

ATL22 Mean Inland Surface Water Data, Release 002

Algorithm Notes and Known Issues

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Introduction

This document contains algorithm notes and known issues identified by the developers of the ICESat-2 ATL22 L3B Mean Inland Surface Water Data Product, Version 2. A complete description of all the ATL22 data products and their development, are provided in Jasinski et al., 2021a. ATL22 products are publicly available at the National Snow and Ice Data Center, Boulder CO (Jasinski et al, 2021a, 2021b).

The ATL22 product means are a derivative of its companion product, the L3A ATL13 Along Track Inland Surface Water Data Ver 5 data which have been published since May 2019 (E.g. Jasinski et al, 2021c). ATL13 contains the high resolution, profiles derived from analysis of ATL03 geolocated photon clouds. ATL22 computes the mean surface water quantities directly from ATL13 products with no additional photon analysis. Both sets of products and subsequent new version of those products are reprocessed from the beginning of ICESat-2 observations (mi-October 2018) to present. A summary of the ATL13 and ATL22 releases to date is provided in Table 1-1 below.

Table 1-1 Summary of Principal Releases of ATL13 and ATL22 Inland Surface Water Data

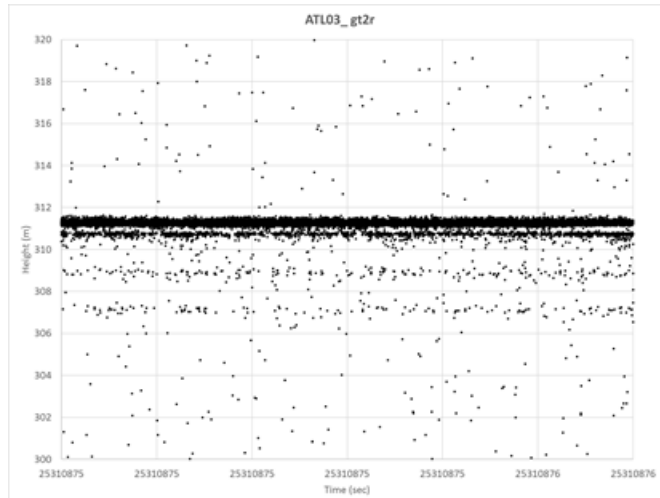
ATL13/22 Version	Release Date	Water Body Types (Number of unique IDs)	Description and Principal/Added Features
ATL13v1	May 2019	Lakes & reservoirs > 10 km ² (19,634)	<ul style="list-style-type: none"> - <u>Continuous, along track surface water products</u> including subsurface attenuation and supporting data. - reported at short segment length - Employs GLWD (Lehner & Doll 2004)
ATL13v2	Nov 2019	Lakes & reservoirs ≥ 10 km ² (19,800) Estuaries, bays, and near shore 7 km buffer (~3500)	<ul style="list-style-type: none"> - Employs HydroLAKES (Messenger & Lehner, 2016) - Adds transitional waters; Named Marine Water Bodies (ESRI) GSHHG Shoreline (Wessel et al, 1996) - Adds significant wave height - coarse bathymetry algorithm - Adds dynamic shore finding
ATL13v3	Mar 2020	Lakes & reservoirs ≥ 0.1 km ² (~1,400,000) Estuaries, bays, and near shore buffer (7 km) (~3500) Rivers ≥ ~50-100 m wide (10,300)	<ul style="list-style-type: none"> - Adds river mask using GRWL (Allen and Pavelsky, 2018) - Adds wind speed for all crossings - Adds Ice on/off flag from multi-sensor NOAA product - Corrects first photon bias error - Adds cloud confidence flag
ATL13v4/v5	Apr/Nov 2021	All above water bodies	<ul style="list-style-type: none"> - Improves photon classification - Improves accuracy of existing data products - Reports additional products
ATL22v2	Dec 2021	All above water bodies	<ul style="list-style-type: none"> - <u>Mean surface water products</u> and supporting products including crossing length - Reported for each transect (uninterrupted water crossing)

Known Issues

Herein, only the most frequent issues are identified. Current known issues within the ATL22 product will be addressed in future releases. We therefore welcome from all users any questions, feedback, or any new issues so they can be addressed in the future to improve the ATL13 product.

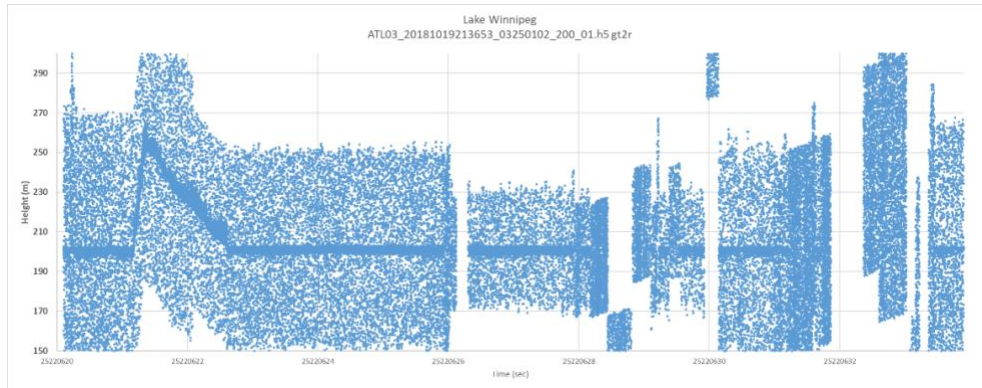
Issue 1. Distorted surface return over some water bodies with very high reflectance due to first photon bias and dead time.

Occasionally, over calm or highly reflective water surfaces, there is a high photon surface return that ATLAS can only partially record due to detector limitations, leading to striping of the returns. In the figure below, the gap just under the top surface return is attributed to dead time, while the deeper striping is due to instrument afterpulses. The gap in the true full surface return usually occurs about 1 m below the surface, in both the weak and strong beams, resulting in a positive bias of the surface elevation. Also, often occurring in these situations are faint afterpulses at depths of about 2.2 and 3.9m. ATL13 Ver 5 partially corrects the height using the ATL03 CAL19 first photon bias correction algorithm, however the error may result in a positive bias of the ATL22 surface height. On-going ICESat-s Project Office analyses will further correct this.



Issue 2. Occasional miss identification of atmospheric clouds as water surface

Although it is rare, sometimes, in the presence of dense clouds, the true water surface is misidentified as the top of the clouds, as shown in the figure below. There is currently no flag in ATL22 to warn users of this miss identification. This issue has been partly addressed in ATL13 Ver 5 by selecting a narrow band window based on a known DEM, which automatically is therefore also propagated to ATL22



Issue 3. Snow and ice on water bodies

In ATL13, snow and ice on inland water bodies are not explicitly identified. Thus, the retrievals apply the same inland water algorithm throughout. While not corrected, to offset this issue, ATL13 Ver 5 does provide a NOAA-derived snow and ice flag, retrieved from ATL09 and resampled at the ATL13 short segment rate. The NOAA map is based on published daily Interactive Multisensor Snow reports. Users who download ATL22 water body heights during a period when snow and ice is possible should check the ATL13 Snow and Ice flag (snow_ice_ATL09) reported in the ATL13 output. When the flag is set at 2 or 3, ATL13 results should be regarded with caution as they may not represent open water.

Issue 4. Inter-beam calibration not available.

Currently, ATLAS calibration occurs only at the instrument level, not individual beams. Inter beam height variations in height on the order of centimeters are known to exist but have not been fully evaluated by the ICESat-2 Project Office, especially in the lower and mid latitudes.

Issue 5. ATL13 overlapping water bodies

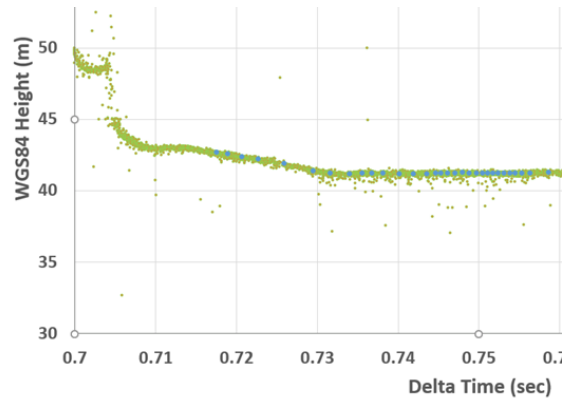
The ATL13/22 Inland Water Body Shape Mask facilitates identification of ICESat-2 crossings over individual water bodies, by delineating the shape and spatial distribution of contiguous individual water bodies. It is a composite mask derived from various published sources, and includes lakes, reservoirs, rivers, and transitional waters including estuaries and bays, and near shore coastal waters. Details are provided in the ATL13 ATBD.

While the mask works very well in most cases, there are several issues. First, in areas of high-density water bodies, the buffering of bodies and different interpretation of boundaries by different sources can cause shapes in the ATL13 Inland Water Body Mask to overlap. River overlaps of lakes were specifically removed to allow the lakes in those cases to be seen in their entirety, but in the cases of other body type overlaps, Body 1 will be fully processed and then the processing of Body 2 will begin only after Body 1 was exited. Thus, the overlapped portion of

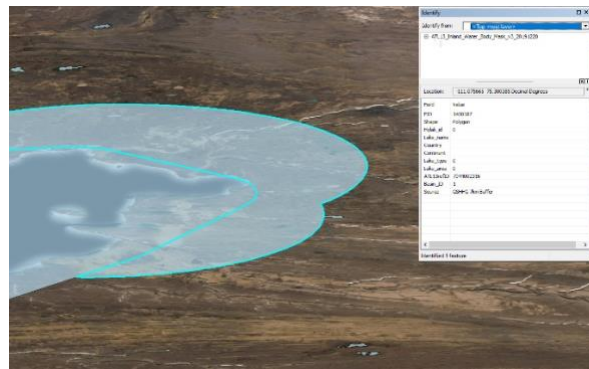
Body 2 may be incorrectly assigned as the final transect(s) in Body 1 and/or not processed at all depending on the nature of the terrain. Both overlaps and interruption might also cause a broken flow in the output for an individual water body where, for example, a lake in the middle of a river shape might cause the report of two transects of the river to be separated by that of a lake in between them.

Issue 6. Land area adjacent to water bodies

Occasionally, ATL13 will incorrectly identify land along the edge of a water body as water surface which will impact on the ATL22 mean height. This release does not include a flag indicating the likelihood of a body edge segment being land. However, a user can in most cases make an accurate determination based on the edge height relative to a segment located further inside the body.

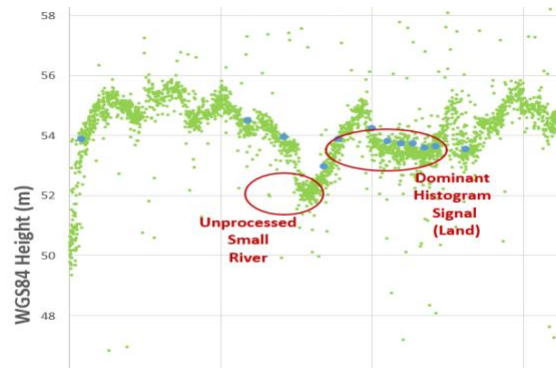


Also, some coastal buffer of narrow inlets and bays caused swaths of land to be included in version 3 of the ATL13 Inland Water Body Mask. In these cases, it is possible that flat land will create enough of a histogram signal to compel the algorithm to process the crossing as if it were water (See example below). This will impact on the ATL22 accuracy.



Issue 7. River crossings with significant adjacent flat land

To ensure the capture of braided and high flow conditions in ATL13 rivers, a wide buffer was provided in the masks of certain river shapes. Because of this approach, land segment heights are often incorrectly reported as water surfaces. It is possible but rare that extensive flat floodplains are dominated by land rather than open water. ATL13 Ver 5 makes every effort to exclude land anomalies. However, when braided rivers are expected, users should also visually examine the ATL13 short segment for anomalous land segments and process accordingly. The inclusion of misidentified land segments will impact on the ATL22 mean elevation.



Issue 8. Detrending at long segment length scales

Along track inland water body slopes are processed for long segments within the detrending algorithm. The reported slope may not be representative of the true slope due to the current ATL03 signal photon classification process. Impacts to the water surface elevation is thought to be minimal.

Issue 9. Inland water quality and classification flags

Quality and classification flags are provided for key ATL13 output products in the ATBD [Section 4.8](#). They show the range of a variable's magnitude for an initial indication of a product's behavior. Current ATL13 ATBD flags are:

- 4.8.1 Inland Water Segment Processing Flag: This flag describes the level of processing used to estimate the surface and subsurface parameters.
- 4.8.2 Background Flag: This flag describes the intensity of the background rate in each short segment. The flags are:
- 4.8.3 Bias Fit Flag: Indicates the range of bias in the Gaussian fit
- 4.8.4 EM Bias Flag: Indicates theoretical range of bias due surface wave slope:
- 4.8.5 Short Segment Length Flag: Indicates length range of short segments,

4.8.6 Long Segment Length Flag: Indicates length range of long segments

4.8.7 Clouds Flag : Cloud confidence flags derived in ATL09 and resampled to convert to ATL13 short segment rates, for Cloud_Flag_ASR, Cloud_Flag_Atm and Layer_Flag.

4.8.8 Flags Associated with Snow and Ice: The ATL13 snow and ice flags are (snow_ice_ATL09), obtained from the ATL09 Snow_Ice flag and the NOAA GMASI product, are assigned at the short segment rate as: 0 = ice free water, 1 = snow free land, 2 = snow, and 3 = ice. When there is more than one overlap, they are assigned the greatest value.

4.8.9 Flags Associated with Surface Temperature: ATL13 reports the ATL09 MET surface (skin) temperature at the short segment rate based on a linear interpolated nearest neighbor approach.

Issue 10. “Deferred” ATL22 Products

Several of the Table 5.2 Output Products scheduled for future release are labeled “deferred”. The deferred output is either populated with an “invalid” placeholder, or is not provided.

Issue 11. ATBD citation link/DOI

The DOI provided by NSIDC for the Inland Water Data Product ATL13 only points to the ICESat-2 data products page, and not to the ATL13 ATBD document itself. Once reaching the page, please scroll down to see the link to the ATL13 ATBD.

Issue 12. ATLAS 523nm subsurface attenuation

There is an error in Equation 4.11 - the expression of α and β in the subsurface attenuation algorithm, This does not affect the surface water height products, but may lead to an overestimation of α by up to 50% in some cases.

Issue 13. Length of partial short segments

The length of partial short segments at the end of water transects can be erroneously reported, as the final photon in the mask transect, rather than the final signal photon in the true water body. This occurs because short segments are determined based on a fixed number of signal photons for a given water body type. If that number is not attained, the algorithm continues to search until it reaches the end of the ATL13 mask, resulting in a longer transect length to be reported in ATL22 than that of the length of the actual processing domain of signal photons.

References

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