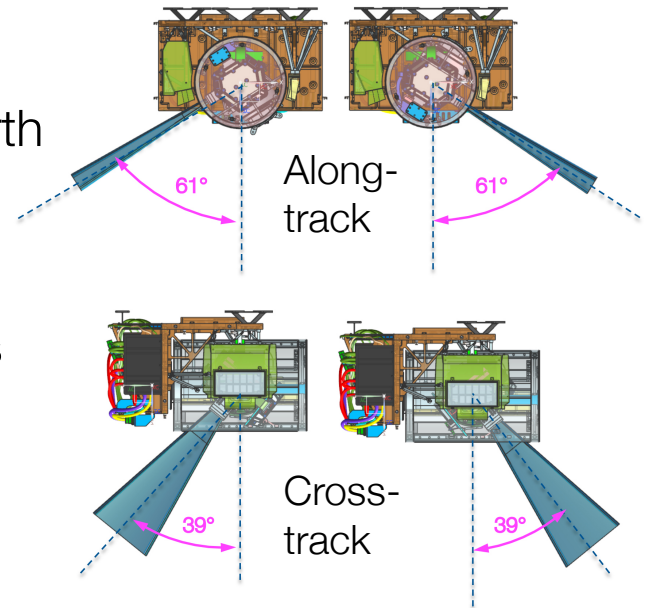
o 14 bands, 3 polarimetric, O_2 and H_2O absorption

Band (nm)	367	389	415	445	551	645	749	762.5	864	943	1039	1607	1880	2124
Polarimetric														

AOD and SSA retrieval

9 angles without polarization

5 angles with polarization

y=ax+b
a: 0.855
b: -0.025
MAD: 0.049

y=ax+b
a: 1.029
b: 0.000
MAD: 0.026

MAD: 0.068

MAD: 0.033
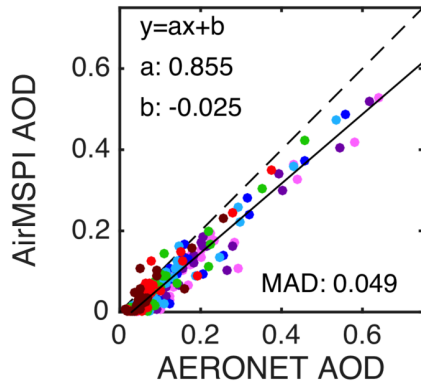
Results using AirMSPI airborne imaging spectropolarimeter

- 355 nm
- 380 nm
- 445 nm
- 470 nm
- 555 nm
- 660 nm
- 865 nm

*Xu et al. (2017)*

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MAIA investigation is target based

○ **Primary Target Areas (PTAs)** are chosen by the MAIA Science Team for conducting epidemiological studies.

○ **Secondary Target Areas (STAs)** are designated for addressing secondary science objectives (e.g., aerosol source regions, climatically important cloud regimes).

○ **Calibration/Validation Target Areas (CVTAs)** are observed for radiometric and polarimetric calibration, and aerosol/PM validation,
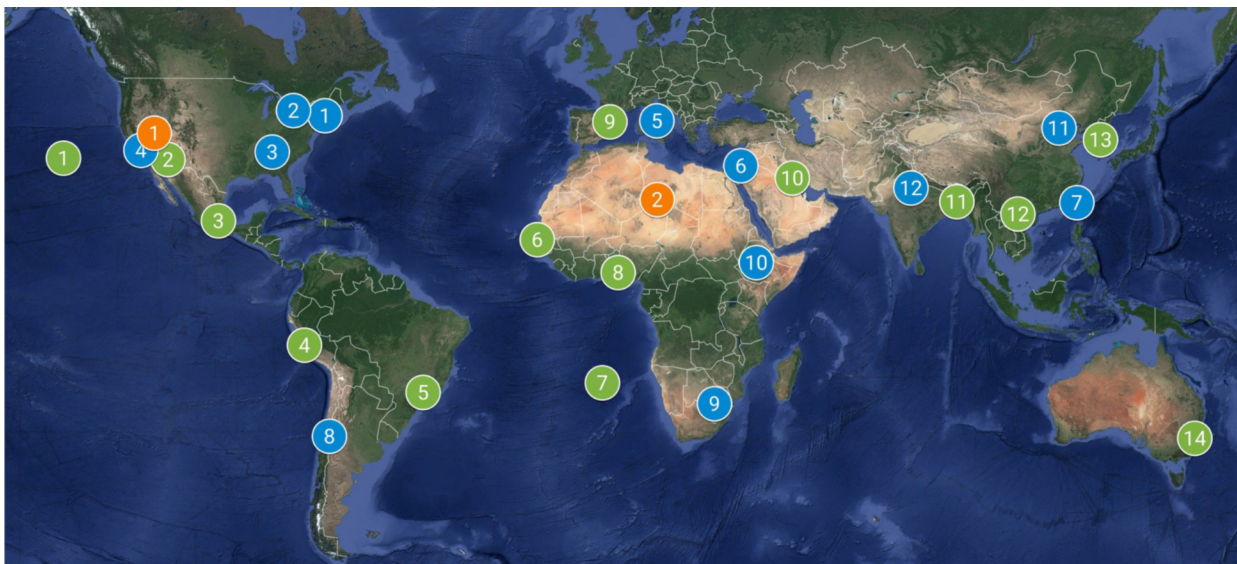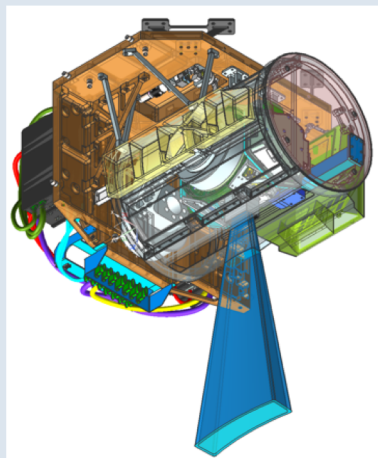

● Primary Target Area   ● Secondary Target Area   ● Calibration/Validation Target Area

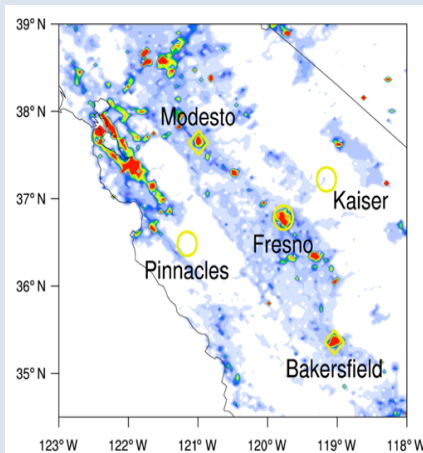# PM concentrations and types in the PTAs

adapted from *Li et al (2017)*
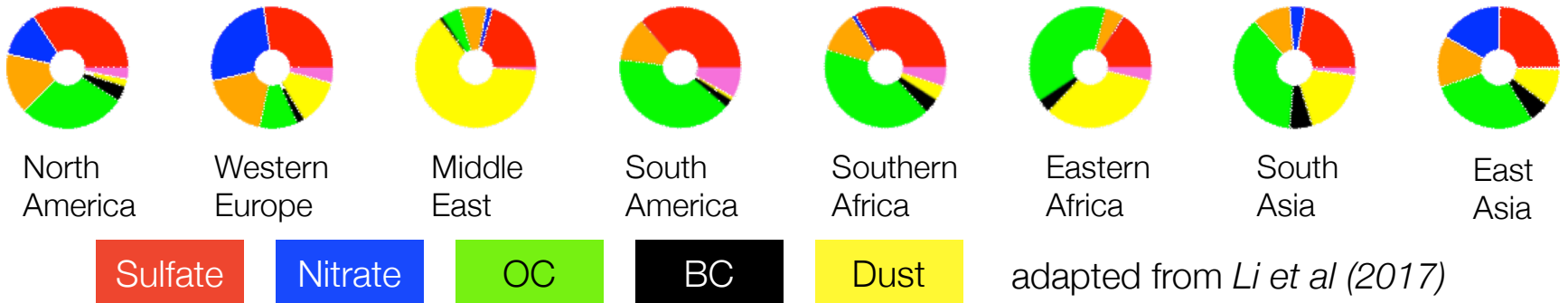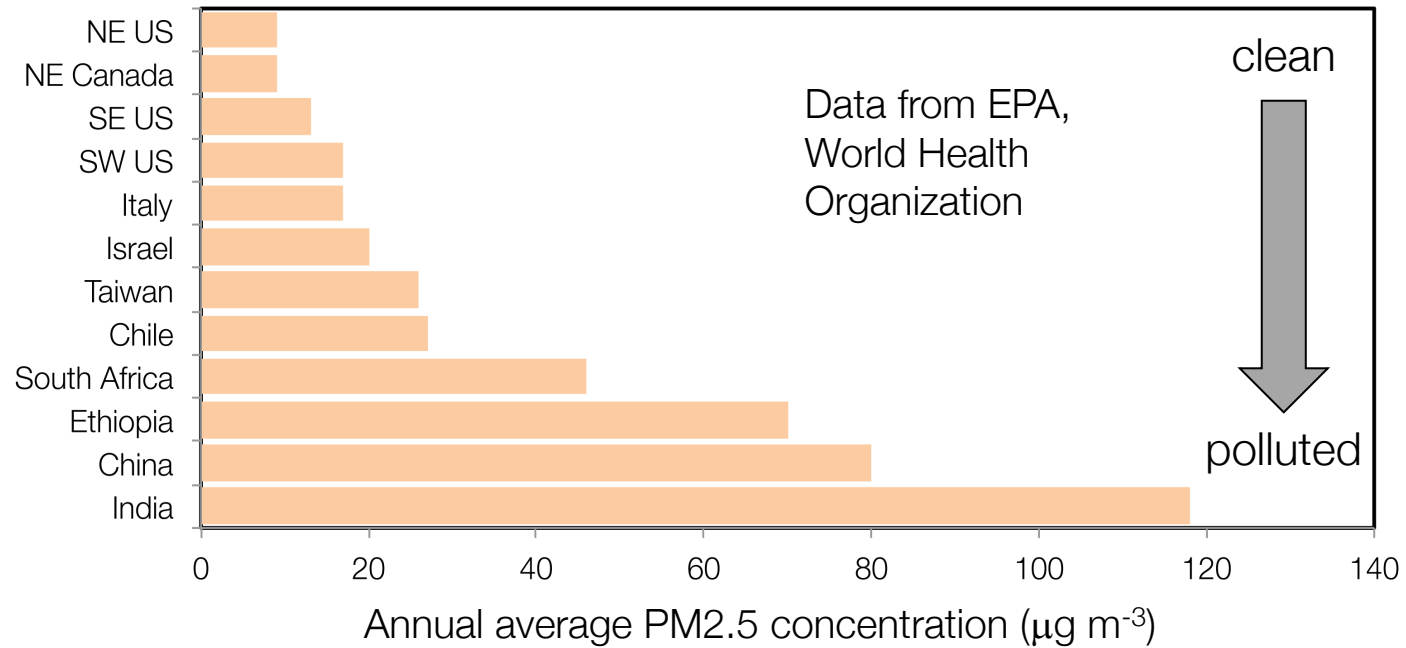
MAIA integrates multiple data sources

MAIA instrument
- Provides calibrated, georectified image data for retrieval of column-integrated aerosol properties over major cities.

Chemical transport model (CTM)
- Constrains the aerosol retrievals.
- Informs column aerosol-to-near surface PM regressions.
- Assists in gap-filling of the PM maps.

Surface PM monitors
- Used with collocated MAIA instrument data and the CTM to "train" the column aerosol-to-near surface PM regressions.

Image credit: L. Tsutsui, KVPR

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MAIA data products

Data level	Description
0	Downlinked instrument telemetry
1	Calibrated and georectified radiance and linear polarization imagery View and solar geometry, latitude, longitude
2	Cloud-screened total and fractional aerosol particle properties at time of satellite overpass 24-hr averaged concentrations of coarse PM, fine PM, and fine PM components on days and locations coincident instrument observations
4	Spatially and temporally gap-filled 24-hr averaged concentrations of daily coarse PM, fine PM, and fine PM components

Processes used for data product generation
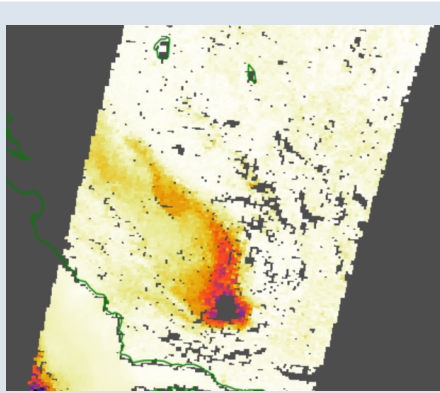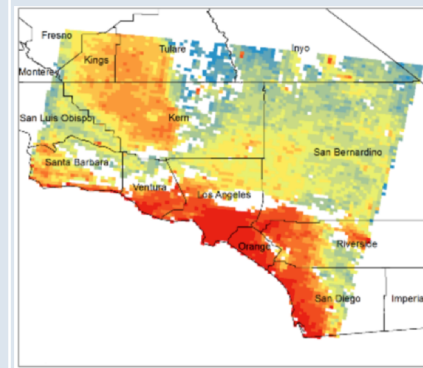

Aerosol optical depth (AOD) retrieval
- Uses MAIA imagery to map AOD fractionated by particle physical properties (size, shape, absorptivity).
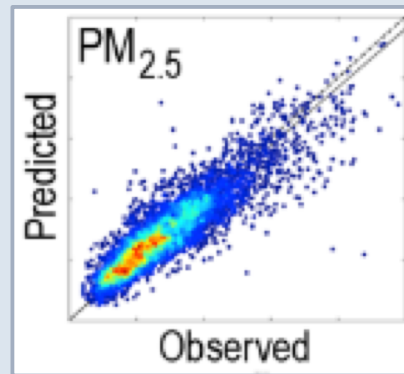
Geostatistical regression modeling
- Relates column aerosol properties to near-surface PM concentrations.

Spatiotemporal gap-filling
- Integrates PM surface monitor, MAIA instrument, and bias-corrected CTM data.

Prospective health investigations

Acute (days to weeks) Hospital visits, heart attacks, strokes, premature deaths	Subchronic (months) Adverse birth outcomes, pregnancy complications	Chronic (years) Cardiovascular and respiratory diseases, cancer

PTA	Representative major cities	Acute	Subchronic	Chronic
NE US	Boston, Providence, Hartford, NYC			
NE Canada	Toronto, Hamilton			
SE US	Atlanta			
SW US	LA, Fresno, Bakersfield, Riverside			
Italy	Rome, Bologna			
Israel	Tel Aviv, Haifa, Jerusalem, Beer Sheba			
Taiwan	Taipei, Taichung, Tainan, Kaohsiung			
Chile	Santiago, Concepción			
South Africa	Johannesburg, Pretoria			
Ethiopia	Addis Ababa, Adama			
China	Beijing			
India	Delhi			

Summary

- The MAIA investigation strategy integrates MAIA instrument observations, PM surface monitor data, and CTM outputs to map size and compositional components of ambient PM.

- Project Preliminary Design Review was completed in April 2018.

- Instrument delivery is planned for April 2020.

- Launch will be on a commercial satellite, earliest mid-2021.

- Epidemiologists on the MAIA team will conduct health impact investigations in the Primary Target Areas.

Thank you

David.J.Diner@jpl.nasa.gov