

VIIRS Corrected Reflectance Science Processing Algorithm (CVIIRS_SPA) User's Guide

Version 1.1

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**GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND**

VIIRS Corrected Reflectance Science Processing Algorithm

CVIIRS_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 (IPOP). IPOP 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 VIIRS Corrected Reflectance Science Processing Algorithm (CVIIRS_SPA). The SPA supports both the SNPP and NOAA-20 (JPSS-1) missions; it can process VIIRS inputs from either spacecraft. The CVIIRS_SPA creates the VIIRS Corrected Reflectance products by performing simple atmospheric correction with VIIRS visible, near-infrared, and short-wave infrared bands (bands M5, M7, M3, M4, M8, M10, M11, I1, I2, and I3). It corrects for molecular (Rayleigh) scattering and gaseous absorption (water vapor and ozone) using climatological values for gas contents. It requires no real-time input of ancillary data, and performs no aerosol correction. The VIIRS Corrected Reflectance products created by CVIIRS_SPA are based on the 6S Radiative

Transfer Model. The SPA functions in two modes: standalone, or as an IPOPP plug-in.

Software Version

Version 1.2 of the DRL algorithm wrapper was used to package the SPA described in this document.

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 7 Linux X86_64 operating system.

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Credits

The Corrected Reflectance algorithm was co-developed by the Land Science Team and the DRL at NASA/GSFC.

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 CentOS 7, using gcc 4.8.8.

Program Inputs and Outputs

CVIIRS_SPA takes VIIRS SDR and geolocation products (M5, M7, M3, M4, M8, M10, M11, I1, I2, I3, and the M-band terrain-corrected geolocation) as input and produces:

- a) a moderate resolution VIIRS corrected reflectance product (containing corrected reflectances in bands M5, M7, M3, M4, M8, M10, M11), and
- b) an imagery resolution VIIRS corrected reflectance product (containing corrected reflectances in bands I1, I2 and I3).

The following table contains descriptions of datasets within the VIIRS Moderate and Imagery resolution Corrected Reflectance HDF4 products.

CVIIRS HDF4 Output Files	HDF4 Dataset Name	Dataset Description
CVIIRS Moderate Resolution Corrected Reflectance HDF	CorrRefl_01	M5 Corrected reflectances
	CorrRefl_02	M7 Corrected reflectances
	CorrRefl_03	M3 Corrected reflectances
	CorrRefl_04	M4 Corrected reflectances
	CorrRefl_05	M8 Corrected reflectances
	CorrRefl_06	M10 Corrected reflectances
	CorrRefl_07	M11 Corrected reflectances
CVIIRS Imagery Resolution Corrected Reflectance HDF	CorrRefl_08	I1 Corrected reflectances
	CorrRefl_09	I2 Corrected reflectances
	CorrRefl_10	I3 Corrected reflectances

The values in the datasets are stored as 16-bit signed integers with a scale factor of 0.0001. The following equation can be used to retrieve the corrected reflectance in reflectance units. Corrected reflectance= Scaled corrected reflectance in the HDF datasets * 0.0001

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 VIIRS corrected reflectance 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 prerequisite 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/CVIIRS directory before decompressing and un-archiving the new SPA tar file.

Download the CVIIRS_1.1_SPA_1.2.tar.gz and CVIIRS_1.1_SPA_1.2_testdata.tar.gz (optional) files into the same directory.

Decompress and un-archive the CVIIRS_1.1_SPA_1.2.tar.gz and CVIIRS_1.1_SPA_1.2_testdata.tar.gz (optional) files:

```
$ tar -xzf CVIIRS_1.1_SPA_1.2.tar.gz
$ tar -xzf CVIIRS_1.1_SPA_1.2_testdata.tar.gz
```

This will create the following subdirectories:

```
SPA
  CVIIRS
    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 CVIIRS_1.1_SPA_1.2_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-cviirs inside the testscripts directory.

To run the CVIIRS algorithm, use

```
$ ./run-cviirs
```

A successful execution usually requires 1 minute or more, depending on the speed of your computer. If everything is working properly, the script will terminate with a message such as:

```
Output viirs.mcirefl is /home/ipopp/drl/SPA/CVIIRS/testdata/output/CVIIRSM.hdf
Output viirs.icirefl is /home/ipopp/drl/SPA/CVIIRS/testdata/output/CVIIRSI.hdf
```

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`, `hdiff`, 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 `CVIIRS`. 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/CVIIRS` is used for creating `CVIIRS` 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 `CVIIRS_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 CVIIRS_SPA.

Input File Labels	Description	Source
viirs.svmxx {xx = 03, 04, 05, 07, 08, 10, 11}	VIIRS 750m Mx {x = 03, 04, 05, 07, 08, 10, 11} Band SDR file	<ol style="list-style-type: none"> The C-SDR_SPA can be used to create these products. Real time VIIRS SDR and geolocation products over the eastern US region are available from the DRL ftp site at: SNPP: <ul style="list-style-type: none"> ftp://is.sci.gsfc.nasa.gov/gsfcddata/npp/viirs/level1/SVMxx_npp_dydddMMdd_thhmmssS_ehhmmssS*.h5 {xx = 03, 04, 05, 07, 08, 10, 11} ftp://is.sci.gsfc.nasa.gov/gsfcddata/npp/viirs/level1/SVlxx_npp_dydddMMdd_thhmmssS_ehhmmssS*.h5 {xx = 01 to 03} ftp://is.sci.gsfc.nasa.gov/gsfcddata/npp/viirs/level1/GMTCO_npp_dydddMMdd_thhmmssS_ehhmmssS*.h5 NOAA-20 <ul style="list-style-type: none"> ftp://is.sci.gsfc.nasa.gov/gsfcddata/jpss1/viirs/level1/SVMxx_j01_dydddMMdd_thhmmssS_ehhmmssS*.h5 {xx = 03, 04, 05, 07, 08, 10, 11} ftp://is.sci.gsfc.nasa.gov/gsfcddata/jpss1/viirs/level1/SVlxx_j01_dydddMMdd_thhmmssS_ehhmmssS*.h5 {xx = 01 to 03} ftp://is.sci.gsfc.nasa.gov/gsfcddata/jpss1/viirs/level1/GMTCO_j01_dydddMMdd_thhmmssS_ehhmmssS*.h5 <p>Where yyyy, MM, dd represents the year, month, and day of month 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.</p> VIIRS SDR and geolocation products for other locations and times are available for download at www.class.noaa.gov
viirs.svixx {xx = 01 to 03}	VIIRS 375m lx {x = 01 to 03} Band SDR file	
viirs.gmtco	VIIRS M-band Terrain-Corrected Geolocation file	

Output Labels	File	Description	Output Format Description
viirs.mcrefl		VIIRS Moderate Resolution Corrected Reflectance output HDF file path (daytime only)	See Section "Program Inputs and Outputs"
viirs.icrefl		VIIRS Imagery Resolution Corrected Reflectance output HDF file path (daytime only)	

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

```
$ ../wrapper/CVIIRS/run \
viirs.svm03 ../testdata/input/SVM03_npp_d20140901_t1738560_e1740201_b14746_c20140908200714455393_noaa_ops.h5 \
viirs.svm04 ../testdata/input/SVM04_npp_d20140901_t1738560_e1740201_b14746_c20140908200714715029_noaa_ops.h5 \
viirs.svm05 ../testdata/input/SVM05_npp_d20140901_t1738560_e1740201_b14746_c20140908200735223402_noaa_ops.h5 \
viirs.svm07 ../testdata/input/SVM07_npp_d20140901_t1738560_e1740201_b14746_c20140908200729256422_noaa_ops.h5 \
viirs.svm08 ../testdata/input/SVM08_npp_d20140901_t1738560_e1740201_b14746_c20140908200803979409_noaa_ops.h5 \
viirs.svm10 ../testdata/input/SVM10_npp_d20140901_t1738560_e1740201_b14746_c20140908200925075349_noaa_ops.h5 \
viirs.svm11 ../testdata/input/SVM11_npp_d20140901_t1738560_e1740201_b14746_c20140908200858348915_noaa_ops.h5 \
viirs.svi01 ../testdata/input/SVI01_npp_d20140901_t1738560_e1740201_b14746_c20140908200814185302_noaa_ops.h5 \
viirs.svi02 ../testdata/input/SVI02_npp_d20140901_t1738560_e1740201_b14746_c20140908200817203819_noaa_ops.h5 \
viirs.svi03 ../testdata/input/SVI03_npp_d20140901_t1738560_e1740201_b14746_c20140908200743066611_noaa_ops.h5 \
viirs.gmtco ../testdata/input/GMTCO_npp_d20140901_t1738560_e1740201_b14746_c20140908200702642321_noaa_ops.h5 \
viirs.mcrefl ../testdata/output/CVIIRSM.h5 \
viirs.icrefl ../testdata/output/CVIIRSI.h5
```

A successful execution usually requires 1 minute or more, depending on the speed of your computer and the size of the input. 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. The VIIRS moderate and imagery resolution corrected reflectance products are not generated during night time.
2. 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-cviirs script from the testscripts directory to the selected directory. Change the values of the variables like WRAPPERCREFL, 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 CVIIRS_SPA data products. Furthermore, 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 prerequisite 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	
CVIIRS ¹	Product Name	Destination (when installed in IPOPP)
	VIIRS Moderate Resolution Corrected Reflectance output HDF (daytime only)	\$HOME/drl/data/pub/gsfcddata/<missiondir>/viirs/level2/CVIIRSM_ppp_dyyyyMMdd_thhmmssS_ehhmmssS*.h5 ²
	VIIRS Imagery Resolution Corrected Reflectance output HDF (daytime only)	\$HOME/drl/data/pub/gsfcddata/<missiondir>/viirs/level2/CVIIRSI_ppp_dyyyyMMdd_thhmmssS_ehhmmssS*.h5 ²

¹The SPA service 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.

²Where *yyyy*, *MM*, *dd* represents the year, month and day of month 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. <missiondir> is the mission specific directory. It is ‘npp’ for SNPP and ‘jpss1’ for NOAA-20.

Table A-2. Prerequisite SPA Services

Prerequisite SPA Services	SPA in which they are available
VIIRS_C-SDR	C-SDR_SPA

Table A-3. Image-generating SPA Services

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

NOTES:

1. 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.
2. The vcviirsfire-geotiff service additionally needs VIIRS-AF_SPA to be installed and the "VIIRS-AF" SPA service enabled in IPOPP in order to run. VIIRS-AF_SPA is available for download from the DRL Web Portal in case it is not already available in your IPOPP installation.
3. 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.