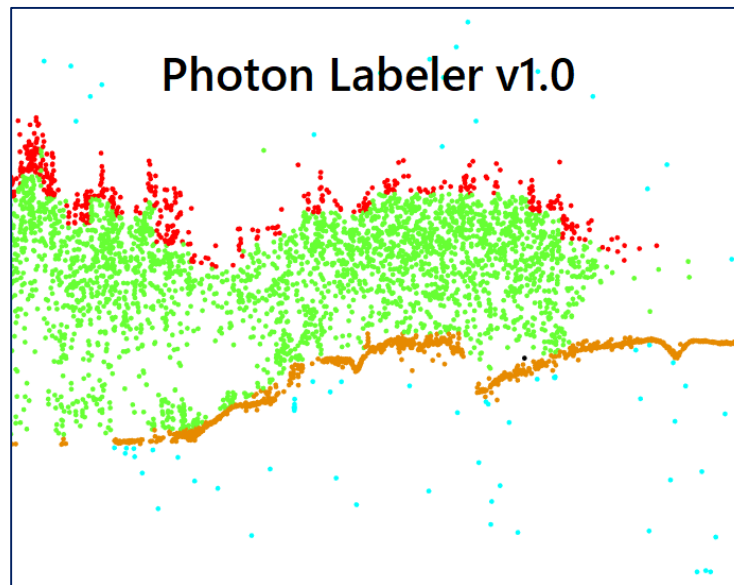


Lidar Applications for the Study of  
Ecosystems with Remote Sensing  
Laboratory (LASERS)  
Ecology and Conservation Biology  
Texas A&M University  
College Station TX  
<https://lasers.tamu.edu/>

## **PhotonLabeler: ICESat-2 Photon Interpretation, Labeling & Visualization**

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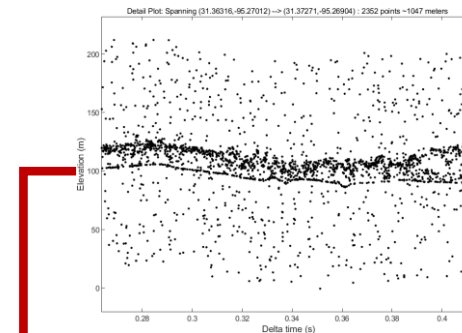
**USER MANUAL**

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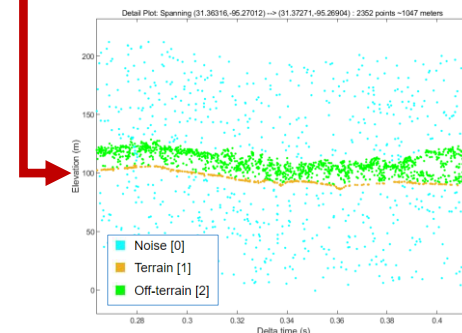
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# ICESat-2 ATL03 data overview

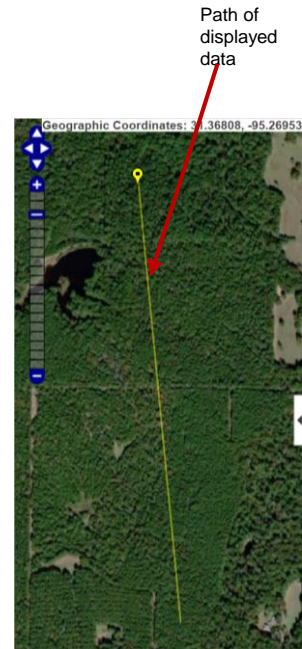
- ICESat-2 geolocated photon data (ATL03) data provide time, latitude, longitude, and ellipsoidal height for each photon detected by the ATLAS instrument in six ground tracks in the WGS-84 reference frame .
- ATL03 data are distributed in HDF format and organized by ground track in the HDF file structure. Point data (latitude, longitude, time, height) can be accessed from the heights sub-group (/gtx/heights) for each respective ground track. See product [Algorithm Theoretical Basis Document](#) for more details
- ATL03 data could be visualized by plotting photon elevation values (y-axis) against time or along-track distance (ATD) values (x-axis) in 2D space. ATL03 data could also be visualized in 3D space by plotting latitude, longitude and elevation values.
- Plotting ATL03 data provides a convenient way for visually interpreting them into classes of interest and is the motivation behind developing the PhotonLabeler application.



*Sample ATL03 data over forested area in eastern Texas*



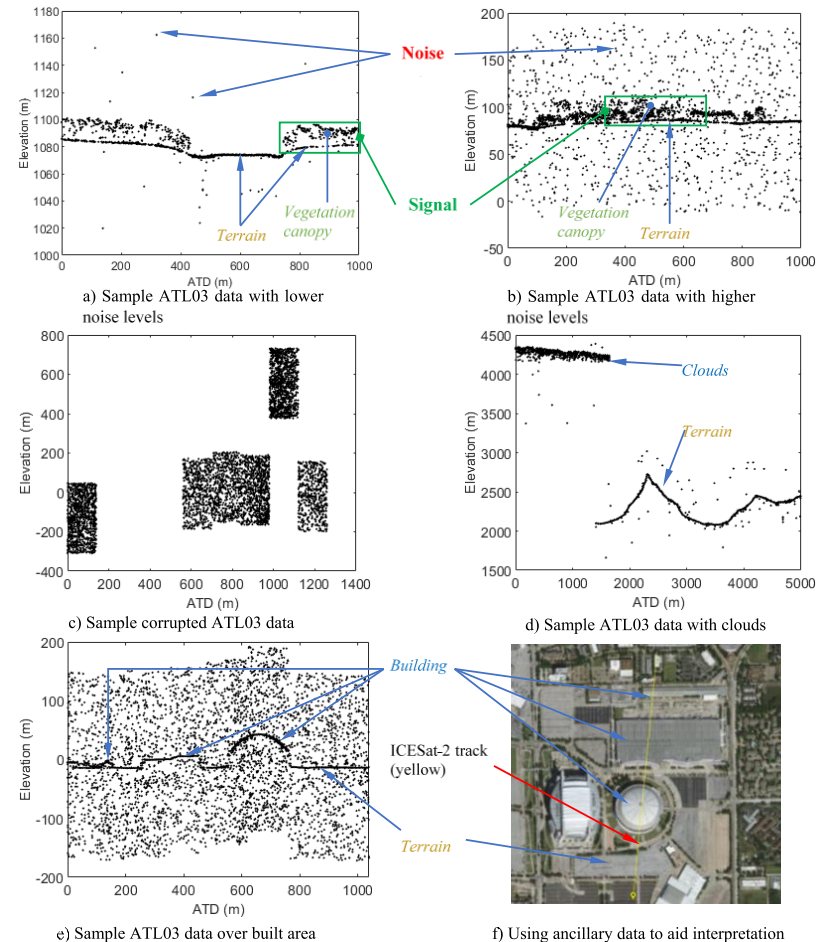
*Sample labeled ATL03 data over forested area in eastern Texas*



*Web map providing ancillary information for interpretation*

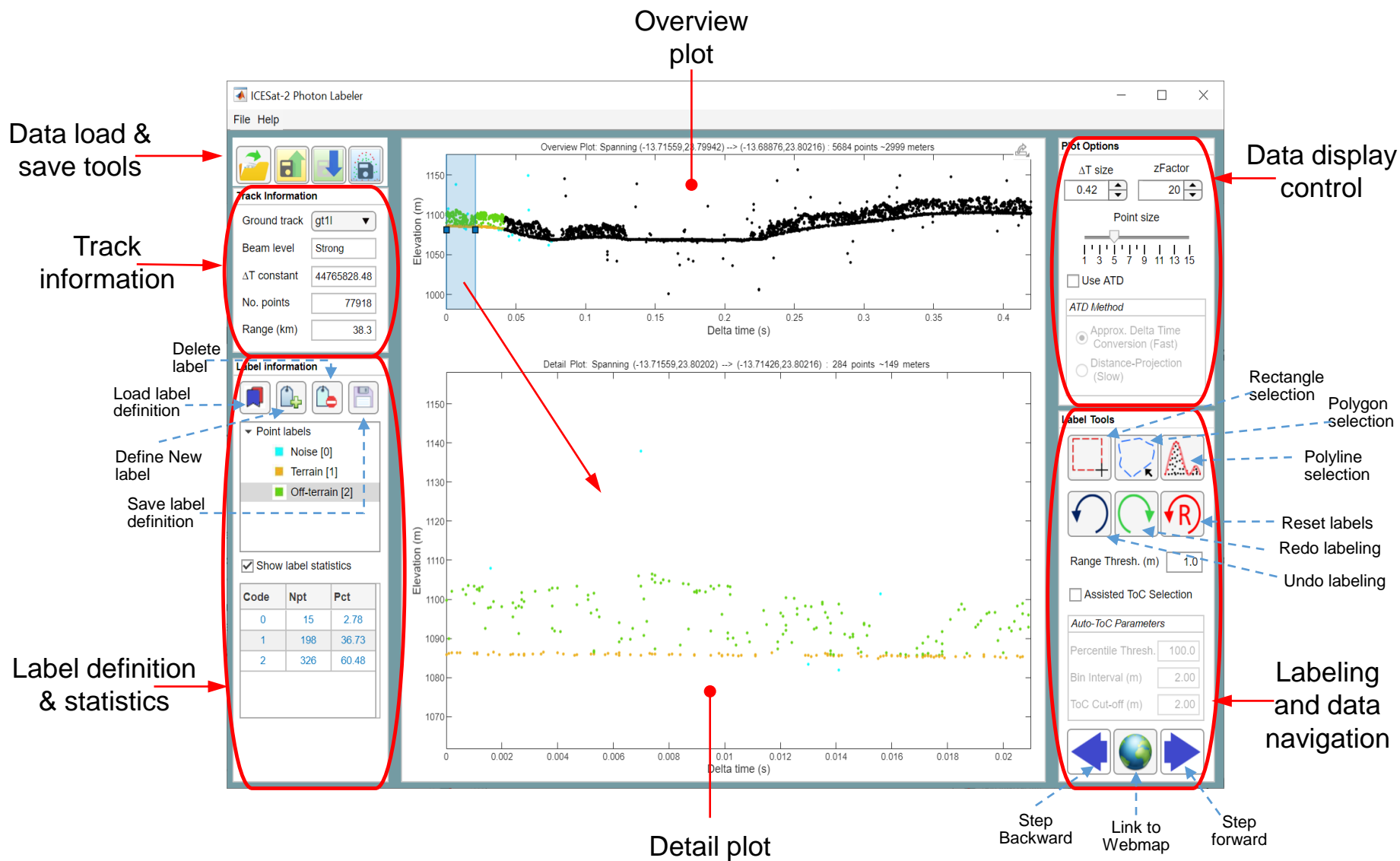
# ICESat-2 PhotonLabeler

- PhotonLabeler is a free graphic user interface (GUI) for visual interpretation, manual labeling and visualization of ICESat-2 Geolocated Photon data (ATL03)
  - Provides [a two-plot layout](#) to enhance the photon interpretation and labeling
  - Overview plot offers an overview of data over large extent; Detail plot provides a more detailed view across a smaller extent.
- PhotonLabeler software capabilities include:
  - reading and display of ATL03 HDF files
  - manual labeling of individual photons into target classes of choice
  - saving of labeled data in ASCII format
  - Saving and loading labeling sessions
- PhotonLabeler can facilitate manual collection of:
  - ground truth for validating various products from ICESat-2 mission
  - training data in the development of new algorithms for generating various ICESat-2 data products



*Sample ATL03 data in different environments with identification of points into classes*

# PhotonLabeler GUI Layout



# Left and right panel parameters

Specify or update data for labeling session e.g. ATL03 file, directories for saving labeled data

Load previously saved session

Load previously saved session

Save labeled data

**Track Information**

Loaded ground track

Ground track: gt2l

Beam strength (strong, weak, undef)

Beam level: Undef

Min delta\_time value. This value is subtracted before plotting data. NA if ATD is used

$\Delta T$  constant: 40568763.63

No. points: 58150

No. points in loaded track

Range (km): 19.7

Total distance covered by track

**Label information**

Load previously saved label definition files

Save label definition

Define new label

Point labels

- Noise [0]
- Terrain [1]
- Off-terrain [2]

Delete label

☒ Show label statistics

Summary of labeled data by class code

Code	Npt	Pct
0	6532	27.57
1	4415	18.63
2	12749	53.80

**Plot Options**

$\Delta T$  size determines span of data loaded in Overview plot

$\Delta T$  size: 1.5

zFactor [3 – 40], affects size of data loaded in detail plot: high value reduces the data resulting a more zoomed view and vice versa

zFactor: 10

Point size

1 3 5 7 9 11 13 15

☐ Use ATD

ATD Method

- ☒ Approx. Delta Time Conversion (Fast)
- ☐ Distance-Projection (Slow)

Uses ATD on x-axis, when enabled

ATD method

**Label Tools**

Labeling tools. See previous page

Range Thresh. (m): 1.0

☐ Assisted ToC Selection

Enables assisted top of canopy (ToC) selection

**Auto-ToC Parameters**

Percentile Thresh.: 100.0

Bin Interval (m): 2.00

ToC Cut-off (m): 2.00

Parameters for assisted top of canopy (ToC) selection

**Overview Plot**

Spanning (31.34632, -95.27796) → (31.44210, -95.26713): 31979 points ~10500 meters

Elevation (m)

Delta time (s)

**Detail Plot**

Spanning (31.34633, -95.26822) → (31.35589, -95.26713): 2263 points ~10.4 meters

Elevation (m)

Delta time (s)

# Downloading and installing PhotonLabeler

- PhotonLabeler can be downloaded from:

<https://github.com/Oht0nger/PhoLabeler/releases/tag/v1.0>

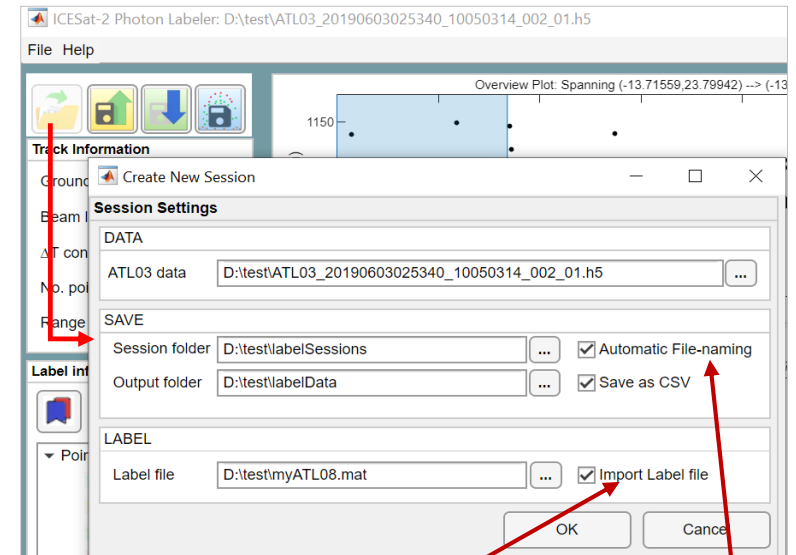
- Install standalone executable, which requires download free MATLAB runtime



1. Navigate to directory you saved the app executable file.
2. Double-click it to start the installation.
3. Follow dialog prompts to finish the installation
4. After installation, launch the application as a standalone software

# Labeling session requirements & setup

- Point visualization and labeling requires specification of :
  - ATL03 file
  - Output directories for labeling sessions and labeled data
  - File formats for saving labeled data
  - Existing label definition file, if available
- A point label definition defines point classes and their respective representation (color and class code)
- Once all parameters are set, clicking OK on the Create New Session dialog loads the data in the two plot axes based on currently set display parameters



When enabled, allows specification of saved label definition

Output session and labeled data files will be named using ATL03 filename as base filename

*Specifying input data and saving options*

Point class color

Point labels

Point class label

Point class code

Noise [0]

Terrain [1]

Off-terrain [2]

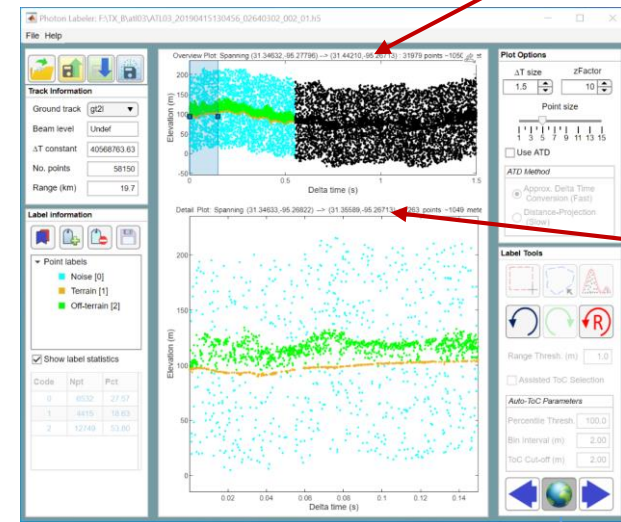
*Sample Label definition*



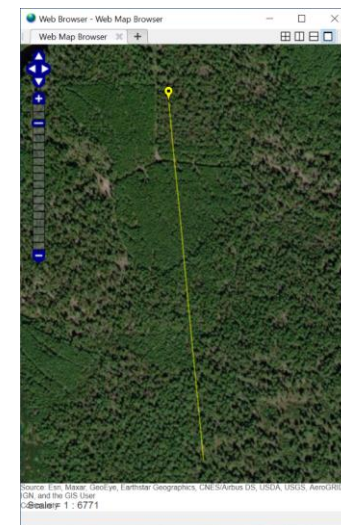
# Data display control and navigation

- PhotonLabeler reads and displays ATL03 HDF data by ground track
- Photon elevation values are plotted against delta time or along-track distance values
- Use the following to control the data display and navigate/explore the data:
  - Adjust  $\Delta T$  size parameter to increase or decrease data loaded in Overview plot. Adjust  $zFactor$  to control data loaded in Detail plot
  - Use *Next* and *Back* buttons to step through data in the Overview plot. Alternatively, drag the blue region to positions of interest
  - Link to web map. Clicking Next or Back button updates the web map.
  - Activate zoom in and out in the Detail plot by turning the scroll wheel on your mouse. Zooming interactions are disabled in the Overview plot.

Data span details including min/max latitude and longitude, number of points and the distance covered in Overview plot



Data span details including min/max latitude and longitude, number of points and the distance covered in Detail plot

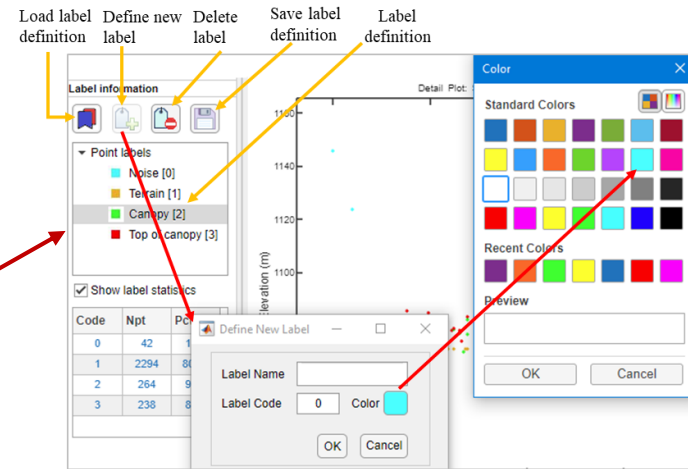


We recommend disabling the web map when you have to step through many sections of the data. This is because the update of the web map can be slower than the plotting of the points. This results in a long queue of web map updates which can degrade performance

Geo-linked web map showing track (yellow).  
Marker shows front direction of track

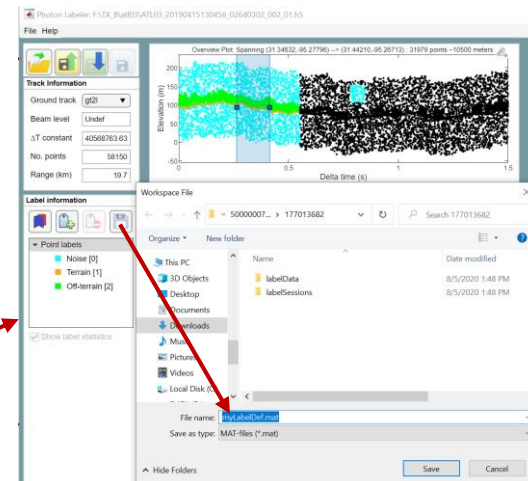
# Creating and saving point label definitions

1. Click the Define New Label button
2. In the Define New Label dialog, specify the class label, code and color. Use the color picker to select color of choice. Choose a label code (an integer representation) equal or greater than zero. Internally, PhotonLabeler uses a code of -1 to represent unlabeled data



*Creating Point label definitions*

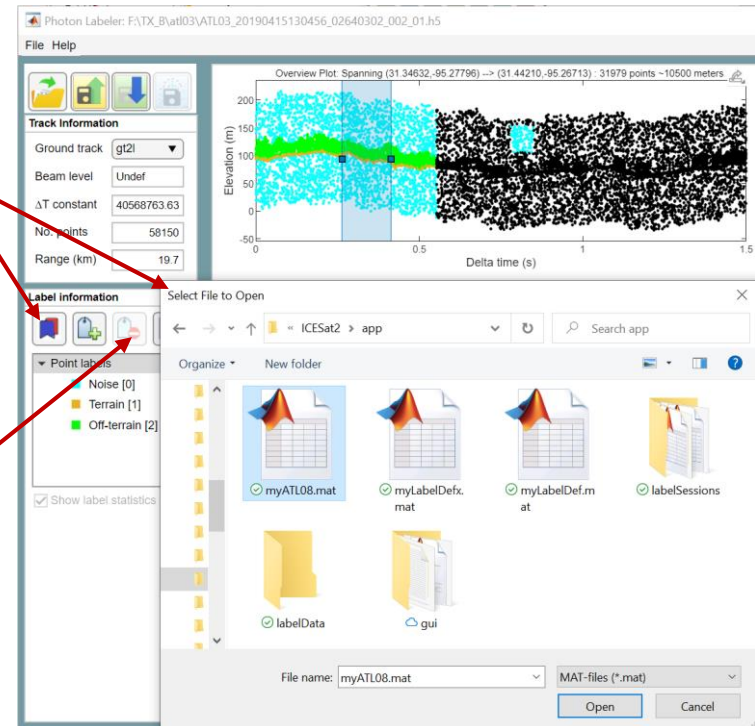
3. Click OK to define the point label.
4. Repeat steps 1 - 3, to define more labels to meet your project requirements
5. Having defined all the classes, you may save the defined labels as a label definition file (\*.mat) using the Save label definition button



*Saving Point label definitions*

# Loading point label definition

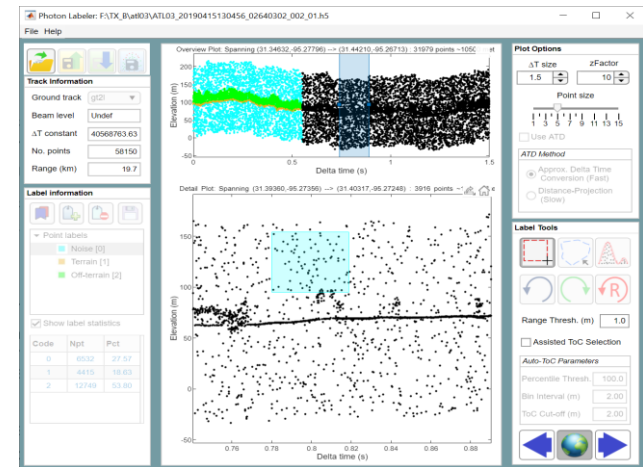
1. Click the Load Point Label Definition button
2. The Select File to Open dialog will open. Navigate to the directory you saved your definition file. Click open to load the file.
3. **Note:** Loading a point label file clears any currently loaded point definitions and resets all labeled data
4. You may delete individual items in the label definition using the Delete label button. Deleting a point label also resets all labeling information associated with the deleted point label.
5. In the current implementation, PhotonLabeler does not provide option to edit an item in the label definition. The only option is to delete it and recreate it with updated values.



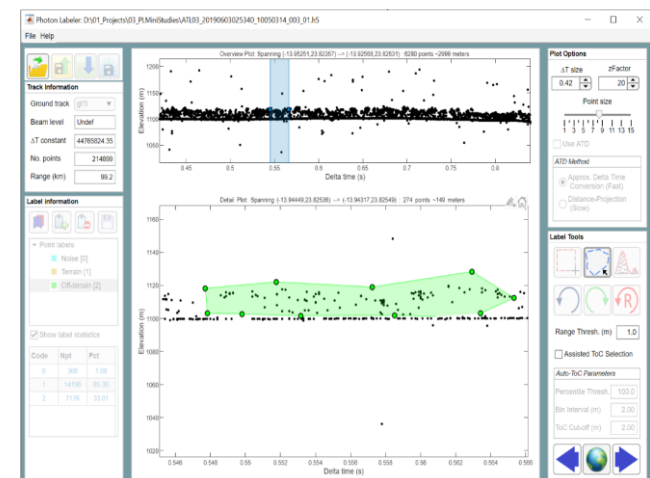
*Loading Point label definition file*

# Manual point labeling

1. Once you have loaded ATL03 and defined point labels, you may proceed with interpreting and labeling points in the Detail plot
2. To commit points to a class, select the class on the label list.
3. Use rectangle, polygon or polyline selection tool to select the points of interest
  1. Rectangle tool: hold and drag rectangle over area of interest and release. Points within the defined rectangle will be classified according to the active class color. The tool stays active for one to continue labeling. Right-click to deactivate.
  2. Polygon tool: use mouse to define boundary of area of interest. Right-click to close polygon. As rectangle tool, this tool remains active. Right-click **twice** to disable!
  3. Polyline tool: draw polyline along points of interest. Right-click to finish. All points within a specified distance (see Range Thresh. (m)) of the drawn polyline will be selected and committed to the active class. This tool does not remain active.
4. Use undo, redo buttons to undo or redo labeling actions. Reset button results all labels in Detail plot.
5. If needed, link to web map for help with point interpretation



*Rectangle selection*

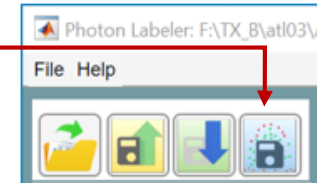


*Polygon selection*

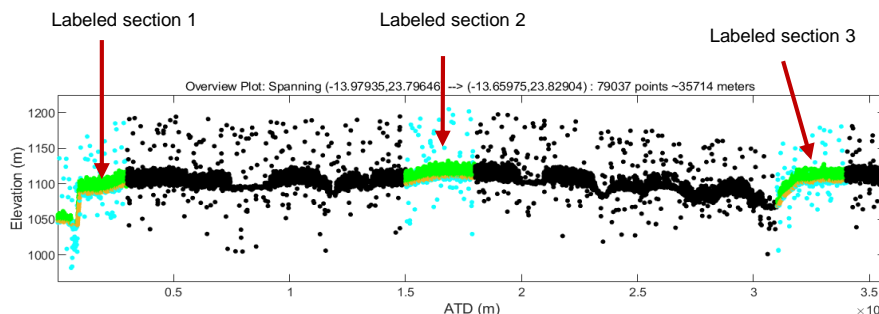


# Saving labeled data

- Labeled data may be saved by clicking the Save Labeled data button in ASCII formats (\*.csv, \*.txt)
- When Auto-file naming is enabled (see [Labeling session requirements section](#)), labeled data are saved to the *labelData* folder with the ATL03 filename as base name and appending the track ID. For example, labeled data in ground track gt1rl from file *ATL03\_20190415130456\_02640302\_002\_01.h5* will be saved as *ATL03\_20190415130456\_02640302\_002\_01\_gt1r.csv*
- When Auto-file naming is off, the user must specify the output file name. Turning off Save as CSV, would also allow one to save data as txt.
- Each contiguous section of labeled is coded with a distinct label section ID. In figure below, there are three separate labeled sections.



	A	B	C	D	E	F	G	H
	PointLabel	PointCode	LabelSection	Longitude	Latitude	Elevation	DeltaTime	AlongTrackDistance
1	Terrain	1	1	-95.26713406	31.34631985	95.73936	40568763.63	0
2	Terrain	1	1	-95.26713406	31.34631984	96.09914	40568763.63	0
3	Terrain	1	1	-95.26713405	31.34631984	96.126	40568763.63	0.714297806
4	Terrain	1	1	-95.26713476	31.34632622	96.07731	40568763.63	0.714297806
5	Terrain	1	1	-95.26713476	31.34632621	96.2446	40568763.63	0.714297806
6	Terrain	1	1	-95.26713476	31.34632622	96.14845	40568763.63	1.428382737
7	Terrain	1	1	-95.26713546	31.3463326	96.14837	40568763.63	1.428382737
8	Terrain	1	1	-95.26713547	31.3463326	96.04877	40568763.63	1.428382737
9	Terrain	1	1	-95.26713546	31.34633259	96.22439	40568763.63	1.428382737
10	Terrain	1	1	-95.26713547	31.3463326	95.98883	40568763.63	2.142627324
11	Terrain	1	1	-95.26713568	31.34633658	148.4134	40568763.63	2.142627324
12	Noise	0	1	-95.26713617	31.34633898	95.98115	40568763.63	2.142627324
13	Terrain	1	1	-95.26713617	31.34633898	95.94794	40568763.63	2.142627324
14	Terrain	1	1	-95.26713617	31.34633897	96.22092	40568763.63	2.85692513
15	Terrain	1	1	-95.26713687	31.34634536	96.09538	40568763.63	2.85692513
16	Terrain	1	1	-95.26713687	31.34634535	96.21167	40568763.63	2.85692513
17	Terrain	1	1	-95.26713745	31.34634817	34.74043	40568763.63	3.571222935
18	Noise	0	1	-95.26713758	31.34635173	96.17885	40568763.63	4.285520741
19	Terrain	1	1	-95.26713812	31.34635731	113.5594	40568763.63	4.285520741
20	Top of canopy	3	1	-95.26713829	31.34635812	96.03467	40568763.63	4.999818546
21	Terrain	1	1	-95.26713896	31.34636435	99.07778	40568763.63	4.999818546
22	Canopy	2	1	-95.26713899	31.34636449	96.16624	40568763.63	4.999818546
23	Terrain	1	1	-95.26713899	31.34636445	96.01941	40568763.63	5.71416957
24	Terrain	1	1	-95.26713928	31.34636885	140.0745	40568763.63	5.71416957
25	Noise	0	1	-95.26713921	31.34636849	147.9185	40568763.63	5.71416957
26	Noise	0	1	-95.26713967	31.34637076	98.4541	40568763.63	5.71416957
27	Canopy	2	1	-95.26713969	31.34637087	96.0289	40568763.63	6.428414157
28	Terrain	1	1	-95.26714033	31.34637692	103.1485	40568763.63	6.428414157
29	Canopy	2	1	-95.26714043	31.34637725	96.07243	40568763.63	7.142711963
30	Terrain	1	1	-95.26714165	31.34638629	37.99593	40568763.63	7.857009768
31	Noise	0	1	-95.26714253	31.34639355	19.64007	40568763.63	7.857009768
32	Noise	0	1	-95.26714243	31.34639301	30.42411	40568763.63	8.571307574
33	Canopy	2	1	-95.26714247	31.34639617	100.5167	40568763.63	8.571307574
34	Canopy	2	1	-95.26714246	31.34639614	101.249	40568763.63	8.571307574
35	Canopy	2	1	-95.26714251	31.34639636	97.7951	40568763.63	8.571307574
36	Canopy	2	1	-95.26714248	31.34639624	99.0202	40568763.63	8.571307574
37	Terrain	1	1	-95.26714387	31.34640886	101.8828	40568763.63	9.999849967
38	Canopy	2	1	-95.26714394	31.34640924	93.62151	40568763.63	9.999849967
39	Canopy	2	1	-95.26714525	31.34642155	104.3155	40568763.63	11.42844558
40	Terrain	1	1	-95.26714533	31.34642481	171.1722	40568763.63	12.14274338
41	Noise	0	1	-95.26714603	31.34642822	96.75472	40568763.63	12.14274338
42	Terrain	1	1	-95.26714602	31.34642821	96.95848	40568763.63	12.14274338
43	Terrain	1	1	-95.26714599	31.34642801	101.1894	40568763.63	12.85709441
44	Canopy	2	1	-95.26714611	31.34643158	162.419	40568763.63	12.85709441
45	Noise	0	1	-95.26714667	31.34643428	103.435	40568763.63	13.57138899
46	Canopy	2	1	-95.26714667	31.34643428	103.435	40568763.63	13.57138899



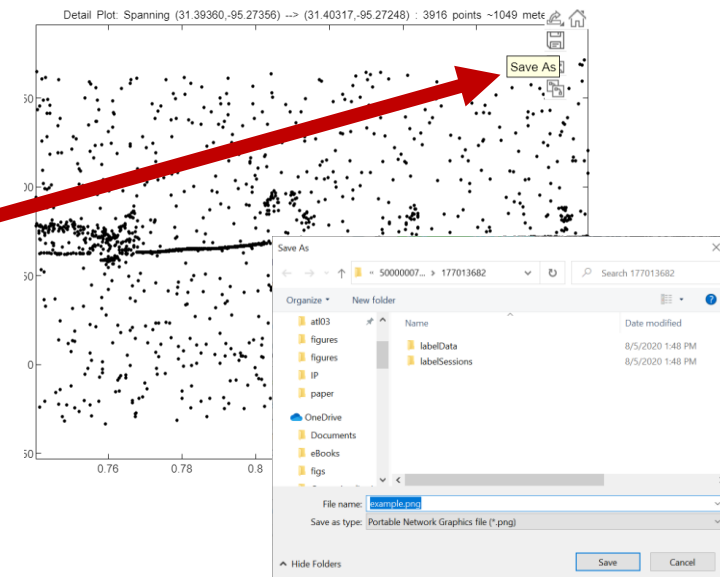
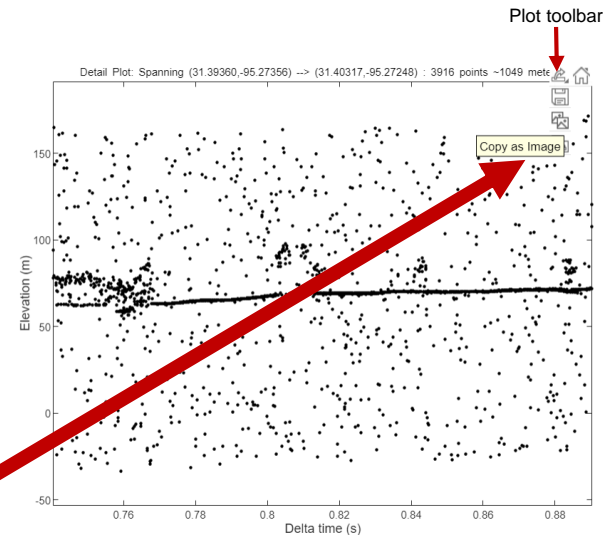
Sample labeled data

# Saving and loading a labeling session

- We understand that labeling tasks could span several data or months
- To manage labeling tasks over time, the PhotonLabeler enables the saving and loading of labeling sessions.
- The session file contains the state of the application at the time of saving and stores input files path and parameters to enable one to pick up labeling from where they left.
- To save a labeling session, click the Save Label Session Button. If Auto-file naming is enabled, the session file will be saved as MAT file to the define Session folder with the ATL03 as base name and appending the date and time the file was created e.g.  
ATL03\_20190415130456\_02640302\_002\_01\_15062020\_1535.mat, for a file saved on 05/15/2020 at 15:35 pm. If Auto-file naming is disable, the user must specify the output file name
- To load a previously saved session file, use the Load session button. Navigate to folder the file was saved and open it. PhotonLabeler should restore the labeling environment to allow for continued labeling

# Saving graphics

- PhotonLabeler enables copying or exporting of the Overview and Detail plots to a variety of image/graphic formats
- To copy the plot, click the plot toolbar dropdown and select Copy as.
- To save the plot, click the plot toolbar dropdown and select Save as. Choose destination folder and output filename to save the graphic.



# Error logging

- PhotonLabeler logs all errors raised during each session. The error log file is saved in the same folder as the ATL03 file.
- We welcome feedback on errors or issues with the software. We encourage users to send us the log file and a description of the issue for easier troubleshooting
- We will continue to make improvement as we receive user feedback

