



ICESat-2 Data Explorer

User Manual

Version 0.10.0

Andrade et al. (2026)

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QGIS 3.44+ · ATL03 · ATL08 · ATL13 · ATL24 · SlideRule · GOT4.10c

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1. Purpose

ICESat-2 Data Explorer is a QGIS plugin for accessing, visualizing, documenting, and analyzing selected ICESat-2 products directly inside QGIS. Version 0.10.0 supports ATL03, ATL08, ATL13, and ATL24 workflows through SlideRule, includes an interactive profile viewer, generates HTML processing reports, and provides an optional model-tide workflow for ATL24 using GOT4.10c through pyTMD.

The plugin is designed so that data acquisition, visualization, profile inspection, and provenance reporting remain in a single GIS environment.

2. Compatibility and requirements

- QGIS 3.44 or later.
- QGIS 3.44 is the recommended and tested family for this release.
- QGIS 3.30 is not supported for automatic SlideRule setup because its bundled Python environment may fail to provide a usable SSL module.
- Internet access is required for SlideRule installation and ICESat-2 requests.
- A NASA Earthdata Login is not required by the plugin download workflow.
- Model tide support is optional and managed separately from SlideRule download support.

Supported products

Product	Main purpose	Current behavior
ATL03	Photon-level geolocated data	ATL03 Version 7; geoid/ocean-tide ancillary fields; granule batching, retry and beam fallback for large requests.
ATL08	Land and vegetation segments	Terrain/canopy visualization and 0-100 server-side quality-score thresholds.
ATL13	Inland-water segments	Water-surface and detected-water-depth visualization with local filters.
ATL24	Coastal/nearshore bathymetry	Version 2 current/default; Version 1 legacy comparison.

3. Installation

3.1 Install the plugin from ZIP

1. Open QGIS.
2. Open Plugins > Manage and Install Plugins.
3. Choose Install from ZIP.

4. Select the ICESat-2 Data Explorer ZIP file.
5. Enable ICESat-2 Data Explorer.
6. Open Plugins > ICESat-2 Data Explorer > Data Explorer.

The plugin menu contains: Data Explorer, Interactive Profile, Model Tide Values, and About.

3.2 First-time download support

1. Open Data Explorer.
2. In Download support, click Install download support.
3. Wait until the status confirms that managed SlideRule support is ready.
4. Use the same support for ATL03, ATL08, ATL13, and ATL24 downloads.

Note: The plugin manages SlideRule support outside the plugin source folder. This improves portability and reduces interference with the scientific Python packages shipped with QGIS.

4. Data Explorer overview

1. Select the ICESat-2 product.
2. Select start and end dates.
3. Define the area of interest.
4. Configure product-specific settings.
5. Choose an output GeoPackage.
6. Run the download.
7. Inspect the output layer and HTML report.

4.1 Date range

Dates are entered as YYYY-MM-DD. The selected period is sent with the data request and recorded in the report.

For broad ATL03 searches, many granules can intersect the selected period. Version 0.10.0 retains CMR resource discovery, one-granule-at-a-time processing, retry of interrupted responses, per-beam fallback when needed, and incremental GeoPackage writing.

4.2 Area of interest

The coordinate boxes use geographic longitude and latitude in decimal degrees. West and East are longitudes; South and North are latitudes. These values are not UTM eastings or northings.

- Use current map extent - adopts the visible map extent.
- Draw polygon on map - interactively draws an AOI.
- Use selected polygon - uses a selected polygon feature already present in QGIS.

Note: The exact request geometry is retained for provenance. The report can also render an AOI overview using visible QGIS project layers.

5. ATL24 bathymetry

5.1 ATL24 release

- Version 2 - current and recommended
- Version 1 - legacy comparison

Use Version 2 for new analyses. Version 1 is retained so that older known results can be compared without silently mixing releases.

5.2 Filters

Minimum confidence accepts values from 0.00 to 1.00. A value of 0.00 is the most permissive setting.

- Exclude low-confidence photons
- Exclude sensor-depth-exceeded photons
- Exclude photons with invalid Kd
- Exclude photons with invalid wind speed

Note: For a diagnostic test in a location where bathymetry is known to exist, start with Minimum confidence = 0.00 and leave all exclusion flags unchecked.

6. ATL08 land and vegetation segments

6.1 Server-side quality filters

Minimum terrain quality score and Minimum canopy quality score use an integer scale from 0 to 100. A value of 0 disables the corresponding server-side filter. Higher thresholds are more restrictive.

Note: Server-side filters change the returned dataset. Local display filters only change what is visible in QGIS and do not delete records from the GeoPackage.

6.2 Display field

- Canopy height
- Mean / maximum / minimum canopy height
- Terrain elevation
- Terrain slope
- Vegetation cover
- Ground photon count
- Canopy photon count
- Canopy openness

6.3 Local display filters

- Hide segments without valid terrain elevation

- Hide segments without ground photons
- Hide segments without canopy photons
- Hide negative canopy heights

7. ATL03 photon-level data

ATL03 can contain very large numbers of photons. For a first test in a new study area, use a smaller AOI or narrower time range.

7.1 Server-side photon selection

Surface type options include Dynamic/all surface types, Land, Ocean, Sea ice, Land ice, and Inland water.

Minimum confidence ranges from no native confidence filter to high-confidence-only selection. Photon quality can be set to all quality classes or nominal photons only.

7.2 Display and local filters

Display options include photon height, orthometric photon height, geoid, geoid free-to-mean conversion, ATL03 ocean tide, signal confidence, photon quality, solar elevation, background rate, and along-track distance.

7.3 Large-area processing

1. Discover ATL03 Version 7 granules through NASA CMR.
2. Process one granule at a time using the exact AOI.
3. Retry transiently interrupted SlideRule responses.
4. If a full-granule stream remains unstable, split that granule into individual beams.
5. Append successful chunks incrementally to a temporary GeoPackage.
6. Commit the final GeoPackage only when the complete task succeeds.

Note: This strategy is intended to reduce failures such as Unexpected termination of response on large ATL03 requests.

8. ATL13 inland-water data

The display field can be Orthometric water-surface height, Ellipsoidal water-surface height, Water-surface standard deviation, or Detected water depth.

Local display options can hide segments without a valid selected value and restrict the view to segments with detected positive water depth. These filters do not remove records from the GeoPackage.

9. Interactive Profile

Open Plugins > ICESat-2 Data Explorer > Interactive Profile. Compatible ATL03, ATL08, ATL13, and ATL24 layers already loaded in QGIS can be selected.

9.1 Select a layer and pass

Available pass / beam lists valid combinations with acquisition date, RGT, cycle, beam, and point count.

2024-07-13 · RGT 0392 · Cycle 06 · gt2r · 951 points

Item	Meaning
Acquisition date	Derived from the observation time.
RGT	Reference Ground Track identifier; spatial/orbital, not a date.
Cycle	ICESat-2 repeat cycle.
Beam (gt)	Ground-track beam identifier.

9.2 Choose X and Y axes

Any numeric attributes available in the selected layer can be chosen for X and Y.

Product	Default X	Default Y
ATL24	Latitude	Depth
ATL08	Latitude	Terrain elevation (h_te_median)
ATL03	Latitude	Photon height (height)
ATL13	Latitude	Orthometric water-surface height (ht_ortho)

For along-track inspection, X = Along-track distance (x_atc) is often useful when present. Positive-down depth fields are displayed with an inverted Y axis; elevations and heights remain positive-up.

9.3 Profile interaction

- Click point selection
- Rectangle selection
- Matplotlib pan/zoom
- Clear selection
- Zoom to profile extent
- Zoom to selected points
- Exclude selected from profile
- Restore excluded points

Note: Exclusion is temporary and does not delete source observations. Longitude/latitude are stored separately from plotted axes so QGIS map zoom remains geographic even when X/Y are non-geographic attributes.

10. Model Tide Values for ATL24

Open Plugins > ICESat-2 Data Explorer > Model Tide Values. This workflow requires an ATL24 layer containing depth, longitude, latitude, and time.

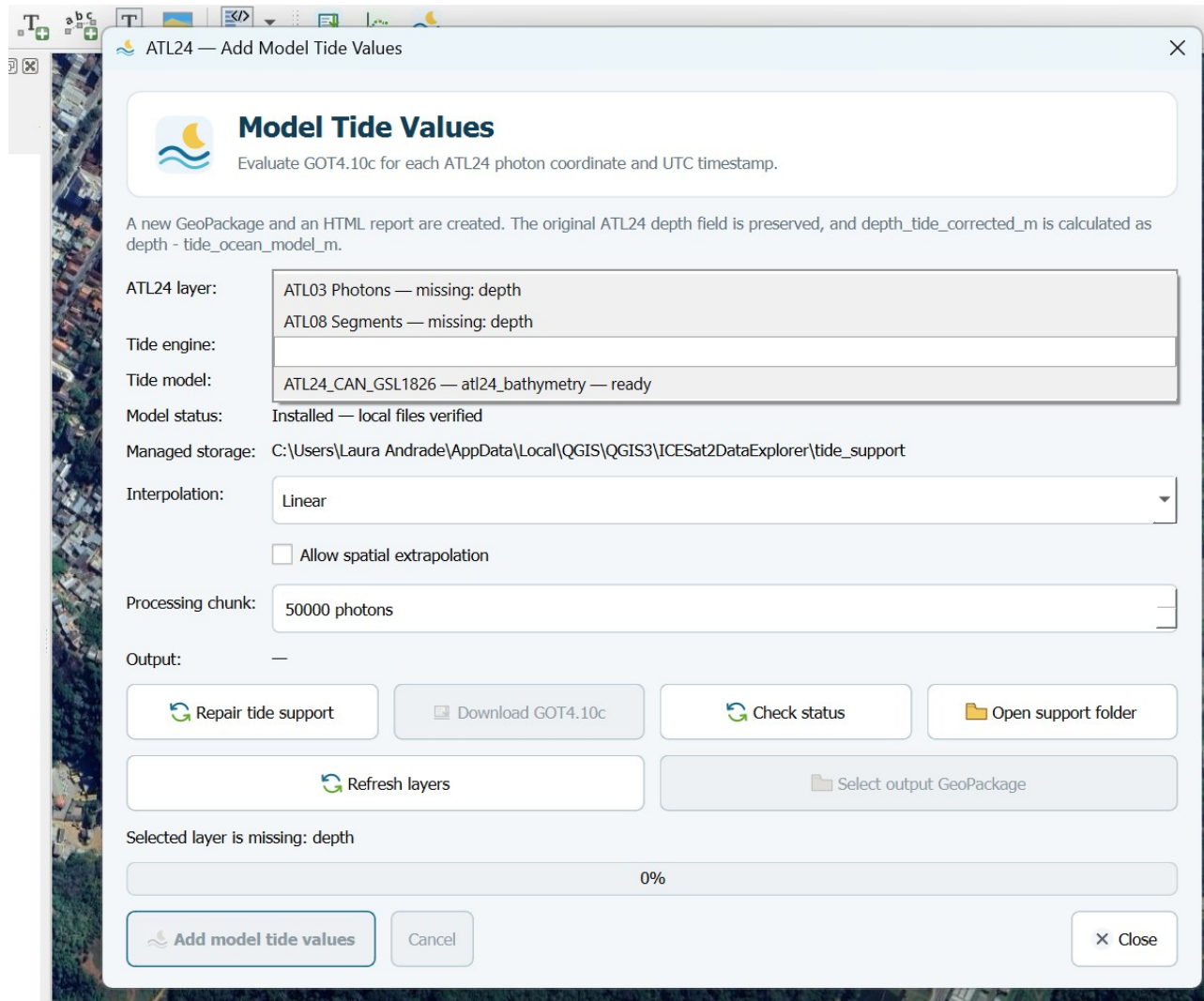


Figure 1. Model Tide Values interface.

10.1 First-time tide support

1. Click Install tide support.
2. Wait for the isolated environment to become ready.
3. Click Download GOT4.10c.
4. Use Check status to verify the environment and local model files.

After reinstalling or moving QGIS, use Repair tide support if the old virtual environment is linked to a missing Python interpreter.

10.2 Interpolation and chunks

Interpolation can be Linear or Nearest. Allow spatial extrapolation is disabled by default. The default processing chunk is 50,000 photons.

10.3 Output fields

Field	Meaning
tide_ocean_model_m	Modeled astronomical ocean-tide elevation from GOT4.10c.
depth_tide_corrected_m	Tide-reduced depth = depth - tide_ocean_model_m.
tide_time_utc	UTC time used for model evaluation.
tide_valid	Validity indicator for the modeled tide.
tide_model	Model identifier.
tide_method	Interpolation method used.

$$\text{depth_tide_corrected_m} = \text{depth} - \text{tide_ocean_model_m}$$

A positive modeled tide means the instantaneous water level is above the model tide zero; subtracting that positive elevation reduces the instantaneous positive-down depth toward the model tide zero. A negative modeled tide increases the reduced depth.

Vertical-reference caution: depth_tide_corrected_m is not automatically a chart-datum, LAT, MLLW, or observed local-MSL depth. It is a tide-reduced value relative to the zero/mean level implicit in the astronomical tide model. Meteorological and other non-astronomical water-level effects are not represented.

11. Output GeoPackages and HTML reports

Successful requests create a GeoPackage and an HTML report. The report is intended to document provenance and interpretation, not just raw parameters.

- Executive summary
- Data source and provenance
- Request and visualization
- Area-of-interest overview
- Vertical-reference notes
- Product statistics
- Classification summary
- Quality assessment
- Attribute dictionary

- Warnings
- Scientific notes
- Technical details and request parameters

The date range is shown as YYYY-MM-DD to YYYY-MM-DD. Exact AOI WKT is retained under Technical details. The Attribute dictionary omits QGIS field-type and NULL-count columns; NULL information remains in quality-oriented sections where relevant.

12. Recommended workflows

12.1 Quick ATL24 workflow

1. Select ATL24 and keep Version 2 for a new analysis.
2. Select dates and AOI.
3. Start with Minimum confidence = 0.00 and no exclusion flags.
4. Choose an output GeoPackage and download.
5. Open Interactive Profile and choose a date/RGT/cycle/beam combination.
6. Use X = along-track distance when available and Y = depth for an along-track bathymetric view.
7. If tide reduction is needed, process the ATL24 output with Model Tide Values.

12.2 Quick ATL03 workflow

1. Start with a modest AOI and limited date range.
2. Select ATL03 and the appropriate native surface type.
3. Use a permissive confidence setting for the first availability test.
4. Download; large requests are processed granule-by-granule.
5. Use Interactive Profile to isolate the desired date, RGT, cycle, and beam.

13. Troubleshooting

Problem	Action
SlideRule is not installed	Open Data Explorer and click Install download support. This is normally required once per QGIS installation.
QGIS 3.30 reports SSL errors	Use QGIS 3.44 or later. Version 0.10.0 does not support automatic setup in QGIS 3.30.
ATL03 reports Unexpected termination of response	Version 0.10.0 retries and can split an unstable granule by beam. If a request still fails, reduce AOI or date range.

Known ATL03 data are not returned	Check date range, AOI, surface type, confidence selection, and photon quality. Coastal photons may appear under a native surface category different from intuitive expectations.
Known ATL24 data are not returned	Test Version 2 with confidence 0.00 and no exclusions. If the known result is from an older collection, explicitly test Version 1 - legacy comparison.
Model Tide shows missing: depth	Select a compatible ATL24 bathymetry layer containing the depth field.
Tide environment requires repair	Use Repair tide support, especially after reinstalling or moving QGIS.

14. Data integrity and scientific cautions

- Local display filters do not delete data from the GeoPackage.
- Temporary profile exclusions do not delete source observations.
- Record and keep product releases consistent within an analysis.
- Do not silently mix ATL24 Version 1 and Version 2.
- The original ATL24 depth is preserved by the model-tide workflow.
- GOT4.10c tide reduction is not equivalent to a complete hydrographic chart-datum transformation.
- Retain HTML reports with project outputs because they document processing provenance.

15. Citation and authorship

Recommended short citation:

Andrade et al. (2026). ICESat-2 Data Explorer. Version 0.10.0.

Software authors:

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- Kim Earle Lowell
- Nilcilene das Graças Medeiros
- Arthur Amaral e Silva
- Italo Oliveira Ferreira

16. GitHub documentation structure

```
icesat2-data-explorer/  
├─ README.md  
├─ LICENSE  
├─ CITATION.cff  
├─ metadata.txt  
├─ ... plugin source files ...  
└─ docs/  
    ├─ USER_GUIDE.md  
    ├─ USER_GUIDE_pt-BR.md  
    ├─ ICESat2_Data_Explorer_User_Manual_v0.10.0.pdf  
    └─ images/  
        └─ model_tide_values.png
```

Keep README.md concise and link prominently to docs/USER_GUIDE.md. The Markdown guide is the best primary GitHub manual because it is readable in the browser and version-controlled with the code. The PDF is useful as a fixed release copy.