ICESat-2 Algorithm Theoretical Basis Document for Atmosphere Gridded Products

Steve Palm

Thomas Northam

Version 2.2

December 5, 2019

Contents

Change Log

Note: All changes are in red font.

August 21, 2018: Corrected the logic in section 3.3.1. Changed the units in tables to 2 and 3 to fraction from percent.

February 26, 2019: Corrected mistake in blowing snow description, section 3.4. Changed "If *bsnow_ht* is greater than or equal to -2" to "If *bsnow_con* is greater than or equal to -2"

May 2019: in section 3.1 added the check of "layer_attr" when constructing the global cloud fraction grid.

August 2019: Added section 3.1.1 that defines a new parameter (Global Aerosol Fraction) to be added to ATL16 and ATL17. Added section 3.8 which defines the new control parameters *week_obs_minimum* and *month_obs_minimum*, and replaced old section 4.0 with a new section on smoothing of the images that are made from the data grids. In section 4.0 the new control parameters *smooth_grid* and *center_weight* are described. Changed old section 4.0 to section 5.0. Added section 6.0.

September 2019: ATBD version 2.1. Added observation grids to both ATL16 and ATL17. Specified that smoothing is to be done only on the data to produce the images. The gridded data fields on the product are not smoothed.

December 5, 2019: ATBD version 2.2a. Modifications to certain entries in Section 5.0 Table 2 and Table 3 content. Clarification notes added to Sections 3.1, 3.1.1, and 3.2. Corrections made to text in Section 3.3.1 for definition of low, middle, and high layer altitude boundaries; similar corrections made to Section 5.0 Tables 2 and 3.

Typographical Conventions

Italics are used to specifically denote parameters identified from the input ATL09 backscatter profile data products or to be contained within the output weekly ATL16 or monthly ATL17 gridded atmosphere data products. For example: the *solar_elevation* parameter is obtained from the ATL09 product, and the *Data_type_flag* is written out to the ATL16 and ATL17 data products.

1 Introduction

The gridded atmosphere products consist of the level 3B products ATL16 and ATL17. ATL16 will be a weekly product and ATL17 will be generated monthly. The same atmospheric information will be on both products. The content of both products will include: global cloud fraction, total column optical depth over the oceans, polar cloud fraction, blowing snow frequency, apparent surface reflectivity, and ground detection frequency. The polar cloud fraction will be broken into 6 separate grids representing high, low, middle, transmissive, opaque and total cloud fraction for each hemisphere.

The HDF product files will contain the gridded fields of the above parameters as 2 dimensional arrays and also images of these fields plotted on a map of the respective region. ATL16 weekly products will be generated on a 2x2 degree grid and ATL17 monthly products on a 1x1 degree grid. Table 1 lists the various atmospheric parameters contained in the L3B products and the type of grid used for each. Also, we propose a control parameter read in from an ancillary file which will control whether both night and day data are included in the generation of the product or only night data. The night only data is determined from the ATL09 parameter *solar_elevation*. If it is less than 0.0, then it is considered night data. This control parameter will be on the product as parameter *Data_type_flag*. A value of 0 means to use both day and night data to generate the products, and 1 will mean to use only night data.

Table 1.

Atmospheric Variable	Type of Grid
Global Cloud Fraction	Global
Global Aerosol Fraction	Global
Total Column Optical Depth	Global
Polar Cloud Fraction	Polar
Blowing Snow Frequency	Polar
Apparent Surface Reflectivity	Global and Polar
Ground Detection Frequency	Global and Polar

2 Global and Polar Grids

For the gridded products presented here, we use simple rectangular grids at two resolutions: 1x1 degree grids for the monthly product and 2x2 degree grids for the weekly product. Some atmospheric fields are produced on a global grid while others are produced on a polar grid that covers only the area poleward of 60N or 60S. Global monthly grids (i,j) will be dimensioned at (360,180) and global weekly grids will be dimensioned at (180,90). The latitudes and longitudes of the grids will be on both products (see Tables 2 and 3).

Assuming longitude goes from -180 to 180 and the (i,j) indices start at (0,0), the global grid indices are computed from latitude/longitude coordinates as:

i = int(longitude+180.0), j = int(latitude+90.0) for the 1x1 degree grid

i = int(longitude/2.0+90.0), j = int(latitude/2.0+45.0) for the 2x2 degree grid

Polar monthly grids will be dimensioned at (360,30) and the polar weekly grids are dimensioned at (180,15). The northern polar grid indices are computed as:

i = int(longitude+180.0), j = int(90.0-latitude) for the 1x1 degree grid, where latitude is >= 60.0

i = int(longitude/2.0+90.0), j = int(45.0-latitude/2.0) for the 2x2 degree grid, where latitude is >= 60.0

The southern polar grid indices are computed as:

i = int(longitude+180.0), j = int(90.0+latitude) for the 1x1 degree grid, where latitude is <= -60.0

i = int(longitude/2.0+90.0), j = int(45.0+latitude/2.0) for the 2x2 degree grid, where latitude is <= -60.0

3 Product Definitions

3.1 Global Cloud Fraction

This atmospheric parameter is displayed on a global grid. Define a "cloud counter grid" and an "observation grid". The ATL09 product contains the parameter "*cloud_flag_atm*" which is the number

of layers detected for a given 25 Hz profile. When this parameter is > 0 AND the parameter *layer_attr* = 1 for any layer (i.e., 1=cloud layer attribute), the cloud counter grid box associated with the current location (i,j) indices (computed as in Section 2 above) is incremented for that grid box. The total observation count grid box is incremented for every 25 Hz profile regardless of the value of the product parameter *cloud_flag_atm*. After reading the input ATL09 files for the period in question, the cloud counter grid is divided by the total observation grid to obtain a global grid of cloud fraction. For cases where the number of observations for a grid box is less than *week_obs_minimum* (ATL16) or *month_obs_minimum* (ATL17), set the cloud fraction to invalid. NOTE that the title of the image made from these data is now "Global Cloud and Aerosol Layer Fraction" and must be changed to "Global Cloud Fraction" after the above changes are made. NOTE that the "cloud counter grid" is incremented only once regardless of the number of cloud layers detected after the first determined cloud layer.

3.1.1 Global Aerosol Fraction

This atmospheric parameter is displayed on a global grid. Define an "aerosol counter grid" and an "observation grid". The ATL09 product contains the parameter "*cloud_flag_atm*" which is the number of layers detected for a given 25 Hz profile. When this parameter is > 0 AND the parameter *layer_attr* = 2 for any layer (i.e., 2=aerosol layer attribute), the aerosol counter grid box associated with the current location (i,j) indices (computed as in Section 2 above) is incremented for that grid box. Note that when *cloud_flag_atm* > 1, the *layer_attr* flag must be checked for each of the layers. If any one of them is equal to 2, then the aerosol counter is incremented. The total observation count grid box is incremented for every 25 Hz profile regardless of the value of the product parameter *cloud_flag_atm or layer_attr*. After reading the input ATL09 files for the period in question, the aerosol counter grid is divided by the total observation grid to obtain a global grid of aerosol fraction. For cases where the number of observations for a grid box is less than *week_obs_minimum* (ATL16) or *month_obs_minimum* (ATL17), set the aerosol fraction to invalid. The title of the image made for from these data is "Global Aerosol Fraction". NOTE that the "aerosol counter grid" is incremented only once regardless of the number of aerosol layers detected after the first determined aerosol layer.

3.2 Total Column Optical Depth

On the ATL09 product is a parameter called *column_od_asr* which is the total column optical depth estimated from the apparent surface reflectance. This parameter is computed over the entire globe, but for this product we only want to grid the data over the ocean. Global grids are established as in Section 3.1 above. If the total column optical depth is not invalid (i.e., it will be invalid when there is no ground return detected), and if we are over a water surface (i.e., if the ATL09 product parameter *column_od_asr_qf* is = 4, then we are over water), then it (i.e., *column_od_asr*) is added to the grid box corresponding to the current location (i,j) indices (value computed as in section 2 above), and the corresponding counter grid box is incremented. After all of the ATL09 granules have been read in, the total column optical depth grid is divided by the counter grid (where the counter grid is > 0) to establish the average total column optical depth over the oceans for the period in question. As in Section 3.1, the low-resolution grid (i.e., 2x2 degree) is used for the weekly product and the high-resolution grid (i.e., 1x1 degree) for the monthly product. For cases where the number of observations for a grid box is less than *week_obs_minimum* (ATL16) or *month_obs_minimum* (ATL17), set the average total column optical depth to invalid. NOTE that the 0 to 1.5 range constraint is applied to the image and not to the parameter gridded array values.

3.3 Polar Cloud Fraction

3.3.1 High, Middle, Low and Total Cloud Fraction

For each observation period (weekly/monthly) eight separate polar grids are established that cover the latitude range 60N to 90N and 60S to 90S. For the polar regions, we want to create four cloud fraction grids for each hemisphere. Grid 1 will contain the fraction of clouds that occur below and up to and including 4 km altitude. Grid 2 will contain the cloud fraction for clouds above 4 km and up to and including 8 km. Grid 3 will contain the cloud fraction for clouds that occur above 8 km. Grid 4 will represent total cloud fraction. So, there are 4 grids for each polar region (4 North and 4 South). The grids are populated in the same way as described in section 3.1, except segregated by altitude of the cloud layer top. NOTE that *layer_attr* has to be equal to 1 for the layer to be a cloud. The top height of the layers is contained in the ATL09 parameter "*layer_top*", which is dimensioned at 10 but the elements of *layer_top* will only be defined up to the number of layers found. The number of layers found is stored in the ATL09 parameter *cloud_flag_atm*. Thus, if *cloud_flag_atm* is = 0, that would mean that there were no clouds found in this profile. We want to look at *layer_top*(1) up to *layer_top*(*cloud_flag_atm*) to obtain the top heights of the various cloud layers.

Assuming *cloud_flag_atm* is > 0, then for each value of x from 1 to *cloud_flag_atm*:

   If any *layer_top(x)* is <= 4 km AND *layer_attr* = 1, then increment the counter for Grid 1.
   If any *layer_top(x)* is > 4 km and <= 8 km AND *layer_attr* = 1, then increment the counter for Grid 2.
   If any *layer_top(x)* is > 8 km AND *layer_attr* = 1, then increment the counter for Grid 3.
   If *cloud_flag_atm is > 0* AND *layer_attr* = 1 for any layer, then increment the counter for Grid 4.
Note that each of the 4 counter grids are to be incremented (at most) only once per 25 Hz profile. Meaning if there are two cloud layers between say 4 and 8 km, the counter Grid 2 is incremented only once, not twice.

A separate observation counter grid is established and the appropriate grid box is incremented for every 25 Hz profile regardless of the value of the value of *cloud_flag_atm*. All four grids are then divided by the total observation grid (where it is > 0) to obtain the various cloud fractions (4 cloud fractions for each hemisphere). For cases where the number of observations for a grid box is less than *week_obs_minimum* (ATL16) or *month_obs_minimum* (ATL17), set the cloud fraction to invalid.

3.3.2 Transmissive and Opaque Cloud Fraction

Four polar grids are established, 2 for each hemisphere. As in Section 3.3.1, the grids will cover the latitudes 60N to 90N and 60S to 90S. The ATL09 product contains the parameter "*cloud_flag_atm*" which is the number of cloud layers detected for a given 25 Hz profile. When this parameter is > 0, AND the ATL09 parameter "*Surface_sig*" is > 0 AND "*layer_attr*" = 1 for any layer, then the current grid box for the transmissive cloud grid is incremented. When the parameter "*cloud_flag_atm*" is > 0 AND the parameter "*surface_sig*" is = 0 AND "*layer_attr*" = 1, then the current grid box for the opaque cloud grid is incremented. As before, for each observation (25 Hz profile) the current observation grid box is incremented. When the period in question (weekly/monthly) has been analyzed, divide the transmissive and opaque cloud grids by the observation grid (for all observation grid boxes > 0). For

cases where the number of observations for a grid box is less than *week_obs_minimum* (ATL16) or *month_obs_minimum* (ATL17), set the cloud fraction to invalid.

3.4 Blowing Snow Frequency

On the ATL09 product is the parameter *bsnow_h* at both high-rate (i.e., 25 Hz) and low-rate (i.e., 1 Hz). To create the blowing snow frequency we will use the low-rate (1 second) blowing snow height. An observation grid and a detection grid are set up to cover the polar regions (poleward of 60 degrees North and South). *bsnow_h* will only be > 0 (and not invalid) when there is a detected blowing snow layer. Thus, when the latitude is poleward of 60N or 60S and whenever *bsnow_h* > 0 (and not invalid), increment the grid box of the detection grid corresponding to the current latitude/longitude. If *bsnow_con* is greater than or equal to -2 (but not invalid), then increment the observation grid box of the current location. After all ATL09 files for the period in question have been processed in this way, the blowing snow frequency grid is obtained by dividing the detection grid by the observation grid for all observation grid boxes where the number of observations is >= *week_obs_minimum* (ATL16) or *month_obs_minimum* (ATL17), and multiply by 100 to obtain percent. For cases where the number of observations for a grid box is less than *week_obs_minimum* (ATL16) or *month_obs_minimum* (ATL17), set the blowing snow frequency to invalid. Note that blowing snow frequency is the only parameter with units of percent.

3.5 Apparent Surface Reflectivity (ASR)

Apparent Surface Reflectivity (ASR) represents the true surface reflectivity modified by the two-way atmospheric transmission. It will generally be a number between 0 and 1. ASR is related to the ratio of the received energy to the transmitted energy and assumes a Lambertian surface reflectance. North and South Polar grids and a global grid are established (each one at 2x2 degree resolution for the weekly product and one at 1x1 degree resolution for the monthly product). The parameter *apparent_surf_reflec* on ATL09 will have a value of 0.0 unless there was a signal detected from the surface. When the latitude is poleward of 60N or 60S and the parameter *apparent_surf_reflec* is greater than 0.0, it (i.e., *apparent_surf_reflec*) is added to the ASR grid box at the current location and the corresponding observation grid box is incremented. If the ASR is equal to 0.0, do nothing. After the period in question has been processed, the ASR grid is divided by the observation grid to get the average ASR. For cases where the number of observations for a grid box is less than *week_obs_minimum* (ATL16) or *month_obs_minimum* (ATL17), set the ASR to invalid.

3.6 Ground Detection Frequency

For ground detection frequency, the ATL09 high-rate parameter *surface_sig* should be used. This will be 0.0 unless the surface signal was detected. North and South Polar grids and a global grid are set up as in Section 3.3 above, and when *surface_sig* is > 0.0, the surface signal grid box at the current location is incremented. The corresponding observation grid box is incremented regardless of the value of *surface_sig*. After the period in question has been processed, the ground detection frequency is calculated by dividing the surface signal grid by the observation grid for non-zero values of the observation grid. For cases where the number of observations for a grid box is less than

7

week_obs_minimum (ATL16) or *month_obs_minimum* (ATL17), set the ground detection frequency to invalid.

3.7 Images of Gridded Fields

Included on both products will be images of selected atmospheric variables. A map will be drawn on top of the image showing continental and country boundaries. Polar stereographic projection is used for the polar plots and equirectangular projection for the global images. The images can be either jpeg or png format. See the bottom of Tables 2 and 3 for a list of images to be included on the product. NOTE that the list of images contained in Tables 2 and 3 is not meant to be definitive. It is acceptable if images of other data fields are included.

3.8 Minimum Number of Observations for Each Grid Box

In the computation of the various data fields, the data are divided by the number of observations in each grid box. For this ATBD version, we introduce two new control parameters called week_*obs_minimum* and *month_obs_minimum*. If the number of observations for a given grid box is less than week_*obs_minimum* for ATL16, then the value of that grid box is set to invalid. It would be as if there were no observations at all for that grid box. If the number of observations is less than month_*obs_minimum* for ATL17, then the value of that grid box is set to invalid. The nominal values for these parameters are: *week_obs_minimum* = 2 and *month_obs_minimum* = 4.

3.9 Observations Grids

For version 2.1 of this ATBD we add to the products the following 5 observation grids:

North Polar Blowing Snow Frequency – new parameter *NPolar_bsnow_obs_grid*
South Polar Blowing Snow Frequency – new parameter *SPolar_bsnow_obs_grid*
Global ASR – new parameter *ASR_obs_grid*
Global Total Column Optical Depth - *TCOD_obs_grid*
Global - *Global_cloud_aerosol_obs_grid*

4.0 Smoothing of Images

For version 2.0 of this ATBD, we introduce two control parameters called *smooth_grid* and *center_weight*. If *smooth_grid* is equal to 1, then it means to apply the smoothing algorithm below to only the weekly product (ATL16) images. If *smooth_grid* = 2, then it means to apply the smoothing algorithm to only the monthly product (ATL17) images. If *smooth_grid* = 3, then the smoothing algorithm will be applied to both ATL16 and ATL17 images. When it is equal to zero, no smoothing will be applied to either product. NOTE that the smoothing algorithm is to be applied only to the data to produce the images and not to the gridded data fields that are written to the products. The nominal value of *smooth_grid* is 1. *center_weight* is a real value from 0.0 to 1.0 with a nominal value of 0.6. The below algorithm shall be used in the smoothing of the gridded data fields.

Smoothing shall be applied in the following manner. Let imax be the number of longitude points in a given grid and jmax the number of latitude points. Let the addressing indices go from 1 to imax (i.e., not

0 to imax-1) and let Grid represent a gridded data parameter. The grid may contain invalid or missing data.

```
smooth_grid(*,*) = invalid

for j=2,jmax-1 do begin
 for i=2,imax-1 do begin
   cnt = 0.0
   sum = 0.0
   for ii=i-1,i+1 do begin
    for jj=j-1,j+1 do begin
     if (jj ne j or ii ne i) then begin
       if (grid(ii,jj) ne invalid) then begin
          cnt++
          sum = sum + Grid(ii,jj)
       endif
     endif
    endfor
   endfor
   avg = 0.0
   if (cnt gt 0.0) then avg = sum / cnt
   pix = 0.0
   weight = 0.0
   if (grid(i,j) ne invalid) then begin
     weight = center_weight
     pix = Grid(i,j)*weight
   endif
   spix = avg * (1.0 – weight) + pix
   if (spix ne 0.0) then smooth_grid(i,j) = spix
 endfor
endfor

for i=1,imax do begin
 if (Grid(i,1) ne invalid and Grid(i,2) ne invalid) then smooth_grid(i,1) = (Grid(i,1) + Grid(i,2)) / 2.0
 if (Grid(i,jmax-1) ne invalid and Grid(i,jmax) ne invalid) then smooth_grid(i,jmax) = (Grid(i,jmax-1) +
   Grid(i,jmax)) / 2.0
endfor
for j=1,jmax do begin
 if (Grid(1,j) ne invalid and Grid(2,j) ne invalid) then  smooth_grid(1,j) = (Grid(1,j) + Grid(2,j)) / 2.0
 if (Grid(imax,j) ne invalid and Grid(imax-1,j) ne invalid) then smooth_grid(imax,j) = (Grid(Imax-1,j) +
   Grid(Imax,j)) / 2.0
endfor
```

5.0 Product Formats

As mention in section 1, ATL16 and ATL17 contain the same gridded atmospheric variables. The only difference between the products is the resolution of the grids and the frequency that they will be produced. ATL16 will be produced weekly and contain the gridded variables on a 2x2 degree grid. ATL17 will be produced monthly and will contain 1x1 degree gridded variables. Tables 2 and 3 list the products for ATL16 and ATL17, respectively.

Table 2. ATL16 Product List – frequency 1 per week

Parameter	Type/Dimension	Units	Description
Start_time	double precision	seconds since 2018-01-01	start time/date of data used to make product
End_time	double precision	seconds since 2018-01-01	end time/date of data used to make product
Data_type_flag	integer	0,1	tells whether night only data was used to make product. 0=no, 1=yes
Data_QA_flag	integer		TBD
NPolar_grid_lat	float (15)	degrees	latitudes of North Polar grid
SPolar_grid_lat	float (15)	degrees	latitudes of South Polar grid
NPolar_grid_lon	float (180)	degrees	longitudes of North Polar grid
SPolar_grid_lon	float(180)	degrees	longitudes of South Polar grid
Global_grid_lat	float (90)	degrees	latitudes of Global grid
Global_grid_lon	float (180)	degrees	longitudes of Global grid
NPolar_bsnow_obs_grid	float(180,15)	NA	The number of blowing snow observations used in the computation of blowing snow frequency for Arctic
SPolar_bsnow_obs_grid	float(180,15)	NA	The number of blowing snow observations used in the computation of blowing snow frequency for Antarctic
ASR_obs_grid	float(180,90)	NA	The number of observations used to compute the average Global Apparent Surface Reflectance (ASR)
TCOD_obs_grid	float(180,90)	NA	The number of observations used to compute the average Global total column optical depth
Global_cloud_aerosol_obs_grid	float(180,90)	NA	The number of observations used to compute the average Global cloud and aerosol fraction

Parameter	Type/Dimension	Units	Description
Global_cloud_frac	float (180,90)	fraction	Global cloud fraction
Global_aerosol_frac	float (180,90)	fraction	Global aerosol fraction
Global_column_od	float (180,90)	unitless	Global (over ocean) total column optical depth
NPolar_lowcloud_frac	float (180,15)	fraction	North Polar low (<= 4 km) cloud fraction
SPolar_lowcloud_frac	float (180,15)	fraction	South Polar low (<= 4 km) cloud fraction
NPolar_midcloud_frac	float (180,15)	fraction	North Polar mid (> 4 km and <= 8 km) cloud fraction
SPolar_midcloud_frac	float (180,15)	fraction	South Polar mid (> 4 km and <= 8 km) cloud fraction
NPolar_highcloud_frac	float (180,15)	fraction	North Polar high (> 8 km) cloud fraction
SPolar_highcloud_frac	float (180,15)	fraction	South Polar high (> 8 km) cloud fraction
NPolar_totalcloud_frac	float (180,15)	fraction	North Polar total cloud fraction
SPolar_totalcloud_frac	float (180,15)	fraction	South Polar total cloud fraction
NPolar_transcloud_frac	float (180,15)	fraction	North Polar transmissive cloud fraction
SPolar_transcloud_frac	float (180,15)	fraction	South Polar transmissive cloud fraction
NPolar_opaquecloud_frac	float (180,15)	fraction	North Polar opaque cloud fraction
SPolar_opaquecloud_frac	float (180,15)	fraction	South Polar opaque cloud fraction
NPolar_blowing_snow_freq	float (180,15)	percent	Blowing snow frequency for the northern hemisphere polar region
SPolar_blowing_snow_freq	float (180,15)	percent	Blowing snow frequency for the southern hemisphere polar region
NPolar_ASR	float (180,15)	0 - 1	North Polar Apparent Surface Reflectance
SPolar_ASR	float (180,15)	0 - 1	South Polar Apparent Surface Reflectance
Global_ASR	float (180,90)	0 - 1	Global Apparent Surface Reflectance
NPolar_grnd_detect	float (180,15)	fraction	North Polar ground detection frequency
SPolar_grnd_detect	float (180,15)	fraction	South Polar ground detection frequency
Global_grnd_detect	float (180,90)	fraction	Global ground detection frequency

Parameter	Type/Dimension	Units	Description
NPolar_totalcloud_frac.png	image	fraction	North Polar Total Cloud Fraction
SPolar_totalcloud_frac.png	image	fraction	South Polar Total Cloud Fraction
Global_cloud_frac.png	image	fraction	Global Cloud Fraction
Global_column_od.png	image	0 - 1.5	Global Total Column Optical Depth (0-1.5)
NPolar_grnd_detect.png	image	fraction	North Polar Ground Detection Frequency (fraction)
SPolar_grnd_detect.png	image	fraction	South Polar Ground Detection Frequency (fraction)
NPolar_blowing_snow_freq.png	image	percent	North Polar Blowing Snow Frequency (percent)
SPolar_blowing_snow_freq.png	image	percent	South Polar Blowing Snow Frequency (percent)
NPolar_ASR.png	image	0 - 1	North Polar Apparent Surface Reflectance (0-1)
SPolar_ASR.png	image	0 - 1	South Polar Apparent Surface Reflectance (0-1)
Global_ASR.png	image	0 - 1	Global Apparent Surface Reflectance (0-1)
Global_aerosol_frac.png	image	fraction	Global Aerosol Fraction
NPolar_lowcloud_frac.png	image	fraction	North Polar Low Cloud Fraction ($\leq$ 4km)
SPolar_lowcloud_frac.png	image	fraction	South Polar Low Cloud Fraction ($\leq$ 4km)
NPolar_midcloud_frac.png	image	fraction	North Polar Mid Cloud Fraction (> 4km and $\leq$ 8km)
SPolar_midcloud_frac.png	image	fraction	South Polar Mid Cloud Fraction (> 4km and $\leq$ 8km)
NPolar_highcloud_frac.png	image	fraction	North Polar High Cloud Fraction (> 8km)
SPolar_highcloud_frac.png	image	fraction	South Polar High Cloud Fraction (> 8km)
NPolar_transcloud_frac.png	image	fraction	North Polar Transmissive Cloud Fraction
SPolar_transcloud_frac.png	image	fraction	South Polar Transmissive Cloud Fraction
NPolar_opaquecloud_frac.png	image	fraction	North Polar Opaque Cloud Fraction
SPolar_opaquecloud_frac.png	image	fraction	South Polar Opaque Cloud Fraction
Global_grnd_detect.png	image	fraction	Global Ground Detection Frequency (fraction)

NOTE: for the images the Description field contains the label for the projection graphic.

Table 3. ATL17 Product List – frequency 1 per month

Parameter	Type/Dimension	Units	Description
Start_time	double precision	seconds since 2018-01-01	start time/date of data used to make product
End_time	double precision	seconds since 2018-01-01	end time/date of data used to make product
Data_type_flag	integer	0,1	tells whether night only data was used to make product. 0=no, 1=yes
Data_QA_flag	integer		TBD
NPolar_grid_lat	float (30)	degrees	latitudes of North Polar grid
SPolar_grid_lat	float (30)	degrees	latitudes of South Polar grid
NPolar_grid_lon	float (360)	degrees	longitudes of North Polar grid
SPolar_grid_lon	float(360)	degrees	longitudes of South Polar grid
Global_grid_lat	float (180)	degrees	latitudes of Global grid
Global_grid_lon	float (360)	degrees	longitudes of Global grid
NPolar_bsnow_obs_grid	float(360,30)	NA	The number of blowing snow observations used in the computation of blowing snow frequency for Arctic
SPolar_bsnow_obs_grid	float(360,30)	NA	The number of blowing snow observations used in the computation of blowing snow frequency for Antarctic
ASR_obs_grid	float(360,180)	NA	The number of observations used to compute the average Global Apparent Surface Reflectance (ASR)
TCOD_obs_grid	float(360,180)	NA	The number of observations used to compute the average Global total column optical depth
Global_cloud_aerosol_obs_grid	Float(360,180)	NA	The number of observations used to compute the average Global cloud and aerosol fraction
Global_cloud_frac	float (360,180)	fraction	Global cloud fraction
Global_aerosol_frac	float (360,180)	fraction	Global aerosol fraction
Global_column_od	float (360,180)	unitless	Global (over ocean) total column optical depth
NPolar_lowcloud_frac	float (360,30)	fraction	North Polar low (<= 4 km) cloud fraction

Parameter	Type/Dimension	Units	Description
SPolar_lowcloud_frac	float (360,30)	fraction	South Polar low (<= 4 km) cloud fraction
NPolar_midcloud_frac	float (360,30)	fraction	North Polar mid (> 4 km and <= 8 km) cloud fraction
SPolar_midcloud_frac	float (360,30)	fraction	South Polar mid (> 4 km and <= 8 km) cloud fraction
NPolar_highcloud_frac	float (360,30)	fraction	North Polar high (> 8 km) cloud fraction
SPolar_highcloud_frac	float (360,30)	fraction	South Polar high (> 8 km) cloud fraction
NPolar_totalcloud_frac	float (360,30)	fraction	North Polar total cloud fraction
SPolar_totalcloud_frac	float (360,30)	fraction	South Polar total cloud fraction
NPolar_transcloud_frac	float (360,30)	fraction	North Polar transmissive cloud fraction
SPolar_transcloud_frac	float (360,30)	fraction	South Polar transmissive cloud fraction
NPolar_opaquecloud_frac	float (360,30)	fraction	North Polar opaque cloud fraction
SPolar_opaquecloud_frac	float (360,30)	fraction	South Polar opaque cloud fraction
NPolar_blowing_snow_freq	float (360,30)	percent	blowing snow frequency for the northern hemisphere polar region
SPolar_blowing_snow_freq	float (360,30)	percent	blowing snow frequency for the southern hemisphere polar region
NPolar_ASR	float (360,30)	0 - 1	North Polar Apparent Surface Reflectance
SPolar_ASR	float (360,30)	0 - 1	South Polar Apparent Surface Reflectance
Global_ASR	float (360,180)	0 - 1	Global Apparent Surface Reflectance
NPolar_grnd_detect	float (360,30)	fraction	North Polar ground detection frequency
SPolar_grnd_detect	float (360,30)	fraction	South Polar ground detection frequency
Global_grnd_detect	float (360,180)	fraction	Global ground detection frequency
NPolar_totalcloud_frac.png	image	fraction	North Polar Total Cloud Fraction
SPolar_totalcloud_frac.png	image	fraction	South Polar Total Cloud Fraction
Global_cloud_frac.png	image	fraction	Global Cloud Fraction
Global_aerosol_frac.png	image	fraction	Global Aerosol Fraction
Global_column_od.png	image	0 - 1.5	Global Total Column Optical Depth (0-1.5)

Parameter	Type/Dimension	Units	Description
NPolar_grnd_detect.png	image	fraction	North Polar Ground Detection Frequency (fraction)
SPolar_grnd_detect.png	image	fraction	South Polar Ground Detection Frequency (fraction)
NPolar_blowing_snow_freq.png	image	percent	North Polar Blowing Snow Frequency (percent)
SPolar_blowing_snow_freq.png	image	percent	South Polar Blowing Snow Frequency (percent)
NPolar_ASR.png	image	0 - 1	North Polar Apparent Surface Reflectance (0-1)
SPolar_ASR.png	image	0 - 1	South Polar Apparent Surface Reflectance (0-1)
Global_ASR.png	image	0 - 1	Global Apparent Surface Reflectance (0-1)
NPolar_lowcloud_frac.png	image	fraction	North Polar Low Cloud Fraction (<= 4km)
SPolar_lowcloud_frac.png	image	fraction	South Polar Low Cloud Fraction (<= 4km)
NPolar_midcloud_frac.png	image	fraction	North Polar Mid Cloud Fraction (> 4km and <= 8km)
SPolar_midcloud_frac.png	image	fraction	South Polar Mid Cloud Fraction (> 4km and <= 8km)
NPolar_highcloud_frac.png	image	fraction	North Polar High Cloud Fraction (> 8km)
SPolar_highcloud_frac.png	image	fraction	South Polar High Cloud Fraction (> 8km)
NPolar_transcloud_frac.png	image	fraction	North Polar Transmissive Cloud Fraction
SPolar_transcloud_frac.png	image	fraction	South Polar Transmissive Cloud Fraction
NPolar_opaquecloud_frac.png	image	fraction	North Polar Opaque Cloud Fraction
SPolar_opaquecloud_frac.png	image	fraction	South Polar Opaque Cloud Fraction
Global_grnd_detect.png	image	fraction	Global Ground Detection Frequency (fraction)

NOTE: for the images the Description field contains the label for the projection graphic.

6.0 Product Production Considerations

List of ATBD Lead suggestions regarding the date/time span for production of atmosphere gridded data products:

- the monthly product will begin on the first day of the month;

- the monthly data product will end on the last day of the month;
- the first weekly data product within the month will begin on the first day of the month, end on the seventh day of the month, and contain seven days;
- the second weekly data product within the month will begin on the eighth day of the month, end on the fourteenth day of the month, and contain seven days;
- the third weekly data product within the month will begin on the fifteenth day of the month, end on the twenty-first day of the month, and contain seven days;
- the fourth weekly data product within the month will begin on the twenty-second day of the month, end on either the twenty-eighth, twenty-ninth, thirtieth, or thirty-first day of the month, and will contain either seven days, eight days, nine days, or ten days, respectively, depending on the calendar month and leap year.

The following tables supply the beginning and ending dates for the control file generation for production of monthly ATL17 and weekly ATL16 gridded atmosphere data products.

Monthly ATL17 Product File Content Control Information
(used to control the collection and specification of ATL09 files to compose the product)

Month	Beginning Date	Ending Date	Number of Days	Possible Number of Files (RGTs)
January	January 01	January 31	31	474
February	February 01	February 28	28	428
February (leap year)	February 01	February 29	29	443
March	March 01	March 31	31	474
April	April 01	April 30	30	459
May	May 01	May 31	31	474
June	June 01	June 30	30	459
July	July 01	July 31	31	474
August	August 01	August 31	31	474
September	September 01	September 30	30	459
October	October 01	October 31	31	474
November	November 01	November 30	30	459
December	December 01	December 31	31	474

Table 4. Monthly ATL17 Data Product ATL09 File Composition by Month

Weekly ATL16 Product File Content Control Information
(used to control the collection and specification of ATL09 files to compose the product)

Month	Week	Beginning Date	Ending Date	Number of Days	Possible Number of Files (RGTs)
January	01	January 01	January 07	07	107

Month	Week	Beginning Date	Ending Date	Number of Days	Possible Number of Files (RGTs)
January	02	January 08	January 14	07	107
January	03	January 15	January 21	07	107
January	04	January 22	January 31	10	153
February	01	February 01	February 07	07	107
February	02	February 08	February 14	07	107
February	03	February 15	February 21	07	107
February	04	February 22	February 28	07	107
February (leap year)	04	February 22	February 29	08	123
March	01	March 01	March 07	07	107
March	02	March 08	March 14	07	107
March	03	March 15	March 21	07	107
March	04	March 22	March 31	10	153
April	01	April 01	April 07	07	107
April	02	April 08	April 14	07	107
April	03	April 15	April 21	07	107
April	04	April 22	April 30	09	138
May	01	May 01	May 07	07	107
May	02	May 08	May 14	07	107
May	03	May 15	May 21	07	107
May	04	May 22	May 31	10	153
June	01	June 01	June 07	07	107
June	02	June 08	June 14	07	107
June	03	June 15	June 21	07	107
June	04	June 22	June 30	09	138
July	01	July 01	July 07	07	107
July	02	July 08	July 14	07	107
July	03	July 15	July 21	07	107
July	04	July 22	July 31	10	153
August	01	August 01	August 07	07	107
August	02	August 08	August 14	07	107
August	03	August 15	August 21	07	107
August	04	August 22	August 31	10	153
September	01	September 01	September 07	07	107
September	02	September 08	September 14	07	107
September	03	September 15	September 21	07	107
September	04	September 22	September 30	09	138
October	01	October 01	October 07	07	107
October	02	October 08	October 14	07	107
October	03	October 15	October 21	07	107
October	04	October 22	October 31	10	153
November	01	November 01	November 07	07	107

Month	Week	Beginning Date	Ending Date	Number of Days	Possible Number of Files (RGTs)
November	02	November 08	November 14	07	107
November	03	November 15	November 21	07	107
November	04	November 22	November 30	09	138
December	01	December 01	December 07	07	107
December	02	December 08	December 14	07	107
December	03	December 15	December 21	07	107
December	04	December 22	December 31	10	153

Table 5. Weekly ATL16 Data Product ATL09 File Composition by Month and Week