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User Guide: The MISR Enhanced Research and Lookup Interface (MERLIN)

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Multi-angle Imaging SpectroRadiometer (MISR)

User Guide: The MISR Enhanced Research and Lookup Interface (MERLIN)

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Document Change Log

Revision	Date	Affected Portions and Description
	January 6, 2022	All, original release

1 Executive Summary

The Multi-angle Imaging SpectroRadiometer (MISR) is an instrument on the NASA Terra satellite, which launched in 1999. The MISR instrument observes radiances in blue, green, red, and near-infrared wavelengths using nine cameras fixed at various angles relative to the Earth's surface.

One application of MISR data is analyzing the height of objects (smoke, clouds, ash, etc.) in the atmosphere, which is accomplished using the apparent motion of features from camera to camera as the viewing angle changes. A freely available software package, dubbed the MISR Interactive Explorer (MINX), was developed by the MISR team to facilitate the generation of object heights using a graphical user interface[1].

The MISR Plume Height Project[2] is a publicly available database of MINX-generated heights for wildfire smoke plumes that have been produced over many years thanks to the contributions of many JPL interns. As of this writing, the database includes all smoke plumes observed by MISR, and able to be digitized, around the globe for the years 2008 – 2011 as well as the summers (June, July, August) of 2017 and 2018. These data have been used to validate plume rise in models and other satellite-derived datasets, as well as to study the dynamics of individual fires and climatology of fire in the environment.

Previously, Plume Height Project data was accessible and searchable via a Cold Fusion database on the MISR website, with the data files themselves stored at the NASA Atmospheric Science Data Center. The MISR Enhanced Research and Lookup Interface (MERLIN) was designed to replace the outdated Cold Fusion database and provide additional tools to enable users to draw new scientific conclusions from the dataset. The MERLIN prototype was developed by Jarod Boone, Adrian Galvin, and Pooja Nair as a Data to Discovery Visualization Program project, sponsored by Caltech and the Art Center College of Design as well as the MISR project. The prototype was further developed into a beta tool by JPL intern Harold Ainsworth and has been prepared for public release by Sebastian Val and Makhan Virdi.

This user guide covers MERLIN's graphical user interface and known issues with MERLIN that will be addressed in a future release.

Note: The user will observe many references to "biome" and "region" of the plumes within the MISR Plume Height Project database in this guide. Plumes in the database are categorized into biomes according to the 2008 version of the MODIS Land Cover Product (MCD12C1) classification for the plume origin point. Plumes are assigned to one of the following regions: Africa, Australia, Southwest Eurasia, North America, Boreal Eurasia, South America, and South Asia (see Figure 1).
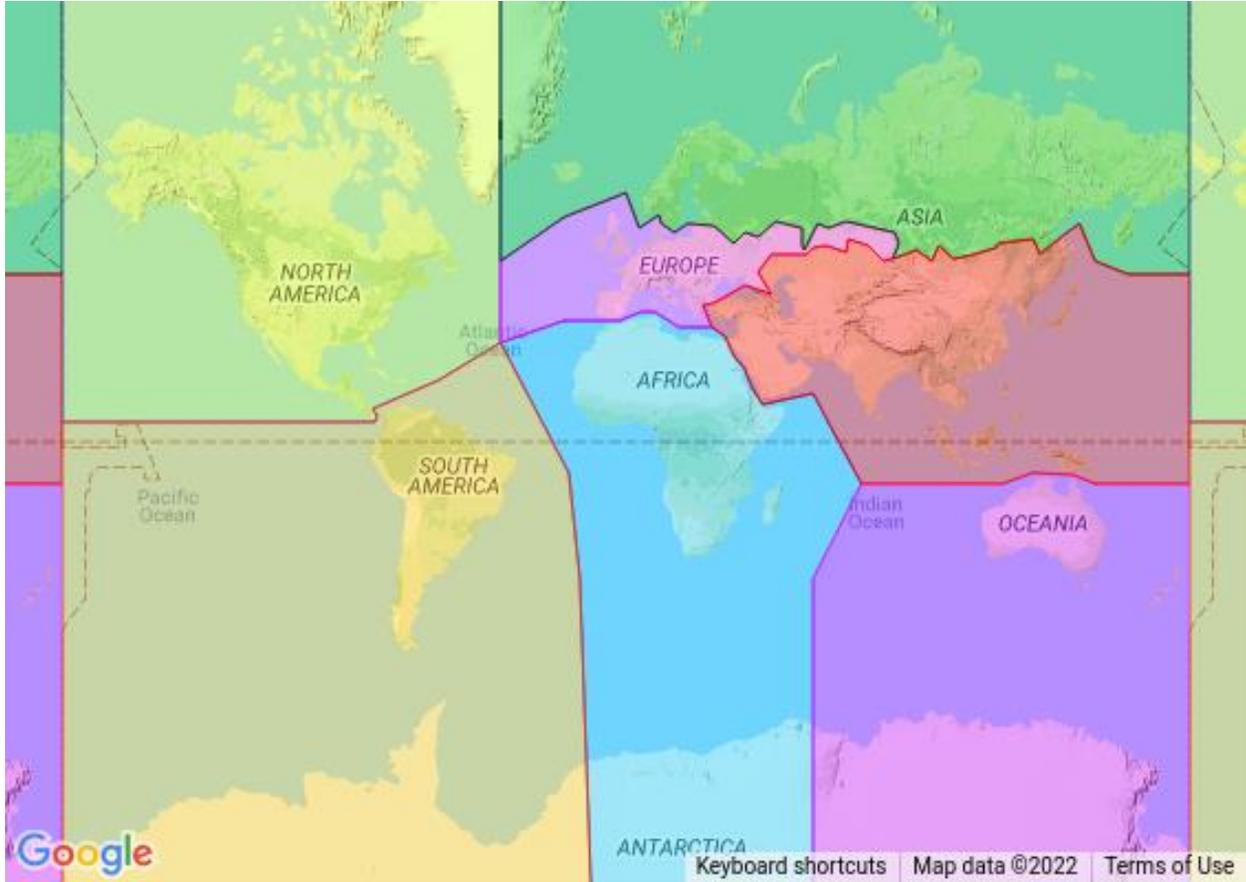
Figure 1. The region map used by MINX to assign plumes to regions.
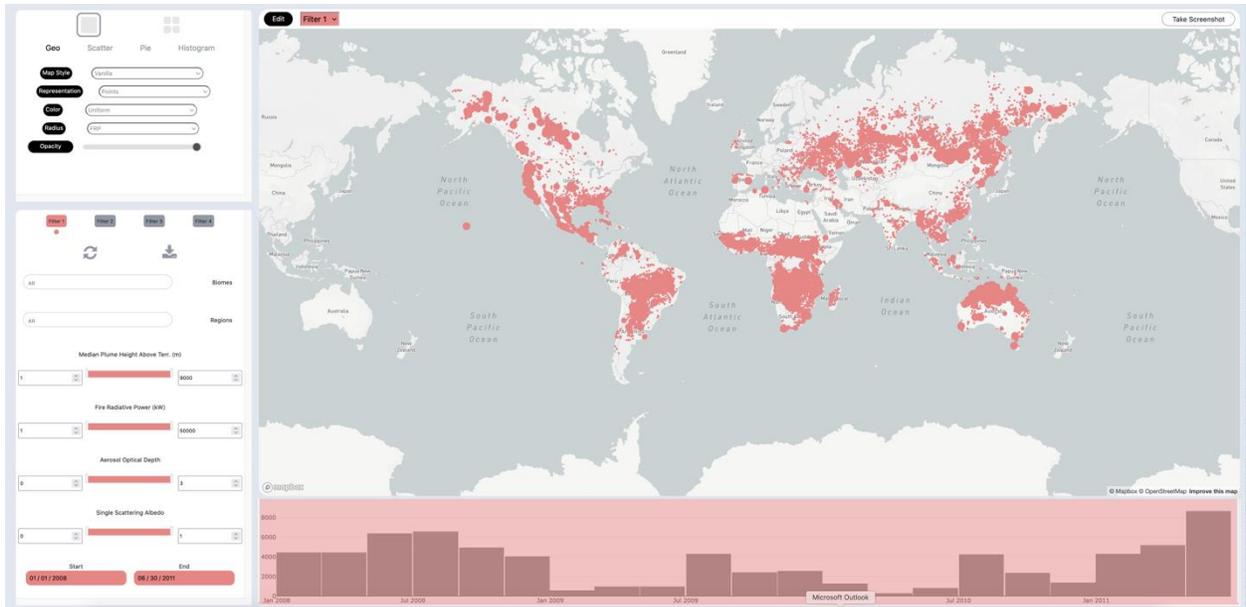
2 MERLIN User Interface

Figure 2. The default view of the MERLIN user interface.

When visiting the MERLIN interface, the user is presented with a default view consisting of a one-plot layout showing a map (*Geo*) view of the entire Plume Height Project dataset in the main window (Figure 2). The number and type of plots is controlled by the plot menu in the upper left, while the user can filter what plumes are displayed using the filter menu at the lower left. It is also possible to filter on the date range shown using the timeline histogram at the lower right.

In the following descriptions, MERLIN's default selection for each menu option is highlighted in bold.

2.1 Plot Menu

One plot *vs. four plot view:* The uppermost option in the plot menu controls whether the user sees one large plot in the main window or four smaller plots, each of which can be adjusted individually (as seen in Figure 3).

When in four plot view, select the "Edit" button at the upper left of a plot to manipulate that plot using the plot menu.

Figure 3. MERLIN in four plot mode. In this screenshot, the lower right plot is currently being edited, as can be seen by the "Edit" button on that plot being selected.

Plot style: Changes the type of plot. The available options are map view (**Geo**), scatter plot (Scatter), pie chart (Pie), or Histogram. Figure 3 shows one of each type of plot.

The options for controlling the plot in the plot menu will change depending on which type of plot is selected.
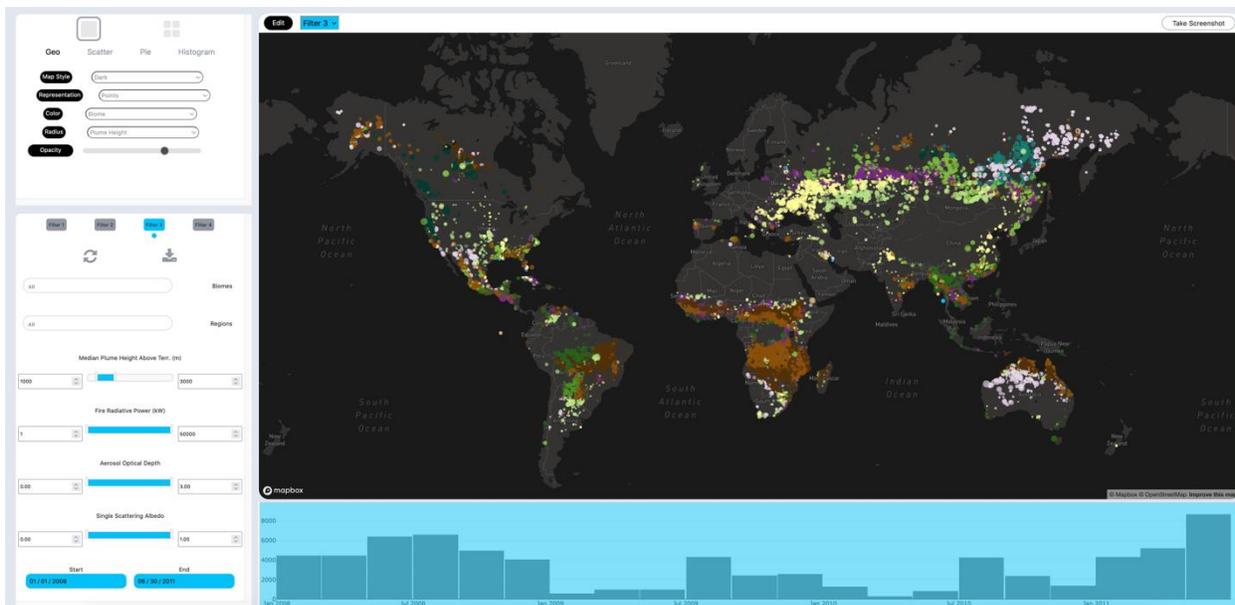
2.1.1 Geo plot options

Figure 4. An example geo plot (map view) showing all plumes in the database with median heights between 1 and 3 km. The base map option is dark and representation is by points, which are colored according to biome. The points are sized according to their median plume height above terrain. The opacity is turned down to show point density.

Map style: Changes the base map shown. The available options are: **Vanilla** (light theme, as shown in Figure 2), Satellite, Roadmap, and Dark (as shown in Figure 4).

Representation: Changes how plumes are displayed. The available options are: **Points** (as shown in Figure 2 and 4), Grid (the plumes are gridded into boxes of equal geographic size, as shown in Figure 5), and Pillars (the plumes are gridded into cells of equal geographic size with a height representation, as shown in the lower right plot in Figure 3 and Figure 6). The additional options below Representation will change depending on which option is selected.

Points options:

> *Color:* Changes how the points are colored. The available options are: **Uniform** (points are all colored according to what filter is selected, shown in Figure 2), Biome (the points are colored according to what biome the plume origin is located within, as shown in Figure 4), and Region (the points are colored according to what region of the world the plume origin is located within).

> *Radius:* Changes how the size of each point is represented. The available options are: **Uniform** (all points are the same size, shown in Figure 2), FRP (the point size is scaled with the MODIS fire radiative power associated with that plume), and Plume height (the point size is scaled with the median plume height above terrain as derived by MINX, as shown in Figure 4).

> *Opacity:* A scale bar controlling the opacity of the points. Turning the opacity down allows the user to determine the density of points in a location. The default is 100% opacity.
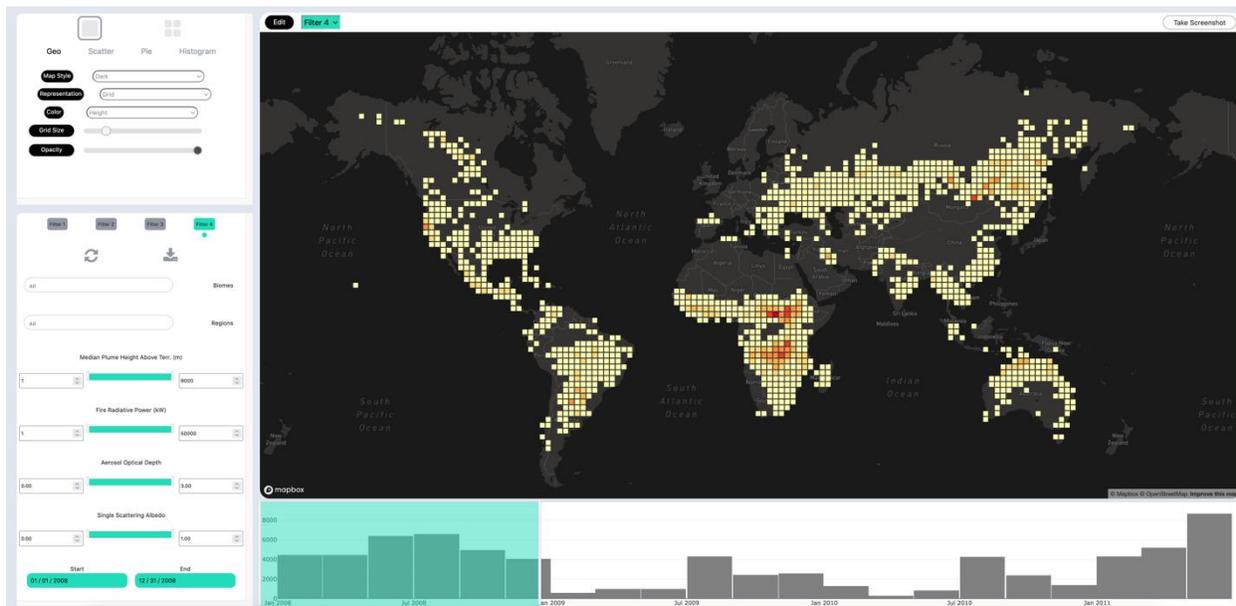
Grid options:

Figure 5. An example geo (map) view showing the grid representation option for all plumes in the database from the year 2008, with a relatively small grid size and the grid colored to represent the median height of each grid cell.

Color: Changes how the grid cells are colored. The options are: **FRP** (the grid cell is colored according to the average MODIS fire radiative power associated with the plumes in that bin) and Height (the grid cell is colored according to the average of the median plume heights above terrain as derived by MINX for plumes in that bin, as shown in Figure 5).

Grid size: Changes the geographic size of the grid cells. Moving the scale bar to the right will increase the size of the grid cells, while moving it to the left will decrease the size.

Opacity: A scale bar controlling the opacity of the grid cells over the base map. The default is 100% opacity.

Pillars option:
Note: The pillar heat map indicates the quantity of plumes in that bin. This is not a editable option.
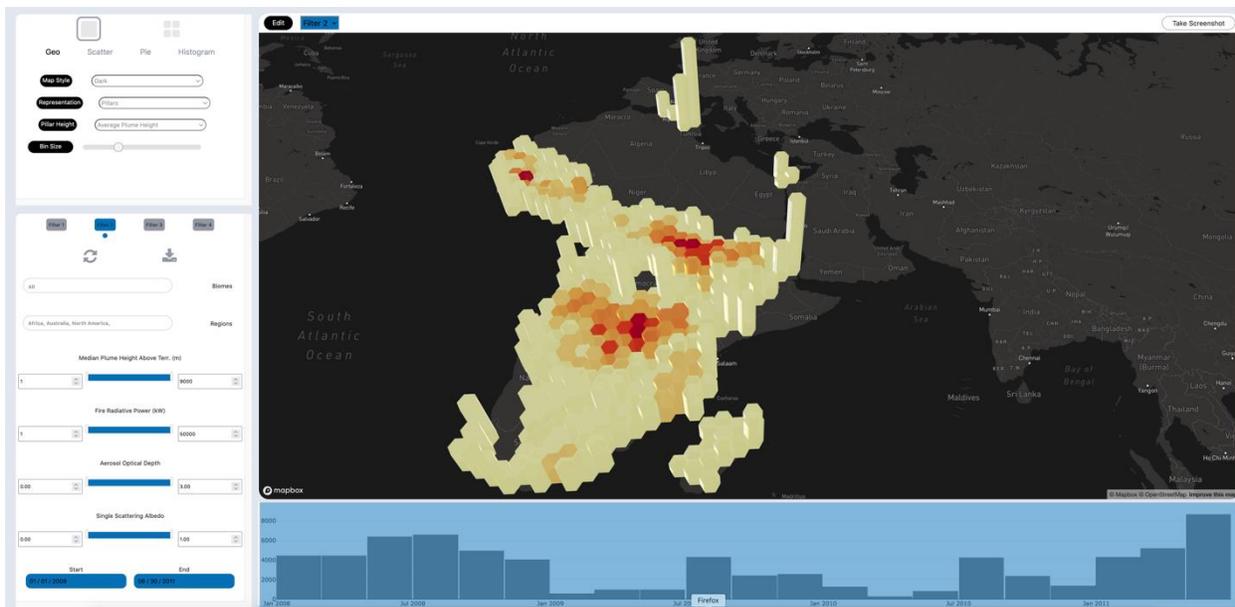
Figure 6. An example geo (map) view showing the pillars representation option, zoomed in to view all the plumes in the database from Africa. The height of the pillars represents the average plume height in each bin, while their color indicates the quantity in each bin.

Pillar height: Changes the quantity used to scale the height of each pillar. The options are: **Quantity** (the height of the pillar scales to the number of plumes in the bin), FRP (the height of the pillar scales to the average MODIS fire radiative power associated with all the plumes in the bin), and Average Plume Height (the height of the pillar scales to the average of the median plume height above terrain of all the plumes in the bin, as shown in Figure 6).

Bin size: Changes the geographic size of the pillar bins. Moving the scale bar to the right will increase the size of the bins, while moving it to the left will decrease the size.
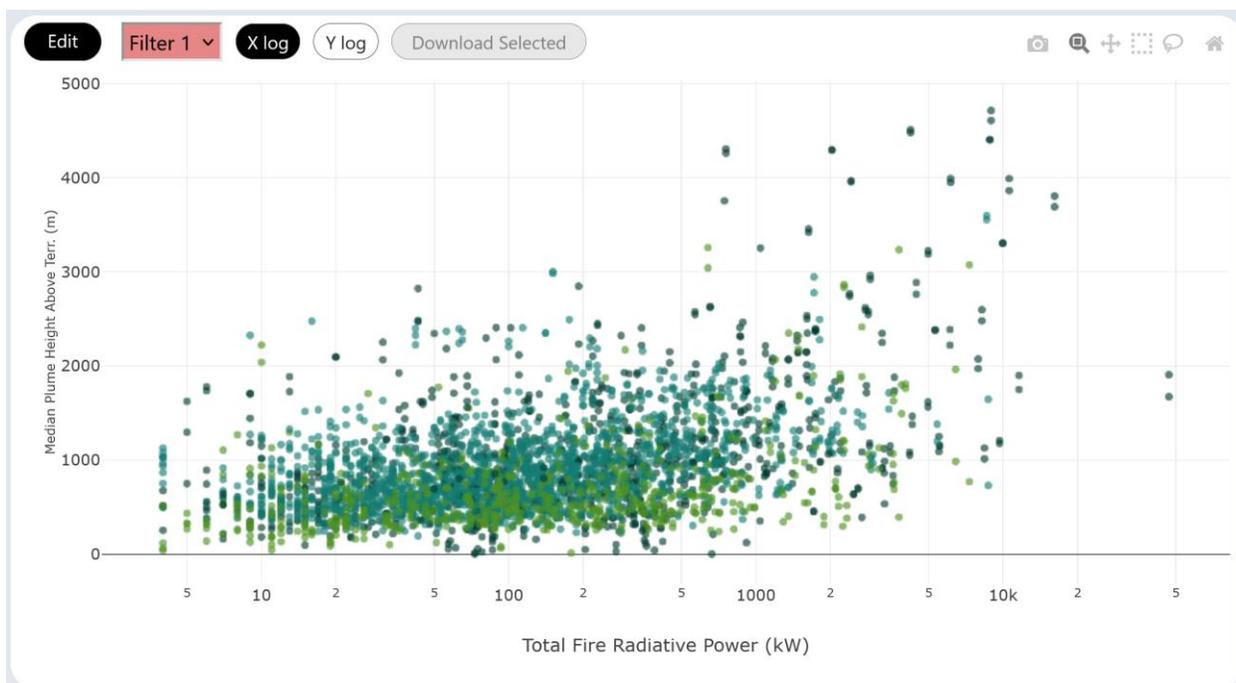
2.1.2 Scatter plot options

Figure 7. An example scatter plot of plume height vs. fire radiative power for all plumes in the database from the evergreen needleleaf forest, deciduous needleleaf forest, and deciduous broadleaf forest biomes. Points have been colored according to biome and the opacity is reduced to create a density plot. Additionally, the X log option has been selected (see section 2.2.2) to display the X axis in logarithmic scale.

X Variable: Determines the variable plotted on the X-axis of the scatter plot. The available options are: **FRP** (the MODIS fire radiative power associated with the plume, as shown in Figure 7), Height (the median plume height above terrain derived by MINX for this plume), AOD (the average MISR-derived AOD for pixels covering the area of the plume), and Albedo (the average MISR-derived single scattering albedo for pixels covering the area of the plume).

Y Variable: Determines the variable plotted on the Y-axis of the scatter plot. The available options are: FRP (the MODIS fire radiative power associated with the plume), **Height** (the median plume height above terrain derived by MINX for this plume, as shown in Figure 7), AOD (the average MISR-derived AOD for pixels covering the area of the plume), and Albedo (the average MISR-derived single scattering albedo for pixels covering the area of the plume).

Color: Determines how the points on the scatter plot are colored. The available options are: **None** (the points are all colored according to which filter is selected), Biome (the points are colored according to what biome the plume origin is located within, as shown in Figure 7), and Region (the points are colored according to what region of the world the plume origin is located within).

Opacity: A scale bar controlling the opacity of the points. Turning the opacity down allows the user to create a density scatter plot. The default is 100% opacity.
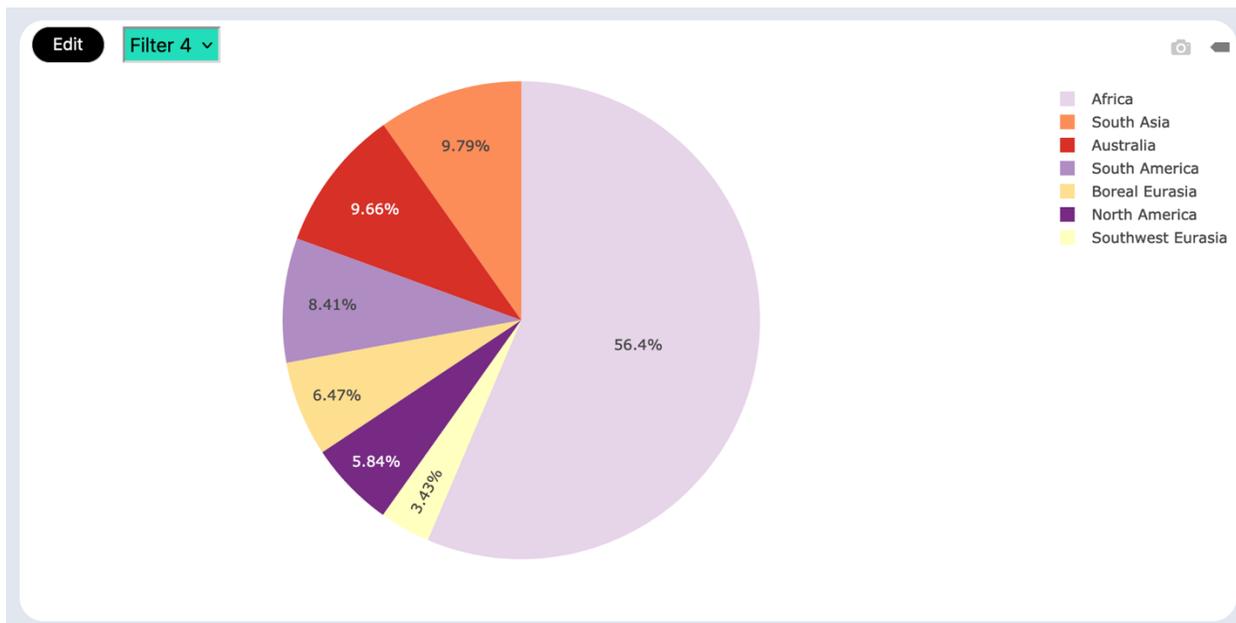
2.1.3 Pie chart options

Figure 8. An example pie chart showing the regions of all plumes in the database from the year 2009.

Variable: Determines the variable that is used to create the pie chart. The available options are: **Biome** (what biome the plume origin is located within) and Region (what region of the world the plume origin is located in, as shown in Figure 8).
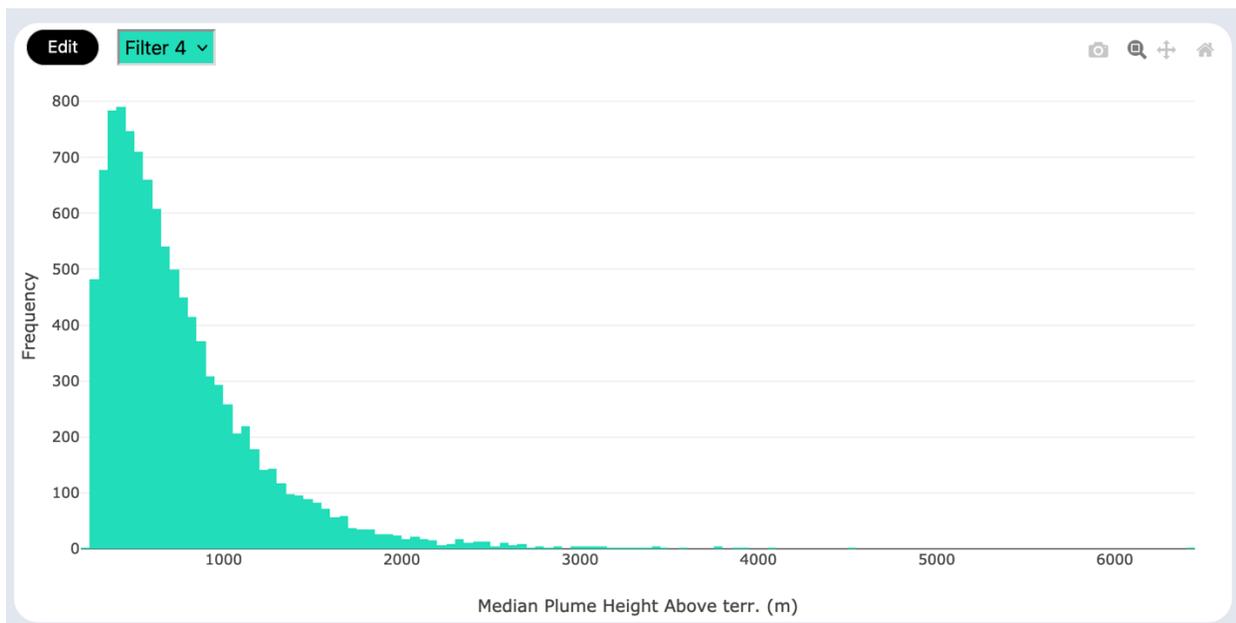
2.1.4 Histogram plot options

Figure 9. An example histogram showing the height distribution of all plumes in the database from the year 2009.

Variable: Determines the variable that is used to bin the histogram. The available options are: FRP (the MODIS fire radiative power associated with the plume), **Height** (the median height above terrain for the plume, as shown in Figure 9), AOD (the average MISR-derived AOD for pixels covering the area of the plume), and Albedo (the average MISR-derived single scattering albedo for pixels covering the area of the plume).

2.2 Main window plot options

In addition to the plotting options located in the plot menu at the upper left, each plot type (Geo, Scatter, Pie, and Histogram) has a number of options located in the menu at the top of the plot in the main window. These options vary by plot type, so are described here for each plot type.

2.2.1 Main window Geo plot options

Figure 10. The main window plot options for the Geo plot type.

Edit: Selects this plot as the active plot controlled by the plot menu at the upper left.

Filter selection: Determines which filter (see section 3) is used to generate the plot.

Take Screenshot: Saves the current plot view as a PNG. The default file name is "MERLIN_Map_Screenshot.png." Take care not to overwrite files if you save multiple map screenshots.
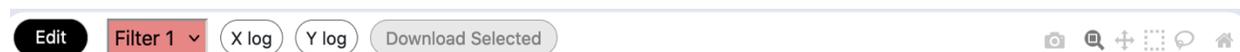
2.2.2 Main window Scatter plot options

Figure 11. The main window plot options for the Scatter plot type.

Edit: Selects this plot as the active plot controlled by the plot menu at the upper left.

Filter selection: Determines which filter (see section 3) is used to generate the plot.

X log: Toggle the x-axis from non-logarithmic to logarithmic.

Y log: Toggle the y-axis from non-logarithmic to logarithmic.

Download Selected: When a portion of the points are selected using the box select or lasso select tools (see below), the "Download selected" button allows the user to obtain a script to download the MINX data files from ASDC for only those plumes currently selected.

Download plot [camera icon]: Download the current plot view as a PNG file. The default filename is "newplot.png." Take care to avoid overwriting files if you save multiple plots.

Zoom [magnifying glass icon]: Zooms in on a portion of the scatter plot. The user can click and drag to draw a box to zoom in on a particular area. Use the "reset axes" option to reset to default after zooming.

Pan [two axes icon]: Pans around within plot area, while maintaining level of zoom. Allows the user to click and drag the plot view. Use the "reset axes" option to reset to default after panning.

Box Select [dashed rectangle icon]: Allows the user to draw a box to select certain area of points on the image. The user can then use the "Download Selected" button to generate a script to download only those plume files. To cancel the selection, click once on the plot.

Lasso Select [lasso icon]: Performs the same function as the box select but uses a free-form shape made by clicking and dragging. The user can then use the "Download Selected" button to generate a script to download only those plume files. To cancel the selection, click once on the plot.

Reset axes [home icon]: Reset the plot axes after panning or zooming.

2.2.3 Main window Pie chart options

Figure 12. The main plot window options for the Pie chart type.

Edit: Selects this plot as the active plot controlled by the plot menu at the upper left.

Filter selection: Determines which filter (see section 3) is used to generate the plot.

Download plot [camera icon]: Download the current plot view as a PNG file. The default filename is "newplot.png." Take care to avoid overwriting files if you save multiple plots.

Toggle show closest data on hover [tag icon]: if selected, this option will display a caption for each segment of the pie chart when the user hovers over it.

2.2.4 Main window Histogram plot options

Figure 13. The main plot window options for the Histogram plot type.

Edit: Selects this plot as the active plot controlled by the plot menu at the upper left.

Filter selection: Determines which filter (see section 3) is used to generate the plot.

Download plot [camera icon]: Download the current plot view as a PNG file. The default filename is "newplot.png." Take care to avoid overwriting files if you save multiple plots.

Zoom [magnifying glass icon]: Zooms in on a portion of the histogram. The user can click and drag to draw a box to zoom in on a particular area. Use the "reset axes" option to reset to default after zooming.

Pan [two axes icon]: Pans around within plot area, while maintaining level of zoom. Allows the user to click and drag the plot view. Use the "reset axes" option to reset to default after panning.

Reset axes [home icon]: Reset the plot axes after panning or zooming.
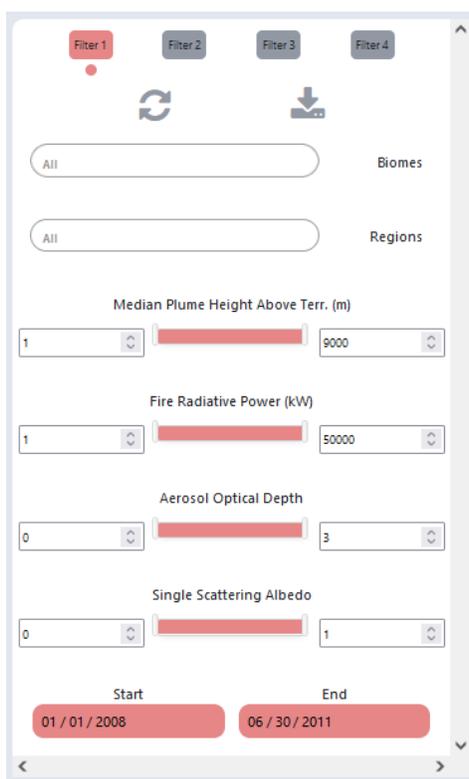
2.3 Filter menu

Figure 14. The filter menu interface, showing the default options for Filter 1.

The filter menu (lower left in the MERLIN interface) allows the user to apply four different filters simultaneously on the Plume Height Project database using a variety of filtering options, and then use those filters to create visualizations or download the plume files corresponding with the filter. Note: since database functions must be performed every time a filter is changed, expect a small delay before the current visualization updates.

Filter selection: Allows the user to select the active filter for editing. There are four possible filters, which are color coded in both the filter menu and for relevant plot options. Filter 1 is pink, Filter 2 is navy, Filter 3 is sky blue and Filter 4 is teal.

Reset [recycle icon]: Resets the currently active filter to default on all options.

Download [download icon]: Generates a download script for the plumes in the currently viewed filter. This allows the user to download the MINX data files associated with those plumes from ASDC for further analysis. The script includes information on how to initiate the download. The user should keep in mind how many plumes are in the current filter when preparing for download (creating a separate folder for large downloads, for example).

Biomes selection: Allows the user to specify plumes from which biomes to include in the filter using a drop-down menu. The default option is all. It is possible to select only one biome or many of them.

Regions selection: Allows the user to specify plumes from which regions to include in the filter using a drop-down menu. The default option is all. It is possible to select only one region or many of them.

Median Plume Height Above Terrain (m): Allows the user to specify a minimum and maximum plume height for the current filter. The user may use the sliders to change the minimum and maximum or input the desired min/max using the text boxes. The plume height is specified in meters. For each plume, the median of all plume heights above terrain for the plume is calculated.

Fire Radiative Power (kW): Allows the user to specify a minimum and maximum MODIS fire radiative power (FRP) associated with each plume for the current filter. The user may use the sliders to change the minimum and maximum or input the desired min/max using the text boxes. The FRP is specified in kilowatts.

Aerosol Optical Depth: Allows the user to specify a minimum and maximum MISR-derived aerosol optical depth (AOD) associated with each plume for the current filter. The user may use the sliders to change the minimum and maximum or input the desired min/max using the text boxes. AOD is a unitless quantity. For each plume, the average of the MISR-derived AOD results for pixels covering that plume is calculated.

Single Scattering Albedo: Allows the user to specify a minimum and maximum MISR-derived single scattering albedo (SSA) associated with each plume for the current filter. The user may use the sliders to change the minimum and maximum or input the desired min/max using the text boxes. SSA is a unitless quantity. For each plume, the average of the MISR-derived SSA results for pixels covering that plume is calculated.

Dates selection: The user can select the start and end dates for the current filter. The user can use a calendar selection tool at the bottom of the filter menu, or can also use

the sliders on the date histogram (lower right of the MERLIN interface) to select the start and end dates.

3 Known issues

At the time of initial release, a few known issues have been identified. These will be addressed in future updates to the MERLIN tool.

Issue	Suggested Workaround
Plot window and timeline histogram extent do not resize when the browser window is resized.	Ensure you have your browser window sized as desired before beginning work in MERLIN. If you need to resize the browser window later, you will have to reload the page to get the map and histogram to resize, which will result in loss of plot and filter customizations.
MERLIN sometimes displays a blank screen in the main window when switching back to one plot mode after using four plot mode.	Try toggling back and forth between one-plot and four-plot mode a few times; this sometimes resolves the issue. If not, you will need to reload MERLIN, but this will result in loss of filter/plot customizations. Ensure you have saved desired plots and data download scripts before switching back to one plot mode.
You may receive a "there was an error" message when changing the date range in the filter menu using the calendar tool. Error message forces the user to reload MERLIN to continue working, resulting in loss of plot/filter customizations.	Try changing the year first using the calendar selector, then opening the calendar tool again to change the month and day.
MERLIN loads slowly and updates slowly after filter changes.	This is due to the database lookup functions necessary for MERLIN to display the desired plumes, and is most noticeable over slow internet connections. Ensure you have the maximum possible bandwidth for MERLIN operations (e.g. close other browser tabs, avoid streaming media while working with MERLIN).

4 Contacts

To report an issue additional to those detailed in section 3, of if you have questions about MERLIN or the Plume Height Project, please contact Abigail Nastan at abigail.m.nastan@jpl.nasa.gov.

5 References

1. Nelson, D.L., M.J. Garay, R.A. Kahn, and B.A. Dunst (2013). **"Stereoscopic Height and Wind Retrievals for Aerosol Plumes with the MISR INteractive eXplorer (MINX)."** *Remote Sensing* **5** (9): 4593-4628. DOI: 10.3390/rs5094593

2. Val Martin, M., R. A. Kahn, and M.G. Tosca (2018). **"A Global Analysis of Wildfire Smoke Injection Heights Derived from Space-Based Multi-Angle Imaging."** *Remote Sensing* **10** (10): 1609. DOI: 10.3390/rs10101609.

6 Acronym List

AOD	Aerosol Optical Depth
ASDC	Atmospheric Science Data Center
FRP	Fire Radiative Power
JPL	Jet Propulsion Laboratory
MERLIN	MISR Enhanced Research and Lookup Interface
MISR	Multi-angle Imaging SpectroRadiometer
MINX	MISR Interactive Explorer
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
PNG	Portable Graphics Format
SSA	Single Scattering Albedo