



## Multiangle SpectroPolarimetric Imager

# Data Product Specification for the AirMSPI Level 1B2 Products (V006)

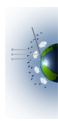
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Airborne Multiangle SpectroPolarimetric Imager (AirMSPI)

# **Data Product Specification for the AirMSPI Level 1B2 Products (V006)**

APPROVALS:

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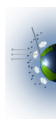
AirMSPI Principal Investigator

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Approval signatures are on file with the AirMSPI Project.  
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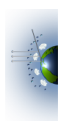


## Document Change Log

Revision	Date	Affected Portions and Description
	3 December 2013	Original release for V003
A	11 April 2014	Updated for V004: RDQI, other
B	5 February 2018	Updated for V005: elevation and land water mask, other
C	23 February 2018	Updated to include changes to V006

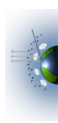
## Which Product Versions Does this Document Cover?

Product Filename Prefix	Version Number in Filename	Brief Description
AirMSPI_ER2_GRP_ELLIPSOID	V006	L1B2 Ellipsoid-Projected Georectified Radiance and Polarization Data
AirMSPI_ER2_GRP_TERRAIN	V006	L1B2 Terrain-Projected Georectified Radiance and Polarization Data



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# 1 INTRODUCTION

## 1.1 AirMSPI L1B2 Products

The Airborne Multiangle SpectroPolarimetric Imager (AirMSPI) Level 1B2 products contain radiometric and polarimetric observations of clouds, aerosols, and the surface of the Earth made from the National Aeronautics and Space Administration (NASA) ER-2 high-altitude research aircraft. The AirMSPI instrument acquires data using one of two possible modes, step-and-stare and sweep. Step-and-stare data are gridded with 10 m spatial sampling, with one file provided for each view angle. Sweep data are gridded with 25 m spatial sampling. Files are distributed in HDF-EOS-5 format.

The instrument reports for eight spectral bands (355, 380, 445, 470, 555, 660, 865, and 935 nm) the incident radiance (Stokes  $I$ ), complemented with the linear polarization state (Stokes  $Q$  and  $U$ ) in three of the bands (470, 660, and 865 nm) for a total of 14 channels.

## 1.2 AirMSPI Data Processing and Distribution

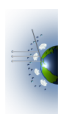
The MISR Science Computing Facility (SCF) at the Jet Propulsion Laboratory (JPL) supports the development of AirMSPI science algorithms and software, instrument calibration and performance assessment, and also provides quality assessment and data validation services with respect to AirMSPI Science Data 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](https://eosweb.larc.nasa.gov/project/airmspi/airmspi_table).

## 1.3 Controlling Documents

- 1) Multiangle Spectropolarimetric Imager (MSPI) Algorithm Theoretical Basis Document Rev. B Draft, November 2009 (or latest version).

## 1.4 Related Documents

- 1) User Guide for the AirMSPI Level 1B2 Products, JPL D-78962, April 2014 (or latest version).



## 2 AirMSPI LEVEL 1B2 DATA PRODUCT SPECIFICATION

### 2.1 AirMSPI Level 1B2 Product Granule Brief Description

The AirMSPI L1B2 Product contains radiance information in eight spectral bands (nominally 355, 380, 445, 470, 555, 660, 865, and 935 nm) as well as polarimetric information in three of these bands (470, 660, 865 nm) – representing 14 total channels. Quality indicators, solar and view geometry, and temporal information associated with the acquired imagery are provided, as well as geolocation (latitude and longitude) and geographic (elevation, land-water mask) information.

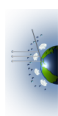
### 2.2 AirMSPI Level 1B2 Product Granule Components

Each granule of the AirMSPI L1B2 Product corresponds to a single data acquisition: a single stare in a step-and-stare sequence or a single sweep (forward or aftward). Each file uses the HDF-5 General Cartographic Transformation Package (GCTP) Universal Transverse Mercator (UTM) grid format at either 10 m (step-and-stare) or 25 m (sweep) spatial sampling. Table 1 shows some example product file names and describes the naming conventions.

*Table 1 – L1B2 Example Product Files and Grid*

<b>Collection (Shortname)</b>	<b>Local Granule ID<sup>1</sup></b>
AirMSPI_ORACLES_GRP_Data	AirMSPI_ER2_GRP_ELLIPSOID_yyyymmdd_hhmmssZ_tttt_aaa[A,N,F]_Fff_Vvvv.hdf and/or AirMSPI_ER2_GRP_TERRAIN_yyyymmdd_hhmmssZ_tttt_aaa[A,N,F]_Fff_Vvvv.hdf

<sup>1</sup> Where yyyy is the year, mm is the month, dd is the day, hh is the hour, mm is the minute, ss is the second in UTC of the central observation, ttttt corresponds to the target name, aaa is the view angle, A is aftward, N is nadir, F is forward, Fff is the file format version, and Vvvv is the version number. For a step-and-stare image, the view angle aaa is reported to the nearest tenth of a degree  $\times 10$ , whereas SWP is reported for a sweep image.

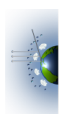


## 2.3 AirMSPI Level 1B2 Product

### 2.3.1 Granule Metadata Description (.met File)

Table 2 – Metadata (.met)

Field Name	Definition	Example Contents
DatasetName	Name of dataset	AirMSPI_ORACLES_Ellipsoid-projected_Georegistered_Radiance_Data
GranuleName	Name of specific data granule	AirMSPI_ER2_GRP_ELLIPSOID_20160914_112935Z_SouthAtlanticOcean-17S9E_SWPA_F01_V006.hdf
StartDate	UTC date at start of data acquisition for this granule (yyyy-mm-dd)	2016-09-14
StartTime	UTC time at start of data acquisition for this granule (hh:mm:ss.sssssZ)	11:29:01.915930Z
EndDate	UTC date at end of data acquisition of this granule (yyyy-mm-dd)	2016-09-14
EndTime	UTC time at end of data acquisition for this granule (hh:mm:ss.sssssZ)	11:30:10.035016Z
MaxLat	Maximum geographic latitude of data in this granule (degrees N)	-16.191646
MaxLon	Maximum geographic longitude of data in this granule (degrees E)	9.245757
MinLat	Minimum geographic latitude of data in this granule (degrees N)	-16.886023
MinLon	Minimum geographic longitude of data in this granule (degrees E)	8.885219
FlightHeadingAzimuth	Mean aircraft heading for data in this granule (degrees relative to N)	180.0
GranuleSize	Size of data granule (bytes)	346324508
Processing Date-Time	UTC date and time of data processing (yyyy-mm-ddThh:mm:ssZ)	2017-05-06T14:01:42Z
VersionID	Product version number	006
Browse	Indicates existence of .jpeg browse product	Y
Browsjpeg	Filename of .jpeg browse product	AirMSPI_ER2_GRP_ELLIPSOID_20160914_112935Z_SouthAtlanticOcean-17S9E_SWPA_F01_V006.jpg
jpegsize	Size of .jpg browse product (bytes)	963183
Browskml	Name of associated Google Earth KML file	AirMSPI_ER2_MAP_INFO_ELLIPSOID_20160914_112935Z_SouthAtlanticOcean-17S9E_V006.kml
kmlsize	Size of .kml Google Earth file (bytes)	81633
Resolution	Pixel resolution of data in granule (meters)	25.0
TargetType	Text description of target type for this	Ocean



	granule (Land or Ocean)	
GeolocationStage	Level of geolocation processing for this granule (Direct or Indirect)	Indirect
GeoPolygon	Latitude/longitude coordinate pairs describing location of data within granule	((-16.200207,9.103753),(-16.233493,9.095399),..., (-16.212925,9.048235),(-16.200207,9.103753))

### 2.3.2 HDF-EOS-5 Format Description

HDF-EOS-5 files are organized into groups and subgroups. The tables below describe the content of an AirMSPI HDF-EOS-5 file in a manner consistent with this organization.

*Table 3 – Top Level Contents*

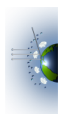
Field Name	Description
Channel_Information	Contains information about the AirMSPI spectral channels and solar constant values
HDFEOS	Contains the primary data contents of the file
HDFEOS INFORMATION	Contains ancillary information (metadata) about the file

*Table 4 – Channel\_Information Contents*

Field Name	Description
Center_wavelength	Measured central wavelength (in nm) for each AirMSPI spectral channel
Channel_name	AirMSPI channel designation; channel names ending with I are radiometric channels, channel names ending with Q or U are polarimetric channels
Channel_number	Field that maps HDF index (0–13) to numerical channel number (1–14)
Effective_bandwidth	Bandwidth (in nm) of a rectangular filter having the same area as the actual spectral response function (SRF) as determined by a moments analysis for each AirMSPI spectral channel
Effective_transmittance	The transmittance (in the range from 0 to 1) of a rectangular filter having the same area as the actual SRF for each AirMSPI spectral channel
Solar_irradiance_at_1_AU	The extraterrestrial solar irradiance (in $W\ m^{-2}\ nm^{-1}$ ) weighted by the total-band spectral response function for each channel at the nominal Earth-Sun distance (1 AU)

*Table 5 – HDFEOS Contents*

Field Name	Description
ADDITIONAL	Contains additional information useful to users of the L1B2 data products
GRIDS	Contains the gridded HDF-EOS data





*Table 6 – HDFEOS/ADDITIONAL Contents*

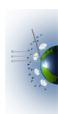
<b>Field Name</b>	<b>Description</b>
FILE_ATTRIBUTES	Contains additional information useful to users of the L1B2 data products

*Table 7 – HDFEOS/ADDITIONAL/FILE\_ATTRIBUTES Contents*

<b>Field Name</b>	<b>Description</b>
Band Table	Provides the band number (1-8) and the associated band name
GeoPolygon	Latitude/longitude coordinate pairs describing location of data within granule

*Table 8 – HDFEOS/ADDITIONAL/FILE\_ATTRIBUTES Attributes Contents*

<b>Field Name</b>	<b>Description</b>
Acquisition end time	UTC date and time of end of data acquisition
Acquisition start time	UTC date and time of start of data acquisition
Aircraft heading (degrees)	Mean aircraft heading during data acquisition (relative to North)
BRF equation	Equation used to convert radiance to at-altitude bidirectional reflectance factor (BRF) $BRF = Radiance \times \pi \times sun\_distance^2 \times (1/solar\_irradiance) \times [1/\cos(sun\_zenith)]$
Epoch (UTC)	UTC time used as the reference epoch for this data granule
Geolocation stage	Level of geolocation processing for this granule (Direct or Indirect)
Gimbal angle average (degrees)	Average gimbal angle for this data granule
Gimbal angle maximum (degrees)	Maximum gimbal angle for this data granule
Gimbal angle minimum (degrees)	Minimum gimbal angle for this data granule
Gimbal scan direction	Direction of gimbal scan (forward or aftward)
Lower left latitude	Geographic latitude of data in the lower left corner of the granule (degrees N)
Lower left longitude	Geographic longitude of data in lower left corner of the granule (degrees E)
Lower right latitude	Geographic latitude of data in the lower right corner of the granule (degrees N)
Lower right longitude	Geographic longitude of data in the lower right corner of the granule (degrees E)
Production time	UTC date and time of product generation
Radiance units	Units of radiance data reported in the product ( $W\ m^{-2}\ sr^{-1}\ nm^{-1}$ )
Resolution	Pixel resolution of data in product (m)
Sun distance	Earth-Sun distance for use in calculation of BRF (AU)
Target type	Text description of target type for this granule
Upper left latitude	Geographic latitude of data in the upper left corner of the granule (degrees N)
Upper left longitude	Geographic longitude of data in upper left corner of the granule (degrees E)
Upper right latitude	Geographic latitude of data in the upper right corner of the granule (degrees N)



Upper right longitude	Geographic longitude of data in the upper right corner of the granule (degrees E)
[config]	Configuration parameters used in data processing
[history]	Processing history information
[input]	Input information used in data processing
granule_id	ID name for this data granule

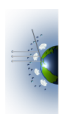
*Table 9 – HDFEOS/GRIDS Contents*

Field Name	Description
355nm_band	Parameters associated with the 355 nm (UV) spectral channel (I)
380nm_band	Parameters associated with the 380 nm (UV) spectral channel (I)
445nm_band	Parameters associated with the 445 nm (VIS) spectral channel (I)
470nm_band	Parameters associated with the 470 nm (VIS) polarized spectral channels (I, Q, and U)
555nm_band	Parameters associated with the 555 nm (VIS) spectral channel (I)
660nm_band	Parameters associated with the 660 nm (VIS) polarized spectral channels (I, Q, and U)
865nm_band	Parameters associated with the 865 nm (NIR) polarized spectral channels (I, Q, and U)
935nm_band	Parameters associated with the 935 nm (NIR) spectral channel (I)
Ancillary	Ancillary geographic information.
XDim	UTM projection X coordinate (see note after Table )
YDim	UTM projection Y coordinate (see note after Table )

**Note:** Each Field at the HDFEOS/GRIDS level, with the exception of XDim and YDim, contains its own *Data Fields* Subdirectory described below

*Table 10 – HDFEOS/GRIDS/Data Fields Contents for Unpolarized Spectral Channels*

Field Name Parameter Description	Dimension List	Number Type	Units	Flag Values
<b>Step-and-stare (Spatial Sampling: 10 m x 10 m; e.g. XDim = 3072, YDim = 3072)</b>				
<b>Sweep (Spatial Sampling: 25 m x 25 m; e.g. XDim = 2560, YDim = 4608)</b>				
<b>Glint_angle</b> The angle between the vector pointing in the direction of specularly reflected direct sunlight from a horizontal surface and the vector pointing toward the instrument	XDim YDim	FLOAT32	Degrees	FillValue = -999.0
<b>I</b> Radiance	XDim, YDim	FLOAT32	W m <sup>-2</sup> sr <sup>-1</sup> nm <sup>-1</sup>	FillValue = -999.0
<b>I.mask</b> Indicates locations with valid data	XDim, YDim	INT32	None	0 = Not valid 1 = Valid
<b>RDQI</b> Radiometric Data Quality Indicator	XDim, YDim	FLOAT32	None	0 = Within specifications 1 = Reduced accuracy



				2 = Not usable for science 3 = Unusable for any purpose
<b>Scattering_angle</b> The angle between the vector pointing in the direction of direct sunlight and the vector pointing toward the instrument	XDim YDim	FLOAT32	Degrees	FillValue = -999.0
<b>Sun_azimuth</b> Angle measured clockwise relative to local North of the projection of the solar illumination vector onto a horizontal plane. The illumination vector points in the direction of photon travel. Note that for a vector pointing <i>toward</i> the position of the Sun in the sky the azimuth relative to local North is given by [(Sun_azimuth + 180°) mod 360°]	XDim, YDim	FLOAT32	Degrees	FillValue = -999.0
<b>Sun_zenith</b> Solar zenith angle relative to overhead sun (0°)	XDim, YDim	FLOAT32	Degrees	FillValue = -999.0
<b>Time_in_seconds_from_epoch</b> Time in seconds from the epoch	XDim, YDim	FLOAT64	Seconds	FillValue = -999.0
<b>UTM_projection</b> Universal Transverse Mercator projection information*	1	CHAR8	See footnote*	
<b>View_azimuth</b> Angle measured clockwise relative to local North of the projection of the view vector onto a horizontal plane. The view vector points in the direction of photon travel.	XDim, YDim	FLOAT32	Degrees	FillValue = -999.0
<b>View_zenith</b> View zenith angle relative to nadir (0°)	XDim, YDim	FLOAT32	Degrees	FillValue = -999.0
<b>XDim</b> UTM projection x coordinate*	XDim	FLOAT64	Meters	
<b>YDim</b> UTM projection y coordinate*	YDim	FLOAT64	Meters	

\*UTM projection defines a horizontal coordinate transform, using NetCDF style attributes attached to a single byte placeholder variable. The UTM information is contained in the UTM\_projection attributes, which are: inverse\_flattening, semi\_major\_axis, transform\_name, and utm\_zone\_number. The UTM information is identical for each band and is provided for compatibility with mapping software.

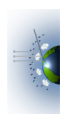
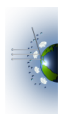


Table 11 – Additional HDFEOS/GRIDS/Data Fields Contents for Polarized Spectral Channels

Field Name Parameter Description	Dimension List	Number Type	Units	Flag Values
<b>Step-and-stare (Spatial Resolution: 10 m x 10 m; e.g. XDim = 3072, YDim = 3072)</b>				
<b>Sweep (Spatial Resolution: 25 m x 25 m; e.g. XDim = 2560, YDim = 4608)</b>				
<b>AOLP_meridian</b> Angle of linear polarization (AOLP) relative to the meridian plane (the plane containing the observed beam and the z-axis of the surface) $AOLP = 0.5 \tan^{-1} \left( \frac{U}{Q} \right)$	XDim, YDim	FLOAT32	Degrees	FillValue = -999.0
<b>AOLP_scatter</b> AOLP relative to the scattering plane (the plane containing the incident beam and the scattered beam)	XDim, YDim	FLOAT32	Degrees	FillValue = -999.0
<b>DOLP</b> Degree of linear polarization $DOLP = \sqrt{\left(\frac{Q}{I}\right)^2 + \left(\frac{U}{I}\right)^2}$	XDim, YDim	FLOAT32	None (Range 0.0 – 1.0)	FillValue = -999.0
<b>IPOL</b> The polarized radiance = I × DOLP	XDim YDim	FLOAT32	W m <sup>-2</sup> sr <sup>-1</sup> nm <sup>-1</sup>	FillValue = -999.0
<b>Q.mask</b> Indicates locations with valid Q data	XDim, YDim	INT32	None	0 = Not valid 1 = Valid
<b>Q_meridian</b> Q Stokes parameter relative to the meridian plane	XDim, YDim	FLOAT32	W m <sup>-2</sup> sr <sup>-1</sup> nm <sup>-1</sup>	FillValue = -999.0
<b>Q_scatter</b> Q Stokes parameter relative to the scattering plane	XDim, YDim	FLOAT32	W m <sup>-2</sup> sr <sup>-1</sup> nm <sup>-1</sup>	FillValue = -999.0
<b>U.mask</b> Indicates locations with valid U data	XDim, YDim	INT32	None	0 = Not valid 1 = Valid
<b>U_meridian</b> U Stokes parameter relative to the meridian plane	XDim, YDim	FLOAT32	W m <sup>-2</sup> sr <sup>-1</sup> nm <sup>-1</sup>	FillValue = -999.0
<b>U_scatter</b> U Stokes parameter relative to the scattering plane	XDim, YDim	FLOAT32	W m <sup>-2</sup> sr <sup>-1</sup> nm <sup>-1</sup>	FillValue = -999.0



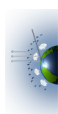
*Table 12 – HDFEOS/GRIDS/Data Fields Contents for Ancillary Data*

<b>Field Name</b> Parameter Description	Dimension List	Number Type	Units	Flag Values
<b>Step-and-stare (Spatial Resolution: 10 m x 10 m; e.g. XDim = 3072, YDim = 3072)</b>				
<b>Sweep (Spatial Resolution: 25 m x 25 m; e.g. XDim = 2560, YDim = 4608)</b>				
<b>Elevation</b> Surface elevation at the reported latitude and longitude relative to the World Geodetic System (WGS) 84 ellipsoid*	XDim, YDim	FLOAT64	Meters	FillValue = -999.0
<b>Land_water_mask</b> Mask indicating the presence of land (1) or water (0)	XDim, YDim	INT32	None	FillValue = -999.0
<b>Latitude</b> Geographic Latitude	XDim, YDim	FLOAT64	Degrees North	FillValue = -999.0
<b>Longitude</b> Geographic Longitude	XDim, YDim	FLOAT64	Degrees East	FillValue = -999.0
<b>UTM_projection</b> Universal Transverse Mercator projection information	1	CHAR8	See footnote below Table	
<b>XDim</b> UTM projection x coordinate	XDim	FLOAT64	Meters	
<b>YDim</b> UTM projection y coordinate	YDim	FLOAT64	Meters	

\*Note that the surface elevation is not necessarily the altitude to which the AirMSPI data are projected (e.g., in the Ellipsoid product, the projection altitude is always the WGS84 ellipsoid).

*Table 13 – HDFEOS INFORMATION Contents*

<b>Field Name</b>	<b>Description</b>
StructMetadata.0	Structural metadata for the file. This is ancillary information regarding the HDF-EOS contents of the grids within the file, including field names, dimensions, and data types, in a human readable format.
StructMetadata.1	Continuation of the structural metadata.



### 3 APPENDIX

Acronym List:

AirMSPI	Airborne Multiangle SpectroPolarimetric Imager
AOLP	Angle of Linear Polarization
ASDC	Atmospheric Science Data Center
AU	Astronomical Unit
BRF	Bidirectional Reflectance Factor
DOLP	Degree of Linear Polarization
EOS	Earth Observing System
GCTP	General Cartographic Transformation Package
HDF-EOS	Hierarchical Data Format for EOS
JPL	Jet Propulsion Laboratory
LaRC	Langley Research Center (NASA)
MISR	Multi-angle Imaging SpectroRadiometer
NASA	National Aeronautics and Space Administration
NetCDF	Network Common Data Form
NIR	Near Infrared
ORACLES	ObseRvations of Aerosols above CLouds and their intEractionS
SCF	Science Computing Facility
SDP	Science Data Processing
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
UV	Ultraviolet
VIS	Visible
WGS84	World Geodetic System 1984

