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Limb Gridded Radiance README

OMPS-LP_SDR_EV_GRID-0.1

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The OMPS Limb instrument measures three geographically distinct radiance profiles of the earth's atmosphere by viewing the limb aft of the Suomi NPP Satellite. The measurements correspond to different altitudes above a point called the 'tangent point' on the earth's surface. The vertical resolution of the instrument is approximately 1 km.

The bulk of the photons collected at each altitude can be considered to come from a 196 km path centered about the normal to the tangent point. The light measured at each altitude is spectrally resolved via a prism. The measurements are made with a 2 dimensional CCD: one dimension corresponds to altitude and the other to wavelength. There are no scanning mirrors.

The raw counts are converted to calibrated radiances and are produced in a product referred to as the Science Data Record (SDR). The SDR is not necessarily the most convenient form in which to use the profile data. In the product described below steps have been taken to make it more convenient.

1 The LP_SDR_EV_GRID Product

The product LP_SDR_EV_GRID contains calibrated radiances from the SDR which have been subject to a number of processing steps to make the data easier to use. These are outlined here. The latitude and longitude of the profile *remain* the same as they were in the original data.

For each measured profile four images are taken at different exposure times (2) and with different aperature sizes (2, via separate optical paths and regions on the CCD sensor). This is done to increase the effective dynamical range of the instrument. These have been combined in LP_SDR_EV_GRID to produce a unified radiance profile.

For each measured profile a unified radiance spectrum is provided on an orthogonal, but non-uniform, wavelength-altitude grid in the LP_SDR_EV_GRID product. Due to spectral smile the wavelength and altitude do not fall uniformly across the the grid of CCD pixels. For convenience, in the LP_SDR_EV_GRID product, the radiances have been interpolated onto an orthogonal wavelength-altitude grid. The spacing in the altitude direction is nominally a uniform half kilometer. The spacing in the wavelength direction is non-uniform and is determined dynamically for each profile.

The radiances on the non-uniform grids are interpolated onto a 2D grid which is uniform in wavelength and altitude and also is the same for the two aperatures. The second step is to combine the radiances on these uniform uniform grids into a single grid by taking weighted averages.

A more detailed description of this process can be found in the Algorithm Theoretical Basis Document (ATBD) for the SDR. The ATBD is found at: .

In addition to the dimensions of wavelength and altitude is that of time. The instrument can collect about 160 images of usable data on the day side of an orbit. (Often the instrument is run for 180 images per orbit, but the additional 20 tend to be post-terminator and thus are not useful for ordinary retrievals.)

1.1 Getting Data

The data corresponding to this document can be found via this Digital Object Identifier.

1.2 File format

The data are provided in the HDF5 file format. The hdf5 library is required to read the files. This library is available from the www.hdfgroup.org. In addition to interfaces in C and Fortran, which The HDF Group develops and distributes, there is a high quality interface for Python called H5py distributed independently. These are all open source. In addition to the library The HDF Group also distributes a number of tools for exploring and manipulating HDF5 files. The graphical tool HDFView is highly recommended, especially for those just starting with HDF5 or the OMPS data.

In addition the HDF5 library is incorporated into many common commerical data analysis tools: Matlab, IDL, TecPlot, Mathematica, etc.

The HDF5 file consists of named Groups (which behave analogously to folders or directories in your computer's file system) and named datasets. Because the objects are named they can be accessed by name rather than by file offset.

1.2.1 Datasets, and dimensions

The Datasets in the HDF5 include dimensional and type information. The routines in the HDF5 library can query the file to determine these. Refer to the HDF5 documentation for details in C or Fortran. The higher level languages often have convenience functions which reduce some of the programming burden. These are recommended for users new to HDF5.

1.2.2 Nonrectangular (Ragged) Datasets

The Wavelength, Radiance, and SNR datasets are nonrectangular or ragged. This means that the number of valid indexes in the wavelength dimension is less than or equal to the size of that dimension in the HDF5 dataset. The number of valid indexes is contained in the dataset NumberOfPrimaryChannels and the valid indexes are the lowest. Thus an wavelength dimension has a nominal size of 250. If the number of primary channels is 180 than the first (lowest) 180 indexes will contain good data and the remaining 70 will have fill values. The number of valid indexes is recomputed throughout the orbit and can be different for each slit. This can be seen graphically in Figure 1.

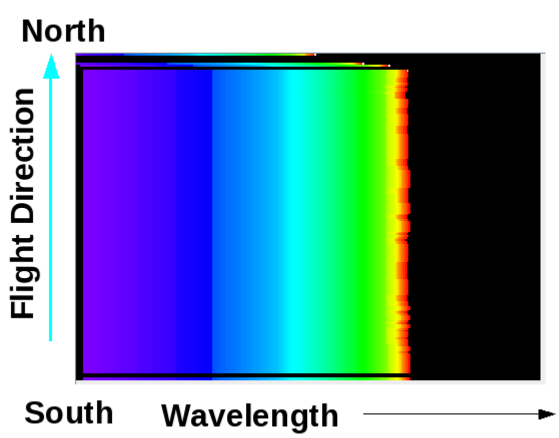


Figure 1: This image shows the wavelengths computed in the gridding process for different measurements during the course of a single orbit for the center slit. The black region on the right are fill values (-999.0). The ragged right hand side edge of color is due to the varying ability of the algorithm to find the same wavelengths for different measurements. Similarly, several horizontal black bands are measurements for which the algorithm could not place any data onto the grid. The black region on the left hand side are small values of wavelength colored black due to an artifact of the color scale.

1.3 Wavelength

A wavelength is assigned for each index of the wavelength dimension of the Radiance dataset. These assignments are non-uniform for three reasons. The first is simply that the light is spectrally resolved via a prism which inherently produces a non-uniform spacing in wavelength space. The second is that bandwidth considerations prevent the entire 2D image on the CCD from being downlinked from the satellite. The selection of which pixels are downlinked is made by a reprogramable table (referred to as the Sample Table). Parts of the spectra which are physically less interesting or are not useful due to instrumental effects (e.g. filter edges) are not downlinked. The Sample Table is programable and subject to change during the mission and while this is expected to be a rare occurance it is possible that a wavelength could appear or disappear during the mission. The wavelength assigments are in the Wavelength dataset described below.

The third reason is that the algorithm which makes the wavelength assigments is trying to produce a profile. If insufficient data (due to saturation or low signal level) are available in a particular profile to interpolate to a particular wavelength then the gridding algorithm will not include that wavelength assignment for that measurement. Since this is scene dependent it can change during the course of an orbit.

Figure 2 shows an example of a profile spectra of the center slit for one measurment.

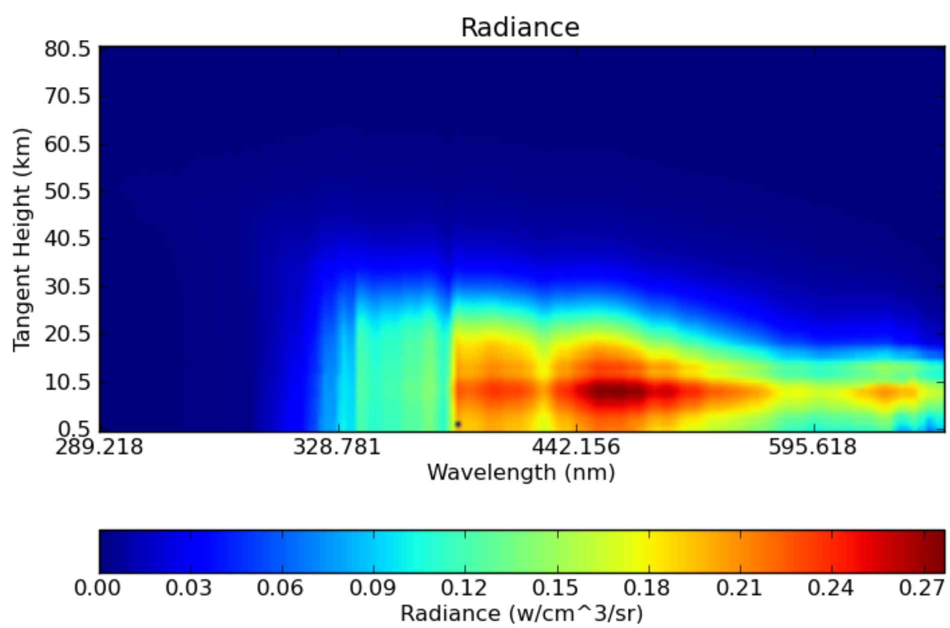
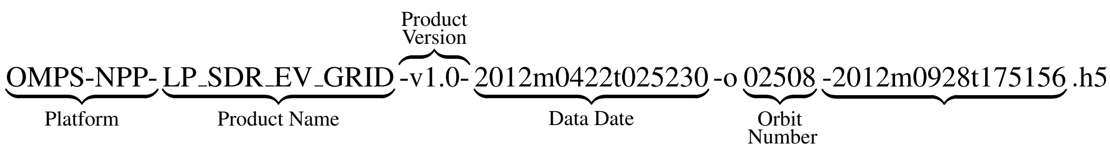


Figure 2: Radiance Spectra

1.4 Product Filenames

The product file names follow this pattern:



1.5 Contents of the Product

1.5.1 Data

The LP_SDR_EV_GRID product contains two important groups, the GRIDDED_DATA group and the GEOLOCATION_DATA group. Using the HDFView TreeView window the contents of the GRIDDED_DATA group looks like Figure 3:

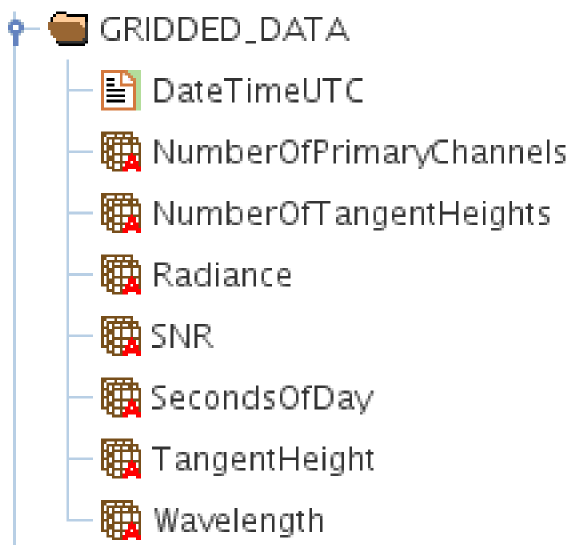


Figure 3: The GRIDDED_DATA group.

and the names of the datasets and their associated units are in Table 2 for GRIDDED_DATA.

The geolocation data group looks like Figure 4:

Dimension Label	**Description**
nTimes	The image dimension. Each index in this dimension corresponds to an image taken at different time. The index is ordered–larger indexes are later in time.
nSlit	The slit dimension. There are three slits and the ordering is left, center right.
nTH	The tangent height dimension. This dimensions corresponds to the tangent height of the grid points. Higher indexes correspond to higher altitudes.
nWave	The wavelength dimension. This dimension corresponds to the wavelength of the grid points. The valid indexes are discussed in Section 1.2.2.

Table 1: Dimension labels and descriptions

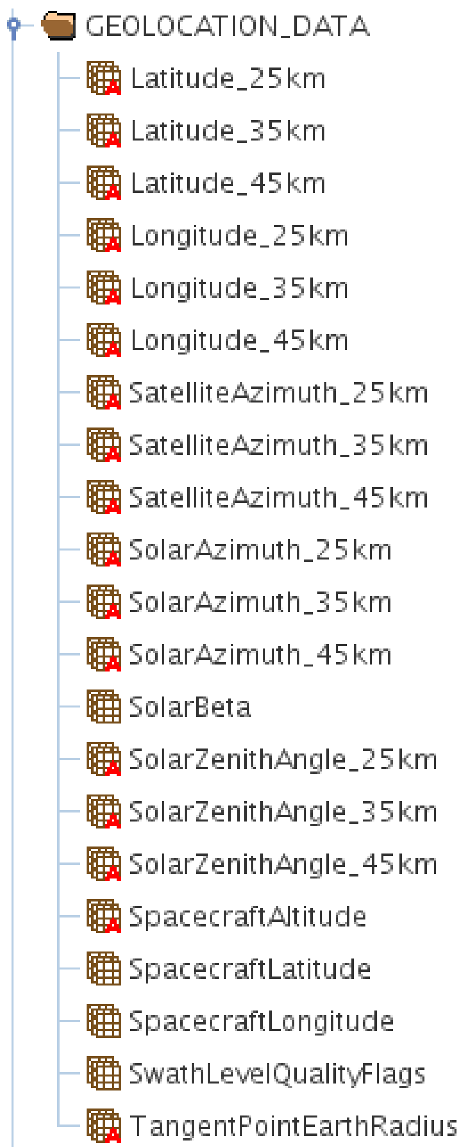


Figure 4: The GEOLOCATION_DATA group.

Dataset Name	Description	Dimensions	Units	Abbrv
DateTimeUTC	Date string in Universal Coordinated Time. Format example is 2012-02-10T05:49:32.954987Z	nTimes x nSlit		
NumberOfPrimaryChannels	The number of valid indexes in the nWave dimension of a dataset. See Section 1.2.2 for details.	nTimes x nSlit	Unitless	NA
NumberOfTangetHeights	The number of tanget heights the G&C algorithm was able to extract.	nTimes x nSlit	Unitless	NA
Radiance	Radiance values combined and interpolated to the grid point.	nTimes x nSlit x nTH x nWave	Watt per centimeter cubed per steradian	$\mathrm{w/cm^3/sr}$
SNR	Estimate of detector noise and *not* an estimate of random measurement uncertainty.	nTimes x nSlit x nTH x nWave	Unitless	NA
TangentHeight	Height above surface along normal to WGS84 elipsoid.	nTimes x nSlit x nTH	kilometers	km
SecondsOfDay	Number of seconds of day.	nTimes x nSlit	UTC time	seconds
Wavelength	The wavelength corresonding to the corresponding index in the Radiance field.	nTimes x nSlit x Wavelimit	microns	μ

Table 2: Field names, description, dimensions, and associated units for GRIDDED_DATA group.

and Table 3 for the GEOLOCATION_DATA.

The gridding algorithm analyzes the data from each event independently and establishes a new Wavelength grid for each one. Thus the array of wavelength axes has a time dimension because the wavelength grid is not fixed for the entire orbit.

For the various azimuth fields 0 is defined as the direction of North. They are defined between -180 and 180 degress. Positive azimuth is East of North.

Table 4 tabulates bits dedicated to flagging instrument-level phenomena such as a celestial body visible in a given slit, relative intensity of SAA particle hits on an OMPS sensor, the likely presence of solar eclipse conditions, and perhaps more. Details of each type of flagging are described following the table.

1.5.2 SAA Flags

Passage through the South Atlantic Anomaly (SAA) is flagged at the swath level because The effect on the CCD of charged-particle hits (primarily protons of solar origin trapped in the Earth's magnetic field) depends only on the spacecraft latitude, longitude, and altitude. While individual pixels may be affected, causing errors in the number of counts for particular FOVs in a particular frame, the geolocation of those pixels is irrelevant to the estimate of the probable number of hits to the CCD; only the spacecraft (and therefore instrument) position matters.

The nominal SAA boundaries are currently configured as follows:

SAA Lon1 = -115.0 deg – Western boundary

SAA Lon2 = 37.5 deg – Eastern boundary

SAA Lat1 = -55.0 deg – Southern boundary

SAA Lat2 = 10.0 deg – Northern boundary

The bounding box can be seen in Figure 5.

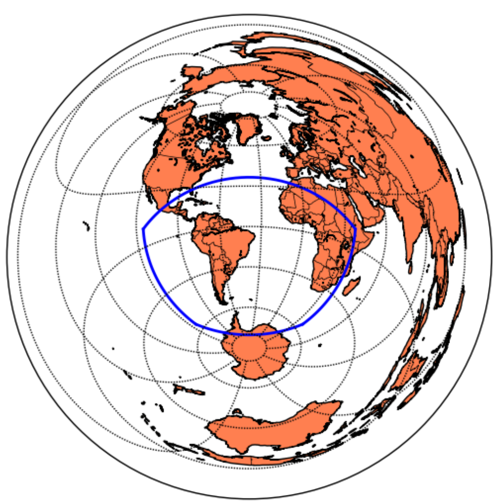


Figure 5: The South Atlantic Anomoly with bounding box in blue.

Dataset Name	Descrption	Dimensions	Units	Abbrv
Latitude_25km Latitude_35km Latitude_45km	The latitude of the tangent point at the indicated reference altitude.	nTimes x nSlit	degrees degrees degrees	
Longitude_25km Longitude_35km Longitude_45km	The longitude of the tangent point at the indicated reference altitude.	nTimes x nSlit	degrees degrees degrees	
SatelliteAzimuth_25km SatelliteAzimuth_35km SatelliteAzimuth_45km	The satellite azimuth of the tangent point at the indicated reference altitude.	nTimes x nSlit	degrees degrees degrees	
SolarAzimuth_25km SolarAzimuth_35km SolarAzimuth_45km	The solar azimuth of the tangent point at the indicated reference altitude.	nTimes x nSlit	degrees degrees degrees	
SolarBeta		nTimes		
SolarZenithAngle_25km SolarZenithAngle_35km SolarZenithAngle_45km	The solar zenith angle of the tangent point at the indicated reference altitude.	nTimes x nSlit	degrees degrees degrees	
SpacecraftAltitude	The spacecraft altitude above the WGS84 elipsoid.	nTimes x nSlit	kilometers	km
SpacecraftLatitude SpacecraftLongitude	The latitude and longitude of the spacecraft ground point on the WGS84 elipsoid.	nTimes	degrees degrees	
SwathLevelQualityFlags	Flags describing various aspects of the measurement.	nTimes	unitless	
TangentPointEarthRadius	Radius of earth at tangent point.		kilometers	km

Table 3: Field names, description, dimensions, and associated units for GEOLOCATION_DATA group.

Byte	Bits	Value
1	0-1	Mercury
	2-3	Venus
	4-5	SAA
	6-7	Mars
2	0-1	Jupiter
	2-3	Saturn
	4-5	Uranus
	6-7	Neptune
3	0-1	Pluto+Charon
	2-3	Moon (Earth's)
	4-7	spare
4	0	Solar Eclipse
	1-7	spare

Table 4: Swath-Level Geolocation Flags for OMPS LP.

bits 4 and 5	Meaning
00	outside SAA boundaries
01	$<$ 5% of nominal maximum SAA effect
10	between 5% and 40% of nominal maximum SAA effect
11	$>$ 40% of nominal maximum SAA effect.

The SAA flag consists of bits 4 and 5 (from 0) of the first byte (1-4) of the 32-bit SwathLevelQualityFlags dataset. Four flag states are possible, see Table 1.5.2.

1.5.3 Solar Eclipse Flag

For OMPS Limb, exactly where the shadow falls on Earth may not be a useful measure of how sunlight may be affected for these measurements during an eclipse. Therefore, the eclipse algorithm sets a flag at in SwathLevelQualityFlags based on the time rather than the specific path of the eclipse. This flag is intended as a qualitative warning for OMPS Limb Earthview and solar calibration measurements. This is how Byte 4 of the 4-byte InstrumentQualityFlags entry looks for a possible solar eclipse at this time somewhere on Earth (generally relevant only on daytime side of Terminator): bbbbbbb1; 0 instead of 1 indicates no eclipse.

1.6 Metadata

1.6.1 Input Pointers

The product file has a group called **Input Pointers**. It contains information about how the data processing proceeded for the file in question. In general this is of little interest to the end user. However, it contents may be useful in specific situations when requesting help from the OMPS Limb PEATE. Figure 1.6.1 shows the TreeView of the input pointers. The dataset **ControlFileContents** is a string containing a data structure in the YAML data serialization language.

Product	DigitalObjectIdentifier	10.5067/suomi-npp/omps-limb/sdr-grid/data11
	Authority	http://dx.doi.org/

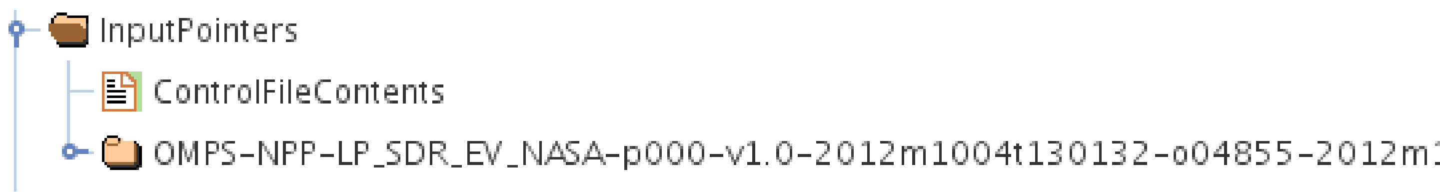


Figure 6: The InputPointers group.

1.6.2 Digital Object Identifier

The data are provided with a Digitial Object Idenifier (DOI). This is similar to a World Wide Web address. It is resolved by a DOI authority which is considered to be more long lived than a particular web site or domain name. The authority resolves the references to an actual web site which contains useful information about the product. Should the responsibility for maintaining the product's web site be shifted to a different organization with a new web address the DOI will be updated in its authority's database so it can continue to function seamlessly.

Figure 7: The DigitalObjectIdentifier dataset.

The DOI is contained in a top level character dataset. The dataset is encoded in JavaScript Object Notation (JSON) which is a data serialization language which is comparatively simple for humans to read. In addition, parsers exist in many languages so that software can automatically parse the string and resolve its different components.

The DOI for the product consists of two components. One is the DOI itself. The second is the DOI authority for resolving the DOI into a Web address, also known as the Landing Page. Figure 1.6.2 shows an example of the value of the DigitalObjectIdentifier dataset. It is broken out into its components in Table 1.6.2.

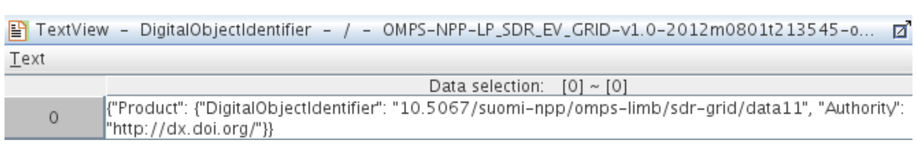


Figure 8: An example of the digital object identifer dataset as viewed in HDFView.

Users seeking to resolve a DOI should also do so