



ATLAS/ICESat-2 L3B Slope-Corrected Land Ice Height Time Series, Version 7

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Smith, B., Dickinson, S., Jelley, B., Neumann, T., Hancock, D., Lee, J., & Harbeck, K. (2025). *ATLAS/ICESat-2 L3B Slope-Corrected Land Ice Height Time Series, Version 7* (ATL11, Version 7). [Data set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. <https://doi.org/10.5067/ATLAS/ATL11.007> [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT <https://nsidc.org/data/ATL11>



National Snow and Ice Data Center

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1 DATA DESCRIPTION

The ATL11 data product is described in detail in the ICESat-2 Algorithm Theoretical Basis Document (ATBD) for Land-Ice Along-Track Products Part 2: Slope-Corrected Land Ice Height Time Series (Smith et al., 2025).

1.1 Summary

ATL11 provides spatially organized time series of land-ice surface heights and ice-shelf locations where ICESat-2 operates in repeat-track mode (i.e., for polar ice), along with parameters useful in determining whether each height estimate is valid or a result of potential errors. ATL11 is derived from the ATLAS/ICESat-2 L3A Land Ice Height product (ATL06) and intended primarily as an input for higher-level gridded products.

1.2 File Information

1.2.1 Format

Data are provided as HDF5-formatted files.

1.2.2 File Contents

A complete list of all ATL11 parameters is available in the [ATL11 Data Dictionary](#).

To keep file sizes manageable, ATL11 breaks up Reference Ground Track (RGT) data by region (see Figure and Table 1). The ATLAS instrument is configured to make repeat measurements along RGTs in polar regions (poleward of 60° N and 60° S). This strategy allows ATL11 to construct time series of ice height changes from cycle to cycle (i.e., 91 days apart) for regions 3, 4, and 5 and 10, 11, and 12. Each ATL11 file contains data for a single reference ground track for one of the subregions defined for ATLAS granules.

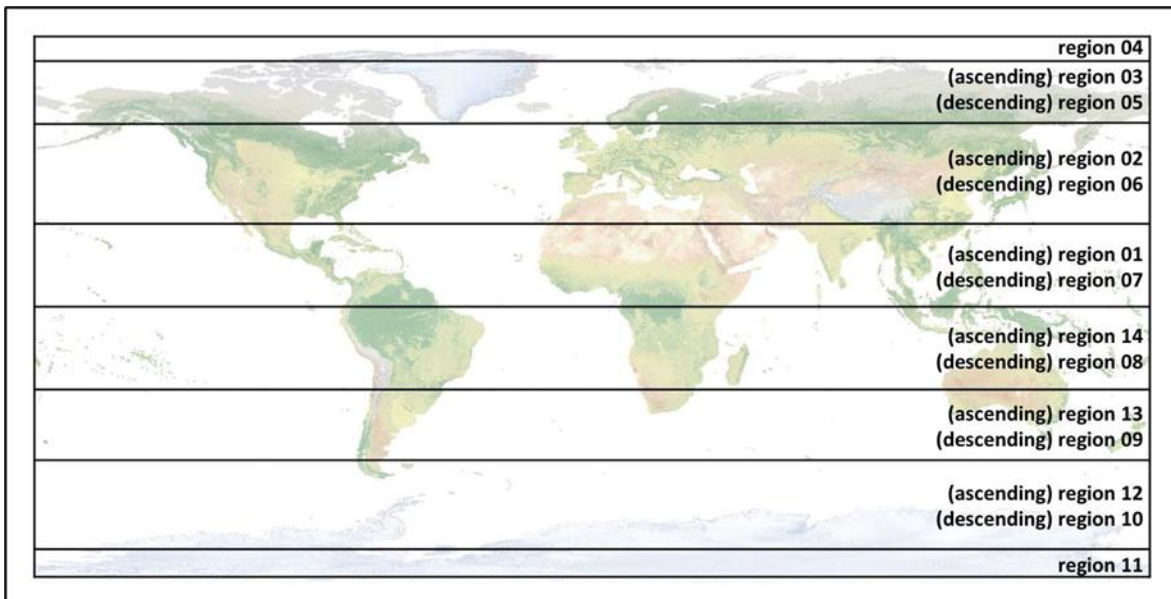


Figure 1. ATLAS/ICESat-2 region boundaries.

Table 1. ATLAS/ICESat-2 Region Latitude Bounds (A = Ascending, D = Descending). ATL11 Data Are Available for Regions 03, 04, 05, 10, 11, and 12 (in bold).

Reg.	Latitude Bounds	Reg.	Latitude Bounds
01	Equator → 27° N (A)	08	Equator → 27° S (D)
02	27° N → 59.5° N (A)	09	27° S → 50° S (D)
03	59.5° N → 80° N (A)	10	50° S → 79° S (D)
04	80° N (A) → 80° N (D)	11	79° S (D) → 79° S (A)
05	80° N → 59.5° N (D)	12	79° S → 50° S (A)
06	59.5° N → 27° N (D)	13	50° S → 27° S (A)
07	27° N (D) → Equator	14	27° S → Equator (A)

Within data files, similar variables such as science data, instrument parameters, and metadata are grouped together according to the HDF model. ATL11 data are organized within the following top-level groups:

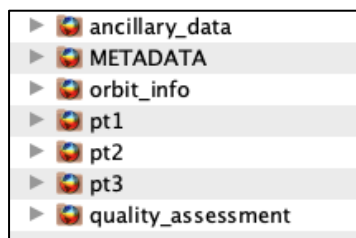


Figure 2. ATL11 top-level groups.

The following sections summarize the contents of the above data groups and identify parameters of interest. For a list and description of all output parameters on the ATL11 product, see “Section 4.0 | Land Ice Products: Land Ice H(t)” in the ATBD (Smith et al., 2025).

1.2.2.1 ancillary_data

This group contains parameters that pertain to the granule in its entirety, such as product and instrument characteristics and/or processing constants.

1.2.2.2 METADATA

ISO19115 structured metadata with sufficient content to generate the required geospatial metadata. The version(s) of the input files are included in the file name attribute under the Lineage group.

1.2.2.3 orbit_info

Polygon extent vertex count (bounding_polygon_dim1), polygon extent vertex latitude in degrees north (bounding_polygon_lat1), and polygon extent vertex longitude in degrees east (bounding_polygon_lon1).

1.2.2.4 pt[x]

The pt1, pt2, and pt3 groups contain the primary science parameters for each pair track:

- cycle_number: Cycle number
- delta_time: Mean number of GPS seconds since the ATLAS reference epoch
- h_corr: Mean corrected height (m)
- h_corr_sigma: Mean corrected height error (m)
- h_corr_sigma_systematic: Magnitude of all errors that might be correlated at scales larger than a single fit center (m)
- latitude: Center latitude based on selected segments (degrees north)
- longitude: Center longitude based on selected segments (degrees east)
- quality_summary: Summary flag (zero indicates high-quality cycles), where min_signal_selection_source ≤ 1 and min_SNR_significance < 0.02, and ATL06_summary_zero_count > 0
- ref_pt: The reference point is the segment_id corresponding to the center of the ATL06 data used for each ATL11 point. Segment_id is counted from the equator crossing of the RGT, with one segment every 20 m.

as well as subgroups:

- ref_surf: Parameters describing the reference surface at each reference point.
- cycle_stats: Parameters describing the input data for each cycle at each reference point

1.2.2.5 quality_assessment

Contains quality assessment data. This may include QA counters, QA along-track data, and/or QA summary data.

1.2.3 Naming Convention

Data files utilize the following naming convention:

ATL11_[tttt][ss]_[cccc]_[vvv_rr].h5

ATL11_023412_0329_007_02.h5

The following table describes the file naming convention variables:

Table 2. File Naming Convention Variables and Descriptions

Variable	Description
ATL11	ATLAS/ICESat-2 L3B Slope-Corrected Land Ice Height Time Series product
tttt	RGT. The ICESat-2 mission has 1,387 RGTs, numbered from 0001 to 1387.
ss	Region number. Region numbers for the ICESat-2 mission range 01–14; however, data files for this product are only produced for regions that lie poleward of 60° N and 60° S (regions 3, 4, 5, 10, 11, and 12).
cccc	First and last cycles of data included in the file. E.g., “0329” would indicate the file contains data from cycles 3–29, inclusive*.
vvv_rr	Version and revision number*

*When new ATL06 data are available, NSIDC receives reprocessed ATL11 granules from our data provider. These granules have the same file name as the original granule but the cycle number and/or revision number has been incremented. Although NSIDC deletes the superseded granule, the process can take several days. If you encounter multiple granules with the same file name but different cycle and/or revision numbers, please use the granule with both the highest cycle *and* revision numbers.

1.2.4 Browse Files

Each ATL11 data file has the following JPG browse files:

- Three-panel figure showing height data from the most recent cycle, number of cycles with valid height data, and change in height over time (default1)
- Number of valid height measurements from each beam pair (default2)
- Change in height over time (dHdt)
- Histograms of change in height over time (dHdt_hist)
- Histograms of heights minus DEM heights (h_corr-DEM_hist_cycles)
- Heights for each beam pair and heights minus DEM (h_corr_h_corr-DEM)
- Histogram of number of cycles with valid height measurements (validRepeats_hist)

For more information about browse files, see “Section 7.0 | Browse Products” in the ATBD (Smith et al., 2025).

1.3 Spatial Information

1.3.1 Coverage

Coverage spans the regions poleward of 60° N and 60° S, and data files are only generated for regions in which the satellite makes repeat-track measurements (see note) and crosses a land surface (i.e., does not lie entirely over open ocean).

The ICESat-2 orbit does not cross directly over the North and South poles. This produces a gap in coverage, or “pole hole,” between 88° and 90° in both the Northern and Southern Hemisphere.

1.3.2 Resolution

ATL11 data are posted every 60 m at locations that correspond to the center of every third ATL06 segment (ATL06 segment ID). The ATL11 algorithm uses all available ATL06 segments whose centers lie within 60 m of the central segment such that ATL11 data are derived from measurements spanning 120 m in the along-track direction.

1.3.3 Geolocation

World Geodetic System 1984 (EPSG 4326)

1.4 Temporal Information

1.4.1 Coverage

The temporal coverage is 29 March 2019 (beginning of cycle 3) through the most current processing. Data are only available at times when the satellite is poleward of 60° N and 60° S and crossing land. A new batch of ATL06 data becomes available approximately every 1.5–2 months.

1.4.2 Resolution

The ICESat-2 satellite traverses each of its 1,387 RGTs once every 91 days, i.e., the satellite has a 91-day repeat cycle.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

A number of successful techniques have been used to determine elevation changes from repeat-track data from ICESat/GLAS, the predecessor to ATLAS/ICESat-2. For example, where surface slopes are small relative to background geophysical processes, height changes have been isolated by subtracting the mean height from a collection of measurements along the same repeat track. In regions where off-track surface slopes are not negligible, height changes have been recovered by subtracting the mean height plus an estimate of the surface slope.

ATL11 extends this approach by fitting low-degree polynomial surfaces to ATL06 surface heights and surface-slope information and using these small patches to correct for sub-kilometer surface topography.

2.2 Acquisition

ATL11 height estimates are generated by correcting ATL06 height measurements for the combined effects of short-scale surface topography around the fit centers and small horizontal offsets between repeat measurements.

2.3 Processing

2.3.1 Coordinate System

Although ATL11 heights are geolocated with lat/lon coordinates, computations are performed using the ATL06 along-track coordinate system. Briefly, this coordinate system is defined separately for each RGT, with an x-coordinate that starts (and ends) at the equator and increases in the ascending direction (north from the equator). The y-coordinate is perpendicular to the x-coordinate and positive to the left. Thus, the x-coordinate for each RGT runs from zero to about 4×10^7 m and the y-coordinate runs from about -3.3×10^3 m (the right beam pair) to approximately 3.3×10^3 m (the left beam pair).

2.3.2 Along-Track Ice Heights

ATL06 land ice height estimates consist of 40 m overlapping surface segments whose centers are spaced 20 m apart along each of ICESat-2's three reference pair tracks (RPTs). These segments are displaced horizontally both relative to the RPT and to one another due to small imprecisions in measurement locations on the ground (a few tens of meters or less). ATL11 heights are corrected

for these offsets between the reference tracks and the location of the ATLAS measurements by using ATL06 height and local surface slope information to construct a reference surface.

For a set of reference points spaced every 60 meters along each RPT (centered on every third segment center), the ATL11 algorithm considers all ATL06 segments whose centers lie within 60 m along-track and 65 m across-track of a reference point. As such, the fit for each ATL11 segment contains as many as seven distinct along-track ATL06 segments from each beam and cycle.

To calculate the reference surface using the most reliable subset of available data, the algorithm performs tests on these segments and selects a subset with self-consistent slopes and small errors, which it uses to define a time-variable surface height and a polynomial surface-shape model. The algorithm then applies the surface-shape model to calculate corrected heights for segments which were not chosen for the initial subset.

The ATL11 ATBD describes these steps in “Section 3.0 | Algorithm Theory: Derivation of Land Ice H (t)/ATL11 (L3B)” (Smith et al., 2025).

2.4 Quality, Errors, and Limitations

The ATL11 algorithm propagates errors for each step and computes formal height error estimates that account for sampling error in ATL06 and systematic errors due to geolocation errors in the slope of the surface-shape model.

In the Antarctic data, there are systematic spot-to-spot elevation biases that vary on periods of a few months. These biases are consistent with biases in the geolocation for the entire array. Starting with Version 6, these biases were corrected, producing a smaller systemic height variation between the left and right beam pairs.

Error estimates are described in the ATBD for ATL11 in “Section 3.3 | Reference-shape Correction Error Estimates”, “Section 3.5 | Calculating Systematic Error Estimates”, and “Section 3.9 | Antarctic Geolocation Biases” (Smith et al., 2025).

3 VERSION HISTORY

Table 3. Version History Summary

Version	Date	Description of Changes
7.0	5 Feb 2026	Added data for cycle 29

Version	Date	Description of Changes
7.0	4 Nov 2025	<ul style="list-style-type: none"> • Match valid min/max to data type for all datasets • Update atlas_meta and atl11_qa_util to latest versions • Correct root file level title and description for ATL11 • Remove h_corr_CrossOver from browse plots • Remove crossing_track_data group from ATL11 • Implement additional checks to filter ATL06 anomalies • Use alternate least squares algorithm in reference surface for validity check
6.0	14 May 2025	Added data for cycle 26 (through 2 Mar 2025).
6.0	12 Mar 2025	Added data for cycle 26 (through 24 Dec 2024).
6.0	29 Jan 2025	Added data for cycle 25 (through 16 Dec 2024).
5.0 (retire)	26 Feb 2024	Removed data access for v5.0. Temporal coverage was 29 Mar 2019 to 21 Jun 2022.
6.0	22 Aug 2023	<ul style="list-style-type: none"> • Corrected height bias from geolocation imperfections • Adjusted y polynomial fit sensitivity for small distances • Added dh_geoloc to /ptx/crossing_track_data • Added dh_geoloc to /ptx/cycle_stats • Removed slope_change_t0, slope_change_rate_x, slope_change_rate_x_sigma, slope_change_rate_y, and slope_change_rate_y_sigma from /ptx/ref_surf
4.0 (retire)	23 Sep 2022	Removed data access for v4.0. Temporal coverage was 29 Mar 2019 to 23 Jun 2021.
3.0 (retire)	25 Apr 2022	Removed data access for v3.0. Temporal coverage was 29 Mar 2019 to 24 Dec 2020.
5.0	24 Mar 2022	<ul style="list-style-type: none"> • Added data for cycles 12 and 13 • Removed orbit specific parameters from /orbit_info group as crossing time, rgt, orbit_number, and sc_orient are not needed. • Implemented mean-tide inclusion for converting geoid heights. Included additive value to convert geoid heights from the tide-free system to the mean-tide system, derived from ATL06. This maps adjustment from ATL06 to ATL11 for changing the permanent tide state of ATL11 to geoid heights: ATL11 provides a weighted average of the geoid_free2mean parameter from ATL06, which allows users to change the vertical datum of ATL11 height estimates to an approximation of local sea level when the adjustment is added to the tide-free geoid heights.
2.0 (retire)	25 Jan 2022	Removed data access for v2.0. Temporal coverage was 29 Mar 2019 to 24 Sep 2020.
4.0	7 Dec 2021	<ul style="list-style-type: none"> • Added data for cycles 10 and 11 • Removed group attribute poly_exponent_list. The same information is available from the /ptx/ref_surf/poly_exponent_x and /ptx/ref_surf/poly_exponent_y datasets.

Version	Date	Description of Changes
1.0 (retire)	24 May 2021	Removed data access for v1.0. Temporal coverage was 29 Mar 2019 to 25 Jun 2020.
3.0	29 Apr 2021	<ul style="list-style-type: none"> • Added new parameter pt[x]/ref_surf/geoid_h, a weighted average of the geoid_h parameter from ATL06. This allows users to compare ATL11 height estimates to an approximation of local sea level. • Added root attribute short_name. • Modified quality assurance to allow for partial population of beam pair groups. • Modified ancillary_data to correctly reflect ATL11 release and version numbers. • Corrected /orbit_info/sc_orient_time as the dimension scale in that group. • Added missing root level attributes. • Modified long_name of /pt[x]/crossing_track_data/h_corr to read 'corrected height'. • Implemented bug fix that prevented the dynamic atmosphere correction from being calculated for along-track data
2.0	12 Jan 2021	<ul style="list-style-type: none"> • Calculated all crossovers (including near 88 °S) • Determined the center of the y_atc search from the median of unique pair center locations
1.0	1 Dec 2020	Initial release

4 REFERENCES

Magruder, L. A., Brunt, K., Neumann, T., Klotz, B., & Alonzo, M. (2020). Passive ground-based optical techniques for monitoring the on-orbit ICESat-2 altimeter geolocation and footprint diameter. *ESS Open Archive*. <https://doi.org/10.1002/essoar.10504571.1>

Smith, B., Dickinson, S., Harbeck, K., Neumann, T., Hancock, D., Lee, J., & Jelley, B. (2025). *Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2) Project Algorithm Theoretical Basis Document (ATBD) for Land-Ice Along-Track Products Part 2: Slope-Corrected Land Ice Height Time Series*. NASA Goddard Space Flight Center. <https://doi.org/10.5067/48KATQQLB8JP>

5 DOCUMENT INFORMATION

5.1 Publication Date

November 2025

5.2 Date Last Updated

November 2025

APPENDIX A: ATLAS/ICESAT-2 DESCRIPTION

The ICESat-2 observatory utilizes a photon-counting lidar (the ATLAS instrument) and ancillary systems (GPS, star tracker cameras, and ground processing) to measure the round-trip time a photon takes to travel from ATLAS to Earth and back again. The time-of-flight, absolute time, spacecraft location and pointing are used to determine the reflected photon's geodetic height, latitude, and longitude.

The ATLAS instrument uses a single laser and a beam splitter to illuminate six different “spots” that each trace out a ~11 m wide track (Magruder et al., 2020) as ICESat-2 orbits Earth (Figure A - 1). Three of the spots are considered “strong” (spots 1, 3, and 5) and the other three “weak” (spots 2, 4, and 6). Three independent Photon Counting Electronics (PCEs) record the photons returned to the telescope, each for a single pair of strong/weak spots. PCE1 records spots 1 and 2; PCE2 records spots 3 and 4; and PCE3 records spots 5 and 6.

Higher-level ATLAS/ICESat-2 data products are organized by ground track (GT), with GT1L and GT1R forming pair one, GT2L and GT2R forming pair two, and GT3L and GT3R forming pair three. Each GT is numbered according to the relative location of the laser spot that generates it, with GT1L on the far left and GT3R on the far right. Left/right beams within each pair are approximately 90 m apart in the across-track direction and 2.5 km in the along-track direction.

The mapping between the strong and weak spots of ATLAS, and their relative positions on the ground, depends on the orientation (yaw) of the ICESat-2 observatory, which is changed approximately twice per year to maximize solar illumination of the solar panels. The forward orientation corresponds to ATLAS traveling along the +x coordinate in the ATLAS instrument reference frame (Figure A - 1, left), with the weak spots leading the strong spots. In the backward orientation, ATLAS travels along the -x coordinate in the instrument reference frame, with the strong spots leading the weak spots (Figure A - 1, right). Atmospheric profiles are generated from strong spots only, and the instrument orientation determines which GT label (“gtx”) corresponds to which profile. The spacecraft orientation is tracked in the [ICESat-2 Major Activities](#) document (.xlsx).

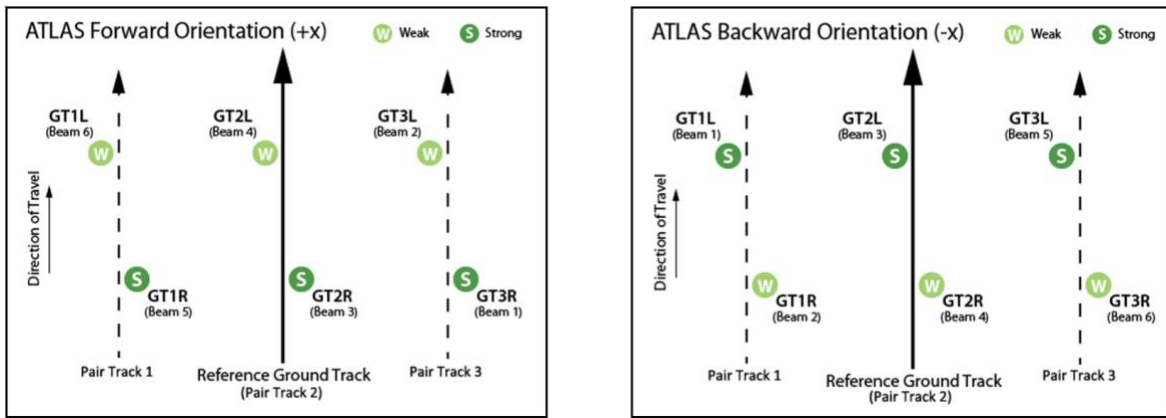


Figure A - 1. Spot and Ground Track (GT) naming convention.

The Reference Ground Track (RGT) is an imaginary track on Earth through the six-spot pattern that is used to point the observatory. 1,387 RGTs are sampled over the course of 91 days, allowing seasonal height changes to be detected. Onboard software aims the laser beams so that the RGT is between GT2L and GT2R (i.e., coincident with Pair Track 2). Nominal RGT pointing occurs over the oceans and polar regions and is periodically adjusted over vegetated land areas to broaden global coverage. Cycle numbers track the number of 91-day periods that have elapsed since the ICESat-2 observatory entered the science orbit. RGTs are uniquely identified by appending the two-digit cycle number (cc) to the RGT number.

Over lower latitudes, the satellite points slightly off the RGT during most cycles to measure canopy and ground heights. Off-pointing began on 1 August 2019 with RGT 518 after the ATLAS/ICESat-2 Precision Pointing Determination (PPD) and Precision Orbit Determination (POD) solutions were adequately resolved, and the instrument had pointed directly at the RGT for at least a full 91 days (1,387 orbits).

NOTE: ICESat-2 RGTs with dates and times can be downloaded as KML files from NASA's [ICESat-2 | Technical Specs](#) page, below the Orbit and Coverage table. Pointing plans summarized by cycle and off-pointing angle are posted in the [ICESat-2 Major Activities](#) document.

The ATLAS data and data collected from ancillary systems are telemetered to the ground and processed into several data products (Figure A - 2). The ATL01 algorithm reformats and unpacks the Level 0 data and converts it into engineering units. ATL02 processing converts ATL01 data to science units, applies instrument corrections, and produces photon time-of-flight data. The PPD and POD solutions compute the pointing vector and position of the ICESat-2 observatory as a function of time. ATL02, PPD, and POD are used to produce the global geolocated photon data of ATL03 and the normalized relative backscatter profiles of ATL04, which are the base products for all higher-level data sets.

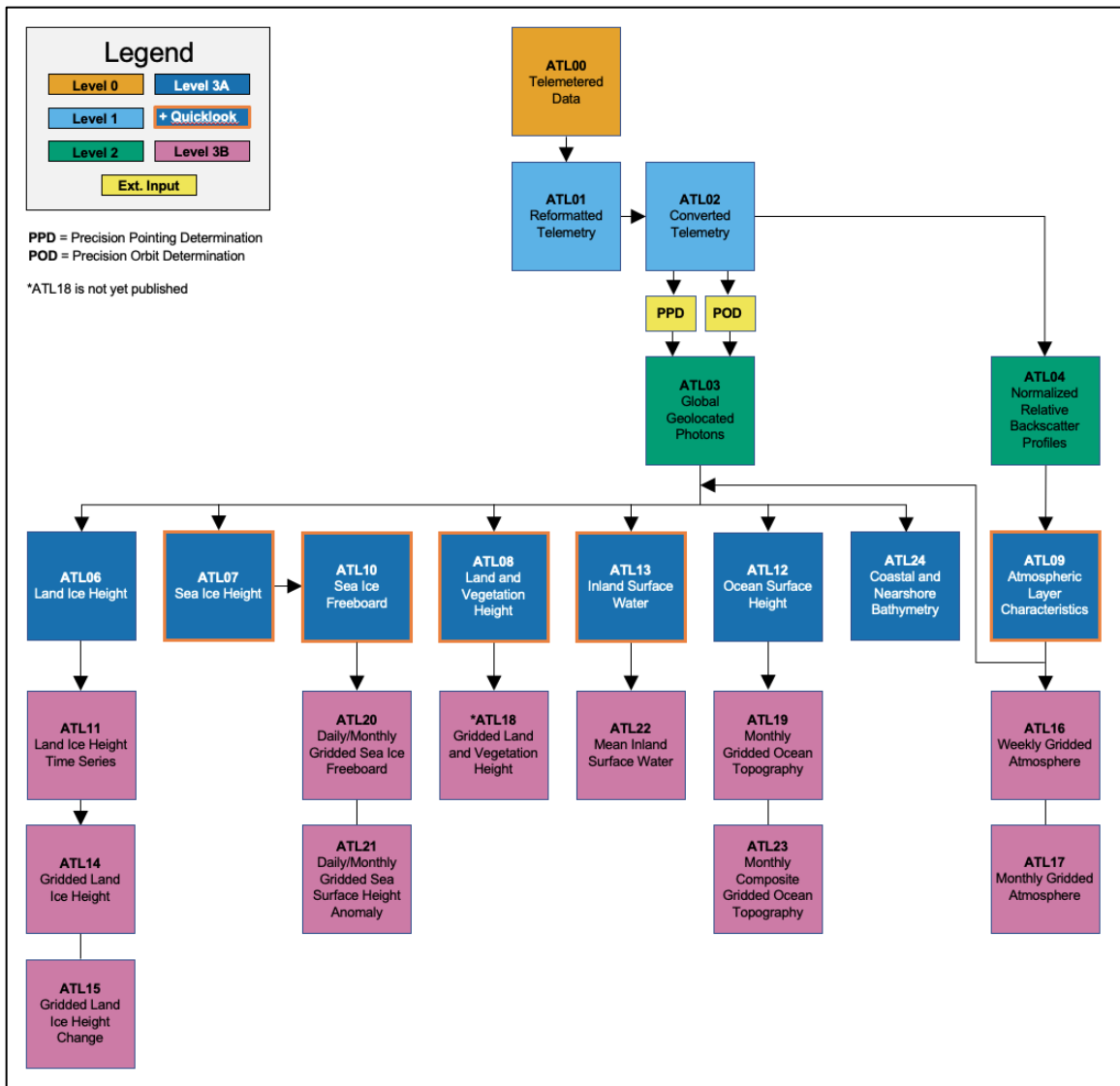


Figure A - 2. Schematic of ICESat-2 data processing and data products.

In satellite altimetry, the reflection point of an emitted signal occurs on an instantaneous and often dynamic planetary surface (Figure A - 3). For ICESat-2, reflective surfaces include oceans, inland water bodies, solid ground, ice, vegetation, and manmade structures. Depending on the product and surface type, geophysical corrections are applied to measurements to account for various time-varying processes (Table A - 1). Upper-level products may undergo additional height corrections, including corrections for pulse shape and instrument characteristics. For more information, refer to the data product's ATBD.

Table A - 1. Geophysical Corrections Applied to ICESat-2 Products

ICESat-2 Products by Surface Type	Geophysical Corrections ¹
Photon-level product (ATL03) (i.e., corrections applicable across all surface types)	Ocean loading Solid Earth tide Solid Earth pole tide Ocean pole tide Total column atmospheric delay
Land Ice, Land, and Inland Water (ATL06, ATL08, and ATL13)	<i>No geophysical corrections beyond ATL03</i>
Sea Ice (ATL07 and ATL10)	ATL03 corrections Referenced to mean sea surface Ocean tide Long period equilibrium ocean tide Dynamic atmosphere correction
Ocean (ATL12)	ATL03 corrections Ocean tide Long period equilibrium ocean tide

¹For details, see Section 5 of the *ICESat-2 Data Comparison User's Guide for Rel007* available on the ATL03 data set landing page.

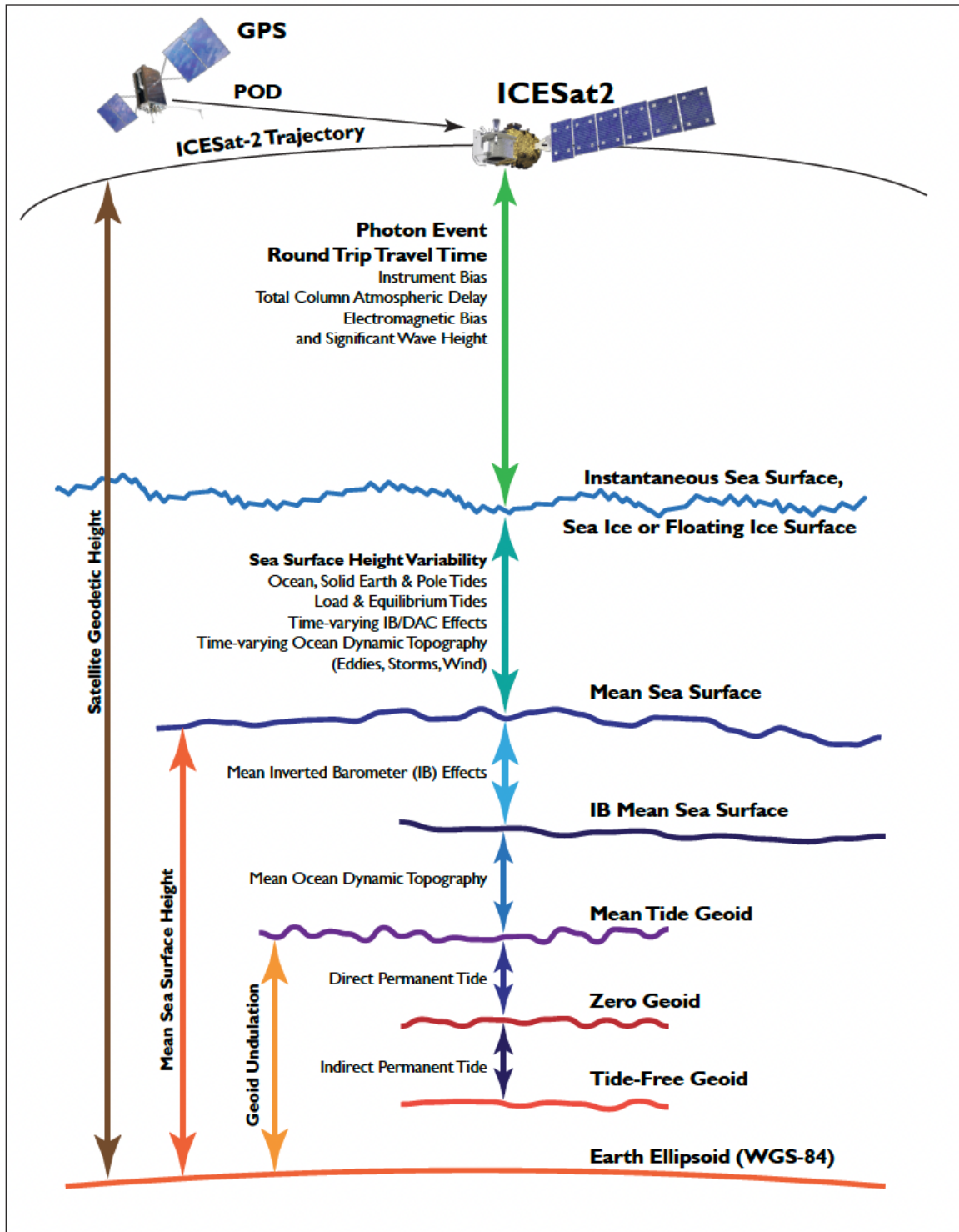


Figure A - 3. Geophysical corrections used in satellite altimetry (Source: *ICESat-2 Data Comparison User's Guide for Rel007*, Available on the ATL03 Data Set Landing Page).