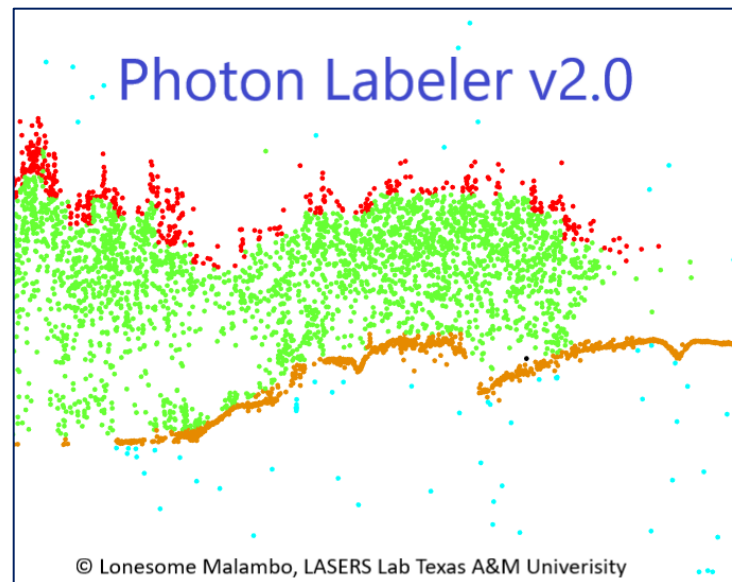Lidar Applications for the Study of
Ecosystems with Remote Sensing
Laboratory (LASERS)
Ecology and Conservation Biology
Texas A&M University
College Station TX
https://lasers.tamu.edu/

PhotonLabeler: ICESat-2 Photon Interpretation, Labeling & Visualization

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Table of Contents

ICESat-2 PhotonLabeler

PhotonLabeler is a free software tool for visualization, visual interpretation, manual labeling 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

- Merging of ATL03 points with ATL08 photon classifications

- Saving of labeled data in ASCII format

- Saving and loading labeling sessions

PhotonLabeler use cases include:

- Collection of reference point data for validating various products from ICESat-2 mission

- Collection of training data to support development of new algorithms for generating various ICESat-2 data products

- General data exploration for research and education purposes

a) Sample ATL03 data with lower noise levels

b) Sample ATL03 data with higher noise levels

c) Sample corrupted ATL03 data

d) Sample ATL03 data with clouds

c) Sample ATL03 data over built area
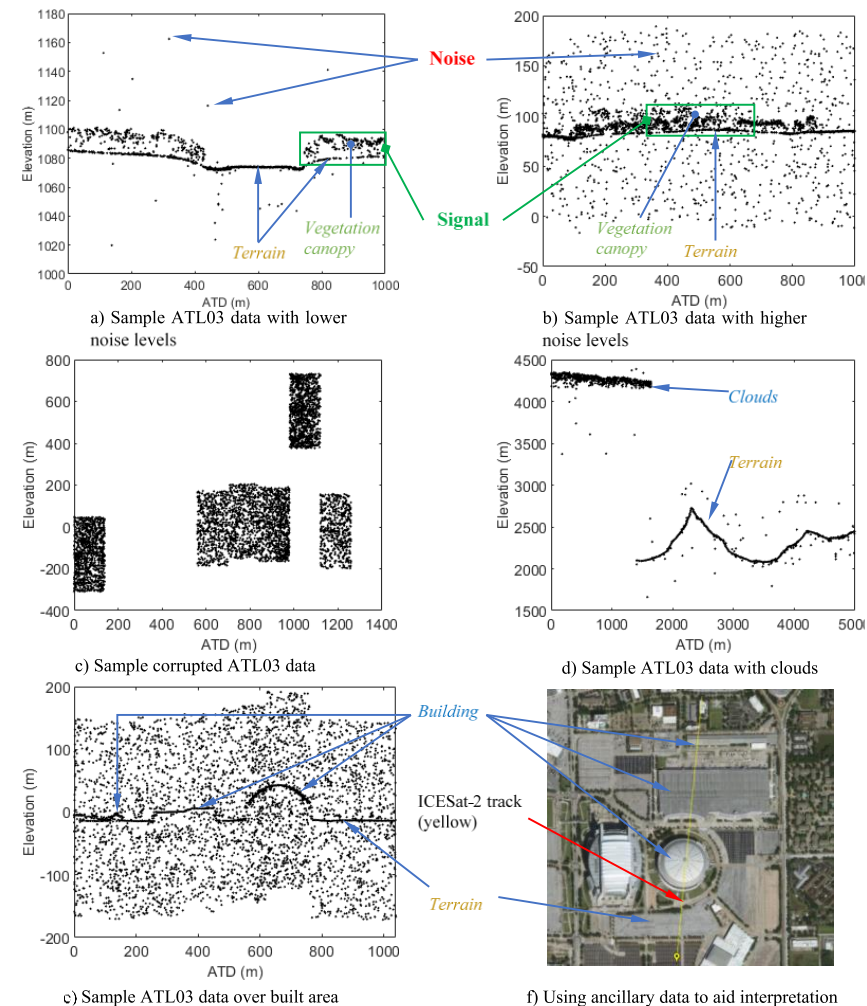
f) Using ancillary data to aid interpretation

Figure 1:Sample ATL03 data in different environments with identification of points into classes

Downloading and installing PhotonLabeler

PhotonLabeler can be downloaded from GitHub (https://github.com/Oht0nger/PhoLabeler/releases/tag/v1.0)

Install standalone executable, which will download the required (free) MATLAB runtime.

https://github.com/Oht0nger/PhoLabeler

Main Updates and New PhotonLabeler User Interface

Here are the new features and updates in the new version:

1) The Create New Session Dialog has been split to enable independent loading of ATL03 data 🗁 and setting of session parameters ⚙

2) Added capability to link ATL08 photon class values 🔗 to speed-up creating of labeled data

3) Added capability to add trackmarks for quick navigation to section of interest along a track

4) Added option to render point cloud by signal confidence and plot calculated ATL08 terrain canopy height values

5) Point selection tools are now state (on/off) buttons. Click to start and click to stop the tool.

6) Added button to enable skipping to beginning ◄ or end ►| of track

Data input & output

Display panel

Control data display, mark datamarks, overlay data layers (signal confidence and ATL08 heights)

Point label panel

Define point labels, import saved label definitions, link ATL08 classes, label statistics

Point selection & navigation panel

Select and label points, navigate back and forth along track, link to
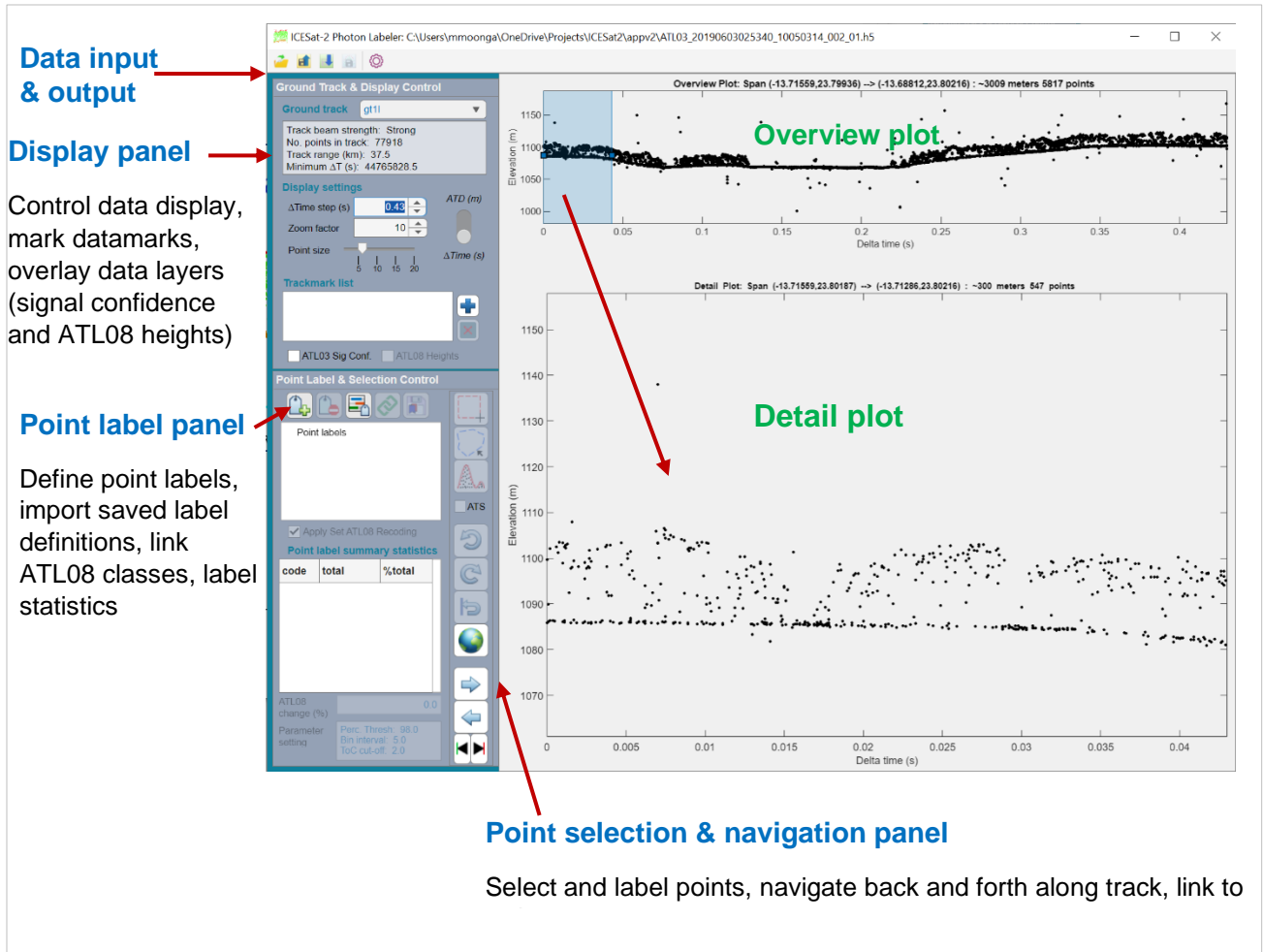
Input/Output & Display Panel Elements

The *Input/Output* menu enables loading of ATL03 h5 data, loading/saving labeling sessions, saving labeled data. This menu bar also has the preferences button, which facilitates setting of various processing preferences via a sub-window.

The *Ground Track & Display Control* panel shows various details on the loaded ground track (Beam strength, number of points, track range and the minimum delta time value. A user can control how much data or how data is displayed in the two plots by adjusting the Delta time step (ΔTime), Zoom factor and Point size. Users can switch between dt and along-track distance for the x-axis variable

What's New?

1) Mark trackmarks in the data. A *trackmark* is a shortcut to interesting sections along a track(s). Marking a trackmark saves display settings and extents of the two plots.

2) Display signal confidence (*signal_conf_ph*). Values range from 0 (background noise) to 4 (High confidence signal, See ATL03 ATBD)

3) Overlay estimated ATL08 heights – only the *h_te_best_fit* and the *canopy_h* can be displayed (See ATL08 ATBD).

Load ATL03 data

Load Session

Save Session

Save Labeled data

Session settings

Switch between DT and ATD

Mark datamark

Delete datamark

Show ATL08 heights

Show ATL03 signal confidence

Session and labeled data output folder settings

Save settings
Now users can choose to save all labeled data, only data covered by Overview plot or data in Detail plot

Range selection and ATS parameters

Point Label and Selection Control

The *Point Label and Selection Control* panel combines various tools for managing point label information and for manual point selection.

Point Label Control:

- Add/Delete Point Label
- Import saved Point Label file
- Link ATL08 class values
- Save Point Label Definition

Selection and Navigation Control

- Rectangular/Polygon/Range point selection tools
- Undo/Redo/Reset labeling
- Next/Back buttons for data exploration and navigation
- Link to Web map
- Assisted ToC selection (ATS)

What's New?

1) Linking ATL08 class values to aid interpretation and speed up collection of labeled data. Linking ATL08 class values is done on a track-by-track basis and requires ready defined label.

2) Behavior of selection tools has been modified. A selection tool will be active upon selection of a point label to reduce number of clicks when labeling. Clicking on an active selection tool again will disable it. Users can also change the target point label while a selection tool is active
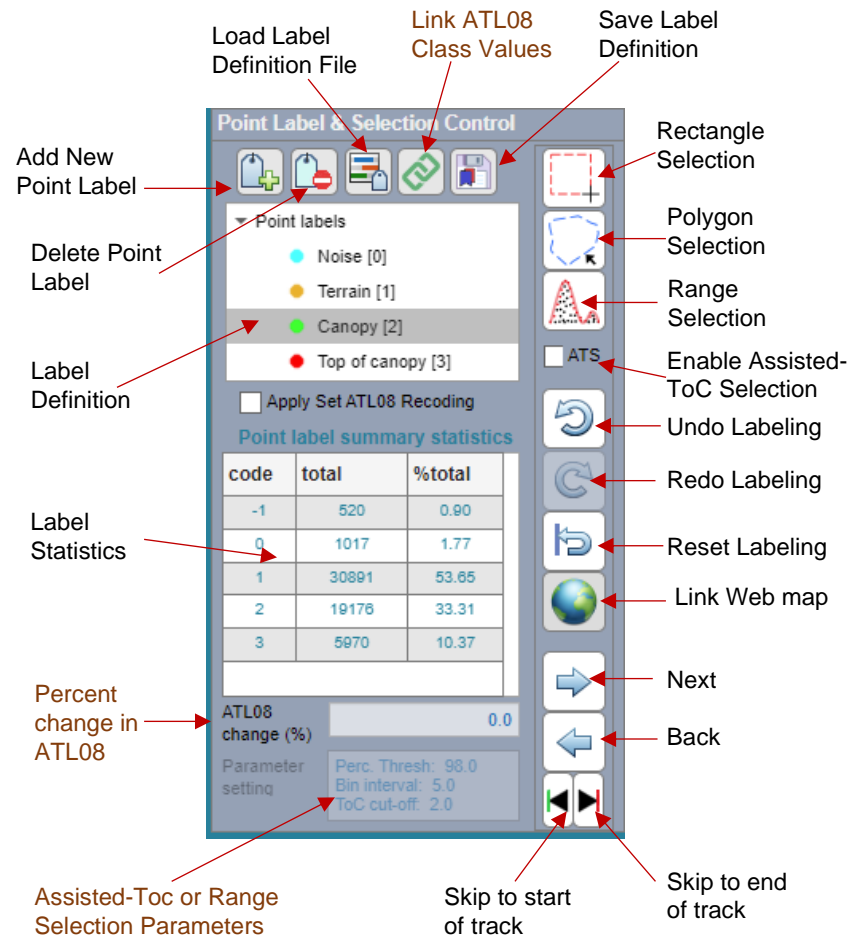

Figure 2: Point Label and Selection Tools

Setting Labeling Session Options

Prior to the labeling of ATL03 data, it is recommended (though optional) to specify several preferences for your labeling session. These settings include output directories for session files, output directories for labeled data and labeled data output formats. You may also specify what extent of the labeled data is saved either all labeled data, only data covered by the Overview Plot or only data in the Detail plot. Other process-related settings include ATD calculation method and parameters for Assisted ToC and Range Selection.

- To set session preferences Click the Session Settings icon
  ⚙ in the menu toolbar
- Session and Output folders can be automatically generated based on the loaded ATL03 path or may be manually specified.
- If you wish to define paths automatically, enable the Generate Output Folder/File Paths Automatically checkbox. Otherwise, use the three-dot buttons to specify the target directories.
- ATD Calculation Method section provides two approaches for calculating ATD values, one based on approximate time conversion, the other uses distance projection method
- Assisted ToC Selection section provides interface to define parameters for assisted selection of top of canopy points (See Malambo & Popescu, 2020)
- Once you have specified your preferences, Click OK to save your settings.
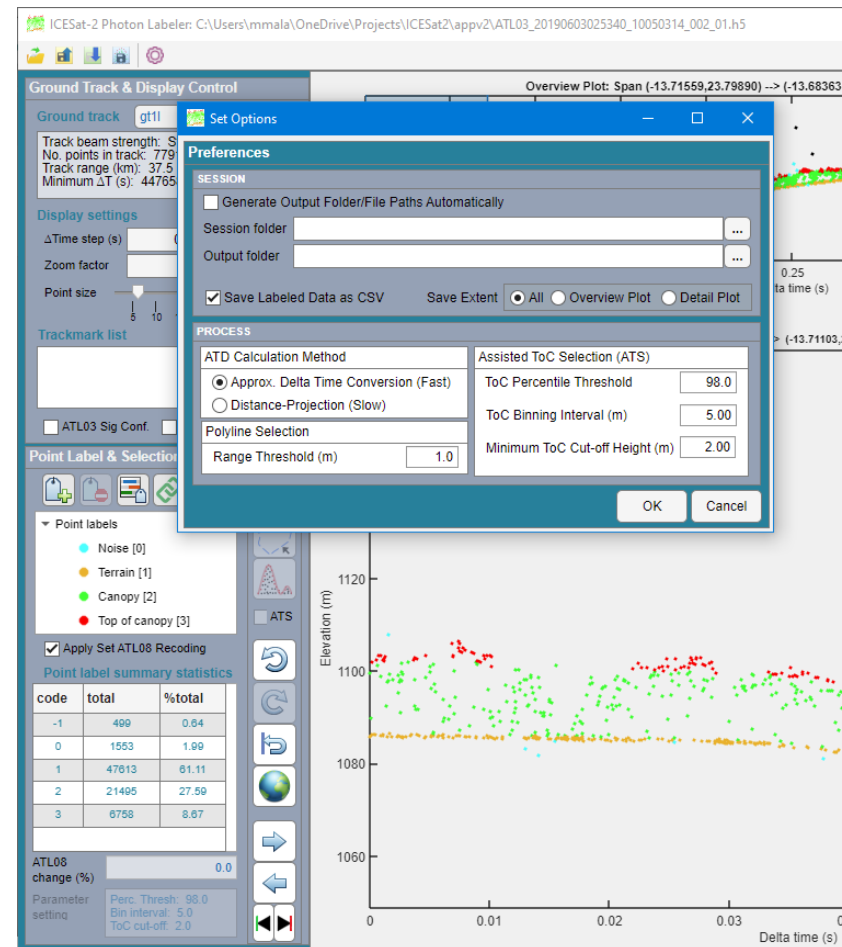

Figure 3: Setting labeling session options

Malambo, L., & Popescu, S. (2020). PhotonLabeler: An inter-disciplinary platform for visual interpretation and labeling of icesat-2 geolocated photon data. Remote Sensing, 12(19), 3168.

Loading ATL03 data, Display and Navigation Control

PhotonLabeler reads and displays ATL03 HDF data by ground track by plotting photon elevation values against delta time or along-track distance (ATD) values.

- To load an ATL03 file, click the Load ATL03 button 📂. Navigate to the file location, select it and click Open. Data will be loaded in the Overview and Detail plot axes.
- To visualize ATL03 point signal confidence, enable the ATL03 Sig. Conf check box

Use the following to control the data display and navigate/explore the data:

- Adjust ΔT size parameter to increase or decrease data loaded in Overview plot. Adjust Zoom Factor 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 disable in the Overview plot.
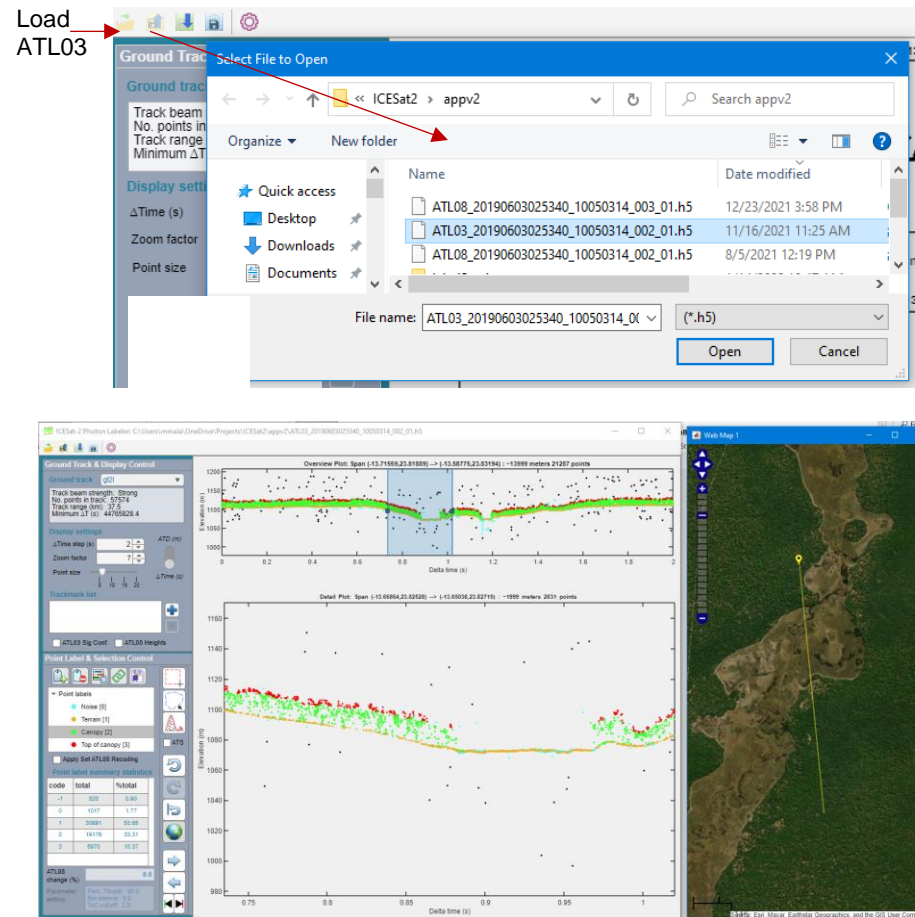
Linked Web map

Figure 4: Loading ATL03 data, Display and Navigation Control

Marking Trackmarks

PhotonLabeler creation of shortcuts to interesting sections along a track(s), called trackmarks or datamarks. Marking a trackmark saves display settings and extents of the two plots.

- To mark a trackmark, click the Add trackmark button ➕. In the Define Trackmark dialog, specify the datamark label. *It is advisable to use descriptive labels that capture the characteristics or phenomena in the data.*

- Click OK to create the defined datamark.

- To delete define trackmarks, use the Delete Trackmark button ❌.

- Remember, trackmark details are lost when the program is closed. To retain the trackmark details in for the file, save the labeling session (See page 14).
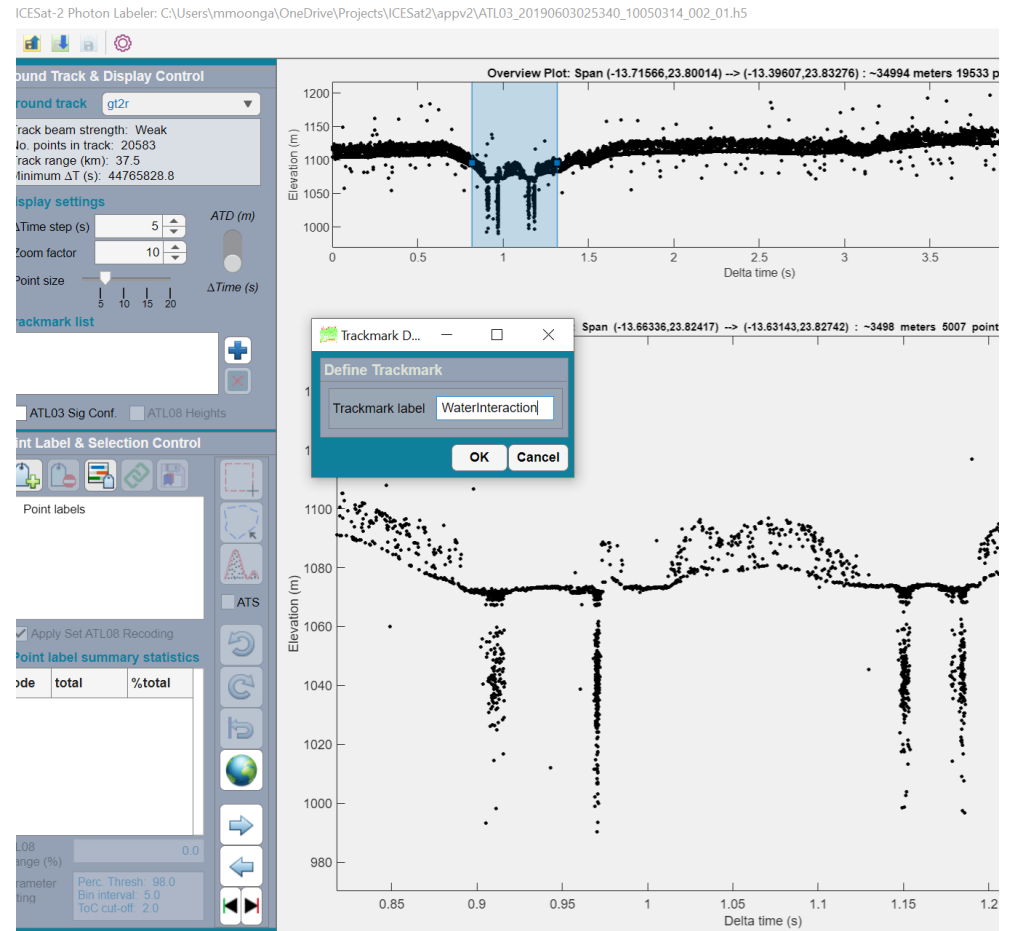
Figure 5: Marking trackmarks

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 represented unlabeled data

3. Click OK to define the point label.

4. Repeat steps 1 - 3, to define more labels to meet your project requirements

5. *The capability to edit labels is not yet implemented. To change a label, delete it and redefine it according to your preference.*

6. Having defined all the classes, you may save the defined labels as a label definition file (*.mat) using the Save label definition button
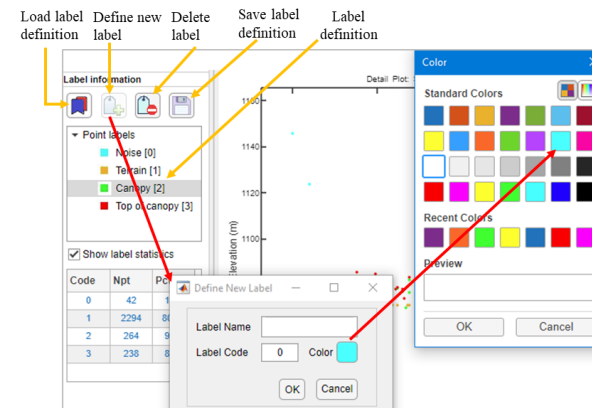
Creating Point label definitions
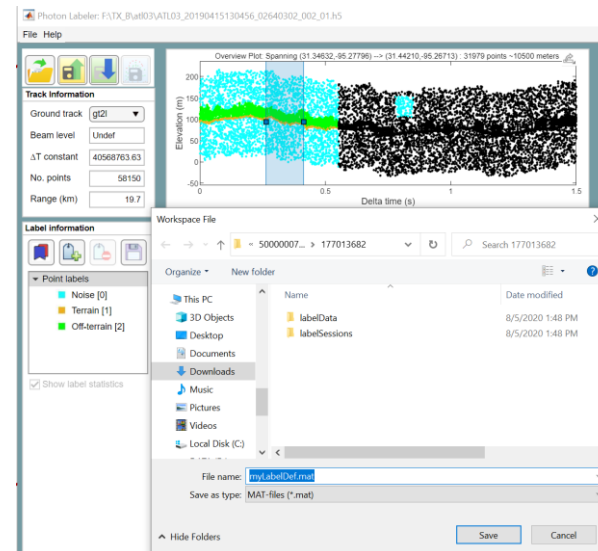
Saving Point label definitions

Figure 6: Create and saving point labels

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Loading Point Label Definition File

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.
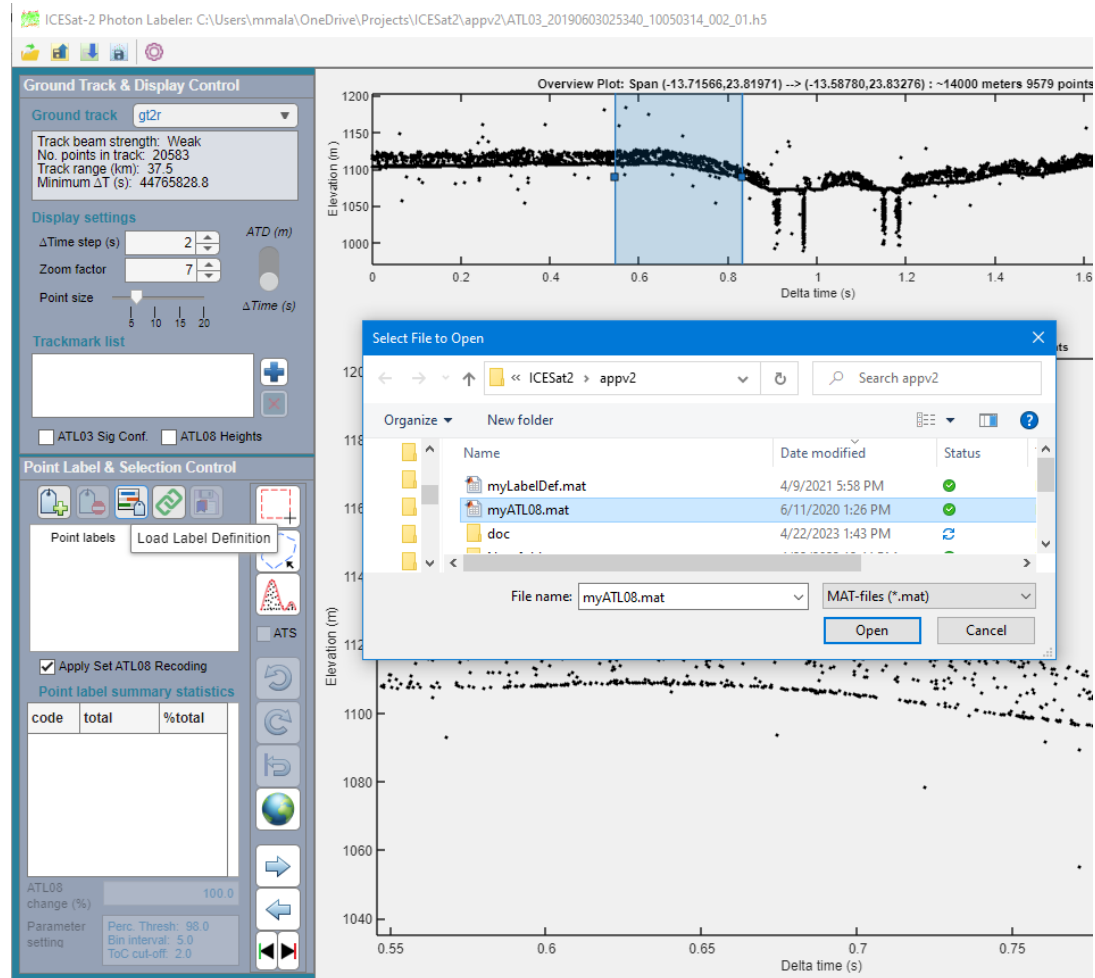
Figure 7: Loading a predefined point label definition file

Manual Point Selection and 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
   - *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. Click the tool button again to deactivate.
   - *Polygon tool:* use mouse to define boundary of area of interest. Right-click to close polygon. As rectangle tool, this tool remains active. Click the tool button again to deactivate.
   - *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. Click the tool button again to deactivate.

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
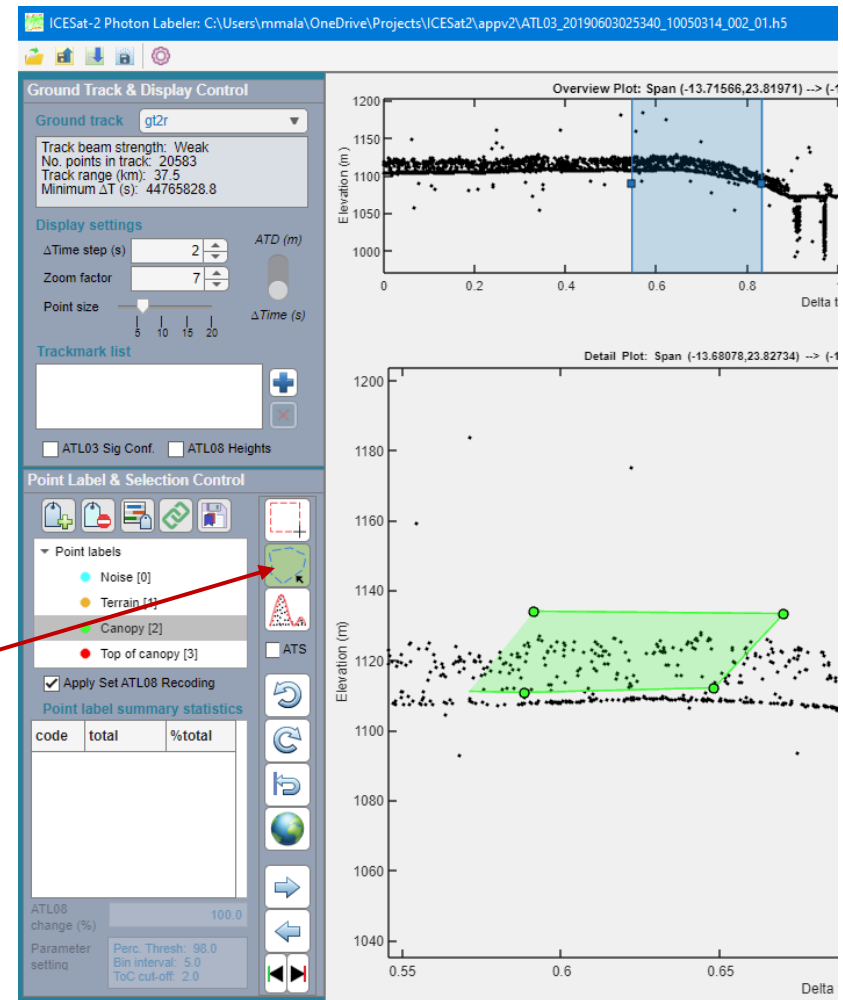
Figure 8: Point selection using Polygon Selection Tool

Linking ATL08 Class Values

The PhotonLabeler mow enables linking ATL08 photon classes to the loaded ATL03 file to enhance the visual interpretation and labeling of ATL03 data. Linking an ATL08 file in essence traces each classified photon to a specific photon in the ATL03 file.

Linking an ATL08 file requires prior definition of point labels and ATL08 classes are matched to defined class labels based on specified recoding settings.

1. To link ATL08 photon classes, click the Import ATL08 Photon Classification button.

2. In the Import ATL08 Class Data dialog box, specify the target ATL08 file.

3. Once, the file is opened complete linking ATL08 photon class IDs to match the defined point labels. Specify the target point codes in the table.

4. Optionally, disable the Overwrite Existing Labels checkbox if you would like to keep existing labeling.

5. Click OK to import the ATL08 classes.

Figure 9: Linking ATL08 photon class values to ATL03 points

Saving Labeled Data

PhotonLabeler facilitates saving of labeled point data to an ASCII text file (*.csv, *.txt).

The amount of data that is saved depends on the save extent preference you choose (refer to page 8). By default, all labeled data for a target track is saved. However, you also have the option to save only the data that falls within the extents defined by the Overview or Detail plot.

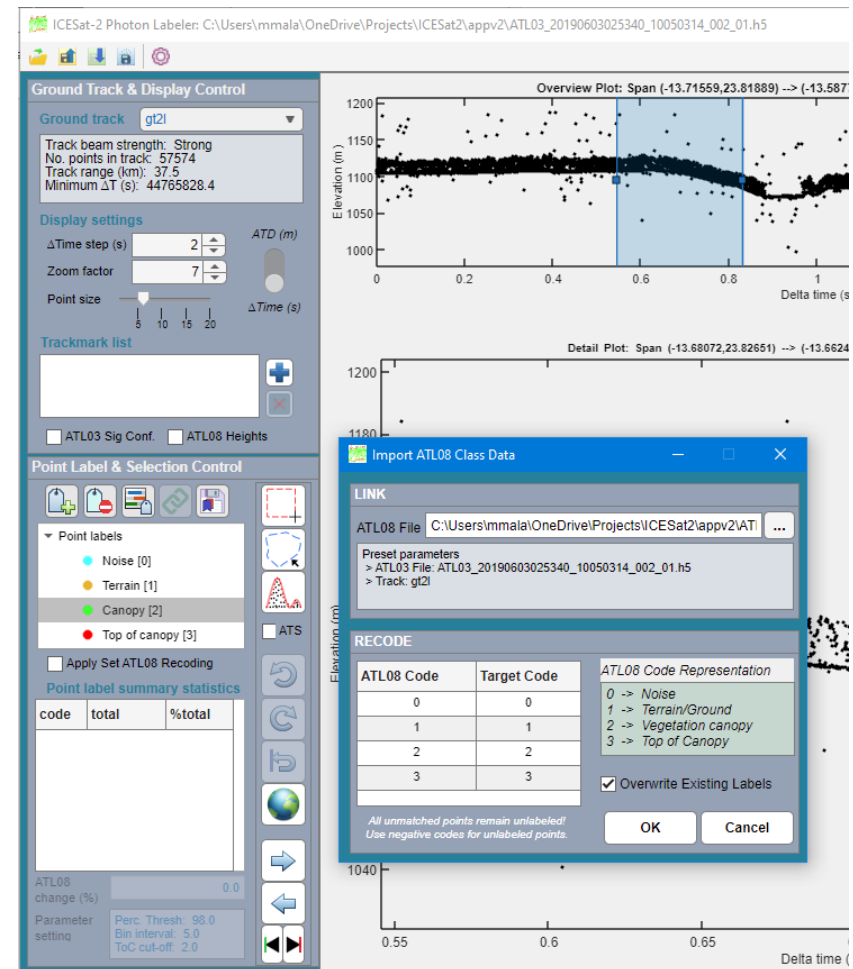Saving data is also controlled by specified auto-naming settings in the preferences. When Auto-file naming is enabled (see Labeling session requirements section), labeled data are saved to the labelData folder with the ATL03 filename as base name and appending the track ID. For example, labeled data 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.

To save labeled data, click the Save Labeled data button.

	A	B	C	D	E	F	G	H	I	J
1	PointLabel	PointCode	ATL08PointCode	LabelSection	Signal_Conf	DeltaTime	AlongTrackDistance	Longitude	Latitude	Elevation
2	Canopy	2	2	1	4	44765828	0	23.80216	-13.7156	1099.757
3	Terrain	1	1	1	4	44765828	0	23.80216	-13.7156	1085.915
4	Canopy	2	2	1	4	44765829	0.700011849	23.80216	-13.7156	1089.965
5	Terrain	1	1	1	4	44765829	0.700011849	23.80216	-13.7156	1086.131
6	Top of canopy	3	3	1	4	44765830	1.400023699	23.80216	-13.7156	1102.052
7	Terrain	1	1	1	4	44765830	1.400023699	23.80216	-13.7156	1086.38
8	Terrain	1	1	1	4	44765831	2.799995244	23.80216	-13.7156	1086.36
9	Terrain	1	1	1	4	44765832	3.500059247	23.80215	-13.7156	1086.266
10	Top of canopy	3	3	1	4	44765833	4.200071096	23.80216	-13.7156	1102.557
11	Canopy	2	2	1	4	44765833	4.900082946	23.80215	-13.7156	1101.256
12	Top of canopy	3	3	1	4	44765834	5.600094795	23.80215	-13.7155	1103.549
13	Top of canopy	3	3	1	4	44765835	7.00006634	23.80215	-13.7155	1103.408
14	Canopy	2	2	1	4	44765835	7.00006634	23.80215	-13.7155	1098.957
15	Terrain	1	1	1	4	44765835	7.00006634	23.80215	-13.7155	1086.18
16	Top of canopy	3	3	1	4	44765836	7.700078189	23.80215	-13.7155	1102.495
17	Terrain	1	1	1	4	44765836	7.700078189	23.80215	-13.7155	1086.06
18	Terrain	1	1	1	4	44765836	7.700078189	23.80215	-13.7155	1086.405
19	Top of canopy	3	3	1	4	44765837	8.400090039	23.80215	-13.7155	1102.838
20	Top of canopy	3	3	1	4	44765837	8.400090039	23.80215	-13.7155	1102.295
21	Top of canopy	3	3	1	4	44765838	9.099893272	23.80215	-13.7155	1103.126
22	Canopy	2	2	1	4	44765838	9.799852967	23.80215	-13.7155	1092.49
23	Canopy	2	2	1	4	44765839	10.49986482	23.80215	-13.7155	1097.852
24	Terrain	1	1	1	4	44765839	10.49986482	23.80215	-13.7155	1085.927
25	Canopy	2	2	1	4	44765840	11.19987667	23.80215	-13.7155	1097.999
26	Noise	0	0	1	4	44765840	11.19987667	23.80215	-13.7155	1107.912
27	Canopy	2	2	1	4	44765840	11.89988852	23.80215	-13.7155	1099.432
28	Terrain	1	1	1	4	44765840	11.89988852	23.80215	-13.7155	1086.525
29	Terrain	1	1	1	4	44765842	13.29996437	23.80215	-13.7155	1085.885
30	Canopy	2	2	1	4	44765842	13.99992406	23.80215	-13.7155	1098.123
31	Terrain	1	1	1	4	44765845	16.09995961	23.80214	-13.7154	1085.813
32	Canopy	2	2	1	4	44765845	16.79991931	23.80214	-13.7154	1099.078
33	Canopy	2	2	1	4	44765845	16.79991931	23.80214	-13.7154	1095.462
34	Terrain	1	1	1	4	44765845	16.79991931	23.80214	-13.7154	1086.091
35	Canopy	2	2	1	4	44765846	17.49993116	23.80214	-13.7154	1097.823
36	Canopy	2	2	1	4	44765847	18.19994301	23.80214	-13.7154	1098.219
37	Terrain	1	1	1	4	44765847	18.19994301	23.80214	-13.7154	1085.844
38	Terrain	1	1	1	4	44765847	18.19994301	23.80214	-13.7154	1085.827
39	Canopy	2	2	1	4	44765847	18.19994301	23.80214	-13.7154	1091.174

Figure 10: Sample labeled data output

Saving/Loading a Labeling Session

Labeling tasks may span several days or months depending on how much labeled data are needed. 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

1. 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

2. 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
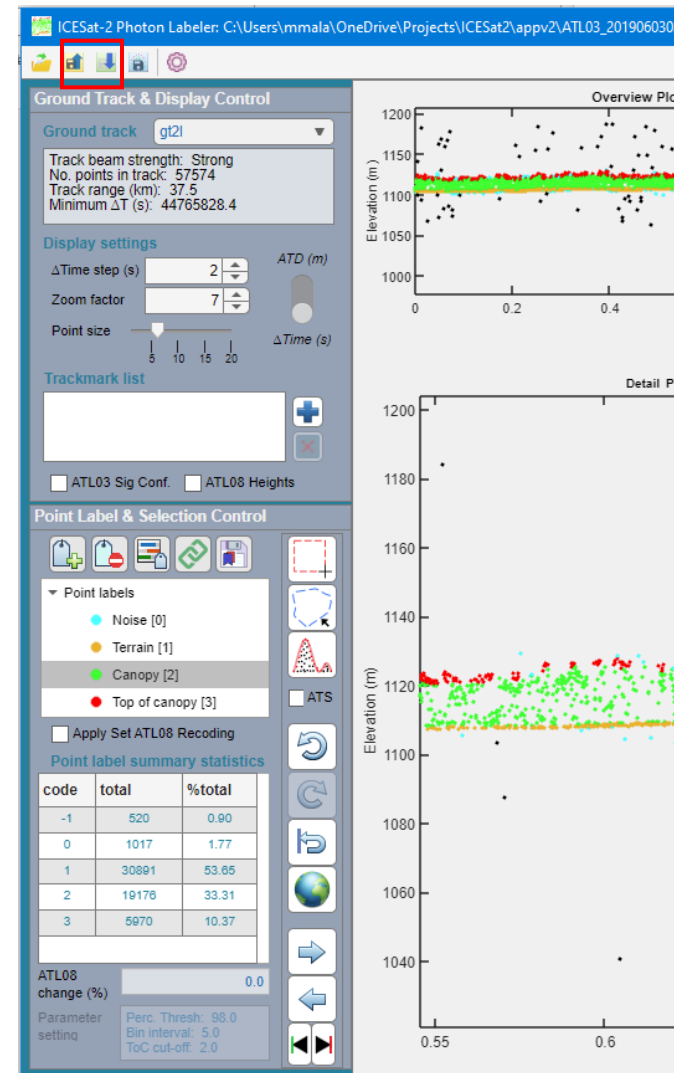

Figure 11: Saving and loading labeling sessions

Saving graphics

PhotonLabeler enables copying or exporting of the Overview and Detail plots to a variety of image/graphic formats

1. To copy the plot, clip the plot toolbar dropdown and select Copy as.
2. To save the plot, click the plot toolbar dropdown and select Save as. Choose destination folder and output filename to save the graphic.
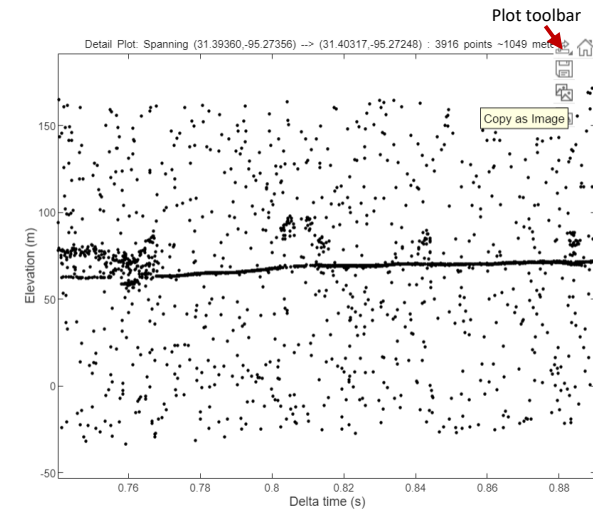
Copying plot graphics
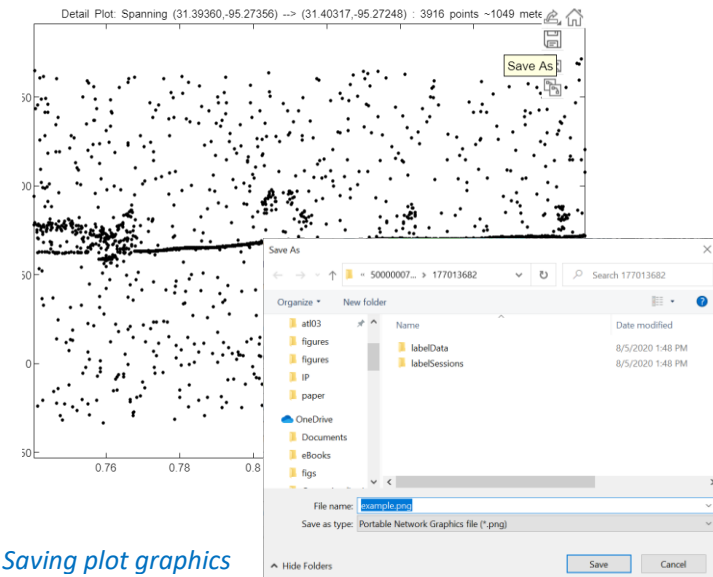
Saving plot graphics

Error logging

1. PhotonLabeler logs all errors raised during each session. The error log file is saved in the same folder as the ATL03 file.
2. 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
3. We will continue to make improvement as we receive user feedback