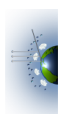JPL D-101482

MSPI
Multiangle SpectroPolarimetric Imager

AirMSPI Cloud Droplet Size and Cloud Optical Depth Data Product Specification

Release V001

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INTRODUCTION

1.1 AirMSPI L2 Cloud Droplet Products

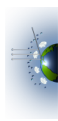The purpose of this document is to describe the format of the AirMSPI Level 2 Cloud Droplet products. The Airborne Multiangle Spectro Polarimetric Imager (AirMSPI) Level 2 Cloud Droplet products contains retrieved values related to the droplet size distribution at cloud tops, as well as cloud optical depths, from AirMSPI polarimetric and radiometric measurements in the vicinity of cloudbows. An effective radius and variance are used to describe the droplet distribution, along with their uncertainties. Values are retrieved from the polarimetric channels of AirMSPI Level 1B2 data where the instrument was operating in continuous sweep mode to observe cloudbows. Files are distributed in NetCDF4 format.
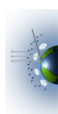
1.2 AirMSPI Data Products

The MISR Science Computing Facility (SCF) at the Jet Propulsion Laboratory (JPL) supports the development of AirMSPI science algorithms and software, instrument calibration and performance assessment, and also provides quality assessment and data validation services with respect to AirMSPI Science Data Processing (SDP). The MISR SCF is used to perform the standard processing of the AirMSPI data. After AirMSPI data processing is complete, the standard output products are archived and made available to users via the Langley Research Center (LaRC) Atmospheric Science Data Center (ASDC) client services. See https://eosweb.larc.nasa.gov/project/airmspi/airmspi_table.
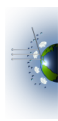
1.3 Controlling Documents

- Cloud Droplet Size and Cloud Optical Depth Retrieval Algorithm Theoretical Basis, D-100521, 17 January 2018

1.4 Related Documents

- AirMSPI Level 2 Cloud Product Quality Statement: ORACLES Campaign, D-101481, 17 January 2018

- Data Product Specification for the AirMSPI Level 1B2 Products, JPL D-100523, 30 June 2018

DATA PRODUCT SPECIFICATION

The AirMSPI Level 2 Product contains retrieved values describing the droplet size distribution at cloud tops, as well as cloud optical depths, along with the uncertainty in these parameters. Per spectral band data only use the polarimetric bands of 470, 660 and 865 nm.

Quality indicators, convergence criteria, data on the scattering angles and derived data are also provided.

Each granule of the AirMSPI Level 2 Product corresponds to a single data acquisition, a single sweep (forward or aftward) corresponding to a single Level 1B2 file.

2.1 File Naming Convention

Level 2 product filenames are based on the input Level 1B2 product names. The *GRP_ELLIPSOID* portion of the L1B2 filename is substituted with the string *CLOUD_DROPLET*. Additionally, filenames have the NetCDF extension of *nc*.

An example product name is shown below:

```
AirMSPI_ER2_CLOUD_DROPLET_20130206_222622Z_NorthPacificOcean-31N123W_SWPA_F01_V005.nc
```

2.2 Dimensions

The following table describes the meaning behind dimension short codes used elsewhere in the document to describe the shape of datasets.

Dim Name	Description
XDim	Number of along track image samples dimension, matches L1B2 product
YDim	Number of across track image samples, matches L1B2 product
Band	Number of polarimetric spectral bands
RetAng	Size of binned data along scattering angles used in retrieval, determined from retrieval_min, retrieval_max and resolution configuration parameters
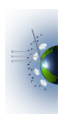
2.3 Attributes

The following global attributes are always set to the same value and are used to identify the file type and algorithm used for processing:

Attribute Name	Value
title	AirMSPI Cloud-Top Droplet Size and Cloud Optical Depth product
source	AirMSPI polarimetric and radiometric measurements
project	AirMSPI
instrument	AirMSPI ultraviolet/visible/near-infrared (UV/VNIR) push broom camera
acknowledgment	Support for this research was provided by NASA
processing_level	Level 2

The following global attributes are generated during processing:

Attribute Name	Description
campaign	The field campaign that is the source of the L1B2 data
product_format_version	Version of the output product format
software_version	Version of the software used to create the product file
time_coverage_start	Beginning time of data used to create product
time_coverage_end	Ending time of data used to create product
band_names	L1B2 names of bands used for the retrieval
band_wavelengths	Wavelengths of the bands used for the retrieval
latitude_upper_left	Geographic latitude of cloud image in the upper left corner of the granule
latitude_lower_right	Geographic latitude of cloud image in the lower right corner of the granule
longitude_upper_left	Geographic longitude of cloud image in the upper left corner of the granule
longitude_lower_right	Geographic longitude of cloud image in the lower right corner of the granule
input_file_names	Full path to the input files used to produce the product
input_file_types	The types of the files named in input_file_names in the same order as that attribute
production_time	The time when the output product was produced
production_hostname	The hostname of the machine used for production of the output product

2.4 Masks

The mask datasets described below are used in processing are derived from both the L1B2 file, and thresholds on radiances to determine the location of clouds:

Table 2.1: /Auxillary/Masks

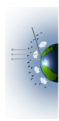| Field Name / Description	Dimension List	Data Type	Units
data_mask Mask indicating cloudy pixel locations based on L1B2 band masks, set to 1 where data are suitable for the retrieval, otherwise set to 0. Covers the full size of the Level 1 grid.	YDim XDim	int8	N/A

Continued on next page

Table 2.1 – continued from previous page

Field Name / Description	Dimension List	Data Type	Units
cloud_mask Mask indicating good and bad pixel locations based on cloud detection algorithm plus data_mask, set to 1 where data is good, otherwise set to 0. Covers the full size of the Level 1 grid.	YDim XDim	int8	N/A

2.5 Intermediate Data

The following datasets are the intermediate data created during the binning phase where L1B2 Q radiances are converted into discrete scattering angle bins:

Table 2.2: /Auxillary/IntermediateData

Field Name / Description	Dimension List	Data Type	Units
Q_bin_mean Mean Stokes vector component Q over scattering angle bins	RetAng Band	float32	$W \cdot m^{-2} \cdot nm^{-1} \cdot sr^{-1}$
Q_bin_std Standard deviation of Stokes vector component Q over scattering angle bins	RetAng Band	float32	$W \cdot m^{-2} \cdot nm^{-1} \cdot sr^{-1}$
scattering_ang_bin_mean Binned scattering angle mean	RetAng Band	float32	deg

2.6 Cloud Droplet Size

The following datasets are the result of the cloud droplet size retrieval process, the key datasets being effective_variance and effective_radius with their associated uncertainty.

Table 2.3: /DropletSize

Field Name / Description	Dimension List	Data Type	Units
effective_variance Retrieved effective variance of gamma distribution of droplet size	YDim XDim	float32	
effective_radius Retrieved effective radius of gamma distribution of droplet size	YDim XDim	float32	μm
a_lambda 1st linear coefficient ('a') in modeled polarized phase function equation that accounts for cloud fractional coverage, reported for each band	Band	float32	

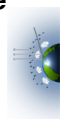Table 2.3 – continued from previous page

Field Name / Description	Dimension List	Data Type	Units
b_lambda 2nd linear coefficient ('b') in modeled polarized phase function equation that accounts for the above-cloud aerosol and ozone contributions to the polarized radiance and other unmodeled effects, reported for each band	Band	float32	
c_lambda Constant offset ('c') in modeled polarized phase function equation that accounts for the above-cloud aerosol and ozone contributions to the polarized radiance and other unmodeled effects, reported for each band	Band	float32	
chi_sq_fit_value Reduced Chi-square fitting error	SCALAR	float32	
quality_indicator Retrieval quality indicator (RQI); RQI = 1 indicates a successful retrieval, meaning that (a) both effective radius and variance are within their bounds, and (b)the Chi-square fitting error is smaller than the criterion value; RQI = 2 indicates that (a) is violated; RQI = 3 indicates that (b) is violated; RQI = 4 indicates that retrieval exceeds the maximum number of iterations without convergence; RQI = 5 indicates unperformed retrieval due to that the number of observations is less than the number of parameters to retrieve	SCALAR	int32	
observed_phase_function Observed polarized phase function (with Rayleigh correction) for all bands and all bins in the retrieval scattering angle range	RetAng Band	float32	
modeled_phase_function Modeled polarized phase function for all bands calculated using lookup table Mie phase function interpolated for the retrieved effective variance and effective radius values. It is calculated for all bins in the retrieval scattering angle range	RetAng Band	float32	

Table 2.4: /DropletSize/Uncertainty

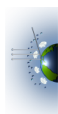| Field Name / Description	Dimension List	Data Type	Units
effective_variance_retrieval_uncertainty Retrieval uncertainty for effective variance	YDim XDim	float32	
effective_radius_retrieval_uncertainty Retrieval uncertainty for effective radius	YDim XDim	float32	μm

Table 2.4 – continued from previous page

Field Name / Description	Dimension List	Data Type	Units
a_lambda_retrieval_uncertainty Retrieval uncertainty for the 1st linear coefficient ('a') in modeled polarized phase function equation that accounts for cloud fractional coverage, reported for each band	Band	float32	
b_lambda_retrieval_uncertainty Retrieval uncertainty for the 2nd linear coefficient ('b') in modeled polarized phase function equation that accounts for the above-cloud aerosol and ozone contributions to the polarized radiance and other unmodeled effects, reported for each band	Band	float32	
c_lambda_retrieval_uncertainty Retrieval uncertainty for the constant offset ('c') in modeled polarized phase function equation that accounts for the above-cloud aerosol and ozone contributions to the polarized radiance and other unmodeled effects, reported for each band	Band	float32	

2.7 Cloud Optical Depth

Without accounting for the 3D radiative effects and assuming homogeneous droplet size distribution throughout the cloud layer, the 1D-RT based cloud optical depth is retrieved at each cloudy pixel using the radiance at the three polarimetric bands.

Table 2.5: /CloudOpticalDepth

Field Name / Description	Dimension List	Data Type	Units
cloud_optical_depth Retrieved cloud optical depth	YDim XDim Band	float32	
cloud_optical_depth_retrieval_uncertainty Retrieval uncertainty of cloud optical depth	YDim XDim Band	float32	
modeled_radiance Modeled radiance calculated using lookup table radiance interpolated for the retrieved effective variance, effective radius and view geometry. It is calculated for all cloudy pixels	YDim XDim Band	float32	$W \cdot m^{-2} \cdot nm^{-1} \cdot sr^{-1}$
observed_radiance Observed radiance for all cloudy pixels	YDim XDim Band	float32	$W \cdot m^{-2} \cdot nm^{-1} \cdot sr^{-1}$

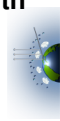Table 2.5 – continued from previous page

Field Name / Description	Dimension List	Data Type	Units
chi_sq_fit_value Reduced chi-square radiance fitting error associated with pixel-scale cloud optical depth retrieval	YDim XDim	float32	
cloud_optical_depth_mean Mean cloud optical depth	Band	float32	
cloud_optical_depth_std Standard deviation of cloud optical depth	Band	float32	
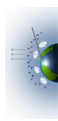
APPENDIX

Acroynm	Meaning
ASDC	Atmospheric Science Data Center
AirMSPI	Airborne Multiangle SpectroPolarimetric Imager
JPL	Jet Propulsion Laboratory
L1B2	Level 1B2
L2	Level 2
LUT	Lookup Up Table
LaRC	Langley Research Center (NASA)
MISR	Multi-angle Imaging SpectroRadiometer
NASA	National Aeronautics and Space Administration
NIR	Near Infrared
SCF	Science Computing Facility
SDP	Science Data Processing