CIPS Data Overview

The CIPS instrument (*McClintock et al*., 2009) consists of four wide-angle cameras that measure 265-nm radiation scattered by the atmosphere over a wide range of scattering angles. The fundamental measurement is an albedo, which is the measured radiance divided by the input solar irradiance. From the measured albedo, the presence and structure of polar mesospheric clouds (PMCs; *Lumpe et al*., 2013) and gravity waves (GWs; *Randall et al*., 2017) are derived.

On each of ~15 orbits per day, ~20-30 four-camera images are acquired. Prior to February of 2016, these images were acquired every 43 seconds over the summer pole, between the terminator and ~40° latitude on the sunlit side, with overlapping successive images. In late February of 2016 CIPS began taking images with an approximately 3-minute cadence, with global coverage. In November of 2018 CIPS was commanded to take all of its images over a period of ~70 minutes in order to confine imaging to sunlit latitudes while AIM was experiencing high beta angles. This was modified to 60 minutes in October of 2019.

The current version of CIPS PMC data is v5.20r05. *Lumpe et al*. (2013) described the retrieval algorithm for version 4 PMC data; a paper describing the version 5 algorithm is in preparation. As explained by *Randall et al*. (2017), GW information is derived from CIPS measurements of Rayleigh Albedo Anomaly (RAA). The current version of RAA data is v1.10r05.

The PMC and RAA data products for all levels are listed below. More details can be found in documentation specific to the individual levels. CIPS data for levels 2 and above are available online at the AIM CIPS website (http://lasp.colorado.edu/aim/index.php) and at the NASA Space Physics Data Facility (SPDF; https://spdf.gsfc.nasa.gov/).

Level 0: Raw, uncalibrated images. Images are binned on-chip to 170 × 340 pixels (cross track by along track) for each camera. Effective spatial resolution varies from ~2.4 km × 2 km (nadir) to ~4.5 km × 3 km (forward & aft cameras). This is common to both PMC and RAA retrievals.

Level 1A: Calibrated and geolocated albedo. NetCDF files contain all images from a single camera over one orbit, so there are 4 files per orbit (one per camera). This is common to both PMC and RAA retrievals.

Level 1B: Map-projected albedo at 25 km^2 resolution, calculated from level 1a data. One NetCDF file per orbit. These files register all measurements of a single location into data "stacks" to facilitate level 2 retrievals. This is used only for PMC retrievals for v4.20 and earlier versions.

Publicly Available PMC Data Products

Level 2: Retrieved cloud parameters at 25 km^2 resolution for v4 and earlier versions, and at 56.25 km^2 resolution for v5 and later versions. Four NetCDF files per orbit containing, respectively:

(1) Geolocation ("catalog") data (e.g., latitude, longitude, time, etc.). The file name extension is _cat.nc.

(2) Cloud properties, including albedo, particle radius, and ice water content. The file name extension is _cld.nc.

(3) Cloud phase function (cloud albedo vs. scattering angle). The file name extension is _psf.nc.

(4) Retrieved ozone parameters; only experimental at this time.

Cloud albedo in file #2 is normalized to 90° scattering angle and nadir view. Most users of level 2 data will only require files #1 and #2. File #4 is experimental and not publicly available at this time. Images (png files) of cloud albedo, particle radius and ice water content for each orbit are also available.

Level 3A: Quicklook data product of daily cloud albedo maps, produced by combining level 2 data from all individual orbits on a given day. Where pixels from different orbits overlap, the brightest pixel (not the average) is used. Same resolution as level 2. One NetCDF and one png file per day. Each individual png file uses a color scale appropriate for that day.

Level 3B: Movies of daily cloud albedo maps for an entire PMC season. One MPEG4 file per season. Same resolution as level 3A. Each individual MPEG4 file uses a single color scale appropriate for that season.

Level 3C: Season-long files of level 2 data. Retrievals of cloud albedo, particle size, and ice water content from each orbit are binned in one-degree latitude bins and output for an entire PMC season. Files are available in NetCDF and IDL save formats.

Level 3D: Season-long files of level 2 data in the "common volume" viewed by both CIPS and SOFIE. The CIPS Level 3D data are pulled directly from the Level 2 data files, and consist of the subset of pixels that are co-located with the SOFIE line-of-sight. The CIPS level 3D file contains the primary CIPS level 2 retrieval products and associated auxiliary data, in the CV, for each orbit over an entire PMC season. The file format is ASCII text.

Level 3E: Analogous to Level 3D, but these files contain data that are coincident with a selected group of ground stations.

Publicly Available Rayleigh Albedo Anomaly (RAA) Data Products

Level 2A: Retrieved CIPS RAA data in a scene-by-scene format. A CIPS scene contains simultaneous images from the four CIPS cameras, with a footprint of approximately 2000 km by 900 km, as described in *Lumpe et al*. (2013). Four files for each scene are provided:

(1) Geolocation file, including variables such as date, time, latitude, longitude, solar zenith angle, etc. The file name extension is _cat.nc.

(2) Albedo anomaly file, including derived RAA and error, and diagnostics. The file name extension is _alb.nc.

(3) Albedo anomaly variance file, including FFT-filtered RAA and RAA variance. The file name extension is _var.nc. This data product is under validation and not yet publicly available.

(4) Measurement geometry file, containing satellite view angles and scattering angles for each scene. The file name extension is _ang.nc.

Level 2B: Retrieved RAA in an orbit-by-orbit format. All the scenes from an orbit are merged together by combining overlapping pixels from different cameras in much the same way as the CIPS Level 2 PMC data products. Four files for each orbit are provided:

(1) Geolocation file, including variables such as date, time, latitude, longitude, solar zenith angle, etc. File content is similar to the Level 2a cat file. The file name extension is _cat.nc.

(2) RAA file, including derived RAA and error, and total measured Rayleigh albedo. The file name extension is _alb.nc.

(3) Orbit-strip image of RAA. The file name extension is _alb.png.

(4) Orbit-strip image of RAA variance. The file name extension is _var.png. This data product is under validation and not yet publicly available.

Level 2C: Daily, global maps of RAA and of RAA variance, produced by over-plotting level 2B RAA and RAA variance data for all orbits each day; file format is png. This data product is under validation and not yet publicly available.

Level 3A: Daily, global maps of gridded (1° × 1°) RAA variance; file format is NetCDF and png. This data product is under validation and not yet publicly available.

References:

Lumpe, J. D., et al. (2013), Retrieval of polar mesospheric cloud properties from CIPS: algorithm description, error analysis and cloud detection sensitivity, *J. Atmos. Solar-Terr. Phys.*, doi:10.1016/j.jastp.2013.06.007.

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Randall, C. E., J. Carstens, J. A. France, V. L. Harvey, L. Hoffmann, S. M. Bailey, M. J. Alexander, J. D. Lumpe, J. Yue, B. Thurairajah, D. E. Siskind, Y. Zhao, M. J. Taylor, and J. M. Russell, III (2017), New AIM/CIPS global observations of gravity waves near 50-55 km, *Geophys. Res. Lett*., 44, 7044–7052, doi:10.1002/2017GL073943.

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