VIIRS Surface Reflectance Science Processing Algorithm (SURFREFLECT_SPA) User's Guide

Version 1.5.08.04

December 2018

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

VIIRS Surface Reflectance Science Processing Algorithm

SURFREFLECT_SPA

General

The NASA Goddard Space Flight Center's (GSFC) Direct Readout Laboratory (DRL), Code 619.1, developed this software for the International Planetary Observation Processing Package (IPOPP). IPOPP maximizes the utility of Earth science data for making real-time decisions by giving fast access to instrument data and derivative products from the NOAA-20 [Joint Polar Satellite System (JPSS)], Suomi National Polar-orbiting Partnership (SNPP), Aqua, and Terra missions.

Users must agree to all terms and conditions in the Software Usage Agreement on the DRL Web Portal before downloading this software.

Software and documentation published on the DRL Web Portal may occasionally be updated or modified. The most current versions of DRL software are available at the DRL Web Portal:

https://directreadout.sci.gsfc.nasa.gov/?id=software

Questions relating to the contents or status of this software and its documentation should be addressed to the DRL via the Contact DRL mechanism at the DRL Web Portal:

https://directreadout.sci.gsfc.nasa.gov/?id=dspContent&cid=66

Algorithm Wrapper Concept

The DRL has developed an algorithm wrapper to provide a common command and execution interface to encapsulate multi-discipline, multi-mission science processing algorithms. The wrapper also provides a structured, standardized technique for packaging new or updated algorithms with minimal effort.

A Science Processing Algorithm (SPA) is defined as a wrapper and its contained algorithm. SPAs will function in a standalone, cross-platform environment to serve the needs of the broad Direct Readout community. Detailed information about SPAs and other DRL technologies is available at the DRL Web Portal.

Software Description

This software package contains the Visible Infrared Imaging Radiometer Suite (VIIRS) Surface Reflectance Science Processing Algorithm (SURFREFLECT_SPA). The SPA supports both the SNPP and NOAA-20 (JPSS-1) missions; it can process VIIRS inputs from either spacecraft. The VIIRS Surface Reflectance algorithm takes as inputs VIIRS M-band Sensor Data Record (SDR) products; VIIRS I-band SDR products; the VIIRS M-Band Terrain-Corrected Geolocation product; the VIIRS I-Band Terrain-Corrected Geolocation product; the VIIRS Cloud Mask Intermediate Product (IP); the Aerosol Optical Thickness IP; and the Aerosol Model Index IP and

meteorological ancillary. The algorithm produces the mission-compliant VIIRS Surface Reflectance HDF5 IP. The SPA functions in two modes: Standalone, or as an IPOPP plug-in.

Software Version

Version 1.5 of the DRL algorithm wrapper was used to package the SPA described in this document. The Surface Reflectance algorithm has been ported from the IDPS OPS (Interface Data Processing Segment Operational Code) Version 1.5.08.04.

Enhancements to this SPA include support for NOAA-20 (JPSS-1) VIIRS data processing. The NOAA-20 algorithm is an Engineering Version.

This software will execute on a 64-bit computer. This software has been tested on a computer with 32GB of RAM and a CentOS Linux 7 X86_64 operating system.

Credits

The VIIRS Surface Reflectance algorithm was provided to the DRL by the JPSS Mission. This algorithm was ported to run outside of the IDPS by the DRL in collaboration with the Land Product Evaluation and Algorithm Test Element (LPEATE).

Prerequisites

To run this package, you must have the Java Development Kit (JDK) or Java Runtime Engine (JRE) (Java 1.6.0_25 or higher) installed on your computer, and have the Java installation bin/ subdirectory in your PATH environment variable. This package contains 64-bit binaries statically pre-compiled on an x86-compatible 64-bit computer running under Fedora 14, using gcc 4.5.1.

Program Inputs and Outputs

The SPA uses the following inputs:

a) VIIRS Moderate Resolution Sensor Data products (SVM01, 02, 03, 04, 05, 07, 08, 10, 11);

b) VIIRS Image Resolution Sensor Data products (SVI01, 02, 03),

c) VIIRS Moderate Resolution Terrain-Corrected Geolocation product (GMTCO);

d) VIIRS Image Resolution Terrain-Corrected Geolocation product (GITCO);

e) VIIRS Cloud Mask IP (IICMO);

f) Aerosol Optical Thickness IP (IVAOT);

g) Aerosol Model Index IP (IVAMT);

h) meteorological ancillary.

The SPA produces the mission-compliant VIIRS Surface Reflectance HDF5 IP as output.

Installation and Configuration

NOTE: Due to limited resources, as well as the many variables that impact scientific integrity and algorithm stability, the DRL will soon no longer support the Standalone Mode for SPA processing. We strongly encourage you now to run SPAs in IPOPP Mode exclusively, that is, from within the IPOPP processing framework. IPOPP will autonomously:

- discover and register raw sensor data;
- retrieve ancillaries from the DRL's real-time and archived ancillary repositories;
- register ancillaries in its Ancillary File Cache;
- schedule SPA executions;
- fulfill science data/ancillary requests from SPAs;
- generate science data products; and
- manage the IPOPP file system.

Installing into an IPOPP Framework: This SPA can also be installed dynamically into an IPOPP framework to automate production of SURFREFLECT_SPA data products. The SPA installation process will install SPA service(s) into IPOPP. An SPA service is an IPOPP agent that provides the mechanism necessary for running an SPA automatically within the IPOPP framework. Once this SPA is installed, users must enable the service(s) corresponding to this SPA along with any other pre-requisite service(s). Instructions for installing an SPA and enabling its services are contained in the IPOPP User's Guide (available on the DRL Web Portal). The SPA services associated with this SPA are listed in Appendix A.

Installing as a Standalone Application:

NOTE: If you have a previous version of this SPA installed, delete the SPA/SurfReflect directory before decompressing and un-archiving the new SPA tar file.

Download the SURFREFLECT_1.5.08.04_SPA_1.5.tar.gz and SURFREFLECT_1.5.08.04_SPA_1.5_testdata.tar.gz (optional) files into the same directory.

Decompress and un-archive the SURFREFLECT_1.5.08.04_SPA_1.5.tar.gz and SURFREFLECT_1.5.08.04_SPA_1.5_testdata.tar.gz (optional) files:

$ tar -xzf SURFREFLECT_1.5.08.04_SPA_1.5.tar.gz
$ tar -xzf SURFREFLECT_1.5.08.04_SPA_1.5_testdata.tar.gz

This will create the following subdirectories:

- SPA
  - SurfReflect
    - algorithm
    - ancillary
    - station
    - testdata
    - testscripts
    - wrapper

Software Package Testing and Validation

The testscripts subdirectory contains test scripts that can be used to verify that your current installation of the SPA is working properly, as described below. Note that the optional SURFREFLECT_1.5.08.04_SPA_1.5_testdata.tar.gz file is required to execute these testing procedures.

Step 1: cd into the testscripts directory.
Step 2: There is a script named run-vsurfrefl inside the testscripts directory. To run the Surface Reflectance algorithm, use

```
$ ./run-vsurfrefl
```

A successful execution usually requires 2 minutes or more, depending on the speed of your computer. If everything is working properly, the scripts will terminate with a message such as:

```
Output viirs.srflip is
/home/ipopp/drl/SPA/SurfReflect/testdata/output/IVISR_npp_d20130323_t1851552.h5
```

You can cd to the output directory to verify that the science products exist. Test output product(s) are available for comparison in the testdata/output directory. These test output product(s) were generated on a 64-bit PC architecture computer running Fedora 14. The output products serve as an indicator of expected program output. Use a comparison utility (such as diff, h5diff, etc.) to compare your output product(s) to those provided in the testdata/output directory. Locally generated files may differ slightly from the provided output files because of differences in machine architecture or operating systems.

If there is a problem and the code terminates abnormally, the problem can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile*. Other log and intermediate files may be generated automatically within the directory used for execution. They are useful for traceability and debugging purposes. However it is

strongly recommended that users clean up log files and intermediate files left behind in the run directory before initiating a fresh execution of the SPA. Intermediate files from a previous run may affect a successive run and produce ambiguous results. Please report any errors that cannot be fixed to the DRL.

Program Operation

In order to run the package using your own input data, you can either use the run scripts within the wrapper subdirectories, or modify the test scripts within the testscripts subdirectory.

To Use the Run Scripts

Identify the 'run' scripts: The wrapper directory within this package contains one subdirectory named SurfReflect. The subdirectory contains an executable called 'run'. Execute 'run' within the correct wrapper subdirectory to generate the corresponding product. For instance, the 'run' within wrapper/SurfReflectis used for creating Surface Reflectance outputs. Note that to execute 'run', you need to have java on your path.

Specify input parameters using <label value> pairs: To execute the 'run' scripts, you must supply the required input and output parameters. Input and output parameters are usually file paths or other values (e.g., an automatic search flag). Each parameter is specified on the command line by a <label value> pair. Labels are simply predefined names for parameters. Each label must be followed by its actual value. Each process has its own set of <label value> pairs that must be specified in order for it to execute. Some of these pairs are optional, meaning the process would still be able to execute even if that parameter is not supplied. The two types of <label value> pairs that the SURFREFLECT_SPA uses are:

a) Input file label/values. These are input file paths. Values are absolute or relative paths to the corresponding input file.

b) Output file label/values. These are output files that are produced by the SPA. Values are absolute or relative paths of the files you want to generate.

The following tables contain labels, and their descriptions, required by the SURFREFLECT_SPA.

Input File Labels	Description	Sources
viirs.svm01	VIIRS Moderate Resolution Band M1 input HDF5 file path (SVM01)	The C-SDR_SPA can be used to create these products. DRL ftp site for real-time VIIRS SDRs over the eastern US region: SNPP: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level1/<SVM01|SVM02|SVM03|SVM04|SVM05|SVM07|SVM08|SVM10|SVM11|GMTCO|SVI01|SVI02|SVI03|GITCO>_npp_dyyyyMMdd_thhmmssS_ehhmmssS*.h5 NOAA-20: ftp://is.sci.gsfc.nasa.gov/gsfcdata/jpss1/viirs/level1/<SVM01|SVM02|SVM03|SVM04|SVM05|SVM07|SVM08|SVM10|SVM11|GMTCO|SVI01|SVI02|SVI03|GITCO>_j01_dyyyyMMdd_thhmmssS_ehhmmssS*.h5 Where yyyy, MM, dd represents the year, month, and date for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath. These products can also be ordered from CLASS for other locations and times at www.class.noaa.gov
viirs.svm02	VIIRS Moderate Resolution Band M2 input HDF5 file path (SVM02)	
viirs.svm03	VIIRS Moderate Resolution Band M3 input HDF5 file path (SVM03)	
viirs.svm04	VIIRS Moderate Resolution Band M4 input HDF5 file path (SVM04)	
viirs.svm05	VIIRS Moderate Resolution Band M5 input HDF5 file path (SVM05)	
viirs.svm07	VIIRS Moderate Resolution Band M7 input HDF5 file path (SVM07)	
viirs.svm08	VIIRS Moderate Resolution Band M8 input HDF5 file path (SVM08)	
viirs.svm10	VIIRS Moderate Resolution Band M10 input HDF5 file path (SVM10)	
viirs.svm11	VIIRS Moderate Resolution Band M11 input HDF5 file path (SVM11)	
viirs.gmtco	VIIRS M-Band Geolocation input HDF5 file path (GMTCO)	
viirs.svi01	VIIRS Imagery Resolution Band I1 input HDF5 file path (SVI01)	
viirs.svi02	VIIRS Imagery Resolution Band I2 input HDF5 file path (SVI02)	
viirs.svi03	VIIRS Imagery Resolution Band I3 input HDF5 file path (SVI03)	
viirs.gitco	VIIRS I-Band Geolocation input HDF5 file path (GITCO)	
viirs.aotip	Aerosol Optical Thickness IP input HDF5 file path (IVAOT)	The AEROSOL_SPA creates these products. DRL ftp site for real-time VIIRS Aerosol IP over the eastern US region: SNPP: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2
viirs.amiip	Aerosol Model Information IP input HDF5 file path (IVAMT)	

Input File Labels	Description	Sources
		NOAA-20: ftp://is.sci.gsfc.nasa.gov/gsfcdata/jpss1/viirs/level2 These products can also be ordered from CLASS for other locations and times at www.class.noaa.gov Filenames are of the form: TTTTT_ppp_dyyyyMMdd_thhmmssS_ehhmmssS*.h5 Where TTTTT is a data product ID from the CDFCB (IVAOT, IVAMT), and yyyy, MM, dd represents the year, month, and date for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath. 'ppp' is the spacecraft field and is either 'npp' for SNPP or 'j01' for NOAA-20.
viirs.cmip	Cloudmask IP input HDF5 file path (IICMO)	The CLOUDMASK_SPA creates this product. DRL ftp site for real-time VIIRS Cloud Mask IP over the eastern US region: SNPP: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2 NOAA-20: ftp://is.sci.gsfc.nasa.gov/gsfcdata/jpss1/viirs/level2 These products can also be ordered from CLASS for other locations and times at www.class.noaa.gov Filenames are of the form: IICMO_ppp_dyyyyMMdd_thhmmssS_ehhmmssS*.h5 Where yyyy, MM, dd represents the year, month, and date for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath. 'ppp' is the spacecraft field and is either 'npp' for SNPP or 'j01' for NOAA-20.

Input File Labels	Description	Sources
ncep_met	NCEP Numerical Weather Prediction GRIdded Binary (GRIB) File. This can be either a Global Data Assimilation System (GDAS1, 6 hourly, 1 degree global) analysis field file or a Global Model Forecast Fields (GFS) file. The SPA requires GDAS and GFS files in grib1 format.	Current Data: ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gdas (for GDAS) ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gfs (for GFS) Archived Data: ftp://is.sci.gsfc.nasa.gov/ArchivedAncillary/temporal/global/gdas Filenames are of the form: gdas1.PGrbF00.yymmdd.hhz Where yy represents the last two digits of the year, and mm, dd, and hh represent the month, day and hour of the date and time of the GRIB file's data.

Output File Labels	Description	Output Format Description
viirs.srflip	Surface Reflectance IP output HDF file path	Refer to JPSS Common Data Format Control Book (CDFCB) Vol IV-Part 1 – IPs, ARPs, and Geolocation Data https://jointmission.gsfc.nasa.gov/documents.html

Execute the 'run': The following is an example of the command line to run the Surface Reflectance algorithm from the testscripts directory:

```
$ ../wrapper/SurfReflect/run \
viirs.svm01 ../testdata/input/SVM01_npp_d20130323_t1851552_e1853194_b07270_c20130329144557882056_noaa_ops.h5 \
viirs.svm02 ../testdata/input/SVM02_npp_d20130323_t1851552_e1853194_b07270_c20130329144420790139_noaa_ops.h5 \
viirs.svm03 ../testdata/input/SVM03_npp_d20130323_t1851552_e1853194_b07270_c20130329144447345002_noaa_ops.h5 \
viirs.svm04 ../testdata/input/SVM04_npp_d20130323_t1851552_e1853194_b07270_c20130329144448698975_noaa_ops.h5 \
viirs.svm05 ../testdata/input/SVM05_npp_d20130323_t1851552_e1853194_b07270_c20130329144411503651_noaa_ops.h5 \
viirs.svm07 ../testdata/input/SVM07_npp_d20130323_t1851552_e1853194_b07270_c20130329144352689405_noaa_ops.h5 \
viirs.svm08 ../testdata/input/SVM08_npp_d20130323_t1851552_e1853194_b07270_c20130329144555556037_noaa_ops.h5 \
viirs.svm10 ../testdata/input/SVM10_npp_d20130323_t1851552_e1853194_b07270_c20130329144540110579_noaa_ops.h5 \
viirs.svm11 ../testdata/input/SVM11_npp_d20130323_t1851552_e1853194_b07270_c20130329144429442736_noaa_ops.h5 \
viirs.gmtco ../testdata/input/GMTCO_npp_d20130323_t1851552_e1853194_b07270_c20130329144438416689_noaa_ops.h5 \
viirs.svi01 ../testdata/input/SVI01_npp_d20130323_t1851552_e1853194_b07270_c20130329144457901126_noaa_ops.h5 \
viirs.svi02 ../testdata/input/SVI02_npp_d20130323_t1851552_e1853194_b07270_c20130329144508343727_noaa_ops.h5 \
viirs.svi03 ../testdata/input/SVI03_npp_d20130323_t1851552_e1853194_b07270_c20130329144453693755_noaa_ops.h5 \
viirs.gitco ../testdata/input/GITCO_npp_d20130323_t1851552_e1853194_b07270_c20130329144559539969_noaa_ops.h5 \
viirs.aotip ../testdata/input/IVAOT_npp_d20130323_t1851552_e1853194.h5 \
viirs.amiip ../testdata/input/IVAMI_npp_d20130323_t1851552_e1853194.h5 \
viirs.cmip ../testdata/input/IICMO_npp_d20130323_t1851552_e1853194_b07270_c20130618184731407557_noaa_ops.h5 \
ncep_met ../testdata/input/gdas1.PGrbF00.*z \
viirs.srflip ../testdata/output/IVISR_npp_d20130323_t1851552.h5
```

A successful execution usually requires 2 minutes or more, depending on the speed

of your computer and the size of the granule. If execution fails, you will see an error message indicating the cause of failure (e.g., a file cannot be found, or a label cannot be recognized). Correct it and run again. If the problem has some other cause, it can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile* and can be deleted after execution. Other log and intermediate files may be generated automatically within the directory used for execution. They are useful for traceability and debugging purposes. However it is strongly recommended that users clean up log files and intermediate files left behind in the run directory before initiating a fresh execution of the SPA. Intermediate files from a previous run may affect a successive run and produce ambiguous results. The 'run' can be executed from any directory the user chooses. This can be done by prefixing it with the file path for the 'run' script.

NOTES:

1. Either GDAS or Global Model Forecast Fields (GFS) files may be used for the ncep_met label. Try to use a GDAS file that is within ±3 hours of the SDR observation time. If that file is not available (as is often the case for real-time processing), use a GFS file instead. The naming convention for grib1 gfs files is gfs.thh.yymmdd.pgrbfxx (here yymmddd and hh represent analysis time, and xx represents forecast time step). Thus a file named gfs.t12.100201.pgrbf03 corresponds to 1500 hours (12+3) UTC on February 1, 2010. If you have to choose GFS data as input, you should attempt to use a file that is within ±1.5 hours of the SDR file. If there is more than one such GFS file, use the one with the smaller forecast time step. For example, if your data time is 15 UTC, you should try to use the 3 hour forecast field from the 1200 UTC model run, instead of the 9 hour forecast field from the 0600 UTC run. If no GDAS or GFS file is available using the above logic, use a GDAS file that is closest in time but within ±7 days of the granule time.

2. The Surface Reflectance algorithm requires the Aerosol Optical Thickness IP and Aerosol Model Index IP, which are produced by the Aerosol SPA. The Aerosol SPA will not produce the aerosol products if the input swath has an insufficient number of daytime granules. Therefore, the Surface Reflectance SPA will not be able to process a swath with an insufficient number of daytime granules.

3. The data products generated by this SPA may be visualized with the DRL's H2G_SPA (Hierarchical Data Format [HDF] to Georeferenced Tagged Image File Format [GeoTIFF] Converter Science Processing Algorithm). H2G is designed specifically for Direct Readout applications to create geolocated GeoTIFF images, jpeg browse images, and png browse images for parameter datasets in SNPP, NOAA-20 and EOS products. H2G_SPA and its User Guide are available for download from the DRL web-portal. Please refer to Appendix A for information on enabling image production for this SPA in

IPOPP.

To Use the Scripts in the testscripts Directory

One simple way to run the algorithms from the directory of your choice using your own data is to copy the run-vsurfrefl script from the testscripts directory to the selected directory. Change the values of the variables like WRAPPERHOME, INPUTHOME and OUTPUTHOME to reflect the file paths of the wrapper directories and the input/output file paths. Then modify the input/output file name variables. Run the script to process your data.

Appendix A
SPA Services

Installation of this SPA in IPOPP mode will make the SPA services listed in Table A-1 available to IPOPP. These services along with any other prerequisite services (listed in Table A-2) will need to be enabled to allow IPOPP to automate production of the VIIRS-AF data products. Further, users who wish to generate image products from the data products generated by this SPA will need to enable the image-generating services listed in Table A-3. The SPAs containing the pre-requisite and the image-generating services listed in Tables A-2 and A-3 can be downloaded from the DRL Web Portal, in case they are not already available in your IPOPP installation. Details about these other SPAs are available in the respective SPA User's Guides. Please refer to the IPOPP User's Guide for instructions on how to install an SPA in IPOPP and enable the corresponding services.

Table A-1. SPA Services

Services for this SPA	**Data Products produced**	
SurfReflect[1]	**Product Name**	**Destination (when installed in IPOPP)**
	VIIRS Land Surface Reflectance IP (Daytime only)	$HOME/drl/data/pub/gsfcdata/<missiondir>/viirs/level2/IVISR_ppp_dyyyyMMdd_thhmmssS_ehhmmssS*.hdf [2]

[1]The SPA service(s) for SNPP processing is available on the "SNPP-VIIRS" tab of the IPOPP dashboard, while the corresponding SPA service for NOAA-20 processing is available on the "JPSS-1-VIIRS" tab.

[2]Where *yyyy*, *MM*, *dd* represents the year, month and day of month for start of the swath; the first *hh*, *mm*, *ss*, *S* represents the hour, minutes, seconds and 10th of a second for the start of the swath and the second *hh*, *mm*, *ss*, *S* represents the end time of the swath. 'ppp' is the spacecraft field and is either 'npp' for SNPP or 'j01' for NOAA-20. <missiondir> is the mission specific directory. It is 'npp' for SNPP and 'jpss1' for NOAA-20.

Table A-2. Pre-requisite SPA Services

Pre-requisite SPA Services	SPA in which they are available
VIIRS_C-SDR	C-SDR_SPA
CloudMask	CLOUDMASK_SPA
Aerosol	AEROSOL_SPA

Table A-3. Image-generating SPA Services

Image-generating SPA Services	SPA in which they are available
vsurfreflh5d-geotiff	H2G_SPA

NOTE: Please refer to the H2G_SPA User's Guide for more details about the image products, including their locations and filename patterns when they are generated in IPOPP. The SPA service(s) for SNPP processing is available on the "SNPP-VIIRS" tab of the IPOPP dashboard while, the corresponding SPA service for NOAA-20 processing is available on the "JPSS-1-VIIRS" tab.