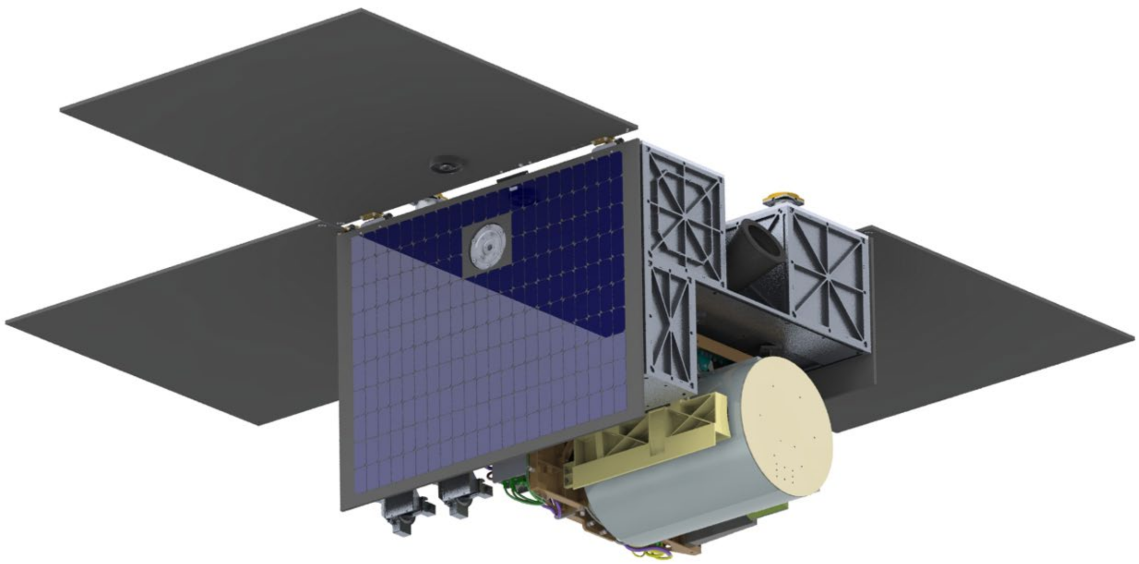
Inaugural MAIA Early Adopters Workshop Report
Pasadena Hilton, Pasadena, CA – June 5, 2019



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This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

1. Introduction

The Multi-Angle Imager for Aerosols (MAIA) project is NASA's first competitively selected instrument investigation with societal benefit as its primary objective. MAIA's primary science objective is to study the effects of various chemical makeups of particulate matter (PM) air pollution on human health. Exposure to PM air pollution is recognized as the largest environmental risk factor, as opposed to personal risk factors like heredity and behavior, for premature death. MAIA will use a combination of spaceborne technologies to collect multispectral, multi-angle, and polarimetric observations, which provide information about the size, shape, and composition of the particles that comprise air pollution. The data collected from the instrument will be combined with other information, including measurements from air pollution monitors on the ground and outputs from a chemical transport model to calculate the concentrations of various PM types over a globally distributed set of Primary Target Areas worldwide. Epidemiologists on the MAIA team will conduct studies on the health impacts of these aerosol mixtures.

From the very beginning, MAIA has included co-investigators from the Environmental Protection Agency, National Institutes of Health, Centers for Disease Control and Prevention, and National Oceanic and Atmospheric Administration. This unique and diverse science team will help ensure that MAIA data products and science advancements are able to make a concrete impact to those managing public health air quality issues. More recently, collaborations with the US Agency for International Development (USAID) and the US Department of State have been established. In addition to these substantial efforts on the part of the MAIA project, the NASA Applied Science Program (ASP) is committed to developing and implementing a broad-reaching applications program to reach further potential users of the MAIA data. Lawrence Friedl, the NASA ASP Director, and John Haynes, ASP Health and Air Quality Program Manager, oversee the applications efforts associated with various missions. ASP funds the MAIA Deputy Program Applications (DPA) Lead, who acts on behalf of the ASP specifically for MAIA.

The primary goal of the MAIA Applications Program is to maximize the benefit of the NASA Earth Science Directorate (ESD) investment by enhancing the applications value and overall societal benefits of the project. The MAIA applications effort will create resources and conduct various types of events to provide inspiration, information, and capacity-building among practicing and potential users of MAIA data. Because MAIA is an applications-focused mission, the efforts of the Applications Program need to be carefully coordinated with the activities of the project and science teams. The keystone of the MAIA applications effort is the Early Adopters Program, through which interested potential users will have the opportunity to avail themselves of regular updates from the science team, use resources included simulated data products prior to launch, and offer feedback to the project on potential improvements.

The Inaugural MAIA Early Adopters Workshop was held on June 5, 2019, in Pasadena, California. The objectives of this workshop, held approximately three years before MAIA's planned launch date, were:

1. Develop relationships with potential Early Adopters and generate buy-in on the planned MAIA data products.
2. Provide a forum for the anticipated core end-users (epidemiologists, environmental health researchers, and air quality managers) outside the MAIA Science Team to learn about MAIA's planned target areas and when/what data will be available.
3. Provide a forum for potential end-users other than those listed above to discuss how MAIA products could be incorporated into their work. This will allow the MAIA team to evaluate to what extent MAIA can support these uses.
4. Gather feedback from potential Early Adopters on the plans for the data products, enabling the MAIA team to entrain this feedback to the greatest extent possible into the first iteration of the simulated data products.

The one-day event was divided into three sections: first, a summary of the MAIA project and relevant information for potential data users; second, presentations by stakeholders external to the science team on their plans for MAIA data; and third, group discussion on MAIA's planned target areas and data products. (The full agenda for the workshop is included here in Appendix A.) 43 in-person and 12 remote participants attended the workshop, including epidemiologists, environmental health researchers, air quality managers, environmental advocates, and others. The full list of attendees is included in Appendix B.

Due to the need to fully integrate the online attendees, an online tool called Mentimeter was employed to allow all participants to answer questions provide feedback in real time. This included some initial questions before the workshop began to gauge the attendees' previous knowledge, as well as two quizzes to ensure the MAIA team had successfully communicated the most salient points about the project. In the afternoon two discussion exercises were conducted to gather feedback about MAIA's planned targets and data products.

2. MAIA 101

A summary of the material presented by the MAIA team is provided here for the benefit of those who were not able to attend the workshop.

2.1 Introduction to the MAIA Early Adopters Program (presenter: Abigail Nastan, JPL)

The workshop began with a welcome from John Haynes and an introduction to the MAIA Early Adopters Program given by Abigail Nastan. MAIA's science objectives are driven by the large detrimental impact of particulate matter (PM) air pollution worldwide; the Global Burden of Disease estimates that more than 4 million premature deaths are caused by PM annually. The MAIA instrument, science team, and project approach are all tailored to investigate the health impacts of various compositional mixtures of PM. The MAIA investigation will therefore produce aerosol and PM data, as well as epidemiological studies of health impacts completed by science team members. The Early Adopters program is intended to entrain potential users outside the MAIA science team pre-launch and provide resources to ensure the MAIA project is meeting their individual needs to the greatest possible extent. Early Adopters will have the opportunity to offer feedback on MAIA's planned targets (see section 2.6) and data products through workshops; experiment with test versions of the products pre-launch; and take advantage of the expertise of the MAIA science team. More details about the Early Adopters program and other MAIA activities related to reaching data users are available from the MAIA Applications Plan (https://maia.jpl.nasa.gov/assets/pdf/MAIA-Applications-Plan-original-release.pdf).

2.2 Introduction to the MAIA satellite instrument, observations, and products (presenter: David Diner, JPL)

MAIA's principal investigator David Diner offered an introduction to the project, including the instrument and data products, and an update on current status. MAIA's launch is currently scheduled for 2022, and NASA has selected General Atomics-Electromagnetic Systems Group to build the spacecraft that will host the MAIA instrument. The instrument is an imaging spectropolarimeter mounted on a two-axis gimbal (see Figure 1).

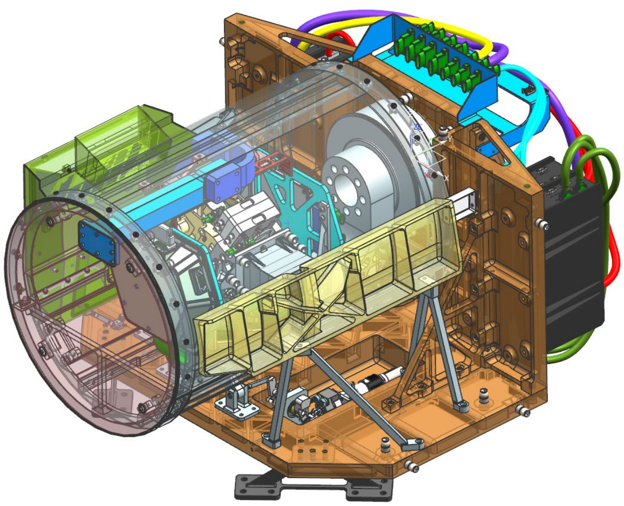


Figure 1. A CAD model of the MAIA instrument as of May 2019.

For brevity, the full technical description of the instrument is omitted here. For more details, consult the MAIA website https://maia.jpl.nasa.gov and the publications listed therein. The instrument will collect multi-angular views of each target (see section 2.6) and produce radiance and polarization information, from which aerosol optical properties will be retrieved. The approach to produce speciated PM concentrations is geostatistical regression modeling, which will take the MAIA aerosol product and geospatial and spatiotemporal predictors, including PM surface monitor data, as inputs. A daily-averaged, gap-filled PM concentration product will be produced using a CTM as input to cover areas and days that have no MAIA aerosol retrievals. The full details of the MAIA aerosol and PM retrieval approach and validation will be detailed in several Algorithm Theoretical Basis Documents and a Science Validation Plan, which will be available online and accessible from the MAIA website once published.

2.3 Surface monitor data and integration (presenter: Kristal Verhulst, JPL)

The MAIA approach to retrieve total and speciated PM concentrations requires data from surface PM monitors as an input to the geostatistical regression model, in order to transform column aerosol properties from the instrument to surface PM concentrations. Monitors measuring total PM_{10} and $PM_{2.5}$ and others measuring sulfate, nitrate, organic carbon, elemental/black carbon, and dust will be used. For total PM, MAIA's data system will ingest data from continuous monitors that provide data in near-real time; the speciated monitors, however, are mostly filter-based, meaning they require lab analysis and can have 6-12 month data latency. The MAIA team has conducted a thorough review of the surface monitor data available in each target area (see Figure 2 for a view of the MAIA surface monitor map) to ensure the final selection of target areas meets project requirements for monitor quantity (at least 10 total $PM_{2.5}$ monitors, 4 total PM_{10} monitors, and 2 speciated monitors per target area), as well as monitor distribution, sampling, data access and latency. By June 2020, the team plans to have developed a system to ingest and process all the relevant monitor data sources, and delivered the software to the Atmospheric Science Data Center (ASDC, see section 2.5).

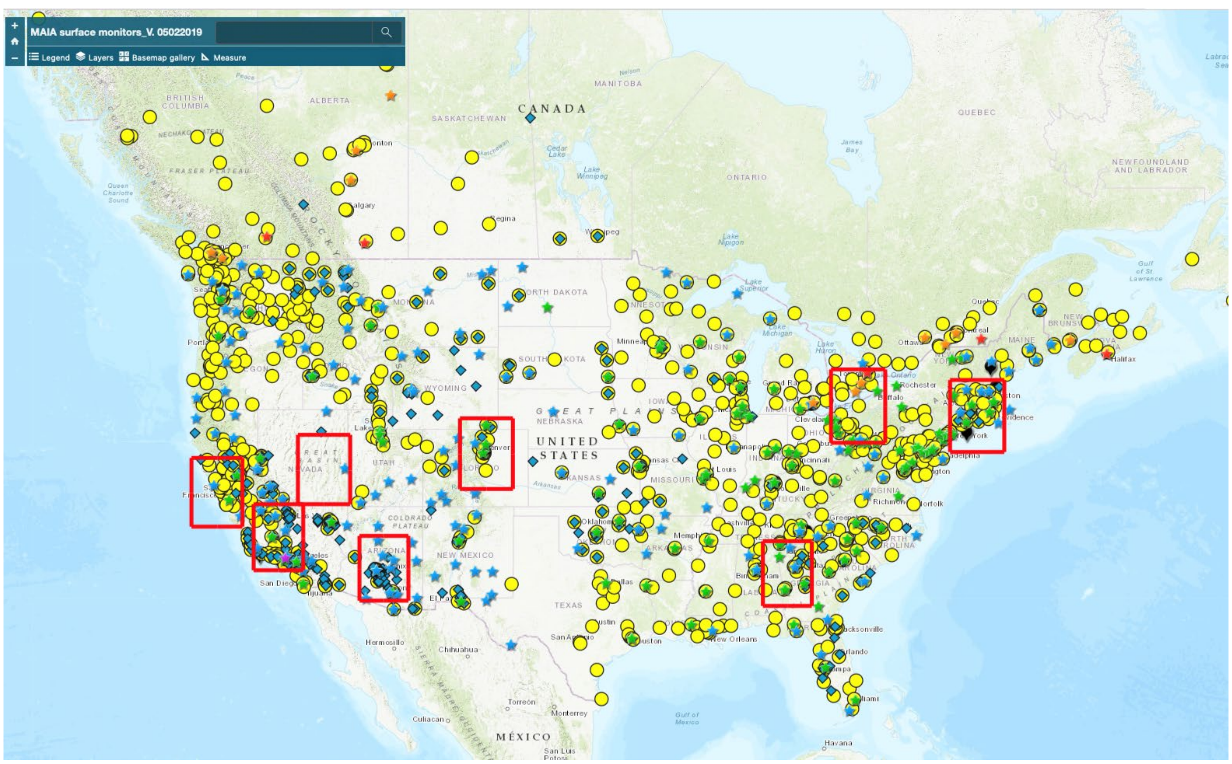


Figure 2. A screenshot of the MAIA team's map of the various types of surface monitors. While this screenshot shows North America, the team has conducted a similar review for each of the target areas.

2.4 Overview of MAIA data production (presenter: Scott Gluck, JPL)

The MAIA Science Data System will generate the various MAIA data products, archive them, and provide them to the public, free of charge. The public data products will include:

1. Level 1 radiance/polarization product: this will include calibrated and georectified radiance data for MAIA's fourteen spectral bands and Stokes parameters describing linear polarization for the three polarimetric bands. This product will be produced for every angle of MAIA observations, at 250 meter spatial resolution.
2. Level 2 aerosol product: this product is the output of the aerosol retrieval algorithm, and will include total and fractional aerosol optical depths along with other optical and microphysical particle properties. Ancillary variables such as precipitable water vapor, surface albedo, surface bidirectional reflectance factors, and solar and view angle information will also be included. The aerosol data will have associated uncertainties. One file will be produced per set of MAIA observations of a target, at 1-kilometer spatial resolution.
3. Level 2 PM product: This product will include daily-averaged total PM2.5 and PM10 concentrations, as well as concentrations of PM2.5 sulfate, nitrate, organic carbon, elemental carbon, and dust components on the days of satellite overpass. One file will be produced per set of MAIA observations of a target, at 1-kilometer spatial resolution.
4. Level 4 PM product: This product will include the same variables and be produced at the same resolution as the level 2 PM product, but will be produced every day, whether MAIA observations were taken on that day or not, and will be gap-filled using chemical transport model PM estimates, corrected for biases using the geostatistical regression model approach.

The data products will be produced in NetCDF format. Due to the time required to build up the geostatistical regression models, the products will be reprocessed on a regular cycle (likely every year) in order to take advantage of better model performance with more input data available; therefore, the PM products' performance will improve as the mission goes on. Because the model relies on speciated PM surface monitor data, which often has a latency of many months, "provisional" products will be produced during the mission's first year after launch, using pre-launch monitor data.

2.5 NASA ASDC plans for data distribution (presenters: Jeff Walter and Makhan Virdi, NASA LaRC)

The NASA Atmospheric Science Data Center (ASDC) at NASA's Langley Research Center is responsible for processing the MAIA data using software provided by the MAIA team, as well as archiving and distributing the data products. NASA Earthdata is distributed by its 12 data centers, known as DAACs (Distributed Active Archive Center), with each DAAC responsible for its assigned disciplines. ASDC disciplines include data for Aerosols, Tropospheric Composition, Clouds, and Radiation Budget. ASDC makes these data available through tools and services, such as NASA Earthdata Search, NASA Worldview, OPeNDAP and HTTPS data access, and example scripts in various languages for data processing. ASDC also provides interactive user support through the forums and one-on-one interactions. ASDC is interested in discussing use cases, preferred programming languages, data tools, and file formats with potential MAIA users, in order to better adapt their data tools, services and visualizations to answer user needs.

2.6 MAIA target areas (presenters: David Diner and Abigail Nastan, JPL)

Due to the pointing nature of the MAIA instrument, as well as the need for surface monitor data, the MAIA team must choose targets to observe on a regular basis. There are four types of MAIA targets: Primary Target Areas, Secondary Target Areas, Calibration/Validation Target Areas (sites used to perform vicarious calibration of the MAIA instrument), and Targets of Opportunity (when possible, these include serendipitous episodic events MAIA will observe such as major wildfires, volcanic eruptions, and other events that affect air quality). See Figure 3 for a map of the candidate target areas at the time of the workshop.

Figure 3. The MAIA candidate target areas as of the time of the workshop. For a current candidate target area map, see the MAIA website.

The Primary Target Areas (PTAs) are regions where the MAIA science team will conduct one or more epidemiological studies on the health impacts of certain compositional mixtures of PM. Therefore, they must be carefully selected based on science value, availability of surface monitor data, planned access to adequate health data by one or more MAIA science team members and their collaborators, cloud cover, and ability to be observed at least three times weekly from MAIA's sun-synchronous, low-Earth polar orbit – meaning that the targets cannot conflict too often with each other. The current candidate PTA list includes 11 globally distributed areas (see Figure 1). The targets are currently planned to be 300 kilometers (east-west) x 400 kilometers (north-south), which is the area over which the PM products will be produced.

Secondary Target Areas (STAs) are additional target regions MAIA will observe after meeting the requirements for the PTAs. They will be chosen to address MAIA's secondary science objectives regarding aerosol source regions or climatically important cloud regimes, or areas where Early Adopters have demonstrated significant science value toward health studies or other applications including (but certainly not limited to) aerosol-cloud interaction, aerosol climate forcing, and air quality forecasting. STAs cannot interfere with meeting MAIA's observation requirements for PTAs (this generally becomes an issue only when a proposed STA is in close proximity to a PTA). The MAIA team is not yet able to guarantee which of the MAIA data products will be produced for STA observations. This will depend on the total number of target areas, which data products Early Adopters are interested in, observation frequency, computing resources available, and team resources needed to build and test the model runs and integrate surface monitor data.

The finalization of the PTAs and selection of the STAs are ongoing at this time, in conjunction with development and testing of the MAIA Science Data System. Once finalized, more details about each target area will be available from the Target Science Implementation Plan, which will be published and available on the MAIA website.

3. MAIA applications examples

The second portion of the workshop consisted of presentations by potential Early Adopters who have worked with members of the MAIA team previously. They shared a sampling of previous work with other satellite datasets and their thoughts on how MAIA data might benefit their particular use case.

3.1 Health studies in Kuwait (presenter: Meredith Franklin, USC)

Meredith Franklin, Professor of Clinical Preventive Medicine at the Keck School of Medicine, University of Southern California, presented a summary of her ongoing research project studying the health impacts of PM from open burn pits utilized for disposal on US military bases in Kuwait and other locations, especially prior to 2011. She utilized ground monitors and aerosol optical depths from the MODIS for this work. MAIA has a candidate STA in Kuwait, which would provide benefit to a Veterans Administration Cooperative Study Dr. Franklin has been awarded to develop an exposure assessment tool to assist the VA in treating veterans who served in Kuwait and other locations.

3.2 Denver/Front Range MAIA target area (presenter: James Crooks, National Jewish Health)

James Crooks, Associate Professor at National Jewish Health and Clinical Assistant Professor at the Colorado School of Public Health, presented a summary of the factors that prompted him to request that the MAIA team consider the greater Denver area as an STA. Apart from the densely populated urban corridor along the Front Range and its associated PM sources, as of 2017, Colorado has 60,000 fracking wells, many of which fall within the proposed target area. Fracking itself emits methane and volatile organic compounds, and the construction of wells produces a significant amount of $PM_{2.5}$ related to diesel-fueled equipment. In addition, the region west of the urban corridor experiences many wildfires, and the San Luis Valley to the southwest is a major agricultural region with a large dust loading from the Great Sand Dunes National Park. Dr. Crooks and his local partners have several proposed health studies in relation to exposure to fracking, pesticides, wildfire smoke, and urban sources in the region, all of which could potentially use MAIA data as a source of exposure assessments.

3.3 Some emissions, air quality forecasting and health issues in Phoenix (presenter: Daniel Tong, GMU)

Daniel Tong, Research Professor at the Center for Spatial Science and Systems at George Mason University and a member of the NASA Health and Air Quality Applied Science Team, presented his reasons for advocating for a MAIA STA over the greater Phoenix area. Phoenix is a rapidly growing city in a desert region, leading to major concerns of a large population in close proximity to dust storms and PM sources related to dryland agriculture. In addition to health impacts of inhaling the dust itself, dust storms cause many car accidents, reduce the efficacy of the many solar farms in the region, and can also expose people to valley fever, a dangerous and poorly understood fungal infection. Dr. Tong has previously used the IMPROVE network, MODIS and VIIRS aerosol data, and the NAQFC model to study dust effects in this region, and he hopes MAIA data in this region can be applied to source contribution, high-resolution emission inventories, and advancing dust storm forecasting.

3.4 California Air Resources Board's perspective on MAIA (presenter: Hyung Joo Lee, CARB)

Hyung Joo Lee, a Staff Air Pollution Specialist at the California Air Resources Board, presented CARB's take on how MAIA could fit in to their mission to protect the California public from the harmful effects of air pollution. The goals of CARB's research program are to identify air pollution hotspots, quantify emissions, inform emission mitigation strategies, and assess the effectiveness of regulations. They have previously incorporated MODIS aerosol data with the ground monitors they oversee to generate their statewide maps of spatially resolved total $PM_{2.5}$ concentrations. Additionally, they are collaborating with MISR team members to produce regional and statewide data of speciated $PM_{2.5}$ using MISR aerosol data, ground monitors, and other sources. CARB hopes that data from MAIA's Southern California PTA and candidate Northern California STA will support the Community Air Protection Program laid out in California Assembly Bill 617, as well as advancing hotspot assessment for $PM_{2.5}$ species, providing comparison with their regulatory Community Multiscale Air Quality Modeling System (CMAQ) model, contributing to health studies, and potentially providing input to the California Communities Environmental Health Screening Tool (CalEnviroScreen) tool.

3.5 South Coast Air Quality Management District's perspective on MAIA (presenter: Sang-Mi Lee, SCAQMD)

Sang-Mi Lee, Program Supervisor of the Planning Division at the South Coast Air Quality Management District (SCAQMD), presented on the use of satellite data to assist air quality policy development at SCAQMD. While both ozone and PM concentrations have decreased significantly over the past decades in the South Coast basin, the area is still in non-attainment for both pollutants. Predicting concentrations of both rely on accurate emissions inventories as input to SCAQMD's CMAQ model, and satellite data can help improve these inventories and assist model performance evaluation. SCAQMD is currently working on using 10-meter resolution leaf area index data from Sentinel to improve urban canopy emissions data. Satellite data will be utilized in the Multiple Toxics Exposure Study V (MATES-V), the latest of the studies, to estimate cancer risk. Satellite images also assist to track wildfire plumes. Dr. Lee hopes that MAIA's Southern California PTA can provide an additional source to assist in these efforts.

4. Discussion exercises

The third portion of the workshop consisted of two discussion exercises, conducted using the Mentimeter online tool.

4.1 Target area discussion exercise

The first discussion exercise was designed to:

1. gather attendees' feedback on the currently proposed PTAs and STAs, and
2. walk through the vetting process of a "dummy" STA, to encourage those who might want to propose an STA themselves to consider the various factors affecting the target selection.

First, the attendees rated all eleven PTAs according to their personal interest in using the data from that location, in a system where each attendee had 100 points to distribute as desired among the targets (Figure 4). Unsurprisingly, given the workshop's location within the Los Angeles target area, it was by far the most popular.

Figure 4. Workshop attendee ratings of the current Primary Target Area candidates, in which the size of the circle indicates the percentage of total points which were awarded to that target area by all participants.

Next, the attendees were asked to rate the current candidate STAs in a similar manner, except that the targets were separated roughly by continent since there were 22 candidates, too many to reasonably rate all at once. Figure 5 displays the results color coded by the regions used for voting.

Figure 5. Secondary Target Area candidate voting results. The color of the circle corresponds to the regions by which the STA candidates were separated for voting. The size of the circles corresponds to the percentage of the total points awarded; therefore, the largest circle of each color represents the highest-ranked STA in that region.

Some of the results of the STA voting exercise were somewhat surprising to the MAIA team, especially that Lagos was the STA of most interest in Europe and Africa, given that it is an extremely cloudy location. The attendees indicated that, although the MAIA data quality might be somewhat handicapped by cloudiness, the lack of other reliable air pollution data there made it a priority.

The attendees were asked which additional target area they would pick (one vote per person). They then voted on the suggestions, and the most popular (greater Washington, D.C.) was selected to vet as if the attendees were the MAIA Science Team conducting the target selection. In terms of science value, the attendees agreed the region was interesting due to the many health studies ongoing, the many freeways, the rapid expansion of the area and the associated construction-related emissions, and the cross-state transport that is a large concern of the applicable air quality agencies. Cloudiness was quickly checked via the Weatherspark online tool and found to not be a large impediment to observations. Attendees viewed the MAIA team's map of surface monitors in the US and found that adequate monitors did exist to produce PM data. However, the region is in close proximity to two PTAs (Boston and Atlanta) and another STA (Toronto). Given that, David Diner estimated that Washington, D.C. might only be able to receive one MAIA observation per week, and the science team members present expressed that they would probably vote for an area that would receive more frequent observations. Afterward, attendees were given the option to reconsider their original vote based on their experience. While 31% decided to stay with Washington, D.C, the remainder switched to Kenya, which had been in second place during the first round.

Attendees were also asked to suggest additional criteria to the MAIA science team to vet PTAs and STAs. They suggested considering the mortality due to PM (using the Global Burden of Disease), the recent trend of PM concentrations, the number and quality of currently available PM data and health studies, and the likelihood of MAIA results to successfully inform air quality policy in the region.

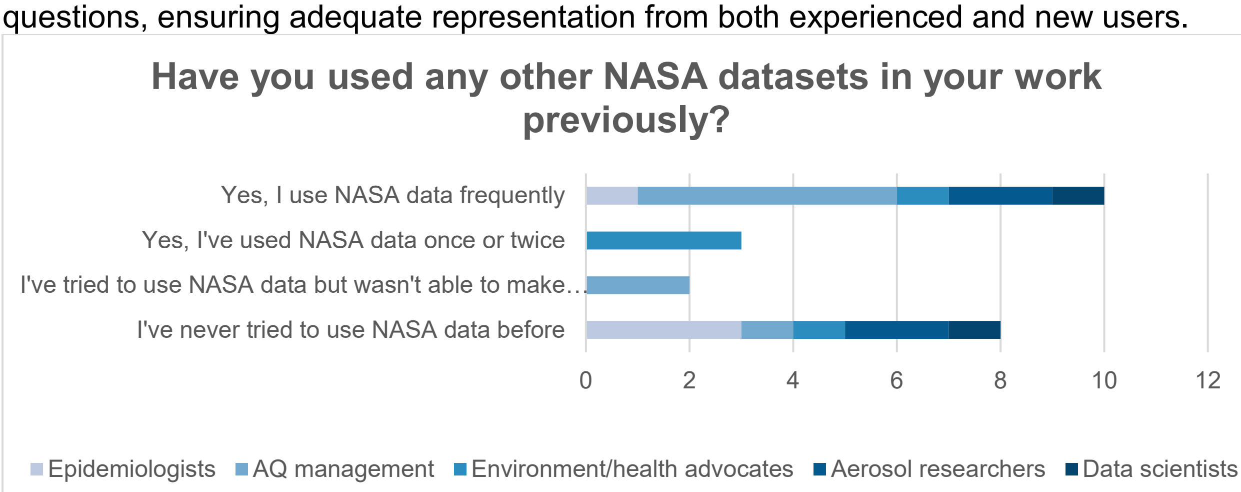
4.2 Data product needs discussion exercise

The next discussion exercise was focused on the details of the attendees' needs in regards to how they envisioned using MAIA data. First, after a brief review of the planned products, their content and structure, and data production schedule, the attendees were asked to specify the applications they might use MAIA data to accomplish. Their input included:

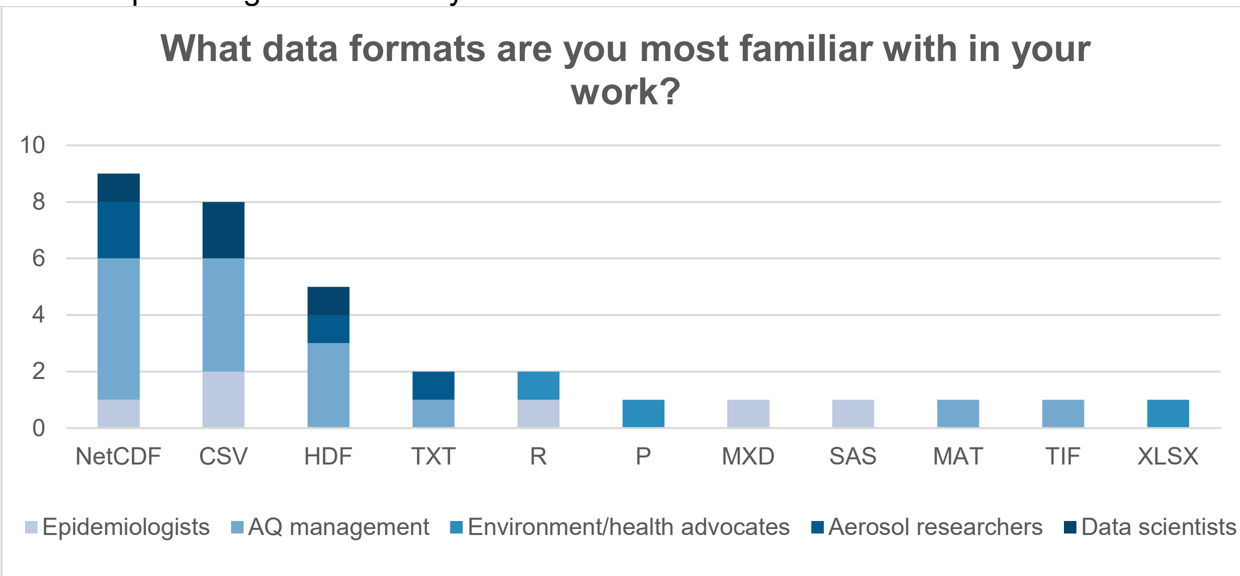
- Epidemiological studies and health impact assessments (including the health effects of dust storms and the impact of PM on mental health and homelessness)
- Aerosol characterization (including wildfire and inversion layer impacts)
- Hotspot identification and source apportionment
- Informing ground monitor siting
- Improving air quality forecast models
- Evaluating and validating models
- Providing information to health leaders to increase regional awareness of issues
- Informing policy makers

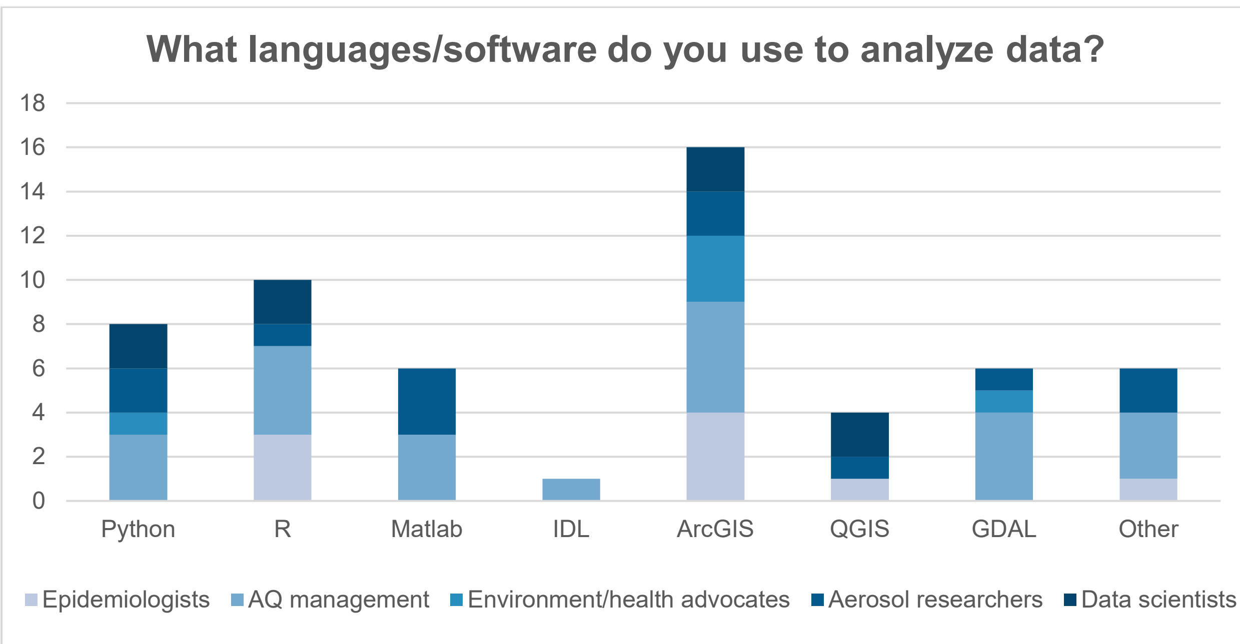
Next, the attendees were answered a series of questions on their data needs. For the purpose of this exercise, they were asked to divide into the following groups: epidemiologists, air quality management, environment/health advocates, aerosol researchers, and data scientists. (While the MAIA team members who didn't fall into these categories were able to answer these questions, their results are not included here as they are considered the providers rather than the users of the data.)

Most of the attendees had either used NASA data frequently, or had never attempted to use NASA data before. This made the audience a good test case for the following questions, ensuring adequate representation from both experienced and new users.

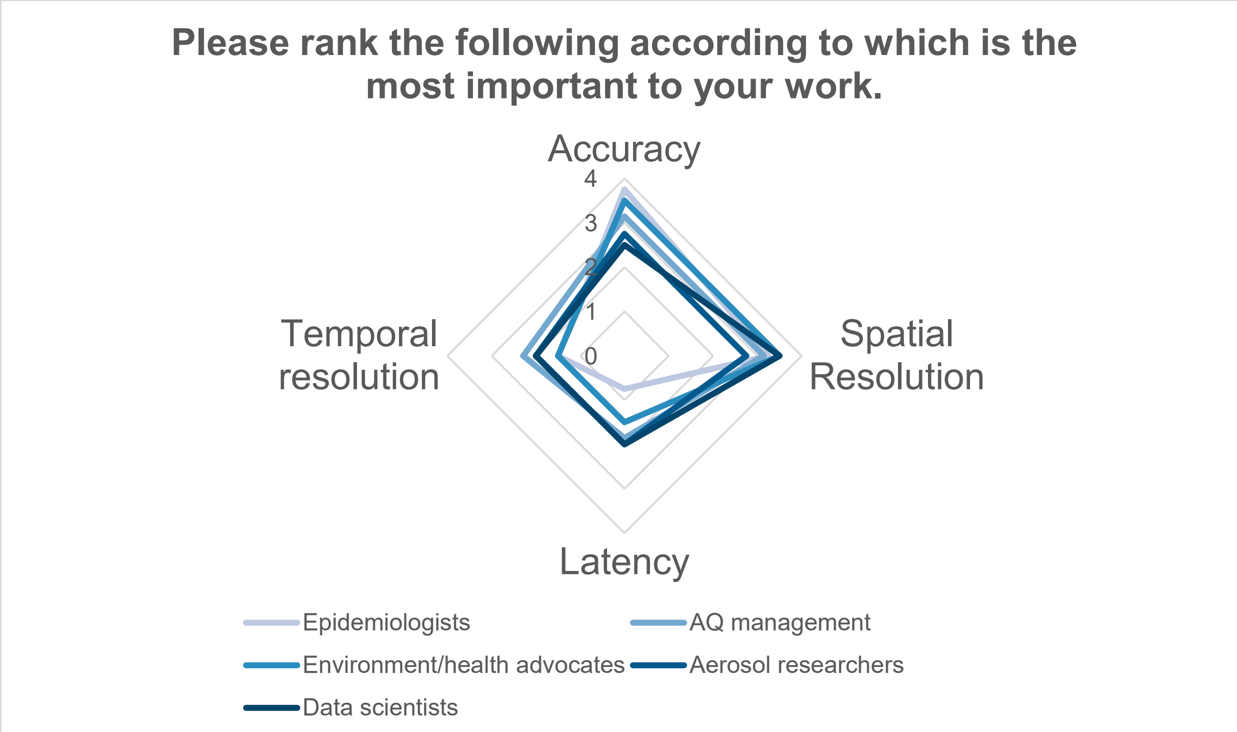


First, the attendees specified which data formats and analysis tools they were most familiar with. The results indicate that the team's choice of NetCDF for the planned MAIA products will be familiar to many stakeholders, but that it would be beneficial to consider providing tools to easily convert files to CSV and work with files in GIS tools.

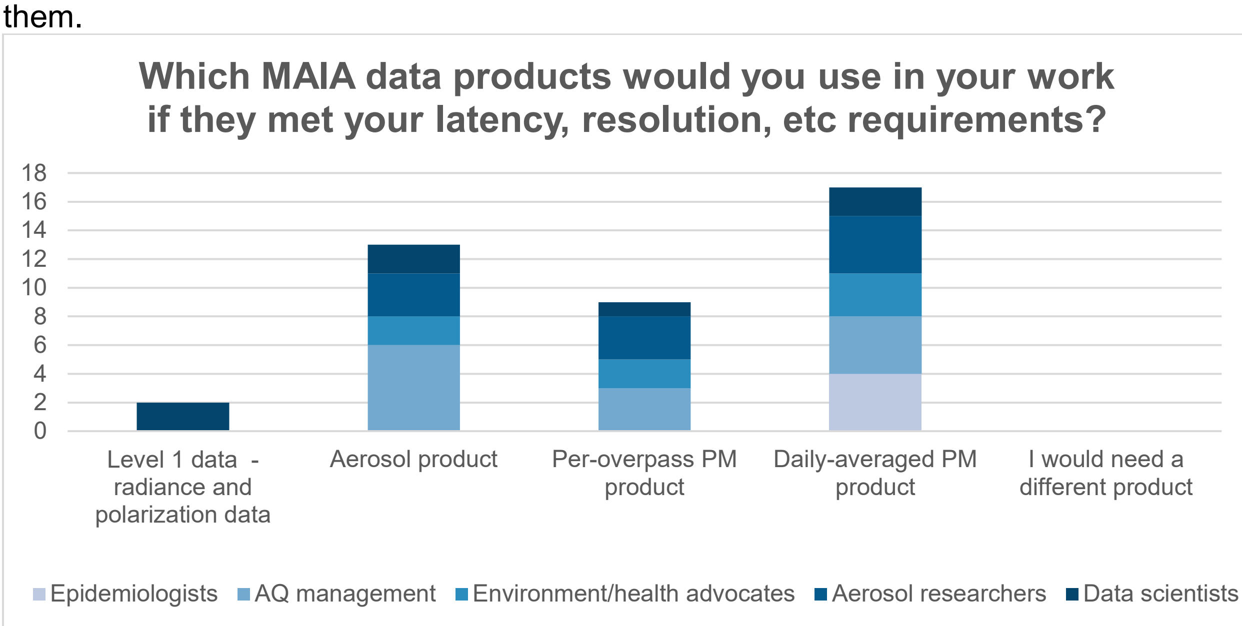




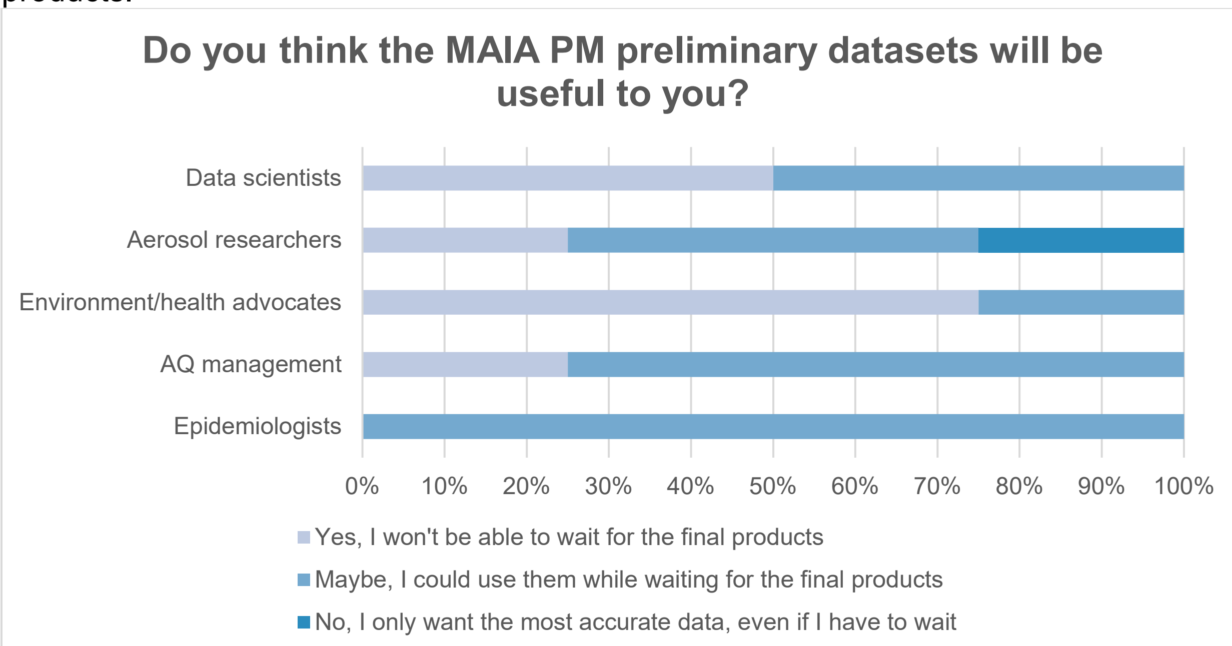
Next, the attendees were asked to rank whether accuracy, spatial resolution, temporal resolution, or latency was most important to them. In general, accuracy was the most important to each group except the two data scientists (who ranked spatial resolution as most important). Spatial resolution was generally the second most important, followed by temporal resolution and finally latency. This matches well with MAIA's planned products, which will provided at relatively high spatial resolution (1 kilometer planned resolution for the PM products), but with daily or coarser temporal resolution and with relatively high latency. More details about each groups' individual resolution and latency needs can be found in Appendix C.



Attendees also evaluated which of MAIA's planned data products they would ideally like to use. Results of note include that the data scientist group were the only ones to express interest in the Level 1 radiance and polarization data, and all the epidemiologists present responded that they would only use the Level 4 PM product, while the other groups were interested in a variety of products. A good sign is that no attendees responded that none of the planned MAIA data products were of interest to them.



Attendees were also asked about their likelihood to use the MAIA preliminary PM data products, which are the product versions that will be produced using a geostatistical regression model trained using pre-launch data. While these products will have reduced quality, they will be the only ones available for up to a year after launch. Only one attendee (an aerosol researcher) did not want to examine the preliminary data products, while 36% of the attendees said they would require the preliminary products in order to be able to use MAIA data at all, with the remainder indicating that the preliminary products would be a useful way to prepare while waiting for the final products. Overall, this supports the MAIA team's decision to produce the reduced-quality preliminary data products.



Finally, attendees were asked to give feedback on what additional measurements/products would make MAIA more useful to them, and what data "pet peeves" the MAIA team should work to avoid. The suggestions for additional data were:

- PM_1 data: While the MAIA team has no science requirements in regards to PM_1, the team is aware it is a burgeoning topic in the air quality community and is conducting some preliminary conversations regarding PM_1 in certain target areas.
- Trace metals: While this is another expanding topic in air quality, nothing so far indicates that any current or planned spaceborne instruments have the capability to detect atmospheric trace metals.
- Near real-time products: The MAIA team is currently evaluating the minimum latency that might be possible, but this depends on both the runtime of the algorithms and the latency with which ASDC will receive the data downlinked from the host satellite.
- Public-friendly visualizations/products to allow individuals to learn about air pollution at their location: The MAIA team and ASDC are very interested in addressing this need, and conversations are ongoing amongst the team.

In terms of avoiding data pet peeves, the attendees emphasized the following:

- Constructing an efficient system to download large volumes of data
- Providing clear, easy-to-find documentation for first time users (ideally within the products themselves)
- Providing in-depth per-pixel confidence screening, ideally based on inventory strength, proximity to surface monitors, gaps in the MAIA aerosol data, etc.
- Ensuring that clear guidelines are provided on the appropriate use and overall accuracy of the MAIA data products, given that the mission is concerned with an issue of interest to the general public and will probably attract inexperienced users to download the MAIA data products.

5. Conclusions and recommendations

The discussion of MAIA candidate target areas provided some new feedback for the team to consider while refining the choice of target areas. In particular, some target areas such as Lagos may receive higher priority from the team given the emphasis placed on providing whatever data possible in regions that lack other sources of air pollution information. The team may also consider additional criteria for target area selection, especially the recent trends in PM. Based on continuing conversations with individual attendees and other contacts, the team may consider additional target areas for selection.

Based on attendee feedback, the MAIA team should feel confident in their decisions to produce the MAIA data in NetCDF format and provide preliminary products during the first year of mission. However, the team should investigate options for ensuring the products can be easily converted to CSV and are compatible with GIS programs, as well as looking into opportunities to provide public-friendly data product versions and visualizations. Feedback also emphasized the importance of the data validation effort and the need to provide Early Adopters with estimates of data accuracy and latency, as well as simulated data products, as soon as possible.

In regards to the workshop format, the use of the Mentimeter online feedback tool appeared to increase the interactivity of the workshop and lend an element of fun. The anonymous online tool created the expectation that every attendee participate, which most likely generated more feedback than a traditional verbal discussion might. The initial questions at the beginning allowed the presenters to take the audience's prior knowledge into account, and the quizzes allowed the MAIA team to check in real time whether the audience had absorbed the correct information from their presentations, and correct any misconceptions on the spot. The use of Mentimeter also ensured that individual feedback was recorded and preserved in the discussion exercises. Several attendees expressed appreciation afterward for the use of the tool.

Attendees rated the workshop highly, giving a response of 4.9 out of 5 to the statement "I learned what I need to determine if MAIA is useful to me" and 4.7 out of 5 to the statement "I had fun at the workshop." Overall, the workshop was effective at conveying information; attendees' average rating of the statement "I know a lot about MAIA" increased from 3.4 to 4.7 (out of 5) before and after the workshop, while “I know how to get involved with MAIA” increased from 3.5 to 4.9 and “I think MAIA can help me in my work” increased from 4.4 to 4.9. Based on this feedback, future MAIA Early Adopter Workshops will most likely employ a similar format, perhaps with even more time for interactive discussion once more technical details about MAIA are available online or through publications.

Appendix A: Agenda

MAIA Early Adopters Workshop
Pasadena Hilton, 168 S Los Robles Ave, Pasadena, CA 91101
Wednesday, 5 June 2019

Welcome and introductions

8:30 AM	Sign-in and refreshments	All	30
9:00 AM	Introduction from NASA Applied Science Program	John Haynes	10
9:10 AM	Introductions and overview of Early Adopters Program	Abbey Nastan	25

MAIA: What you need to know

9:35 AM	MAIA satellite instrument, observations, and products	David Diner	30
10:05 AM	Surface monitor data and integration	Kris Verhulst	15
10:20 AM	Break	All	15
10:35 AM	Overview of MAIA data production: latency, formats, etc.	Scott Gluck	15
10:50 AM	NASA ASDC: plans for data distribution	Jeff Walter/Makhan Virdi	15
11:05 AM	Questions/discussion	All	15

MAIA Target Areas

11:20 AM	Introduction to target types	David Diner	5
11:25 AM	Primary Target Areas	David Diner	15
11:40 AM	Secondary Target Areas	Abbey Nastan	15
11:55 AM	Discussion	All	20
12:15 PM	Lunch	All	75

Example applications of MAIA data

1:30 PM	Health studies in Kuwait	Meredith Franklin	15
1:45 PM	Health studies in Denver	Jim Crooks	15
2:00 PM	Emission/forecasting and health studies in Phoenix	Daniel Tong	15
2:15 PM	CARB plans and MAIA	Hyung Joo Lee	15
2:30 PM	SCAQMD plans and MAIA	Sang-Mi Lee	15
2:45 PM	Questions/Discussion	All	15
3:00 PM	Break and refreshments	All	15

Discussion exercises

3:15 PM	Exercise 1: Target Areas	All	30
3:45 PM	Exercise 2: Latency, spatial/temporal resolution, content and format	All	30
4:15 PM	Questions/summarization	All	30
4:45 PM	Wrap-up and summary of future plans	Abbey Nastan	15
5:00 PM	Adjourn		

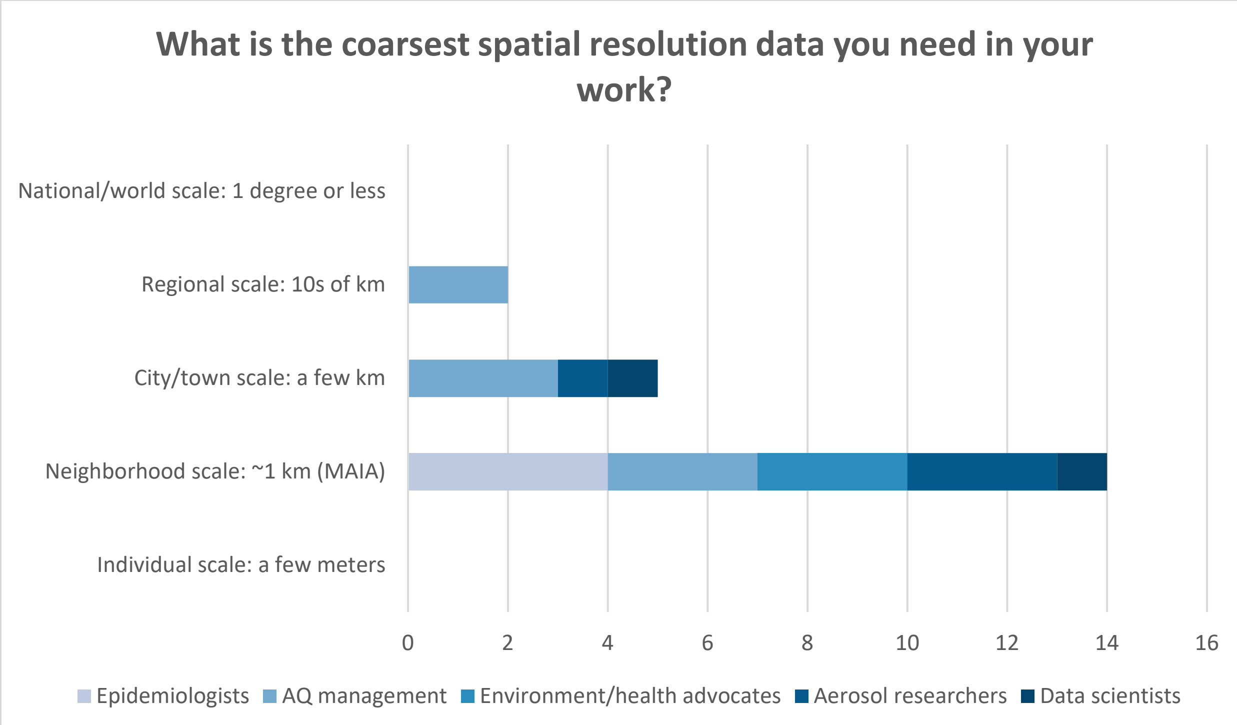
Appendix B: Attendees

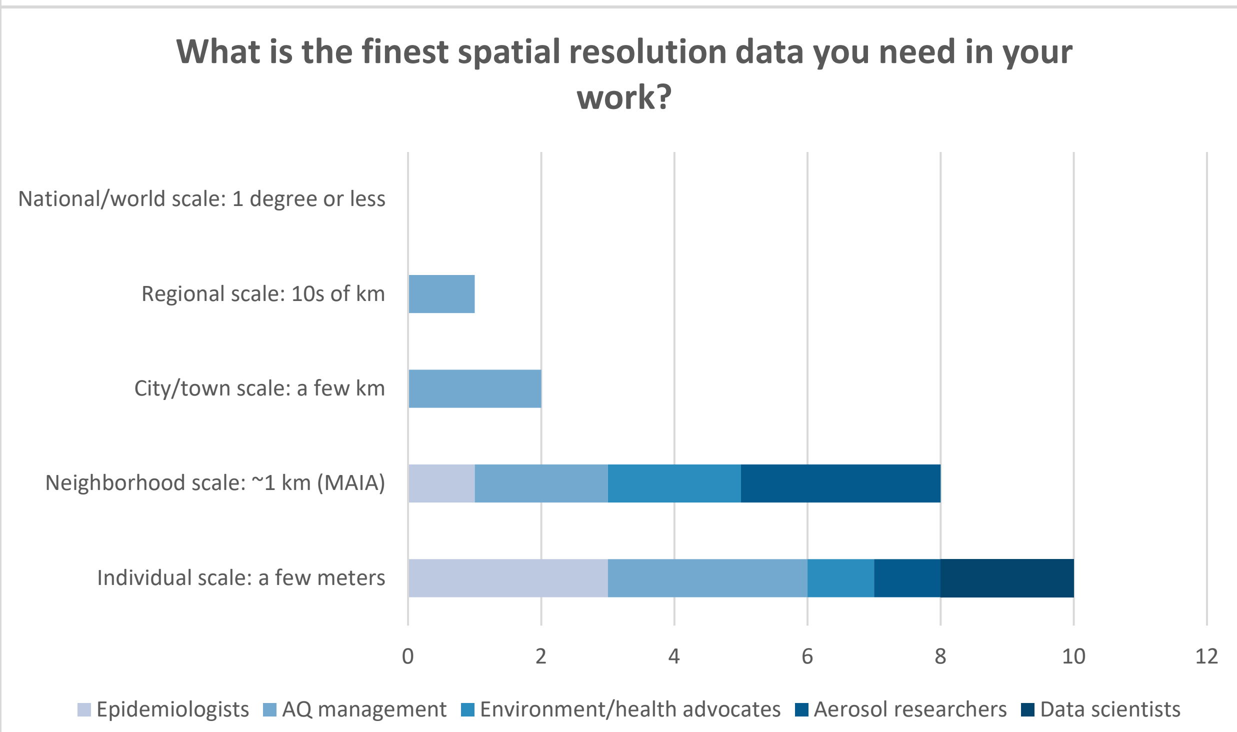
Name	Affiliation	In-person/online
Abigail Nastan	Jet Propulsion Laboratory	In person
Alexandra Chudnovsky	Tel Aviv University	Online
Allan Just	Mount Sinai Hospital	Online
Alyssa Deardorff	Jet Propulsion Laboratory	In person
Anthony Lyons	City of Los Angeles	In person
Beate Ritz	University of California Los Angeles	In person
Cade DeVere	California Communities Against Toxics	In person
Charles Davidson	Sunflower Alliance	In person
Christian Pelayo	California State University Los Angeles	In person
Christina Isaxon	Lund University	In person
Daniel Tong	George Mason University	In person
David Broday	Technion	Online
David Diner	Jet Propulsion Laboratory	In person
Dejian Fu	Jet Propulsion Laboratory	In person
Ebba Malmqvist	Lund University	In person
Edward Hyer	Naval Research Laboratory	Online
Elizabeth Masekoameng	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	Online
Evenor Masis	Los Angeles County Public Health Department	In person
Feng Xu	Jet Propulsion Laboratory	In person
Gerard van Harten	Jet Propulsion Laboratory	In person
Helena Chapman	NASA Headquarters	In person
Huanxin Zhang	University of Iowa	In person
Hye-Youn Park	California Air Resources Board	Online
Hyung Joo Lee	California Air Resources Board	In person
Ivan Gutierrez-Avila	Mexican National Institute of Public Health	Online
James Crooks	National Jewish Health	In person
James Tang	Los Angeles County Public Health Department	In person
Jane Williams	California Communities Against Toxics	In person
Jason Schroeder	California Air Resources Board	In person
Jeanne Holm	City of Los Angeles	In person
Jeff Walter	NASA Atmospheric Science Data Center	In person
Jesse Marquez	Coalition for a Safe Environment	In person
John Haynes	NASA Headquarters	In person
Karin Ardon-Dryer	Texas Tech University	In person
Keita Ebisu	Office of Environmental Health Hazard Assessment (Cal EPA)	Online

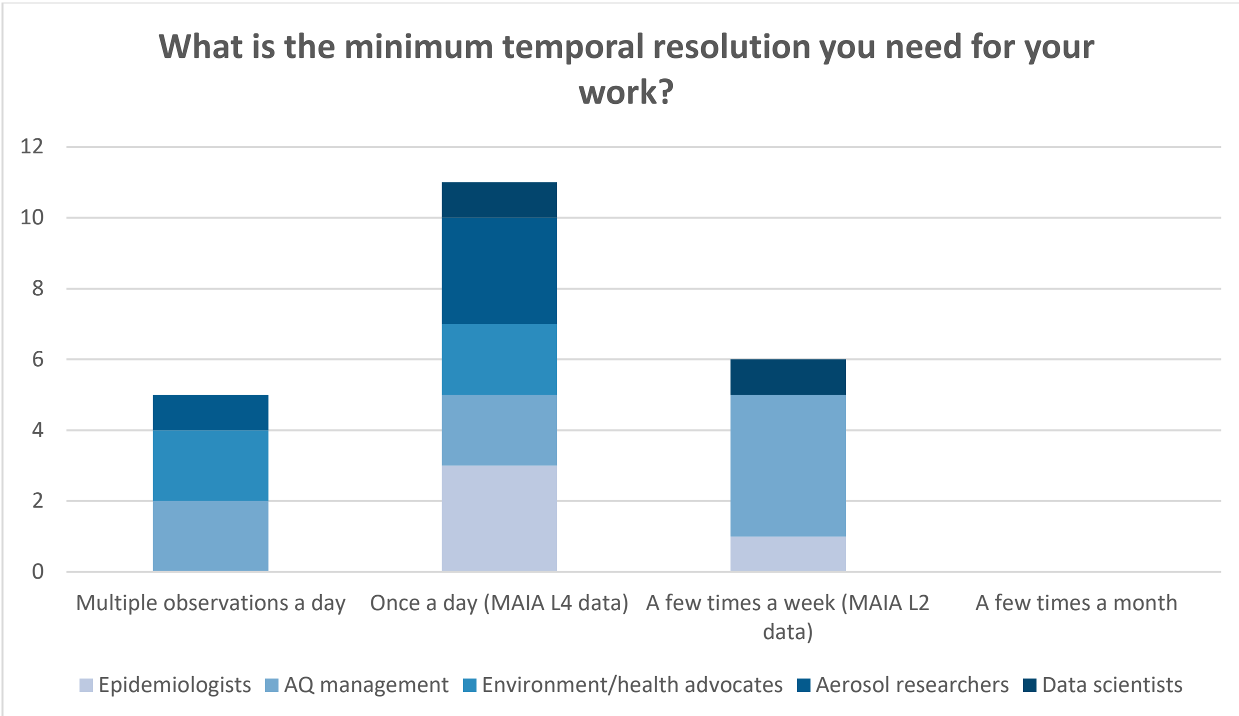
Ken Szutu	Citizen Air Monitoring Network	In person
Kiros Berhane	University of Southern California	In person
Makhan Virdi	NASA Atmospheric Science Data Center	In person
Meredith Franklin	University of Southern California	In person
Michael Garay	Jet Propulsion Laboratory	In person
Michael Glenn	Retired from USDA	Online
Lotta Mayana	South African Air Quality Information System	In person
Myungje Choi	Jet Propulsion Laboratory	In person
Pablo Saide	University of California Los Angeles	In person
Pei Chen Lee	National Taipei University of Nursing and Health Sciences	In person
Rebecca Garland	Council for Scientific and Industrial Research (South Africa)	Online
Robert Vasquez	Los Angeles County Public Health Department	In person
Sagnik Dey	Indian Institute of Technology Delhi	In person
Sang-Mi Lee	South Coast Air Quality Management District	In person
Scott Gluck	Jet Propulsion Laboratory	In person
Sina Hasheminassab	South Coast Air Quality Management District	Online
Stephen Broccardo	NASA Ames	In person
Sue Estes	NASA Headquarters	In person
Susan Alexander	University Alabama Huntsville	In person
Toshihiro Kuwayama	California Air Resources Board	In person
Victor M. Polanco	Coalition for Clean Air	Online

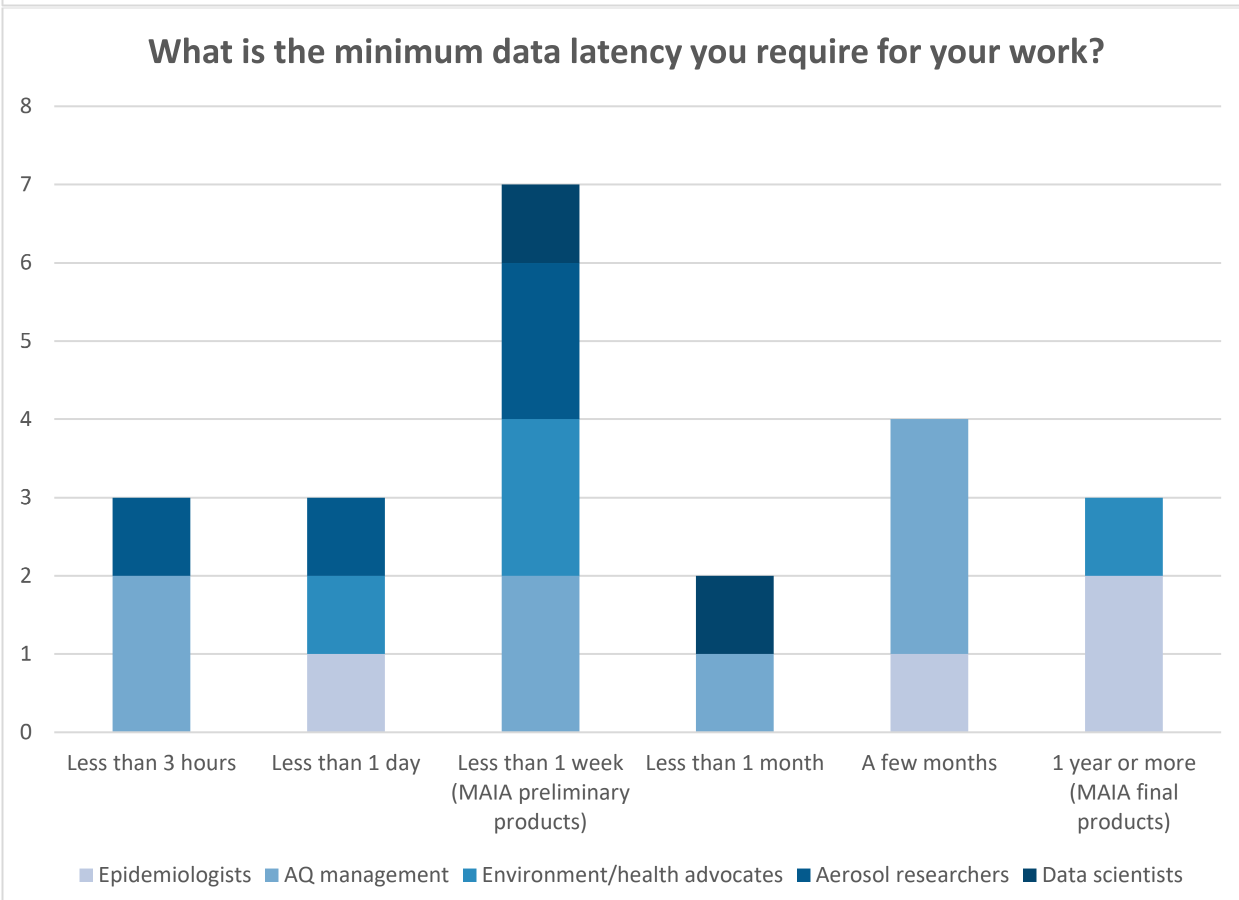
Appendix C: Resolution and latency user needs

The following charts summarize the spatial and temporal resolution and latency needs of the surveyed groups.






What is the minimum temporal resolution you need for your work?
12
10
8
6
4
2
0
Multiple observations a day
Once a day (MAIA L4 data)
A few times a week (MAIA L2 data)
A few times a month
Epidemiologists
AQ management
Environment/health advocates
Aerosol researchers
Data scientists


What is the minimum data latency you require for your work?
8
7
6
5
4
3
2
1
0
Less than 3 hours
Less than 1 day
Less than 1 week (MAIA preliminary products)
Less than 1 month
A few months
1 year or more (MAIA final products)
Epidemiologists
AQ management
Environment/health advocates
Aerosol researchers
Data scientists