ATLAS/ICESat-2 L3B Monthly Gridded Dynamic Ocean Topography, Version 2

USER GUIDE

How to Cite These Data

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

Morison, J. H., D. Hancock, S. Dickinson, J. Robbins and L. Roberts. 2022. *ATLAS/ICESat-2 L3B Monthly Gridded Dynamic Ocean Topography, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/ATLAS/ATL19.002. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/ATL19

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set contains monthly gridded dynamic ocean topography (DOT) over mid-latitude, north-polar, and south-polar grids derived from the along-track ATLAS/ICESat-2 L3A Ocean Surface Height product (ATL12). Monthly gridded sea surface height (SSH) can be calculated by adding the mean DOT and the weighted average geoid height also provided. Both single beam and all-beam gridded averages are available: single beam averages are useful for identifying potential biases among the beams, and the all-beam averages are useful in physical oceanography. Simple averages, degree-of-freedom averages, and averages interpolated to the center of grid cells are included, as well as uncertainty estimates.

1.2 File Information

1.2.1 Format

Data are provided as HDF5 formatted files. HDF is a data model, library, and file format designed specifically for storing and managing data. For more information about HDF, visit the HDF Support Portal.

1.2.2 File Contents

Data files contain monthly gridded DOT and related parameters.

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 ATL19 data files.

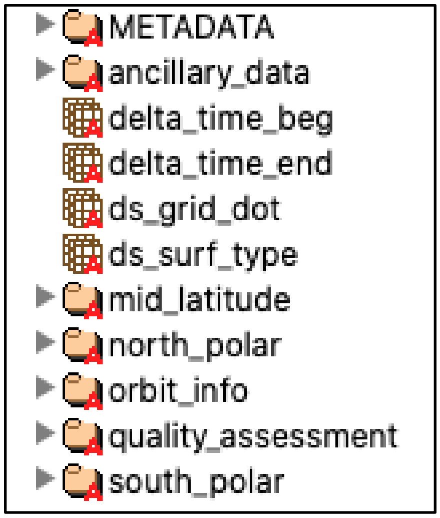

Figure 1. ATL19 Top-Level Data Groups and Variables

The following sections describe the data groups and their contents plus the variables stored at the top level in ATL19 data files.

For additional information, see the following Technical References on the ATL19 data set landing page:

- ATL19 Data Dictionary (complete list of variables stored)
- ATBD for Gridded Dynamic Ocean Topography (ATL19)

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 mid_latitude

Mid latitude DOT and related parameters averaged across all beams and for individual beams in separate subfolders.

1.2.3.4 north_polar

North polar DOT and related parameters averaged across all beams and for individual beams in separate subfolders.

1.2.3.5 orbit_info

Orbit parameters that are constant for a granule, such as the RGT number, cycle, and spacecraft orientation.

1.2.3.6 quality_assessment

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

1.2.3.7 south_polar

South polar DOT and related parameters averaged across all beams and for individual beams in separate subfolders.

1.2.3.8 Other Variables

The following variables are stored at the top level of ATL19 data files alongside the data groups described above:

- delta_time_beg: Earliest time in the data granule
- delta_time_end: Latest time in the data granule
- ds_grid_dot: DOT histogram for the data granule
- ds_surf_type: Surface types (1 = Land, 2 = Ocean, 3 = Sea Ice, 4 = Land Ice, 5 = Inland Water)

1.2.4 Naming Convention

Data files utilize the following naming convention:

Example:

ATL19_20190901004029_09920401_002_01.h5
ATL19_[yyyymmdd][hhmmss]_[ttttccss]_[vvv_rr].h5

Table 1. File Naming Convention

Variable	Description
ATL19	ATLAS/ICESat-2 L3B Monthly Gridded Dynamic Ocean Topography product
yyyymmdd	4-digit year, 2-digit month, and 2-digit day of month of the first ATL12 input file in each granule.
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.

Variable	Description
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: Occasionally, NSIDC receives duplicate, 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. Thus, 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

An HDF5 browse file is provided for each granule that contains two browse images in the default group called default1 and default2. Default 1 visualizes the average DOT for all beams and default2 the average significant wave height (SWH) for all beams.

1.3 Spatial Information

1.3.1 Coverage

Spatial coverage spans the world ocean surface from approximately 88° N latitude to 88° S.

1.3.2 Resolution

- Data between 60° N and 60° S have a 1/4° grid resolution. (Note: In future releases, this will be expanded to 66° N and 66° S).
- Data north of 60° N and south 60° S have a 25 km grid resolution.

1.3.3 Geolocation

ATL19 uses three grids, North and South polar stereographic 25-km grids as well as an overlapping mid-latitude curvilinear 1/4° latitude-longitude grid between 60°N and 60°S. The gridding is done individually for each beam on the ocean segments with average positions inside the grid cell. The following tables describe the different projection and grid details.

Table 2. Mid Latitude Projection 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
Units	degree
False easting	N/A
False northing	N/A
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs
Reference	https://epsg.io/4326

Table 3. North Polar Projection Details

Geographic coordinate system	N/A
Projected coordinate system	NSIDC Sea Ice Polar Stereographic North
Longitude of true origin	-45°
Latitude of true origin	0°
Scale factor at longitude of true origin	1
Datum	unspecified
Ellipsoid/spheroid	Hughes 1980
Units	Meters
False easting	0
False northing	0
EPSG code	3411
PROJ4 string	+proj=stere +lat_0=90 +lat_ts=70 +lon_0=-45 +k=1 +x_0=0 +y_0=0 +a=6378273 +b=6356889.449 +units=m +no_defs
Reference	https://epsg.io/3411

Table 4. South Polar Projection Details

Geographic coordinate system	N/A
Projected coordinate system	NSIDC Sea Ice Polar Stereographic North
Longitude of true origin	0°

Latitude of true origin	-70°
Scale factor at longitude of true origin	1
Datum	unspecified
Ellipsoid/spheroid	Hughes 1980
Units	Meters
False easting	0
False northing	0
EPSG code	3411
PROJ4 string	+proj=stere +lat_0=-90 +lat_ts=-70 +lon_0=0 +k=1 +x_0=0 +y_0=0 +a=6378273 +b=6356889.449 +units=m +no_defs
Reference	https://epsg.io/3412

Table 5. Grid Details

Hemisphere	North Polar	South Polar	Mid Latitude
Grid cell size (x, y pixel dimensions)	25 km, 25 km	25 km, 25 km	0.25°, 0.25°
Number of rows	448	332	480
Number of columns	304	316	1440
Geolocated lower left point in grid	30.98°(Lat) 168.35° (Lon)	-39.23°(Lat) 317.16°(Lon)	-60°(Lat) 180°(Lon)
Nominal gridded resolution	25 km	25 km	0.25°
Grid rotation	N/A	N/A	N/A
ulxmap – x-axis map coordinate of the center of the upper-left pixel (XLLCORNER for ASCII data)	-3850 projected km	-3950 projected km	-179.875°
ulymap – y-axis map coordinate of the center of the upper-left pixel (YLLCORNER for ASCII data)	5850 projected km	4350 projected km	59.875°

1.4 Temporal Information

1.4.1 Coverage

13 October 2018 – 1 May 2022

1.4.2 Resolution

Monthly

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 Gridded Dynamic Ocean Topography (ATBD for ATL19 | V02, DOI: 10.5067/51MR1VVXQ8F6). This ATBD provides a detailed description on the gridding of the dynamic ocean topography and related variables from ATL12 sea surface height. To obtain the ATBD for Sea Ice Products, see Technical References on the ATL19 data set landing page.

2.1 Background

The ATL19 gridded product is intended to provide users with a realization of the ocean surface height mapped over the world ocean in 1-month averages. ATL19 aggregates ATL12 along-track DOT and computes monthly gridded DOT in NSIDC Polar Stereographic Northern and Southern Hemisphere 25 km grids for data collected north of 60° N and south 60° S. In the mid-latitudes (from 60° N to 60° S), the ATL19 data are presented in a curvilinear 1/4° latitude-longitude grid.

The ATL12 along-track ocean surface height is derived from ATL03 photon heights, removing variations from tides and atmospheric forcing. To further reduce variability of the photon heights, the EGM2008 geoid is subtracted in the mean tide system to express photon heights as DOT.

The upcoming ATL23 product will contain 3-month gridded fields similar to those of ATL19 but for all-beam gridded averages only using simple averages and degree-of-freedom weighted averages.

2.2 Acquisition

The ATL19 algorithm inputs ATL12 granules and computes gridded monthly DOT and related parameters as described in the following section.

2.3 Processing

For each grid in ATL19 all the available along-track ATL12 data in a given month are aggregated and averaged. Data from all six beams are used, both individually and averaged together. Prior to the summer of 2021, only strong beam data was available over the ocean.

The ATL19 gridding process is computed for the first four moments of sea surface height (mean (*h*), variance (*h_var*), skewness (*h_skewness*) and kurtosis (*h_kurtosis*)) for each segment from ATL12. Both simple averages and averages weighted by the degrees-of-freedom for each ocean segment are included.

For more details on the gridding process see “Section 3.2 | Gridding DOT for ATL19” in the ATL19 ATBD.

Not all grid cells in the monthly averages contain values, as particularly at low latitudes where data are sparce. This is due to the ICESat-2 repeat cycle of only 91 days close to the equator. Consequently, in the future this data product is planned to also include a 3-month moving average to provide data in every grid cell. Grids not corresponding to ocean are set to a default invalid value.

2.4 Quality, Errors, and Limitations

Errors in the ATLAS/ICESat-2 height retrievals can arise from a variety of sources, including:

- Sampling error (heights reflect random point sample of the height distribution)
- Background noise from random non-signal photon returns
- Misidentified signal photons
- Atmospheric forward scattering delays
- Subsurface scattering within ice or snow
- First-photon bias (inherent with photon-counting detectors)

These errors in ATLAS/ICESat-2 upstream products can propagate into ATL19.

2.5 Instrumentation

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

3 VERSION HISTORY

Version 2 (April 2022)

The input data for ATL19 Version 2 is ATL12 Version 5.

Changes for this version include:

- Added average ice concentrations (`ice_con`) parameter derived from the ice concentration in ATL12 Version 5.

Version 2 was retired in March 2024.

4 RELATED DATA SETS

- ATLAS/ICESat-2 L3A Ocean Surface Height (ATL12)

- ATLAS/ICESat-2 L3B Monthly Composite Gridded Dynamic Ocean Topography (ATL23, coming soon)

5 RELATED WEBSITES

- Polar Stereographic Data | NSIDC Polar Stereographic Grid Definitions

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7 DOCUMENT INFORMATION

7.1 Publication Date

April 2022

7.2 Date Last Updated

March 2024

APPENDIX A: ATLAS/ICESAT-2 DESCRIPTION

The ATLAS instrument and ICESat-2 observatory utilize a photon-counting lidar and ancillary systems (GPS and star cameras) to measure the time a photon takes to travel from ATLAS to Earth and back again and to determine the photon's geodetic latitude and longitude. Laser pulses from ATLAS illuminate three left/right pairs of spots on the surface that as ICESat-2 orbits Earth trace out six ground tracks that are typically about 14 m wide. 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 ATL06 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 Figures A1 and A2). 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). 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 A2). The first yaw flip was performed on December 28, 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 Reference Ground Track (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 (i.e. the satellite has a 91-day repeat cycle) 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 by appending the two-digit cycle number to the RGT number, e.g. 000103 (RGT 0001, cycle 03) or 138705 (RGT 1387, cycle 05).

Users should note that between 14 October 2018 and 30 March 2019 the spacecraft pointing control was not yet optimized. Thus, ICESat-2 data acquired during that time do not lie along the nominal RGTs, but are offset at some distance from the RGTs. Although not along the RGT, the geolocation information for these data is not degraded.

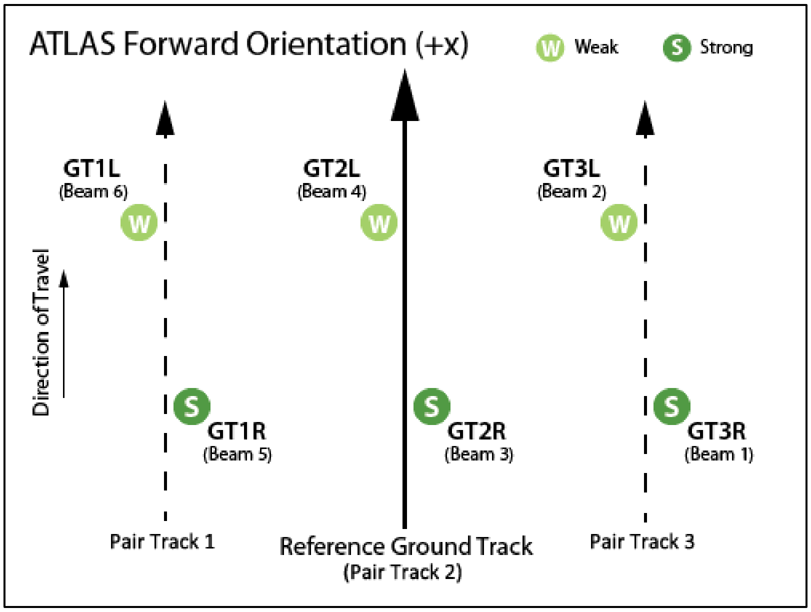

Figure A1. Spot and ground track (GT) naming convention with ATLAS oriented in the forward (instrument coordinate +x) direction.

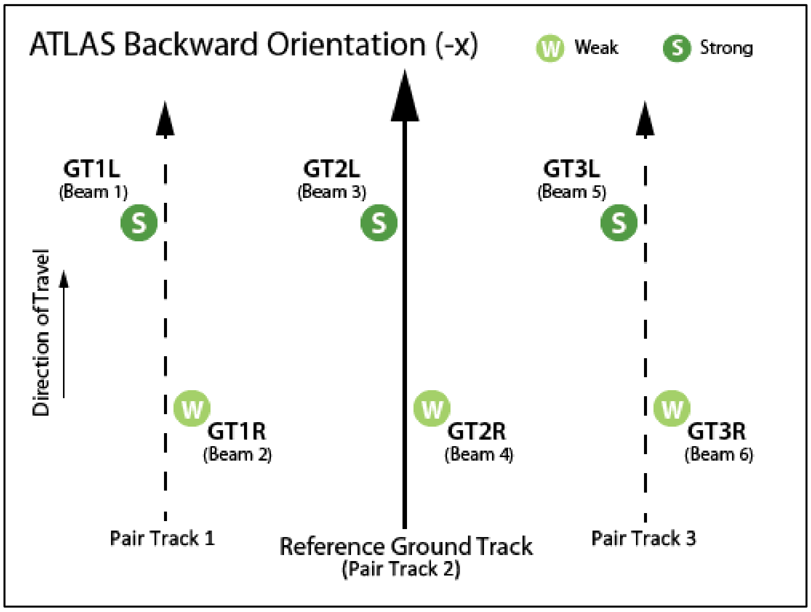

Figure A2. Spot and ground track (GT) naming convention with ATLAS oriented in the backward (instrument coordinate -x) direction.