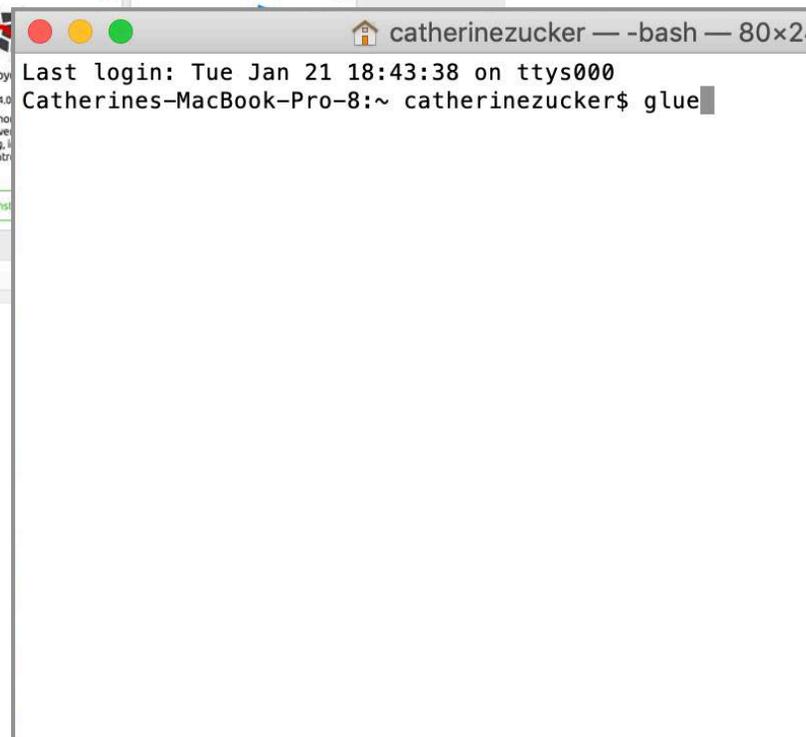
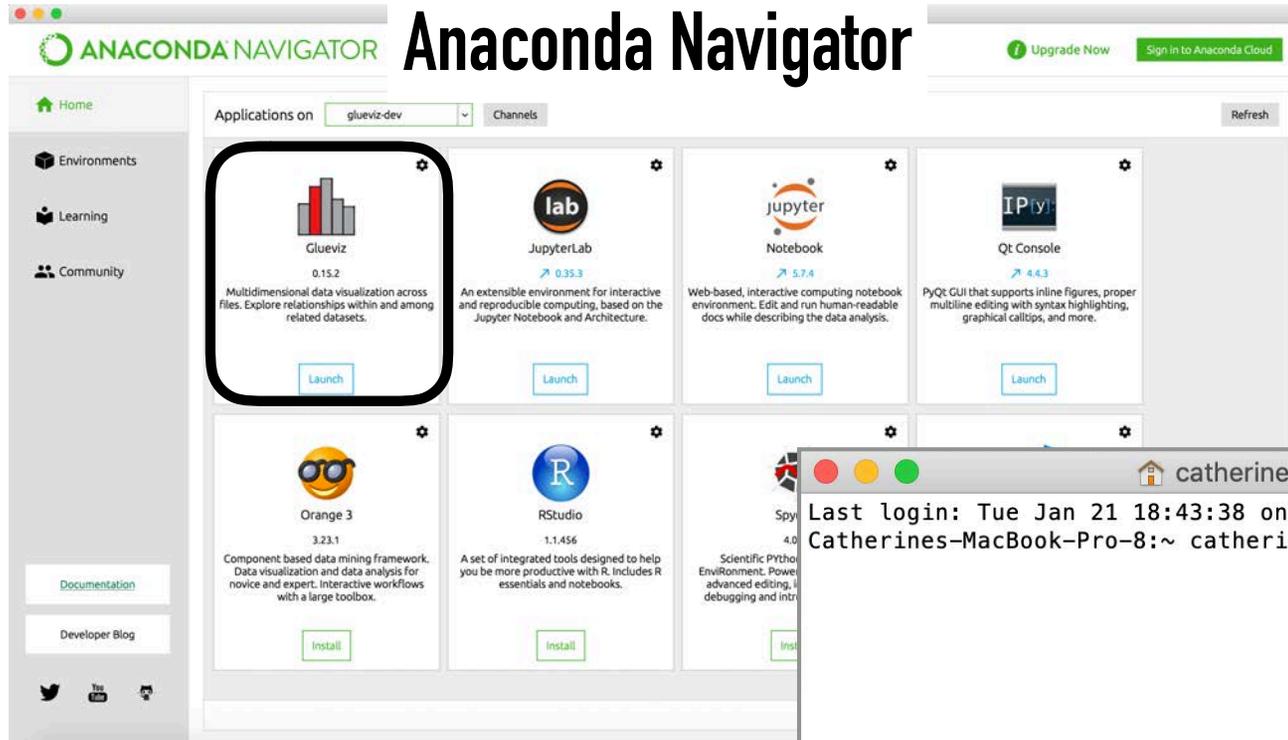


# Starting up glue

To start up glue, you can click the glue icon in the anaconda navigator application, or open up a terminal and type “glue”



## Terminal

# Your glue dashboard

The image shows a screenshot of the Glue dashboard interface. The window title is "Glue". The top menu bar includes: "Open Session", "Export Session", "Import Data", "Export Data/Subsets", "Link Data", "Arithmetic attributes", "Active Subset: None/Create New", "(the next selection will create a subset)", "Terminal", and "Preferences".

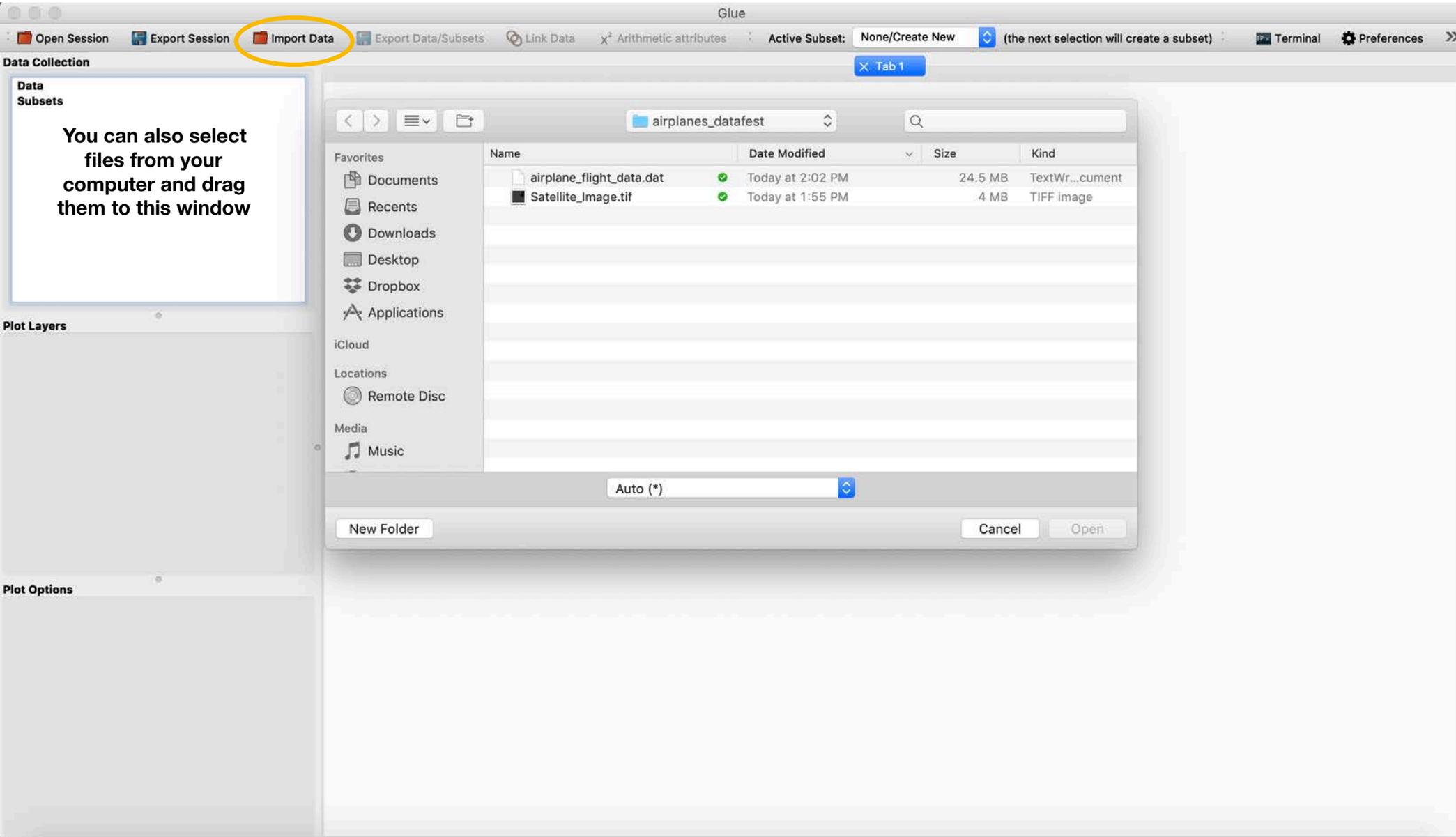
The interface is divided into three main vertical sections on the left and a large central plot canvas on the right.

- Data Collection:** A white box with the text: "This is the **data collection manager**. It lists all datasets and subsets".
- Plot Layers:** A grey box with the text: "This is the **plot layers** menu. You can choose which datasets are visible in individual plots".
- Plot Options:** A grey box with the text: "This is the **plot options** menu. You can tweak aesthetics (e.g. axis limits) of individual plots".

The central plot canvas is a large white area with the text: "This is the **plot canvas** (drag data here to plot)" and "Drag Data To Plot" in a large, light grey font.

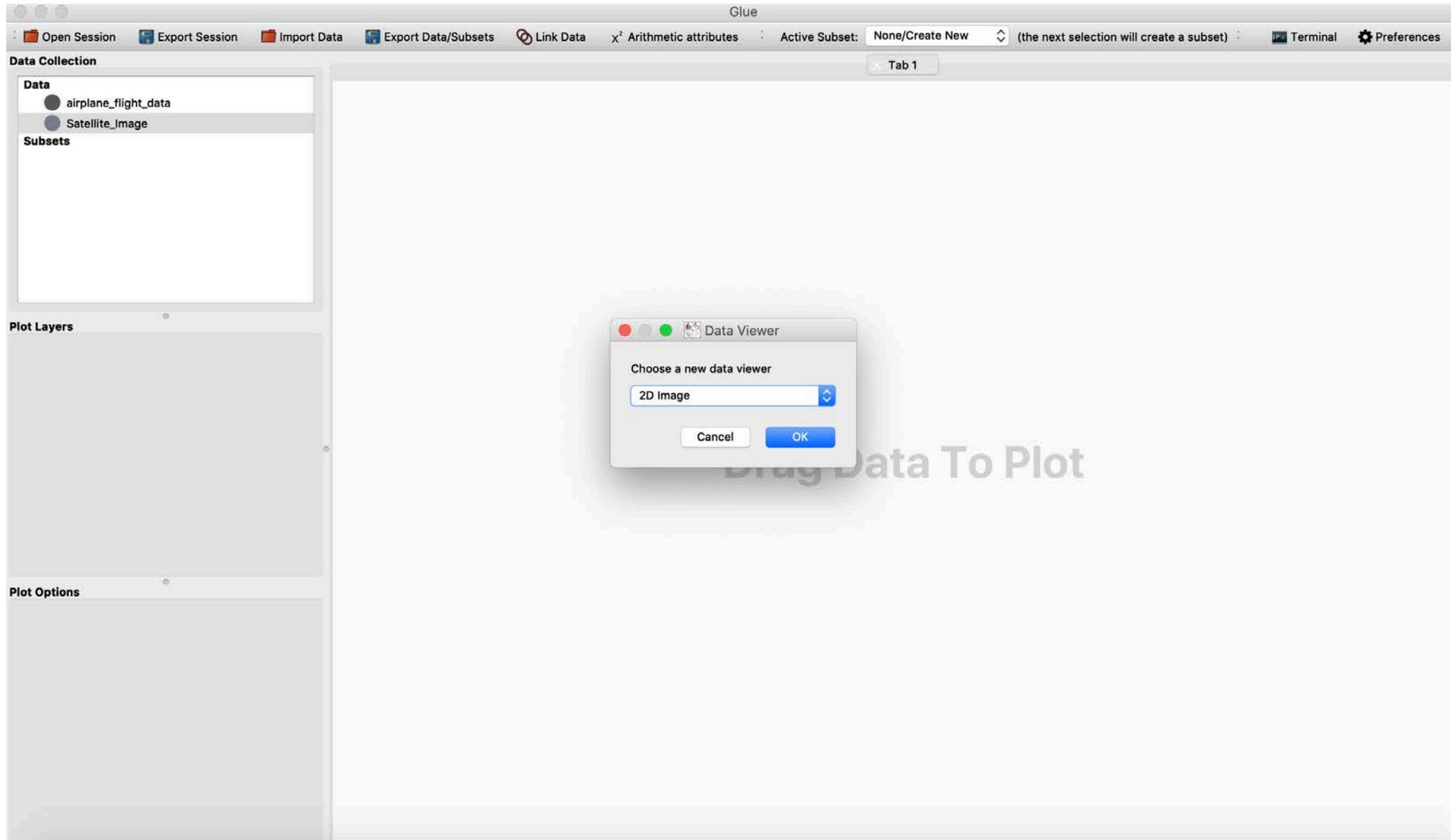
# Loading Data

To load data, click on the “Import Data” button and select the datasets to load. Alternatively, you can drag and drop files into the Data Collection window



# Plotting Data

Click on the “Satellite\_Image” dataset in the Data Collection Manager. Drag it onto the plot canvas and select “2D Image” as your data viewer



# Play around with plot layers menu

Once you create your 2D image viewer, you can adjust the colormap, the stretch and limits of the colormap, and the opacity of the color map with the plot layers menu. We only have one layer (the Satellite\_Image dataset) active at the moment, but we will add more layers soon... stay tuned!

The screenshot displays the Glueviz application window. The main view is a 2D plot titled "2D Image" showing a grayscale satellite image of a coastal region. The plot has a latitude axis on the left (ranging from 42.1 to 42.4) and a longitude axis at the bottom (ranging from -71.2 to -70.6). The plot is surrounded by a toolbar with various navigation and analysis tools.

On the left side, there are two panels:

- Data Collection:** Shows a list of data sources: "airplane\_flight\_data" and "Satellite\_Image".
- Plot Layers - 2D Image:** Shows a list of active layers: "Satellite\_Image (Band 1)".

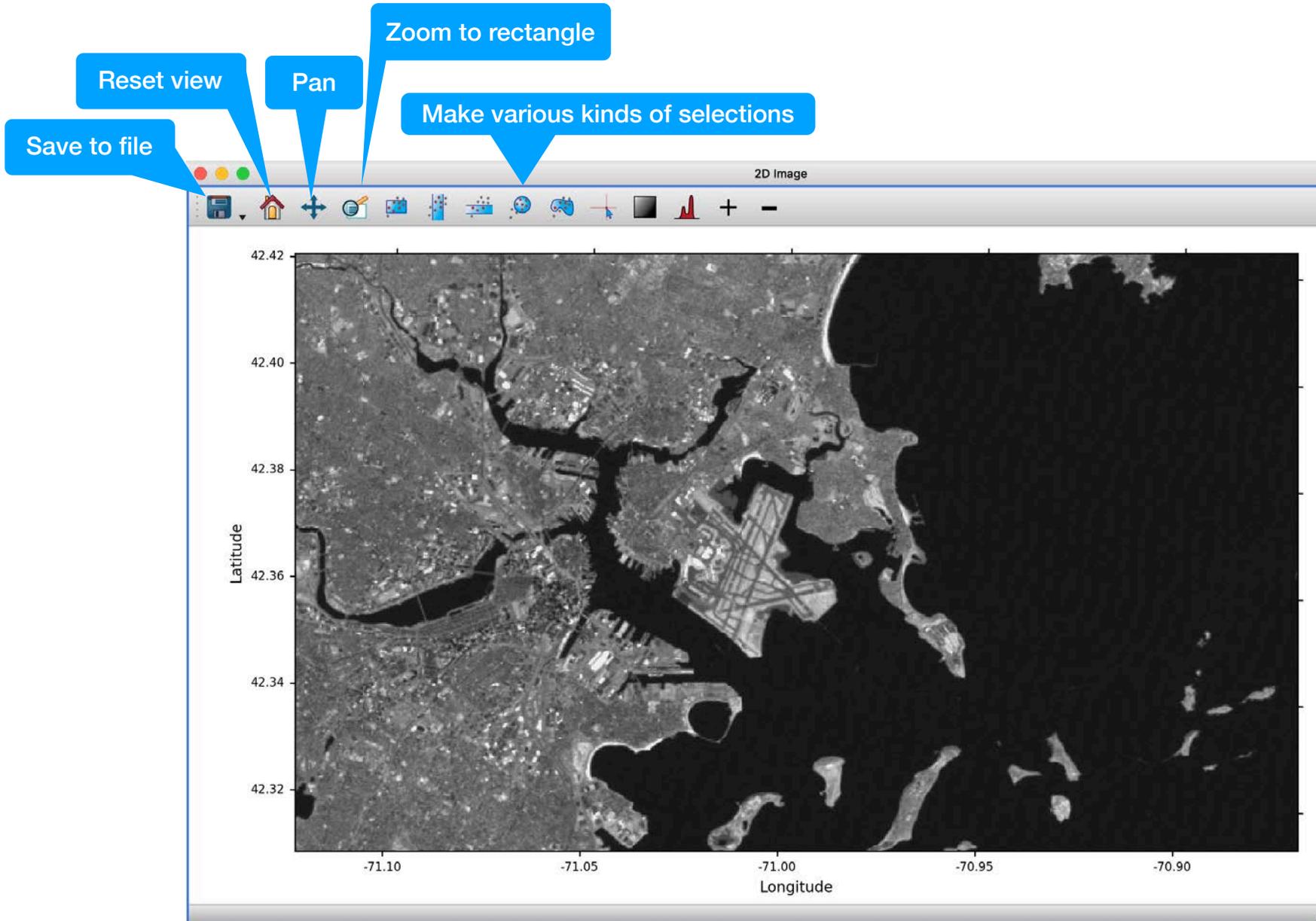
Two yellow callout boxes highlight the configuration options for the "Satellite\_Image (Band 1)" layer:

- Top Callout:** Shows the "attribute" set to "Band 1", "limits" set to "Custom" with a range from 0 to 133, and "color/opacity" set to a dark gray color.
- Bottom Callout:** Shows the "attribute" set to "Band 1", "limits" set to "99.5%" with a range from 0 to 133, and "color/opacity" set to a dark gray color.

At the bottom left, there is a "Plot Options - 2D Image" panel with tabs for "General" and "Limits". The "General" tab is selected, showing options for "mode", "aspect", "reference", "x axis", and "y axis".

# Use the “in-viewer” controls

Each type of viewer (e.g. 2D image viewer, histogram, 3D scatter plot) has its own set of “in-viewer” buttons to control (e.g. zoom in/out, reset to original display, pan). This is also the way you will make selections (we will get to that in a bit!). For now, just try them out!



# Hmmm... shouldn't we be glue-ing things together?

Next, we are going to link two datasets that have like attributes. The first dataset ("Satellite\_Image") is a GIS image of the Boston area. Our second dataset will be the "airplane\_flight\_data" file, which is a catalog of data on flight positions, speeds, headings, etc for airplanes. Both datasets share the same spatial information — i.e. they both use "latitude" and "longitude." We will link these two attributes so the both datasets can be visualized in the same viewer.

1. Click "link data"

Click on two datasets to set up links or click on an existing connection to edit links. Selected datasets are shown in green. When one dataset is selected, the colors show directly and indirectly linked (blue) and inaccessible (red) datasets.

**Dataset 1**

- airplane\_flight\_da
- Main components
  - timestamp
  - longitude
  - latitude
  - altitude
  - ground\_speed
  - air\_speed
  - heading
  - vertical\_rate
  - date
  - time
  - Coordinate component
  - Pixel Axis 0 [x]

**Dataset 2**

- Satellite\_Image
- Main components
  - Band 1
  - Coordinate component
  - Pixel Axis 0 [y]
  - Pixel Axis 1 [x]
  - Latitude
  - Longitude

**Links between Dataset 1 and Dataset 2**

- identity(latitude <-> Latitude)
- identity(longitude <-> Longitude)

**Link details**

Link conceptually identical components

**Dataset 1 attributes**

x longitude

**Dataset 2 attributes**

y Longitude

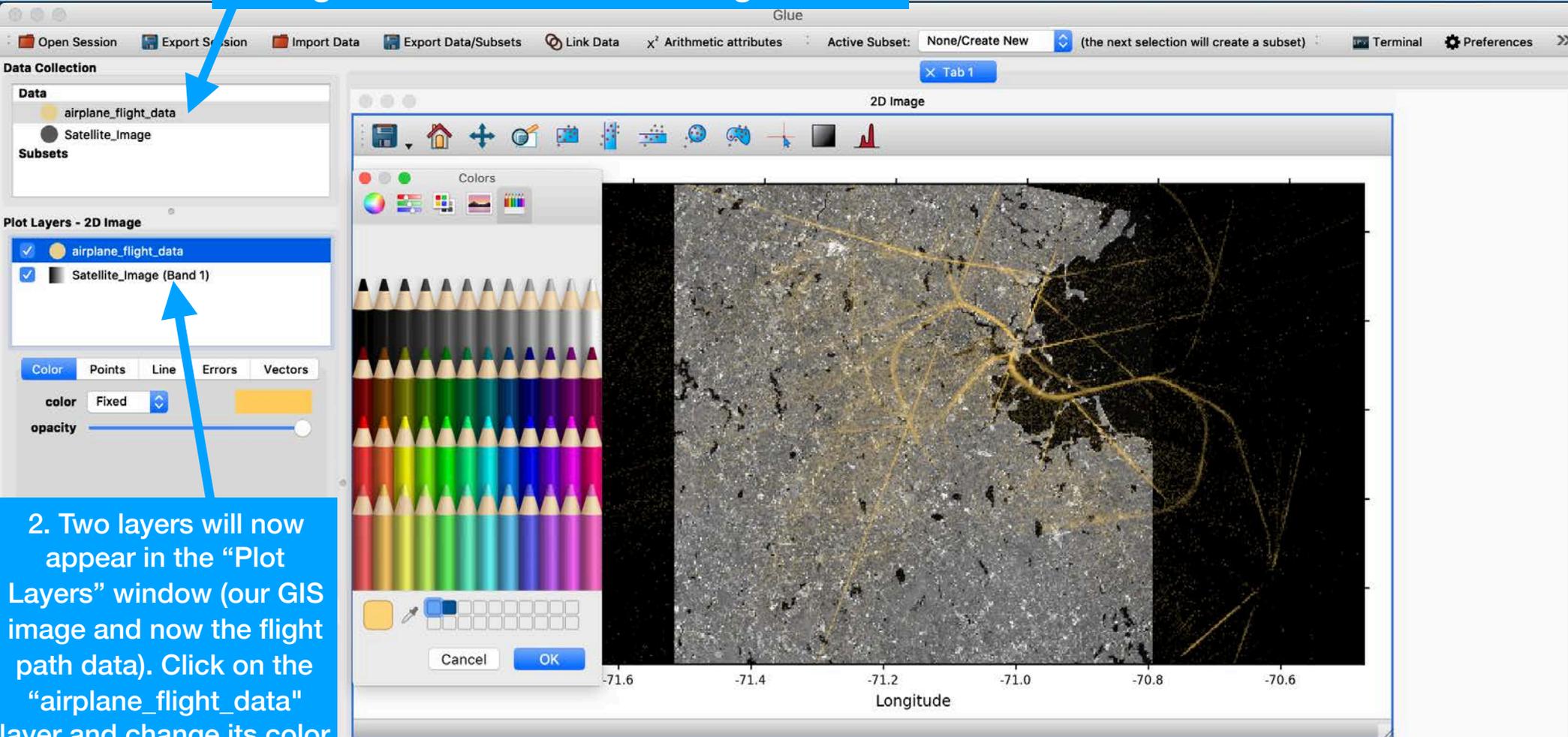
2. Select "longitude" in both windows. Click "Glue Attributes." Do the same for latitude.

3. Press OK!

# Visualize Two Datasets in the Same Plot!

First, drag “airplane\_flight\_data” from the data collection manager on to the 2D image window to see the airplane positions on top of the satellite image.  
Two layers should now appear in the “plot layers” window. Click on the “airplane\_flight\_data” layer and click on “Color” to change its color to yellow.

1. Drag this dataset on to 2D image window



2. Two layers will now appear in the “Plot Layers” window (our GIS image and now the flight path data). Click on the “airplane\_flight\_data” layer and change its color to gold. You can also change the size of points (click “Points”) etc.

# Let's make a second plot, to visualize the flight path data

To make a second plot, select "airplane\_flight\_data" in the Data Collection manager, and drag it onto an EMPTY space on the canvas. Select "2D scatter" plot as the plot option. Then use the Plot Options window to change the variables plotted on the x and y axis. Select "time" as the x variable and "vertical\_rate" as the y variable.

The screenshot displays a software interface with several panels. On the left, the 'Data Collection' panel lists 'airplane\_flight\_data' and 'Satellite\_Image'. Below it, the 'Plot Layers - 2D Scatter' panel shows 'airplane\_flight\_data' selected. The 'Plot Options - 2D Scatter' panel has 'time' set for the x-axis and 'vertical\_rate' for the y-axis. A blue callout box with the text '1. Drag this dataset on to EMPTY spot in canvas, select 2D scatter' points to the 'airplane\_flight\_data' item in the Data Collection panel. In the center, a '2D Scatter' plot window shows a scatter plot of 'vertical\_rate' (y-axis, ranging from -4000 to 6000) versus 'time' (x-axis, ranging from 0 to 20). The plot shows a dense cloud of orange points with a horizontal line at zero. On the right, a '2D Image' plot window shows a satellite image with yellow lines overlaid, representing flight paths. The axes are 'Latitude' (y-axis, ranging from 42.0 to 42.5) and 'Longitude' (x-axis, ranging from -71.8 to -70.6). A second blue callout box with the text '2. After creating 2D scatter plot, the "Plot Options" menu will appear. Plot time vs. vertical\_rate' points to the 'vertical\_rate' dropdown in the Plot Options panel.

1. Drag this dataset on to EMPTY spot in canvas, select 2D scatter

2. After creating 2D scatter plot, the "Plot Options" menu will appear. Plot time vs. vertical\_rate

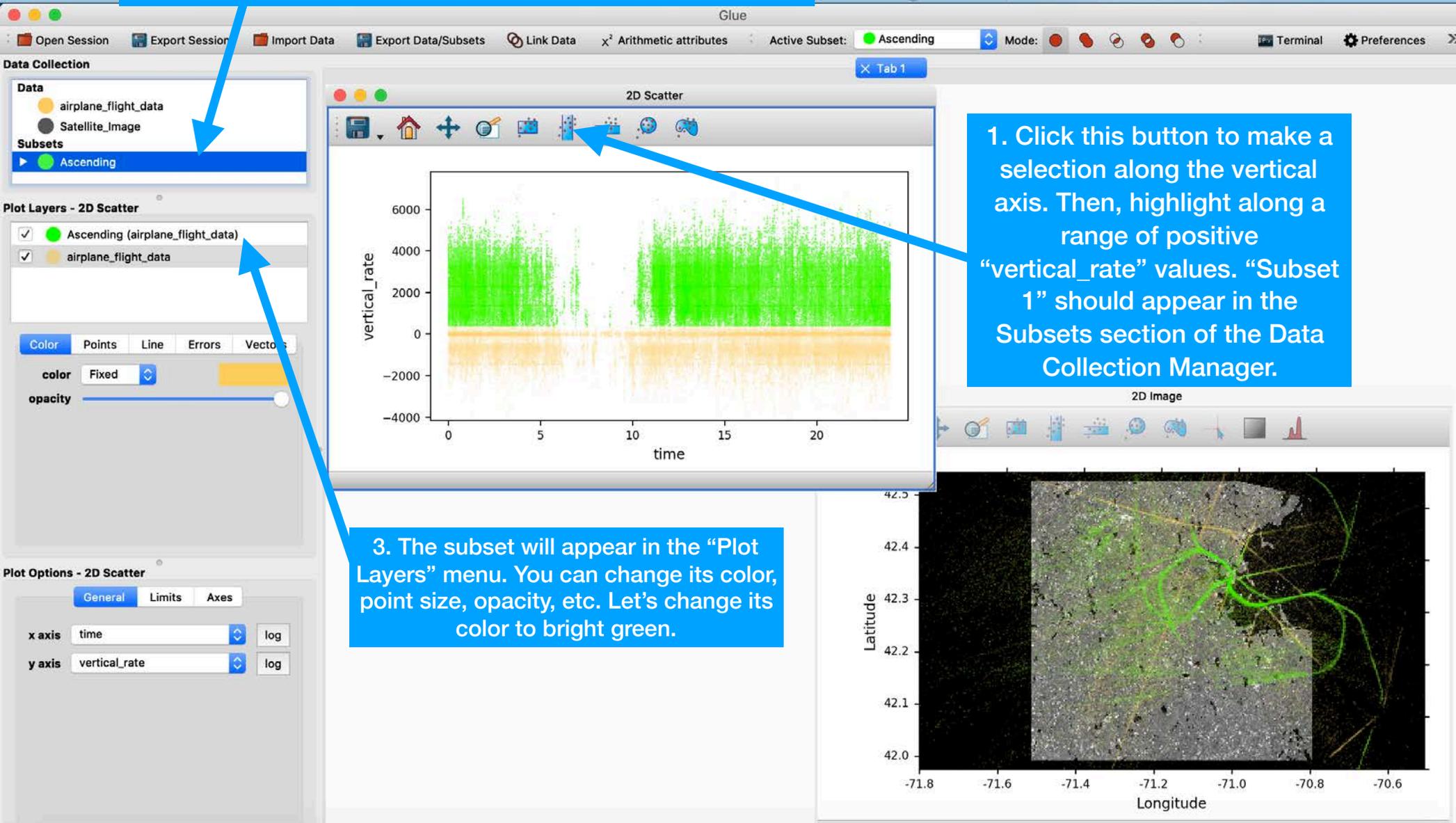
# Now, let's make a selection!

A selection is an interesting subset of the data you want to explore. Since data are linked across plots, selections in one plot will propagate to other plots. We are going to select data points with positive “vertical\_rate” in the 2D scatter viewer. Those planes are ascending! The selection will propagate across both viewers. Yay!

2. Double-click on the newly created subset in the Subset list. Change its name from "Subset 1" to “Ascending”.

1. Click this button to make a selection along the vertical axis. Then, highlight along a range of positive “vertical\_rate” values. “Subset 1” should appear in the Subsets section of the Data Collection Manager.

3. The subset will appear in the “Plot Layers” menu. You can change its color, point size, opacity, etc. Let's change its color to bright green.



# And another selection!

Follow the same process as the previous slide, except now select **NEGATIVE** vertical\_rate in the 2D scatter viewer. Call it “Descending” and make it magenta! Again, the selection will propagate across both viewers!

**3. Double-click on the newly created subset in the Subset list. Change its name from "Subset 2" to "Descending".**

**1. Click on the "None/Create New" Option in the "Active Subset"**

**2. Click this button to make a selection along the vertical axis. Then, highlight along a range of negative "vertical\_rate" values. "Subset 2" should appear in the Subsets section of the Data Collection Manager.**

**4. The subset will appear in the "Plot Layers" menu. You can change its color, point size, opacity, etc. Let's change its color to bright magenta.**

The interface includes a "Data Collection" panel with "Subsets" (Ascending, Descending) and "Plot Layers - 2D Scatter" (Descending, Ascending, airplane\_flight\_data). The "2D Scatter" plot shows vertical\_rate (y-axis, -4000 to 6000) vs time (x-axis, 0 to 20). The "Plot Options - 2D Scatter" panel shows x axis: time, y axis: vertical\_rate. The "Active Subset" dropdown menu shows Ascending, Descending, and None/Create New. The "Color" dropdown is set to Fixed. The "Plot Layers" panel shows Descending (airplane\_flight\_data) selected. The "Plot Options" panel shows General, Limits, and Axes tabs.

# 2D is cool... but what about 3D?!?!?!?!?

Next, let's make a 3D scatter plot of the flight data. We will drag our airplane flight data onto the EMPTY canvas again and select 3D scatter plot. Select "longitude, latitude, altitude" as the "x,y,z" axes variables. Then, for each layer, adjust the size of the points.

**1. Drag this dataset on to empty canvas, select 3D scatter**

**2. Select longitude, latitude, altitude for x,y,z axes.**

**3. Select each layer. Adjust size of points to make them smaller**

**Data Collection**

- Data
  - airplane\_flight\_data
  - Satellite\_Image
- Subsets
  - Ascending
  - Descending

**Plot Layers - 3D Scatter**

- Descending (airplane\_flight\_data)
- Ascending (airplane\_flight\_data)
- airplane\_flight\_data

**Plot Options - 3D Scatter**

x axis: longitude  
min/max: -72.5466 -69.9001  
stretch: 1.00

y axis: latitude  
min/max: 41.5872 43.0827  
stretch: 1.00

z axis: altitude  
min/max: -0.3048 13.716  
stretch: 1.00

Native aspect ratio  
 Perspective  
 Show axes

**2D Image**

vertical\_rate

time

Latitude

Longitude

**3D Scatter**

altitude

longitude

latitude

# Make a 3D selection

Next, we are going to make an interesting selection in the 3D scatter plot. Specifically, we want to highlight all the flight paths where the altitude remains constant over its flight path. Those are the planes that are just passing over (not landing at Boston Logan!). They have ~ zero vertical rate!

The screenshot shows a software interface with several panels:

- Data Collection:** Lists 'airplane\_flight\_data' and 'Satellite\_Image'. Under 'Subsets', 'Ascending' (green), 'Descending' (pink), and 'Passing Over' (blue) are visible.
- Plot Layers - 3D Scatter:** Shows 'Passing Over (airplane\_flight\_data)' selected with a blue color and size of 7.
- Plot Options - 3D Scatter:** Shows 'x axis' as 'longitude', 'y axis' as 'latitude', and 'z axis' as 'altitude'.
- 2D Scatter:** A scatter plot of 'vertical\_rate' vs. an unlabeled x-axis, showing green points at the top and pink points at the bottom.
- 3D Scatter:** A 3D scatter plot of 'altitude' vs. 'longitude' vs. 'latitude', showing a dense cloud of points with a blue rectangular selection box.

Four blue callout boxes provide instructions:

1. Click on the "None/Create New" Option in the "Active Subset"
2. Click the rectangular selection button and highlight all points with altitude > 10.
3. As before, change the subset name to "Passing Over"
4. As before, change color to blue, and change point size

# Create new data attribute

What if we want to explore another facet of our data, but it's not currently in our dataset? We can create a new data attribute and it will be immediately available to plot! We will compute the angular distance of each plane from Logan Airport.

The screenshot shows the Glueviz software interface with several windows and panels. The main window displays a 3D scatter plot of airplane flight data. The 'Data Collection' panel on the left shows the dataset 'airplane\_flight\_data' and its subsets: 'Ascending', 'Descending', and 'Passing Over'. The 'Plot Layers - 3D Scatter' panel shows the 'Passing Over' subset selected. The 'Plot Options - 3D Scatter' panel shows the x-axis set to 'longitude', the y-axis to 'latitude', and the z-axis to 'altitude'. The 'Arithmetic editor' dialog is open, showing the dataset 'airplane\_flight\_data' and a table with one row: 'distance\_fr...' with the expression 'np.sqrt((latitude) - 42.3656)\*\*2 + ((longitude) + 71.0096)\*\*2'. The 'Equation Editor' dialog is also open, showing the same expression. A yellow box highlights the expression: 
$$\text{np.sqrt}(\{\text{latitude}\} - 42.3656)^2 + (\{\text{longitude}\} + 71.0096)^2$$

1. Click the "Arithmetic Attributes" button

2. Select New arithmetic attribute

3. Call it "distance\_from\_logan"

4. Enter the following expression and press OK (42°N and 71°W are the coordinates of the airport!):

Available attributes: timestamp

Note: Attribute names in the expression should be surrounded by { } brackets (e.g. {date}), and you can use Numpy functions using np.<function>, as well as any other function defined in your config.py file.

Example expressions:

- Subtract 10 from 'date': {date} - 10
- Scale 'date' to [0:1]: ((date) - np.min((date))) / np.ptp((date))

Valid expression

# Now visualize your new attribute

We are going to make a histogram of the "distance\_from\_logan" variable. Planes "Passing over" tend to be a farther distance from Logan, as you would expect!

1. Drag this dataset on to EMPTY spot in canvas, select "1D Histogram"

2. Select "distance\_from\_logan" as x-axis variable

3. Adjust histogram options. For example, increase the number of bins to 100!

Drag

Plot Options - 1D Histogram

General Limits Axes

x axis distance\_from\_logan log

bins 0.00092957 1.17154 100

Update bins to view

y axis normalized cumulative log

Fixed # of numerical bins

Number

distance\_from\_logan

# Make publication-quality figures.

glue can make publication-quality figures, and export those figures (and the code to make them) to file! Let's do this with our 2D image viewer, which shows the flight paths (ascending, descending, passing over) on top of the GIS image

The screenshot shows the Glue software interface. The main window displays a 2D image of a city with flight paths overlaid. The x-axis is labeled 'Longitude (deg)' and the y-axis is labeled 'Latitude (deg)'. The plot options panel shows settings for the axes, including label size and weight. A histogram is visible in the bottom right corner, showing the distribution of 'distance\_from\_logan'.

**4. Save pretty plot to file (e.g. png) or save python script to make the plot (and add further customization in python)**

**1. Click axes tab**

**2. Change axes labels**

**3. Change size/weight of labels**

# Save session

Let's save the current state of our session (including state of data, selection, plots, newly created attributes, etc.)

1. Click Export Session

2. Name the session!

4. To reopen, click Open Session!

Save As: airplane\_demo.glu

Tags:

Glue Session with absolute paths to data (\*.glu)

Glue Session with relative paths to data (\*.glu)

Glue Session including data (\*.glu)

Cancel

Save

3. There are three session save options. By default, these files store references to the files you opened (either using absolute or relative paths), and not copies of the files themselves. Thus, you won't be able to re-load this session if you move any of the original data. To include the data in the session file, you can select 'Glue Session including data' when saving

# BONUS: WorldWide Telescope Viewer

glue also has the ability to link TOOLS together. WorldWide Telescope is a "virtual observatory" software package that allows you to view a variety of Earth and Space based data in the context of real images of Earth and our Universe. Let's use WorldWide Telescope to view our airplane flight path data on the globe!

**2.** Click on the little gray arrow to the left of the new subset label. Drag the "Close to Logan (airplane\_flight\_data)" subset onto empty canvas and select "World Wide Telescope" Viewer

**1.** Use the rectangle selection to make a subset of the planes right around the Logan runway in the 2D image viewer. As before, you can change the name of the subset to "Close to Logan" and color of the subset to e.g. white

**4.** Pan and zoom in the globe viewer to visualize the flight data. Once zoomed into runway, press "control" and scroll around to see the altitude of the planes as they land/depart!

**3.** In the plot options menu, select "Earth" mode, "Longitude" and "Latitude" as Longitude and Latitude, "Altitude" as altitude, and select units of km.