

Installation Instructions for the Community Satellite Processing Package (CSPP) VIIRS Active Fire Software Version 2.1

University of Wisconsin-Madison, Space Science and Engineering Center (SSEC)
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Section 1: Introduction

1.1 Overview

This document contains instructions for installation and operation of the Community Satellite Processing Package (CSPP) release of the NOAA/NESDIS/STAR JPSS VIIRS Active Fire Retrieval Software in support of direct broadcast NOAA-21, NOAA-20 and SuomiNPP (SNPP) VIIRS Sensor Data Records (SDRs). The NOAA JPSS Active Fires Team is led by Ivan Csiszar at the NOAA NESDIS Center for Satellite Applications and Research (STAR). NOAA's VIIRS active fire product development has been done through collaboration between STAR, the University of Maryland and the NASA VIIRS Land Science Team. This CSPP release provides the NESDIS Data Exploitation (NDE) operational version 1.0 of the VIIRS 375m "I-band" algorithm (equivalent to offline vfire375 version 2.5.4), and the NESDIS/STAR version of the 750m "M-band" algorithm, both adapted and tested for execution in a real-time direct broadcast environment.

Retrieval software is provided for both VIIRS M-Band (750m) and I-Band (375m) resolutions. Users can choose one or both resolutions. The software includes binary executable files, wrapper scripts and supporting static data files. A separate test data package can be downloaded for verifying a successful installation.

The CSPP NOAA Active Fire Version 2.1 software is available from the CSPP website:

<https://cimss.ssec.wisc.edu/cspp/>

Software, test data, and documentation may be downloaded from this website. Please use the 'Contact Us' form on the website to submit any questions or comments about CSPP. Source code for the Active Fire package is not included in this release.

For more information on NOAA STAR JPSS Active Fires, please visit

<https://www.star.nesdis.noaa.gov/jpss/fires.php>

1.2 What's New in CSPP Active Fire Version 2.1?

- Added support for NOAA-21 VIIRS.
- Separate configuration files for each VIIRS sensor for Fire Radiative Power (FRP).
- Updated instructions for creating images and overlays using CSPP Polar2Grid Version 3.0.

1.3 System requirements

System requirements for the CSPP Active Fire v2.1 software are as follows:

- Intel or AMD CPU with 64-bit instruction support.
- 16 GB RAM.
- Rocky Linux 8; the software has also been tested on CentOS 7.9.
- 6 GB of disk space (plus space for your own data and Active Fire products).

1.4 Disclaimer

Original scripts and automation included as part of this package are distributed under the GNU GENERAL PUBLIC LICENSE agreement version 3. Binary executable files included as part of this software package are copyrighted and licensed by their respective organizations, and distributed consistent with their licensing terms.

The University of Wisconsin-Madison Space Science and Engineering Center (SSEC) makes no warranty of any kind with regard to the CSPP software or any accompanying documentation, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. SSEC does not indemnify any infringement of copyright, patent, or trademark through the use or modification of this software.

There is no expressed or implied warranty made to anyone as to the suitability of this software for any purpose. All risk of use is assumed by the user. Users agree not to hold SSEC, the University of Wisconsin-Madison, or any of its employees or assigns liable for any consequences resulting from the use of the CSPP software.

1.5 Active Fire Algorithms

The main difference between the VIIRS M-Band (750 m) and I-Band (375 m) algorithms is the use of the I-Band 4 (3.74 μm) brightness temperature for hot spot detection, as opposed to M-Band 13 (4.05 μm). Both algorithms use similar fixed-threshold and contextual approaches to detect hot spots. The VIIRS I-Band 4 has been found to be very useful in detecting fires at higher spatial resolution, however, because it frequently saturates (367 K), it is not capable of producing reliable Fire Radiative Power (FRP) retrievals. Therefore, the I-Band FRP is retrieved from co-located M13 pixels using the M-Band FRP algorithm.

The VIIRS I-Band Active Fire Algorithm Theoretical Basis Document (ATBD) includes the algorithm description along with references and is available online at:

https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/ATBD_Iband_ActiveFires_v1.0.pdf

The VIIRS M-Band ATBD includes the algorithm description along with references and is available online at:

https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/ATBD_NDE_AF_v2.6.pdf

1.6 Input Data Requirements

CSPP Active Fire Version 2.1 produces single Field-of-View (FOV) retrievals from input VIIRS Moderate (750m) and Imager (375m) Resolution NOAA-21, NOAA-20 and SNPP VIIRS Sensor Data Records (SDRs). **Please note:** This software supports CSPP SDR Version 3.3 or higher inputs.

The required input files for the **Moderate resolution** retrieval algorithm are:

- VIIRS M-Band SDR Terrain Corrected Geolocation Files (GMTCO*.h5), and
- VIIRS M-Band SDR Radiance Files SVM05, SVM07, SVM11, SVM13, SVM15 and SVM16 (.h5).

The required input files for the **Imager resolution** retrieval algorithm are:

- VIIRS I-Band SDR Terrain Corrected Geolocation Files (GITCO*.h5)
- VIIRS I-Band SDR Radiance Files SVI01, SVI02, SVI03, SVI04, SVI05 (.h5)
- VIIRS M-Band SDR Radiance Files (SVM13*.h5)
- VIIRS Calibrated Dual-Gain Band Files (IVCDB*.h5).

Please note that all bands listed above are required as input to the Active Fire software, even when the data set observations are collected at night.

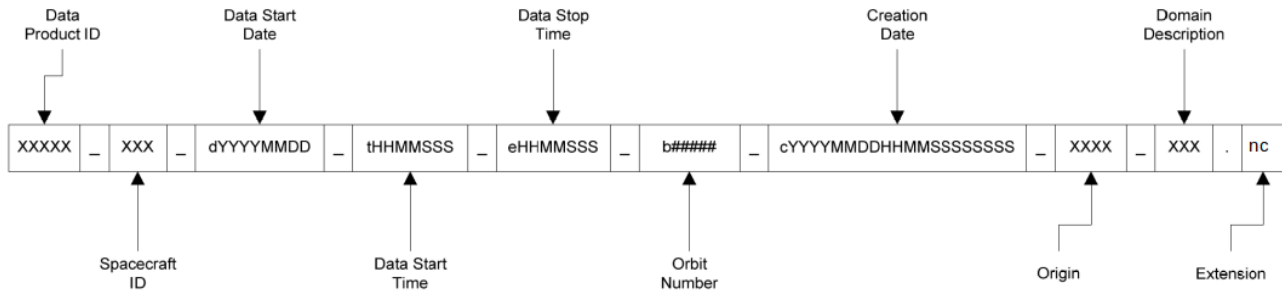
The input file format is HDF5. Input files can be created using CSPP SDR software or ordered from the NOAA CLASS or AWS archive.

1.7 Output Products

The CSPP NOAA VIIRS Active Fire algorithm creates two output products per script execution (either Imager or Moderate resolution) as part of normal execution; a NetCDF4 Data file, and an ASCII Text file containing a select subset of fields.

1.7.1 Output NetCDF4 Data files

A NetCDF4 product data file is created for each input Moderate or Imager resolution VIIRS granule. The output will always be single granule files for both aggregated **AND** unaggregated inputs. The output files have the following naming convention, adapted from the [JPSS Common Data Format Control Book - Volume I - Overview](#).



where:

- <Data Product ID>; AFIMG (375m) or AFMOD (750m)
- <Spacecraft ID>; npp (SNPP), j01 (JPSS-1 / NOAA-20) or j02 (JPSS-2 / NOAA-21)
- <Data Start Date>; granule UTC start date (YYYYMMDD)
- <Data Start Time>; granule UTC start time (HHMMSS)
- <Data End Time>; granule UTC end time (HHMMSS)
- <Orbit Number>; Begins at the ascending node (nnnnn)
- <Creation Date>; granule UTC creation datetime (YYYYMMDDHHMMSSSSSSSS)
- <Origin>; Originator of the data file (cspp)
- <Domain Description>; Development domain (dev)
- <Extension>; NetCDF4 (nc) or text (txt)

For example, a JPSS-2/NOAA-21 Imager resolution active fires NetCDF4 file:

```
AFIMG_j02_d20230818_t1923373_e1925019_b03994_c20231003181715675683_cspp_dev.nc
```

and similarly for the Moderate resolution:

```
AFMOD_j02_d20230818_t1923373_e1925019_b03994_c20231003185621797297_cspp_dev.nc
```

For the Moderate resolution NetCDF4 output, the list of key parameters is shown below. Please note that the "FP_confidence" array for the Moderate Resolution files contains the detection confidence in percent (0-100%).

M-Band Active Fire NetCDF File Key Parameters

group: Fire Mask variables:

```

ubyte fire_mask(row, col) ;
  fire_mask:long_name = "fire mask" ;
  fire_mask:legend = "Classes:
    0 missing input data
    1 bowtie
    2 unused
    3 non-fire water
    4 cloud
    5 non-fire land
    6 unknown
    7 fire (low confidence)
    8 fire (nominal confidence)
    9 fire (high confidence)" ;
uint fire_qa(row, col) ;
  fire_qa:long_name = "algorithm QA" ;

```

group: Fire Pixels variables:

```

short FP_line(nfire) ;
  FP_line:long_name = "granule line of fire pixel" ;
short FP_sample(nfire) ;
  FP_sample:long_name = "granule sample of fire pixel" ;
float FP_latitude(nfire) ;
  FP_latitude:long_name = "latitude of fire pixel" ;
  FP_latitude:units = "degrees" ;
float FP_longitude(nfire) ;
  FP_longitude:long_name = "longitude of fire pixel" ;
  FP_longitude:units = "degrees" ;
ubyte FP_confidence(nfire) ;
  FP_confidence:long_name = "detection confidence" ;
  FP_confidence:units = "%" ;
float FP_T13(nfire) ;
  FP_T13:long_name = "M13 brightness temperature of fire pixel" ;
  FP_T13:units = "kelvins" ;
float FP_T15(nfire) ;
  FP_T15:long_name = "M15 brightness temperature of fire pixel" ;
  FP_T15:units = "kelvins" ;
float FP_power(nfire) ;
  FP_power:long_name = "fire radiative power" ;
  FP_power:units = "MW" ;

```

For the Imager resolution NetCDF4 output, the list of key parameters is shown below. It also includes a Persistent Anomaly array (FP_PersistentAnomalyCategory). Please note that the "FP_confidence" array for the Imager Resolution files contains the detection confidence in a single digit value of either 7=low, 8=nominal, or 9=high.

I-Band Active Fire NetCDF File Key Parameters

group: Fire Mask variables:

```

ubyte fire_mask(row, col) ;
  fire_mask:long_name = "fire mask" ;
  fire_mask:legend = "
    0 not-processed (non-zero QF)
    1 bowtie
    2 glint
    3 water
    4 clouds
    5 clear land
    6 unclassified fire pixel
    7 low confidence fire pixel
    8 nominal confidence fire pixel
    9 high confidence fire pixel
uint fire_qa(row, col) ;
  fire_qa:long_name = "algorithm QA" ;
  fire_qa:units = "bit field" ;

```

group: Fire Pixels variables:

```

ushort FP_line(nfire) ;
  FP_line:long_name = "granule line of fire pixel" ;
ushort FP_sample(nfire) ;
  FP_sample:long_name = "granule sample of fire pixel" ;
float FP_latitude(nfire) ;
  FP_latitude:long_name = "latitude of fire pixel" ;
float FP_longitude(nfire) ;
  FP_longitude:long_name = "longitude of fire pixel" ;
float FP_T4(nfire) ;
  FP_T4:long_name = "I04 brightness temperature of fire pixel" ;
  FP_T4:units = "kelvins" ;
float FP_T5(nfire) ;
  FP_T5:long_name = "I05 brightness temperature of fire pixel" ;
  FP_T5:units = "kelvins" ;
float FP_Rad13(nfire) ;
  FP_Rad13:long_name = "M13 radiance of fire pixel" ;
  FP_Rad13:units = "W/(m^2*sr*µm)" ;
float FP_power(nfire) ;
  FP_power:long_name = "fire radiative power" ;
  FP_power:units = "MW" ;
ubyte FP_confidence(nfire) ;
  FP_confidence:long_name = "detection confidence" ;
ubyte FP_PersistentAnomalyCategory(nfire) ;
  FP_PersistentAnomalyCategory:long_name = "persistent industrial or nature source";
  FP_PersistentAnomalyCategory:legend = "
    0 none
    1 oil or gas
    2 volcano
    3 solar panel
    4 urban
    5 unclassified";

```

1.7.2 Output ASCII Text Files

An ASCII Text File is also created for each Imager Resolution and Moderate Resolution VIIRS granule **when there has been at least one active fire detected within that granule**. Therefore, your output may consist of more NetCDF4 data files than ASCII output text files.

The text files follow the same naming conventions as the output NetCDF files, with the .nc replaced with .txt. For example, an Imager resolution ASCII file name could be:

```
AFIMG_j02_d20230818_t1923373_e1925019_b03994_c20231003181715675683_cspp_dev.txt
```

and similarly for the Moderate resolution active fire ASCII output file:

```
AFMOD_j02_d20230818_t1923373_e1925019_b03994_c20231003185621797297_cspp_dev.txt
```

These text files contain the following information:

- Latitude of fire pixel (degrees)
- Longitude of fire pixel (degrees)
- M-Band 13 brightness temperature of fire pixel (K) (**Moderate Resolution only**)
- I-Band 4 brightness temperature of fire pixel (K) (**Imager Resolution only**)
- Along-scan fire pixel resolution (km)
- Along-track fire pixel resolution (km)
- Fire detection confidence:
 - 7=low, 8=nominal, 9=high (Imager Resolution)
 - 0-100 % (Moderate Resolution)
- Fire radiative power (MW)
- Persistent Anomaly (**Imager Resolution only**)
 - 0 - none
 - 1 - oil/gas
 - 2 - volcano
 - 3 - solar panel
 - 4 - urban (not in use)
 - 5 - unclassified

An example of an M-band Active Fire output text file retrieved from a NOAA-21 VIIRS granule observed on 18 August 2023 follows:

```
# Active Fires M-band EDR
#
# source:
AFMOD_j02_d20230818_t1922114_e1923360_b03994_c20231003185621797264_cspp_dev.nc
# version: CSPP Active Fires version: 2.1
#
# column 1: latitude of fire pixel (degrees)
# column 2: longitude of fire pixel (degrees)
# column 3: M13 brightness temperature of fire pixel (K)
```



```

# column 4: Along-scan fire pixel resolution (km)
# column 5: Along-track fire pixel resolution (km)
# column 6: detection confidence (%)
# column 7: fire radiative power (MW)
#
# number of fire pixels: 6
#
44.16184235, -90.05208588, 315.98205566, 0.750, 0.750, 76, 11.87435436
43.66904449, -107.74921417, 330.76541138, 0.750, 0.750, 61, 19.07435608
43.66738129, -107.74462128, 325.23373413, 0.750, 0.750, 75, 10.67929077
43.66445923, -107.75642395, 328.09799194, 0.750, 0.750, 79, 14.50995922
42.69156647, -111.58646393, 311.19024658, 0.750, 0.750, 49, 8.79298019
42.68877411, -111.59614563, 311.00659180, 0.750, 0.750, 58, 8.83912182

```

Similarly, the ASCII text output NOAA-11 VIIRS I-band Active Fires from the same granule observed on 18 August 2023:

```

# Active Fires I-band EDR
#
# source:
AFIMG_j02_d20230818_t1922114_e1923360_b03994_c20231003181715675633_cspp_dev.nc
# version: CSPP Active Fires version: 2.1
#
# column 1: latitude of fire pixel (degrees)
# column 2: longitude of fire pixel (degrees)
# column 3: I04 brightness temperature of fire pixel (K)
# column 4: Along-scan fire pixel resolution (km)
# column 5: Along-track fire pixel resolution (km)
# column 6: detection confidence ([7,8,9]->[lo,med,hi])
# column 7: fire radiative power (MW)
# column 8: Persistent Anomaly
#
#     0 - none
#     1 - oil/gas
#     2 - volcano
#     3 - solar panel
#     4 - urban (not in use)
#     5 - unclassified
#
# number of fire pixels: 14
#
39.61872101, -108.71027374, 367.00000000, 0.375, 0.375, 9, 14.22081184, 0
39.61769485, -108.71410370, 348.96640015, 0.375, 0.375, 8, 11.89411926, 0
44.11699677, -86.27003479, 326.92181396, 0.375, 0.375, 8, 2.73697376, 0
44.15560150, -90.04824066, 329.09594727, 0.375, 0.375, 8, 4.37323809, 0
44.15991974, -90.04891968, 348.88873291, 0.375, 0.375, 8, 11.70273590, 0
44.90655899, -95.40755463, 332.25765991, 0.375, 0.375, 8, 4.23087978, 0

```

45.41393661,	-92.03164673,	328.53784180,	0.375,	0.375,	8,	5.15613604,	0
41.63132095,	-112.17903900,	331.05410767,	0.375,	0.375,	8,	3.80737662,	0
43.51729584,	-105.32075500,	340.01025391,	0.375,	0.375,	8,	4.77778292,	0
43.66623306,	-107.75088501,	367.00000000,	0.375,	0.375,	9,	18.59439850,	0
43.66457367,	-107.74623871,	342.56774902,	0.375,	0.375,	8,	10.42732716,	0
43.66311646,	-107.75212097,	348.02734375,	0.375,	0.375,	8,	7.07526636,	0
43.66733551,	-107.75455475,	336.22735596,	0.375,	0.375,	7,	7.07526636,	0
42.68684006,	-111.59237671,	353.21759033,	0.375,	0.375,	8,	8.57052898,	5

Section 2: Installation and Configuration

2.1 Installation of CSPP NOAA Active Fire Software

Download the following file from the CSPP website (<https://cimss.ssec.wisc.edu/cspp/>):

```
cspp-active-fire-noaa_2.1.tar.gz
```

Install the software as shown below (a new directory named `cspp-active-fire-noaa_2.1` will be created):

```
tar xf cspp-active-fire-noaa_2.1.tar.gz
```

Set the `CSPP_ACTIVE_FIRE_HOME` environment variable to the name of the directory where the software is installed, and execute the environment script as shown below:

```
cd cspp-active-fire-noaa_2.1
```

```
export CSPP_ACTIVE_FIRE_HOME=$PWD ; cd ..
```

```
source $CSPP_ACTIVE_FIRE_HOME/cspp_active_fire_noaa_env.sh
```

The software is now ready to use. Execute the main driver script now with no arguments:

```
cspp_active_fire_noaa.sh
```

If the installation has been successful to this point, you will be presented with the CSPP NOAA Active Fire software command line switches and options.

2.2 Installation of CSPP NOAA Active Fire Test Data

Test data files are available in the tar file named

`cspp-active-fire-noaa-test_data_2.1.tar.gz`. Unpacking the tar file expands the test data into a directory named `fire_test_data/`:

```
tar -xf cspp-active-fire-test_data_2.1.tar.gz
```

The test data includes input SDRs, and output products for verification of a successful installation on your local server.

Section 3: CSPP NOAA Active Fire Software

3.1 Implementation Notes

The CSPP NOAA VIIRS Active Fire software was provided by Marina Tsidulko working as part of the Active Fire Team at NOAA/NESDIS/STAR. The software includes statically compiled binary distributions of the NOAA operational JPSS Active Fire moderate (`vfire_iband_static`) and imager (`vfire750_static`) resolution software. The directory structure is shown below. Bash and python scripts are provided by the University of Wisconsin CSPP team.

```

cspp-active-fire-noaa_2.1
├── bin
│   ├── afire_compare_netcdf.sh
│   ├── cspp_active_fire_noaa.sh
│   ├── cspp_afimg_compare.bash
│   └── cspp_afmod_compare.bash
├── lib
│   └── libgriddingAndGranulation.so
├── scripts
│   ├── ancillary
│   │   ├── GridIP
│   │   │   ├── __init__.py
│   │   │   ├── LandWaterMask.py
│   │   │   └── Utils.py
│   │   ├── __init__.py
│   │   └── stage_ancillary.py
│   ├── active_fire_interface.py
│   ├── afire_compare_netcdf.py
│   ├── args.py
│   ├── cspp_active_fire_noaa.py
│   ├── dispatcher.py
│   ├── log_common.py
│   ├── unaggregate.py
│   └── utils.py
├── static_ancillary
│   ├── AF-LAND_MASK_NASA_1KM.cdl
│   ├── AF-LAND_MASK_NASA_1KM.nc
│   ├── dem30ARC_Global_LandWater_compressed.h5
│   ├── IETTime.dat
│   ├── NPP_VIIRS_LAND_MASK_NASA_1KM.cdl
│   └── NPP_VIIRS_LAND_MASK_NASA_1KM.nc
├── vendor
│   ├── ShellB3
│   ├── anc
│   │   ├── config_j01
│   │   ├── config_j02
│   │   └── config_npp
│   ├── persistentAnomaly
│   │   ├── GVP_Volcano_List_Holocene.csv
│   │   ├── persistent_anomalies.categories.hdf
│   │   ├── persistent_anomalies.shp
│   │   ├── published_static_sources_doi_10.1016-j.rse.2017.10.019-polygon.categories.hdf
│   │   └── published_static_sources_doi_10.1016-j.rse.2017.10.019-polygon.shp
│   ├── add_industrial_flag_iband_static
│   ├── granulation_iband_static
│   ├── persistent_anomalies_iband_static
│   ├── vfire750_static
│   ├── vfire_iband_static
│   └── nagg
├── cspp_active_fire_noaa_env.sh
├── cspp_active_fire_noaa_runtime.sh
├── LICENSE
├── README.md
└── VERSION

```

3.2 Active Fire Driver Script

The principal processing script is

```
cspp-active-fire-noaa_2.1/bin/cspp_active_fire_noaa.sh
```

Execution of this bash script checks for the `CSPP_ACTIVE_FIRE_HOME` environment variable, and then invokes the python script `$CSPP_ACTIVE_FIRE_HOME/scripts/cspp_active_fire_noaa.py`. The script operates by default in the current directory. It creates intermediate granulated Land/Water Mask files, as well as final NetCDF4 and ASCII text output files. A log file is also created for each granule processed. It is recommended that all files be removed from the work directory before each execution of `cspp_active_fire_noaa.sh`.

To create the CSPP Active Fire product, you must provide the path and name of the VIIRS SDR directory or directories containing the VIIRS M-Band and I-Band input SDR HDF5 files, or a list of the files.

By default, the software will create I-Band resolution output files. In order to generate M-Band resolution files, use the `-M` flag.

```
cspp_active_fire_noaa.sh <VIIRS M-BAND or I-BAND SDR directory>,
```

for example, to generate the M-Band Resolution Active Fires product:

```
cspp_active_fire_noaa.sh -M /data/viirs/mband
```

or

```
cspp_active_fire_noaa.sh -M /data/viirs/mband/GMTCO*.h5
```

(assuming the matching required SVM Band Radiance files are also located in the same directory).

Similarly, to create the I-Band Resolution Active Fires product:

```
cspp_active_fire_noaa.sh /data/viirs/iband
```

or

```
cspp_active_fire_noaa.sh /data/viirs/iband/GITCO*.h5
```

Several options are available for `cspp_active_fire_noaa.sh`. A subset is shown below. For a complete list of options, execute `cspp_active_fire_noaa.sh -x`.

```
usage: cspp_active_fire_noaa.py [-M] [-W work_dir] [--cache-dir CACHE_DIR]
      [--noaa-txt-output] [--pa-dir PA_DIR] [--num-cpu NUM_CPU]
      [-d] [-v] [-V] [-h] [-x]
      [inputs [inputs ...]]
```

Run NOAA Active Fire algorithm on VIIRS SDR files.

positional arguments:

inputs One or more input files or directories.

optional arguments:

-M, --m-band Process inputs using the 750m M-Band algorithm, otherwise use the 375m I-Band algorithm [default].

-W work_dir, --work-dir work_dir The work directory.

--cache-dir CACHE_DIR The directory where the granulated land water mask files are kept. Can also be specified by setting the CSPP_ACTIVE_FIRE_CACHE_DIR environment variable, otherwise defaults to "cspp_active_fire_cache_dir" in the current directory.

--noaa-txt-output Output NOAA-style text summary of the Active Fires output. [default is false: Output CSPP style text summary files.]

--pa-dir PA_DIR The directory where the Persistent Anomaly tracking file is created. Can also be specified by setting the CSPP_ACTIVE_FIRE_PA_DIR environment variable, otherwise defaults to "CSPP_ACTIVE_FIRE_CACHE_DIR". Only used for I-band (375m) processing.

--num-cpu NUM_CPU The number of CPUs to try and use. [default: 1]

-d, --debug Always retain intermediate files. [default: False]

-v, --verbosity Each occurrence increases verbosity 1 level from ERROR: -v=WARNING, -vv=INFO, -vvv=DEBUG [default: 2]

-V, --version Print the CSPP Active Fires package version.

-h, --help Show this help message and exit.

-x, --expert Display all help options.

Execution includes the creation of granulated Land/Sea Mask files that cover the region of the data being processed. The option `--cache-dir` can be set if you intend to process the same granules again, reusing the granulated Land/Sea Mask files. Otherwise, the default is to create a sub-directory within the execution directory in which to store the files. This directory remains upon completion.

3.3 VIIRS I-Band Persistent Anomalies

The VIIRS I-Band 375 m Active Fire product also includes an array (FP_PersistentAnomalyCategory) consisting of flags that indicate the presence of potential false fire detections due to non-biomass burning related radiative signatures, such as reflection from solar farms, volcanos, and gas flares. The flags are added based on collocation of fire detections with published or empirically determined persistent anomalies as follows:

- 0 – no persistent anomaly
- 1 – oil or gas flare (based on Liu et al., 2017, reference listed below)
- 2 – volcano (Global Volcanism Program, Smithsonian Institution, 2013)
- 3 – solar panel (empirically determined, CONUS only)
- 4 – urban (currently not used)
- 5 – unclassified (empirically determined)

Liu, Yongxue & Hu, Chuanmin & Zhan, Wenfeng & Sun, Chao & Murch, Brock & Ma, Lei. (2017). Identifying industrial heat sources using time-series of the VIIRS Nightfire product with an object-oriented approach. *Remote Sensing of Environment*. 204. 10.1016/j.rse.2017.10.019

This information is taken directly from the VIIRS I-Band Active Fire Algorithm Theoretical Basis Document (ATBD).

The persistent anomaly information is provided on a best effort basis and should not be considered as a validated data layer. This information is not recommended for scientific analysis of sources of persistent anomalies. The empirical database used to assign persistent anomaly flags is intended to be periodically updated as new persistent anomaly sources are identified.

3.3.1 Persistent Reference File

The persistent reference file (PersistentWaterFireRef.txt) is a text file that contains locations and observation times of low intensity heat sources detected over water (e.g., gas flares). If the persistent file logs more than three recurring detections at the same location in the last 30 days, the algorithm will be prompted to mark that pixel as a detected fire. In order to determine if these should be marked as verified persistent anomaly detections, the persistent file accumulates these entries over multiple runs so the algorithm can cross reference the locations in the future.

The PersistentWaterFireRef.txt file contains the following 5 columns of information:

Longitude	Latitude	Oldest Observation Time	Older Observation Time	Most Recent Observation Time
-----------	----------	-------------------------	------------------------	------------------------------

The observation times are stored in microseconds since January 1, 1958.

Example of persistent reference file entries:

```
-85.370, -33.170, 0, 0, 1769800389805544
-96.838, 36.758, 0, 2028998391038738, 2029001420093162
-105.034, 36.250, 2029174960343882, 2029392990077193, 2029395974017399
```

As stated above, if a thermal anomaly is detected for a latitude/longitude over or near water for three observations in the last 30 days, the algorithm will mark the detection as a fire. If it is already included in the persistent anomalies sources database, the output Active Fire product NetCDF and .txt files will label that detection with a Persistent Anomaly value of 1 – oil or gas flare.

An example verified persistent anomaly entry in the PersistentWaterFireRef.txt file is shown below.

```
-85.370, -33.170, 1769800389591289, 1769800389700125, 1769800389805544
```

If the most recent observation is older than 30 days, the algorithm removes the entry for housekeeping purposes.

The default location for the PersistentWaterFireRef.txt file is the CSPP_ACTIVE_FIRE_CACHE_DIR which defaults to the cspp_active_fire_cache_dir which is created in the execution directory. The directory can be explicitly set by using the --pa-dir option as part of the active fire execution or through the use of the CSPP_ACTIVE_FIRE_PA_DIR environment variable.

3.4 Running the CSPP NOAA Active Fire Test Cases

It is recommended that you verify a correct installation by executing the software on the test cases. It will confirm that your installation is running correctly and also give some guidance on runtimes on your hardware. **Note that a typical runtime is a few seconds.**

Unpack the test data as shown in **Section 2.2** and then execute the commands below. The test case consists of a 4 granule NOAA-21 VIIRS overpass, containing a set of unaggregated M-Band and I-Band resolution SDR granules observed on 8 August 2023.

```
cd fire_test_data/
mkdir work
cd work
```

```
cspp_active_fire_noaa.sh --num-cpu 4 --pa-dir ../PA_dir ../input
```

```
cspp_active_fire_noaa.sh -M --num-cpu 4 ../input
```

Executing the I-Band and M-Band resolution test cases runs in less than 10 seconds. The imager and moderate resolution processing creates one NetCDF4 (AFIMG*cspp_dev.nc) output file and

one ASCII text file (AFIMG*cspp_dev.txt) per granule (4 granules total) using 4 CPU cores. The moderate resolution processing also creates one NetCDF4 (AFMOD*cspp_dev.nc) output file and one ASCII text file (AFMOD*cspp_dev.txt) per granule. If the Active Fire processing script runs normally, it will return a status code equal to zero. If the Active Fire processing script encounters a fatal error, it will return a non-zero status code. The Appendix contains representative Active Fire screen output from executing the imager band test command.

To compare your NetCDF4 output to the reference output using the verification scripts, execute the following commands:

```
cd ..
cspp_afimg_compare.bash img_output_fires/ work/

cspp_afmod_compare.bash mod_output_fires/ work/
```

This script compares the contents of key fields in the NetCDF4 files for all granules. If the comparisons are successful, the word "SUCCESS" will appear.

The output from our test system for one granule of both the imager resolution and moderate resolution is shown below.

```
cspp_afimg_compare.bash img_output_fires/ work/
```

```
Checking Active Fire outputs...
Comparing Files:
AFIMG_j02_d20230818_t1922114_e1923360_b03994_c20231003181715675633_cspp_dev.nc
checking
Comparing fire\ mask Array
SUCCESS
Comparing FP_line Array
SUCCESS
Comparing FP_sample Array
SUCCESS
Comparing FP_latitude Array
SUCCESS
Comparing FP_longitude Array
SUCCESS
Comparing FP_T04 Array
SUCCESS
Comparing FP_T05 Array
SUCCESS
Comparing FP_power Array
SUCCESS
Comparing FP_confidence Array
SUCCESS
```

```
cspp_afmod_compare.bash mod_output_fires/ work/
```

```
Comparing Files:
```

```
AFMOD_j02_d20230818_t1925032_e1926261_b03994_c20231003185621797317_cspp_dev.nc
```

```
checking
```

```
Comparing /Fire Mask/fire_mask Array
```

```
SUCCESS
```

```
Comparing /Fire Pixels/FP_line Array
```

```
SUCCESS
```

```
Comparing /Fire Pixels/FP_sample Array
```

```
SUCCESS
```

```
Comparing /Fire Pixels/FP_latitude Array
```

```
SUCCESS
```

```
Comparing /Fire Pixels/FP_longitude Array
```

```
SUCCESS
```

```
Comparing /Fire Pixels/FP_T13 Array
```

```
SUCCESS
```

```
Comparing /Fire Pixels/FP_T15 Array
```

```
SUCCESS
```

```
Comparing /Fire Pixels/FP_power Array
```

```
SUCCESS
```

```
Comparing /Fire Pixels/FP_confidence Array
```

```
SUCCESS
```

4.0 Displaying Your CSPP Active Fire Output Product

There are a number of tools that can be used to create images of the active fire output products. The following is an example using CSPP Polar2Grid software showing how to overlay the Imager Resolution output active fire NetCDF fire locations onto GeoTIFF true color imagery.

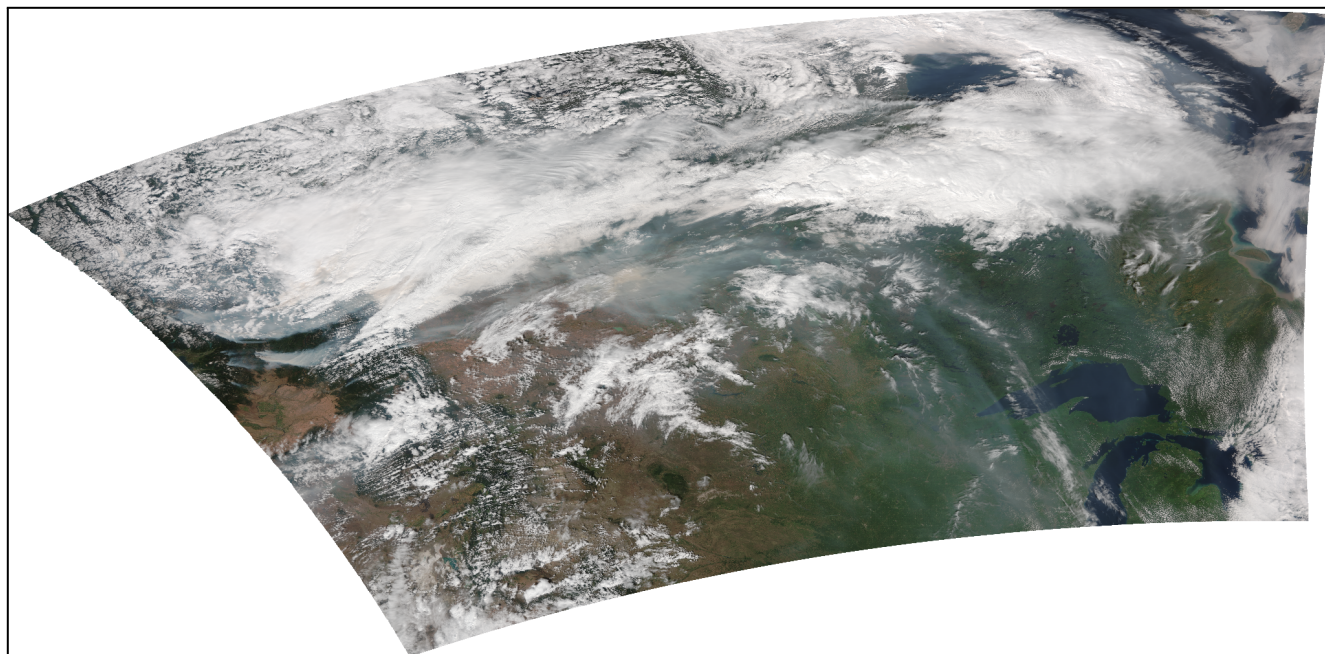
4.1 Overlay Active Fires Locations onto a Polar2Grid Image

Download the Polar2Grid Version 3.0 software from the CSPP website.

https://cimss.ssec.wisc.edu/cspp/polar2grid_v3.0.shtml

Install the software as described in the Installation Guide. This software allows you to create reprojected individual band images as well as true and false color GeoTIFF images from input NOAA-21, NOAA-20 and SNPP VIIRS SDRs along with a subset of EDRs. The default projection is WGS84, which is also known as the Google Earth Projection, or Platte Carée Projection.

A Polar2Grid image created from our test data pass is included in the fire_test_data/output_images directory (noaa21_viirs_true_color_20230818_192211_wgs84_fit.tif). It covers a region over the western United States and parts of Canada. It is displayed below.



To create this true color image that will serve as the background for our fire overlay, run the following Polar2Grid commands in the work directory where your Imager Resolution Active Fire output files were created:

```
cd fire_test_data/work
$POLAR2GRID_HOME/bin/polar2grid.sh -r viirs_sdr -w geotiff -p true_color \
  -f ../input
```

Then use the following Polar2Grid command to create Active Fire Confidence Category, I-Band 4 Fire Temperature, and Fire Radiative Power product GeoTIFF images from your output CSPP VIIRS EDR I-Band Active Fire NetCDF files. This image set is the default Active Fire I-Band image product suite.

```
$POLAR2GRID_HOME/bin/polar2grid.sh -r viirs_edr_active_fires -w geotiff \
  --radius-of-influence 2000 -f AFIMG_j02*.nc
```

Executing this command will result in the creation of these output GeoTIFF images.

```
noaa21_viirs_confidence_cat_20230818_192211_wgs84_fit.tif
noaa21_viirs_power_20230818_192211_wgs84_fit.tif
noaa21_viirs_T4_20230818_192211_wgs84_fit.tif
```

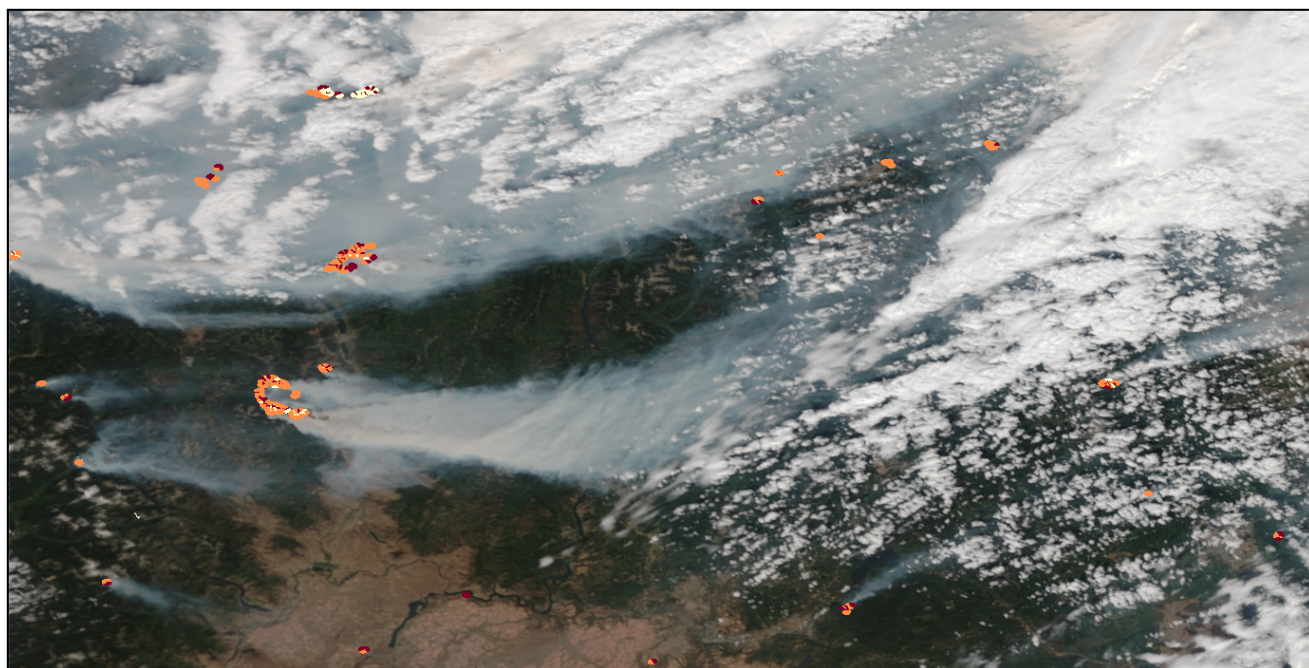
Now use the Polar2Grid “overlay.sh” command to overlay the Confidence Category VIIRS GeoTIFF onto the VIIRS true color GeoTIFF.

```
$POLAR2GRID_HOME/bin/overlay.sh -h
```

Usage: overlay.sh background.tif foreground.tif out.tif

```
$POLAR2GRID_HOME/bin/overlay.sh noaa21_viirs_true_color_20230818_192211_wgs84_fit.tif \
noaa21_viirs_confidence_cat_20230818_192211_wgs84_fit.tif AFIMG_polar2grid.tif
```

The result of executing this command is the active fires locations, color coded by detection confidence (Red: high confidence; Orange: nominal confidence; Yellow: low confidence), overlaid on the true color image (AFIMG_polar2grid.tif). A zoomed in section of this GeoTIFF image (AFIMG_polar2grid.tif) is displayed below, that includes the Canadian province of British Columbia.



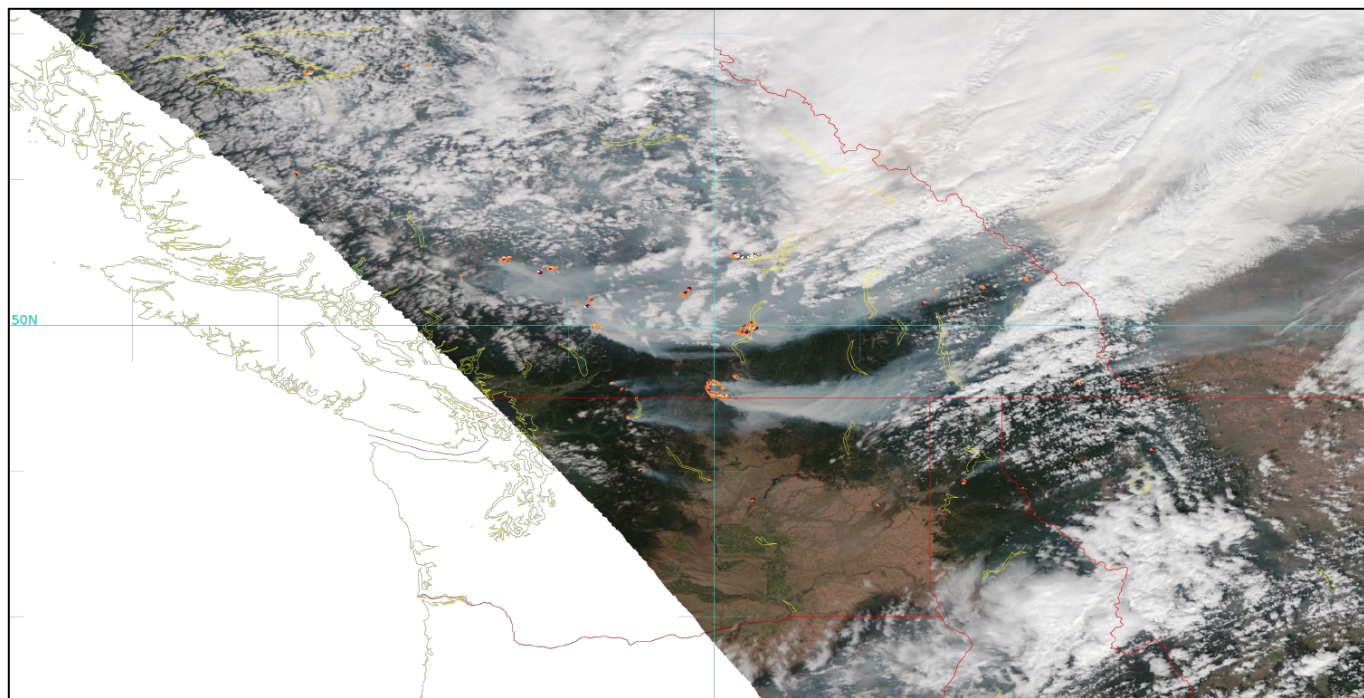
To overlay borders on your image, use the Polar2Grid command “add_coastlines.sh”, which can overlay political boundaries, coastlines and latitude/longitude grid lines onto a GeoTIFF file. There are many options to choose from, including the overlay resolution and color. Execute \$POLAR2GRID_HOME/bin/add_coastlines.sh -h to see all of the options.

Executing this command,

```
$POLAR2GRID_HOME/bin/add_coastlines.sh --add-coastlines --add-borders --borders-resolution=h \
--borders-outline='red' --add-grid AFIMG_polar2grid.tif -o AFIMG_polar2grid.png
```

will create an output PNG file containing the AFIMG_polar2grid.tif image overlaid with coastlines in yellow, political boundaries in red and latitude/longitude grid lines in cyan. In our execution we have chosen to display the political boundaries at high resolution.

The PNG image, AFIMG_polar2grid.png, is displayed below.



Appendix A: CSPP Active Fire example screen output

```

cspp_active_fire_noaa.sh --num-cpu 4 --pa-dir ../PA_dir ../input

#####
#                               Community Satellite Processing Package           #
#                               VIIRS Active Fires                             #
#                               #                                               #
#                               CSPP Active Fires: Version 2.1                 #
#                               I-band: Version 2.5.4, compiled Jul  7 2023 02:13:57. #
#                               Current date: 2023-10-03 20:06:34.087610+00:00   #
#####
Using dir /data/kathys/tmp/fire/fire_test_data/work/cspp_active_fire_cache_dir for LWM cache.
Using dir /data/kathys/tmp/fire/fire_test_data/PA_dir for Persistent Anomaly cache.
>>> Preparing inputs
>>> Input Files
    <Granule ID>                <Granule Start Time>
J02003730585341      2023-08-18 19:22:11.400000
J02003730586194      2023-08-18 19:23:37.300000
J02003730587048      2023-08-18 19:25:03.200000
J02003730587901      2023-08-18 19:26:27.300000
>>> Cleaning the ancillary cache back 6.0 hours...
No old files need to be removed from the ancillary cache
/data/kathys/tmp/fire/fire_test_data/work/cspp_active_fire_cache_dir
>>> Running Active Fires
There are 64 available CPUs
We have requested 4 CPUs
We are using 4/64 available CPUs
Submitting 4 Active Fire tasks to the pool...
Processing granule_id J02003730586194...
Processing granule_id J02003730585341...
Processing granule_id J02003730587048...
Processing granule_id J02003730587901...
    Staging the required ancillary data for granule_id J02003730586194...
    Staging the required ancillary data for granule_id J02003730585341...
    Staging the required ancillary data for granule_id J02003730587901...
    Staging the required ancillary data for granule_id J02003730587048...
    LWM granulation for J02003730585341 took 0 minutes, 1.315619 seconds
    LWM granulation for J02003730587048 took 0 minutes, 1.505798 seconds
    LWM granulation for J02003730586194 took 0 minutes, 1.541600 seconds
    LWM granulation for J02003730587901 took 0 minutes, 1.561516 seconds
    I-band Active Fires execution for J02003730587901 took 0 minutes, 4.838022 seconds
    I-band Active Fires execution for J02003730586194 took 0 minutes, 5.869096 seconds
    Persistent Anomaly execution for J02003730587901 took 0 minutes, 0.861017 seconds
    I-band Active Fires execution for J02003730585341 took 0 minutes, 7.117491 seconds
    Persistent Anomaly execution for J02003730586194 took 0 minutes, 0.858808 seconds
    I-band Active Fires execution for J02003730587048 took 0 minutes, 7.725803 seconds
    Industrial Sources execution for J02003730587901 took 0 minutes, 0.992923 seconds
    Granule J02003730587901 has 40 fire pixels
    Persistent Anomaly execution for J02003730585341 took 0 minutes, 0.840251 seconds
    Industrial Sources execution for J02003730586194 took 0 minutes, 1.045913 seconds
    Granule J02003730586194 has 30 fire pixels
    Persistent Anomaly execution for J02003730587048 took 0 minutes, 0.858221 seconds
    Industrial Sources execution for J02003730585341 took 0 minutes, 1.057051 seconds
    Granule J02003730585341 has 14 fire pixels
    Industrial Sources execution for J02003730587048 took 0 minutes, 1.050393 seconds
    Granule J02003730587048 has 810 fire pixels
Active Fire execution took 0 days, 0 hours, 0 minutes, 13.266954 seconds

```

```
attempted_runs ['J02003730585341', 'J02003730586194', 'J02003730587048', 'J02003730587901']
successful_runs ['J02003730585341', 'J02003730586194', 'J02003730587048', 'J02003730587901']
problem_runs []
crashed_runs []
```