September 2021 MAIA Early Adopters Workshop Report

Virtual workshop, September 14, 2021

Coordinator:

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1. Introduction

The Multi-Angle Imager for Aerosols (MAIA) project is a competitively selected NASA instrument investigation focused on the study of air quality and societal benefit. The project is part of NASA's Earth Venture Instrument program and will be hosted on a spacecraft to be named at a future date, with launch likely occurring no earlier than 2023.

The third annual MAIA Early Adopters Workshop was held on September 14, 2021, in a virtual format. The objectives of this workshop were to:

1. Inform new MAIA Early Adopters about the MAIA mission, target areas, and data products.
2. Inform workshop participants of progress and updates on the MAIA project since the 2020 joint workshop with TEMPO, including important information about the current MAIA launch delay.
3. Debut the MAIA Simulated Data products created using the pre-launch version of the MAIA software system, which are intended to help Early Adopters plan for MAIA data and enable them to provide feedback on the data products, and provide tutorials for their use.

The full agenda for the workshop is included here in Appendix A. 141 people registered for the Early Adopters workshop, of which 80 attended live and the remainder received the workshop recording for asynchronous viewing. The participants included epidemiologists, environmental health researchers, air quality managers, environmental justice advocates, and others. The full list of attendees is included in Appendix B.

Due to the ongoing COVID-19 pandemic, the coordinator decided the 2021 workshop would be held virtually, similar to the 2020 joint workshop held with the TEMPO project. To reduce teleconference fatigue, the agenda was compressed to five hours and introductory material about the projects was migrated to slides made available to participants in advance of the workshop.

The workshop was presented via Webex teleconference and an online tool called Mentimeter (https://www.mentimeter.com) was employed to allow all participants to ask questions and provide feedback in real time. Activities included some initial questions before the workshop began to gauge the attendees' previous knowledge, as well as quizzes to ensure that the teams had successfully communicated the most salient points about the projects. The workshop was also recorded, both for the benefit of registrants with conflicting obligations or in disparate time zones, and also to serve as a future resource for those receiving the MAIA Simulated Data.

1.1 Introduction to the NASA Multi-Angle Imager for Aerosols (MAIA) Early Adopters Program

MAIA's primary science objective is to study the effects of various compositional makeups of particulate matter (PM) air pollution on human health. Exposure to PM air pollution is recognized as the largest worldwide 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 PM air pollution. The data collected from the instrument will be combined with 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. Epidemiologists on the MAIA team will conduct studies on the health impacts of the derived PM compositions.

From the beginning, MAIA has included a diverse team of co-investigators along with collaborators from the Environmental Protection Agency (EPA), National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the National Oceanic and Atmospheric Administration (NOAA). This unique team will help ensure that MAIA data products and science advancements are able to make a material impact on those managing public health air quality issues. More recently, collaborations with the South Coast Air Quality Management District (SCAQMD), the US Agency for International Development (USAID), and the US Department of State have been established, and a cadre of collaborators who will assist in surface monitor operations and epidemiological studies in the target areas has been identified. In addition, the NASA Applied Sciences Program (ASP) is committed to developing and implementing a broad-reaching applications program to reach additional 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 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, take advantage of resources including simulated data products prior to launch, and offer feedback to the project on potential product improvements. The Early Adopters program is intended to entrain potential users outside the MAIA science team prior to launch and provide resources to ensure the MAIA project is meeting their individual needs to the greatest possible extent. MAIA Early Adopters, who numbered 178 individuals at the time of this writing, will have the opportunity to offer feedback on MAIA's planned 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, including a link to sign up for the MAIA Early Adopters mailing list and apply to receive the MAIA Simulated Data, are available on the applications page of the MAIA website (https://maia.jpl.nasa.gov/resources/data-and-applications/).

2. Summary of workshop proceedings

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 and other interested parties.

2.1 MAIA project updates

2.1.1 MAIA project and launch update (presenter: David Diner, JPL)

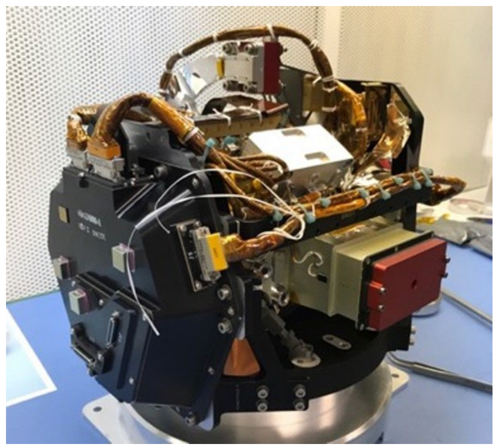

Figure 1. The completed MAIA camera assembly.

The workshop began with a welcome from John Haynes, NASA ASP Health and Air Quality Program Manager, and an introduction to the workshop from MAIA Deputy Program Applications Lead, Abigail Nastan. After this, MAIA's principal investigator David Diner offered an introduction to the project, including an update on current status of the instrument build, surface monitor deployments, target areas, and data products. At the time of the workshop MAIA instrument delivery was expected in February 2022. The current projection for receipt of the two-axis gimbal from the vendor has moved the instrument completion date to late Spring 2022. Deployment of the surface monitors MAIA will use to supplement existing networks is ongoing, and should be complete by end of CY 2021 or early CY 2022. The project reported a delay in the expected launch date, which was previously expected in late 2022 and will now occur no earlier than 2023. The launch delay is the result of a NASA decision to change the spacecraft provider. For planning purposes the project is assuming launch in the October 2024-March 2025 timeframe. This is subject to update once the host is selected.

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 Figure 2) 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 dailyaveraged, gap-filled PM concentration product will be produced using a chemical transport model 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.

The latest list of candidate MAIA target areas (Figure 2) was also presented. The MAIA Primary Target Areas, wherein epidemiologists on the MAIA Science Team will conduct health studies, are mostly finalized with a list of 11 identified targets, and two additional targets (Seoul, South Korea and Santiago, Chile) that may be upgraded to Primary Target Areas depending on surface monitor data availability. Deployments of Surface PARTiculate mAtter Network (SPARTAN) and Aerosol Mass and Optical Depth (AMOD) filter-based samplers, AethLabs aethelometers, PurpleAir low-cost sensors, and AERONET sunphotometers to supplement surface monitors already present in the Primary Target Areas are underway in several of these areas to ensure sufficient surface-based measurements to complement the satellite data acquisitions. The MAIA Secondary Target Areas include cities with major PM pollution, aerosol source regions, climatically important cloud regimes, or other locations of scientific interest. As of September 2021, the MAIA team has identified 27 potential Secondary Target Areas based on team and Early Adopter input, with San Juan, Puerto Rico and Yakutsk, Russia being the most recently added. Calibration/Validation Target areas will be primarily used for instrument radiometric, polarimetric, and geometric calibration while in flight.

Primary Target Areas

- USA-LosAngeles
- USA-Atlanta
- USA-Boston
- ESP-Barcelona
- ITA-Rome
- ZAF-Johannesburg
- ISR-TelAviv
- ETH-AddisAbaba
- IND-Delhi
- CHN-Beijing
- TWN-Taipei

Secondary Target Areas

- USA-Hilo
- PAC-OceanStCu
- USA-SanFrancisco
- USA-Phoenix
- USA-Denver
- MEX-MexicoCity
- CAN-Toronto
- PER-Lima
- CHL-Santiago
- PRI-SanJuan
- BRA-SãoPaulo
- SEN-Dakar
- GHA-Accra
- ATL-OceanStCu
- NGA-Lagos
- ZAF-CapeTown
- SRB-Belgrade
- KEN-Nairobi
- ETH-Harar
- KWT-KuwaitCity
- PAK-Karachi
- IND-Chennai
- BGD-Dhaka
- THA-Bangkok
- VNM-Hanoi
- MNG-Ulaanbaatar
- RUS-Yakutsk
- KOR-Seoul
- AUS-Sydney

Calibration/Validation Target Areas

- USA-RailroadValley
- MRT-Mauritania1
- NAM-Gobabeb
- LBY-Libya4

Figure 2. The MAIA candidate target areas (current as of September 2021).

2.1.2 ASDC updates and plans for MAIA data (presenter: Makhan Virdi, ASDC)

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 Earthdata forum 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.

2.1.3 Special topic: MAIA-TEMPO crowdsourcing algorithm challenge (presenter: Aaron Naeger, NASA MSFC/University of Alabama-Huntsville)

Aaron Naeger, the Deputy Program Applications Lead for the TEMPO project, spoke on an upcoming joint MAIA-TEMPO event sponsored by the NASA Tournament Lab. The MAIA and TEMPO projects have collaborated closely over the past years, as they are both NASA Earth Venture Instrument projects that will provide complementary data on air quality. MAIA's data products, focusing on particulate air pollution, will have higher spatial resolution and will be generated over discrete locations distributed around the globe, while TEMPO's data products focusing on trace gas pollutants including ozone and nitrogen dioxide will have higher temporal resolution and will provide complete coverage of North America.

The MAIA and TEMPO applications programs are currently jointly supporting the development of a crowdsourcing challenge, funded by a successful proposal to the NASA Tournament Lab. The task of the participants is to use satellite imagery, meteorological data, and other data sources to develop models for estimating daily levels of PM2.5 and NO2 with high spatial resolution over several discrete locations worldwide. By vetting a large number of submissions employing various model structures and data inputs, we can gather more information on what algorithm designs lead to the highest-performing models.

The challenge is expected to launch in January 2022. The MAIA and TEMPO Deputy Program Application Leads are currently working with the vendor selected to run the challenge, DrivenData, to finesse the challenge design and develop the data starter package that will be distributed to participants.

2.2 MAIA Simulated Data background

The second portion of the workshop consisted of background about the MAIA Simulated Data, which was debuted at this workshop.

2.2.1 What is the MAIA Simulated Data and how was it made? (presenters: James McDuffie and Greg Moore, JPL)

James McDuffie, MAIA L2/L4 data system development lead, and Greg Moore, MAIA L4 PM algorithm developer, presented on the techniques used to create the MAIA Simulated Data provided to workshop participants. First, James McDuffie presented a brief summary of how the MAIA L2 aerosol algorithm retrieves total column aerosol properties using an iterative non-linear optimization model. Once MAIA launches, the L2 aerosol algorithm will use MAIA L1 radiance and polarization data as input. To create the pre-launch Simulated L2 aerosol product, the MAIA team used results from the WRF-Chem chemical transport model, MAIAC surface properties, and the simulated MAIA L1B2 files to create a simulated radiance/polarization file to use as input to the MAIA forward aerosol model. The simulated data provided to Early Adopters uses the products of the "mission like" testing of the algorithm, which uses the pre-launch settings for the initial guess and runs in an identical fashion to how the post-MAIA retrieval algorithm is intended to run. The algorithm was also tested in “truth in/truth out” mode, which tests that providing the algorithm with a simulated result as an initial guess results in an identical retrieval, but these results were not included in the Early Adopter package as they are purely intended to test that the retrieval is stable.

The package of L2 aerosol simulated data provided to workshop participants contains the “mission like” testing results for a single-day test of the Mexico City, Boston, Denver, and Los Angeles target areas. Future releases of the Simulated Data may include more target areas, and will also include updates to the algorithm such as noise from simulated measurement uncertainty and simulated instrument characteristics.

Next, Greg Moore spoke about the process used to create the L2 PM Simulated Data provided to the workshop participants. The MAIA PM retrieval approach uses a geostatistical regression model (GRM) with a Bayesian Hierarchical approach, trained by regressing measurements from PM surface monitors against geospatial and spatiotemporal predictors, and then used to predict ground-level PM. There will be two post-launch MAIA PM products, the L2 product that will use the L2 aerosol product as a predictor, and the L4 product will use a bias-corrected CTM as input where L2 aerosol data is not available. (The motivation for the L4 product is to provide a daily, gap-filled PM product to end users.) To create the pre-launch version of the L2 PM Simulated Data given to workshop participants, AERONET AODs and inputs from the pre-launch runs of the project’s customized instance of WRF-Chem (including boundary layer height, surface wind speed, relative humidity, and CTM-scaled AOD) were used as substitute inputs.

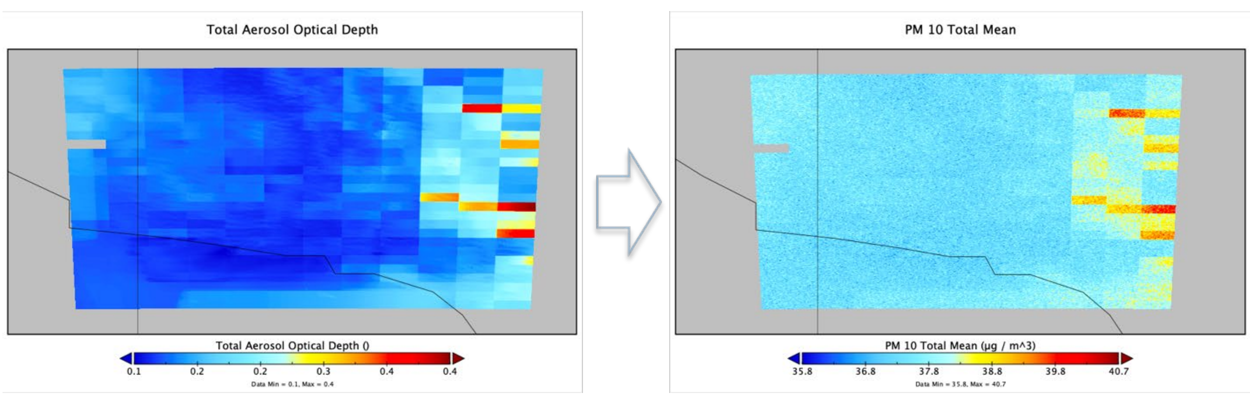

Figure 3. An example demonstrating the application of pre-launch GRM coefficients to L2 Simulated Aerosol data to generate PM_{10} estimates.

The development of the pre-launch versions of the MAIA PM forecast models will not only be used for software testing and creating Simulated Data for Early Adopters, but also to generate training/regression coefficients for the first post-launch version of the PM data products. This is because generation of the L2 and L4 PM products proceed in two phases: first, training using several months’ worth of data, followed by daily mapping (or regression) using these training coefficients.

The L2 PM Simulated Data file provided to participants is a single-day test for the Los Angeles target area, and importantly, only contains simulated data in the PM_{10} and PM_{10} uncertainty fields. The remainder of the structure of the data file is also present, but does not contain any values. Future releases of the PM simulated data will include files with simulated values in all parameters, as well as for additional targets. They will be created using a test algorithm with all of the geospatial and spatiotemporal predictors intended for use in the post-launch version (excepting, of course, the MAIA L2 aerosol data itself). Additionally, a simulated version of the L4 PM product will be made available, though the L2 and L4 products have identical file format.

2.2.2 Intended usage of the MAIA Simulated Data (presenter: Abbey Nastan, JPL)

Following the technical description of the creation of the MAIA Simulated Data products, MAIA Deputy Program Applications Lead Abbey Nastan spoke about encouraged (and discouraged) uses of the simulated data for Early Adopters. The simulated data is provided to Early Adopters by the MAIA project to allow them to evaluate if MAIA data will be helpful for their work; to get familiar with the MAIA product structure and format; to allow time for them to identify/learn tools or write code to process MAIA data; and finally, to allow them to evaluate the MAIA data and provide feedback that can potentially be incorporated before launch. The simulated data is NOT intended to be used for conducting health studies, writing scientific papers, making air quality management decisions, evaluating a person's own local air quality, or in any decision-making context. This is because the simulated data, as described in 2.2.1, was created as the result of tests of the MAIA retrieval algorithms that were only intended to test that the algorithm software is functioning as expected. The data have not been validated in any way and are not meant to represent truth. If Early Adopters have a desire to use the Simulated Data in a way not captured in the list of intended uses above, they are asked to contact Abbey Nastan to discuss the use prior to obtaining the data.

The MAIA team is aware that the current launch delay may negatively impact the plans of Early Adopters and other interested MAIA users, especially those that are working on a time-constrained project. Abbey Nastan offered to discuss potential alternate data sources with any Early Adopters who are so impacted, if desired.

2.2.3 User access agreement and how to obtain Simulated Data (presenter: Abbey Nastan, JPL)

In order to ensure users of the Simulated Data have read and understood the information summarized in the section above, the MAIA Applications Program has instituted a data access agreement that Early Adopters must sign before receiving the Simulated Data. Early Adopters are not required to submit the data access agreement in order to participate in the program; interested people can still submit the interest form to be added to the Early Adopters mailing list and receive notifications of workshops and events without receiving the Simulated Data, if desired. In effect, the MAIA Early Adopters program is now two-tiered: those who are on the mailing list and participate in events when desired, and those who receive the Simulated Data, and, in return, are asked to be somewhat more available to the MAIA team to provide feedback.

Specifically, Early Adopters who receive the Simulated Data are asked to attend at least one Early Adopters workshop and present their work with the Simulated Data and/or their plans for MAIA data (virtual attendance will be accommodated), provide one slide summaries of their use of the Simulated Data twice a year or as needed for reporting to the Health and Air Quality Applied Sciences Program, and to be available for ad-hoc requests for feedback from the MAIA team. In return, those with approved data access agreements will be included in a forum (Slack channel) to ask questions about the Simulated Data and discuss with other Early Adopters, and will receive all future releases of MAIA Simulated Data. Of course, they are also welcome to reach out to the MAIA Deputy Program Applications Lead Abbey Nastan whenever needed for assistance or to submit feedback.

The data access agreement form is available online here. Users are asked to read the agreement carefully and agree to use Simulated Data only for those purposes laid out on the form. The complete form can be submitted via email to abigail.m.nastan@jpl.nasa.gov. Once received, MAIA Deputy Program Applications Lead Abbey Nastan will review the submitter's intended use of the Simulated Data and then share the link to access the data through NASA Box, assuming there are no concerns. In the future, the Simulated Data will transition to being available via the Atmospheric Science Data Center and NASA-wide tools (such as Earthdata Search), just as the actual MAIA data will be.

2.2.4 Introduction to user resources (presenter: David Moroni, JPL)

To accompany the first release of the MAIA Simulated Data, the MAIA Applications Program commissioned the development of a user guide and Jupyter notebook (discussed in 2.3.2) covering the L2 PM product from David Moroni, the MAIA applied sciences engineer, who also serves as the data publication coordinator for the Physical Oceanography Distributed Active Archive Center (PO.DAAC), the NASA EOSDIS data center located at JPL. David gave a tour of the user guide during this presentation. The user guide covers some essential background of the MAIA project, instrument, and target areas, the structure of the L2 PM files (which will also be useful for the L4 PM files, as they have identical structure), and some details about access and analysis tools. The user guide is provided along with the Simulated Data files themselves via NASA Box, and will be updated as the Simulated PM files are updated.

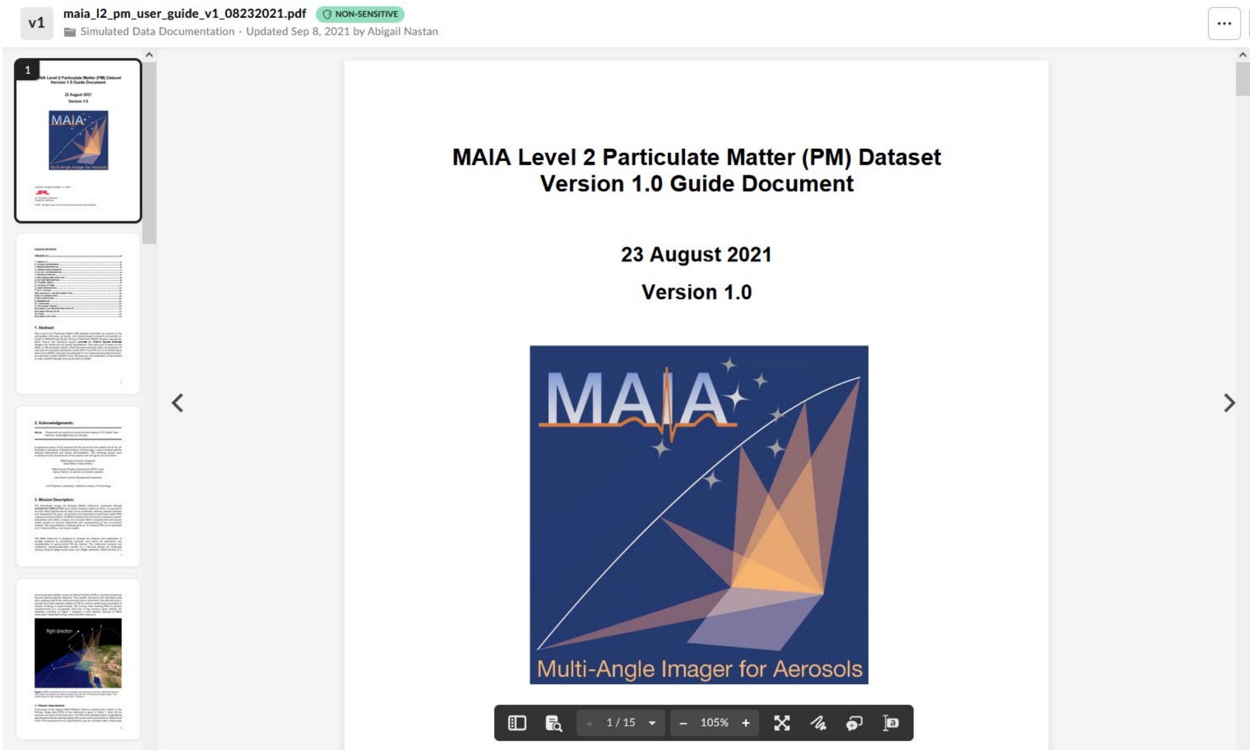

Figure 4. The MAIA L2 PM Simulated Data User Guide as displayed in NASA Box.

2.3 MAIA Simulated Data Tutorials

The third portion of the workshop consisted of three tutorials to help Early Adopters work with the MAIA Simulated Data. These tutorials were intended to both assist those attending live, who all received a copy of the first release of the MAIA Simulated Data before the workshop, and to serve as a future resource for those applying to receive the Simulated Data. Each tutorial will be saved as a separate video and distributed with the Simulated Data in the future.

2.3.1 Tutorial 1: Using NASA Box and Panoply (presenter: Abbey Nastan, JPL)

The first tutorial focused on how to navigate NASA Box to retrieve the Simulated Data files and how to use the free NASA Panoply software to open a file and familiarize oneself with the file contents, make and customize a plot, and export individual parameters as CSV files.

NASA maintains an institutional instance of the Box file-sharing tool, which allows users to share individual files and/or folders, either with other NASA Box users or publicly via a shared link. The initial release of the MAIA Simulated Data, along with supporting files and documentation, have been organized into a Box folder that was shared with workshop participants via shared link, and will also be made available to anyone submitting the data access agreement form (assuming their intended use of the

Simulated Data does not conflict with the terms of the agreement). The top-level directory of the folder contains: background slides on the MAIA project for users new to MAIA or anyone needing to look up relevant MAIA information, a recording of this workshop to serve as a user resource, and a copy of the data access agreement for reference. The Simulated Data is organized into a subfolder titled “Release 1.” Future updates to the Simulated Data will be added to new subfolders with sequential release numbers, to allow data continuity for users. Within the Release 1 folder, there is a “Documentation” subfolder – containing the user guide described in section 2.2.4, in PDF and HTML format – and a “Data” subfolder, which is further divided into “L2 Aerosol Simulated Data” and “L2 PM Simulated Data.” Box can display PDFs such as the user guide within the tool, but the data files themselves must be downloaded in order to display them.

Once the desired Simulated Data files are downloaded, the free NASA-provided Panoply software offers a convenient way to display and perform simple analysis and plotting with the data files. Panoply is compatible with all NetCDF, HDF-5, and GRIB files, and Windows, Macintosh, and Linux versions are available here. For the purposes of this tutorial, participants were shown how to work with the L2 PM Simulated Data file in Panoply. The structure of the data file was demonstrated, which is displayed as a hierarchical tree in Panoply’s data viewer – metadata details are also displayed in a side panel. The demonstration walked through how to use Panoply to make a georeferenced plot of the PM_{10} concentration parameter in the file, as well as common adjustments and customizations users might want to make to their plot, and how to save the plot once satisfied. In addition, Panoply also offers the functionality to export individual parameters as CSV files, which can be of use to those wishing to do further analysis on a small number of data files.

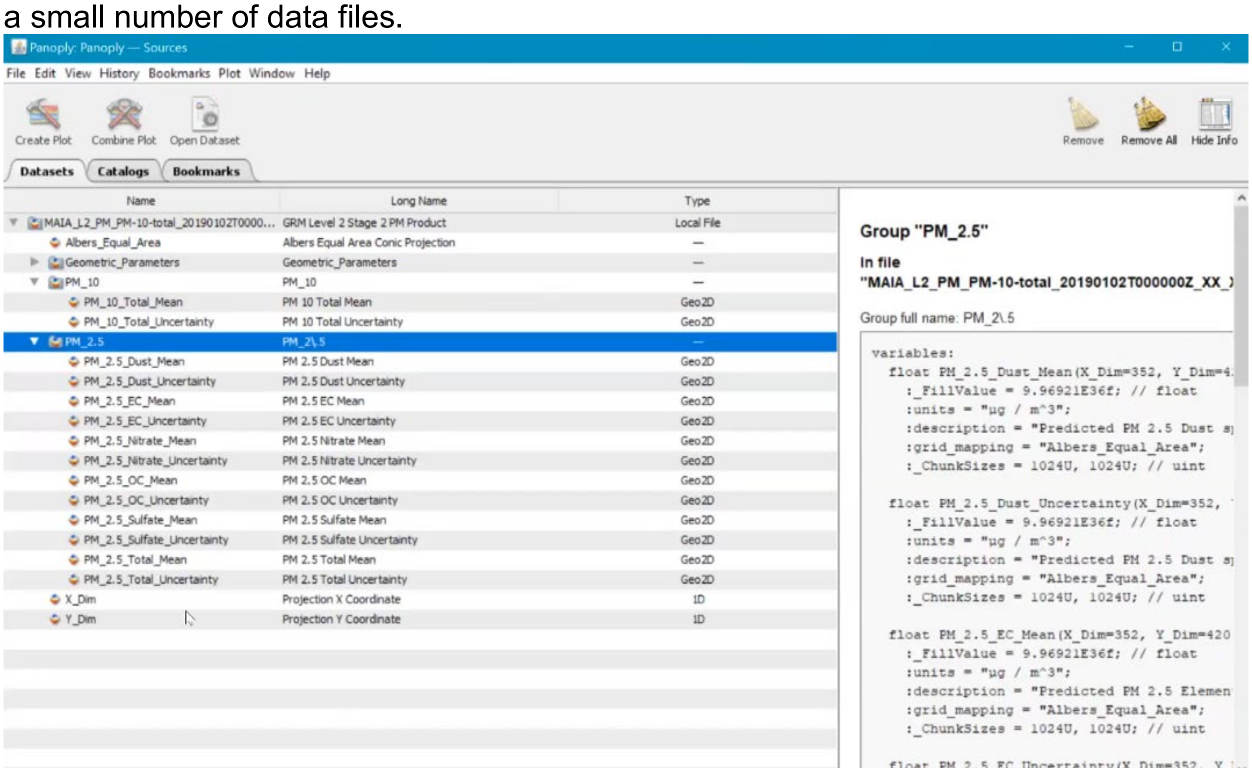

Figure 5. The MAIA L2 PM Simulated Data file structure, as displayed in the NASA Panoply tool.

2.3.2 Tutorial 2: PM product analysis with Jupyter notebook (presenter: David Moroni, JPL)

As discussed in section 2.2.4 above, David Moroni created a Jupyter notebook laying out a potential analysis workflow of the L2 PM Simulated Data file, using Python. During this tutorial, David walked through the various steps of the notebook in realtime. The Jupyter notebook demonstrates opening the file, reading the metadata to understand important parameters, and creating a visualization of the PM_{10} data. There are plans to include more functionality once additional aspects of the PM data product development are complete. Additionally, the notebook could be expanded to other programming languages such as R, depending on user needs. The notebook is publicly available through the Atmospheric Sciences Data center here. Users are encouraged to take advantage of the notebook as a starting point to develop their own codebase and workflows.

2.3.3 Tutorial 3: Aerosol Topics (presenter: Mike Garay, JPL)

The third tutorial focused on the L2 Aerosol Simulated Data files, and was conducted by Michael Garay, a MAIA science team member involved in the development of MAIA's aerosol retrieval approach. The L2 Aerosol files for MAIA have undergone the most extensive changes thus far based on user feedback, which was collected at the 2020 MAIA-TEMPO Early Adopters workshop (for more details on the changes made after the 2020 workshop, see the workshop report, section 4.1). The L2 Aerosol Simulated Data files shared at this workshop incorporate those changes. Compared to the L2 and L4 PM data from MAIA, the L2 Aerosol data is necessarily somewhat more complicated, because it is intended to fulfill the expectations of several user groups with somewhat different needs, notably those wishing to construct their own PM models using the aerosol data as input and those intending to use the MAIA aerosol file for aerosol research in continuity with other satellite products such as those from MODIS, MISR, and VIIRS.

Michael Garay demonstrated the structure of the L2 Aerosol files, and discussed which parameters would likely be of most interest to various user groups and where they are located in the file structure. He also walked participants through creating a plot of total aerosol optical depth. Finally, he also posed some questions to the community for future discussion, including:

- What are stakeholder/Early Adopter expectations regarding data parameters and uncertainties?
- How to best convey information on the product to end users – is metadata, documentation, publications, workshops or some combination the most useful route?
- Is anything missing from the L2 Aerosol files that users expected to be included?

3. Conclusions and recommendations

Attendees rated the workshop highly, giving a response of 4.0 out of 5 to the statement "I learned what I wanted to get out of the workshop" and 4.2 out of 5 to the statement "I enjoyed participating in the workshop." Overall, the workshop was effective at conveying information; attendees' average rating of the statement "I know how to get involved with MAIA" increased from 2.9 to 4.3 and "I know a lot about MAIA" increased from 2.5 to 3.9 in surveys completed before and after the workshop. This indicates that the workshop was an overall success and did accomplish the objectives stated in the introduction of this report, which were mainly focused on disseminating information about the launch delay and conducting capacity building for the Simulated Data. Future workshops will have greater focus on presentations by Early Adopters and collecting additional feedback on the Simulated Data.

While some limitations were posed due to the need to hold the workshop virtually, after over a year of mostly virtual events, some attendees expressed a preference for online options in the future. In the pre-workshop survey, registrants stated that their major pet peeves about online meetings included lack of networking/small group discussion opportunities (25.64% of respondents), technical issues such as participants forgetting to mute (17.95%), tendency to run long/lack of breaks (7.70%), and being double-booked or getting distracted by other work (5.13%).

To reduce these potential negative aspects of virtual meetings, the following strategies were used:

- The use of an online feedback tool like Mentimeter is critical to increase the interactivity of the workshop and lend an element of fun. Mentimeter has several advantages for this type of event, including that: feedback is anonymous; it can be used on any internet-connected device (computer, phone, etc.) and is free to participants; it offers live results for real-time analysis; it can also be used to obtain feedback offline at participants' leisure; it supports many question types and has quiz capabilities for knowledge checks; and it provides data export for later analysis.
- Having shorter talks, longer breaks, and keeping the schedule to half-days is critical to allow participants to stay focused and accommodate multiple time zones in North America. Recording the workshop was also helpful to those on other continents or with additional obligations.
- Having a second person solely tasked with managing the telecon software (Webex in this instance), in addition to the meeting host/presenter, is critical to ensure lines are muted, chat questions and virtual hands raised are addressed in a timely fashion, and any technical issues are addressed without disruption to the flow of the meeting.
- To offer networking opportunities for those who wanted them, we set up a Gather.town instance over the meal break time for those who wanted to try out the tool. Gather allows people to interact in a video game-like environment, in which they pilot an avatar around a virtual space. When they approach others' avatars or enter a private space occupied by others, their webcam and

microphone is used to allow them to interact. Gather also supports interactive tools such as whiteboards to allow real-time collaboration. About 15 of the workshop participants tried out the Gather space. Overall feedback was mixed, and our conclusion is that further trials would be needed to determine if Gather is an efficient use of resources to provide networking opportunities (it does have an associated cost for hosting more than 25 people) and to develop best practices. It is important to make such virtual networking opportunities optional for those that have work/family responsibilities or simply need to eat, exercise and rest their eyes due to teleconference fatigue.

Appendix A: Agenda

MAIA Early Adopters Workshop
Remote Meeting

Tuesday, 14 September 2021

Local time	UTC time			Duration
Welcome and introductions				
8:40 AM	15:40	Webex setup and icebreaker questions	All	20
9:00 AM	16:00	Introduction from NASA Applied Sciences Program	John Haynes	10
9:10 AM	16:10	Introduction from MAIA and logistics	Abbey Nastan	10
MAIA: Recent project updates				
9:20 AM	16:20	Pop quiz: Introductory MAIA material	All	10
9:30 AM	16:30	Update on the MAIA project and target areas	David Diner	20
9:50 AM	16:50	ASDC updates and plans for MAIA data	Makhan Virdi	10
10:00 AM	17:00	Special topic: MAIA-TEMPO crowdsourcing algorithm challenge	Aaron Naeger	10
10:10 AM	17:10	Questions and discussion	All	10
10:20 AM	17:20	Break		10
MAIA Simulated Data Background				
10:30 AM	17:30	What is the MAIA Simulated Data and how was it made?	James McDuffie/ Greg Moore	15
10:45 AM	17:45	Intended usage of the MAIA Simulated Data	Abbey Nastan	10
10:55 AM	17:55	User access agreement and how to obtain data	Abbey Nastan	20
11:15 AM	18:15	Introduction to user resources	David Moroni	15
11:30 AM	18:30	Questions/Discussion	All	15
11:45 AM	18:45	Break	All	45
MAIA Simulated Data Tutorials				
12:30 PM	19:30	Tutorial 1: Using NASA Box and Panoply	Abbey Nastan	30
1:00 PM	20:00	Tutorial 2: PM product analysis w/ Jupyter Notebook	David Moroni	30
1:30 PM	20:30	Tutorial 3: Aerosol topics	Mike Garay	20
1:50 PM	20:50	Wrap-up and summary of future plans	Abbey Nastan	10
2:00 PM	21:00	Adjourn		

Appendix B: Attendees

Note: This list only includes those who attended the workshop live.

Name	Affiliation	Country
Aaron Naeger	University of Alabama-Huntsville	United States
Abi Lawal	Georgia Institute of Technology	United States
Abigail Nastan	NASA/JPL	United States
Allison Patton	Health Effects Institute	United States
Amy Huff	IMSG at NOAA/NESDIS/STAR	United States
Amy Wickham	UNICEF	United States
Araya Asfaw	Addis Ababa University	Ethiopia
Ashlee Autore	NASA ASDC	United States
Behzad Heibati		
Bob Kotchenruther	EPA	United States
Braxton Edwards	Oklahoma Department of Environmental Quality	United States
Brian Tisdale	NASA ASDC	United States
Charles Davidson	Sunflower Alliance	United States
Christian Pelayo	University of California-San Diego	United States
Claudia Rivera	Universidad Nacional Autonoma de Mexico	Mexico
Dan Otis	University of South Florida	United States
Dan Welsh	Colorado Department of Public Health and Environment	United States
Dave Westenbarger	Texas Commission on Environmental Quality	United States
David Diner	NASA/JPL	United States
David Moroni	NASA/JPL	United States
Ethan McMahon	EPA	United States
Fernando Chouza Keil	NASA/JPL	United States
Frederic Chagnon	Environment and Climate change Canada	Canada
Gorica Stanojevic	Geographical Institute "Jovan Cvijic" SASA	Serbia
Gregory Moore	NASA/JPL	United States
Helena Chapman	NASA	United States
Hyung Joo Lee	California Air Resources Board	United States
Iman Nasif	NASA	United States
James Boyle	Maryland Department of the Environment	United States
James McDuffie	NASA/JPL	United States
Jessie Zhang	University of Iowa	United States
Jin Liao	USRA and NASA GSFC	United States
Joel Schwartz	Harvard University	United States
Johan Friberg	Lund University	Sweden
John Haynes	NASA HQ	United States
Jose Hernandez	Bureau of Ocean Energy Management	United States

Joshua Uebelherr	Maricopa County Air Quality Department	United States
Keita Ebisu	OEHHA	United States
Kevin Briggs	Colorado Air Pollution Control Division	United States
Krista Thomason	EPA	United States
Leif Paulson	Wyoming DEQ-Air Quality Division	United States
Lotta Mayana	South African Weather Service	South Africa
Lucy Chisholm	Environment and Climate Change Canada	Canada
Luka Ilic	National Ecological Asociation (NEA) / Institute of Physics Belgrade (IPB)	Serbia
Maeve MacMurdo	Cleveland Clinic	United States
Makhan Virdi	NASA ASDC	United States
Martha Lee	McGill University	Canada
Matthaeus Kiel	NASA/JPL	United States
Michael Garay	NASA/JPL	United States
Mike Newchurch	University of Alabama-Huntsville	United States
Momoka Sugimura	University of Arizona	United States
Nash Skipper	Georgia Institute of Technology	United States
Nathan Pavlovic	Sonoma Technology, Inc	United States
Noelia Rojas	IAG-SUP	Brazil
Olayinka Osuolale	Elizade University	Nigeria
Olga Kalashnikova	NASA/JPL	United States
Pablo Mendez-Lazaro	University of Puerto Rico	United States
Rima Habre	University of Southern California	United States
Ron Pope	Maricopa County Air Quality	United States
Ryan Nicoll	Arizona Dept. of Environmental Quality	United States
Sara Farrell	EPA	United States
Sarah Hafer	NASA	United States
Scott Gluck	NASA/JPL	United States
Sharon Dukes-Allen	NASA	United States
Sina Hasheminassab	South Coast Air Quality Management District	United States
Slavica Malinovic-Milicevic	Geographical Institute “Jovan Cvijić” SASA	Serbia
Sumi Mehta	Vital Strategies	United States
Susan Alexander	University of Alabama-Huntsville	United States
Thomas Frey	Maryland Department of the Environment	United States
Tom Grylls	Clean Air Fund	United Kingdom
Tom Moore	WESTAR	United States
Vanessa Escobar	NOAA NESDIS	United States
Youhua Tang	NOAA	United States
Youngsun Jung	NOAA/NWS	United States