ICE, CLOUD, AND LAND ELEVATION SATELLITE-2 (ICESat-2)

ATL19 Rel. 4 & ATL23 Rel. 2 Gridded Dynamic Ocean Topography

Application Notes and Known Issues

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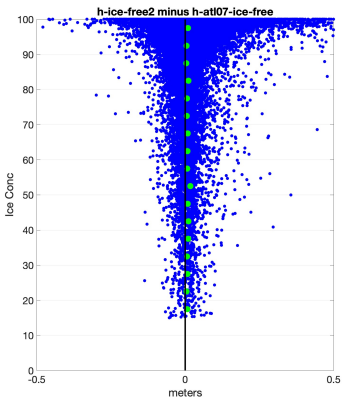
Issue 1. Uncertainty in Gridded DOT

A key improvement in Release 4 of ATL19 and ATL23 is the inclusion of minimum uncertainty values of DOT at grid cell centers. The Release 1 and 2 ATL19 gridded DOT standard deviation and uncertainty reflected only the variability within ocean segments due to waves. They did not include the variation due to temporal and spatial variability of ocean segment-average DOT. Similarly, because the height probability density functions, *Y*, from ATL12 represent only the distributions of the departure from mean DOT (*meonofit2*) over an ocean segment, the grid cell aggregate distributions also only reflect the variability due to ocean waves. In Release 3 of ATL19 and Release 1 of ATL23 this was still true of simple and DFW averages, but the centered averages were computed based on a planar fit over 9 cells centered on the central point, and the RMS variation about the planar fit represented the uncertainty due to all factors in the centered values. In Release 4 of ATL19 (Release 2 of ATL23) the DFW centered averages is changed to weight the planar fit by the uncertainty in the individual ATL12 DOT values, and the resulting "degree-of-freedom-uncertainty" weighted DFW centered value that is the estimate with minimum uncertainty.

Issue 2. DOT in Ice-Covered Regions



Ice Conc	Mean Diff	STDev Diff
2.5		
7.5		
12.5		
17.5	0.0069	0.0344
22.5	0.0041	0.0340
27.5	0.0076	0.0377
32.5	0.0063	0.0269
37.5	0.0103	0.0373
42.5	0.0108	0.0436
47.5	0.0084	0.0412
52.5	0.0170	0.0824
57.5	0.0067	0.0414
62.5	0.0075	0.0429
67.5	0.0086	0.0523
72.5	0.0052	0.0439
77.5	0.0064	0.0448
82.5	0.0110	0.1375
87.5	0.0038	0.0583
92.5	0.0045	0.1106
97.5	0.0090	0.0712

Figure 1. ATL12 v. ATL07 comparison, (left) ***h_ice_free -h_atl07_ice_free*** versus ice concentration and (right) Table of ***h_ice_free - h_atl07_inatl12oc*** versus ice concentration.

DOT as provided by prior releases of ATL12/19/23 was biased by sea ice freeboard in ice covered oceans. With Release 4 ATL19/23, we account for this with estimates of DOT in open water "bright" leads identified in ATL07 and incorporated into ATL12 as bright lead-qualified 10-m bins. In processing ATL12 Release 7 we synchronize with ATL07 to the degree that we can identify the 10-m bins that correspond to the ATL07 segments with ***ssh_flag***=1 indicative that these bright leads are suitable for sea surface height determination. We find that ATL12 DOT, ***htybin***, in 10-m bins, when it is corrected for first photon bias (***fpb_10m***), largely agrees with the corresponding ATL07 DOT with dynamic atmospheric correction as opposed to the dynamic IB correction. For each ATL12 ocean segment with corresponding ATL07, ATL12 computes: ***h_ice_free*** as the average DOT from ATL12 heights, ***htybin-fpb_10m***, in 10-m bins in common with ***ssh_flag*** qualified ATL07 sea ice segments, ***h_atl07_ice_free*** as the average DOT from ATL07 in *ssh_flag=1* qualified sea ice segments with corresponding ATL12 10-m bins, and ***h_atl07_inatl12oc*** as the averaged DOT from all ATL07 *ssh_flag* =1 qualified sea ice segments in an ATL12 ocean segment with or without corresponding ATL12 10-m bins. In testing we find ***h_ice_free*** agrees with ***h_atl07_ice_free*** and ***h_atl07_inatl12oc*** to within 1 or 2 cm for ice

concentrations less than 77.5% (Fig. 1). This indicates the basic surface finding used in ATL12 agrees with that used in ATL07. At high ice concentrations, ***h_ice_free*** is sometimes biased high. We believe this happens because leads are narrow relative to 10-m and laser pulses centered in the lead also pick up photon heights from the top of adjacent ice.

Consequently, in ATL19/23 for ocean segments with ice concentration, ***ice_conc***, greater than 15%, a variable referring to the height of the top of the sea ice surface relative to the geoid, ***h_icetop_geoid***, will be set equal to ***h-geoid_seg-bin_ssbias***.

15% ≤ IC≤ 70%

Also, for ice concentration from 15% to 70%, the value used for DOT in place of ***h-geoid_seg*** is set to invalid unless:

1) ***h_ice_free*** exists, in which case ***h_ice_free*** is substituted for the open ocean DOT variable, ***h-geoid_seg-bin_ssbias***, in the gridding process and the uncertainty in ***h_ice_free***, ***h_ice_free_uncrtn,*** is substituted for ***h_uncrtn*** as the DOT uncertainty in the gridding processes. Note that because sea state bias, ***bin_ssbias***, is computed as an ocean segment average and not at the 10-m bin level, there is no correction for sea state bias in ***h_ice_free***. This acceptable because sea state bias is small for ICESat-2 even in significant waves and wave amplitudes, which sea state bias depends on, are typically very small in the open water between ice floes.
2) If ***h_ice_free*** does not exist (is invalid) but ***h_atl07_inatl12oc*** does exist, ***h_atl07_inatl12oc*** is substituted for the open ocean DOT variable, ***h-geoid_seg-bin_ssbias***, in the gridding process, and if ***h_atl07_inatl12oc_uncrtn*** exists it will be substituted for ***h_uncrtn*** as the DOT uncertainty in the gridding processes, or if ***h_atl07_inatl12oc_uncrtn*** does not exist, a fixed empirical uncertainty, e.g., ± 5 cm, is substituted for ***h_uncrtn*** as the DOT uncertainty in the gridding processes.

IC > 70%

If ice concentration is greater than 70% and ***h_atl07_inatl12oc*** exists, ***h_atl07_inatl12oc*** is substituted for the open ocean DOT variable, ***h-geoid_seg-bin_ssbias***, in the gridding process and the uncertainty in this value, ***h_atl07_inatl12oc_uncrtn*** is substituted for ***h_uncrtn*** as the DOT uncertainty in the gridding processes.

For the polar grid simple averages, where ***ice_conc*** is greater than or equal to 15%, we also all-beam average ***h_ice_free***, ***h_atl07_ice_free*** and ***h_atl07_inatl12oc*** as:

1) ***dot_icefree_avg_albm***

2) ***dot_avginice_07_albm*** for ***h_atl07_ice_free***, and

3) ***dot_avginice_7in12_albm*** for ***h_atl07_inatl12oc***

We also all-beam average the ***h_ice_free_uncrtn***, ***h_atl07_ice_free_uncrtn*** and ***h_atl07_inatl12oc_uncrtn*** as ***dot_icefree_uncrtn_albm , dot_avginice_07_uncrtn_albm*** and ***dot_avginice_7in12_uncrtn_albm***, respectively.

For the polar grids and IC ≥ 15%, we compute and output ***h_icetop_avg_allbm*** as the all-beam average of ***h_icetop_geoid*** (set equal to ATL12 ***h-geoid_seg-bin_ssbias*** for IC ≥ 15%).

This represents the top surface of the sea ice so that users may subtract gridded DOT to represent sea ice freeboard. The average uncertainty in ***h_icetop_avg_uncrtn_allbm*** is computed as the all-beam average of ***h_uncrtn*** for IC $\geq$ 15%.

Issue 3. Unknown Issues

At present, we have only seen limited amounts Release 7 ATL12 samples scattered through 2019. Consequently, there may be a number of issues, particularly with ATL19 and ATL24, that remain to be discovered when Release 7 ATL03, ATL07 (for polar grids), and ATL12 come out.