ATLAS/ICESat-2 L3B Gridded Sea Ice Freeboard Quick Look, Version 5

USER GUIDE

How to Cite These Data

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

Kwok, R., Kurtz, N., Wimert, J. T., Petty, A. A., Cunningham, G. F., Markus, T., Hancock, D. W., Ivanoff, A., Bagnardi, M., Herzfeld, U., Trantow, T., & ICESat-2 Science Team (2026). *ATLAS/ICESat-2 L3B Gridded Sea Ice Freeboard Quick Look* (ATL20QL, Version 5). [Data set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/ATLAS/ATL20QL.005. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/ATL20QL

National Snow and Ice Data Center

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1 DATA DESCRIPTION

The algorithm used to generate the ATL20QL data product is described in detail in the ICESat-2 Project Algorithm Theoretical Basis Document (ATBD) for Sea Ice Products (Kwok et al., 2025).

1.1 Summary

ATL20QL is the Quick Look (QL) version of ATL20 with an expedited latency of 3–5 days. QL data are based on the same algorithms that generate the standard products but do not undergo the same rigorous quality checks; thus, they should be used with caution. Once final files are available, the corresponding QL files are removed. ATL20QL contains rolling 30-day gridded estimates of sea ice freeboard, derived from ATLAS/ICESat-2 L3A Sea Ice Freeboard Quick Look (ATL10QL) along-track freeboard estimates.

1.2 File Information

1.2.1 Format

Data are provided as HDF5-formatted files.

1.2.2 File Contents

The data product comprises two files for each month: one for the Northern Hemisphere and one for the Southern Hemisphere. Each file contains a rolling 30-day gridded composite.

Within data files, similar variables such as science data, instrument parameters, and metadata are grouped together according to the HDF model. The following figure shows data groups and variables stored at the top level in ATL20QL data files:

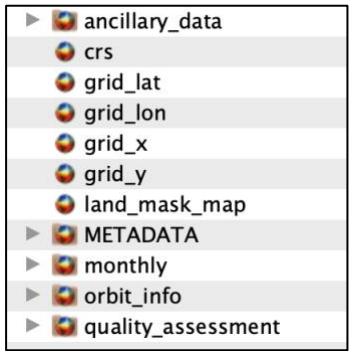

Figure 1. ATL20QL top-level data groups and variables.

The following sections summarize the structure and primary variables of interest in the ATL20QL data files. The main science parameter is sea ice freeboard (e.g., `monthly/mean_fb`).

1.2.2.1 ancillary_data

Information ancillary to the data product such as product and instrument characteristics and processing constants.

1.2.2.2 Top-level variables

- **`crs`**: coordinate reference system identification for NSIDC Sea Ice Polar Stereographic
- **`grid_lat`**: latitude at the center of each grid cell
- **`grid_lon`**: longitude at the center of each grid cell
- **`grid_x`**: x value at the center of each grid cell
- **`grid_y`**: y value at the center of each grid cell
- **`land_mask_map`**: gridded map that denotes each grid cell as land (1) or ocean/sea ice (0)

1.2.2.3 METADATA

ISO19115 structured summary metadata for the granule, including content that describes the required geospatial information. The version(s) of the input files are included in the file name attribute under the `Lineage` group.

1.2.2.4 monthly

- **`delta_time_beg`**: center time of the first freeboard height segment used in the gridded composite in seconds since the ATLAS SDP GPS Epoch
- **`delta_time_end`**: center time of the last freeboard height segment used in the gridded composite in seconds since the ATLAS SDP GPS Epoch
- **`length_sum`**: sum of freeboard height segment lengths for each 30-day grid cell
- **`mean_fb`**: 30-day gridded freeboard
- **`n_segs`**: population count
- **`sigma`**: standard deviation

1.2.2.5 orbit_info

Orbit parameters that are constant for a granule, such as the Reference Ground Track (RGT) number, cycle, and spacecraft orientation.

1.2.2.6 quality_assessment

Quality assessment data for the granule as a whole, including a pass/fail flag and a failure reason indicator.

A complete list of all ATL20QL parameters is available in the ATL20 Data Dictionary.

1.2.3 Naming Convention

Data files utilize the following naming convention:

`ATL20QL-[HH]_[yyyymmdd][hhmmss]_[ttttccss]_[vvv_rr].h5`

Examples:

`ATL20QL-01_20240303011938_11492201_005_03.h5`

`ATL20QL-02_20240304005400_11642201_005_03.h5`

Table 1. File Naming Convention Variables and Descriptions

Variable	Description
ATL20QL	ATLAS/ICESat-2 L3B Gridded Sea Ice Freeboard Quick Look
HH	Hemisphere code. Northern Hemisphere = 01, Southern Hemisphere = 02
yyyymmdd	Year, month, and day of data acquisition of the first ATL10QL granule used in the gridded data set
hhmmss	Start time hour, minute, and second of data acquisition of the first ATL10QL granule used in the gridded data set
tttt	Four-digit RGT of the first ATL10QL granule used in the gridded data set. The ICESat-2 mission has 1,387 RGTs, numbered from 0001 to 1387.
cc	Cycle number of the first ATL10QL granule used in the gridded data set. Each of the 1,387 RGTs is targeted in the polar regions once every 91 days. The cycle number tracks the number of 91-day periods that have elapsed since ICESat-2 entered the science orbit.
ss	Region number. This number corresponds to the first of the ICESat-2 along-track regions considered for input into ATL20QL processing. This region number will always be "01" except when a granule is split along a spacecraft orientation change, in which case, the region number is the last region before the switch and the first region after the switch, in consecutive granules.
vvv_rr	Version and revision number*

*Occasionally, NSIDC receives reprocessed granules from our data provider. These granules have the same file name as the original (i.e., date, time, ground track, cycle, and region number), but the 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, please use the granule with the highest revision number.

1.2.4 Browse Files

Browse files are provided as JPGs that contain images designed to quickly assess the location and quality of each granule's data: 30-day accumulated freeboard lengths (`length_sum`), 30-day mean freeboard (`mean_fb`), 30-day population count (`n_segs`), and 30-day standard deviation (`sigma`). Browse files utilize the same naming convention as their corresponding data file but with "`_BRW`" and descriptive keywords appended. An example browse image is shown below.

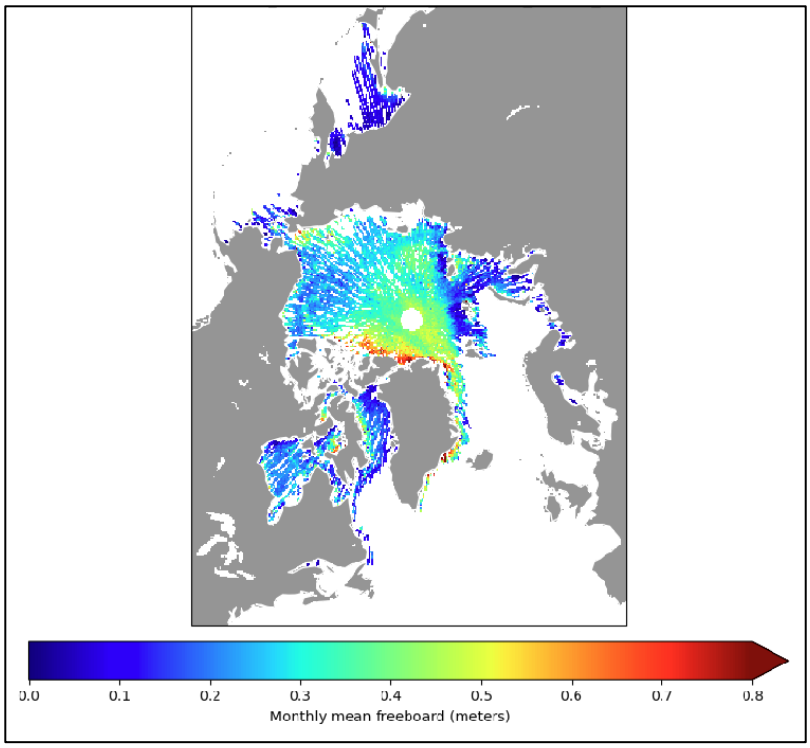

Figure 2. Example browse image of mean freeboard (`mean_fb`).

1.3 Spatial Information

1.3.1 Coverage

Spatial coverage spans the ice-covered oceans of the Northern and Southern Hemispheres where the sea ice concentration (SIC) is greater than 50% and at least 25 km from the coast:

Northern Hemisphere: 37º N to 89º N, 180º E to 180º W
Southern Hemisphere: 53º S to 79º S, 180º E to 180º W

1.3.2 Resolution

25 km

1.3.3 Geolocation

Data are mapped using NSIDC's Polar Stereographic Projection:

NSIDC Sea Ice Polar Stereographic North (EPSG: 3411)
NSIDC Sea Ice Polar Stereographic South (EPSG: 3412)

Grid details for both projections are shown in the table below.

Table 2. Grid Details

	North Polar	South Polar
Nominal gridded resolution (km)	25 × 25	25 × 25
Grid size (rows × columns)	448 × 304	332 × 316
Geolocated lower left point in grid (km)	(-3850, -5350)	(-3950, -3950)
Grid rotation	0	0
ulxmap: x-axis coord, center of upper left pixel (XLLCORNER) (km)	-3,837.5	-3,937.5
ulymap: y-axis coord, center of upper left pixel (YLLCORNER) (km)	5,837.5	4,337.5

1.4 Temporal Information

1.4.1 Coverage

The temporal coverage is a sliding window. Quick look data are published ~72 hours after satellite observation and removed when the final ATL20 files arrive or after three months if the final file does not get released due to quality issues.

Satellite maneuvers, data downlink issues, and other events can introduce data gaps into the ICESat-2 products. Users can download and consult a regularly updated list of data gaps (`.xlsx`) on the data set landing page.

1.4.2 Resolution

Data are processed daily using the last 30 days of ATL10QL data (a rolling 30-day window).

2 DATA ACQUISITION AND PROCESSING

2.1 Background

ICESat-2 provides multiple profiles of sea ice and sea surface heights for improved freeboard and thickness retrievals. Total freeboard is defined as the height of the air–snow interface above the local sea surface. For the Arctic Ocean, the total freeboard is typically assumed to consist of a snow layer superimposed on the freeboard of floating sea ice, i.e., a two-layered system. For Antarctic sea ice, wintertime layering and snow-ice formation (i.e., “flooded ice” from freezing of water-soaked snow) complicate freeboard characterization.

2.2 Acquisition

ATL20QL aggregates ATL10QL along-track freeboard estimates and computes 30-day gridded freeboard in NSIDC Polar Stereographic Northern and Southern Hemisphere 25 km grids.

2.3 Processing

All algorithms for ATL20QL are the same as those used to create ATL20; however, the daily groups are deleted from the product and the monthly groups are 30-day groups.

The 30-day gridded fields of total freeboards are constructed from daily composites to produce equivalent parameters: grid of 30-day mean freeboard; number of sea ice segments in each 30-day grid cell; sum of freeboard segment lengths in each 30-day grid cell; and standard deviation of freeboards in each 30-day grid cell.

The computations are provided in "Section 6 | ALGORITHM DESCRIPTION: GRIDDED FREEBOARD (ATL20) AND SEA SURFACE HEIGHT (ATL21)" in the ATBD (Kwok et al., 2025).

2.4 Quality, Errors, and Limitations

A constraint imposed by the inherent capability of the instrument is the impact of clouds on the visibility of sea ice cover. In particular, a reduction in coverage is significant during the summer after the spring-to-summer seasonal transition. Further, the first photon bias is an inherent problem with the photon-counting detectors selected for ATLAS. Even though the biases are at centimeter to sub-centimeter levels for most sea ice surfaces, the effect is large for intense pulses and for pulses from flat surfaces where the return energy is concentrated over a short duration. A correction for the first photon bias is applied in the retrieval of sea ice height used to determine the sea ice freeboard.

Limitations are imposed by height retrievals and surface classification. Multiple scattering within the ice or snow volume is not quantified and may impact height retrievals. For sea ice, these effects are mitigated in the surface-finding process via windowing of the photon height distributions to avoid potential tails in the distributions. Because snow properties may be unknown at the time of ATLAS acquisitions, a height correction due to subsurface scattering must be determined independently using external data. The design of the surface type retrieval procedure focuses on sea surface signatures, and there are uncertainties associated with the labeling of the other ice types.

There are also assumptions related to height retrievals: (1) sampled photon heights are random realizations from a Gaussian or lognormal distribution and (2) the first photon bias correction assumes that the photon statistics at a given height remain stationary over time. For more details, see "Section 10 | Constraints, Limitations, and Assumptions" in the ATBD (Kwok et al., 2025).

The primary sources of error in the retrieval of sea ice freeboard are due to uncertainties in the local sea surface height as well as differences in surface roughness. A detailed analysis and description of spatial variability in expected errors in the sea ice freeboard data are given in Magruder et al. (2025).

2.4.1 Quick Look Data Quality

Because the higher uncertainties inherent in the quick look data products typically occur over large spatial scales, they have minimal impact on relative height measurements like sea ice freeboard. A primary difference between the quick look and final freeboard products is the use of the inverse barometer (IB) correction in the quick look data because of the lack of availability of the dynamic atmospheric correction (DAC) used in the final data product.

To assess the quality of ATL20QL, monthly aggregations of ATL10QL are compared to the final ATL10 freeboard data (using the same gridding methodology as ATL20) over a five-month period from October 2025 to February 2026. The results demonstrate a mean bias of approximately zero and a standard deviation of differences between 0.02 and 0.03 m. Users should note a slight difference in the total number of valid freeboard segments retrieved between the final and quick look products. This is caused by differences in the preliminary granule quality flags used during initial processing, which accounts for some minor localized discrepancies in the monthly maps. Example comparisons of these monthly aggregations are shown in Figure 3. Overall, users can expect ATL20QL results to be statistically unbiased, with a small additional uncertainty of roughly 0.03 m compared to the final data product.

For information on the ATL07QL height uncertainties and biases that go into the generation of sea ice freeboards, the user is referred to the ATL07QL and ATL10QL user guides.

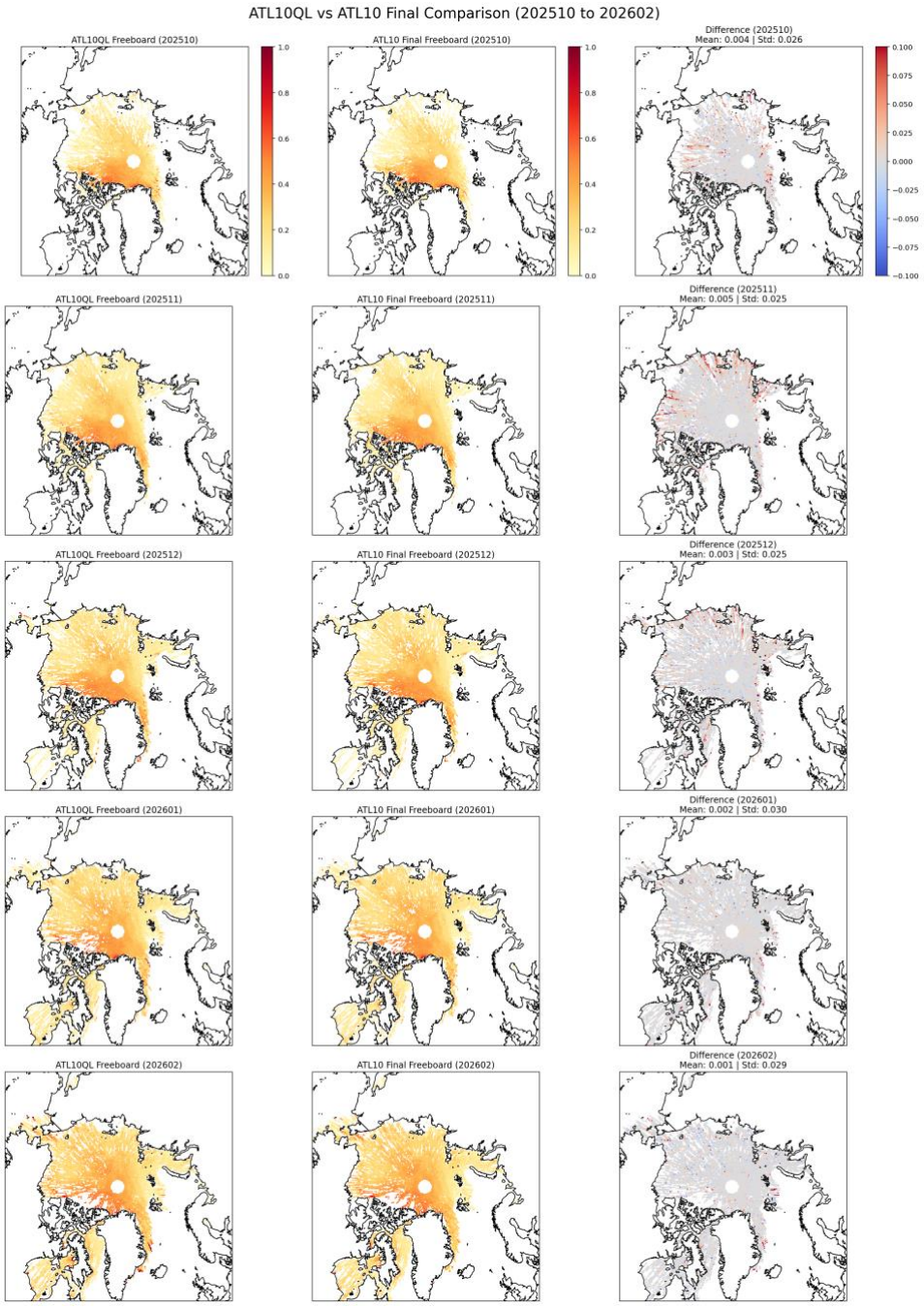

Figure 3. ATL10QL and ATL10 comparisons of monthly aggregations

3 VERSION HISTORY

Table 3. Version History Summary

Version	Date	Description of Changes
5.0	June 2026	Initial release

4 REFERENCES

Kwok, R. Petty, A., Bagnardi, M., Wimert, J. T., Cunningham, G. F., Hancock, D. W., Ivanoff, A., & Kurtz, N. (2025). *Ice, Cloud, and Land Elevation Satellite (ICESat-2) Project Algorithm Theoretical Basis Document (ATBD) for Sea Ice Products*. NASA Goddard Space Flight Center. https://doi.org/10.5067/KPMXUOH7TNIY

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

Magruder, L. A., Neumann, T., Kurtz, N., Sutterley, T. C., Hancock, D., Vornberger, P., et al. (2025). Assessment of the Ice, Cloud, and land Elevation Satellite-2 performance against prime mission science requirements. *Earth and Space Science*, 12, e2025EA004221. https://doi.org/10.1029/2025EA004221

5 DOCUMENT INFORMATION

5.1 Publication Date

June 2026

5.2 Date Last Updated

June 2026

APPENDIX A – ICESAT-2/ATLAS 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).

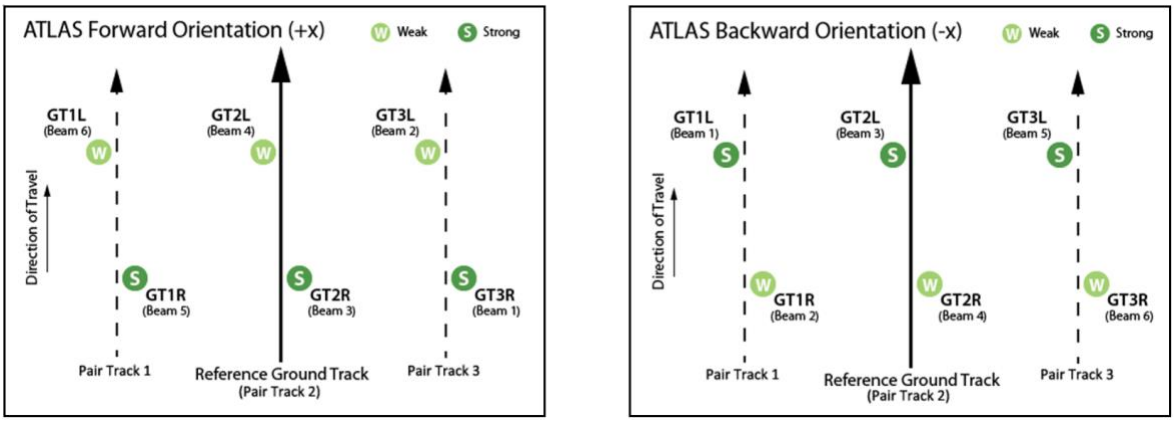

Figure A - 1. Spot and Ground Track (GT) naming convention.

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.

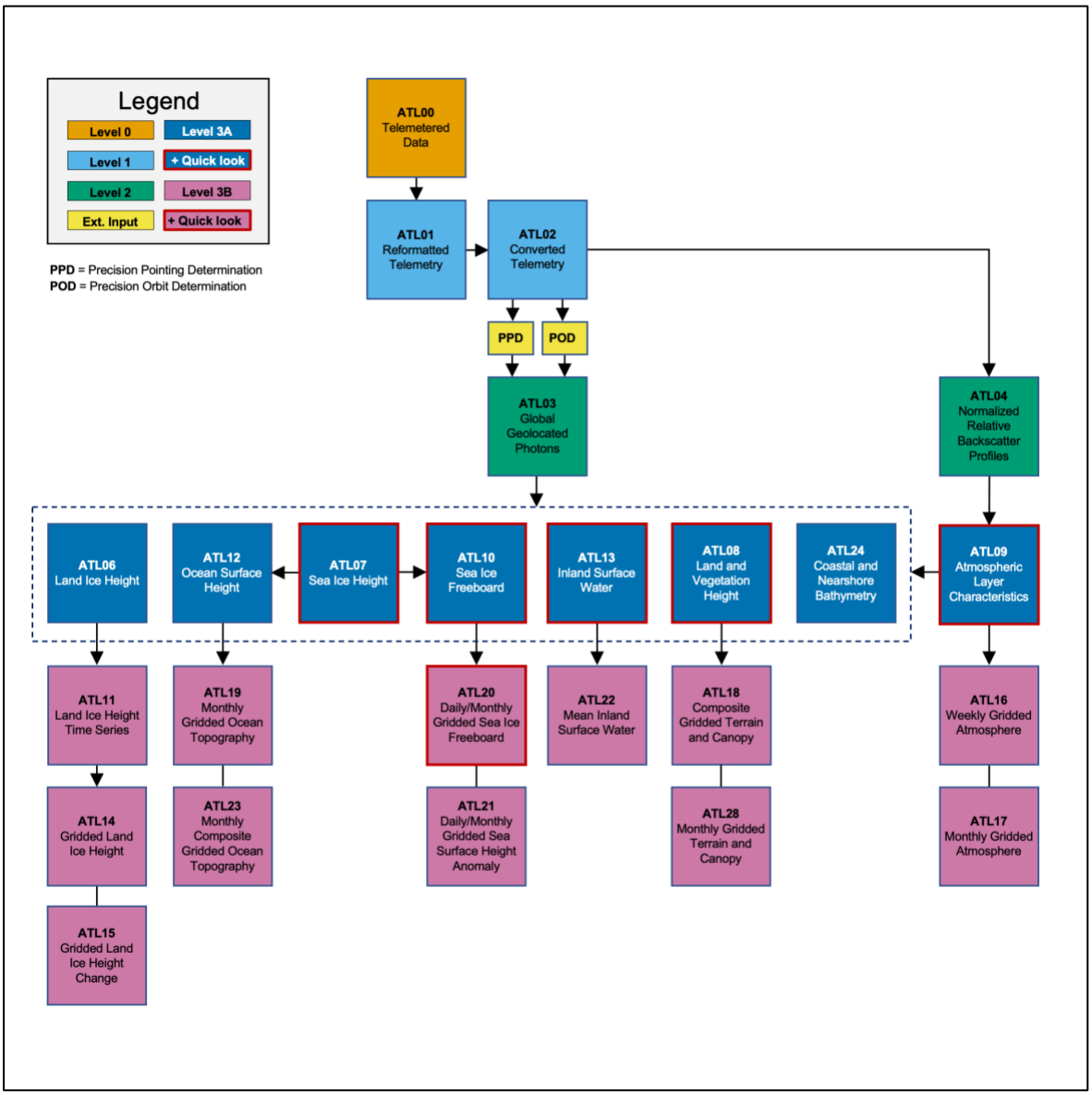

Figure A - 2. Schematic of ICESat-2 data processing and data products.

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)	*No geophysical corrections beyond ATL03*
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

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

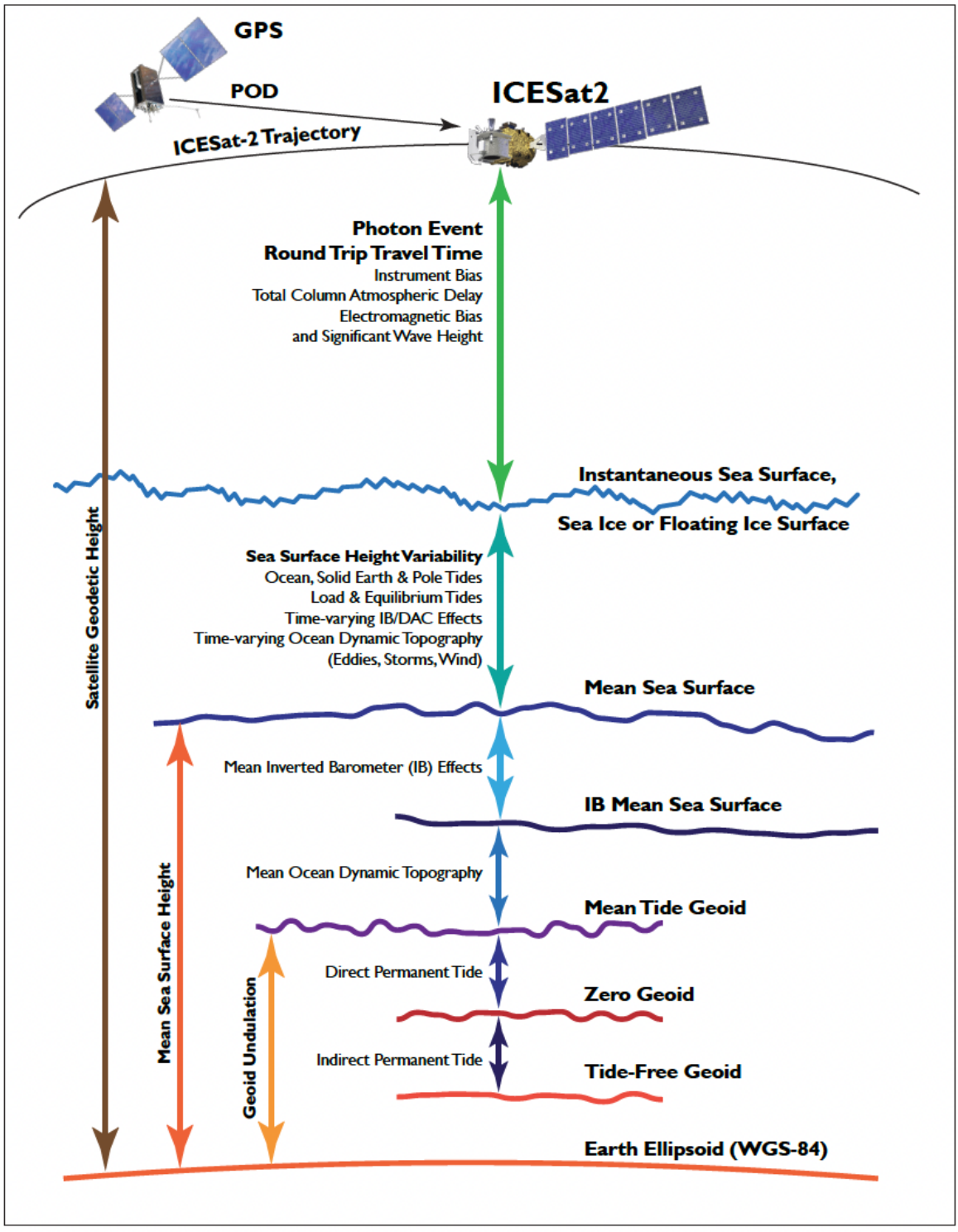

Figure A - 3. Geophysical corrections used in satellite altimetry
(Source: *ICESat-2 Data Comparison User's Guide for Rel007,* available on the ATL03 data set landing page).