VIIRS User Guide Collection 1

This Guide is a living document that describes the VIIRS BRDF and Albedo Products. The purpose of the document is to give the potential user an understanding of the VNP43 products and the current state of the data in those products. For the most recent update of the VIIRS User Guide Collection 1, please see: https://www.umb.edu/spectralmass/viirs/viirs_user_guide

Note: Users are urged to use the band specific quality flags to isolate the highest quality full inversion results for their own science applications.

Data Product Access: The following tools offer options to search the LP DAAC data holdings and provide access to the data:

- Bulk download: LP DAAC Data Pool and DAAC2Disk
- Search and browse: NASA Earthdata Search

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Introduction

Due to its three dimensional structure, the Earth's surface scatters radiation in an anisotropic manner, especially at the shorter wavelengths that characterize solar irradiance. The Bidirectional Reflectance Distribution Function (BRDF) specifies the behavior of surface scattering as a function of illumination and view angles at a particular wavelength. The albedo of a surface describes the ratio of radiant energy scattered upward and away from the surface in all directions to the down-welling irradiance incident upon that surface. The completely diffuse bihemispherical (or white-sky) albedo can be derived through integration of the BRDF for the entire solar and viewing hemisphere, while the direct beam directional hemispherical (or black-sky) albedo can be calculated through integration of the BRDF for a particular illumination geometry. Actual clear sky albedos under particular atmospheric and illumination conditions can be estimated as a function of the diffuse skylight and a proportion between the black-sky and white-sky albedos. The Visible Infrared Imaging Radiometer Suite (VIIRS) BRDF/Albedo Science Data Products provide white-sky albedos and black-sky albedos (at local solar noon) as both spectral and broadband quantities (VNP43IA3,VNP43MA3, and VNP43DNBA3, where M stands for moderate resolution bands, I stands for imagery resolution bands and DNB stands for the Day/Night Band of VIIRS).

The VIIRS BRDF/Albedo Products also provide Nadir BRDF-Adjusted Reflectances (NBAR) --- surface reflectances corrected to a common nadir view geometry at the local solar noon zenith angle of the day of interest (VNP43IA4, VNP43MA4 and VNP43DNBA4). These anisotropically-corrected surface reflectances can serve as important inputs for studies using vegetation indices and for land cover classification efforts (they are used directly as the primary input to the VIIRS Phenology Product (PI, X. Zhang).

The BRDF specification itself is supplied to the scientific community as a separate product (VNP43IA1, VNP43MA1 and VNP43DNBA1) since it is useful in specifying a surface radiation scattering model for boundary layer parameterization of surface vegetation atmospheric transfer schemes in global climate models. With the model weighting parameters (fiso, fvol, fgeo) and a simple polynomial equation, black-sky albedo can be realistically estimated at any solar zenith angle a user may require. And, since the BRDF is an intrinsic property characterizing the structure of the surface, the parameters themselves may also provide biophysical information of interest.

Algorithm

Every day, the NASA standard VIIRS BRDF/Albedo algorithm makes use of 16 days' worth of multi-date data from Suomi National Polar-orbiting Partnership (NPP) with a semiempirical kernel-driven bidirectional reflectance model to determine a global set of parameters describing the BRDF of the land surface (VNP43IA1, VNP43MA1 and VNP43DNBA1) (see Liu et al., 2017). The high quality input observations are weighted as a function of proximity to the day of interest and the observation coverage. The day of interest (the center date of the retrieval period) will be most heavily weighted.

These gridded BRDF model parameters are then used to determine directional hemispherical reflectance ("black-sky albedo" at the solar zenith angle of local solar noon), and bihemispherical reflectance ("white-sky albedo") for the spectral bands(I1, I2, I3 at a 500m scale, and M1- M5, M7-M8, M10-M11, DNB at a 1km scale) and three broad bands (0.3-0.7µm, 0.7-5.0µm, and 0.3-5.0µm) . Note that the VNP43IA1, 2, 3, and 4 products do not refer to the individual I bands but provide the 4 BRDF albedo products (BRDF parameters, Quality, albedo quantities, and NBAR) for all three of the 500m I bands. Similarly with the VNP43MA1, 2, 3, 4 products. Note that only the 1km scale has sufficient bands to estimate a broadband product while the 500m scale does not. Thus only at 1km scale, can the BRDF and albedos be generated for the three broadbands (0.3–0.7 visible, 0.7–5.0 NIR, and 0.3–5.0 nm shortwave) through the use of narrowband to broadband conversion coefficients. The daily Suomi-NPP VIIRS standard algorithm (Liu et al., 2017; Wang et al., 2013; Schaaf et al., 2011; 2002; Lucht et al., 2000) relies on a combination of the RossThick-LiSparseReciprocal kernels (Wannner et al., 1995; 1997) as the semiempirical model used to invert 16 days' worth of cloud clear, atmospherically corrected, VIIRS directional surface reflectance data and to fit a BRDF to each land surface pixel. Broadband values are computed as well.

In the future, VIIRS data on board Joint Polar Satellite System (JPSS) satellites can also be used. The semiempirical kernel-driven BRDF model (Roujean et al., 1992) represents the weighted sum of an isotropic parameter (fiso) and two functions (or kernels) of viewing and illumination geometry. One of these kernels (Kvol) is derived from volume scattering radiative transfer models (Ross, 1981) , while the other (Kgeo) is derived from surface scattering and geometric shadow casting theory (Li and Strahler, 1987).

The BRDF parameters (fiso , fvol , fgeo) computed in the standard product are the spectrally dependent weights of each of these kernels used in forming the overall reflectance:

$$R = f_{iso} + f_{vol} K_{vol} + f_{geo} K_{geo}$$

When insufficient high quality reflectances are available (currently set to less than seven observations) or even more importantly, a poorly representative sampling of high quality reflectances is obtained (as indicated in the quality flags and determined through the weights of determination), it is not possible to perform a high quality full inversion. Instead, use is made of a database of a priori BRDF parameters to supplement the observational data available and perform a lower quality magnitude inversion. This database is currently updated from the latest high quality full inversion retrieved for each pixel.

The VIIRS BRDF/Albedo Science Data Products are provided in a Sinusoidal Grid (SIN) projection with standard tiles representing 10 degree by 10 degree (2400 by 2400 pixels for 500m scale and 1200 by 1200 pixels for 1km scale) on the Earth. While the projection becomes increasingly sheared poleward, the equal area properties of the SIN projection mean that it is a good data storage format and it is possible to convert each tile to other, more common projections through the use of any one of a number of commercial or public software packages. These Level-3 VIIRS Land products are being released in version 5 Hierarchical Data Format - Earth Observing System (HDF-EOS5) for each of the 10 degree by 10 degree land tiles.

The standard product is associated with mandatory quality and additional extensive quality assurance information stored in VNP43IA2, VNP43MA2 and VNP43DNBA2 so that users can reconstruct the processing methodology used for each tile or pixel if they choose. At a minimum, all VIIRS Land products supply a mandatory per-pixel quality flag indicating whether the algorithm produced results or not for that pixel and if so, whether the result is of the highest quality or whether (due to some uncertainties in the processing) the user should check the extensive additional product-specific quality assurance to make sure the output is appropriate for their application. Note that the per-pixel data and the quality information are currently computed for all land, inland water and coastal areas. The products and quality flags are not currently computed for sea water regions.

Data Flow

The Level 2 Surface Reflectance Product for VIIRS (VNP09) provides daily, cloud-cleared, atmospherically-corrected surface reflectances. The data from the moderate resolution bands (M1–M5, M7–M8 and M10–M11), the imagery resolution bands (I1, I2,I3) and DNB are stored in Level 2Glite gridded SIN tiles. The M bands are gridded to 1km, while the I bands are gridded to 500m.This gridding and binning occurs on a daily basis and at the higher latitudes,all layers of valid data for each day will be used for the retrieval for each pixel. The data from sixteen days' worth of VNP09 are then used as the primary input for the VNP43 BRDF/Albedo Product. VNP43M* is the 1km SIN product for the M bands, the VNP43I* is the 500m SIN product for the I bands and VNP43DNB* is the 1km SIN product for the Day/Night band. The algorithm then fits the BRDF model to these directional surface reflectances and the parameters of the BRDF model (RossThick-LiSparseReciprocal) are provided to the community as Science Data Products (VNP43IA1, VNP43MA1 and VNP43DNBA1) for all the appropriate bands. These same parameters are used to compute the albedo measures provided in VNP43IA3, VNP43MA3 and VNP43DNBA3 and the NBAR values provided in VNP43IA4, VNP43MA4 and VNP43DNBA4. These BRDF parameters of the M bands are also produced in a 30 arc-second resolution Climate Modeling Grid (CMG) in a global geographic lat-long projection (VNP43D*). There are also 0.05 degree resolution Climate Modeling Grid (CMG) Products produced in a global geographic lat/long projection (VNP43C1 (BRDF parameters), VNP43C2 (snowfree BRDF parameters), VNP43C3 (albedo quantities), and VNP43C4 (NBAR)). Users are cautioned that the coarser resolution CMG quality flags only indicate the majority quality of the underlying 30 arc-second data and for that reason the 30arc second data is preferable for quantitative research.

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VNP43 File Specifications

For the VNP43 File Specifications, please

visit: https://ladsweb.modaps.eosdis.nasa.gov/filespec/VIIRS/collection1

VNP43IA1 and VNP43MA1 BRDF/Albedo Model Parameters Product

The VNP43IA1 and VNP43MA1 BRDF Model Parameters Products supply the weighting parameters associated with the RossThickLiSparseReciprocal BRDF model that best describe the anisotropy of each pixel. VNP43IA1 provides information for the three VIIRS Imagery bands(I1, I2, and I3) at a 500m scale, and VNP43MA1 provide information for the nine Moderate bands (M1- M5, M7-M8, M10-M11) at a 1km scale , as well as the information for the three broad bands (0.3-0.7µm, 0.7-5.0µm, and 0.3-5.0µm). Thus note that IA1 refers not to just the I1 band but to the first of the 4 BRDF products (the BRDF model parameters) for all I bands.

These parameters can be used in a forward version of the model to reconstruct the surface anisotropic effects and thus correct directional reflectances to a common view geometry (this is the procedure that is used to produce the VNP43IA4 and VNP43MA4 Nadir BRDF-Adjusted Reflectances - NBAR) or to compute the integrated black-sky (at some solar zenith angle) and white-sky albedos (as are done for VNP43IA3 and VNP43MA3). Alternately, these parameters can be used with a simple polynomial to easily estimate the black-sky albedo with good accuracy for any desired solar zenith angle.

The polynomial is as follows:

$$\alpha_{bs}(\Theta,\lambda) = f_{iso}(\lambda)\,(g_{0iso} + g_{1iso}\,\Theta_i^2 + g_{2iso}\,\Theta_i^3) + f_{vol}(\lambda)\,(g_{0vol} + g_{1vol}\,\Theta_i^2 + g_{2vol}\,\Theta_i^3) + f_{geo}(\lambda)\,(g_{0geo} + g_{1geo}\,\Theta_i^2 + g_{2geo}\Theta_i^3)$$

The appropriate constants are:

Term	Isotropic (iso)	RossThick (vol)	LiSparseR (geo)
g_0	1.0	-0.007574	-1.284909
g_1	0.0	-0.070987	-0.166314
g_2	0.0	0.307588	0.041840

Similarly, the white-sky albedo can be computed by using the equation:

$$\alpha_{\omega_S}(\lambda) = f_{iso}(\lambda)\, g_{iso} + f_{vol}(\lambda)\, g_{vol} + f_{geo}(\lambda)\, g_{geo}$$

and the estimates of the white-sky kernel integrals are:

Term	Isotropic (iso)	RossThick (vol)	LiSparseR (geo)
White-sky integral *g*	1.0	0.189184	-1.377622

The product includes four types of Science Data Sets (SDS) for each pixel in the tile. These SDSs are the BRDF_Albedo_Parameters (three model parameters representing fiso, fvol, fgeo for the RossThickLiSparseReciprocal BRDF model that are computed for the spectral bands and three broadbands), and BRDF_Albedo_Band_Mandatory_Quality (containing 1 byte of quality flags). Note that the Collection 1 VIIRS VNP43 products are retrieved daily and represent the best BRDF possible based on 16 days' worth of inputs with the day of interest emphasized. The date associated with each daily retrieval is the center of the moving 16 day retrieval window.

File Specifications

For the File Specifications for VNP43IA1 and VNP43MA1, please visit: https://ladsweb.modaps.eosdis.nasa.gov/filespec/VIIRS/collection1

Local Attributes

In addition to the actual SDS data values produced at each pixel in a tile, each SDS is associated with a number of standard Local Attributes that apply to the data.

VNP43IA2 and VNP43MA2 BRDF/Albedo Quality Product

The VNP43IA2 and VNP43MA2 BRDF/Albedo Quality Products provide extensive band independent quality information. VNP43IA2 provides information at three VIIRS Imagery bands (I1, I2, and I3) at 500m scale, and VNP43MA2 provides information at nine Moderate bands (M1- M5, M7-M8, M10-M11) as well as for three broad bands (0.3-0.7µm, 0.7-5.0µm, and 0.3-5.0µm).

File Specifications

The File Specifications for VNP43IA2 and VNP43MA2 are at https://ladsweb.modaps.eosdis.nasa.gov/filespec/VIIRS/collection1

VNP43IA3 and VNP43MA3 Albedo Products

Albedo is defined as the ratio of upwelling to downwelling radiative flux at the surface. Downwelling flux may be written as the sum of a direct component and a diffuse component. Black-sky albedo (directional hemispherical reflectance) is defined as albedo in the absence of a diffuse component and is a function of solar zenith angle. White-sky albedo (bihemispherical reflectance) is defined as albedo in the absence of a direct component when the diffuse component is isotropic. Black-sky albedo and white-sky albedo mark the extreme cases of completely direct and completely diffuse illumination. Actual albedo is a value which is interpolated between these two as a function of the fraction of diffuse skylight which is itself a function of the aerosol optical depth [1], [4], [8]. The underlying assumption of an isotropic distribution for the diffuse skylight is approximate but avoids the expense of an exact calculation while capturing the major part of the phenomenon [2]. However, for large angles and bright surfaces it's more appropriate to use the full anisotropic expression [8].

The VNP43IA3 and VNP43MA3 Albedo Product (VIIRS/Suomi-NPP Albedo Daily L3 Global 500m/1km SIN Grid) provides both the white-sky albedos and the black-sky albedos (at local solar noon). VNP43IA3 provides information at the three VIIRS Imagery bands(I1, I2, and I3) at a 500m scale, and VNP43MA3 provides information at the nine Moderate bands (M1- M5, M7-M8, M10-M11) as well as for the three broad bands (0.3-0.7µm, 0.7-5.0µm, and 0.3-5.0µm). While the total energy reflected by the Earth's surface in the shortwave domain is characterized by the shortwave (0.3-5.0µm) broadband albedo, the visible (0.3-0.7µm) and near-infrared (0.7-5.0µm) broadband albedos are often also of interest due to the marked difference of the reflectance of vegetation in these two spectral regions. The same approaches used by Liang et al. [3] and Stroeve et al. [9] are used to produce the narrowband to broadband (NTB) conversion coefficients for VIIRS.
The coefficients used by the operational algorithm are in the following tables (Liu et al., 2017):

Table 1. Narrowband to broadband conversion coefficient-snow free.

	M1	M2	M3	M4	M5	M7	M8	M10	M11	Intercept
Visible	0.1561	-	0.2296	0.3328	0.2815	-	-	-	-	-
NIR	-	-	-	-	-	0.5159	0.0746	0.3414	0.089	-0.0323
Shortwave	0.2418	-0.201	0.2093	0.1146	0.1348	0.2251	0.1123	0.086	0.0803	-0.0131

Table 2. Narrowband to broadband conversion coefficient-snow.

	M1	M2	M3	M4	M5	M7	M8	M10	M11	Intercept
Visible	0.0141	0.238	0.1654	0.2997	0.2839	-	-	-	-	-0.0003
NIR	-	-	-	-	-	0.5603	0.3272	-0.3222	0.1219	0.0045
Shortwave	0.2892	-0.4741	0.6996	-	-	0.2738	0.1463	-0.0309	-	-

Science Data Sets

The albedo product includes two Science Data Sets (SDS) for each pixel in the tile. These SDSs are Albedo (containing both black-sky and white-sky values for 12 bands at 1km scale -- 9 spectral and 3 broad, and 3 spectral bands at 500m scale) and BRDF_Albedo_Band_Mandatory_Quality (containing 1 byte of quality flags).

The Albedo SDS is specified as:

- Data Field Name: INT16 Albedo ("YDim", "XDim", "Num_Albedo_Bands", "Num_Albedos")
- Description: Black-Sky Albedo (at local solar noon) and white-sky albedo for spectral bands, and the vis, NIR and SW broadbands
- Data conversions:
    - file data = (Albedo / scale_factor) + add_offset
    - Albedo = (file data - add_offset) * scale_factor

Note that the Collection 1 VIIRS VNP43 products are retrieved daily and represent the best BRDF possible based on 16 days worth of inputs with the day of interest emphasized. The date associated with each daily retrieval is the center of the moving 16 day input window.

File Specifications

The File Specifications for VNP43IA3 and VNP43MA3 are at https://ladsweb.modaps.eosdis.nasa.gov/filespec/VIIRS/collection1.

Local Attributes

In addition to the actual SDS data values produced at each pixel in a tile, each SDS can be associated with a number of standard metadata Local Attributes that apply to the data.

VNP43IA4 and VNPMA4 NBAR Products

The VNP43IA4 and VNP43MA4 Nadir BRDF-Adjusted Reflectance (NBAR) Products are computed for each of the VIIRS spectral bands at the local solar noon of the day of interest.VNP43IA4 provides information at the three VIIRS Imagery bands (I1, I2, and I3) at 500m scale, and VNP43MA4 provides information at the nine Moderate bands (M1- M5, M7-M8, M10-M11). The view angle effects will have been removed from the directional reflectances, resulting in a more stable and consistent product. These products are primarily used for land cover and phenology monitoring.

Science Data Sets

The NBAR product includes two Science Data Sets (SDS) for each pixel in the tile. These SDSs are Nadir_Reflectance (computed for spectral bands at the local solar noon zenith angle of the day of interest) and BRDF_Albedo_Band_Mandatory_Quality SDS (containing 1 byte of quality flags) . Note that the Collection 1 VIIRS VNP43 products are retrieved daily and represent the best BRDF possible based on 16 days-worth of inputs with the day of interest (the center date of the 16 day retrieval period) emphasized.

File Specifications

The File Specifications for VNP43IA3 and VNP43MA3 are at https://ladsweb.modaps.eosdis.nasa.gov/filespec/VIIRS/collection1.

Local Attributes

In addition to the actual SDS data values produced at each pixel in a tile, each SDS can be associated with a number of standard Local Attributes that apply to the data.

VNP43C1 CMG BRDF/Albedo Model Parameters Product

The VNP43C1 Climate Modeling Grid (CMG) BRDF/Albedo Model Parameters Product at 0.05 degrees spatial resolution supplies the weighting parameters associated with the RossThickLiSparseReciprocal BRDF model that best describes the anisotropy of each pixel. These three parameters (fiso , fvol , fgeo) are provided for each of the VIIRS spectral M bands, as well as for the three broad bands (0.3-0.7µm, 0.7-5.0µm, and 0.3-5.0µm), at a 0.05 degree spatial resolution in global files in a geographic (lat/long) projection. These model parameters are based on the underlying 30arcsecond model parameters. Note that along coastlines, this means that the 30arcsecond pixels that lie over shallow water will be averaged into the 0.05 degree CMG pixel. In addition to the spectral and broadband parameters themselves, the VNP43C1 CMG BRDF/Albedo Model Parameters Product also provides mandatory quality information. The quality and inversion status of the majority of the underlying 30arcsecond pixels is provided as well as the percentage of the underlying pixels that were present or were snow covered. Therefore, caution should be used when assessing these products for highest quality.

These parameters can be used in a forward version of the model to reconstruct the surface anisotropic effects and thus correct directional reflectances to a common view geometry (this is the procedure that is used to produce VNP43C4 Nadir BRDF-Adjusted Reflectances - NBAR) or to compute the integrated black-sky (at some solar zenith angle) and white-sky albedos (as is done for VNP43C3). Alternately, the parameters can be used with a simple polynomial to easily estimate the black-sky albedo with good accuracy for any desired solar zenith angle [1],[2].

The polynomial is as follows:

$$\begin{aligned}\alpha_{bs}(\Theta,\lambda) = {} & f_{iso}(\lambda)\,(g_{0iso} + g_{1iso}\,\Theta_i^2 + g_{2iso}\,\Theta_i^3) + \\ & f_{vol}(\lambda)\,(g_{0vol} + g_{1vol}\,\Theta_i^2 + g_{2vol}\,\Theta_i^3) + \\ & f_{geo}(\lambda)\,(g_{0geo} + g_{1geo}\,\Theta_i^2 + g_{2geo}\,\Theta_i^3)\end{aligned}$$

The appropriate constants are:

Term	Isotropic (iso)	RossThick (vol)	LiSparseR (geo)
g_0	1.0	-0.007574	-1.284909
g_1	0.0	-0.070987	-0.166314
g_2	0.0	0.307588	0.041840

Similarly, the white-sky albedo can be computed by using the equation:

$$\alpha_{\omega s}(\lambda) = f_{iso}(\lambda)\, g_{iso} + f_{vol}(\lambda)\, g_{vol} + f_{geo}(\lambda)\, g_{geo}$$

and the estimates of the white-sky kernel integrals are:

Term	Isotropic (iso)	RossThick (vol)	LiSparseR (geo)
White-sky integral *g*	1.0	0.189184	-1.377622

Science Data Sets

The product includes four Science Data Sets (SDS) for each pixel in the tile. These SDSs are BRDF_Albedo_Parameter1, BRDF_Albedo_Parameter2, and BRDF_Albedo_Parameter3 representing the three model parameters fiso, fvol, fgeo for the RossThickLiSparseReciprocal BRDF model (each for the M bands (M1–M5, M7–M8 and M10–M11) and the three broad bands), and BRDF_Albedo_Quality.They are provided in global files in a geographic (lat/long) projection (3600 rows X 7200 columns (X 10 bands)).

Note that the AS 5000 VIIRS VNP43 products are retrieved daily and represent the best BRDF possible based on 16 days worth of inputs with the day of interest (the center day of the retrieval period) emphasized.

Local Attributes

In addition to the actual SDS data values produced at each pixel in a tile, each SDS is associated with a number of standard Local Attributes that apply to the data.

References:

1. Lucht, W., C.B. Schaaf, and A.H. Strahler. An Algorithm for the retrieval of albedo from space using semiempirical BRDF models, IEEE Trans. Geosci. Remote Sens., 38, 977-998, 2000.
2. Schaaf, C. B., F. Gao, A. H. Strahler, W. Lucht, X. Li, T. Tsang, N. C. Strugnell, X. Zhang, Y. Jin, J.-P. Muller, P. Lewis, M. Barnsley, P. Hobson, M. Disney, G. Roberts, M. Dunderdale, C. Doll, R. d'Entremont, B. Hu, S. Liang, and J. L. Privette, First Operational BRDF, Albedo and Nadir Reflectance Products from MODIS, Remote Sens. Environ., 83, 135-148, 2002.

VNP43C2 CMG BRDF/Albedo Model Snow-Free Parameters Product

This product is similar to the VNP43C1 BRDF model parameters at a 0.05 degree spatial resolution in global files in a geographic (lat/long) projection, but are only computed from the underlying 30arc-second snow-free retrievals.

VNP43C3 CMG Albedo Product

The VNP43C3 Climate Modeling Grid (CMG) at 0.05 degree spatial resolution provides both the white-sky albedos and the black-sky albedos (at local solar noon) for the VIIRS spectral M bands (M1–M5, M7–M8 and M10–M11) as well as for the three broad bands (0.3-0.7µm, 0.7-5.0µm, and 0.3-5.0µm) at a 0.05 degree spatial resolution in global files in a geographic (lat/long) projection. These albedo values are calculated from the BRDF model parameters provided in VNP43C1. Note that along coastlines, this means that the 30arcsecond pixels that lie over shallow water will be averaged into the 0.05 degree CMG pixel. In addition to the spectral and broadband albedo quantities themselves, the VNP43C3 CMG Albedo Product also provides mandatory quality information. The quality and inversion status of the majority of the underlying 30arc pixels is provided as well as the percentage of the underlying pixels that were present or were snow covered. Therefore, the quality should be considered with caution for quantitative applications.

VNP43C4 CMG NBAR Product

The VNP43C4 Climate Modeling Grid (CMG) Nadir BRDF-Adjusted Reflectance (NBAR) Product is computed at a 0.05degree spatial resolution for each of the VIIRS spectral M bands (M1–M5, M7–M8 and M10–M11) at the local solar noon zenith angle of the day of interest. The data are provided in global files in a geographic (lat/long) projection. Since the view angle effects have been removed from the directional reflectances, the result is a stable and consistent reflectance product. These NBAR values are calculated from the BRDF model parameters from VNP43C1. Note that along coastlines, this means that the 30arcsecond pixels that lie over shallow water will be averaged into the 0.05 degree CMG pixel. In addition to the spectral and broadband albedo quantities themselves, the VNP43C4 CMG NBAR Product also provides mandatory quality information. The quality and inversion status of the majority of the underlying 30arcsecond pixels is provided as well as the percentage of the underlying pixels that were present or were snow covered. Therefore, quality should be considered with caution when using this product for quantitative results.

VNP43D CMG 30 Arc-Second Products

The Collection 1 VNP43D products are retrieved from the 1km BRDF parameters in VNP43MA1. Because of the large size of the products, each Parameter for each of the 9 VIIRS M bands and the 3 broadbands are stored in a separate VNP43D file. Therefore VNP43D1 is the VIIRS (blue) band M1 fiso parameter, VNP43D2 is the VIIRS band M1 fvol parameter, VNP43D3 is the VIIRS band M1 fgeo parameter , and then VNP43D4 is the VIIRS band M2 fiso parameter and so on through to VNP43D36. MCD43D37-MCD43D49 are the 30arc second BRDF/Albedo Quality values, the Local Solar Noon values, the ValidObs of the M bands (M1–M5, M7–M8 and M10–M11), the Snow Status and the Uncertainty. VNP43D50-VNP43D61 are the black sky albedos (BSA) at local solar noon for the 9 VIIRS M bands followed by the three broadbands. VNP43D62-VNP43D73 are the white sky albedos (WSA) for the 9 M bands and the three broadbands. Finally VNP43D74-VNP43D82 provide the 30arcsecond NBAR values (at local solar noon) for the 9 VIIRS M bands.

ESDT	Description
VNP43D01-36	Daily VIIRS/NPP BRDF Parameters. Bands M1- M5, M7-M8, M10-M11 and visible, NIR, and shortwave broadband.
VNP43D37	BRDF/Albedo Quality: o 0 = best quality, full inversion (WoDs, RMSE good) o 1 = good quality, full inversion o 2 = Magnitude inversion (numobs >=7) o 3 = Magnitude inversion (numobs >=2&<7) o 255 = Fill value
VNP43D38	Local Solar Noon
VNP43D39-47	Valid observations. Bands M1- M5, M7-M8, M10-M11.
VNP43D48	BRDF/Albedo Snow status
VNP43D49	BRDF/Albedo Uncertainty
VNP43D50-61	BRDF/Albedo BSA at local solar noon. Bands M1- M5, M7-M8, M10-M11 and visible, NIR, and shortwave broadband.
VNP43D62-73	BRDF/Albedo WSA. Bands M1- M5, M7-M8, M10-M11 and visible, NIR, and shortwave broadband.
VNP43D74-82	BRDF/Albedo NBAR. Bands M1- M5, M7-M8, M10-M11.

Note that the Collection 1 VIIRS VNP43 products are retrieved daily and represent the best BRDF possible based on 16 days' worth of inputs with the day of interest (the center day of the retrieval period) particularly emphasized. This change is in response to user requests.

VNP43GF CMG Gap-Filled Snow-Free Products

VIIRS BRDF/Albedo/NBAR CMG Gap-Filled Products (VNP43GF) will be produced from Collection 1 VNP43D data and temporally fitted once Collection 1 is completed. These will eventually be placed at the DAACs.

VNP43DNBA1 BRDF/Albedo Model Parameters Product

The VNP43DNBA1 BRDF Model Parameters Products supply the weighting parameters associated with the RossThickLiSparseReciprocal BRDF model that best describe the anisotropy of each pixel. VNP43DNBA1 provides information for the VIIRS DNB band at a 1km scale. These parameters can be used in a forward version of the model to reconstruct the surface anisotropic effects and thus correct directional reflectances to a common view geometry (this is the procedure that is used to produce the VNP43DNBA4 Nadir BRDF-Adjusted Reflectances - NBAR) or to compute the integrated black-sky (at some solar zenith angle) and white-sky albedos (VNP43DNBA3). Alternately, these parameters can be used with a simple polynomial to easily estimate the black-sky albedo with good accuracy for any desired solar zenith angle.

The polynomial is as follows:

$$\alpha_{bs}(\Theta,\lambda) = f_{iso}(\lambda)\,(g_{0iso} + g_{1iso}\,\Theta_i^2 + g_{2iso}\,\Theta_i^3) + f_{vol}(\lambda)\,(g_{0vol} + g_{1vol}\,\Theta_i^2 + g_{2vol}\,\Theta_i^3) + f_{geo}(\lambda)\,(g_{0geo} + g_{1geo}\,\Theta_i^2 + g_{2geo}\Theta_i^3)$$

The appropriate constants are:

Term	Isotropic (iso)	RossThick (vol)	LiSparseR (geo)
g_0	1.0	-0.007574	-1.284909
g_1	0.0	-0.070987	-0.166314
g_2	0.0	0.307588	0.041840

Similarly, the white-sky albedo can be computed by using the equation:

$$\alpha_{ws}(\lambda) = f_{iso}(\lambda)\,g_{iso} + f_{vol}(\lambda)\,g_{vol} + f_{geo}(\lambda)\,g_{geo}$$

and the estimates of the white-sky kernel integrals are:

Term	Isotropic (iso)	RossThick (vol)	LiSparseR (geo)
White-sky integral *g*	1.0	0.189184	-1.377622

The product includes four types of Science Data Sets (SDS) for each pixel in the tile. These SDSs are the BRDF_Albedo_Parameters (three model parameters representing fiso, fvol, fgeo for the RossThickLiSparseReciprocal BRDF model that are computed for the spectral bands and three broadbands), and BRDF_Albedo_Band_Mandatory_Quality (containing 1 byte of quality flags). Note that the Collection 1 VIIRS VNP43 products are retrieved daily and represent the best BRDF possible based on 16 days' worth of inputs with the day of interest emphasized. The date associated with each daily retrieval is the center of the moving 16 day retrieval window.

Local Attributes

In addition to the actual SDS data values produced at each pixel in a tile, each SDS is associated with a number of standard Local Attributes that apply to the data.

VNP43DNBA2 BRDF/Albedo Quality Product

The VNP43DNBA2 BRDF/Albedo Quality Products provide extensive band independent quality information at VIIRS Day/Night Band.

VNP43DNBA3 Albedo Product

Albedo is defined as the ratio of upwelling to downwelling radiative flux at the surface. Downwelling flux may be written as the sum of a direct component and a diffuse component. Black-sky albedo (directional hemispherical reflectance) is defined as albedo in the absence of a diffuse component and is a function of solar zenith angle. White-sky albedo (bihemispherical reflectance) is defined as albedo in the absence of a direct component when the diffuse component is isotropic. Black-sky albedo and white-sky albedo mark the extreme cases of completely direct and completely diffuse illumination. Actual albedo is a value which is interpolated between these two as a function of the fraction of diffuse skylight which is itself a function of the aerosol optical depth [1], [4], [8]. The underlying assumption of an isotropic distribution for the diffuse skylight is approximate but avoids the expense of an exact calculation while capturing the major part of the phenomenon [2]. However, for large angles and bright surfaces it's more appropriate to use the full anisotropic expression [8].

The VNP43DNBA3 Albedo Product (VIIRS/Suomi-NPP Albedo Daily L3 Global 1km SIN Grid) provides *both* the white-sky albedos and the black-sky albedos (at local solar noon) at the Day/Night Band.

Science Data Sets

The albedo product includes two Science Data Sets (SDS) for each pixel in the tile. These SDSs are Albedo (containing both black-sky and white-sky values for Day/Night band at 1km scale) and BRDF_Albedo_Band_Mandatory_Quality (containing 1 byte of quality flags).

The Albedo SDS are specified as:

- Data Field Name: INT16 Albedo ("YDim", "XDim", "Num_Albedo_Bands", "Num_Albedos")
- Description: Black-Sky Albedo (at local solar noon) and white-sky albedo for Day/Night Band
- Data conversions:
    - file data = (Albedo / scale_factor) + add_offset
    - Albedo = (file data - add_offset) * scale_factor

Note that the Collection 1 VIIRS VNP43 products are retrieved daily and represent the best BRDF possible based on 16 days worth of inputs with the day of interest emphasized. The date associated with each daily retrieval is the center of the moving 16 day input window.

Local Attributes

In addition to the actual SDS data values produced at each pixel in a tile, each SDS can be associated with a number of standard metadata Local Attributes that apply to the data.

VNP43DNBA4 NBAR Product

The VNP43DNBA4 Nadir BRDF-Adjusted Reflectance (NBAR) Products are computed for each of the VIIRS Day/Night band at the local solar noon of the day of interest. The view angle effects will have been removed from the directional reflectances, resulting in a more stable and consistent product. These products are primarily used for land cover and phenology monitoring.

Science Data Sets

The NBAR product includes two Science Data Sets (SDS) for each pixel in the tile. These SDSs are Nadir_Reflectance (computed at the local solar noon zenith angle of the day of interest) and BRDF_Albedo_Band_Mandatory_Quality SDS (containing 1 byte of quality flags) .
Note that the Collection 1 VIIRS VNP43 products are retrieved daily and represent the best BRDF possible based on 16 days worth of inputs with the day of interest (the center date of the 16 day retrieval period) emphasized.

Local Attributes

In addition to the actual SDS data values produced at each pixel in a tile, each SDS can be associated with a number of standard Local Attributes that apply to the data.