Software Design Document – Draft 1
LIDAR Pre-Level 1B files generation process

Feburary 24, 2012
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Introduction

It has been found that the assumption of low amount of aerosol in the current calibration region (30 – 34 km) is not valid in the tropics because it has been found significant amounts of aerosols can be presented up to 35 km. Therefore, it can lead to a significant error for calculating the 532 nm nighttime calibration coefficients in the tropics. Therefore a new approach is applied to the 532 nm nighttime calibration coefficient calculations;

1. The location of the baseline region will move higher than the current location (30 – 34 km). Based on SAGE II, the range from 36 to 39 km is almost complete absence of aerosols, so the new calibration region is set to 36 – 39 km.

2. To maintain the current calibration SNR at the new region is required to average over several consecutive nighttime granules, so the new procedure will use more than one orbit calibration coefficients to do smoothing.

Since the new proposed smoothing procedure requires more than one nighttime orbit of 532 nm calibration coefficients, the portion for the 532 nm nighttime calibration coefficient calculations is extracted out from the LIDAR Level 1B processing to become "preprocessing". Similarly, the 1064 calibration coefficient calculation is also changed to require more than one orbit data; therefore, the new LIDAR Level 1 processing is breaking into several PGEs:

1. Level 0 HDF files and Level 1A files generating
2. Pre-Level 1B files generating
3. 532 nm nighttime calibration coefficient calculation
4. 532 nm scattering ratio calculation (for daytime)
5. 1064 nm calibration scale factors calculation
6. Calibration averaging
7. Post-processing

This design document is for the Pre-Level 1B files generation PGE.

The Pre-Level 1B (PreL1B) files can be generated when the dynamic files such as ephemeris data files, attitude data files and Global Modeling and Assimilation Office (GMAO) meteorology files are available. The input data files for this PGE are the Level 1A (L1A) files that contain data directly extracted and converted from the Level 0 (L0) without waiting for any other dynamic input files. Once these dynamic input files are available, more information can be added into the L1A files and become PreL1B files. These PreL1B files are the main input files for the other processes.

The addition information includes the geolocation of field of view (FOV), altitude registration (altitude shift), spacecraft and sun information, viewing angles, and meteorology information. This process will produce two output granules; one for nighttime orbit and one for daytime orbit data.

Section 1 – The purpose of the LIDAR Pre-Level 1B files generation process

The purpose of the LIDAR Pre-Level 1B files generation PGE is adding information to L1A files that requires dynamic input files to calculate these parameters, such as ephemeris data files, attitude data files, and meteorology files. When these files are available, the PGE can perform the geolocation process to locate the FOV, satellite position, and sun position. The PGE can also get the DEM information to perform the altitude registration and can retrieve the surface information and meteorology data. All these are depended on the geolocation information.

For the nominal process, this PGE will generate two output files; one is for nighttime orbit, and the other is for the daytime orbit. The number of input L1A files will be three consecutive files to cover one orbit data. For expedited process, only one input L1A file is needed because the expedited Pre-L1B output file contains the same amount of data as one L1A file.

Section 2 – The high level entities of design

The top level of flow chart for this PGE is showed on the Figure 1.

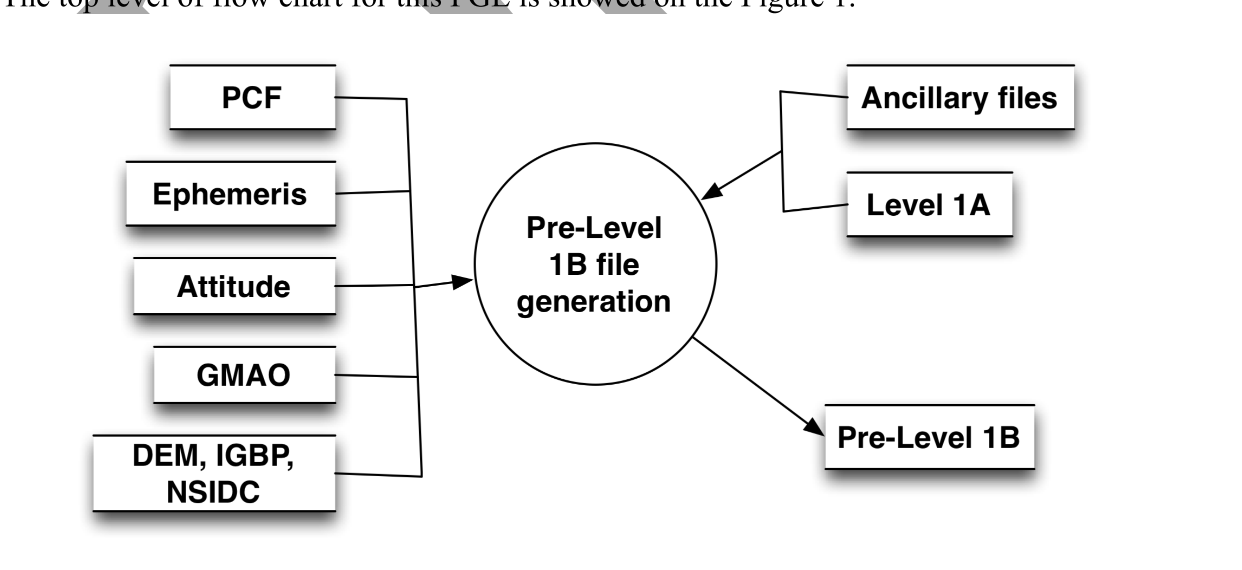

Figure 1 LIDAR Pre-Level 1B process

When the Level 1A files and all the dynamic data files that include ephemeris data file, attitude data file, and GMAO meteorology data file are arrived at DAAC, the CAPS can generate the PCF file that control the process and start the PGE to generate the Pre-L1B file. Other than the dynamic files, it also requires static input files that include the Level 1A correction coefficients, altitude registration input parameters, and SDP Toolkit Digital Elevation Model (DEM) files, International Geosphere Biosphere Programme (IGBP) Ecosystem surface type file, and National Snow and Ice Data (NSIDC) files. The flow chart for this PGE is shown in the Figure 2.

The procedure for this PGE starts with initializing the process with reading the runtime parameters from PCF file and coefficients from the ancillary files. The next step is opening the first L1A input file and starts reading data from the file. The first process is to get the geolocation information for the profile (FOV), the satellite, and the sun using the ephemeris and attitude data file. If this information can be obtained, it will perform the altitude registration process by using the DEM file to retrieve the mean sea level (MSL). Since the latitude and longitude of the FOV are available, the PGE can retrieve the surface types from the IGBP and NSIDC files. If the geolocation information can be obtained, the PGE will indicate it in the QC_Flag.

If the LIDAR mode and submode indicate this is a special operation packet such as polarization or boresight operation, this packet is written to a special operation output file; otherwise, the PGE continues to next step. If the packet contains the daytime data, the PGE will calculate the noise scale factor. The final step before writing to PreL1B file is to retrieve specified meteorology data from the GMAO files.

The PGE loops through all the data within one whole orbit to produce one nighttime orbit file and one daytime orbit file. Each L1A file contains 90 minutes data, so it may require two or three L1A input files to cover one whole orbit data (99 minutes) that it depends where the orbit starts in the first L1A file.

Before the PGE exiting, it calculates the average of the noise scale factors that calculated in the daytime orbit. This averaged noise scale factor will be used for the nighttime portion, as well as where this factor cannot be calculated in the daytime orbit.

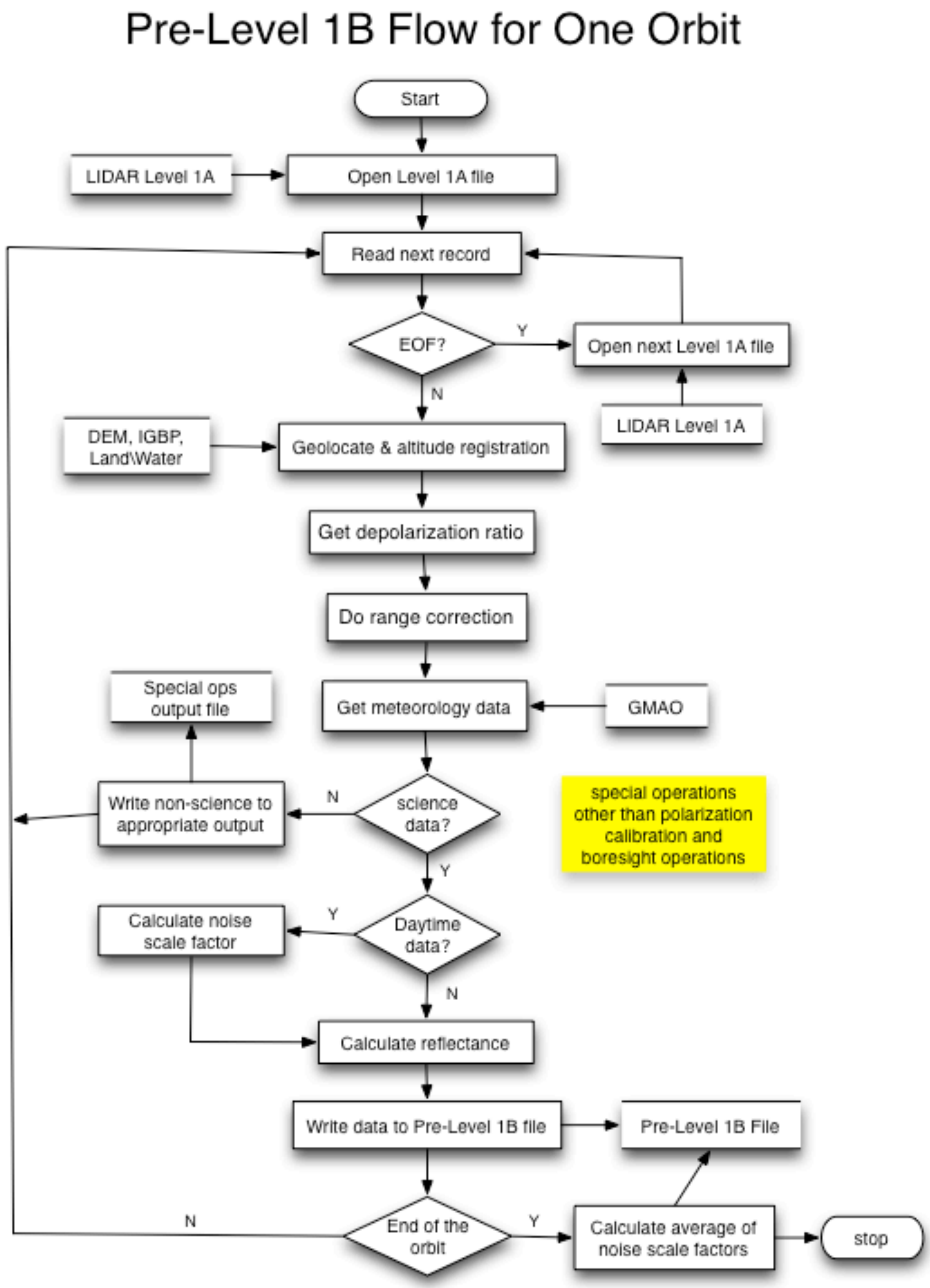

Figure 2 Generating Pre-L1B files flowchart

Section 3 – The low level entities of design

This PGE is part of the Version 3 LIDAR Level 1 process, so some of the codes from the current codes can be reused with some modification. Figure 3 shows the Version 3 LIDAR Level 1 processing. Comparing with the Figure 2, the PreL1B file process can reuse these modules:

1. LidarAltRegistration
2. LidarNoiseScaleFunction
3. LidarSatellite
4. calculateReflectance

The LidarAltRegistration module is for obtaining the geolocation information for the FOV, satellite, and sun and for performing the altitude registration. The LidarSatellite module is for obtaining the position and velocity vectors for satellite and sun. The LidarNoiseScaleFunction is for calculating the noise scale factor for the daytime data. The calculateReflectance is calculating the reflectance for both 532 nm channels.

A few more modules are added to retrieve the specified meteorolgy data from the GMAO data files, to retrieve depolarization ratio from history file, to do range correction to the raw data, and to write data to PreL1B output files.

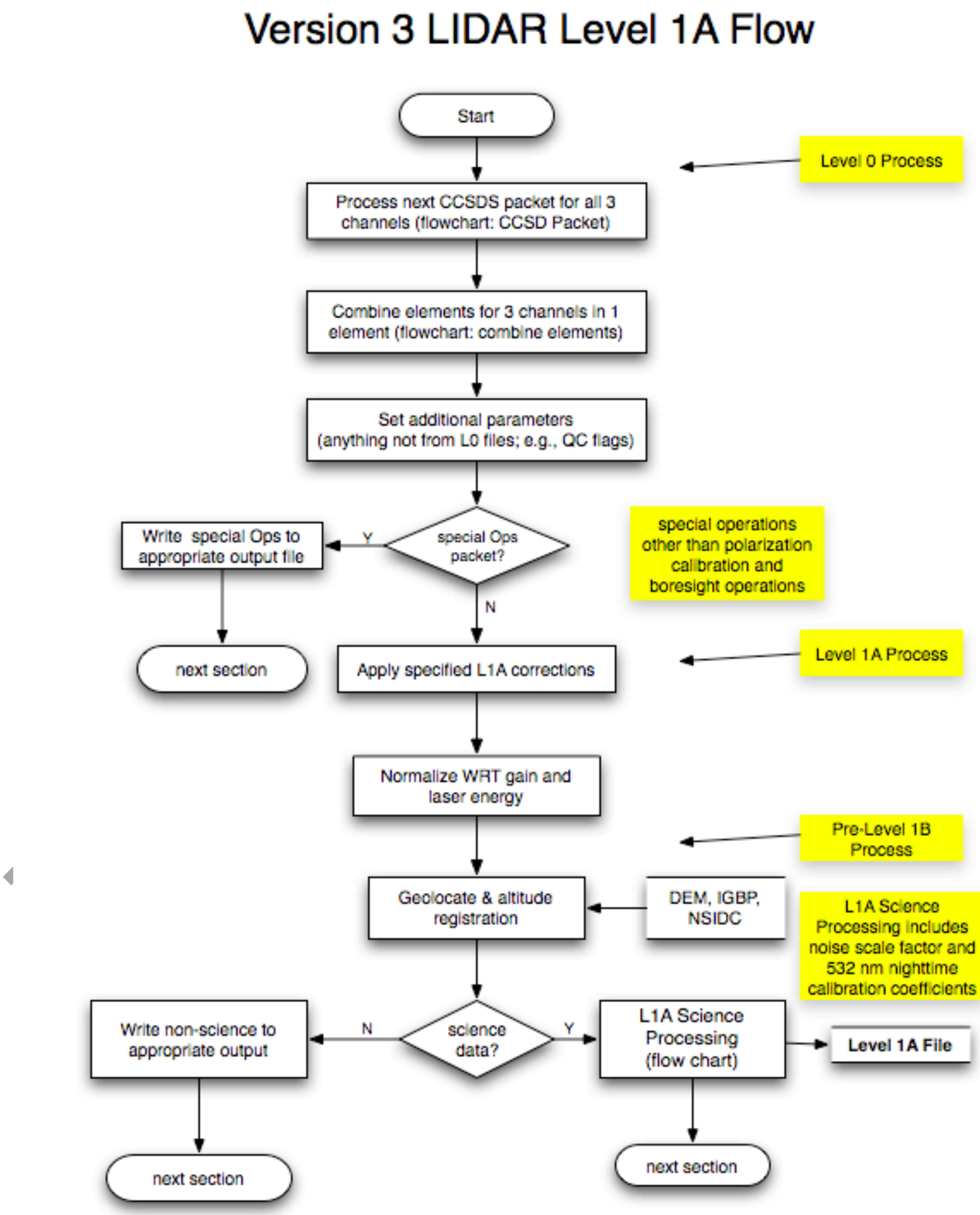

Figure 3 Version 3 LIDAR Level 1 processing

The following sections describe each of these modules.

3.1 LidarAltRegistration

This module is for obtaining the geolocation information for profile (FOV), satellite, and sun. If this information is available, it continues to calculate the off-nadir-angle, which is the angle between pointing vector and satellite location with respect to the subsatellite point. This module also calculates the viewing angles such as viewing azimuth angle, viewing zenith angle, solar azimuth angle, and solar zenith angle.

If the geolocation information is not available, all the geolocation parameters are set to fill values and return to calling function. If the information is available, the PGE will get the geoid height data from the DEM file and perform the altitude registration process. The procedure for this process starts with converting the downlink vertical resolution (583 bins) to uniform 30-meter bin resolution (1400 bins). Based on the off-nadir-angle and the delay time reported in the LIDAR_Receiver_Electronic_Status parameter, the new (actual) uniform 30-meter bins altitude array is calculated. The next step is to match based altitude with the fixed output altitude array. Once it finds the match, the PGE shifts the altitude array and data values. The last step is to reaverage the uniform 30-meter arrays back to the downlink vertical resolution arrays.

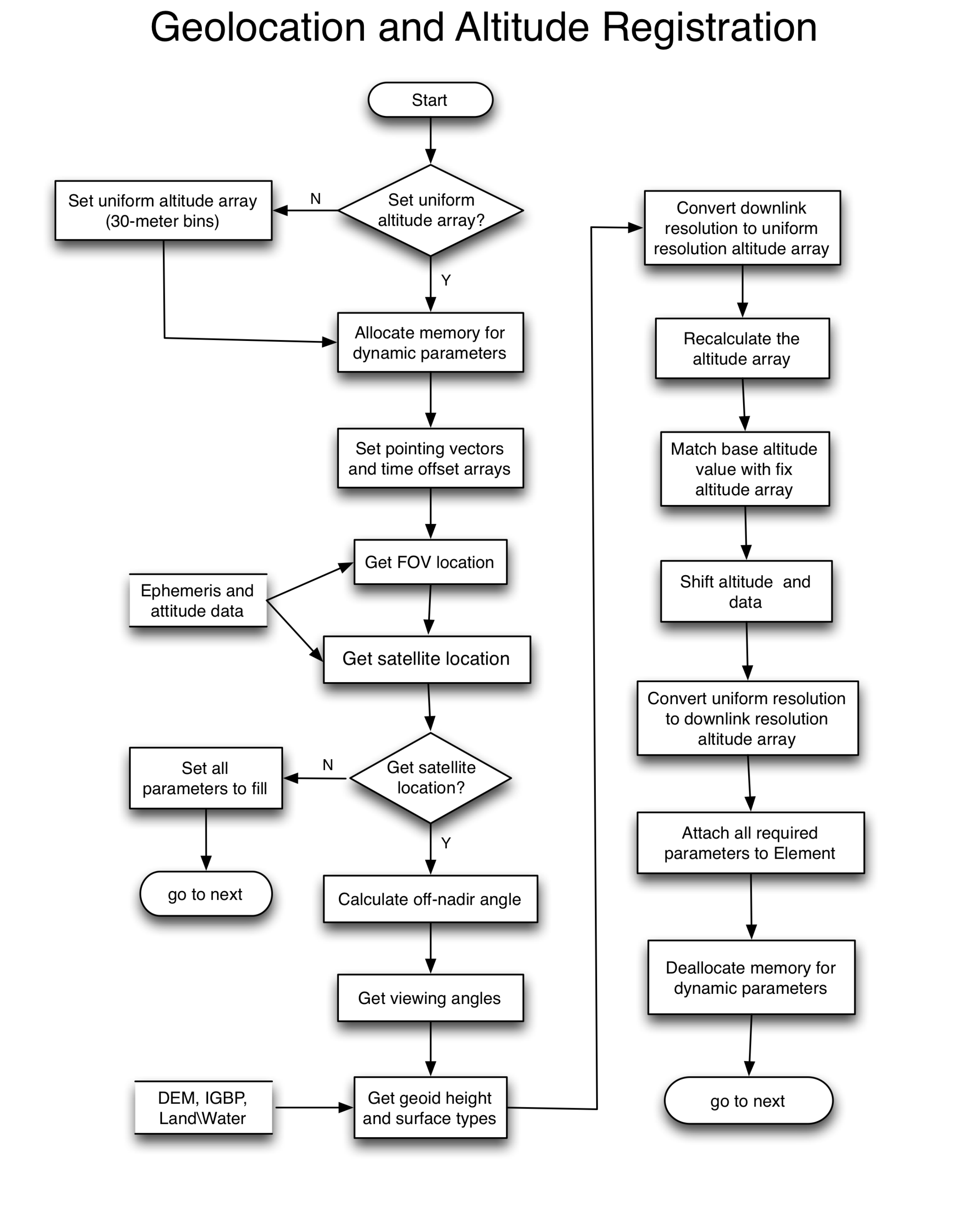

Figure 4 Flow chart for LidarAltRegistration

3.2 LidarNoiseScaleFunction

This module is to calculate the noise scale factor for the 532 nm parallel channel and 532 nm perpendicular channel data. Since the 1064 channel data does not include background energy monitor, which is required to calculate the noise scale factor, this factor will not be calculated for 1064 channel data. The flow chart for this module is shown in Figure 5.

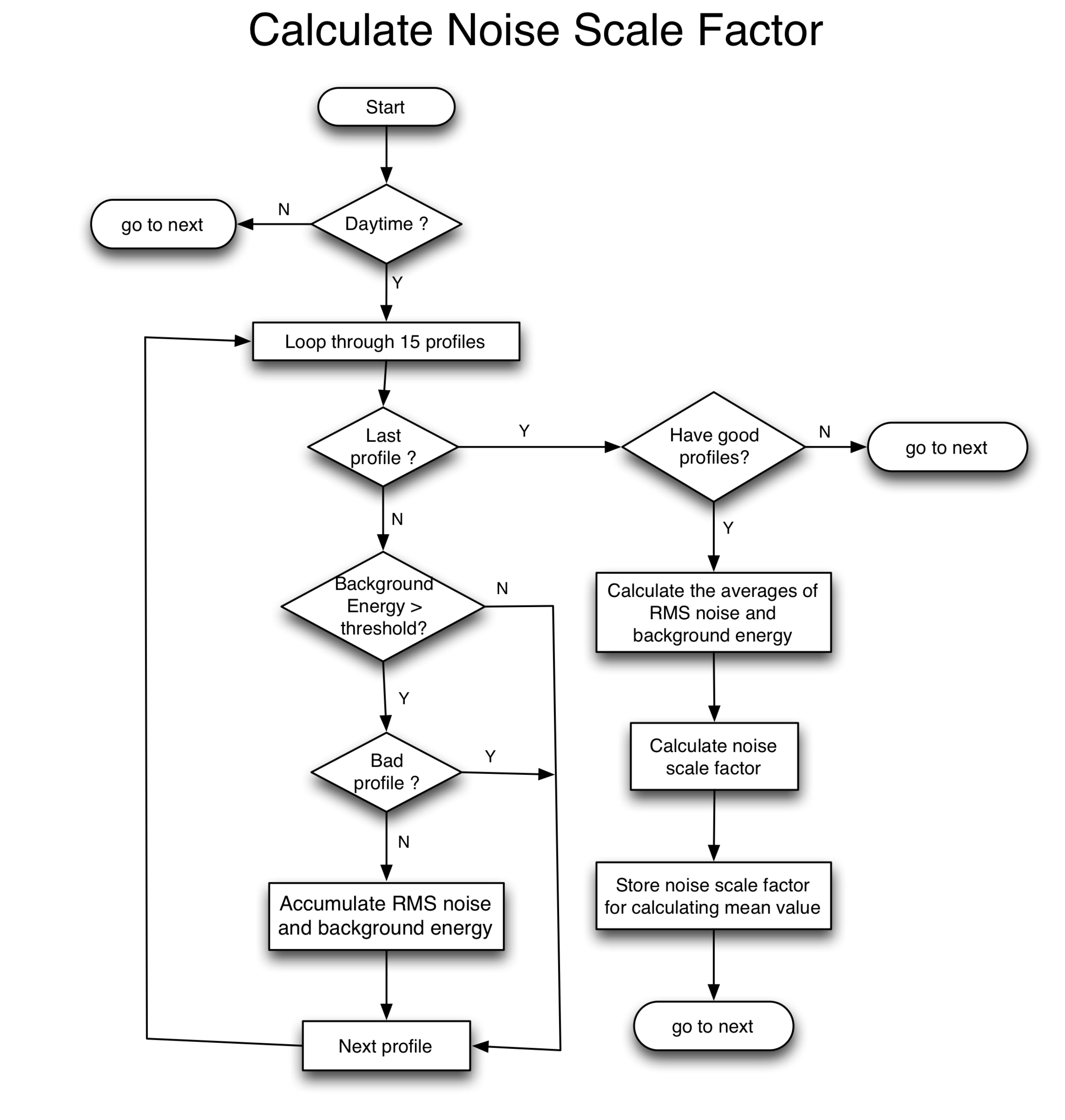

Figure 5 Flow chart of LidarNoiseScaleFunction module

The noise scale factor is calculated only for the daytime data, so the first check is to make sure the data are in daytime portion. When the instrument is set to daytime from nighttime, the background energy requires a period time to reach stable condition, so during this period, the noise scale factor is not calculated. One noise scale factor is calculated every 15 profiles (one major frame), it accumulates the sum of RMS noise and background energy for these 15 profiles and then it calculates the average of these values. The noise scale factor is calculated with these average values and stored in the memory. At the end of the daytime orbit, the mean value is calculated with these noise scale factor and is used for profiles in the nighttime orbit data and the profiles in the daytime orbit that are not calculated.

3.3 LidarSatellite

The LidarSatellite module retrieves the position and velocity vectors for the satellite and the location of the subsolar point. The module uses the SDP Toolkit functions to retrieve the subsatellite points (latitude, longitude, and altitude at the subsatellite point), the position and velocity of satellite in ECR coordinate systems, and the subsolar points (latitude, longitude, and earth to sun distance at the subsolar point). The flow chart of this module is shown in Figure 6.

3.4 calculateReflectance

This function is to calculate the bi-directional reflectances for both 532 nm channels. When the signal data are within the same range of Wide Field Camera (WFC), which is the Sun-Earth-Satellite angles from 290 to 70 degrees, the reflectances are calculated. For the data are not in this range, these reflectances are set to fill data.

3.5 setDepolarizationRatio

This function is to retrieve the depolarization ratio and its uncertainty from the depolarization ratio history file with the corresponding time.

3.6 doRangeCorrection

This function is to apply the range correction to the signal data. If the profile data can be geolocated, this function retrieves the off-nadir angle and range values to calculate the ranges from instrument to all altitude bins.

3.7 getMetdata

The getMetdata function uses the framework MetManager to retrieve meteorology data from the GMAO files. These meteorology data will be used for the other downstream processes.

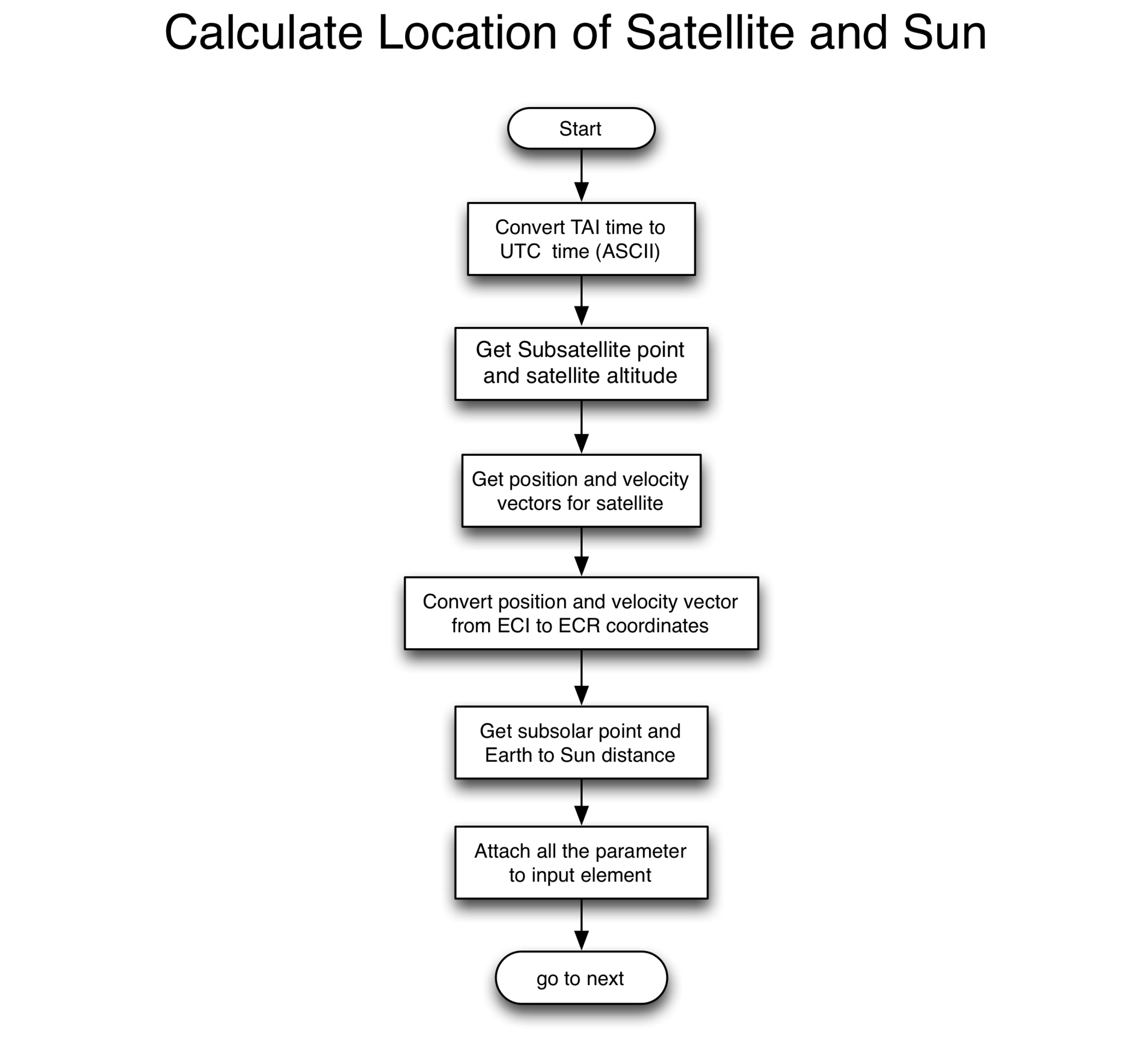

Figure 6 Flow chart for LidarSatellite module

3.8 outputOpsData

This function is to open the special operation output file (depolarization calibration data or boresight alignment data) when this kind of data is detected and write the special operation data to this output file.

3.9 updateNSFValues

This function is replaced NSF that is set to fill value in the output files. After all the data in the daytime orbit are processed, the average values of the NSF for 532 nm parallel and perpendicular are calculated. Then these two averaged values replace the NSF fill values in these two output files.

Section 4 – Input and Output records

The input files for this PGE are L1A files. The contents of these files are described in the "Requirements for generating LIDAR Level 0 (HDF) and Level 1A files process". It will not be given here. If one would like to get more information, he/she can review this document.

The contents of the Pre-L1B file show in Table 1 (Record) and Table 2 (File Metadata) (Note: the contents have not been confirmed yet):

Table 1: LIDAR Pre-Level 1B Record

Parameter Name	Data Type	Elem/Rec
LIDAR Profile Science Record		
Profile_Time (TAI time)	Float_64	1
Profile_UTC_Time (yyyymmdd.ffffff)	Float_64	1
Profile_Elapsed_Time*	Float_64	1
Profile_ID	Int_32	1
Land_Water_Mask	Int_8	1
IGBP_Surface_Type	Int_8	1
Day_Night_Flag	Int_8	1
Frame_Number	Int_16	1
Lidar_Mode	Int_16	1
Lidar_Submode	Int_16	1
Surface_Elevation	Float_32	1
Laser_Energy_532	Float_32	1
Perpendicular_Amplifier_Gain_532	Float_32	1
Parallel_Amplifier_Gain_532	Float_32	1
Perpendicular_Background_Monitor_532	Float_32	1
Parallel_Background_Monitor_532	Float_32	1
Depolarization_Gain_Ratio_532	Float_32	1
Depolarization_Gain_Ratio_Uncertainty_532	Float_32	1
Uncalibrated_Perpendicular_Attenuated_Backscatter_532	Float_32	583
Uncalibrated_Parallel_Attenuated_Backscatter_532	Float_32	583
Perpendicular_RMS_Baseline_532	Float_32	1
Parallel_RMS_Baseline_532	Float_32	1
Laser_Energy_1064	Float_32	1
Amplifier_Gain_1064	Float_32	1
Uncalibrated_Attenuated_Backscatter_Coefficient_1064	Float_32	583
RMS_Baseline_1064	Float_32	1
Ozone_Number_Density	Float_32	33
Relative_Humidity	Float_32	33
Temperature	Float_32	583
Pressure	Float_32	583
Molecular_Number_Density	Float_32	583

Parameter Name	Data Type	Elem/Rec
Molecular_Attenuated_Backscatter_Coefficient_532	Float_32	583
Molecular_Attenuated_Backscatter_Coefficient_1064	Float_32	583
Molecular_Attenuated_Backscatter_Coefficient_532_Parallel	Float_32	583
Molecular_Two_Way_Transmittance_532	Float_32	583
Molecular_Two_Way_Transmittance_1064	Float_32	583
Ozone_Two_Way_Transmittance_532	Float_32	583
Surface_Wind_Speeds	Float_32	2
Tropopause_Height	Float_32	1
Tropopause_Temperature	Float_32	1
Noise_Scale_Factor_532_Perpendicular	Float_32	1
Noise_Scale_Factor_532_Parallel	Float_32	1
Noise_Scale_Factor_1064	Float_32	1
Perpendicular_Column_Reflectance_532	Float_32	1
Perpendicular_Column_Reflectance_Uncertainty_532	Float_32	1
Parallel_Column_Reflectance_532	Float_32	1
Parallel_Column_Reflectance_Uncertainty_532	Float_32	1
QC_Flag	Uint_32	1
QC_Flag_2	Uint_32	1
LIDAR Profile Geolocation and Viewing Geometry Record		
Latitude	Float_32	1
Longitude	Float_32	1
Off_Nadir_Angle	Float_32	1
Viewing_Zenith_Angle	Float_32	1
Viewing_Azimuth_Angle	Float_32	1
Solar_Zenith_Angle	Float_32	1
Solar_Azimuth_Angle	Float_32	1
Scattering_Angle	Float_32	1
Surface_Altitude_Shift	Float_32	1
Number_Bins_Shift	Int_32	1
LIDAR Spacecraft Position, Attitude, and Celestial Record		
Spacecraft_Altitude	Float_32	1
Spacecraft_Position	Float_64	3
Spacecraft_Velocity	Float_64	3
Spacecraft_Attitude	Float_64	3
Spacecraft_Attitude_Rate	Float_64	3
Subsatellite_Latitude	Float_32	1
Subsatellite_Longitude	Float_32	1
Sun_Distance	Float_64	1
Subsolar_Latitude	Float_32	1
Subsolar_Longitude	Float_32	1

* Profile_Elapsed_Time is the reference time for this granule, which is the start time of the nighttime or daytime orbit. The elapsed times of the profiles can be calculated by subtracting this reference time. This parameter has only one record in each file.

Table 2: LIDAR Pre-Level 1B Metadata Record

Parameter Name	Data Type	Elem/Rec
Product_ID	Char	80
Date_Time_at_Granule_Start	Char	28
Date_Time_at_Granule_End	Char	28
Date_Time_of_Production	Char	28
Number_of_Good_Profiles	Int_32	1
Number_of_Bad_Profiles	Int_32	1
Initial_Subsatellite_Latitude	Float_32	1
Initial_Subsatellite_Longitude	Float_32	1
Final_Subsatellite_Latitude	Float_32	1
Final_Subsatellite_Longitude	Float_32	1
Orbit_Number_at_Granule_Start	Uint_32	1
Orbit_Number_at_Granule_End	Uint_32	1
Orbit_Number_Change_Time	Float_64	1
Path_Number_at_Granule_Start	Int_16	1
Path_Number_at_Granule_End	Int_16	1
Path_Number_Change_Time	Float_64	1
Lidar_L1A_Files_Used	Char	240
Ephemeris_Files_Used	Char	160
Attitude_Files_Used	Char	160
GEOS_Version	Char	64
GMAO_Files_Used	Char	480
Percent_532-parallel_Bad	Float_32	1
Percent_532-perpendicular_Bad	Float_32	1
Percent_1064_Bad	Float_32	1
Percent_532-parallel_Missing	Float_32	1
Percent_532-perpendicular_Missing	Float_32	1
Percent_1064_Missing	Float_32	1
Lidar_Data_Altitudes	Float_32	583
Met_Data_Altitudes	Float_32	33
Rayleigh_Extinction_Cross-section_532	Float_32	1
Rayleigh_Extinction_Cross-section_1064	Float_32	1
Rayleigh_Backscatter_Cross-section_532	Float_32	1
Rayleigh_Backscatter_Cross-section_1064	Float_32	1
Ozone_Absorption_Cross-section_532	Float_32	1
Ozone_Absorption_Cross-section_1064	Float_32	1

The parameters with "Bold" are the additional parameters from the L1A files. The parameters in red are suggested to add into the Pre-Level 1B files so that the MetManager is not required to call from the downstream PGEs.

Section 5 – Benefits, assumptions, risks/issues

The benefits for generating the Pre-L1B files are only one input file is required for the downstream PGEs, such as 532 nm nighttime calibration coefficient PGS. The Pre-L1B files contain only the required data for downstream PGEs. Since the Pre-L1B files are output as nighttime orbit and daytime orbit separately, the amount of data input for the other processes will be reduced. The Pre-L1B files contain all the required meteorology data, so the other PGES may not need the MetManager to retrieve meteorology data from the GMAO data files again.

Conclusion

The design of the LIDAR Pre-L1B file generating PGE can be processed after all the dynamic files are available. Since all the required meteorology data are included in the Pre-L1B files, the other PGEs will not need to access the GMAO data files.

References

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"Software Requirements for Version 4 of the CALIPSO Data Processing System"; see 'V4SoftwareRequirements2012-02-01.pdf', available at the CALIPSO wiki (http://www-calipso.larc.nasa.gov/internal/).

"CALIOP Algorithm Theoretical Basis Document, Calibration and Level 1 Data Products", Hostetler, C. A. et al, PC-SCI-201, NASA Langley Research Center, Hampton, VA 23681, 2006. [see http://www-calipso.larc.nasa.gov/resources/project_documentation.php].

"Requirements for generating LIDAR Level 0 (HDF) and Level 1A files process", Lee, K. A., internal document, 2012; see 'newlidarprelevel1b.docx', available at **TBD**

"Requirements for generating LIDAR Pre-Level 1B file process", Lee, K. A., internal document, 2012; see 'newlidarprelevel1b.docx', available at **TBD**