ATLAS/ICESat-2 L3B Mean Inland Surface Water Data, Version 3

USER GUIDE

How to Cite These Data

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

Jasinski, M. F., J. D. Stoll, D. W. Hancock III, J. Robins, and J. Nattala. 2023. *ATLAS/ICESat-2 L3B Mean Inland Surface Water Data, Version 3.* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/ATLAS/ATL22.003. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/ATL22

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set contains mean water surface heights for transects over inland water bodies by the six ICESat-2 beams. Data are reported at the center of the transect and include mean water surface height and the mean ATLAS 532 nm subsurface attenuation coefficient. The length and location of the beginning, end, and center of each transect are also reported.

This data set (ATL22) was derived from ATLAS/ICESat-2 L3A Along Track Inland Surface Water Data (ATL13).

1.2 File Information

1.2.1 Format

Data are provided as HDF5 formatted files.

1.2.2 File Contents

Mean inland surface water data are provided for each beam in separate data groups within the data files.

1.2.3 Data Groups

Within data files, similar variables such as science data, instrument parameters, and metadata are grouped together according to the HDF model. Figure 1 shows data groups and variables stored at the top level in ATL22 data files.

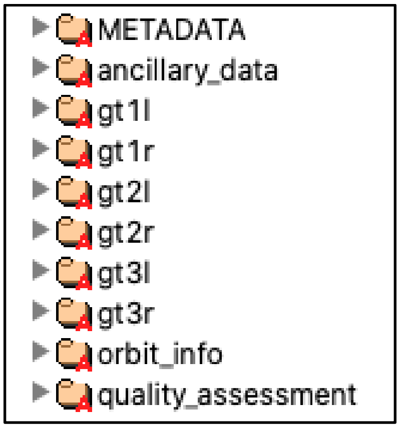

Figure 1. ATL22 Top-Level Data Groups and Variables

The following sections describe the data groups and their contents plus the variables stored at the top level in ATL22 data files. For additional information, see the ATL22 Data Dictionary (complete list of variables stored) on the data set landing page.

1.2.3.1 METADATA

ISO19115 structured summary metadata.

1.2.3.2 ancillary_data

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

1.2.3.3 gt1l–gt3r

Six ground track groups (gt1l, gt1r, gt2l, gt2r, gt3l, gt3r) that contain the per-beam data parameters. Parameters of interest include:

- Mean transect surface water height (`transect_mean_ht_WGS84`) above the WGS 84 ellipsoid;
- Mean orthometric surface water height (`transect_mean_ht_ortho`); i.e., height above the EGM2008 geoid;
- Water body type (`inland_water_body_type`); region (`inland_water_body_region`); and water body ID (`inland_water_body_id`).
- Short segment length flag (`qf_sseg_length`);
- Mean latitude (`transect_lat`), longitude (`transect_lon`), and time (`transect_time`) of inland water body transects;
- Mean ATLAS 532 nm subsurface attenuation coefficient (`transect_mean_subsurf_atten`).

1.2.3.4 orbit_info

Orbit parameters that are constant for a granule, such as the reference ground track (RGT) number, cycle, and spacecraft orientation.

1.2.3.5 quality_assessment

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

1.2.4 Naming Convention

Data files utilize the following naming convention:

`ATL22_[yyyymmdd][hhmmss]_[ttttccss]_[vvv_rr].h5`

Example:

`ATL22_20181014031222_02370101_003_01.h5`

Table 1. File Naming Convention Variables and Descriptions

Variable	Description
ATL22	ATLAS/ICESat-2 L3B Mean Inland Surface Water Data product.
yyyymmdd	4-digit year, 2-digit month, and 2-digit day of data acquisition.
hhmmss	2-digit hour, 2-digit minute, and 2-digit second of data acquisition start time in UTC.
tttt	4-digit reference ground track number. The ICESat-2 mission has 1,387 RGTs, numbered from 0001 to 1387.
cc	2-digit cycle number. Each of the 1387 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	2-digit segment number. Not used. Always 01.
vvv_rr	3-digit version and 2-digit revision number*

*NOTE: From time to time, 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 segment number), but the revision number has been incremented. Although NSIDC deletes the superseded granule, the process can take several days. As such, if you encounter multiple granules with the same file name, please use the granule with the highest revision number.

Each data file has a corresponding XML file that contains additional science metadata. XML metadata files have the same name as their corresponding .h5 file, but with .xml appended.

1.2.5 Browse File

Browse files are provided as JPGs that contain data images for each granule. `default1` and `default2` show the transect mean orthometric height from ground tracks 1R and 3R, respectively. Transect mean orthometric height and transect length from each ground track for Eurasia, North America, and the globe are also provided.

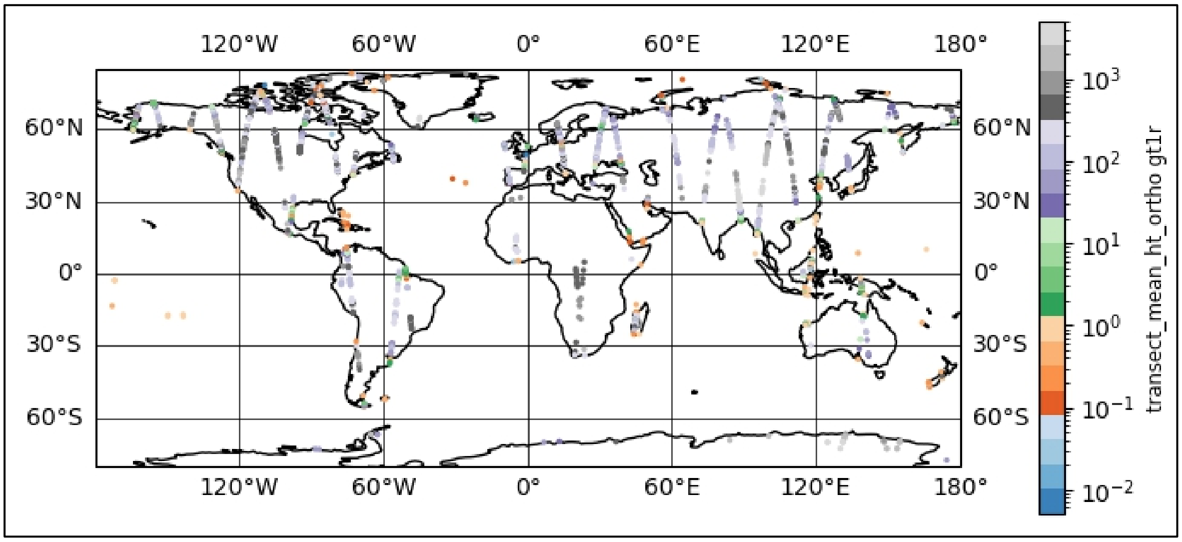

Figure 1. Example `default1` Browse Image.

1.3 Spatial Information

1.3.1 Coverage

Spatial coverage spans approximately 88° N latitude to 88° S.

1.3.2 Resolution

N/A

Data are averaged over individual inland water transects of varying sizes.

1.3.3 Geolocation

Latitudes and longitudes refer to the WGS 84 coordinate system. Surface water heights are provided as both heights above the WGS 84 ellipsoid (ITRF2014 Reference Frame) and as heights above the geoid (EGM2008). The following table contains details about geolocating the data:

Table 2. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	N/A
Longitude of true origin	Prime Meridian, Greenwich
Latitude of true origin	N/A
Scale factor at longitude of true origin	N/A
Datum	World Geodetic System 1984

Ellipsoid/spheroid	WGS 84
Geoid	EGM2008
Units	degrees
False easting	N/A
False northing	N/A
EPSG codes	4326 (WGS 84) 3855 (EGM2008)
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs
Reference	https://epsg.io/4326 (WGS 84) https://epsg.io/3855 (EGM2008)

For information about ITRF2014, see the International Terrestrial Reference Frame | ITRF2014 webpage.

1.4 Temporal Information

1.4.1 Coverage

13 October 2018 to present

1.4.2 Resolution

Repeat observations for any given water body depend on its size and geographic location. The frequency at which ATLAS/ICESat-2 crosses inland water bodies depends on how often the spacecraft's orbital pattern intersects with the water body mask. For high-latitude polar regions (approximately ±65°), the mission requirements mandate repeat observations every 91 days along the precisely established reference tracks (i.e., the satellite has a 91-day repeat cycle).

2 DATA ACQUISITION AND PROCESSING

The following sections refer to the Ice, Cloud, and Land Elevation Satellite (ICESat-2) Project Algorithm Theoretical Basis Document (ATBD) for Mean Inland Surface Water Data (ATBD for ATL22 | V3, https://doi.org/10.5067/5AALHPWLMJ4D). This ATBD provides a detailed description of the averaging of ATLAS/ICESat-2 L3A Along Track Inland Surface Water Data (ATL13, V6).

2.1 Background

ATL22 is a derivative of the continuous, Level 3A ATL13 Along Track Inland Surface Water Data product. ATL13 contains the high-resolution, along-track inland surface water profiles derived by analyzing the geolocated photon clouds from the ATLAS/ICESat-2 L2A Global Geolocated Photon

Data (ATL03) product. Starting from ATL13, ATL22 computes the mean surface water quantities with no additional photon analysis. The two data products, ATL22 and ATL13, can be used in conjunction as they utilize the same orbit and water body nomenclature regardless of version numbers. Both products and all subsequent versions of those products always contain the full record of ICESat-2 observations reprocessed from the beginning of acquisition in October 2018 to present.

ATL22 has been developed as a higher level (L3B), more convenient alternative to ATL13 for hydrologists, water resource engineers, scientists from other disciplines, and applied science users who only require the mean surface water products such as surface water height. Some potential applications for ATL22 are estimating river discharge and changes to water storage in a lake or reservoir. ATL22 offers valuable data especially in remote areas, such as high-latitude boreal zones where in situ data are sparse or non-existent. Furthermore, ATL22 can serve as a source of high-resolution data to calibrate other radar altimeters.

2.1.1 Inland Water Bodies

Inland water bodies are defined as contiguous continental water bodies of the following types: lakes and reservoirs greater than about 0.1 km^2; rivers greater than about 50–100 m wide; transitional water, including estuaries and bays; and a near-shore 7 km buffer. Globally, about 1.5 million water bodies are defined by unique IDs in ATL22.

2.1.2 Inland Water Body Transects

Water bodies are identified by a set of polygons. An ICESat-2 water body transect is any portion of an ICESat-2 beam that crosses a single water body that is interrupted by land (e.g., due to islands, bays, or peninsulas).

2.1.3 Inland Water Masks

An initial water mask of 0.1 km^2 was constructed to flag the existence of one or more water bodies in each grid cell. This mask improves ATL22 calculation efficiency by analyzing only those cells that have been flagged.

A second inland surface water mask is used to organize the ATLAS data in a logical manner. It consists of polygons that represent the outline of entire large river basins. See sections “3.4 | The ATL03 Inland Water Mask (Flag)” and “3.5 | ATL13/22 Inland Surface Water Mask (Shape File)” in the ATBD for ATL22.

2.2 Acquisition

The ATL22 algorithm inputs ATL13 granules and averages inland water body data and related parameters as described in the following section.

2.3 Processing

- Four ATL13 granules (covering approximately 24 hours) are aggregated into one ATL22 file.
- The mean ellipsoidal height, mean orthometric height, and mean subsurface attenuation of a given beam transect are computed as the arithmetic mean of the respective ATL13 segment-rate output.
- The mean is computed over all non-anomalous ATL13 short segments in a transect and reported at a single index location for each beam in the transect based on the latitude and longitude of each segment.
- Latitude, longitude, and time for each ATL22 transect are computed based on the short segment index photon location within the transect that is closest to the arithmetic mean of the corresponding ATL13 data set.
- The length of a transect is defined as the distance between the start and end latitudes and longitudes of the first and last ATL13 segment in the ATL22 transect.
- To allow users to conveniently use ATL22 products, a number of attributes from the ATL13 source data are written to ATL22 files.
- For each ATL22 transect, the ATL13 input file name is provided (`/metadata/lineage`) as well as the water body region, the water body type, and the unique, water body reference identification number (`atl13_gran_ndx`) for the water body to which the transect belongs.
- ATL22 transect output also contains indices that point users to the start and end rows (`transect_start_sseg_idx` and `transect_end_sseg_idx`) of ATL13 input arrays upon which the product is based.

2.4 Quality, Errors, and Limitations

Height accuracy depends on aggregation level and water state but is estimated to be about 10 cm for the strong beam. Section 4.3 “Data Product Precision and Evaluation” of the ATL22 ATBD details ICESat-2 precision, as well as ATL22 data product evaluation, assessment and validation activities, and calibration activities.

2.5 Instrumentation

See APPENDIX A: ATLAS/ICESAT-2 DESCRIPTION for a short instrument description.

3 VERSION HISTORY

Table 3. Version History Summary

Version	Release Date	Description of Changes
2	February 2022	• Initial release. • Version 2 of this data set was derived from ATL13 V5.
3	August 2023	• Version 3 of this data set was derived from ATL13 V6. • The mean values of all parameters improved from ATL22 V2 by filtering ATL13 input heights using histogram analysis that excluded outliers (e.g., land, islands).

4 RELATED DATA SETS

ATLAS/ICESat-2 L3A Along Track Inland Surface Water Data (ATL13)

5 DOCUMENT INFORMATION

5.1 Publication Date

September 2023

5.2 Date Last Updated

February 2024

APPENDIX A: ATLAS/ICESAT-2 DESCRIPTION

The ICESat-2 observatory utilizes a photon-counting lidar (the ATLAS instrument) and ancillary systems (GPS, star cameras, and ground processing) to measure the time a photon takes to travel from ATLAS to Earth and back again and determine the reflected photon's geodetic latitude and longitude. Laser pulses from ATLAS illuminate three left/right pairs of spots on the surface that trace out six approximately 14 m wide ground tracks as ICESat-2 orbits Earth. Each ground track is numbered according to the laser spot number that generates it, with ground track 1L (GT1L) on the far left and ground track 3R (GT3R) on the far right. Left/right spots within each pair are approximately 90 m apart in the across-track direction and 2.5 km in the along-track direction. The ATL13 data product is organized by ground track, with ground tracks 1L and 1R forming pair one, ground tracks 2L and 2R forming pair two, and ground tracks 3L and 3R forming pair three. Each pair also has a Pair Track—an imaginary line halfway between the actual location of the left and right beams (see Figure A1). Pair tracks are approximately 3 km apart in the across-track direction.

The beams within each pair have different transmit energies—so-called weak and strong beams—with an energy ratio between them of approximately 1:4. The mapping between the strong and weak beams of ATLAS, and their relative position 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 (see Figure A1, left). In this orientation, the weak beams lead the strong beams and a weak beam is on the left edge of the beam pattern. In the backward orientation, ATLAS travels along the -x coordinate, in the instrument reference frame, with the strong beams leading the weak beams and a strong beam on the left edge of the beam pattern (see Figure A1, right). The first yaw flip was performed on 28 December 2018, placing the spacecraft into the backward orientation. The current spacecraft orientation, as well as a history of previous yaw flips, is available in the ICESat-2 Major Activities tracking document (`.xlsx`).

The RGT refers to the imaginary track on Earth at which a specified unit vector within the observatory is pointed. During nominal operating conditions onboard software aims the laser beams so that the RGT is between ground tracks 2L and 2R (i.e., coincident with Pair Track 2). The ICESat-2 mission acquires data along 1,387 different RGTs. Each RGT is targeted in the polar regions once every 91 days to allow elevation changes to be detected. 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, for example in ATL02 file names, by appending the two-digit cycle number (cc) to the RGT number, e.g., 0001cc to 1387cc.

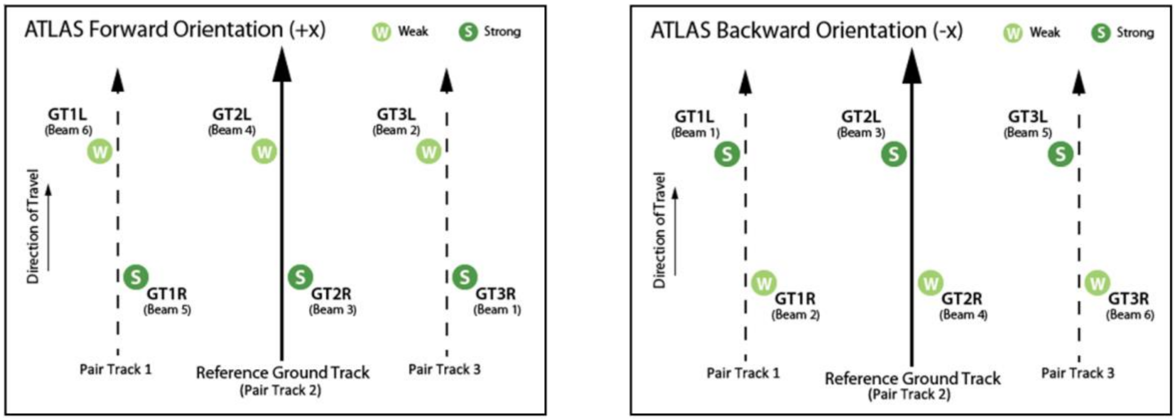

Figure A1. Spot and ground track (GT) naming convention with ATLAS oriented in the forward (instrument coordinate +x) direction and backward (instrument coordinate -x) direction.

Users should note that sometimes, for various reasons, the spacecraft pointing may lead to ICESat-2 data collected offset at some distance from the RGTs instead of along the nominal RGT. Although not along the nominal RGT, the geolocation information and data quality for these data are not degraded. As an example, from 14 October 2018 and 30 March 2019, the spacecraft pointing control was not yet optimized. To identify such time periods, refer to the ICESat-2 Major Activities file.

Various reference systems and dynamic processes, or geophysical corrections, occur during an ATLAS/ICESat-2 measurement (Figure A2). Table A1 lists the corrections needed for each surface type and ICESat-2 product. For example, to determine an estimate of the mean sea surface, several well-modeled, time-varying effects must be accounted for.

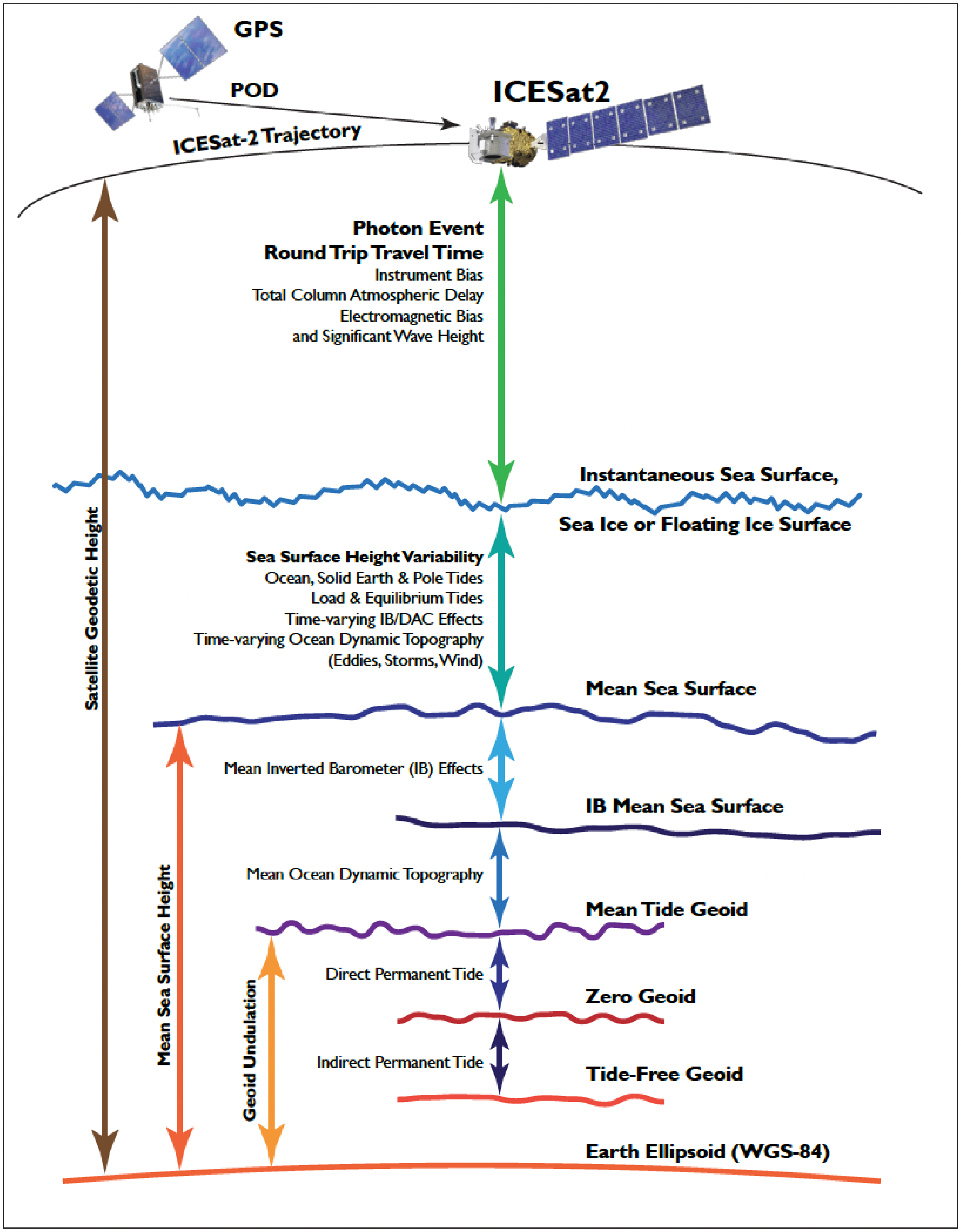

Figure A2. Geophysical corrections used in satellite altimetry.
Taken from *ICESat-2 Data Comparison User's Guide for Rel006*
available on the ATL03 data set landing page.

Table A1. 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 range-delay
Land Ice, Land, and Inland Water (ATL06, ATL08, and ATL13)	*No corrections beyond ATL03*
Sea Ice (ATL07 and ATL10)	Referenced to mean sea surface Ocean tide Long period equilibrium ocean tide Inverted barometer (IB)
Ocean (ATL12)	Ocean tide Long period equilibrium ocean tide

[1]For details, see Section 5 of the *ICESat-2 Data Comparison User's Guide for Rel006* available on the ATL03 data set landing page.