# *Land Surface Bundle (01B-20)*

## *(Surface Reflectance – Polar Orbiter (01B-20a), Normalized Difference Vegetation Index (01B-20b), Leaf Area Index & Fraction of Photosynthetically Active Radiation (01B-20c)*

# User Guide

## 1. Document Purpose

### 1.1 Intent

This document is intended for users who wish to use the *Land Surface Bundle* Climate Data Records. Users are not expected to be experts in the data. This document summarizes essential information needed to understand the context of the dataset observations and issues that affect its fitness for purpose. References at the end of this document provide additional resources and information.

### 1.2 Dataset information

| | |
|---|---|
| Dataset name and version: | *Land Surface Bundle Climate Data Records, version 5.0 (AVHRR), version 1.0 (VIIRS)* |
| Digital Object Identifier (DOI): | Surface Reflectance – Polar Orbiter (01B-20a)<br>https://doi.org/10.7289/V53776Z4 (AVHRR)<br>https://doi.org/10.25921/e86y-fe34 (VIIRS)<br><br>Normalized Difference Vegetation Index (01B-20b)<br>https://doi.org/10.7289/V5ZG6QH9 (AVHRR)<br>https://doi.org/10.25921/gakh-st76 (VIIRS)<br><br>Leaf Area Index & FAPAR (01B-20c)<br>https://doi.org/10.7289/V5TT4P69 (AVHRR)<br>https://doi.org/10.25921/9x3m-0e02 (VIIRS) |
| Email address: | land_sfc_bundle_contacts@noaa.gov |

# Table of Contents

1. Document Purpose 1
1.1 Intent 1
1.2 Dataset information 1
2. Revisions 3
2.1 Document revision history 3
2.2 Dataset history 3
3. CDR Overview 3
3.1 Summary of the dataset 3
3.2 File naming convention 4
3.3 File Format 5
3.4 Spatial Coverage 5
3.5 Temporal Coverage 5
4. CDR production 5
4.1 Observational data sources (input data) 5
4.2 Other data sources (ancillary data) 6
4.3 High-level processing overview 8
5. Using the CDR 9
5.1 Known or recommended applications 9
5.2 Uncertainty Quantification 9
5.3 Limitations and Caveats 10
5.4 Using quality flags 10
5.5 Merged timeseries analysis 14
6. References 15
Appendices 16
Data access 16
Description of variables 16
Table 1: Layers of the Surface Reflectance - Polar Orbiter products 16

# 2. Revisions

## 2.1 Document revision history

| Revision Number | Date | Summary of changes |
|---|---|---|
| 0.0 | 11/17/2026 | *Land Surface Bundle Climate Data Records, version 5.0 (AVHRR), version 1.0 (VIIRS)* |

## 2.2 Dataset history

The Land Surface Bundle CDRs for VIIRS (2014-present) Surface Reflectance – Polar Orbiter, Normalized Difference Vegetation Index (NDVI) and Leaf Area Index-Fraction of Absorbed Photosynthetically Active Radiation (LAI-FAPAR) reflect the current and only version to date using VIIRS as an input, version 1. Version 5 is the most recent version for the AVHRR portion of the Land Surface Bundle CDR time series (1981-2013).

# 3. CDR Overview

## 3.1 Summary of the dataset

Surface reflectance is radiance data corrected for atmospheric effects (Rayleigh scattering, water vapor and ozone), solar and satellite view angles, and aerosols. The VIIRS surface reflectance data used in this CDR is read from daily VIIRS CMGs (Climate Modeling Grids), specifically from bands I1 and I2 in the CMGs. AVHRR Global Area Coverage (GAC) Level 1b reflectance is used as the primary input for the AVHRR surface reflectance CDR. The VIIRS Normalized Difference Vegetation Index (NDVI) is a measure of vegetation density and health, and is obtained from the surface reflectance as the difference between I1 and I2, divided by their sum:

$$NDVI = \frac{\mathrm{I2}-\mathrm{I1}}{\mathrm{I2}+\mathrm{I1}} \quad (1)$$

The VIIRS Leaf Area Index-Fraction of Absorbed Photosynthetically Active Radiation (LAI-FAPAR) are obtained from Artificial Neural Networks (ANN) specifically trained on well-characterized LAI-FAPAR data (the MODIS combined MCD15A2 product), given I1, I2, NDVI and solar zenith values:

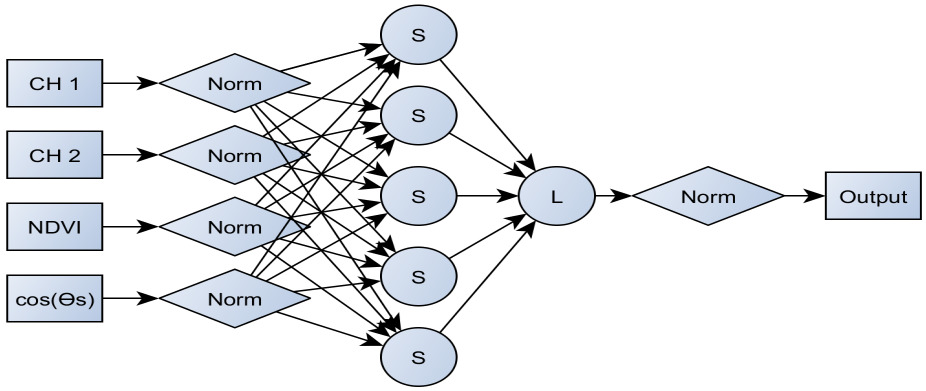


***Figure 1: Conceptual representation of the Artificial Neural Network, including normalization steps. S and L stand for "sigmoid" and "linear" neurons, respectively; CH 1, 2 are reflectances in each channel (equivalent to I1, I2).***

The calculation for the AVHRR NDVI and LAI-FAPAR is similar, except using Channels 1 and 2.

## 3.2 File naming convention

All files are produced daily, covering one data-day. An example filename using VIIRS inputs is:

**VIIRS-Land_v001_NPP09C1_SNPP_20210424_c20210505165924.nc**

or

**<product-name>_<product-version>_<product-type>_<satellite>_<YYYYmmdd>_ c<processing-date>.nc**

With the following naming convention:

<product-name> = static series name of the product with the value, "VIIRS-Land" or "AVHRR-Land"

<product-version> = product version number, "v001" or "v005"

<product-type> = product type identifier with the valid domain:
"AVH09C1" = AVHRR surface reflectance product (1981-2013)
"AVH13C1" = AVHRR NDVI product (1981-2013)
"AVH15C1" = AVHRR LAI-FAPAR product (1981-2013)
"NPP09C1" = VIIRS surface reflectance product from SNPP (2014 to 2022)
"NPP13C1" = VIIRS NDVI product from SNPP (2014 to 2022)
"NPP15C1" = VIIRS LAI-FAPAR product from SNPP (2014 to 2022)
"JP109C1" = VIIRS surface reflectance product from JPSS-1 (2023 to the present)

"JP113C1" = VIIRS NDVI product from JPSS-1 (2023 to the present)
"JP115C1" = VIIRS LAI-FAPAR product from JPSS-1 (2023 to the present)

<satellite> = satellite: "NOAA-07", "NOAA-09", "NOAA-11", "NOAA-14", "NOAA-16", "NOAA-18", "NOAA-19", "S-NPP", "NOAA-20", etc.

<YYYYmmdd> = Date of the data in the file, formatted as year, month and day

c<processing-date> = Creation or processing date of the file identified with a 'c' followed by the year, month, day, hour, minute and second

.nc indicates the format (NetCDF4)

### 3.3 File Format

NOAA Climate Data Records (CDRs) are provided in netCDF4 format. More information on this format is provided by Unidata. Most every programming language and several stand-alone software packages (both free and paid) can process netCDF4 data.

### 3.4 Spatial Coverage

The spatial coverage of all products is from -90° to 90° latitude and -180° to 180° longitude, and mapped on a 0.05°x0.05° latitude/longitude grid, for a total of 3600 lines by 7200 columns, in a Climate Modeling Grid (CMG). However, other than QA (quality assessment) data, no products are generated over any bodies of water – pixels over oceans and lakes remain at fill values. Moreover, no LAI-FAPAR data is generated at pixels flagged as cloudy (these also are fill values).

### 3.5 Temporal Coverage

All data is daily, and the temporal coverage of all data is from June 24, 1981 and continuing. Each day's data is processed once the inputs for it (e.g. daily VNP09CMG, VJ109CMG files) become available. Inputs for data day N are typically available and processed on day N+2 (i. e., what is processed today is typically data from two days ago), but delays in processing the inputs may lengthen this time lag.

## 4. CDR production

### 4.1 Observational data sources (input data)

The AVHRR and VIIRS instruments observe and collect global satellite observations that span visible and infrared wavelengths across land, ocean, and atmosphere. AVHRR Global Area Coverage (GAC) data Level 1b data is used for AVHRR products. Reflectances for Channels 1-

2 and brightness temperatures for Channels 3-5 are key inputs to this CDR bundle. VIIRS is a whiskbroom radiometer by design, it has 22 channels ranging from 0.41 μm to 12.01 μm. Five of these channels are high-resolution image bands or I-bands, and sixteen serve as moderate-resolution bands or M-bands.
The Surface Reflectance retrieval algorithm corrects radiance data for the effects of gaseous absorption, molecular and aerosol scattering, thin cirrus contamination, the coupling of the atmosphere, the elevation of the target and spectral band. Surface Reflectance for three of the I-bands and twelve of the M-bands is written to VNP09 (doi:10.5067/VIIRS/VNP09.002) or VJ109 (doi:10.5067/VIIRS/VJ109.002) files, which in turn serve as inputs to a daily CMG version of the Surface Reflectance data, the VNP09CMG (doi: 10.5067/VIIRS/VNP09CMG.002) or VJ109CMG (doi: 10.5067/VIIRS/VJ109CMG.002 files). The VNP09CMG and VJ109CMG files serve as inputs to the CDR bundle. See the following web pages for more information:
https://www.earthdata.nasa.gov/data/catalog/laads-vj109-2
https://www.earthdata.nasa.gov/data/catalog/lpcloud-vj109cmg-002

## 4.2 Other data sources (ancillary data)

Data from VNP09CMG or VJ109CMG files are adjusted for bi-directional reflectance distribution function (BRDF) effects. The BRDF-coupling adjustment is presently designed after the MODIS approach with a slight modification making the isotropic shape parameter a function of the normalized difference vegetation index, NDVI (Vermote et al, 2009). Four precomputed coefficients ($V_0$, $V_1$, $R_0$, $R_1$) were derived from MODIS observations using the approach presented in Vermote et al. (2009), and serve as look-up tables (LUTs) for the BRDF correction in this CDR.

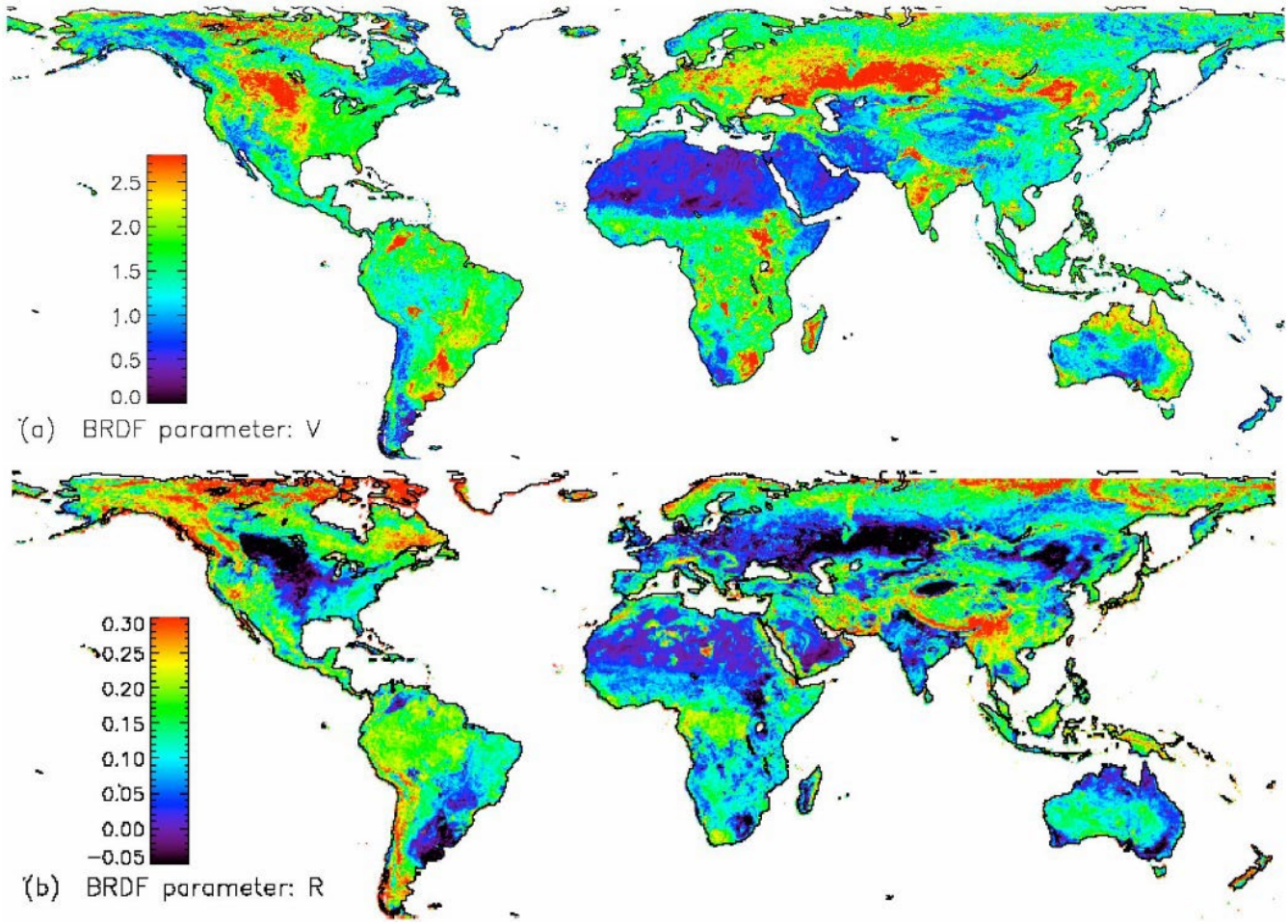


***Figure 2: Global map of the V (a) and R (b) parameters derived by Vermote et al. 2009 applied to the time series of Terra MODIS band 2 (2000–2004). V and R are shown for highest NDVI values of each pixel.***

Multiple ancillary data sets are used in the surface reflectance algorithm including column ozone, precipitable water, surface pressure, and digital elevation models. Another LUT is used in the LAI-FAPAR calculation, the International Geosphere-Biosphere Program's (IGBP) Land Cover classification, resampled to a 0.05° CMG. More details can be found in the relevant C-ATBDs:

**LAI-FAPAR**
https://www.ncei.noaa.gov/pub/data/sds/cdr/CDRs/Leaf_Area_Index_and_FAPAR/AVHRR/AlgorithmDescriptionAVHRR_01B-20c.pdf
https://www.ncei.noaa.gov/pub/data/sds/cdr/CDRs/Leaf_Area_Index_and_FAPAR/VIIRS/AlgorithmDescriptionVIIRS_01B-20c.pdf

**NDVI**
https://www.ncei.noaa.gov/pub/data/sds/cdr/CDRs/Normalized_Difference_Vegetation_Index/AVHRR/AlgorithmDescriptionAVHRR_01B-20b.pdf

https://www.ncei.noaa.gov/pub/data/sds/cdr/CDRs/Normalized_Difference_Vegetation_Index/VIIRS/AlgorithmDescriptionVIIRS_01B-20b.pdf

## 4.3 High-level processing overview

The software specific to this CDR uses AVHRR Global Area Coverage (GAC) data Level 1b data, VNP09CMG or VJ109CMG files as inputs. Bands I1 and I2 (and I3) from the CMGs are corrected for the surface bidirectional reflectance as a function of the viewing and solar geometries, to a constant view zenith (0°, e. g., at nadir) and a constant solar zenith angle (45°). These BRDF-adjusted bands are then written as the first product of this CDR, the Surface Reflectance – Polar Orbiter file. BRDF-corrected bands I1 and I2 are then used to calculate NDVI (equation 1, above), with NDVI written as the second product of this CDR, the Normalized Difference Vegetation Index file.

For calculation of the Leaf Area Index and Fraction of Absorbed Photosynthetically Active Radiation, the BRDF-corrected bands are further adjusted by the VJB algorithm, which restores the reflectance values at their original solar zenith values, since FAPAR algorithm requires the actual solar zenith values. Bands I1, I2, their NDVI and the cosine of the solar zenith are then normalized and entered into Artificial Neural Networks (ANN; Figure 1).

For each configuration (5 different biomes x 2 output variables), 10 ANN had been trained, using the equivalent MODIS surface reflectance bands 1 and 2, resulting in 100 ANN in total. The selection of the "optimal" ANN was based on the RMSE between the outputs and the "true" biophysical variables from sites used for validation (resampled ground-truth MODIS (MCD15A2) LAI and FAPAR data measured at BELMANIP-2 and DIRECT network sites).

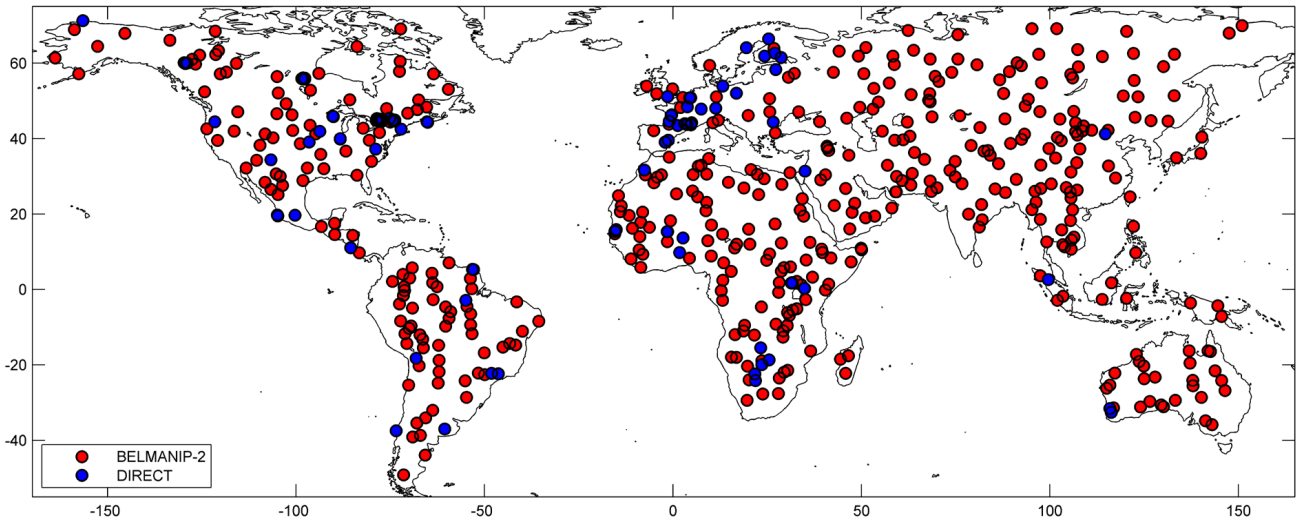


***Figure 3: BELMANIP-2 and DIRECT network sites location.***

The “optimal” ANN were then used to calculate the LAI and FAPAR in the third product of this CDR, the LAI-FAPAR.

For detailed data flow diagrams on all Land Surface Bundle CDRs see the following:

Surface Reflectance – Polar Orbiter (01B-20a) and NDVI (01B-20b)
CDRP-DIA-0460 Rev 1 (AVHRR)
CDRP-DIA-1268 Rev 0 (VIIRS)

Leaf Area Index & FAPAR (01B-20c)
CDRP-DIA-0591 Rev 1 (AVHRR)
CDRP-DIA-1445 Rev 0 (VIIRS)

# 5. Using the CDR

## 5.1 Known or recommended applications

The LAI portion of this CDR has been requested using the Rapid Evaluation Framework for inclusion in the Intergovernmental Panel on Climate Change Assessment Report. The LAI dataset was also submitted for inclusion within the Earth System Grid Federation. The LAI, FAPAR and NDVI portions of the CDR have been incorporated into the Earth Engine Data Catalog (https://developers.google.com/earth-engine/datasets).

## 5.2 Uncertainty Quantification

The Surface Reflectance - Polar Orbiter algorithm performance may be affected by sensor, solar and viewing geometry effects including target elevation above sea level, atmospheric, and coupling of the atmosphere and surface effects, i.e., BRDF, among others. The atmospheric effects include aerosol and Rayleigh scattering, gaseous absorption, and thermodynamic conditions. The largest atmospheric effects on surface reflectance retrieval are from variations in aerosol properties. The absolute error in the retrieved surface reflectance (assuming a Lambertian surface) is typically 0.02 to 0.06 of a unit for a clear atmosphere to 0.03-0.11 for a hazy atmosphere.

The performances of the LAI and FAPAR estimates were evaluated over *in situ* measurements from the DIRECT network; the sites were not used in the ANN learning process. Scatter plot per class are shown in Figure 4. LAI validation scatter plots were divided among the type of measurement: Effective and true LAI, depending if the clumping factor is included or not (see Claverie et al. 2012).

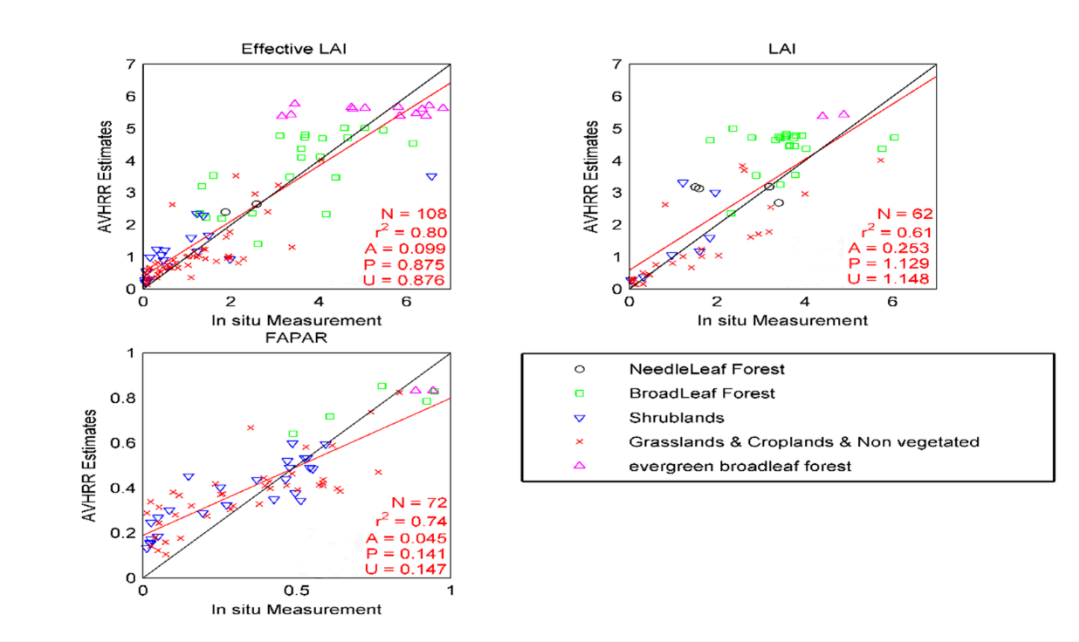


***Figure 4: In-situ validation over DIRECT sites. Ground measurement covered initially a footprint of 3x3 km.; they were extrapolated to 0.05° using MCD15 products. AVHRR LAI/FAPAR and VIIRS LAI/FAPAR are closely correlated (see figure 12 of the VIIRS LAI/FAPAR CATBD).***

## 5.3 Limitations and Caveats

Several algorithms involved in the generation of the Surface Reflectance - Polar Orbiter, NDVI and the LAI-FAPAR CDRs are limited in their accuracy (as determined by ground-truth validation studies). Several factors may affect their accuracy, including:
for the aerosol retrieval algorithm that yields data used by the surface reflectance algorithm,
--- the assumption that the surface is Lambertian
--- optimal performance over dark targets, with suboptimal aerosol retrieval over lighter pixels
for the surface reflectance algorithm itself,
--- the assumption that the surface is Lambertian
--- optimal performance over clear pixels, suboptimal performance over high-aerosol pixels
--- best performance at low solar zenith and view zenith angles
for the LAI-FAPAR algorithm
--- saturation of Channel 1 and 2 signals over dense vegetation cover can result in an underestimation of LAI and FAPAR there.

## 5.4 Using quality flags

The ‘QA’ datasets for the AVHRR Surface Reflectance - Polar Orbiter and NDVI CDRs have the following bit mapping, where users are recommended to use the bold selections to ensure the highest quality data:

| Bits Number | Bits Description | Value |
|---|---|---|
| 15 | Polar flag (latitude over 60 degrees (land) or 50 degrees (ocean)) | 1: yes |
| | | **0: no** |
| 14 | BRDF-correction issues | 1: yes |
| | | **0: no** |
| 13 | RHO3 value is invalid | 1: yes |
| | | **0: no** |
| 12 | Channel 5 value is invalid | 1: yes |
| | | **0: no** |
| 11 | Channel 4 value is invalid | 1: yes |
| | | **0: no** |
| 10 | Channel 3 value is invalid | 1: yes |
| | | **0: no** |
| 9 | Channel 2 value is invalid | 1: yes |
| | | **0: no** |
| 8 | Channel 1 value is invalid | 1: yes |
| | | **0: no** |
| 7 | Channels 1-5 value are valid | **1: yes** |
| | | 0: no |
| 6 | Night (high solar zenith) | 1: yes |
| | | **0: no** |
| 5 | Dense dark vegetation | **1: yes** |
| | | **0: no** |
| 4 | Sunglint | 1: yes |
| | | **0: no** |
| 3 | Water | 1: yes |
| | | **0: no** |
| 2 | Cloud shadow | 1: yes |
| | | **0: no** |
| 1 | Cloudy | 1: yes |
| | | **0: no** |
| 0 | Spare (unused) | --- |

The ‘QA’ datasets for the VIIRS Surface Reflectance - Polar Orbiter and NDVI CDRs have the following bit mapping, where users are recommended to use the bold selections to ensure the highest quality data:

| Bits Number | Bits Description | Value |
|---|---|---|
| 15 | Snow/ice flag | 1: snow/ice |
| | | **0: no snow/ice** |
| 11-14 | Spare (unused) | --- |
| 10 | Cloud flag | 1: cloud |
| | | **0: no cloud** |
| 9 | Thin cirrus emissive | 1: yes |
| | | **0: no** |
| 8 | Thin cirrus reflective | 1: yes |
| | | **0: no** |
| 6-7 | Aerosol quantity:level of uncertainty in aerosol correction | **00: climatology** |
| | | **01: low** |
| | | **10*: Average*** |
| | | 11: High |
| 3-5 | Land/water flag | **000: Land and desert** |
| | | **001: Land/no desert** |
| | | 010: Inland water |
| | | 011: Sea water |
| | | 101: Coastal |
| 2 | Cloud shadow | 1: yes |
| | | **0: no** |
| 0-1 | Cloud state | **00: Confident clear** |
| | | 01: Probably clear |
| | | 10: Probably cloudy |
| | | 11: Confident cloudy |

The ‘QA’ dataset for the AVHRR LAI-FAPAR CDRs has this bit mapping, where users are recommended to use the bold selections to ensure the highest quality data:

| Bits Number | Bits Description | Value |
|---|---|---|
| 9-15 | Spare (unused) | **---** |
| 7-8 | Polygon test | **00: in polygon** |
| | | 01: not in polygon |
| | | 10*:* not tested (water/cloudy) |
| 6 | BRDF corrected | 0: no |
| | | **1: yes** |
| 2-5 | Associated Class | **0001: NeedleLeaf Forest** |
| | | **0010: BroadLeaf Forest** |
| | | **0011: Shrublands** |
| | | **0100: Grasslands & Croplands & Non vegetated** |
| | | **0101: Evergreen broadleaf forest** |
| | | 0110: Water |
| 0-1 | Quality control | **00: OK** |
| | | 01: Input flag as Cloudy |
| | | 10: Invalid input |
| | | 11: Output out of range |

The ‘QA’ dataset for the VIIRS LAI-FAPAR CDRs has this bit mapping, where users are recommended to use the bold selections to ensure the highest quality data:

| Bits Number | Bits Description | Value |
|---|---|---|
| 6-7 | Polygon test | **00: in polygon** |
| | | 01: not in polygon |
| | | 10*:* not tested (water/cloudy) |
| 5 | BRDF corrected | 0: no |
| | | **1: yes** |
| 2-4 | Associated Class | **001: NeedleLeaf Forest** |
| | | **010: BroadLeaf Forest** |
| | | **011: Shrublands** |
| | | **100: Grasslands & Croplands & Non vegetated** |
| | | **101: Evergreen broadleaf forest** |
| | | 110: Water |
| 0-1 | Quality control | **00: OK** |
| | | 01: Input flag as Cloudy |
| | | 10: Invalid input |
| | | 11: Output out of range |

## 5.5 Merged timeseries analysis

There is a significant change between AVHRR and VIIRS in the central wavelengths and bandwidths of several channels. Of particular consequence for this bundle of products are the changes from AVHRR channel 2 to VIIRS channel I2 where the central wavelength changes from 830 to 865 nm. NDVI is particularly sensitive to this shift while LAI and FAPAR are only 7 mildly impacted. This results is a step change in the full time series where the data switches from AVHRR to VIIRS in 2014.

In order to perform long-term climatological analysis on the full time series, the following approach is suggested to mitigate the sensor-induced step change:

1) Calculate C_a = AVHRR climatology (e.g. 1982-2011)
2) Calculate C_v = VIIRS climatology (e.g. 2014-2023)
3) Calculate difference D = C_a - C_v
4) Adjust the VIIRS era time series (2014-present), T_v = T_v + D
5) Calculate full anomaly time series based on the AVHRR climatology, C_a (e.g. 1982-2011)

# 6. References

AVHRR Land Bundle - Surface Reflectance and Normalized Difference Vegetation Index - Climate Algorithm Theoretical Basis Document, NOAA Climate Data Record Program CDRP-ATBD-0459 Rev. 2 (2018). Available at https://www.ncei.noaa.gov/pub/data/sds/cdr/CDRs/Normalized_Difference_Vegetation_Index/AVHRR/AlgorithmDescriptionAVHRR_01B-20b.pdf

Claverie, M., Demarez, V., Duchemin, B., Hagolle, O., Ducrot, D., Marais-Sicre, C., Dejoux, J.-F., Huc, M., Keravec, P., Béziat, P., Fieuzal, R., Ceschia, E., & Dedieu, G. (2012). Maize and sunflower biomass estimation in southwest France using high spatial and temporal resolution remote sensing data. Remote Sensing of Environment, 124, 844-857.

Leaf Area Index (LAI) and Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) – climate Algorithm Theoretical Basis Document, NOAA Climate Data Record Program CDRP-ATBD-0564 Rev. 2 (2018). Available at https://www.ncei.noaa.gov/pub/data/sds/cdr/CDRs/Leaf_Area_Index_and_FAPAR/AVHRR/AlgorithmDescriptionAVHRR_01B-20c.pdf

Vermote, E., Justice, C.O., & Breon, F.M. (2009). Towards a Generalized Approach for Correction of the BRDF Effect in MODIS Directional Reflectances. Ieee Transactions on Geoscience and Remote Sensing, 47, 898-908.

VIIRS Land Bundle - Surface Reflectance and Normalized Difference Vegetation Index - Climate Algorithm Theoretical Basis Document, NOAA Climate Data Record Program CDRP-ATBD-1267 Rev. 0 (2022). Available at https://www.ncei.noaa.gov/pub/data/sds/cdr/CDRs/Normalized_Difference_Vegetation_Index/VIIRS/AlgorithmDescriptionVIIRS_01B-20b.pdf

VIIRS Leaf Area Index (LAI) and Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) -- Climate Algorithm Theoretical Basis Document, NOAA Climate Data Record Program CDRP-ATBD-1451 Rev. 0 (2023). Available at https://www.ncei.noaa.gov/pub/data/sds/cdr/CDRs/Leaf_Area_Index_and_FAPAR/VIIRS/AlgorithmDescriptionVIIRS_01B-20c.pdf

# Appendices

## Data access

Surface Reflectance - Polar Orbiter

- Direct access: https://www.ncei.noaa.gov/data/land-surface-reflectance/access/
- THREDDS: https://www.ncei.noaa.gov/thredds/catalog/satellite/surface-reflectance.html
- Google Cloud: https://console.cloud.google.com/storage/browser/noaa-cdr-surface-reflectance-polar-orbiter
- AWS: https://noaa-cdr-surface-reflectance-polar-orbiter-pds.s3.amazonaws.com/index.html

NDVI

- Direct access: https://www.ncei.noaa.gov/data/land-normalized-difference-vegetation-index/access/
- THREDDS: https://www.ncei.noaa.gov/thredds/catalog/satellite/avhrr-viirs-ndvi.html
- Google Cloud: https://console.cloud.google.com/storage/browser/noaa-cdr-ndvi
- AWS: https://noaa-cdr-ndvi-pds.s3.amazonaws.com/index.html

LAI/FAPAR

- Direct access: https://www.ncei.noaa.gov/data/land-leaf-area-index-and-fapar/access/
- THREDDS: https://www.ncei.noaa.gov/thredds/catalog/satellite/cdr-lai-fapar.html
- Google Cloud: https://console.cloud.google.com/storage/browser/noaa-cdr-leaf-area-index-fapar
- AWS: https://noaa-cdr-leaf-area-index-fapar-pds.s3.amazonaws.com/index.html

## Description of variables

**Table 1: Layers of the Surface Reflectance - Polar Orbiter products**

| Variable name | Description | Dimensions | Data Type | In AVHRR | In VIIRS |
|---|---|---|---|---|---|
| 'latitude' | Latitude of the pixel's center | 3600 × 1 | Floating point | x | x |
| 'longitude' | Longitude of the pixel's center | 7200 × 1 | Floating point | x | x |

| | | | | | |
|---|---|---|---|---|---|
| ‘time’ | Time of acquisition ('days since 1981-01-01 00:00:00') | 1 | Floating point | x | x |
| ‘crs’ | Coordinate reference system | 1 | Int16 | x | x |
| ‘lat_bnds’ | Latitude of pixel’s edges | 3600 × 2 | Floating point | x | x |
| ‘lon_bnds’ | Longitude of pixel’s edges | 7200 × 2 | Floating point | x | x |
| 'BRDF_corrected_I1_SurfRefl_CMG' | I1 band BRDF corrected surface reflectance | 3600 × 7200 | Int16 | | x |
| 'BRDF_corrected_I2_SurfRefl_CMG' | I2 band BRDF corrected surface reflectance | 3600 × 7200 | Int16 | | x |
| 'BRDF_corrected_I3_SurfRefl_CMG' | I3 band BRDF corrected surface reflectance | 3600 × 7200 | Int16 | | x |
| ‘SREFL_CH1’ | Surface Reflectance at 640 nm | 3600 × 7200 | Int16 | x | |
| ‘SREFL_CH2’ | Surface reflectance at 830 nm | 3600 × 7200 | Int16 | x | |
| ‘SREFL_CH3’ | Surface reflectance at 3.75 microns | 3600 × 7200 | Int16 | x | |
| ‘BT_CH3’ | Brightness Temperature at 3.75 microns | 3600 × 7200 | Int16 | x | |
| ‘BT_CH4’ | Brightness Temperature at 11.0 microns | 3600 × 7200 | Int16 | x | |

| | | | | | |
|---|---|---|---|---|---|
| ‘BT_CH5’ | Brightness Temperature at 12.0 microns | 3600 × 7200 | Int16 | x | |
| 'BT_CH12' | M12 band Brightness Temperature | 3600 × 7200 | Int16 | | x |
| 'BT_CH15' | M15 band Brightness Temperature | 3600 × 7200 | Int16 | | x |
| 'BT_CH16' | M16 band Brightness Temperature | 3600 × 7200 | Int16 | | x |
| 'SZEN' | Solar Zenith Angle | 3600 × 7200 | Int16 | x | x |
| 'VZEN' | View Zenith Angle | 3600 × 7200 | Int16 | x | x |
| 'RELAZ' | Relative Azimuth Angle | 3600 × 7200 | Int16 | x | x |
| 'TIMEOFDAY' | Time (hours) since 00:00:00 | 3600 × 7200 | Int16 | x | x |
| 'QA' | Quality Control | 3600 × 7200 | Int16 | x | x |

**Table 2: Layers of the NDVI products**

| Variable name | Description | Dimensions | Data Type | In AVHRR | In VIIRS |
|---|---|---|---|---|---|
| ‘latitude’ | Latitude of the pixel’s center | 3600 × 1 | Floating point | x | x |
| ‘longitude’ | Longitude of the pixel’s center | 7200 × 1 | Floating point | x | x |
| ‘time’ | Time of acquisition ('days since 1981-01-01 00:00:00') | 1 | Floating point | x | x |

| | | | | | |
|---|---|---|---|---|---|
| ‘crs’ | Coordinate reference system | 1 | Int16 | x | x |
| ‘lat_bnds’ | Latitude of pixel’s edges | 3600 × 2 | Floating point | x | x |
| ‘lon_bnds’ | Longitude of pixel’s edges | 7200 × 2 | Floating point | x | x |
| ‘NDVI’ | Normalized Difference Vegetation Index | 3600 × 7200 | Int16 | x | x |
| 'TIMEOFDAY' | Time (hours) since 00:00:00 | 3600 × 7200 | Int16 | x | x |
| 'QA' | Quality Control | 3600 × 7200 | Int16 | x | x |

**Table 3: Layers of the LAI/FAPAR products**

| Variable name | Description | Dimensions | Data Type | In AVHRR | In VIIRS |
|---|---|---|---|---|---|
| ‘latitude’ | Latitude of the pixel’s center | 3600 × 1 | Floating point | x | x |
| ‘longitude’ | Longitude of the pixel’s center | 7200 × 1 | Floating point | x | x |
| ‘time’ | Time of acquisition ('days since 1981-01-01 00:00:00') | 1 | Floating point | x | x |
| ‘crs’ | Coordinate reference system | 1 | Int16 | x | x |
| ‘lat_bnds’ | Latitude of pixel’s edges | 3600 × 2 | Floating point | x | x |
| ‘lon_bnds’ | Longitude of pixel’s edges | 7200 × 2 | Floating point | x | x |
| ‘LAI | Leaf Area Index | 3600 × 7200 | Int16 | x | x |

| | | | | | |
|---|---|---|---|---|---|
| FAPAR | Fraction of Photosynthetically - Available Radiation | 3600 × 7200 | Int16 | x | x |
| 'QA' | Quality Control | 3600 × 7200 | Int16 | x | x |