Summary of Publicly Released CIPS Data Versions.

Last Updated 13 May 2012

V3.11 - Baseline data version, available before July 2008

All CIPS V3.X data versions followed the data processing flow and data level definition summarized in Figure 1.

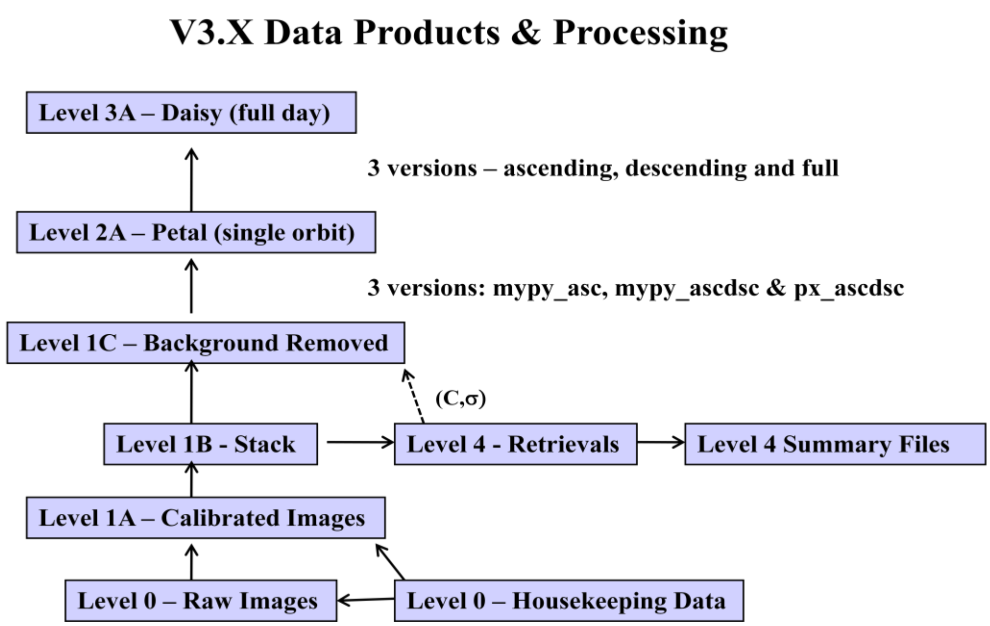

Figure 1. Flow chart illustrating the data processing flow and definition of CIPS data levels for all V3.X data versions.

Note that this involves a somewhat convoluted data flow with the primary cloud detection and retrieval algorithm, level 4, occurring between (and feeding) levels 1C, 2 and 3.

Level 4 is the primary cloud detection and retrieval algorithm in this version. Input to this algorithm is Level 1B albedo and geolocation data. The native 1B data is first binned in 3x3 bins before performing cloud detection or retrievals, resulting in a retrieval resolution of ~ 15x15 km^2.

Cloud detection is performed using the "RATALL" indicator, which is a measure of forward- to back-scattered asymmetry in the total measured albedo scattering profile. Detection is performed on a pixel-by-pixel basis using a fixed threshold value (0.99225) for cloud detection for all CIPS seasons.

After cloud detection, geophysical retrievals proceed on a pixel-by-pixel basis. For non-cloud pixels the effective ozone parameters [C,σ] describing the Rayleigh background are retrieved analytically by solving the linearized (X/Y) form of the C-σ model (see the V4.20 level 2 algorithm documentation for a description of this model). For cloud pixels the IDL non-linear function fitting routine MPFIT is used to perform a nonlinear 4-parameter fit to retrieve background Rayleigh and cloud parameters [C,σ;A, R] simultaneously. Here A and R are the cloud albedo (normalized to 90-deg scattering angle and nadir view), and the cloud particle radius.

The cloud scattering forward model used to drive MPFIT utilizes a theoretical cloud phase function to constrain the cloud phase function dependence on particle radius. CIPS V3.X retrievals assume spherical ice particles and a Gaussian size distribution with a fixed 14-nm width.

The final step is retrieval of ice water content (IWC), which is performed using an empirical linear regression model in which IWC is directly proportional to scattering albedo at a "magic angle". For CIPS this angle is 115 degrees, hence $IWC = \alpha \cdot A(115^{o})$ where α is a constant.

V3.12 - Released July 2008

This version update involved a purely level 4 algorithm change. Thus levels 1A and 1B were unchanged. Primary changes include:

- An additional final fit of the measured cloud phase function ("Step 3") was introduced after the 4-parameter MPFIT cloud retrieval. The purpose of this additional step was to adjust the retrieved cloud albedo and radius values from the MPFIT results to ensure an exact fit between theoretical and measured phase function at the reference 90 degrees scattering angle.
- An error was discovered in the theoretical cloud phase function file used in previous versions (which was accidentally using a mono-disperse size distribution). This was corrected by using a Gaussian distribution of 14-nm width as intended.

V3.13 - Only implemented for NH 2008 season.

This version involved no algorithm changes at all from V3.12. Rather, new flat-field calibration data ("delta flats") were implemented in the Level 1A processing for the NH 2008 season, and therefore the version number was incremented **for this season only**.

V3.20 - Released November 2008

The primary changes made in this data version include:

The level 1A calibration routines were standardized so that calibration data (Delta Flat Field and camera normalization factors) from each season were processed with a common code. See the CIPS calibration document for a complete description of the level 1A calibration process.

The final phase function fitting routine ("Step 3") introduced in V3.12 was modified to obtain the retrieved cloud albedo from a straightforward linear interpolation of the measured residual phase function to 90 deg scattering angle.

Additional arrays were added to the level 1A, 1B and 4 data files to trace the pixel view angles and solar zenith angles to two reference altitudes – cloud deck (83 km) and Raleigh peak scattering altitude (~ 55 km). The view angle was redefined in terms of the slant path angle from the scattering point to the satellite (the required physical quantity) rather than simply the satellite view angle relative to satellite nadir.

V3.21 - Released December 2009

This version was first introduced for the NH 2009 season. The version changes was precipitated by two changes required for processing the SH 2009/2010 season and reprocessing the NH 2009 season:

- Both seasons required reprocessing in order to use newly acquired and improved flat-field calibration data.
- The cloud detection threshold used for the RATALL indicator was modified to account for time-dependent trends in the data, in order to maintain a consistent false cloud detection rate.

Although neither of these changes involved algorithm modifications, they did result in a new data product for these seasons and hence a version update was necessary.

V4.20.r04 - Released May 2011 (revision number here refers to level 2/3 data)

Level 1A: rev02
Level 1B: rev03
Level 2: rev04
Level 3: rev04

This version represents a radical departure from all previous CIPS data versions. All data levels above 1B have been re-defined and simplified and the primary geophysical retrieval algorithm has been completely re-engineered. A preliminary version of this algorithm (V4.10) was produced and released internally to the AIM Science Team in 2010 for evaluation and validation purposes, but never released publically. Preliminary revision numbers of the V4.20 data (01-03) set were also released internally for testing before the public release of the rev_04 data.

The operational data level stream now proceeds much more linearly, consistent with common NASA mission data conventions. Level 2 contains the cloud detection and retrieved geophysical parameters, and is the definitive CIPS high-resolution, single-orbit data product. Figure 2 illustrates the data processing flow and key data products. The key improvements made in each data level are described below.

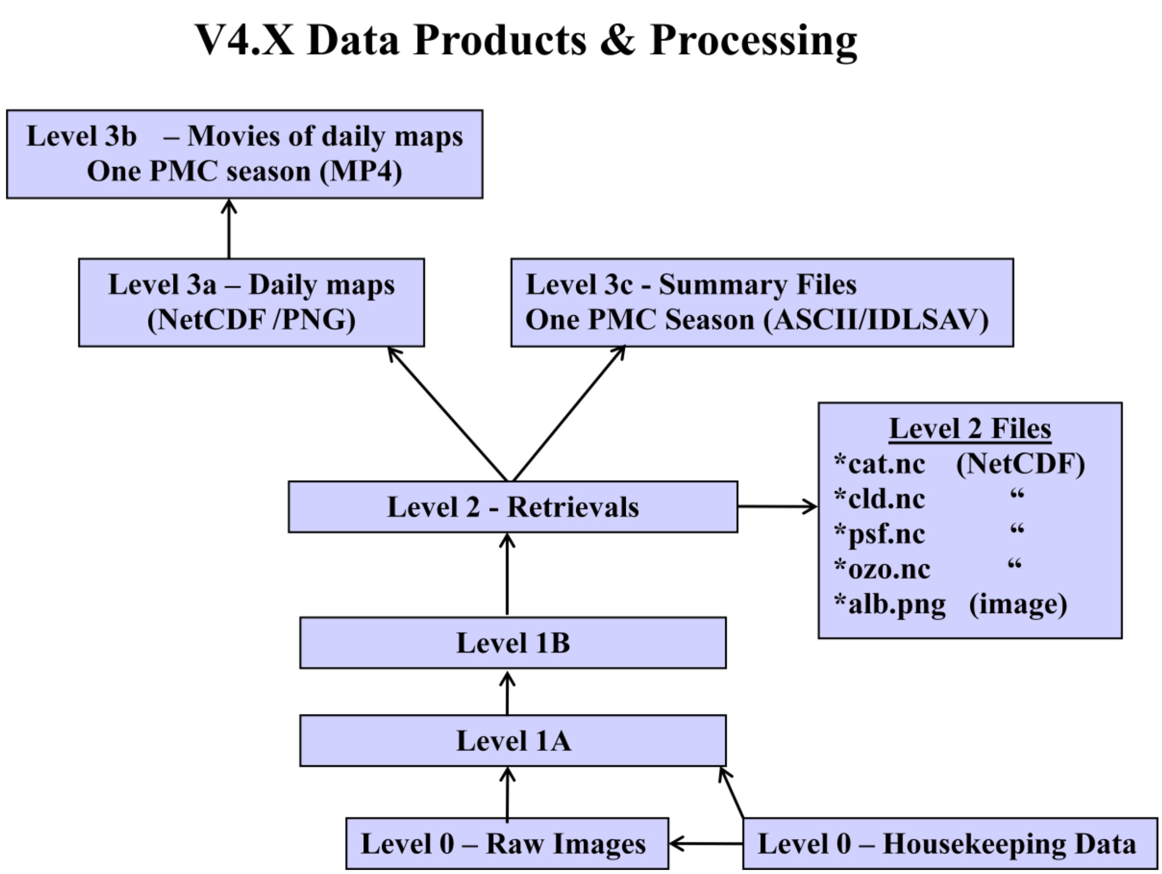

Figure 2. Flow chart illustrating the data processing flow and data level definitions for the V4.20 algorithm and data set.

Level 1A

Several changes were incorporated in the V4.20 level 1A data files, all having to do with calibration. They include:

1) Additional level 0 calibration and data diagnostic parameters are now included in the 1A data file structure, allowing easier tracking of CIPS instrument status.

2) An improved algorithm was implemented for calculating dark counts and dark currents in the calibration process. This algorithm includes much better detection and screening of noisy dark images due to random particle hits as well as the increased noise environment encountered in the South Atlantic Anomaly.

3) Changes to the flat-field correction and camera normalization steps in the 1A calibration, including normalization to the MY nadir camera (rather than PY) and the use of multiple sets of sub-solar, fast cadence images to determine the final flat-field correction for each season (see the CIPS calibration documentation for details).

Level 1B

The level 1B algorithms and data structure is unchanged from V3.X.

Level 2

Level 2 is now the primary geophysical cloud retrieval product. The retrieval algorithms and data file structures have undergone significant change in this version - please see the V4.20 level 2 data and algorithm documentation for more details. Here we simply highlight some of the most important changes:

Level 2 data is split among 4 different netCDF data files for each orbit - a catalog file containing fundamental timing, geolocation and metadata; a cloud file containing the retrieval cloud microphysical parameters; a phase function file containing the derived PMC ice phase function for each cloud pixel; and a file containing the retrieved background ozone parameters (not publically released).

Level 2 cloud detection and retrievals are done directly on the input 25 km^2 resolution Level 1B grid, rather than binning 3x3. Thus the cloud product has nine times better resolution than V3.X.

The retrieval is iterative. The Rayleigh background is determined by fitting the C/σ ozone parameters to best-guess non-cloud pixels in 0.25 deg solar zenith angle bins, rather than pixel-by-pixel. Thus the background atmospheric albedo is more constrained and allowed to vary in a much smoother way, over larger distance scales, than the cloud field. After subtracting the background in each solar zenith angle bin, all pixels having residual albedo values above a set threshold are tagged as “cloud” pixels, and the residual phase function is fit for [A,R]. The cloud signal is then subtracted from total albedo pixel-by-pixel and the background C/σ parameters are updated on the next iteration. This process is iterated till convergence is reached.

The algorithm no longer uses the RATALL indicator for cloud detection. Detection is done by comparing the residual albedo (measured–background) at each iteration to a look up table (LUT) of estimated random and systematic error from C/σ model fits to non-cloud data. LUTs are generated each season by averaging fitting residuals from approximately one week of pre- and post-season cloud free data. This gives both detection threshold and mean error, which are calculated on a 2-D grid of solar zenith angle and view angle.

Ice water content is no longer calculated from the empirical regression model (“magic angle”) approach used in V3.X. Instead a first principles approach is used to determine IWC from the assumed underlying PMC size distribution function (theoretical phase function).

The theoretical phase function assumed in the cloud data fitting is no longer the Gaussian with fixed 14-nm width used in V3.X. Based on extensive analysis and cross-validation with other measurements of PMC particle sizes we now use a phase function constrained by fits to lidar data (see more description and references in the level 2 algorithm document). The microphysical assumptions made are that the ice particles have axial ratio=2 and a distribution width that varies approximately as 0.5*radius.

Using appropriate binning, we can retrieve cloud parameters from pixels at the edges of the CIPS orbit strip that were previously excluded from the cloud retrievals. Thus this data version has extended spatial coverage.

Improvements were made to the Rayleigh albedo (C/σ) model making it more realistic and accurate at high solar zenith angles. This, together with improvements in background removal and cloud detection at low solar zenith angles has extended the range of high retrievals to 42 – 95 degrees solar zenith angle (by comparison the range for V3.21 was 50-92 degrees).

V4.20, revision 05 - Released November 2011

Level 1A: rev02
Level 1B: rev03
Level 2: rev05
Level 3: rev05

This revision fixed a number of minor problems in the level 2 and 3 data. Levels 1A and 1B were not affected at all by this revision. The rev_05 level 2 and 3 cloud data products are qualitatively indistinguishable from the rev_04 data. A brief summary of the changes implemented in rev_05 includes the following.

Level 2

The maximum value allowed for the retrieved particle size was reduced from 101 to 100 nm. This is the only change made to the actual level 2 retrieval algorithms in this revision, and has a negligible effect on the cloud retrievals.

The chi-squared values from the fit to the measured ice phase function, used to derive PMC microphysical parameters, is now saved to the level 2 "cld" data file.

Inconsistencies in the fill (NaN) values of some level 2 arrays were fixed (notably the cloud_presence_array, which in the process was changed from an integer to a floating point array).

A redundant UT time array was eliminated in the level 2 catalog file.

The level 2 single-orbit images (png files) were extended to include particle size and ice water content in addition to albedo.

Level 3a

A number of changes were made to the level 3a images ("daily daisies") to make them more readable. This includes the addition of text showing orbit numbers on each orbit strip in the daily plot as well as the addition of a color bar and screening of data for solar zenith angles less than 42 degrees, to be consistent with the level 2 albedo images. The same screening was applied to the data posted in the 3a netcdf file.

Level 3c

The date information in the summary files was changed from year and day-of-year values to a single date in YYYYMMDD format.